Population and Demographic Trends of Ferruginous Pygmy-owls in Northern Sonora Mexico 2000-2008

2008 Progress Report

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Project Scope: Cactus ferruginous pygmy-owls (*Glaucidium brasilianum cactorum*) are of significant conservation concern in southern Arizona and are now being considered for listing as endangered by the U.S. Fish and Wildlife Service. Persistence and recovery of pygmy-owls in Arizona may depend on efforts to restore habitat and 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 regional persistence, to identify potential source populations of immigrants, and to answer questions that are fundamental to management and recovery in Arizona. 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 Arizona and within 110 km of the international boundary (Fig. 1). During each successive year, I continued to estimate population and demographic parameters of pygmy-owls for a total of nine consecutive years. To assess environmental factors that could potentially drive 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 findings of this program through the 2008 field season. Methods used to sample populations and to analyze data are described elsewhere (Flesch and Steidl 2006, Flesch 2007).

Major Findings: In spring and summer 2008, I surveyed 54 km of transects in northern Sonora for a ninth consecutive year, estimated occupancy within 99 territories, and located and monitored 42 pygmy-owl nests. In 2008, estimates of relative abundance (mean ± SE = 0.18 ± 0.038 males/station) and territory occupancy (49.5 ± 5.0%) were lower than during any previous year since monitoring began. Along transects, I observed 21 territorial male pygmy-owls in 2008, seven fewer than the previous low that I observed in 2004. Over all years combined, relative abundance averaged 0.28 ± 0.025 males/station (range = 0.18-0.45, n = 9 years) and occupancy averaged 60 ± 3.1% (range = 49-71%, n = 7 years).

Population trends—Between 2000 and 2008, I estimate that abundance of pygmy-owls within 75 km of Arizona has declined by an average of 4.4 ± 1.0% per year ($P < 0.001$; 95% confidence interval = 2.2-6.6%) or 35.5% over nine years (Fig. 2). Although since 2004, relative abundance had increased in some regions, in 2008 abundance was universally lower in virtually all regions and did not vary spatially (Fig. 2). Abundance remained low in the Upper Rio Altar watershed and near Sasabe, regions that are closest to the international border and are therefore most relevant to management and recovery in Arizona.

Similarly, between 2002 and 2008, territory occupancy within 110 km of Arizona has declined by an average of 3.5 ± 0.7% per year ($P < 0.001$; 95% confidence interval = 2.1-4.9%) or 21.6% over seven years (Fig. 3). Despite declines in occupancy, there was some degree of variation in trends among regions (Fig. 3). Occupancy near Sasabe has increased each of the last two years.

Demographics—Clutch sizes were much higher in 2008 (4.4 ± 0.1 eggs/clutch, n = 35 nests) than during most previous years (Fig. 4). Higher clutch sizes however, did not result in higher brood sizes and overall, mean brood size reached only moderate levels (3.6 ± 0.2 young/successful nest, n = 29 nests; Fig. 4). Apparent nest success averaged 90 ± 5% (n = 30 nests) among nests that were found within 14 days of clutch completion an estimate that was higher than during most previous years (Fig. 4). Although quantitative analyses that include data from 2008 have not yet been completed, there were no obvious systematic trends in demographic parameters over time (Fig. 4). Data on reproductive performance suggest 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 and prey abundance; I also considered vegetation and land-use factors and described these findings elsewhere (Flesch 2008). 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 of pygmy-owls varied with rainfall and prey abundance (Fig. 5). Abundance of owls increased somewhat as abundance of lizards increased at a lag time of one year (P = 0.097; Fig. 5). Abundance of owls increased markedly as annual rainfall increased at a lag time of two years (P = 0.0083) and rainfall explained 65% of variation in owl abundance over all nine years. Each one inch of rainfall resulted in an increase of 0.13 ± 0.04 (± SE) males per station, an estimate that was equivalent to an increase of 1.6 ± 0.4 owls per inch of rainfall across all 18 transects. Given these associations, changes in pygmy-owl abundance over time corresponded very closely with that for lizard abundance and rainfall when the appropriate lag times were considered (Fig. 5). These associations suggest that rainfall is driving regional population dynamics of pygmy-owls by influencing food availability. Data on lizard populations during 2007 will soon be available.

