

Cactus Ferruginous Pygmy Owl (*Glaucidium brasilianum cactorum*), Ten Year Management Plan to Reestablish Populations in Arizona.

Conor Whalen

Spring 2022

Submitted: April 26th



A paper submitted in partial fulfillment of the requirements for the degree of Bachelor of Science in Fisheries and Wildlife Sciences, Wildlife Concentration, at Paul Smith's College.

Executive Summary:

The cactus ferruginous pygmy owl (*Glaucidium brasilianum cactorum*) is one of the fifteen subspecies of ferruginous pygmy owl, native to Mexico, Central and South America, as well as in southern Arizona and Texas. Populations in Arizona have been found in regions below 4000 feet in elevation with riparian or desert habitat with a high presence of cavity nest structure. Although once abundant in Arizona the pygmy owl has experienced major population declines. Resulting from habitat loss related to the invasive buffelgrass (*Pennisetum ciliare*) and human landscape alterations. The small size and low abundance of the pygmy owl within the state of Arizona has led to limited data and information on the conservation, survivorship, and overall population numbers. Conservation issues most related to this subspecies survival are habitat loss in the form of human land interactions and the invasive plant buffelgrass, as well as the effects of small populations on a species survival. This management plan aims to reestablish populations of the cactus ferruginous pygmy owl in a course of ten years. Objectives in reaching this goal include determining the average population size within the first five years of the management plan, by conducting point count and nest search through transects of past pygmy owl sighting or ideal pygmy owl habitat. Increase public cooperation and knowledge of pygmy owl conservation by 50% within the ten years, by conducting public forums, and releasing a survey to quantify public interest and efforts. Decrease amount of habitat loss by 5% yearly, occurring near areas of known pygmy owl populations, by reducing presence of buffelgrass and the regulation of human land use interactions on pygmy owl habitat. Although delisted for unrelated reason from conservation in 2006 under the Endangered Species Act (ESA). The relisting as threatened or endangered under the ESA will ensure regulatory protection for the pygmy owl. The cryptic nature of the pygmy owl and small population sizes would benefit from the creation and utilization of a successful management plan that would reestablish pygmy owl populations in Arizona. Additionally, gaining an increased understanding of the subspecies.

Link to PDF's: https://livepaulsmiths-my.sharepoint.com/:f/g/personal/cwhalen_paulsmiths_edu/EpAM-96T2AxMIB30VJECw6wBBKc_zq6SEzFICPzPq8FejA?e=JkBZlx

Table of Contents

Introduction.....	5
Natural History.....	6
Taxonomy.....	6
Species Identification.....	7
Spatial Distribution.....	8
Habitat.....	10
Reproduction.....	12
Mortality.....	13
Competition.....	14
Conservation Needs.....	14
Economic.....	14
Sociocultural.....	15
Legal/ Regulatory.....	15
Ecological.....	16
Factors and Deficiencies on Habitat.....	18
Statement of Need.....	18
Goal.....	19
1st Objectives.....	20
Actions.....	20
Final Course of Action.....	21
No Action.....	21
Assessment for 1 st Objective.....	21
2nd Objectives.....	22
Actions.....	22
Final Course of Action.....	23
No Action.....	23
Assessment for 2nd Objective.....	24

3rd Objectives	24
Actions.....	24
Final Course of Action.....	25
No Action.....	25
Assessment for 3rd Objective.....	25
Conclusion	26
Acknowledgements	27
Literature Cited	27
Appendix A: Population Model Documentation	30
Appendix B: Survey	32
Appendix C: Educational Poster	35

Introduction

The cactus ferruginous pygmy owl (*Glaucidium brasilianum cactorum*) currently is considered an unthreatened species. Yet in the state of Arizona fewer than 20 individuals were known to be present and show evidence of continued population decline (Johnson et al. 2003, U.S. Fish and Wildlife Service. 1999). Historically, the pygmy owl was considered abundant throughout its range in Arizona with numerous recorded sightings from the 1800 – 1970's. Research conducted from 2000 - 2016 claims habitat loss as playing a primary role in population declines, with six sub populations experiencing declines and two declining to the level of local extinction (U.S. Fish and Wildlife Service. 2017). As one of the smallest members of family *Strigidae*, this subspecies is commonly lighter in color, stand at five inches tall and weigh in at an incredibly light two point five ounces (Cartron et al. 2000, Proudfoot et al. 1999).

