Population Trends of Ferruginous Pygmy-owls in Northern Mexico and Implications for Tumacácori and other Arizona National Park Units

FINAL REPORT

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TABLE OF CONTENTS

ABSTRACT

Recovery and persistence of cactus ferruginous pygmy-owls (*Glaucidium brasilianum cactorum*) in Arizona likely will depend on owls from northern Sonora, Mexico, where they are more abundant. Because pygmy-owls have declined to near extinction in Arizona yet have been proposed for removal from the federal list of endangered species for reasons unrelated to recovery (USFWS 2005), knowledge of populations in neighboring Sonora, Mexico and on lands in Arizona managed by the U.S. National Park Service will prove important. In 2005, we continued to monitor pygmy-owls in northern Sonora within 75 km of Arizona where we had observed a 37% decline in abundance between 2000 and 2004 (Flesch and Steidl 2006). We also determined territory occupancy at 94 sites and nest success and productivity at 47 nests within 120 km of Arizona where abundance remained relatively stable between 2001 and 2004 (Flesch and Steidl 2005a). We then surveyed potential habitat in Tumacácori National Historical Park (NHP) where pygmy-owls had not been previously surveyed. Although abundance of pygmy-owls in Sonora increased somewhat in 2005 relative to previous years, the trend in abundance is still negative, averaging -6.0 ± 1.9% (± SE) per year ($P = 0.0021$) since 2000, a 30% decline over 6 years. We detected no annual trends in territory occupancy between 2002 and 2005 and little evidence of trends in nest success and nest productivity between 2001 and 2005. We found no pygmy-owls during surveys at Tumacácori NHP in 2005 and 2006, yet vegetation structure is suitable and could be improved to enhance potential nesting opportunities for pygmy-owls. Continued declines of pygmy-owls in northern Sonora may reduce recovery options in Arizona.

INTRODUCTION

Cactus ferruginous pygmy-owls (*Glaucidium brasilianum cactorum*, hereafter pygmy-owls) were once described as common in portions of lowland central and southern Arizona (Bendire 1888, Fisher 1893, Breninger 1898, Gilman 1909, Bent 1938). Extirpated from much of their former range in Arizona during the first half of the 20th Century, pygmy-owls were listed as endangered by the U.S. Fish and

Wildlife Service (USFWS) in 1997 (USFWS 1997, Johnson et al. 2003). Pygmy-owls are currently proposed for delisting for reasons unrelated to recovery of their populations in Arizona (USFWS 2005). Recently in Arizona, pygmy-owls have been found in Organ Pipe Cactus National Monument (OPCNM) (Tim Tibbitts, pers. comm. 2004), Cabeza Prieta National Wildlife Refuge (Flesch and Steidl 2001), Altar Valley (Flesch 1999, 2003a), on the Tohono O'odham Nation (Scott Bailey, pers. comm. 2001), and near Tucson (Abbate et al. 2000). Surveys of recently occupied sites in Arizona suggest that pygmy-owls continue to decline near Tucson where nesting has not been documented recently; only 1 male pygmy-owl is now known to occur near Tucson (Scott Richardson, USFWS, pers. comm. 2005). Despite declines and a high likelihood of imminent extinction near Tucson, a Draft Recover Plan (USFWS 2003) has been in review for over 3 years and recovery actions have not been implemented.

Although populations of pygmy-owls have declined to near extinction in Arizona, portions of southern Arizona may provide important habitat for pygmy-owls; some of these areas are managed by the National Park Service (NPS). Currently, OPCNM is the only NPS unit in Arizona that regularly supports pygmy-owls. Although abundance fluctuates annually (Tim Tibbitts, pers. comm.) pygmy-owls have been present on OPCNM for many years (Hensley 1954, Phillips et al. 1964). Other NPS units with potential to support pygmy-owls in Arizona include Saguaro National Park where there are recent reports (Natasha Kline, pers. comm. 2003) and Tumacácori National Historical Park (NHP) where owls have not been surveyed (Powell et al. 2004).

Immediately south of Arizona in northern Sonora, Mexico, pygmy-owls occupy desertscrub and semidesert grassland vegetation communities where woodlands occur near saguaro cacti (*Carnegiea gigantea*) (Flesch 2003b). Because pygmy-owls are more common in northern Sonora, these populations may prove critical for recovery in Arizona and for long-term persistence of pygmy-owls in the Sonoran Desert. Natural or facilitated dispersal of pygmy-owls from Sonora may augment populations in Arizona especially when combined with habitat management (USFWS 2003). Numerous threats to pygmy-owl habitat exist in northern Sonora, including woodcutting, vegetation clearing for agriculture and buffelgrass (*Pennisetum ciliare*), and often intensive livestock grazing, and there are few regulatory mechanisms to protect habitat (Flesch and Steidl 2006). If populations of pygmy-owls in Sonora decline, recovery strategies in Arizona that rely on Sonoran birds may be jeopardized.

