Status and Ecology of Mexican Spotted Owls in the Gila Region, New Mexico

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Abstract

The highlands of New Mexico's Gila region provide an important stronghold for the Mexican spotted owl (*Strix occidentalis lucida* Nelson). Historical data document that this region supported spotted owls in the past, and recent studies indicate that owls are both relatively common and well distributed in this region at present. Spotted owls are most numerous in mixed-conifer forests within the Gila region but may also occur in other forest types, particularly where rocky cliffs and outcrops are present. These features provide owls with nest and roost sites as well as habitat for common prey species. Spotted owl diets in the region typically are dominated by a few types of nocturnally active small mammals. The Gila region features a convergence of topography, geologic substrates, and forest types that provide suitable habitat for Mexican spotted owls and their prey, and contains large roadless areas that result in minimal disturbance due to land management. These large roadless areas also provide unique opportunities to manage wildfire at landscape scales, thus providing an opportunity to evaluate relationships between spotted owls, forest habitats, and fire. Despite their abundance and widespread distribution in the region, however, studies between 1990 and 2005 suggest that some local owl populations may be declining in the region. This is a concern because the Gila region likely serves as an important source population of spotted owls. Uncertainty over population trends suggests a need for continued monitoring of owl populations in this region.

Introduction

The highlands of New Mexico's Gila region serve as an important center of biodiversity and support important populations of many species of special interest (e.g., Povilitis 1996), including the Mexican spotted owl (*Strix occidentalis lucida* Nelson). This medium-sized owl inhabits canyonlands and forested mountains throughout the southwestern United States and the highlands of northern and central Mexico (Gutiérrez, Franklin, and LaHaye 1995; Ward et al. 1995). It is frequently associated with mature or late-successional forests (Ganey and Balda 1989; Ganey and Dick 1995; Gutiérrez, Franklin, and LaHaye 1995) and was listed as threatened in the United States under the Endangered Species Act, largely due to concerns over loss of such forests to timber harvest and stand-replacing wildfire (USDI 1993). Here we summarize current information on the status of the Mexican spotted owl in the Gila region. We review historical information (defined as prior to 1989, the year when organized surveys for this species began throughout the Southwestern Region, USDA Forest Service) on the presence of these owls in the Gila region; synthesize recent (1989–present) data on spotted owl status and ecology in this region; and speculate on the importance of this region to recovery of this threatened owl. We show that spotted owls were present historically in the Gila region and argue the likelihood that this region currently serves as an important population center for Mexican spotted owls and should continue to do so into at least the near future. We also argue that the nature of the Gila region, coupled with a relatively high population of spotted owls, provides unique opportunities for studying this bird and aspects of its ecology.

The Gila Region

Our primary focus in this paper is on lands administered by the Gila National Forest in west-central New Mexico (fig. 1). This region falls within the Upper Gila Mountains Recovery Unit (fig. 2), one of six recovery units recognized within the U.S. range of the owl (USDI 1995).

The Gila National Forest is dominated by a series of rugged mountain ranges separated by river valleys. Elevation ranges from 1370 to 3350 m, and habitats range from semi-desert grassland to alpine forests. This forest includes more area in wilderness than any other national forest in the Southwest.

The Gila National Forest is contiguous with similar forest lands administered by the Apache National Forest to the west, and is nearly contiguous with the forested San Mateo and Magdalena mountains (Cibola National Forest) to the northeast (fig. 1). Thus the Gila region, broadly defined, could easily be extended beyond the boundaries of our primary focus area within the Gila National Forest.

Natural History of Mexican Spotted Owls in the Gila Region

Distribution and Abundance

Historical information on Mexican spotted owls throughout their range is sparse and anecdotal, but clearly documents that these owls were present in the Gila region and suggests that they were not uncommon. For example, Ligon (1926, 422) observed spotted owls throughout much of New Mexico, but observed them “most commonly through south central New Mexico in the Sacramento Mountains, San Mateo Mountains, Black Range and Mogollon Mountains and in corresponding latitudes in eastern Arizona.” With the exception of the Sacramento Mountains, this describes the Gila region and immediately adjacent areas. Bailey (1928) also lists several locations where spotted owls were observed in and around the Gila region.

Skaggs (1988) compiled available records of the spotted owl in southern New Mexico from his personal observations, the ornithological literature, museum specimens, and sight records by agency biologists and experienced New Mexico bird-watchers. He grouped these records into three broad geographic regions (Basin and Range, Sacramento Mountains, and Mogollon Highlands). The Mogollon Highlands area corresponded to the Gila region and the adjacent San Mateo Mountains (see Skaggs 1988, fig. 1), and contained 77% of the historical records of spotted owls in southern New Mexico. Skaggs noted that differences in regional coverage might bias these results, but also stated, “There is no question in my mind that the Mogollon Highlands contain the greatest proportion of suitable spotted owl habitat in southern New Mexico.”

No historical data on abundance or density of spotted owls are available for the Gila region. As noted, however, Ligon (1926, 422) indicated that these owls were more common in this region than elsewhere, and added that they were “by no means as scarce in favored sections of their range as one unfamiliar with their habits might believe.”

Thus, historical data document that spotted owls were present, and likely not extremely rare, in the Gila region. Because of their threatened status and the association between spotted owls and older forests, considerable attention has focused on these owls in recent years. As a result, we know considerably more about current status than we do about historical status.

Although we still have no rigorous estimates of population size for Mexican spotted owls in the Gila region, several lines of evidence suggest that these owls are more abundant in this region than elsewhere. For example, the Gila National Forest had established 269 Protected Activity Centers (PACs) for spotted owls as of 2008, far more than any other national forest within the Southwestern Region (fig. 3). These PACs are established around discrete areas occupied by pairs of owls or single owls, in accordance with recommendations in USDI (1995). It is not possible to estimate numbers of owls from numbers of PACs, because not all territories are occupied simultaneously, not all occupied PACs are occupied by pairs of owls, and portions of the forest have not been surveyed thoroughly for owls. Nevertheless, the relatively large number of PACs implies a relatively large population of spotted owls in the Gila region.