Populations of the pygmy owl occur in Arizona and Texas, with most population abundance occurring in Mexico and parts of South America (U.S. Fish and Wildlife Service. 2017). Pygmy owl home range requires 9.9 to 47.3 hectares below 4000 feet in elevation in southcentral Arizona. These areas of Arizona which provide habitat for the pygmy owl are projected to experience a human population growth of 132 % from 2005 to 2050 (Fish and Wildlife Service. 2021). This continued human population growth will result in anthropogenic alteration of the landscape, further reducing pygmy owl abundance. A management plan which considers these threats, is required for the conservation of this owl.

Due to its small size and low population numbers in Arizona, the rate and cause of mortality isn't completely known or understood (Cartron et al. 2000). Demographic, environmental, and genetic stochasticity affect all populations, but the effect of each of these is

greatest as population size grows smaller (Little and Webb. 2013). Demographic stochasticity is frequently responsible for affecting sex ratio, reproduction, and population estimates (Little and Webb 2013). I encountered this issue while running my PVA model using stage survival and reproduction rates from various research. Even though we knew the population had been declining, our model predicted that the population should be exponentially increasing (Figure 1). Further research is required to create a more accurate population model for the pygmy owl (Cartron et al. 2000).



Figure 1. Predicted population of the cactus ferruginous pygmy owl in Arizona over the next 10 years. Red line: no actions taken. Dotted green line: use of 10-year management plan.

Natural History

Taxonomy

The cactus ferruginous pygmy owl (*Glaucidium brasilianum cactorum*) belongs to the order Strigiformes, specifically family *Strigidae* (Cartron et al. 2000). Compared to other subspecies of *Glaucidium brasilianum*, this subspecies possesses a lighter brown color, shorter length wings, and a tail proportionally longer than most other small owls (Cartron et al. 2000).

Species I.D.

This small owl has light brown upper wing and back feathers with evenly distributed white spots along the upper wing and primary feathers (Proudfoot et al. 1999). This owl has yellow irises and a beak varying in color from light green, yellow, to grey. The head of these owls are small without any ear tufts present. (Cartron et al. 2000, Proudfoot et al. 1999). Males are darker in color compared to females, with females typically larger in size (Proudfoot et al. 1999). On average these owls are 5 inches tall and weigh only 2.5 ounces (Proudfoot et al. 1999). Fledging's are similar in appearance to their adult counterparts however, in their first 4 weeks post fledging these owls are missing brushes of white and false eye spots on the nape and crown (Cartron et al. 2000, Proudfoot et al. 1999).



Figure 2. Cactus ferruginous pygmy owl (*Glaucidium brasilianum cactorum*) perched on a log, grasping its prey (Proudfoot et al. 1999).

Spatial Distribution

The cactus ferruginous pygmy owl (*Glaucidium brasilianum cactorum*) is one of the fifteen subspecies of ferruginous pygmy owl, native to Mexico, Central and South America, as well as in southern Arizona and Texas (Figure 3.).



Figure 3. The geographic range of all 15 subspecies of ferruginous pygmy owl's (Cartron et al. 2000).

Populations of the *cactorum* subspecies are abundant in northern Sonora, Mexico. While in Arizona populations are few and far between (U.S. Fish and Wildlife Service. 2017). This owl currently resides in lowland areas of southcentral Arizona (U.S. Fish and Wildlife Service 1998). Evidence suggest that the home range of this owl is 9.9 to 47.3 hectares (Flesch & Steidl. 2002).