Conclusions: Abundance of ferruginous pygmy-owls in northern Sonora, Mexico has declined by an estimated 4.4% per year since 2000 or 36% over the past nine years (Fig. 2). Similarly, territory occupancy of pygmy-owls has declined by an estimated 3.5% per year or 22% over the past seven years (Fig. 3). Importantly, estimates of both relative abundance and territory occupancy were the lowest values I have observed since monitoring began. Annual rates of decline in both 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 northern Sonora could be jeopardized.

Monitoring demographic parameters can provide an early warning of potential or developing population declines and can thereby promote faster management responses. In 2008, estimates of clutch size rebounded from low levels in 2007, yet brood sizes were similar to that observed during recent years. Importantly estimates of nest success remained high after rebounding from very low levels in 2006. These observations combined with a lack of any systematic declines in demographic parameters (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 (Fig. 5) 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 nesting (Flesch 2008), and produces greater owl abundance the following year. These relationships have profound implications for population dynamics of pygmy-owls because drought in our region is predicted to intensify in the future (Seager et al. 2007). More years of data are required to assess the presence and magnitude of these relationships yet data from 2008 (when rainfall was 8 inches and owl abundance was 0.18 males/station; see Fig. 5) increased the level of evidence for a relationship between owl abundance and rainfall. Additional factors that have not yet been assessed could also be driving population declines.

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 region. 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 have largely declined (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, especially should ongoing development along the international boundary degrade connectivity (Flesch et al. in prep.). 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 these potential source populations 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 without simultaneous efforts to enhance and restore habitat. Although results suggest that large areas of well-developed riparian vegetation and abundant saguaro cacti will enhance habitat quality for pygmy-owls (Flesch 2008, Flesch and Steidl 2006), detailed information on a wide range of environmental factors across a variety of spatial scales are needed to develop efficient conservation, recovery, and augmentation strategies. When monitoring data that I report are combined with measurements of environmental features at these same sites, these data will enable factors that are associated with high-quality habitat to be identified at a range of spatial scales. By identifying these features, more focused and efficient strategies for enhancing and restoring habitat for pygmy-owls will be possible.