Data on relative occupancy and density of spotted owls from standardized surveys across the Upper Gila Mountains Recovery Unit also suggest that these owls are more numerous in the Gila region than in the overall Recovery Unit. Ganey et al. (2004) used standardized methodology to estimate abundance of spotted owls in 25 randomly located quadrats, ranging in size from roughly 40 to 80 km^2, across this Recovery Unit (fig. 4). Resident owls were found in 8 of 10 quadrats within the Gila region, versus 53% of 15 quadrats located outside of the Gila region.

Not only were owls found in greater proportions of occupied quadrats in the Gila region than elsewhere, but observed density of owls in occupied quadrats was greater there as well. Median owl density in occupied quadrats in the Gila region was more than double the median density in occupied quadrats elsewhere, and only one quadrat outside the Gila region even approached the median density observed within the Gila region (fig. 5). That quadrat was located within the Kachina Peaks Wilderness on the San Francisco Peaks (Ganey et al. 2004), an area seemingly similar to much of the Gila region in that it encompasses a roadless area dominated by montane forests.

Spotted owls also appear to be well distributed throughout the Gila region (fig. 6). PAC locations combined with locations of owls discovered in the quadrat surveys (Ganey et al. 2004) suggest that owls are found throughout the higher-elevation montane areas across the forest; there are records from the Black Range and the Jerky, Mangas, Mogollon, Pinos Altos, San Francisco, and Tularosa mountains and surrounding areas. Again, current knowledge may underestimate actual owl distribution, because surveys have not been conducted thoroughly across the entire forest.

Habitat Use

Data on habitats historically occupied by spotted owls are also sparse and anecdotal. Ligon (1926, 422) observed these owls in "deep, narrow, timbered cañons where there are always cool shady places, at elevations ranging from 6,500 to 9,000 feet" (approximately 1980 to 2745 m). He typically observed them roosting either in trees or in a cave or crevice in canyon walls. Skaggs (1988, 3) summarized breeding-season records of spotted owls in southern New Mexico as ranging from 1370 to 3000 m (mean = 2210 m). The dominant vegetation type at 89% of 18 known breeding areas he examined was mixed-conifer forest (dominated by Douglas fir ([*Pseudotsuga menziesii* Mirb., Franco], white fir [*A. concolor* Lindl. ex Hildebr.], and ponderosa pine [*Pinus ponderosa* Dougl. ex Laws]), with the remaining sites in ponderosa pine forest and pinyon (*P. edulis* Engelm.)–juniper (*Juniperus spp*.) woodland at lower elevations. Most nest and roost sites he observed had " moderate to high densities of understory trees, typically Gambel oak (*Quercus gambelii* Nutt.) and bigtooth maple (*Acer grandidentatum* Nutt.)." Cliffs were present at 15 of 18 (83.3%) sites, and vertical relief was pronounced in the areas surrounding observed roost and nest sites.

Three data sets provide information about recent habitat use. USDI (1995) compiled available information resulting from agency surveys for spotted owls throughout the southwestern U.S. from 1989 to 1993. The resulting data included 238 visual observations of spotted owls within the Gila National Forest. The vast majority of these locations were in mixed-conifer forest (fig. 7). Data were gathered from large portions of the forest, but (1) data represented an unknown number of owls and territories; (2) representation was unequal among owls and territories (i.e., multiple observations were included for some owls and territories but not for others); and (3) survey areas were not selected randomly or systematically. All of these factors could bias the results, with both direction and magnitude of that bias unknown.

Two other studies examined habitat use at different spatial scales in a single study area in the Tularosa Mountains. These studies did not cover as wide a geographic area as USDI (1995), but had the advantage that only one observation per individual owl territory was included in analyses, eliminating potential biases caused by including multiple observations for some territories.

Seamans and Gutiérrez (1995) compared fine-scale habitat characteristics between known owl roost and nest sites and randomly located sites. Owls selected roost and nest sites in mature, closed-canopy mixed-conifer forests, particularly where those forests had a well-developed oak component and contained large trees. Most nest sites (78%, n = 28 nests) were in Douglas fir trees, and the most common nest structures (61%) were platforms in witches' brooms caused by dwarf mistletoe (*Arceuthobium* spp.) infections. Nest trees were older, larger in diameter, and taller than randomly located trees within the nest stand (table 1). Only one cliff nest (4%) was found.

Peery, Gutiérrez, and Seamans (1999) compared landscape composition and pattern between owl nest and roost areas and randomly located areas at eight spatial scales ranging from 79 to >5000 ha (n = 40 discrete territories included). At all scales evaluated, owl sites contained significantly greater amounts of mature mixed-conifer and pine forest than random sites. After controlling for area in mature forest, no differences were observed between owl and random sites in various indices of landscape pattern.

Thus, historical data suggest that owls were most common in mixed-conifer forests, often in areas associated with rocky cliffs. Recent surveys throughout the Gila region also support a strong association between owls and mixed-conifer forest, and recent studies in the Tularosa Mountains suggest that they select mature mixed-conifer forest in that area. These results generally are consistent with habitat use of Mexican spotted owls elsewhere (see review in Ganey and Dick 1995). However, historical data may overestimate, and recent results underestimate, the association between spotted owls and rocky cliff areas. Both Ligon (1926) and Skaggs (1988) noted a strong association between spotted owls and cliffs, and Ligon regarded cliffs as a range requirement. Ganey et al. (2004) did not evaluate habitat use, but some of the highest densities of owls were observed in quadrats where owls inhabited forests interspersed with cliffs and caves (JLG, personal observation). Owls in these areas used cliffs and caves for both nest and roost sites, and rocky areas may provide good foraging opportunities as well. Spotted owls thus appear to be strongly associated with both mixed-conifer forests and rocky cliffs in the Gila region, and the presence of rocky cliffs and caves may allow them to exist outside of the mixed-conifer zone if significant cliffs are present. Recent studies in the Tularosa Mountains reported no strong association with cliffs, however, which suggests that cliffs and caves, although important in parts of the region, are not a habitat requirement for spotted owls in the overall Gila region.

Diet Composition

Again, little historical information is available on diets of spotted owls in the Gila region. Ligon (1926) reported that they fed "almost exclusively on small rodents," and most stomachs he examined contained parts of woodrats (*Neotoma* spp.). A juvenile spotted owl captured near Reserve and kept in a barn overrun with mice and rats quickly "cleaned the barn of these pests" (Steele 1927). This owl refused to eat offered birds and chicken parts, but readily accepted rodents from the author.