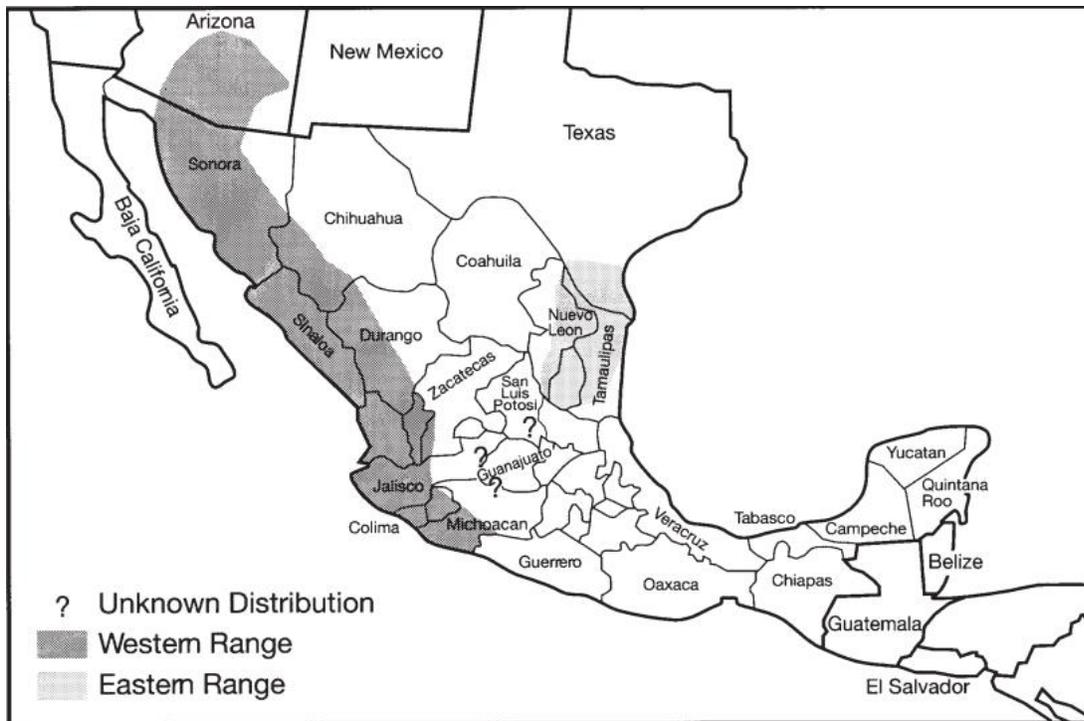


Figure 4. The geographic range of *Glaucidium brasilianum cactorum* (Cartron et al 2000). The Western range contains what's considered to be a genetically distinct population, sharing no gene flow between the Eastern range's population (Proudfoot et al. 2006).

Habitat

This owl has been witnessed preying on various species of birds, mammals, reptiles, and invertebrates (Table. 1) from tree and cacti cavities (Proudfoot et al. 1999). Most frequently observed in areas of cottonwood (*Populus fremontii*), riparian woodlands, and saguaro cactus (*Carnegiea gigantea*) forest. Additionally, with edges, thickets, and densely foliated trees (Johnson et al. 2003). This owl relies on the excavation skills of woodpeckers to create their nest cavity. In Arizona this owl's nest cavities are created commonly by the flickers (*Colaptes spp.*) and the gila woodpecker (*Melanerpes uropygialis*) (Cartron et al. 2000). During the nesting season this owl requires an area of 23 to 47 acres (U.S. Fish and Wildlife Service 1998). Nest

located in the Arizona upland subdivision of the Sonoran Desert ($n = 24$) were found in habitat such as savannah (47.2%), and desertscrub (41.5%) most commonly (Flesh & Steidl. 2002). This owl is considered a prey generalist feeding on a variety of other birds, mammals, reptiles, amphibians, and insects (Proudfoot et al. 1999). In Arizona these owls have been found to feed on reptiles the most frequently (Cartron et al. 2000). Properties which provide at least 3 acres of land along with preserved cacti, and nest trees have been found to support populations of these owls (U.S. Fish and Wildlife Service 1998). Research on the effect of roads on this owl have shown evidence that medium to small size roads don't act as a significant barrier to their habitat ($P \leq .0072$) (Arizona Department of Transportation. 2007)

Table 1. Prey base of the cactus ferruginous pygmy owl in Texas and Arizona (Cartron et al. 2000).

