Population and Demographic Trends of Ferruginous Pygmy-owls in Northern Sonora 2000-2007 and Implications for Recovery in Arizona

2007 Progress Report

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January 2008

Project Scope: Cactus ferruginous pygmy-owls (*Glaucidium brasilianum cactorum*) are of profound conservation concern in southern Arizona where populations have declined precipitously and are now thought to be extinct east of the Santa Cruz River. Augmentation and recovery of pygmy-owls in Arizona likely depends on habitat restoration and efforts to foster immigration from neighboring Sonora, Mexico where pygmy-owls are more abundant. As such, information on status and trends of populations of pygmy-owls in northern Sonora are important to assess long-term prospects for persistence in the region, to identify potential source populations of immigrants, and to answer questions that are fundamental to management and recovery. In 2000, I began monitoring population and demographic trends of pygmy-owls in northern Sonora in a large region (25,000 km^2) that is immediately adjacent to and within 110 km of Arizona (Fig. 1). Over eight consecutive years, I monitored population and demographic parameters of pygmy-owls in an effort to describe the status and trends of this population. To assess environmental factors that could potentially drive these trends, I considered annual estimates of rainfall and prey abundance measured at regional scales and vegetation and land-use factors measured along transects where I monitored owls. This report summarizes the major accomplishments and findings of this program and discusses implications and potential future applications of these data. Methods used to collect and analyze data are described elsewhere (Flesch and Steidl 2006, Flesch 2007) except where noted and will be reported in greater detail in the future.

Major Findings: In spring and summer 2007, I surveyed 54 km of transects in northern Sonora for an eighth consecutive year, estimated occupancy within 99 territories, and monitored 44 nests. In 2007, estimates of relative abundance (mean ± SE = 0.25 ± 0.07 males/station) and occupancy (54 ± 5.0%) of pygmy-owls were among the lowest values I have observed since monitoring began. Over all years combined, relative abundance averaged 0.30 ± 0.02 males/station (range = 0.23-0.45) and occupancy averaged 62 ± 2.3% (range = 54-71%).

Population trends—Between 2000 and 2007, I estimate that abundance of pygmy-owls within 75 km of Arizona has declined by an average of 4.0 ± 1.2% per year ($P = 0.001$; 95% confidence interval = 1.6-6.4%) or 28% over eight years (Fig. 2). Similarly between 2002 and 2007, territory occupancy within 110 km of Arizona has declined by an average of 3.4 ± 0.9% per year ($P < 0.001$; 95% confidence interval = 1.6-5.2%) or 17% over six years (Fig. 3). Despite these declines, there was some degree of variation in trends among regions (Figs. 2 and 3). In the Upper Rio Plomo watershed for example, abundance has increased markedly since an eight-year low in 2004. Abundance declined most precipitously in the Upper Rio Altar watershed and near Sasabe, regions that are closest to Arizona and therefore most relevant to management and recovery in Arizona.

As abundance and occupancy declined, spacing between nests that were occupied simultaneously and nearest neighbors increased by an average of 47 ± 18 m each year over seven years (*P* = 0.010, Fig. 4). This pattern suggests that pygmy-owls may have required additional space to satisfy their resource needs, potentially due to declining resources levels. Alternatively, increased spacing may have resulted from declines in intraspecific interactions among neighboring pairs due to lower overall owl abundance.

Demographic trends—There was no evidence that clutch size or nest success varied systematically across time ($P \geq 0.39$) and only some evidence that brood size increased across time (*P* = 0.066). As brood size increased, spacing between neighboring pairs of nests also increased (*P* = 0.046) suggesting that owls may have been more productive in response to lower overall owl abundance. Clutch and brood sizes were low in 2002 and 2006 and high between 2003 and 2005, whereas nest success was low in 2003 and 2006 and high in 2001, 2005, and 2007 (Fig. 4). Although abundance of pygmy-owls continued to decline in 2007, nest success rebounded in 2007 following low levels in 2006. These data suggest that there are no systematic problems with reproduction of pygmy-owls in northern Sonora.