Because of the importance of populations of pygmy-owls in northern Sonora, we initiated a program to monitor abundance, occupancy, nest success, and productivity in 2000 and 2001. Between 2000 and 2004 we observed an estimated 37% decline in abundance (Flesch and Steidl 2006) and no trends in territory occupancy between 2002 and 2004 and little evidence of trends in nest success and productivity between 2001 and 2004 (Flesch and Steidl 2005a). To further provide information important to management and recovery in Arizona, we continued to monitor populations of pygmy-owls in northern Sonora. We also assessed occupancy and habitat potential in Tumacácori NHP to determine the status of pygmy-owls and discuss the implications of declines in Sonora to NPS units in Arizona.

STUDY AREA

We estimated the trend in abundance of pygmy-owls in northern Sonora within 75 km of Arizona and trends in territory occupancy, nest success, and productivity in northern Sonora within 120 km of Arizona (Fig. 1). Vegetation was dominated by the Arizona Upland subdivision of the Sonoran Desert and semidesert grassland (Brown 1982). Upland desertscrub in the Arizona Upland subdivision is dominated by open woodland of short leguminous trees and shrubs; uplands in semidesert grassland are dominated by open woodland and savannah of mesquite (*Prosopis velutina*) and sub-shrubs. Riparian areas in both vegetation communities are dominated by woodlands of mesquite and acacia (*Acacia* sp.), and occasionally Mexican ebony (*Havardia mexicana*). Saguaros, the typical nest substrate used by pygmy-owls in our area, occurred in both vegetation communities.

We surveyed pygmy-owls and assessed habitat potential in 2 of the 3 management units of Tumacácori NHP, Tumacácori, the main unit, and Calabazas located 15 km SSE of Tumacácori. Although originally established to protect the San Jose de Tumacácori mission that was founded by the Spanish in 1691, the Tumacácori unit has recently been expanded to include a perennial stretch of the

Santa Cruz River and well-developed gallery forests of cottonwood (*Populus fremontii*) and willow (*Salix gooddingii*). These broadleaf deciduous woodlands are bounded by large mesquite bosques, xeroriparian scrublands, and abandoned agricultural fields on the river's terraces and in adjacent uplands. The Calabasas unit is dominated by mesquite-invaded grasslands on ridges and well-developed mesquite and netleaf hackberry (*Celtis reticulata*) woodlands along drainages.

METHODS

Design

Trends in abundance.—We surveyed 71 transects clustered around 23 randomly selected points in northern Sonora in 2000 (Flesch 2003b) and randomly selected 6 of 14 random points where ≥1 male pygmy-owl was detected per transect as a baseline to monitor abundance (Flesch and Steidl 2006). Transects were located along drainages >2-m wide and began within 1 km of a road in as many as 4 topographic formations (valley bottoms, lower bajadas, upper bajadas, and canyons) that occurred within 20 km of random points. These 6 points included a total of 18 transects located in 4 geographic regions: in the watersheds of the Upper Rio Altar, the Middle Rio Sasabe, and the Upper Rio Plomo and near the town of Sasabe (Fig. 1). All 18 transects combined totaled 53.7 km in length and were located between 740- and 1,035-m elevation in or at the edge of the Arizona Upland subdivision (n = 7) and semidesert grassland (n = 11). We surveyed the same 18 transects once each year between 2000 and 2005.

Trends in nest occupancy, success, and productivity.—We searched for nests along occupied transects and incidentally in potential habitat between 2001 and 2005 and selected a random sample of up to 85% of all nest sites for surveys each year (Flesch 2003b, Flesch and Steidl 2002, 2004, 2005a, b). We located nests by observing owls detected during surveys, by searching for sign (pellets, scat, and prey remains) around potential nests, and using a small pole-mounted video camera and video display to confirm nesting. We visited most nests 2 to 4 times per season, recorded number of eggs or young, estimated age of nestlings, and determined success (≥1 young within 1 week of fledging) and productivity (no. young within 1 week of fledging/attempt). To determine territory occupancy, we surveyed areas within 300 m of previous nest locations. We attempted to survey nest areas and locate nests as early in the nesting season as possible although we found nests throughout the entire nesting cycle.

Pygmy-Owls and Habitat at Tumacácori National Historical Park.— We surveyed the Tumacácori Unit in July 2005 and March 2006 and the Calabasas Unit in March 2006. To assess habitat suitability, we compared the environment within Tumacácori NHP to that in northern Sonora where pygmy-owls are locally common. To determine if low availability of potential nest cavities could limit pygmy-owls, we assessed abundance and condition of potential nest cavities within Tumacácori and comparing these to those used by pygmy-owls for nesting in northern Sonora. We then assessed potential management options based on these findings.