Three recent data sets estimated diet composition of spotted owls in the Gila region. The largest of these data sets was from the Tularosa Mountains study by Seamans and Gutiérrez (1999), discussed above. The others resulted from a USDA Forest Service contract study across the Gila region and adjacent areas (Reichenbacher and Duncan 1992). Patterns were similar throughout: Owls consumed a wide variety of animals, but diet biomass was dominated by relatively few types of small mammals (fig. 8). These typically included woodrats, mice (*Peromyscus* spp.), rabbits (*Sylvilagus* spp.), voles (*Microtus* spp.), and pocket gophers (*Thomomys bottae* Eydoux and Gervais), with woodrats being the dominant prey in all three areas.

These results are generally consistent with studies of diet composition of Mexican spotted owls in other geographic areas, which also typically show diets dominated by a few species of nocturnally active small mammals (e.g., Ganey 1992; Ward and Block 1995). The relative proportions of prey species differ among geographic areas, likely reflecting differences in habitats present and relative distribution of prey taxa. In general, woodrats tend to dominate diets in areas where rocky cliffs are present (Ganey 1992; Ward and Block 1995). The primary woodrat taken in most montane areas is the Mexican woodrat (*N. Mexicana* Baird; Ganey 1992; Ward and Block 1995). In New Mexico, this woodrat occurs primarily in montane mixed-conifer forests (Findley et al. 1975), often in association with rock outcrops, rocky slopes, and cliffs (Cornely and Baker 1986). Thus, the relative dominance of woodrats in diets of spotted owls in the Gila region is consistent with the habitat of these owls. Areas where rocky cliffs or outcrops are present within montane mixed-conifer forests may provide optimal foraging conditions for spotted owls.

Population Trend

No historical data exist on population trends of Mexican spotted owls. Recent studies suggest that populations may be declining in the Gila region. Stacey and Peery (2002) studied populations of owls in four mountain ranges from 1991 to 1999. One of these ranges (Black Range) was within the Gila region as defined here, with the other three ranges (Magdalena, San Mateo, and Zuni mountains) nearby. They reported that the combined population declined at a rate of almost 20% per year during this period, that all of the owl territories monitored in the two smallest ranges (Magdalena and Zuni mountains) "became vacant" by the end of the study, and that populations in the larger San Mateo Mountains and Black Range declined annually by approximately 30% and 16%, respectively.

Seamans et al. (1999) reported on short-term trends in a spotted owl population in the Tularosa Mountains, and Gutierrez et al. (2003) provided data for this population over a longer time frame. From 1993 to 2000, the population declined by approximately 6% per year (ibid. 2003). Using estimates of "realized change," they estimated that the owl population remaining in the study area in the year 2000 was only 60.8% as large as the 1993 population.

Air Combat Command (2006) monitored occupancy and reproductive rates for 83 spotted owl territories in the Gila National Forest south of Reserve from 2000 through 2005. There, both overall occupancy rates and pair occupancy rates declined during this period, possibly in response to several poor reproductive years early in that period (fig. 9). Reproduction improved in 2004 and 2005, however, with numerous young fledging in those years (fig. 9). Because populations of Mexican spotted owls appear to track reproduction with a short "lag period"

(Seamans et al. 1999; Gutiérrez et al. 2003), this suggests a possibility for increased occupancy rates in 2006 and subsequent years. Data to document that response are lacking, however.

Reasons for apparent population declines are unknown, but may involve climatic variability. Seamans, Gutiérrez, and May (2002) modeled the influence of climate on survival and reproduction of spotted owls. Both reproduction and survival were positively correlated with precipitation in the Tularosa Mountains. Precipitation during the previous monsoon season (July–Sept.) explained almost half of the temporal variability in owl reproduction, and precipitation during the previous winter explained more than half of the temporal variability in owl survival. These authors speculated that climate may influence owl vital rates indirectly by influencing prey abundance. Regardless of the underlying cause-and-effect relationships, however, their results suggest that continued drought may result in continued declines in numbers of spotted owls.

In contrast, surveys conducted in 2000 by National Forest personnel located numerous owls both in the Gila region (Gila National Forest 2000, table 1) and in nearby mountain ranges (San Mateo and Magdalena mountains, Cibola National Forest; Gila National Forest 2000, table 2) where Stacey and Peery reported precipitous declines prior to 2000. These results do not appear consistent with rapidly declining populations. We are unsure how to reconcile these conflicting data, but suggest that enough uncertainty exists to warrant continued monitoring of the owl population in the Gila region.

Biogeography and Population Genetics

Over the subspecies' range, Mexican spotted owl distribution is discontinuous, reflecting the fragmented distribution of canyonlands and forested mountains throughout the Southwest. Thus, Mexican spotted owl populations may constitute one or more metapopulations, or systems of local populations connected by dispersing individuals (Keitt, Franklin, and Urban 1995; Gutierrez and Harrison 1996; Hanski 1998). Maintaining connectivity between different populations of spotted owls thus may be important to maintaining overall viability of the subspecies. The Gila region may serve as both an important source population and an important connecting link between habitat "islands."

Keitt and others (1995; 1997) modeled landscape connectivity for spotted owls throughout the southwestern U.S. They mapped habitat islands based on land-cover maps and assessed connectivity by varying values for effective dispersal distance. They found a threshold change in landscape connectivity at a dispersal distance of about 45 km. That is, the landscape suddenly changed from a set of largely unconnected habitat islands to a set of largely connected islands if owls could effectively disperse approximately 45–50 km between clusters. Current information suggests that this is a reasonable estimate for effective dispersal distance in spotted owls (Gutiérrez, Franklin, and LaHaye 1995; Ganey et al. 1998; Willey and van Riper 2000). Their analysis further documented that numerous connections between habitat islands went through the Gila region (Keitt, Urban, and Milne 1997, fig. 3).