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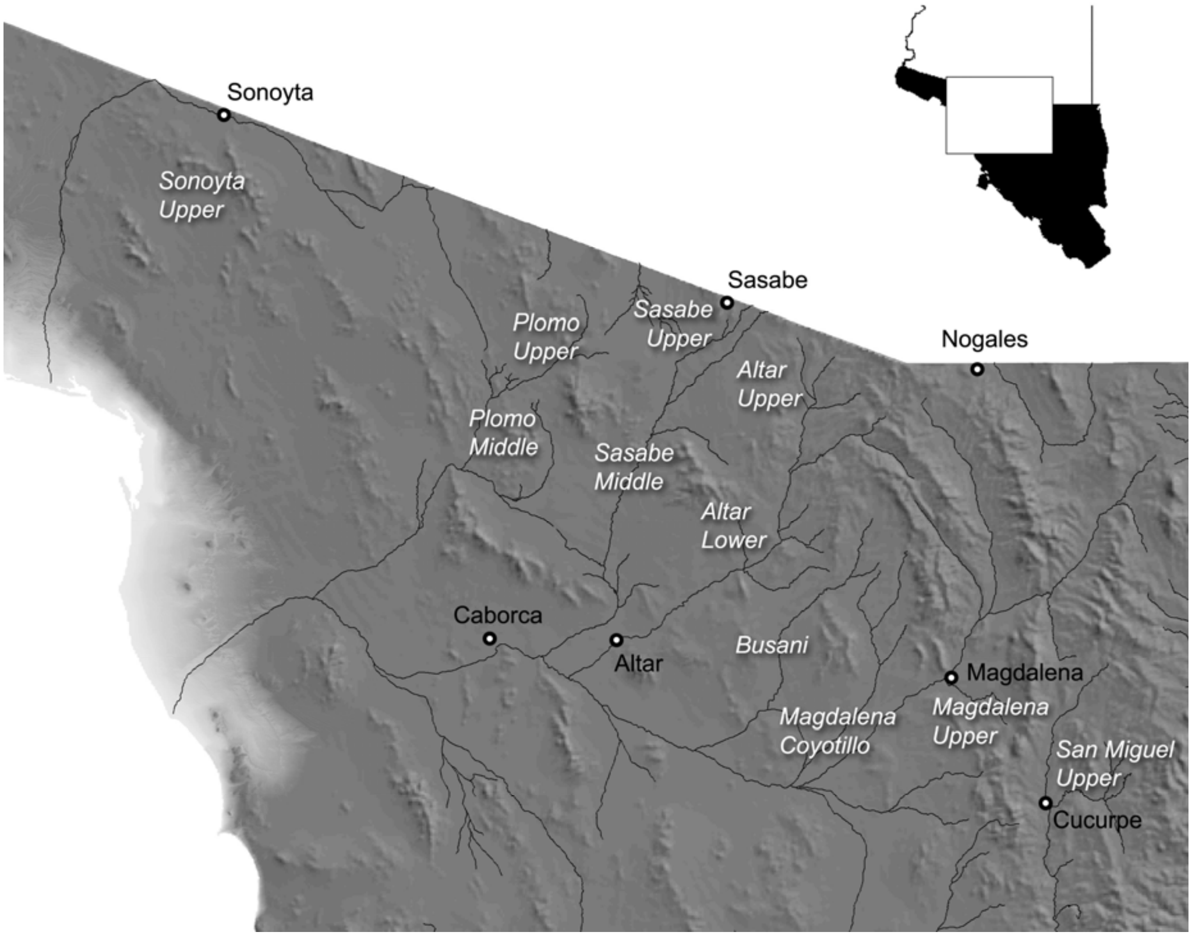

Figure 1. Map of study area in northern Sonora, Mexico illustrating 11 geographic regions in which I monitored pygmy-owls. I estimated abundance in the Upper and Middle Sasabe, Upper Altar, and Upper Plomo regions and estimated occupancy and demographic parameters in all 11 regions. Major cities and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