Owl Surveys

To determine occupancy along transects and in nest areas occupied previously, we broadcast territorial calls to elicit responses from pygmy-owls. In Sonora, we placed a series of 5 to 10 stations, 350 to 400 m apart along drainage channels and within 300 m of nest areas. In Arizona, we placed a series of 3 to 13 stations 200 to 400 m apart along drainages and placed additional station on adjacent ridges and terraces to facilitate complete coverage (Fig. 2). At each station we alternated listening and calling sequences every 30 to 45 sec with listening periods during the first and last 30 to 60 sec. In Sonora, we remained at stations for 8 min or until 1 min after an owl was detected, an approach adequate to detect 99% of territorial male pygmy-owls (Flesch 2003b). In Arizona, we remained at stations for 10 to 12 min. During initial surveys along transects, if we detected an owl we increased spacing of the next station to 550 to 600 m to reduce the probability of detecting the same bird more than once. We then used these same stations in successive years. Detectability of male pygmy-owls during nesting approaches 100% using this survey design (Flesch and Steidl, in review). We surveyed transects during mornings (1 hr before to 3 hrs after sunrise) in the incubation and nestling stages of the breeding season (17 April and 5 June) and in Arizona and during July 2005 and March 2006. We surveyed nest areas or areas where owls were observed in previous years at all times of day, although most surveys were from 1 hr before to

5 hrs after sunrise or 3 hrs before to 1 hr after sunset. We surveyed across a broader range of times in nest areas because detectability remains high throughout the day (Flesch and Steidl, in review) and inaccessibility of many areas prevented early-morning surveys. We did not survey during rain or when wind exceeded 20 kph. We determined sex of each owl based on vocalization patterns and used distance and direction of responses to differentiate among owls that did not respond simultaneously. All surveys in Arizona were conducted under Federal Fish and Wildlife Permit number TE073460-0.

Environmental Measurements

We noted whether nests were located in semidesert grasslands or desertscrub. For each territory, we recorded nest locations (UTM) with use of a GPS and elevation with use of 1:50,000-m topographic maps and if nest locations varied within territories among years we averaged information for each territory. We considered nest locations that changed in successive years to be in the same nest areas when locations among years occupied discrete areas relative to neighboring territories; mean distance among nests occupied in successive years within territories (n = 53) averaged 143 ± 25 m (range 0-640), more than 7 times less than mean distance between nearest neighbor nests on the same transects (1,064 ± 73 m, n = 39) (Flesch and Steidl, in review). We recorded the watershed in which each nest was located, which included the Altar, Magdelena (above Altar confluence), Plomo, San Miguel, Sasabe, Sonoyta, and Vamori. We considered small watersheds that drained into the sands of the Gran Desierto to be in the Sonoyta Valley because of their close proximity and similar ecological condition.

Analyses

Trends in abundance.—We estimated abundance of pygmy-owls by calculating the number of males recorded per station for each of the 18 transects for each year. We assessed within-transect trends in owl abundance by regressing abundance against year after blocking on transects, which is equivalent to a repeated-measures ANOVA. We treated year as a fixed effect and transect as a random effect.

Trends in nest occupancy, success, and productivity.—To assess trends in territory occupancy and nest success we used logistic regression and included year, watershed, and vegetation community as explanatory variables; for territory occupancy we considered territories the year after they were initially occupied and thereafter. Because successful nests have a greater probability of being found than those that fail (Mayfield 1961), we considered only those nests found within 14 days of clutch completion separately as well as all nests combined. We calculated nest-initiation dates by averaging estimates of median nestling age among visits to estimate hatch date, then subtracting 23 days for incubation and 1 day for each egg in a clutch. To estimate initiation dates when clutch sizes were unknown (n = 54) we used the average clutch size among all years combined (4.2, SE = 0.05, n = 175) rounded to the nearest whole number. When nests failed during incubation such that we could not estimate nest age, we used the mean initiation date for that year because within-year variation in timing was low, with 75% of nests initiated within 4 days of one another between 2001 and 2004 and within 6 days in 2005. For pygmy-owls laying and incubation averages 27-28 days and brooding averages 28 days (Proudfoot and Johnson 2000).

To assess patterns in productivity we used multiple linear regression and included year, watershed and vegetation community as explanatory variables. Because many of the same territories were measured in successive years, we also examined a subset of data from territories monitored >1 year and regressed productivity against year after blocking on territories. We treated year as a fixed effect and territory as a random effect then compared results between methods. We did not use elevation as a potential explanatory variable because it was highly correlated with vegetation community.

RESULTS

Trends in Abundance in Sonora

Effort and detections.— Transect length averaged 2,983 ± 116 m (± SE) (range = 2,300-3,850) with 6.8 ± 0.2 stations per transect and a total of 123 stations along the 18 transects. We detected a total of 222 males over 6 years; 55 in 2000, 32 in 2001, 36 in 2002, 37 in 2003, 28 in 2004, and 34 in 2005.

Number of males detected per transect averaged 2.1 ± 0.2 overall and ranged from 0 to 7 for all transects and years.