Prey category	Texas	Arizona
Amphibians	narrow-mouth toad (<i>Gastrophryne olivacea</i>)	—
Birds	Bewick's wren (<i>Thryomanes bewickii</i>) blue grosbeak (<i>Guiraca caerulea</i>) brown-crested flycatcher (<i>Myiarchus tyrannulus</i>) eastern meadowlark (<i>Sturnella magna</i>) Nashville warbler (<i>Vermivora ruficapilla</i>) northern cardinal (<i>Cardinalis cardinalis</i>) northern mockingbird (<i>Mimus polyglottos</i>) pyrrhuloxia (<i>Cardinalis sinuatus</i>)	cactus wren (<i>Campeylorhynchus brunneicapillus</i>) Gambel's quail (<i>Callipepla gambelii</i>) house finch (<i>Carpodacus mexicanus</i>) mourning dove (<i>Zenaidura macroura</i>) verdin (<i>Auriparus flaviceps</i>)
Mammals	common evening bat (<i>Nycticeius humeralis</i>) hispid cotton rat (<i>Sigmodon hispidus</i>) hispid pocket mouse (<i>Chaetodipus hispidus</i>) house mouse (<i>Mus musculus</i>) northern pygmy-mouse (<i>Baiomys taylori</i>) Texas kangaroo rat (<i>Dipodomys compactus</i>)	Bailey's pocket mouse (<i>Chaetodipus baileyi</i>) Merriam's kangaroo rat (<i>Dipodomys merriami</i>)
Reptiles	four-lined skink (<i>Eumeces tetragrammus</i>) ground skink (<i>Scincella lateralis</i>) Great Plains skink (<i>Eumeces obsoletus</i>) keeled earless lizard (<i>Holbrookia propinqua</i>) rose-bellied lizard (<i>Sceloporus variabilis</i>) six-lined racerunner (<i>Cnemidophorus sexlineatus</i>) Texas horned lizard (<i>Phrynosoma cornutum</i>) Texas spiny lizard (<i>Sceloporus olivaceus</i>) Texas spotted whip-tail (<i>Cnemidophorus gularis</i>)	desert spiny lizard (<i>Sceloporus magister</i>) western whiptail lizard (<i>Cnemidophorus tigris</i>) zebra-tailed lizard (<i>Callisaurus draconoides</i>)
Invertebrates ^a	cicada (Cicadidae) click-beetle (Elateridae) cone-nosed blood sucker (Reduviidae) dragonfly (Aeshnidae) grasshopper (Acrididae and Tettigoniidae) lighting bug (Lampyridae) preying mantis (Mantidae) round-headed katydids (Phaneropterinae) true katydids (Pseudophyllinae) walking stick (Heteronemiidae)	butterfly (Lepidoptera) cicada (Cicadidae) grasshopper (Orthoptera) sphinx moth (Sphingidae)

^a Invertebrates are identified to the order or family level only.

Reproduction

This owl will make a pair bond with another mate in the fall of the first year after hatch, mating as a monogamous pair indefinitely (Proudfoot et al. 1999). This owl's clutch size consists of four eggs on average in Arizona. If the first clutch is unsuccessful then a new clutch might be reproduced in 21 days (Cartron et al. 2000). Once pair bonds are formed this owl will mate during each spring, between March and June (Proudfoot et al. 1999). Incubation lasts for about a month until the eggs hatch (Table. 2). The father is responsible for providing food for the mother and young once hatched. Three weeks after hatching the mother will begin to leave the nest with the father to forage (Proudfoot et al. 1999). It takes another month before the young will fledge. Once fledged the area they use around the nest increases and contact with the adults decreases, lasting for two months before becoming fully independent (Cartron et al. 2000, Proudfoot et al. 1999). The average relative abundance of males ($.29 \ln \frac{\text{no. detect}}{\text{station}} \pm SE$) is higher than females ($.06 \ln \frac{\text{no. detect}}{\text{station}} \pm SE$) according to monitoring conducted in Pima County, Arizona (Office of Sustainability and Conservation. 2021).

Table 2. The Breeding Biology of Ferruginous Pygmy-Owls in Texas (Proudfoot et al. 1999).

Breeding Biology of Ferruginous Pygmy-Owls in Texas	
• Laying season	April 2 to June 2
• Egg-laying interval	1 egg every 32 to 39 hours
• Average clutch size	4.8 eggs/nest
• Incubation period	About 28 days
• Hatching interval	1 egg hatches every 20 to 26 hours
• Hatching efficiency (eggs hatched/eggs laid)	Nest boxes: 72% Natural cavities: 78%
• Average egg weight	About 1/4 ounce
• Nestling development	Nestlings gain about 1/3 ounce/week
• Fledging (when young leave the nest)	Occurs 23 to 29 days after hatching
• Fledging weight	About 2 ounces
• Fledging efficiency (number hatched/number fledged)	Nest boxes: 78% Natural cavities: 70%
• Productivity (number of eggs laid/number of fledglings)	Nest boxes: 56% Natural cavities: 54%
• Fecundity (number of young fledged/nest attempt)	Nest boxes: 2.8 Natural cavities: 2.6