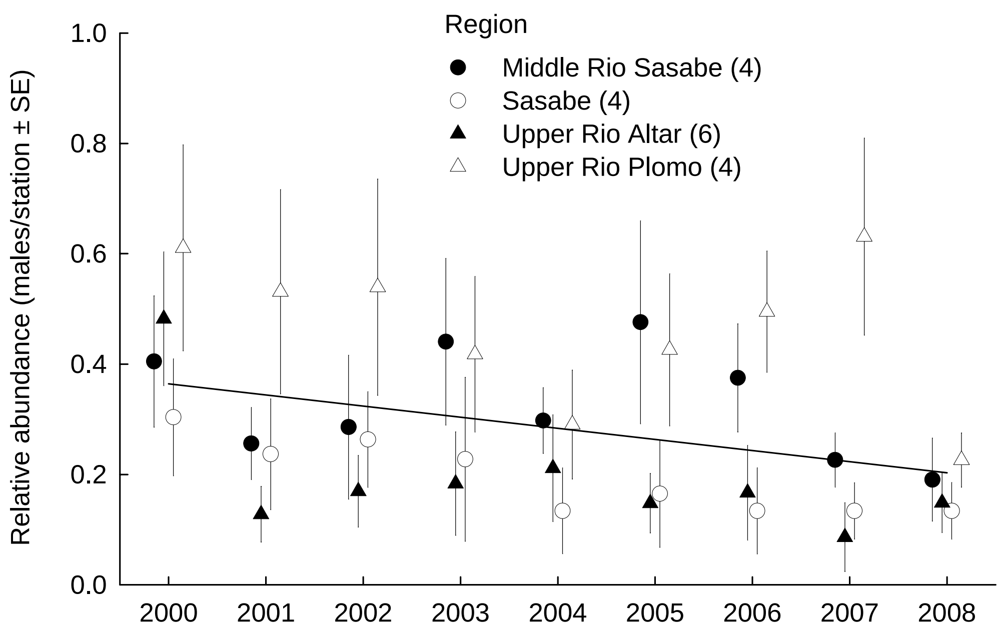

Figure 2: Abundance of male pygmy-owls (males/station) along fixed transects (*n* = 18) in four geographic regions between 2000 and 2008 in northern, Sonora, Mexico. Point and error bars equal mean ± 1 standard error and parenthetical numbers are number of transects sampled in each region. Regression line is for all transects combined.

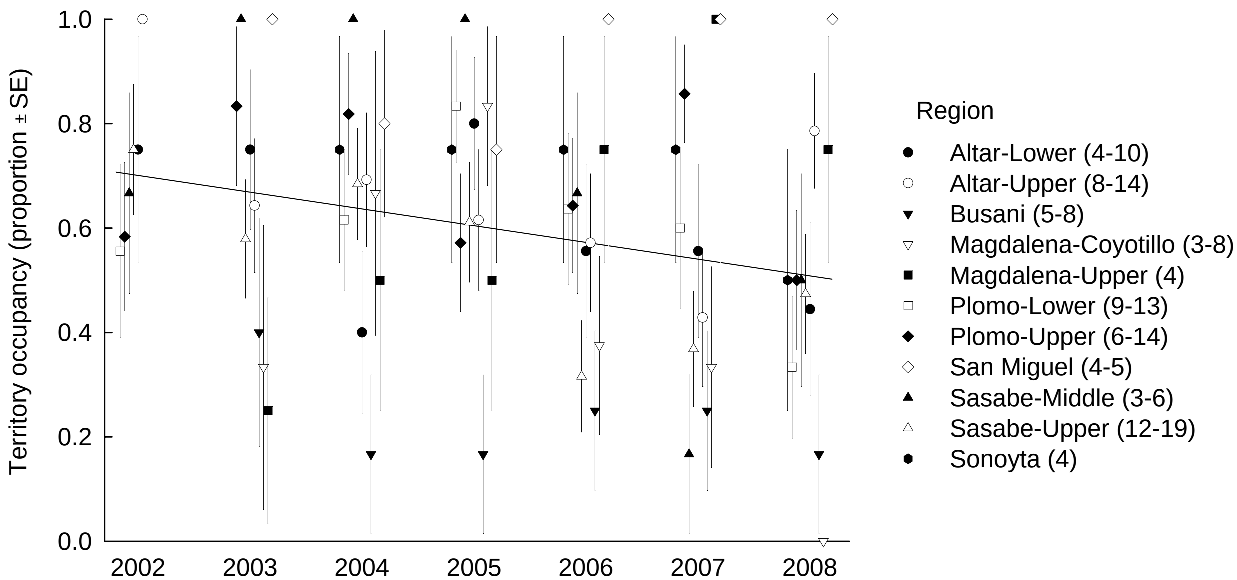

Figure 3: Proportion of territories occupied by ferruginous pygmy-owls in each of 11 geographic regions between 2002 and 2008 in northern Sonora, Mexico. Point and error bars equal the mean proportion and 1 binomial standard error within each region during each year and parenthetical numbers are number of territories surveyed in each region among years. Between 52 and 102 territories were surveyed each year and territories were considered in estimates the year after they were found to be initially occupied. Regression line estimates change in the mean proportion of territories occupied across years.