Trends in abundance.—Across the study area, relative abundance of pygmy-owls declined by an average of 0.027 ± 0.0085 males/station/year from 2000 to 2005 (t_{88} = 3.17, P = 0.0021), the equivalent of a 6.0 ± 1.9% decline per year or 29.8% decline over all 6 years (Fig. 3). Despite continued evidence of an overall decline, relative abundance increased somewhat in 2005 relative to a 6-year low in 2004. Although there were too few transects (n = 4-6) for quantitative comparisons within each of the 4 geographic areas we sampled, abundance continued to decline in the Upper Rio Altar watershed and remained nearly stable near Sasabe in 2005; these areas were closest to Arizona. In contrast, relative abundance increased in the Middle Rio Sasabe watershed, the southernmost area sampled, where relative abundance was greater in 2005 than in other years (Fig. 3).

Trends in Occupancy, Nest Success, and Productivity in Sonora

Effort and detections.—We determined occupancy 415 times once per year at 117 nest territories between 2001 and 2005 and 305 times in years after nest territories were found to be initially occupied. Occupancy averaged 66.8% across all years. We located 269 nests, 216 of which (80.3%) we were able to determine nest outcome. On average, nests were located 23 ± 3 days after initiation and apparent nest success was 84.3% (n = 182 successful nests). Of 88 nests located within 2 weeks of clutch completion, apparent nest success was 78.4% (n = 69 successful nests). Average date of nest initiation was 15 April in 2001, 24 April in 2002, 19 April in 2003, 10 April in 2004, and 13 April in 2005 (SE = 1 day for each year). Productivity (number of young within 1 week of fledging/attempt) averaged 3.1 ± 0.2 young with most nests (41.5%) producing 4 young (range = 0-5, n = 193).

Trends in occupancy, success, and productivity.—Occupancy did not vary with year (χ^2_{297} = 0.17, P = 0.67) but did vary among watersheds (χ^2_{297} = 17.84, P = 0.0066) and vegetation communities (χ^2_{297} = 3.19, P = 0.074). Occupancy averaged 70.4% in 2002 (n = 38 of 54), 64.7% in 2003 (n = 44 of 68), 66.3% in 2004 (n = 59 of 89), and 66.0% in 2005 (n = 62 of 94). Occupancy was 64.7% (n = 99 of 153) in semidesert grasslands and 68.4% (n = 104 of 152) in desertscrub. Occupancy was lower in the Río Magdelena watershed (n = 41.9% of 43, P = 0.0002) and somewhat higher in the Río San Miguel watershed (n = 84.6% of 13, P = 0.090) than in other watersheds (n = 69.9% of 249, $P \geq 0.38$).

Nest success did not vary among years, watersheds, or vegetation communities for nests located within 2 weeks of clutch completion ($\chi^2_{79} \leq 1.15$, $P \geq 0.28$, n = 88) and for all nests combined ($\chi^2_{208} \leq 2.54$, $P \geq 0.11$, n = 216). Nest success was 90% in 2001, 80% in 2002 and 2003, 73% in 2004, and 78% in 2005 for nests found within 2 weeks of clutch completion (n = 10-32 per year), and 92.5% in 2001, 84.6% in 2002 and 2003, 78.4% in 2004, and 83.0% in 2005 for all nests (n = 13-60 per year). Nest success may have been overestimated during earlier years as the age at which nests were found declined by 4.2 ± 0.6 days per year (t_{214} = 6.85, $P < 0.0001$).

Productivity did not vary among years, watersheds, or vegetation communities ($t_{192} \leq 1.19$, $P \geq 0.23$). Productivity averaged 2.8 ± 0.3 in 2001 (n = 26), 2.8 ± 0.2 in 2002 (n = 58), 3.2 ± 0.4 in 2003 (n = 13), 3.1 ± 0.3 in 2004 (n = 49), and 3.3 ± 0.2 in 2005 (n = 47). Although there was no annual trend in productivity, 22 to 23% of nests in 2004 and 2005 produced 5 young whereas in others years <4% of nests produced 5 young. Productivity ranged from as low as 2.7 ± 0.3 in the Rio Sasabe watershed to 3.6 ± 0.5 in the Rio Sonoyta watershed near OPCNM for all years combined and was similar in desertscrub (3.1 ± 0.2, n = 91) and semidesert grassland (3.0 ± 0.2, n = 102).

Pygmy-Owls and Habitat at Tumacácori National Historical Park

Surveys.—We surveyed 9 stations in July 2005 and 13 stations in March 2006 in the Tumacácori Unit (Fig. 2) and 3 stations in March 2006 in the Calabasas Unit. Survey results during all surveys were negative. Response by other birds to pygmy-owl calls included agitation calls by Gila woodpecker (*Melanerpes uropygialis*), verdin (*Auriparus flaviceps*) and other species. Wind speed was minimal during surveys facilitating near perfect listening conditions.