The same authors also evaluated relative importance of individual habitat islands to landscape connectivity by sequentially removing individual islands and reassessing connectivity in their model. They identified the Upper Gila Mountains Recovery Unit as extremely important to landscape connectivity based on both its central location and large patch size (Keitt, Urban, and Milne 1997, fig. 6). A further analysis weighted by patch area identified several small habitat islands in northern New Mexico as very important to maintaining connectivity for this owl (ibid., figs. 6 and 7). These islands are too small to serve as important source populations, but rather serve as stepping stones linking larger areas of habitat. Logic dictates that these patches remain important only if they remain connected to larger habitat islands that support source populations, and the nearest likely source population is located within the Gila region. Thus, because of both its size and location, the Gila region appears likely to play a large role in metapopulation dynamics of Mexican spotted owls, and may have importance beyond the local population.

This conclusion is further supported by current knowledge of genetic structure in this subspecies. Barrowclough et al. (2006, fig. 1b) identified three relatively distinct clades or genetic types in Mexican spotted owls. One clade was dominant in the northwestern portion of the range (southwestern Utah) and absent from the southeastern portion of the range (Sacramento Mountains, New Mexico). A second clade dominated the southeastern portion of the range but was absent from the northwestern populations. A third clade was most common in the Upper Gila Mountains Recovery Unit and southeastern Arizona, but was present throughout the range of the owl. All three clades were present in the Gila region, suggesting that populations within the Gila region facilitate gene flow across the range of the owl. Viewing their results in light of Keitt, Urban, and Milne (1997), Barrowclough et al. (2006) suggested that maintaining stepping-stone habitat fragments connecting the Upper Gila Mountains region to the rest of the population was important to maintaining population viability for Mexican spotted owls. We argue that the Gila region is particularly important within the larger Upper Gila Mountains Recovery Unit, because of both its geographic location and the relative abundance of owls there.

Prospects for the Future

Because of its relatively high abundance and geographic location, the population of Mexican spotted owls in the Gila region may be vital to maintaining viability for this threatened subspecies and in fostering its ultimate recovery. In theory, Mexican spotted owls should thrive in the Gila region, which features large expanses of montane terrain, much of it dominated by the mixed-conifer forest favored by spotted owls (Ganey and Dick 1995). The region also features geologic formations prone to forming cliffs and large outcrops containing caves and potholes, features that provide both roost and nest sites for spotted owls and suitable habitat for important prey species such as Mexican woodrats. Furthermore, the Gila region features extensive roadless areas where disturbance by land management is minimal, and where large areas of late-successional forests provide suitable habitat for spotted owls.

All of these features should interact to provide favorable conditions for this bird. Thus, the suggestion that populations of spotted owls in the Gila region may be declining (Seamans et al. 1999; Stacey and Peery 2002; Gutiérrez et al. 2003) is cause for concern, and suggests a need for continued monitoring of population status in this region.

There are other good reasons for monitoring population trends in this region. One is that this region may provide unique opportunities to evaluate relationships between spotted owls and fire. Following years of fire suppression, southwestern forests have become prone to large, stand-replacing wildfires (Gila National Forest 2005). Management intervention is often needed to restore these forests to structural conditions more in line with natural fire regimes. In many cases, initial intervention includes mechanical thinning of small trees, prescribed burning, or both treatments used in combination. The effects of such treatments on owls and their prey and habitat are not well understood. Further, mechanical thinning is not a viable option in the large roadless areas of the Gila region. Consequently, the Gila National Forest uses wildland fire management in an attempt to use naturally occurring fires, burning when climatic conditions are favorable, to reduce fuels without subjecting large areas to stand-replacing crown fires (Gila National Forest 2005). In some cases large, stand-replacing wildfires occur despite the efforts of forest managers. The large roadless areas of the Gila region, with their limited access and rugged terrain, are particularly prone to such wildfires.

Available data suggest that Mexican spotted owls are reasonably resilient with respect to even large wildfires in the short term (Bond et al. 2002; Jenness, Beier, and Ganey 2004), but long-term data on owl response to fire is generally lacking. Given current knowledge, it seems reasonable to expect that owls will also be resilient with respect to prescribed fire (e.g., Willey 1998b) and wildland fire use. Monitoring occupancy and reproduction of owl territories burned under varying conditions could provide information on how owls respond to varying fire severity and extent. Monitoring of owl response over longer time frames would also be helpful to determine whether or not short-term responses persist over these longer time frames. As a result of prescribed fires, wildland use fires, and wildfires, the Gila region features forests that represent a wide range of fire effects, in terms of both fire intensity and fire extent, and includes areas that have burned multiple times in recent history. Thus, the Gila provides unique opportunities to understand how fire affects spotted owls and their prey and habitat. Lessons learned in the Gila region regarding the effects of fire on spotted owls may be relevant throughout the broader region as fire managers strive to return southwestern forests to fuel conditions within the natural range of variability.

Other factors potentially influencing future spotted owl populations in this area include introduced avian diseases and climate change. West Nile virus has had significant impacts on populations of some birds (Peterson et al. 2004), including owls (Fitzgerald et al. 2003), and this virus has now reached New Mexico. Susceptibility of Mexican spotted owls to West Nile virus remains unknown. Similarly, avian influenza has spread throughout much of Asia, Europe, and Africa, and may spread to North America at some point. Both diseases could result in mortality or reduced fecundity in spotted owls, and these effects would likely go unnoticed in the absence of population monitoring.

Climate change also has the potential to impact spotted owls and their habitat. Climatic effects on fecundity and survival of spotted owls have been demonstrated (Seamans, Gutiérrez, and May 2002), and suggest that if drought conditions persist in the Gila region, owl populations may continue to decline. Many climate models predict increased and rapid warming in the near future (IPCC 2007). Changes predicted by these models are sufficiently large to affect the distribution of forest types occupied by spotted owls (Dale et al. 2001; Koprowski, Alanen, and Lynch 2005; Mueller et al. 2005; CIRMOUNT 2006). These changes may occur too rapidly to allow for migration of forest types. Climate change also may alter disturbance regimes, resulting in disturbances (such as wildfire and insect outbreaks) that are both more frequent and more severe than those typical of the past (Dale et al. 2001; McKenzie et al. 2004; Koprowski, Alanen, and Lynch 2005; CIRMOUNT 2006). Thus, the potential for habitat loss from climate change appears real. There may be little land managers can do to minimize such loss, but monitoring of population trends could provide an early warning if population declines occur.