Factors potentially driving trends—Efforts to conserve and recover populations of pygmy-owls necessitate information on factors that are driving population declines. To assess these factors, I considered the influence of rainfall, prey abundance, vegetation, and land-use on pygmy-owls. To quantify rainfall, I used data from weather stations located near the international boundary at Sasabe and Organ Pipe Cactus National Monument (Western Regional Climate Center 2007). To quantify prey abundance, I used annual estimates of lizard abundance from Organ Pipe Cactus National Monument (2006), which is immediately adjacent to the study area. I considered lizards because they are the primary prey of pygmy-owls within the study area during the nesting season (A. Flesch, unpubl. data).

Abundance and demographic parameters of pygmy-owls varied with rainfall and prey abundance (Figs. 5 and 6). Abundance of owls increased somewhat as abundance of lizards increased with a lag time of one year (*P* = 0.097; Fig. 5). Abundance of owls increased markedly as annual rainfall increased with a lag time of two years (*P* = 0.019) and rainfall explained 63% of variation in owl abundance over all eight years. Given these associations, changes in pygmy-owl abundance over time corresponded very closely with that for lizard abundance and annual rainfall when the appropriate lag times were considered (Fig. 5). Clutch size of owls increased as rainfall that occurred during the year immediately before the nesting season increased (*P* = 0.037) and there was suggestive evidence that nest success also increased with rainfall during this same period (*P* = 0.12; Fig. 6). In contrast, brood size increased sharply from low to moderately high levels of rainfall based on six years of data, and decreased sharply thereafter based on estimates from 2001 ($P = 0.017$). In 2001, high rainfall may not have influenced brood size because nest spacing was very low (Fig. 4), and therefore interactions among neighboring pairs of owls may have been high. These associations suggest that rainfall is driving regional population and demographic dynamics of pygmy-owls by influencing food availability.

Habitat quality—If populations of pygmy-owls are indeed declining due to drought-induced declines in prey abundance, persistence and eventual recovery of pygmy-owls may depend on identifying, conserving, and restoring areas of high-quality habitat that can buffer declines over time. Understanding environmental factors that are associated with high-quality habitat for pygmy-owls will require focused research that is completed in junction with monitoring. Information on vegetation and land use along transects in northern Sonora however, can facilitate an assessment of factors associated with lower declines in abundance and higher reproductive performance, which are good indicators of habitat quality. To assess environmental factors that explained transect-level variation in population trends across time, I used regression residuals from trends in relative abundance. These residuals were scaled so that owl populations along transects that had positive residuals tended to decline less over time as compared to those with negative residuals where owls tended to decline more over time. To assess relationships between the magnitude of declines in abundance and demographic parameters, I averaged estimates of nest success and clutch and brood sizes for all nests along each transect across time.

Relative abundance of pygmy owls declined more along transects with lower relative abundance of saguaro cacti and narrower zones of riparian vegetation that was shorter in height and had lower overall vegetation volume ($P \leq 0.013$; Fig. 7). Pygmy owls also tended to decline more along transects where the combined intensity of agriculture, wood cutting, buffelgrass (*Pennisetum ciliare*) planting, and housing density increased ($P = 0.055$). Importantly, nests along transects where declines in owl abundance were greater had lower average brood sizes ($P = 0.061$) and these nests tended to change locations and be further from prior nest locations during successive years ($P = 0.004$). These results suggest that larger, well-developed areas of riparian vegetation and areas with more abundant saguaro cacti and lower overall intensity of land use provide higher quality habitat for pygmy-owls. Further, these results also suggest that regional declines in abundance of pygmy-owls can be buffered, at least to some extent, by restoring and enhancing these vegetation features even despite the influence of drought.

Conclusions: Abundance of ferruginous pygmy-owls in northern Sonora, Mexico has declined by an estimated 4% per year since 2000 or 28% over the past eight years (Fig. 2). Similarly, territory occupancy of pygmy-owls has declined by an estimated 3.4% per year or 17% over the past six years (Fig. 3). Notably, annual rates of decline in abundance and territory occupancy did not differ statistically (based on 95% confidence intervals) despite somewhat different sampling methods and the much larger area in which I estimated occupancy (Fig. 1). Similarity of these estimates provides an additional line of evidence that populations of pygmy-owls are indeed declining in northern Sonora. Should these declines continue, recovery strategies that rely on pygmy-owls from northern Sonora and persistence of pygmy-owls in the Sonora Desert Ecoregion may be jeopardized.