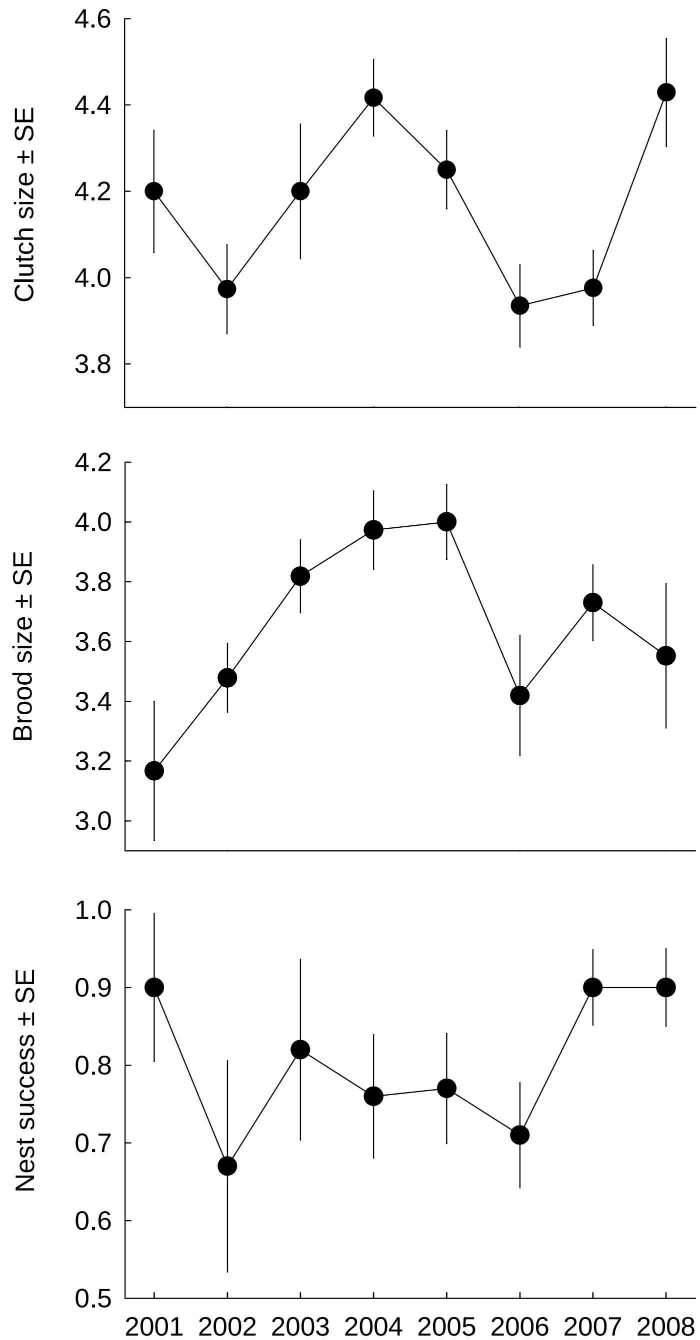

Figure 4: Variation in demographic parameters of ferruginous pygmy-owls between 2001 and 2008 in northern Sonora, Mexico. Each point and error bar represents the mean ± 1 standard error for each year and are not adjusted for site effects. To estimate nest success I considered only nests that were initially detected within 14 days of clutch completion (Flesch 2007).