In summary, the Gila region appears to be an important population center for Mexican spotted owls, and the health of the owl population there may affect the viability of the overall population of this subspecies. The Gila region at present has a wealth of suitable habitat for spotted owls, which in theory should thrive there. The large-scale fire management occurring within the Gila region also provides unique opportunities to study relationships between spotted owls and fire. Significant uncertainties for future prospects of spotted owls in this region include short-term climatic fluctuations (e.g., drought), long-term climate change and associated changes in forest types and disturbance regimes, introduction of exotic avian diseases, and possible changes in management strategies (e.g., a return to the intensive timber management implemented in Arizona and New Mexico, which factored heavily into the decision to list the owl as a Threatened Species [USDI 1993]). Monitoring of owl populations in this region could provide both information on population trends and an early warning system if negative effects of avian diseases and/or climate change operate.

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Table 1. Selected characteristics of 27 Mexican spotted owl nest trees and 27 randomly located trees within the nest stand in the Tularosa Mountains, New Mexico

	Nest trees		Random trees	
Variable	Mean	SD[a]	Mean	SD[a]
Age (yrs)	163.6	44.8	119.6	64.6
Tree height (m)	7.2	6.5	18.2	8.6
Dbh (cm)[b]	60.6	22.4	43.1	25.4

Source: Seamans and Gutiérrez (1995: table 3).
Note: Differences between nest and random trees were significant ($P < 0.05$) for all variables shown.
[a]Standard deviation.
[b]Diameter at breast height.

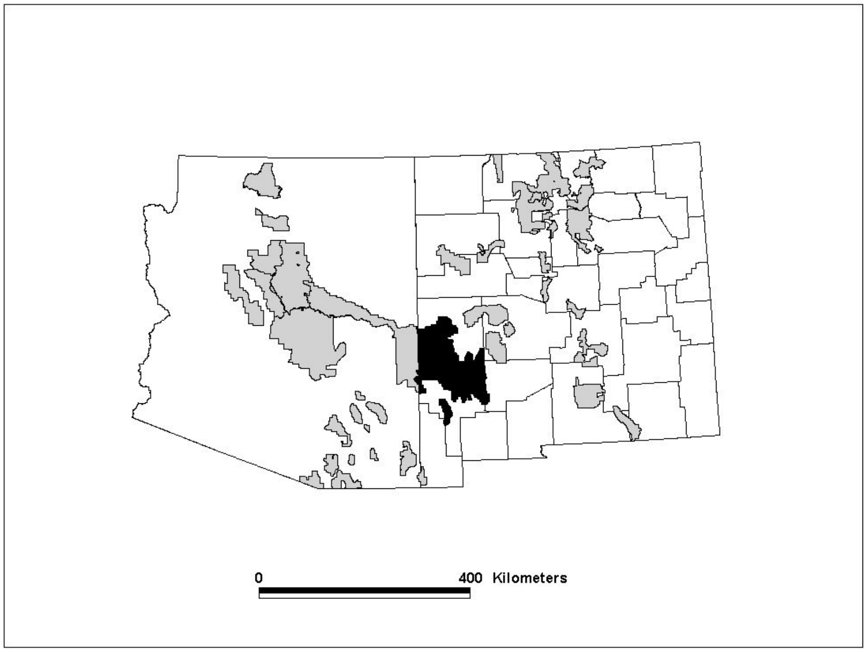

Fig. 1. Map of Arizona and New Mexico showing the location of the Gila National Forest (in black) in relation to other National Forest System lands (in gray).

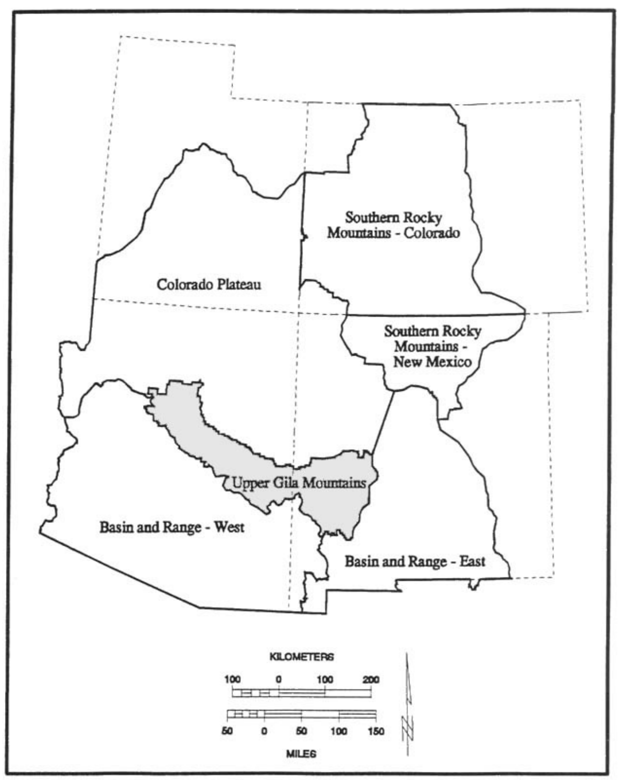

Fig. 2. Recovery Units within the United States recognized in the Mexican spotted owl recovery plan (USDI 1995). The Gila region falls within the Upper Gila Mountains Recovery Unit.