Monitoring demographic parameters can provide an early warning of potential or developing population declines and can thereby promote faster management responses. In 2007, estimates of nest success and especially brood size rebounded from low levels in 2006. These increases combined with a lack of any systematic declines in demographic parameters over time (Fig. 4), suggest there are no widespread problems with reproduction of pygmy-owls in northern Sonora.

My findings suggest that rainfall and its influence on prey abundance are driving regional population declines of pygmy-owls. Associations at the lag times I observed (Figs. 5-6) suggest that reproductive performance of pygmy-owls is enhanced during times of higher food availability, which results from above average rainfall during the year immediately prior to the nesting season, and results in greater owl abundance during the following year. These relationships have profound implications for population dynamics of pygmy-owls because drought in our region is predicted to intensify as the climate changes to a more arid state in the future (Seager et al. 2007). More years of data are required to assess the presence and magnitude of these relationships. Further, additional factors which I have not yet investigated could also be driving population declines in the region.

Implications and Future Directions: Continued declines of pygmy-owls in northern Sonora may reduce opportunities for recovery in neighboring Arizona unless active measures are taken. Pygmy-owls in northern Sonora are critical for recovery in Arizona and for long-term persistence in the Sonoran Desert Ecoregion. This is because natural or facilitated dispersal from Sonora can augment populations in neighboring portions of Arizona especially when combined with efforts to restore and enhance habitat (USFWS 2003). Pygmy-owls just south of Sasabe, Sonora for example, are closer to Arizona than virtually any other population of pygmy-owls in Sonora and are therefore especially relevant to recovery. Because abundance and occupancy of pygmy-owls near Sasabe has declined considerably in recent years (Figs. 2 and 3), relying on natural or passive dispersal from this population may be less efficient than other more active alternatives such as facilitated dispersal. Importantly, augmentation efforts that use pygmy-owls from northern Mexico should remove owls only from areas where populations are stable or increasing so that Mexican populations are not harmed. Additional information and analyses are required to identify potential source populations of pygmy-owls in northern Sonora.

Movement of pygmy-owls from northern Sonora into neighboring Arizona may be insufficient to appreciably augment and eventually recover populations of pygmy-owls in Arizona unless efforts to enhance and restore habitat are galvanized simultaneously. Although my results suggest that large areas of well-developed riparian vegetation and abundant saguaro cacti will provide higher quality habitat for pygmy-owls, detailed information on a wider range of environmental factors across a variety of spatial scales are needed to develop efficient conservation and recovery strategies for pygmy-owls. When monitoring data that I report are combined with measurements of environmental features at sites where I monitored pygmy-owls, these data will allow high-quality habitat for pygmy-owls to be identified across the landscape. Further, identification of these features will aid development of focused strategies to enhance and restore habitat for pygmy-owls. Management and recovery strategies based on detailed data obtained across large spatial and temporal scales will augment the success of regional conservation plans.

Acknowledgements: For support in 2007, I thank Defenders of Wildlife, T&E, Inc. and the Center for Biological Diversity. For support during past years, I thank the U.S. Fish and Wildlife Service (2000-2002), Arizona Department of Transportation (2002-2004), National Park Service, Desert Southwest Cooperative Ecosystems Studies Unit (2004-2005), T&E, Inc. (2004-2005), Defenders of Wildlife (2006), Center for Biological Diversity (2006), Tucson Audubon Society (2006), and the Rincon Chapter of the Sierra Club (2006). For field assistance, I thank Sky Jacobs, Rachael Tenney, Gabriel Valencia, Andres Villareal, Elliot Swarthout, Greg Greene, Shawn Lowery, and others. For logistical support, I thank Eduardo Lopez Saavedra of Instituto del Medio Ambiente y el Desarrollo Sustentable del Estado de Sonora and Jaqueline Garcia Hernandez of Centro de Investigación en Alimentación y Desarrollo A.C. I thank Robert Steidl for suggestions on analyses, administrative support, and for other substantial contributions to this effort and Brian Powell for administrative and moral support. I thank Peter Holm, Charles Conner, and Ami Pate of Organ Pipe Cactus National Monument and Phil Rosen of the University of Arizona for data on lizard abundance. This program is dedicated to the memory of Tom Wootten whose commitment to science-based conservation helped enable this effort.