Habitat.— Vegetation structure within Tumacácori NHP is similar to other areas occupied by pygmy-owls in northern Sonora (Flesch 2003b), especially in mesquite bosques and around historical and home sites. Notably, however, saguaro cacti are absent which is important because they often provide nest cavities to pygmy-owls. Despite absence of saguaros, Gila woodpeckers were detected at most survey stations in the Tumacácori Unit and we observed woodpecker-excavated cavities in cottonwoods in the Tumacácori Unit and a single cavity in a large elderberry (*Sambucus* sp.) in the Calabasas Unit. All woodpecker-excavated cavities we observed had horizontal- and vertical-entrance dimensions between approximately 4.5 and 7 cm, which are suitable to support nesting by pygmy-owls (Flesch and Steidl 2002).

DISCUSSION

Trends in Abundance in Sonora

Between 2000 and 2005, abundance of pygmy-owls in northern Sonora, Mexico declined by an estimated 30%. Although this estimate is somewhat less than that reported after 2004 (Flesch and Steidl 2006), data from 2005 were mixed. Two of the 4 geographic areas we sampled showed some evidence of a short-term increase in 2005, yet abundance in areas closest to Arizona continued to decline or remained unchanged. Should this apparent decline continue, recovery strategies in Arizona that rely on pygmy-owls from Sonora will be jeopardized as will the persistence of pygmy-owls in portions of northern Sonora. Determining whether the trend we observed was a result of short-term natural variation or truly represents a long-term systematic decline will require further study given that declines in abundance over short periods may not indicate systematic declines (Robinson 1992). The population decline we observed was influenced strongly by the year 2000, which if excluded from the analysis reduced the magnitude of the estimated decline from 6.0% to 0.6% per year. Nonetheless, because pygmy-owl populations have declined to endangered levels in Arizona, we believe that the decline we observed in northern Mexico is cause for concern and continued study.

Trends in Occupancy, Nest Success, and Productivity in Sonora

Despite declines in abundance between 2000 and 2005, territory occupancy did not vary between 2002 and 2005 and there was little systematic variation in nest success and productivity between 2001 and 2005. Although nest success declined by 12% between 2001 and 2005, this result may be confounded by finding fewer nests early in the nesting season during the earlier years of our study. Nests were found closer to their initiation dates in later years increasing the likelihood of detecting nest failure during these years. Information on relationships between abundance and site-specific demographic processes will help elucidate whether the decline in abundance we observed in Sonora will have long-term consequences for populations of pygmy-owls (Van Horne 1983, Vickery et al. 1992). Collecting additional demographic data in combination with abundance will increase our understanding of population dynamics of pygmy-owls in northern Sonora and provide a strong foundation on which to develop conservation and recovery strategies for pygmy-owls in Arizona.

Territory occupancy was at least 21% lower in the Rio Magdelena watershed than in any of the 6 other watersheds we studied. Such variation may be related to differences in habitat characteristics that explained variation in trends in abundance among years (Flesch and Steidl 2006). For example, the cumulative effects of land-use activities by humans (mainly woodcutting and agriculture) were associated with greater declines in abundance between 2000 and 2004 (Flesch and Steidl 2006). Land use by humans is especially intense in the Rio Magdelena watershed that harbors a larger human population than any of the other watersheds we studied, which likely reduces habitat quality for pygmy-owls.

Should recovery efforts for pygmy-owls in Arizona involve translocation of individuals from northern Sonora, owls should only be removed from areas where trends in abundance, occupancy, and nest success are positive or at least stable over multiple years and where nest productivity is consistently high. To this end removing owls from the middle Rio Sasabe watershed where trends in abundance have been stable since 2000 may be warranted pending additional evidence in the future.

Status at Tumacácori National Historical Park

Although we did not detect pygmy-owls in Tumacácori NHP in 2005 or 2006, we expect that occupancy within the park is possible because habitat exists. We are aware of 4 records of pygmy-owls near Tumacácori NHP; one was reported along Sonoita Creek below Patagonia in 1976 (Monson and Phillips 1981) and 3 radio-marked juveniles were as close as 11.3 to 20 km of Tumacácori NHP during dispersal between 2003 and 2005, the closest of which reached the western foothills of the Tumacácori Mountains in 2004 (Dennis Abbate, Arizona Game and Fish Department, pers. comm.). Potential for occupancy by pygmy-owls in Tumacácori NHP could be limited because few immigrants may reach this area as it is both distant and somewhat isolated from occupied areas. The nearest known nesting pygmy-owls are located 40 km away on the southwest side of the Sierrita Mountains, 50 km away near Sasabe, and over 90 km away in the northwest Tucson area. Connectivity between the upper Santa Cruz Valley in southern Arizona and areas occupied by pygmy-owls near Imuris and Saríc, Sonora may be limited by higher-elevation areas of non-breeding habitat to the south and west that may reduce immigration rates.