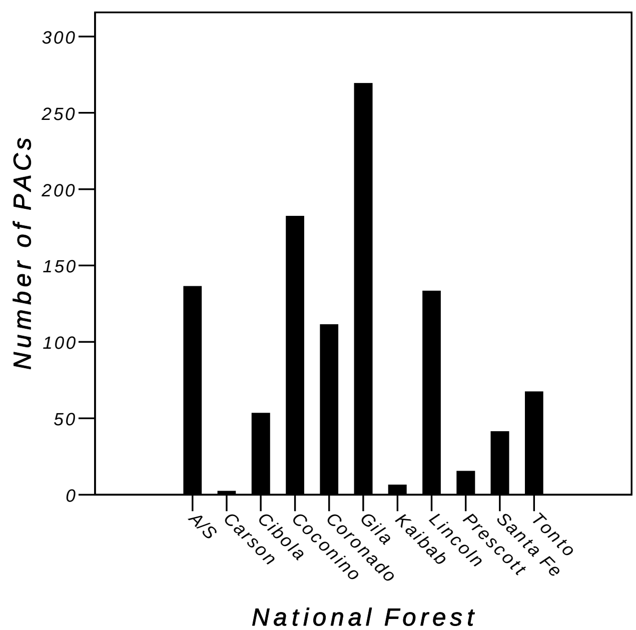

Fig. 3. Numbers of Protected Activity Centers (PACs) delineated by national forest within the Southwestern Region, USDA Forest Service. A/S = Apache-Sitgreaves National Forest. (*Source:* Unpublished data provided by S. Hedwall, US Fish and Wildlife Service, Flagstaff, AZ, Jan 2008.)

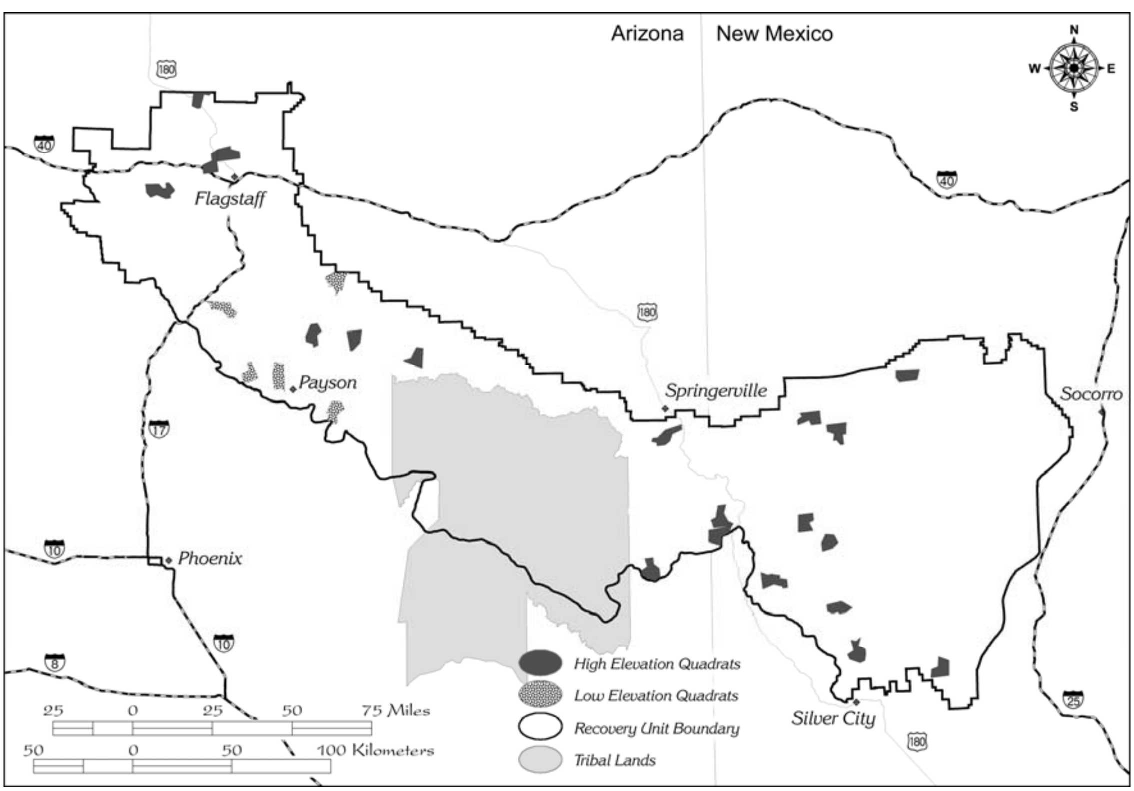

Fig. 4. Locations of 25 quadrats surveyed for Mexican spotted owls across the Upper Gila Mountains Recovery Unit in 1999. (*Source:* Ganey et al. 2004: fig. 16.2.)

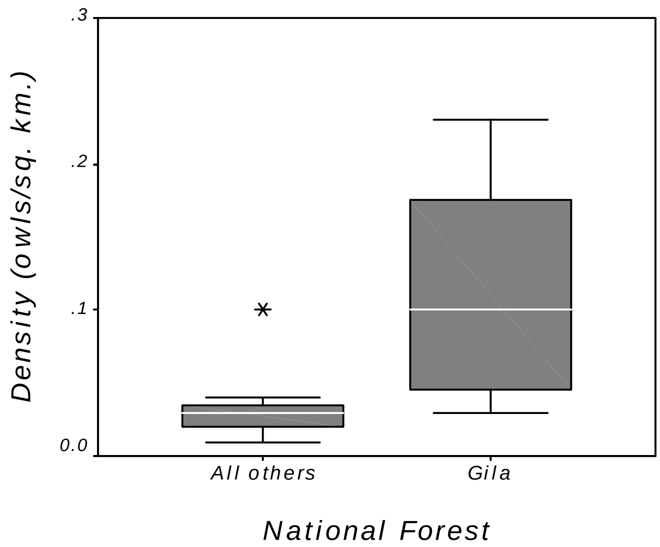

Fig. 5. Box plots of estimated density of resident Mexican spotted owls in occupied quadrats surveyed within and outside of the Gila region (n = 8 occupied quadrats in each area). The box indicates the range from the 25th to 75th percentiles, with the median shown by the line within the box. Exterior lines indicate the range in the data excluding extreme values, which are shown as asterisks. Extreme values were defined as values more than 3 box lengths outside the box.