Literature Cited (and imbedded web links)

FLESCH, A. D. 2007. Population and demographic trends of ferruginous pygmy-owls in northern Sonora Mexico and implications for recovery in Arizona. Report to Defenders of Wildlife, Tucson Audubon Society, Rincon Chapter of the Sierra Club, and Center for Biological Diversity.

FLESCH, A. D. AND R. J. STEIDL. 2006. Population trends and implications for monitoring cactus ferruginous pygmy-owls in northern Mexico. Journal of Wildlife Management 70:867-871.

ORGAN PIPE NATIONAL MONUMENT. 2006. Ecological Monitoring Program Project Report 1997-2005. Organ Pipe National Monument, Arizona.

SEAGER, R., ET AL. 2007. Model projections of an imminent transition to a more arid climate in southwestern North America. Science 316:1181-1184.

U.S. FISH AND WILDLIFE SERVICE. 2003. Cactus ferruginous pygmy-owl (*Glaucidium brasilianum cactorum*) draft recovery plan. Albuquerque, New Mexico.

WESTERN REGIONAL CLIMATE CENTER. 2007. Western U.S. historical summaries for individual stations. Available at: http://www.wrcc.dri.edu/summary/Climsmaz.html.

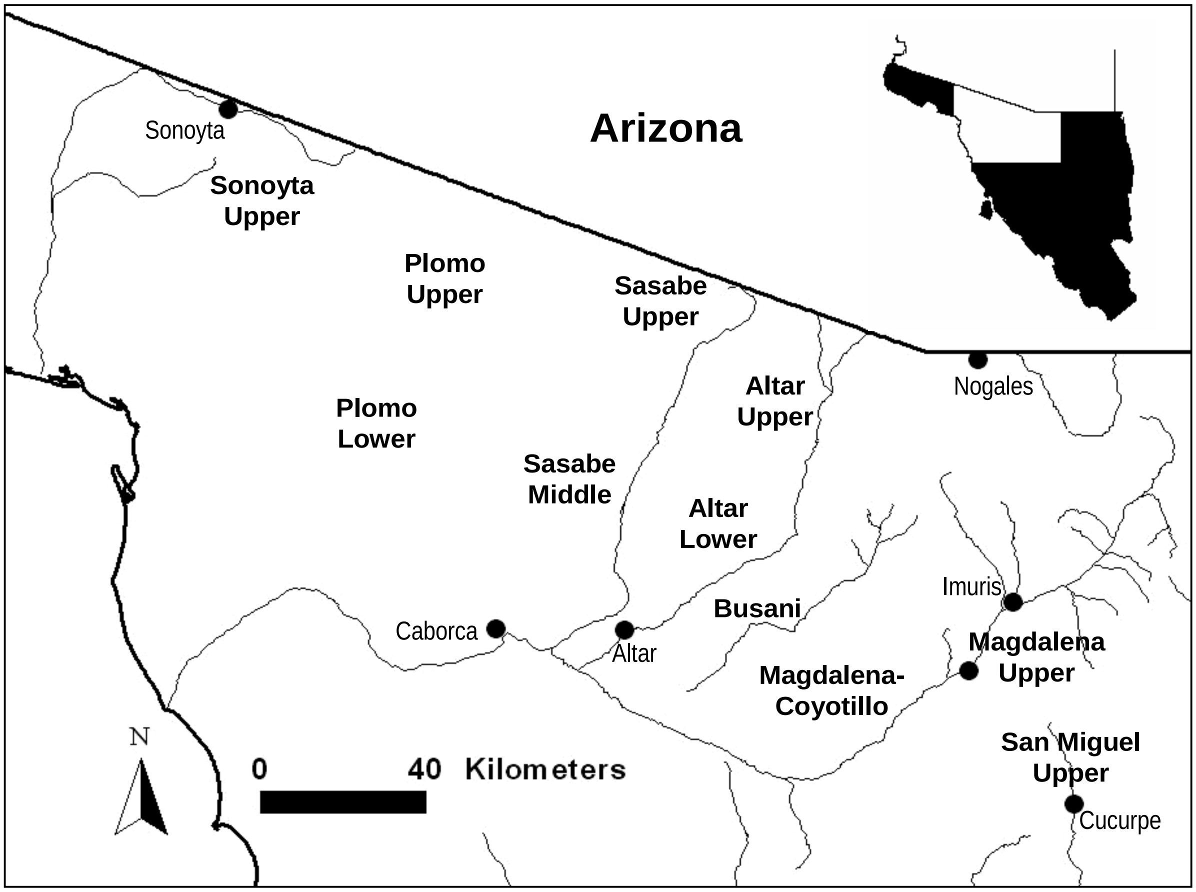

Figure 1. Map of study area in northern Sonora, Mexico illustrating 11 geographic regions in which I monitored pygmy-owls. I estimated abundance in the Upper and Middle Sasabe, Upper Altar, and Upper Plomo regions and estimated occupancy and demographic parameters in all 11 regions. Major cities and drainages are illustrated.