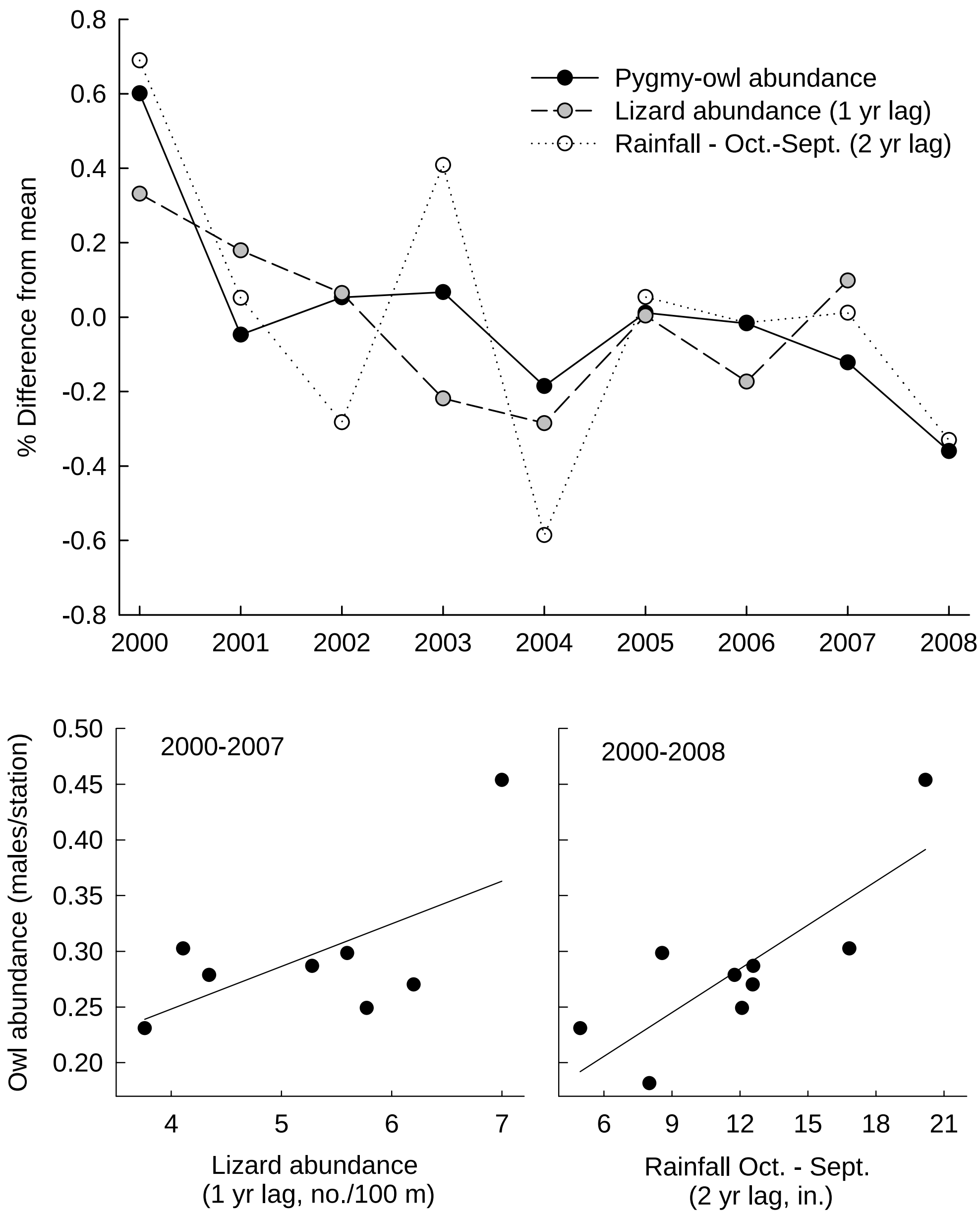

Figure 5: Relationships among pygmy-owl abundance (males/station), diurnal lizard abundance (no./100 m) at a lag time of 1 yr, and annual rainfall (Oct. – Sept, inches) at a lag time of 2 yrs between 2000 and 2008. Owl abundance was estimated along 54 km of transects each year in northern Sonora, lizard 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. Lizard data for 2007 has not yet been analyzed.