Gila woodpeckers are one of the most common species found during the breeding season in riparian areas at Tumacácori NHP (Powell et al. 2004). During pygmy-owl surveys, we observed cavities that were likely excavated by Gila woodpeckers based on their external entrance dimensions (Kerpez and Smith 1990) but all cavities were in cottonwood or elderberry and none were observed in mesquite. Because most pygmy-owl nest in cavities excavated by Gila woodpeckers (Flesch and Steidl, in review), suitable nest cavities are likely available to pygmy-owls in Tumacácori NHP. Although in our region pygmy-owls rarely use tree cavities, they may nest in tree cavities when saguaros cavities are not available (Flesch 1999, Flesch and Steidl 2002, in review). Additional observations of trees cavities used by nesting by pygmy-owls will help elucidate whether suitable nesting structures for pygmy-owls exist in Tumacácori NHP and elsewhere.

Vegetation structure in Tumacácori NHP is similar to many areas occupied by pygmy-owls in northern Sonora. Bosques or woodlands of mesquite, common in Tumacácori NHP, are often used by pygmy-owls in both northern Sonora and in Arizona (Flesch 1999, 2003a, b), and the quantity of riparian vegetation along drainages seems to augment habitat quality for pygmy-owls (Flesch and Steidl 2006). Despite presence of mesquite woodlands, we did not observe potential nest cavities in these areas although they were present nearby in adjacent cottonwoods. Therefore, at least qualitatively, vegetation structure seems suitable for pygmy-owls within much of Tumacácori NHP.

MANAGEMENT RECOMMENDATIONS

Population monitoring programs must quantify temporal variation in population parameters despite spatial variation and sampling error. For organisms that are difficult to detect or that respond unpredictably, variation in detectability increases sampling error and likely reduces the ability to detect meaningful trends. High response rates and high detectability of male pygmy-owls to broadcast calls (Proudfoot and Beasom 1996, Flesch and Steidl in review) make pygmy-owls an efficient choice for monitoring. Further, because most male pygmy-owls seem to settle for life on territories (Proudfoot and Johnson 2000), systematic temporal changes in abundance likely represents loss of adults without replacement.

Collecting demographic data in future years in combination with estimates of abundance will contribute to our understanding of the population dynamics of pygmy-owls in northern Sonora and provide a strong foundation on which to develop conservation and recovery strategies for pygmy-owls in Arizona. In northern Sonora, maintaining stands of saguaro cacti, riparian and adjacent upland vegetation, while mitigating the adverse effects of land-use practices on vegetation, will likely foster persistence of pygmy-owl populations.

Tumacácori NHP harbors sufficient habitat to support 1 or possibly 2 pairs of pygmy-owls especially in mesquite woodland along the Santa Cruz River, yet the probability of pygmy-owls occupying this area is low due to a limited source of potential immigrants and the distance to occupied areas. Nonetheless, management to maintain both closed- and open-canopied woodlands of mesquite and potential nest cavities will maintain and enhance habitat for pygmy-owls within Tumacácori NHP. Placing nest boxes within mesquite woodlands, where cavities were rare, can augment this critical resource where it is needed most. Nest-box design for pygmy-owls should be based on existing guidelines (Proudfoot et al. 1999) with placement criteria based on vegetation conditions around natural nests (Flesch and Steidl unpubl. ms.). Nest-box programs are inexpensive to implement, potentially very valuable, and offer an opportunity for the park to take a management action for an endangered species that is visible to visitors. In addition to nest boxes, restoration of recently acquired agricultural fields in the southwest portion of Tumacácori NHP to a mosaic of closed- and open-canopied woodlands of mesquite will enhance habitat for pygmy-owls. With direct collaboration and information exchange between researchers, managers, and the public on both sides of the international border, conservation and recovery of pygmy-owls and their habitat can be realized.