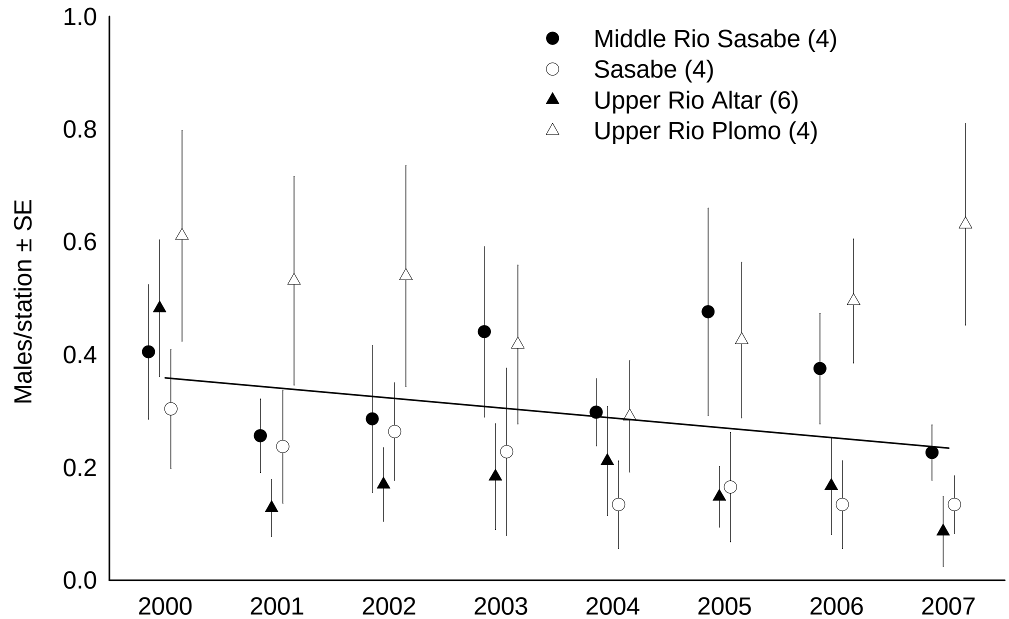

Figure 2: Abundance of male pygmy-owls (males/station) along fixed transects (*n* = 18) in four geographic regions between 2000 and 2007 in northern, Sonora, Mexico. Point and error bars equal mean ± 1 standard error and parenthetical numbers are number of transects sampled in each region. Regression line is for all transects combined.