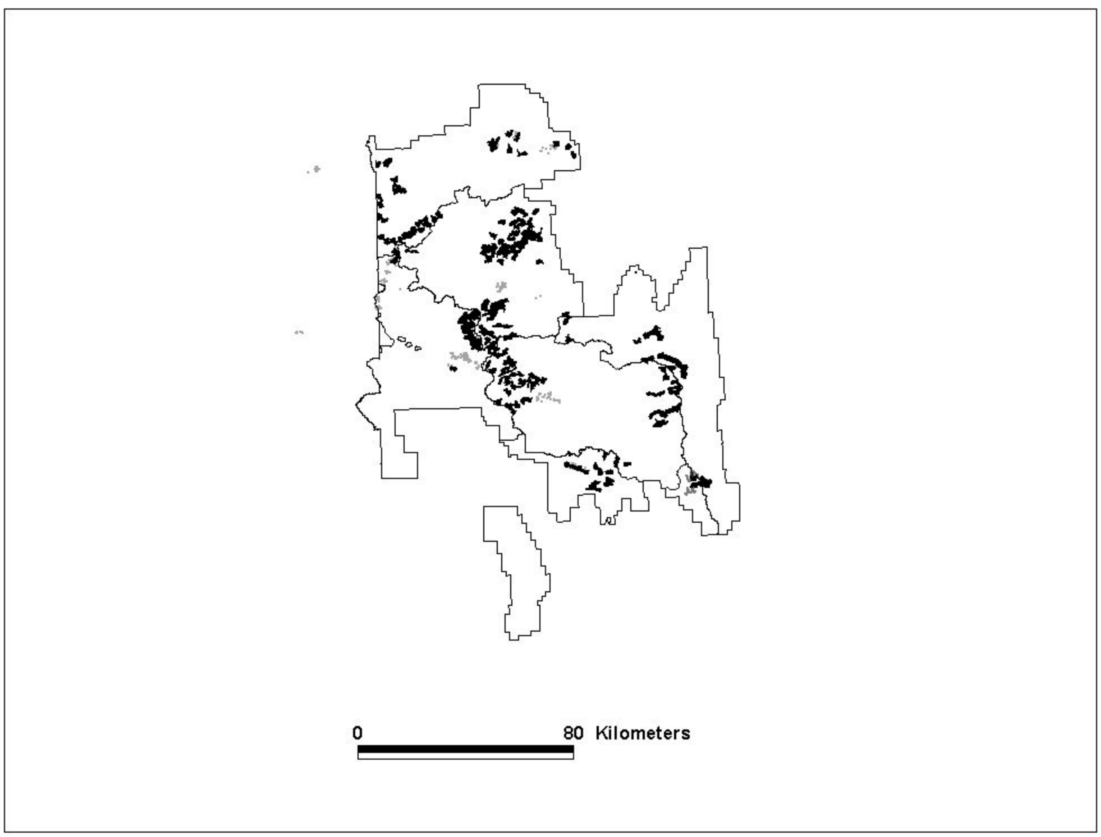

Fig. 6. Map of the Gila National Forest showing Mexican spotted owl Protected Activity Centers (PACs) in black, and locations of owls within quadrats surveyed in 1999 in gray. These data sets combined indicate that owls are well distributed throughout montane areas across the forest.

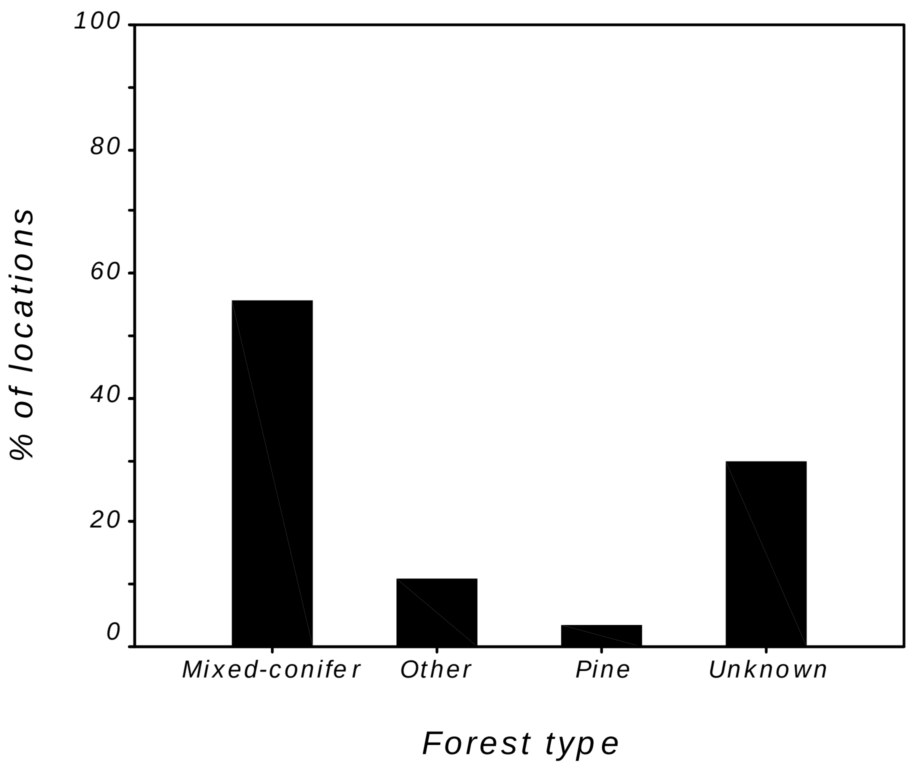

Fig. 7. Percent of Mexican spotted owl locations in various forest types in the Gila National Forest, based on a reanalysis of USDA Forest Service survey data collected 1989 to 1993 and compiled by the Mexican Spotted Owl Recovery Team in 1993 (see USDI 1995). Analysis included only visual observations of owls. *Mixed-conifer forest* was dominated by Douglas fir and/or white fir. *Pine* included both ponderosa pine and pine-oak forest types. *Other* included all other forest types, including broadleaved riparian forest types, pinyon-juniper woodlands, and spruce-fir forest. *Unknown* indicates observations where forest type was not classified.