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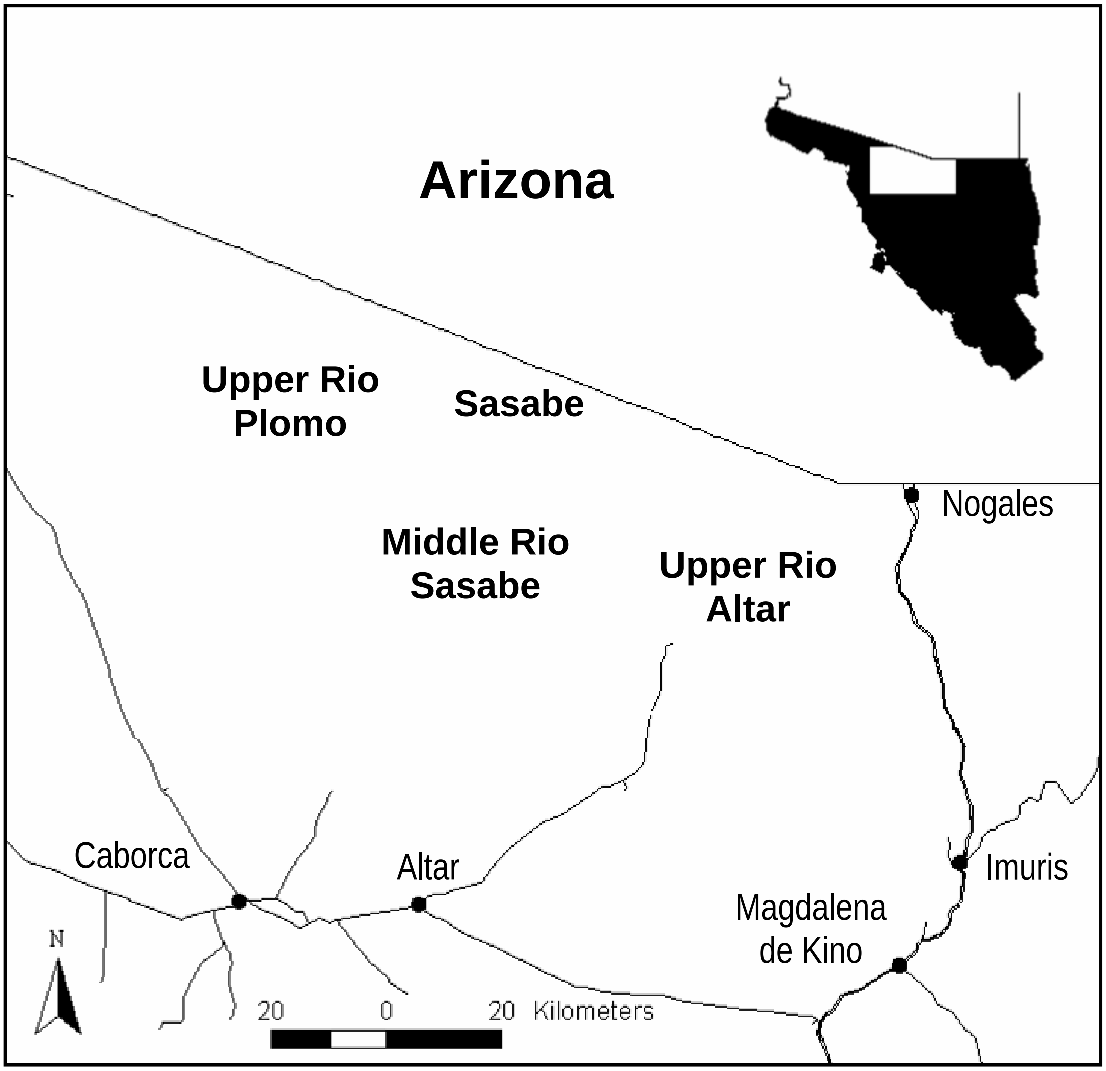

Figure 1. Map of study area in northern Sonora, Mexico illustrating 4 geographic areas monitored, major cities, and roadways.