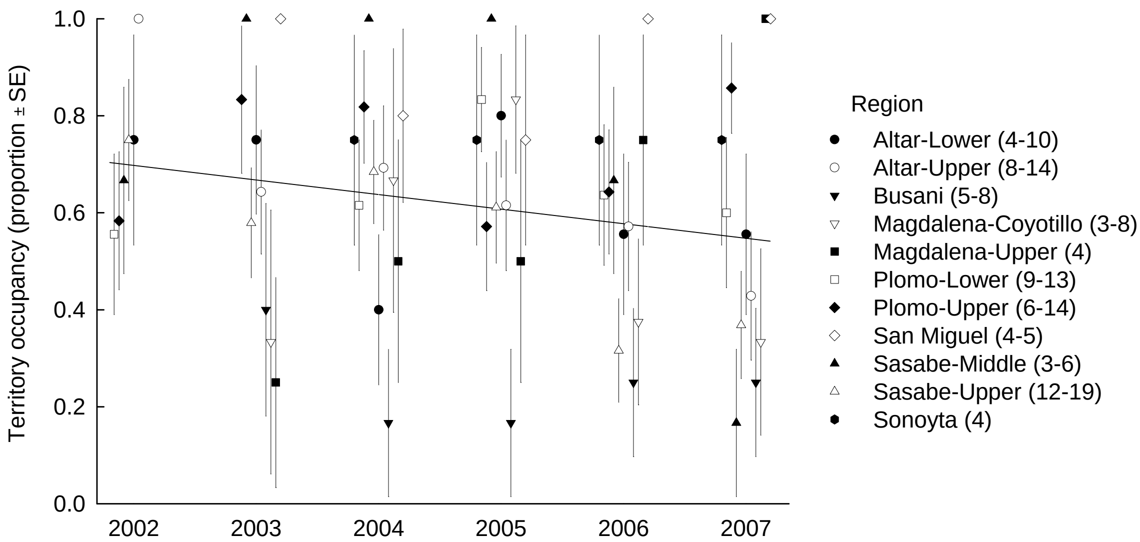

Figure 3: Proportion of territories occupied by ferruginous pygmy-owls in 11 geographic regions between 2002 and 2007 in northern Sonora, Mexico. Point and error bars equal the mean proportion and 1 binomial standard error within each region in each year and parenthetical numbers are number of territories surveyed in each region among years. Between 52 and 102 territories were surveyed each year and territories were considered in estimates one year after they were found to be initially occupied and thereafter. Regression line estimates change in the mean proportion of territories occupied across years.

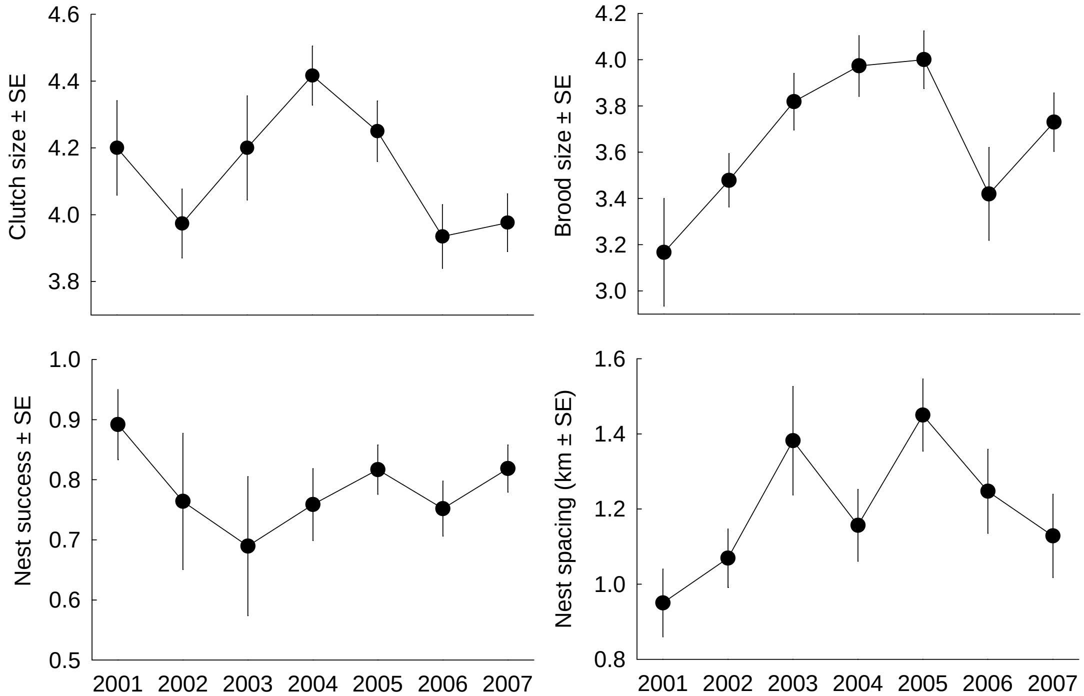

Figure 4: Trends in demographic parameters and nest spacing of ferruginous pygmy-owls between 2001 and 2007 in northern Sonora, Mexico. Each point and error bar represents the mean ± 1 standard error for each year adjusted for site effects. To estimate nest success I considered only nests that were initially detected within 14 days of clutch completion (Flesch 2007).