Mortality

Currently data on the rate of mortality for this owl in Arizona is limited, due to their rarity (estimated fewer than 20) (Cartron et al. 2000). The average risk of mortality from first being hatched to leaving the nest was found to be 38% (Proudfoot et al. 1999). Various species have been found to predate on this owl including the Cooper's hawk (*Accipiter cooperi*) (Cartron et al. 2000). Fledging's which lack flight coordination are highly susceptible to predation. After monitoring 18 fledging's in Texas for twenty-four hours one had died, and five others had experienced injuries or human interference to prevent fatalities (Cartron et al. 2000). Trichomoniasis is a protozoal disease transmissible from prey to predator consumption. Many of the prey which this owl consumes carry the disease. Although no research has been done on this disease's effect on the pygmy owl, it has shown high nestling mortality in the Cooper's hawk (*Accipiter cooperi*) (Cartron et al. 2000). *Protocalliphora sialia* (Diptera: Calliphoridae) was found in a nestling and among the nest litter *Hesperocimex sonorensis*

(Hemiptera: Cimicidae), both which are parasites that consume their host's blood. The three total nestlings successfully fledged, however 8 days later two were found dead and one missing (Proudfoot et al. 2005).

Competition

Cases of siblicide have occurred due to young competing for food (Cartron et al. 2000). Competition for nest cavity access occurs between them and other species that use cavities, such as the purple martin (*Progne subis*), and Gila woodpeckers (*Melanerpes uropygialis*). Gila woodpeckers also have been found to take the stored food of the pygmy owl (Cartron et al. 2000).

Conservation Needs

Economic

Various economic factors play a role in the management of this owl. The decline in population of this owl in the United States, isn't something seen globally. This is a major factor which benefits this owl. With abundant populations in northern Mexico and similar habitat structure. Our study area is provided with an excellent population source of these owls (Flesch and Steidl 2002). We can manage these populations by relocating individuals into Arizona affordably if natural dispersal proves ineffective. By ensuring we implement our plan cost-effectively, additional management actions can be performed with the savings from relocation. When focusing on habitat management areas which were located near study area showed a significant increase in property value, after implementation of habitat restoration. Another economic factor is how the economy is within the study area. If the economy is poor around

our management area, then additional public support might be limited, leading to decreased funding and availability for more costly measures. Especially in Arizona where the predicted sociocultural index, representing people's stance on wildlife conservation in the south-central area of Arizona is at .50 (Manfredo et al. 2021). With such an even divide on the predicted index the economic climate of the community will play a major role in their willingness to participate in the conservation of wildlife.

Sociocultural

Before implementing a management plan for the conservation of a species it is vital to consider the sociocultural factors which affect them. It's important to know how members of the public in your area of management value wildlife and the conservation of it. The predicted sociocultural index, representing people's stance on wildlife conservation in the south-central area of Arizona is at .50, compared to a maximum of .75 and minimum of .25 nationally (Manfredo et al. 2021). With only a 50 percent rating on the sociocultural index, management decisions should reinforce the promotion to the public on the conservation of this owl and other wildlife. After delisting from the Endangered Species Act, people from around the country would continue to sign multiple petitions for the little owl to be reinstated (Fish and Wildlife Service. 2021). Although this is clearly a legal/policy issue, the level of effort citizens nationwide invested with their many petitions shows a positive management outlook. This is helpful for the management of this owl as active participation from community members in the conservation of this owl on their own property will increase the effectiveness of our management plan.

Legal/Regulatory

The delisting of this species in 2006 was unrelated to recovery, even though populations continued to decline (Office of Sustainability and Conservation. 2021). Little population data is available on this owl in Arizona after delisting, but populations are believed to be continuing to decline (U.S. Fish and Wildlife Service. 2017). In 1999 this owl received 730,565 acres within southern Arizona by the USFWS as critical habitat (Cartron et al. 2000). This action has helped prevent the continued habitat destruction as desert areas become more developed and altered for residential purposes. State protection of this owl is overall limited with Arizona considering it a species of concern and Texas considering it a threatened species, leaving little regulation and protection of habitat (Fish and Wildlife Service. 2021). The relisting of this species into the Endangered Species Act will not only provide regulation to protect the owl but also their habitat.