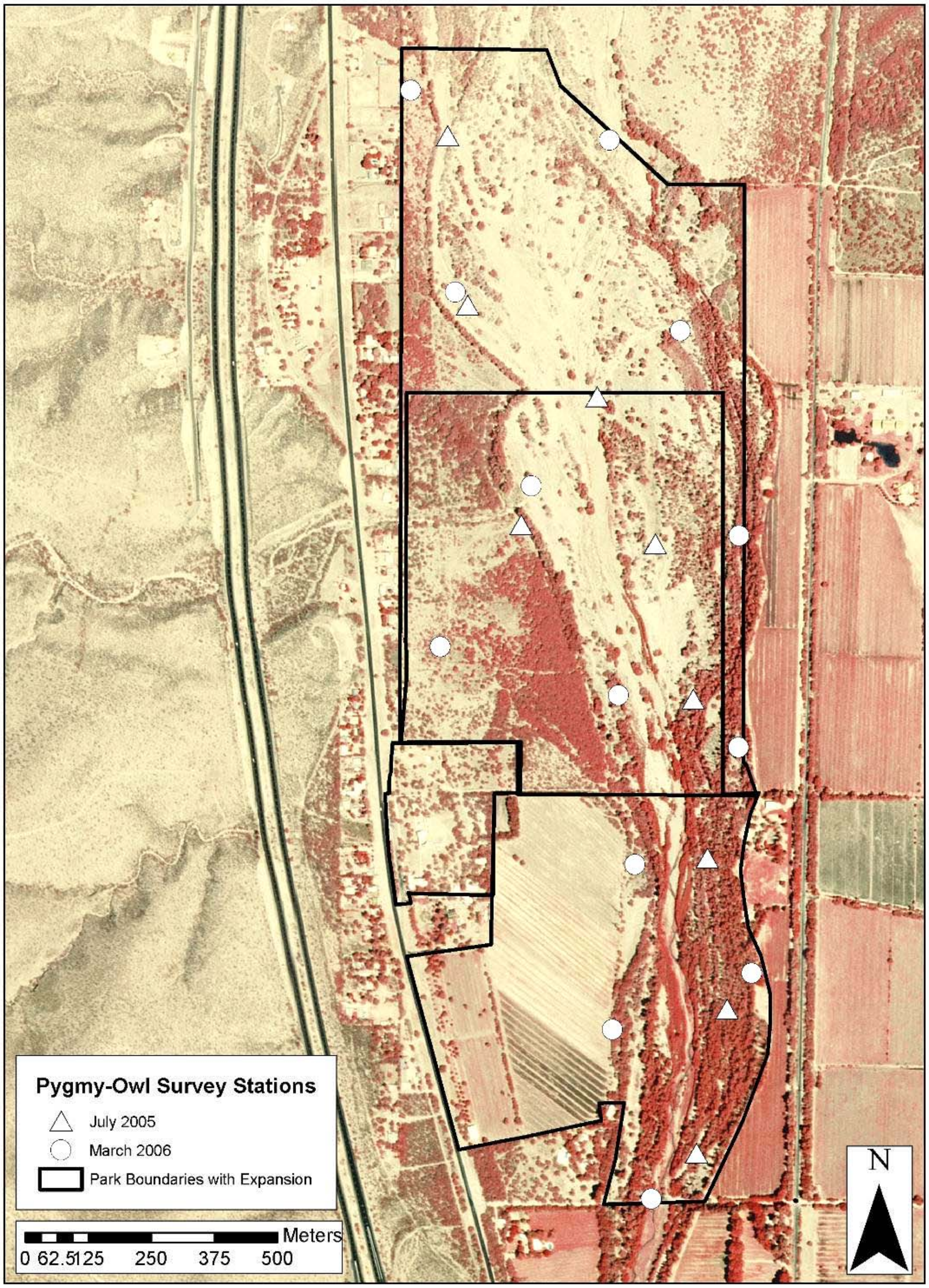

Figure 2. Map of Tumacácori National Historical Park illustrating property boundaries of the recent expansion area and locations of stations used during ferruginous pygmy-owl surveys in July 2005 (n = 9) and March 2006 (n = 13). We also surveyed 3 stations in the Calabasas Unit that are not illustrated.

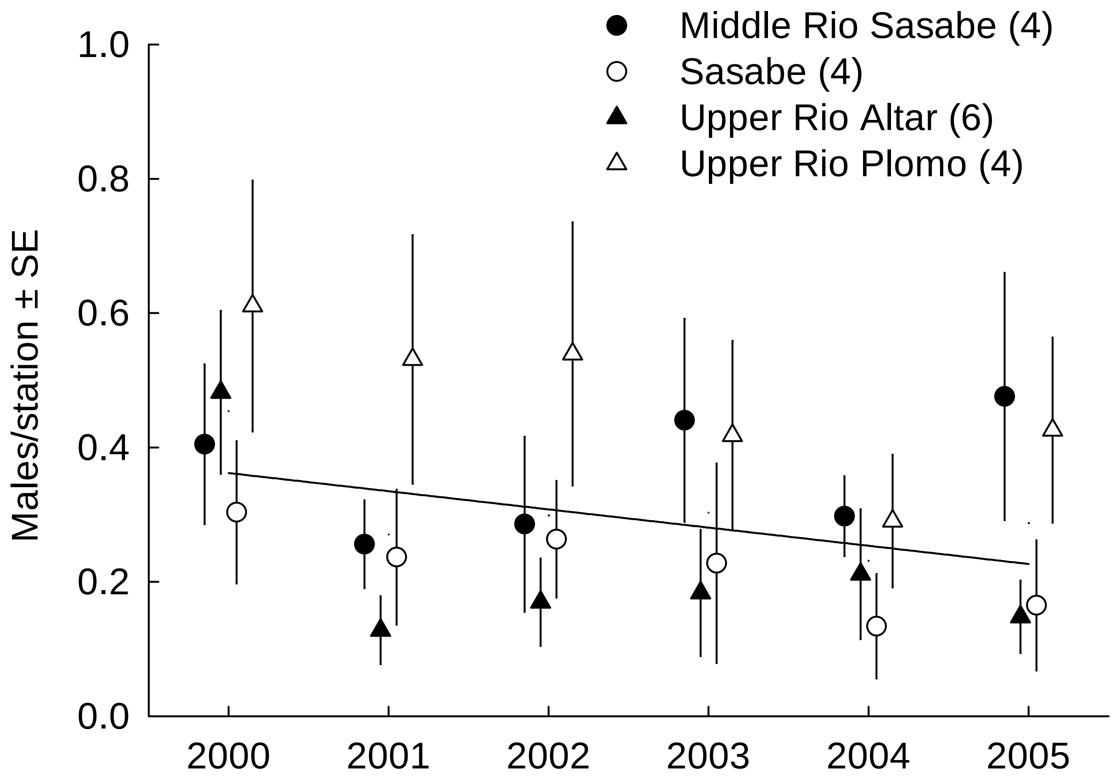

Figure 3. Relative abundance of male pygmy-owls (males/station) along fixed transects (n = 18) in 4 geographic areas across time from 2000 to 2005 in northern, Sonora, Mexico. Point and error bars equal mean ±1 standard error and parenthetical numbers are number of transects sampled in each area. Regression line is for all transects combined.