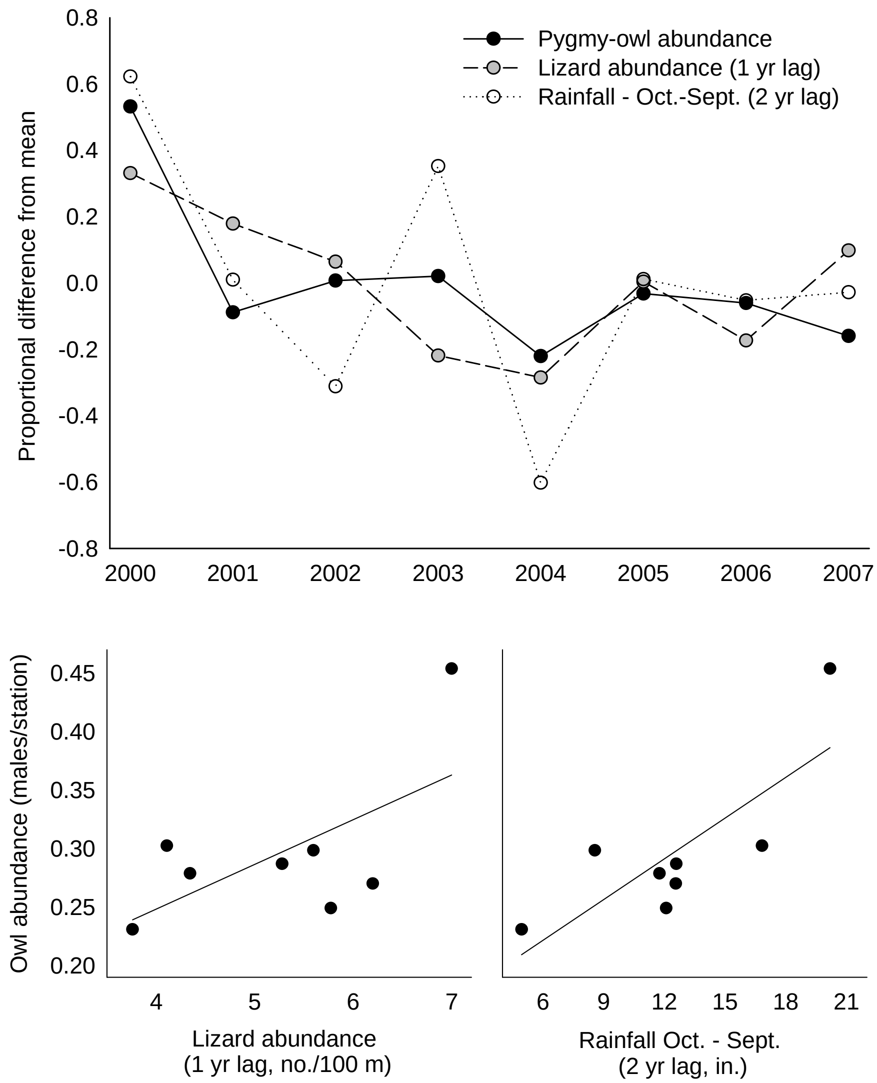

Figure 5: Relationships among pygmy-owl abundance (males/station), diurnal lizard abundance (no./100 m) at a lag time of 1 yr, and annual rainfall (Oct. – Sept, inches) at a lag time of 2 yrs between 2000 and 2007. Owl abundance was estimated along 54 km of transects each year in northern Sonora, lizard abundance was measured annually in adjacent Organ Pipe National Monument (2006), and rainfall was measured along the international border at Sasabe and Organ Pipe National Monument (Western Regional Climate Center 2007). Lines in lower figures are based on linear regression.