Ecological

This owl requires various biotic and abiotic features through its habitat. Although the physical habitat composition varies greatly between its range in Texas and Arizona, this owl has been found to have a distinct preference for densely foliated landscape trees, edge, and thickets (Cartron et al. 2000). In the state of Arizona this owl's habitat will be below 4000 feet in elevation, riparian habitat of cottonwood and willow along water, desert habitat with cavity structures created from woodpeckers (Fig. 1) (U.S. Fish and Wildlife Service). Artificial nest

structures for this owl in Texas have been found to increase fecundity (2.6 to 2.8) (Proudfoot et al. 1999).

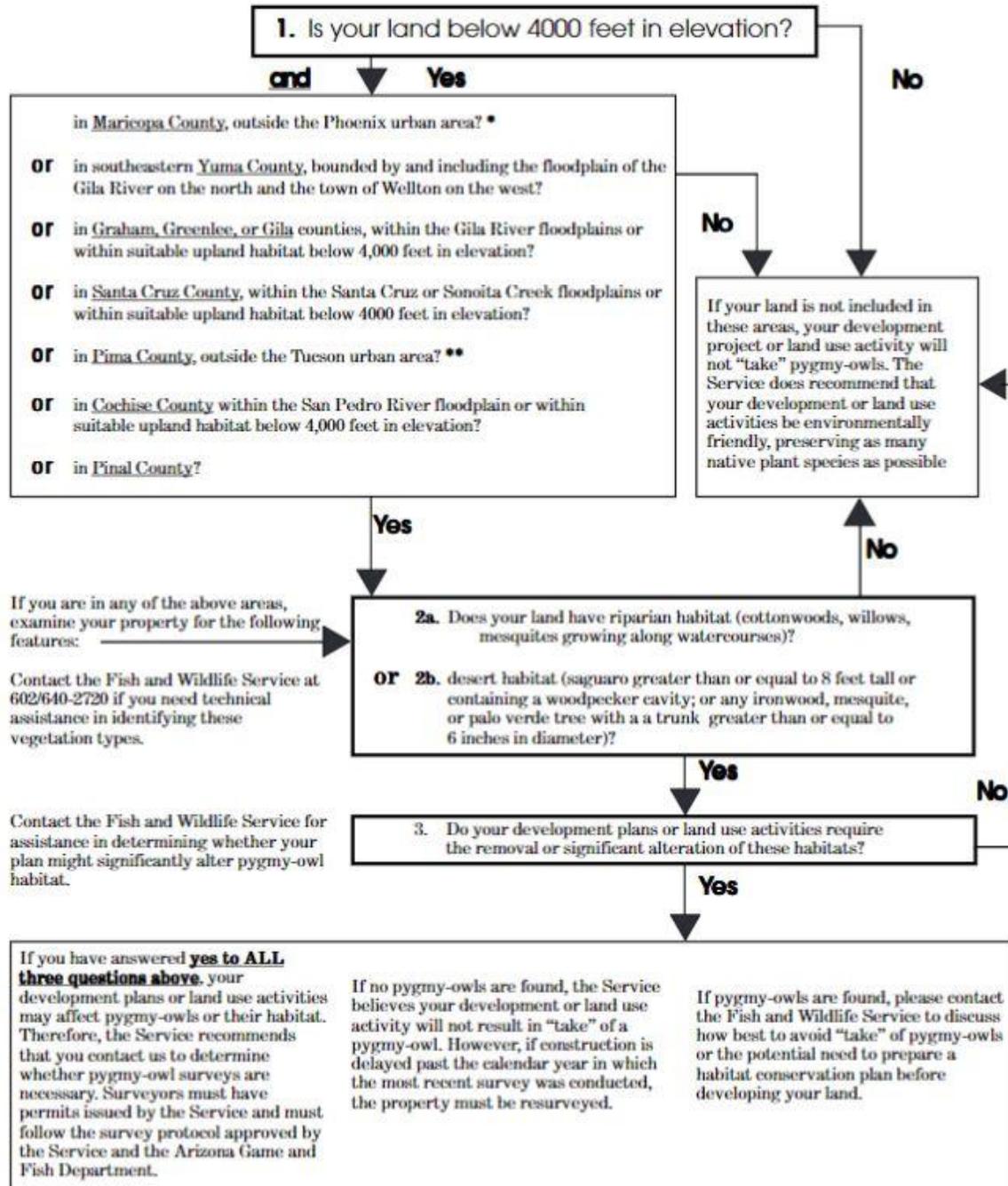


Figure 5. Which properties in Arizona are habitat for *Glaucidium brasilianum cactorum* (U.S. Fish and Wildlife Service. 1998).