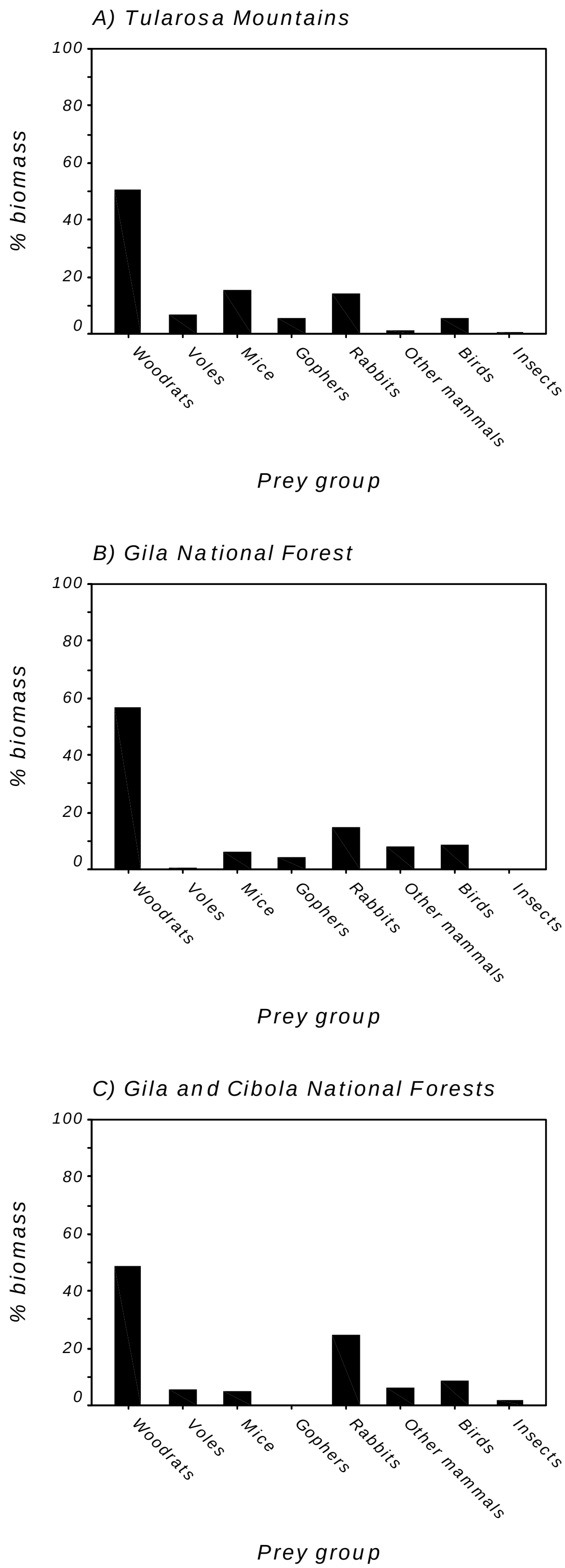

Fig. 8. Diet composition (% biomass) of Mexican spotted owls in three geographic areas within the greater Gila region. (*Sources:* [A] Tularosa Mountains, Seamans and Gutiérrez 1999; *n* = 2,162 prey items. [B] Gila National Forest, exact areas covered not specified, Reichenbacher and Duncan 1992, Appendix I; *n* = 114 prey items. [C] Gila and Cibola National Forests, exact areas covered not specified, Reichenbacher and Duncan 1992, Appendix F; *n* = 35 prey items.)

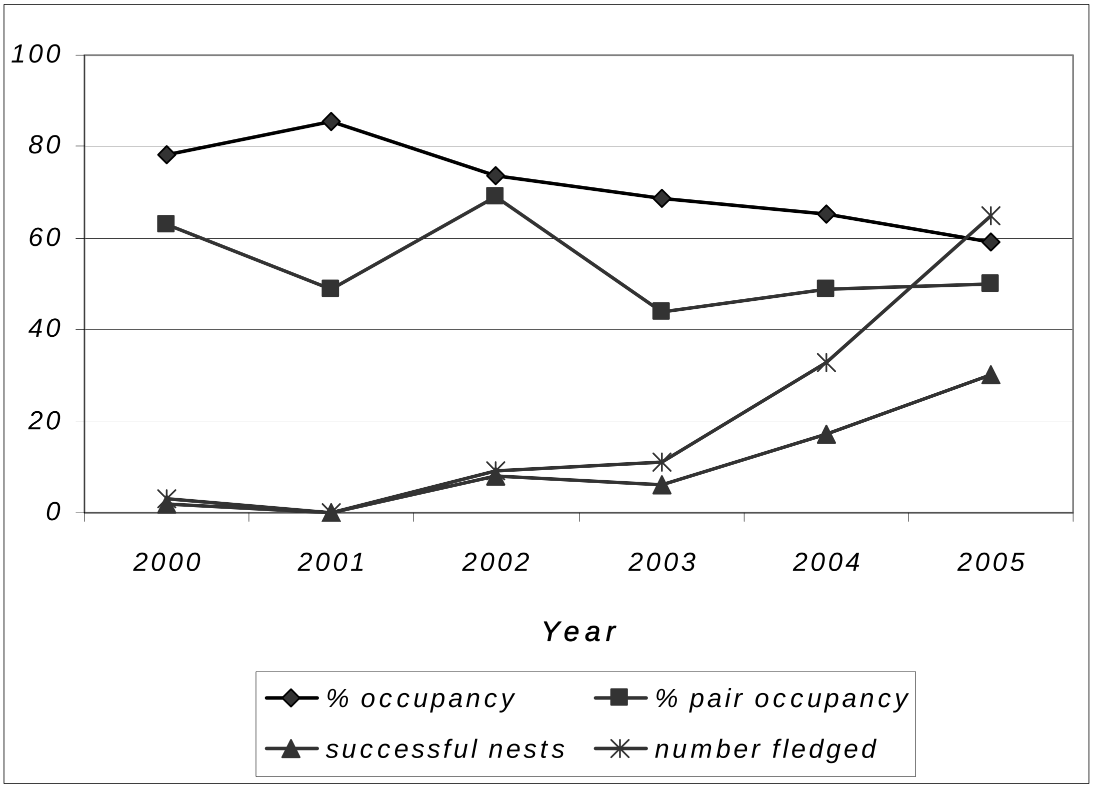

Fig. 9. Percentage of 83 Mexican spotted owl territories occupied by single owls (% occupancy) or pairs of owls (% pair occupancy), and numbers of successful nests and young fledged from those territories in the Reserve area, Gila National Forest, 2000 through 2005. Values on the *y*-axis represent percentages for occupancy variables and actual numbers for reproductive variables. (*Source:* Air Combat Command 2006.)