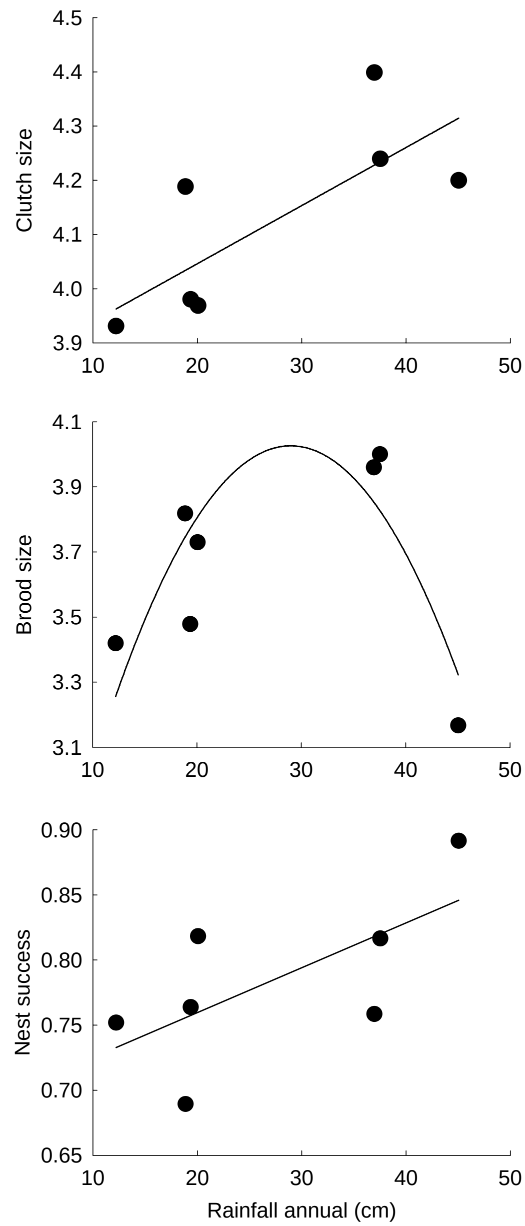

Figure 6: Associations between demographic parameters of ferruginous pygmy-owls and quantity of annual rainfall in northern Sonora, Mexico 2000 to 2007. Rainfall is for the 12-month period from 1 June of the prior year to 31 May of the current nest year and was measured along the international boundary at Sasabe and Organ Pipe National Monument (Western Regional Climate Center 2007). Lines are based on quadratic and linear regression.

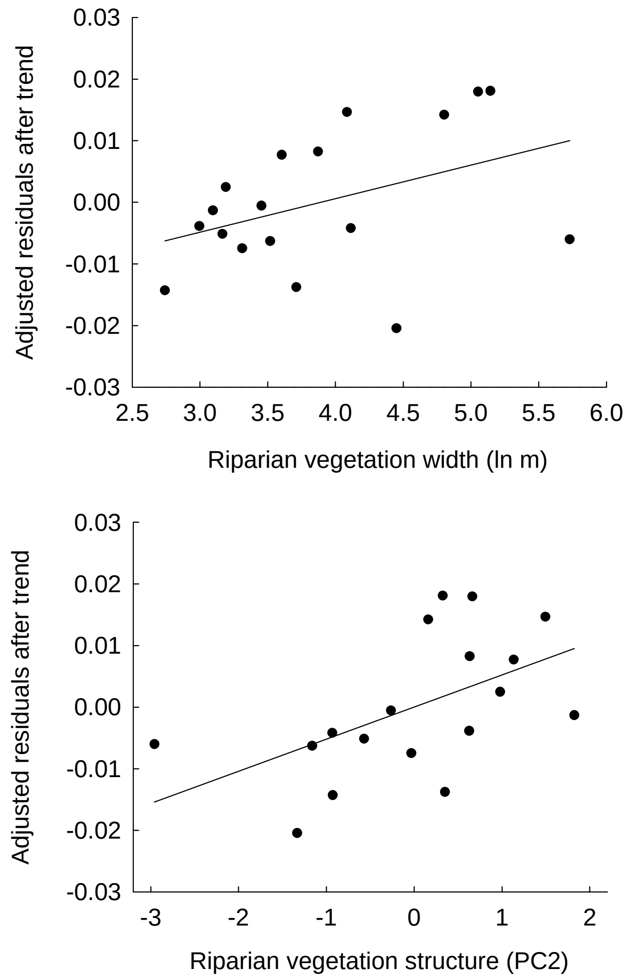

Figure 7: Relationships between the magnitude of declines in abundance of ferruginous pygmy-owls and variation in environmental factors along 18 transects over eight years and in northern Sonora, Mexico. Residual variation is variation that remained after fitting a linear trend to estimates of relative abundance of pygmy-owls along monitoring transects. Positive residuals indicate transects along which owls tended to decline less over time. Riparian vegetation structure is represented by a principal component that described 23% percent of variation in vegetation height and volume and was positively correlated with vegetation height and vegetation volume between 1-12 m above ground and negatively correlated with vegetation volume between 0-1 m. Residuals were adjusted for all other explanatory factors.