Factors and Deficiencies on Habitat

The threat of invasive species, and habitat loss from human interference are the biggest things affecting this owl's habitat. Buffelgrass (*Pennisetum ciliare*) is the primary invasive species, which is affecting this owl's habitat in Arizona. Increasing the risk of range fires and reducing habitat biodiversity (Van Devender and Dimmitt. 2006). Areas of Arizona which possess this owl's habitat are expected to grow in human population by 132 percent from 2005 to 2050 (Fish and Wildlife Service. 2021). This growth will further reduce and fragment this owl's current habitat range.

Statement of Need

The cactus ferruginous pygmy owl (*Glaucidium brasilianum*) had been abundant through their range as recently as the 1970's, however fewer than 20 were known to be in Arizona during the nineties (Johnson et al. 2003, U.S. Fish and Wildlife Service. 1998). These low population numbers led to this owl being listed as an endangered species, under the Endangered Species Act by the U.S. Fish and Wildlife Service in 1997. Unrelated to recovery this owl was delisted as an endangered species in 2006(Office of Sustainability and Conservation. 2021). Various legal/regulatory, ecological, economic, and sociocultural factors affect this species.

One ecological factor which affects this owl is the presence of mature trees and cacti with cavities created by primary cavity nesters. Primary cavity nesters rely on their excavation skills to create their nest cavity. In Arizona this owl's nest cavities are created commonly by primary cavity nesters such as the flickers (*Colaptes spp.*) and the gila woodpecker (*Melanerpes*

uropygialis) (Cartron et al. 2000). Habitat providing riparian vegetation and nearby uplands is also an important factor affecting this owl. Selecting specifically these areas when choosing a nest site (Flesh, and Steidl. 2002). Additionally, research on the effect of roads on this owl have shown evidence that medium to small size roads don't act as a significant barrier to their habitat ($P \leq .0072$) (Arizona Department of Transportation. 2007). Competition between this owl and other species is a major ecological factor affecting the pygmy owl. Species that use cavities compete for access to each cavity, such as the purple martin (*Progne subis*), and Gila woodpeckers (*Melanerpes uropygialis*). Gila woodpeckers also have been found to take the stored food of the pygmy owl (Cartron et al. 2000).

The decline in population of this owl in the United States, isn't something seen globally. This is a major factor which benefits this owl. With abundant populations in northern Mexico and similar habitat structure. Our study area is provided with an excellent population source of these owls (Flesh and Steidl 2002).

The pygmy owl small stature and rarity makes it the perfect poster species for conservation of Arizona land. Historically this area has been successful in preserving large areas of land, even before this owl was listed in 1997 (Cohn. 2001). The predicted sociocultural index, representing people's stance on wildlife conservation in the south-central area of Arizona is at .50, compared to a maximum average of .75 and minimum average of .25 nationally (Manfredo et al. 2021).

Goal: Reestablish populations of the cactus ferruginous pygmy owl (*Glaucidium brasilianum cactorum*) in the state of Arizona.

Objective 1:

Determine the average population size of the cactus ferruginous pygmy owl in the state of Arizona. Within the first 5 years of plan.

Action 1.1:

Transects will be placed through the pygmy owl's preserved critical habitat in southern Arizona by the U.S. Fish and Wildlife Service. A nest search and point count will be conducted on an annual basis. Nest searches will take place on 100 randomly selected transects (1000 × 1000 meter). With point counts being conducted within 400 meters from where each nest is found. Previous population surveys for the pygmy owl considered a radius of 400 meters from the nest as a conservative estimate of this owl's home range (≤ 430 meters) (Flesch and Steidl. 2002).

Action 2.1:

A mark recapture survey using various trapping methods such as mist nets will be used on each transect for a period of two continuous days. Additionally attaching radio collars to adult owls which have been captured. Mark recapture methods if successful could provide samples for DNA analysis, giving insight into a population's health (Arsenault et al. 2005).

Action 3.1:

Use camera traps throughout the year in areas of pygmy owl habitat being continuously monitored for a period of 5 years. Camera traps will be installed specifically in or adjacent to pygmy owl nest. Using a camera trap near where predatorial birds are perching, set to operate

when sensing only close-range movement, we can increase chances of detection (Hong et al. 2022).

Final Course of Action:

Action 3.1 and 1.1, The collection of both field and office observation for these owls will be most effective for determine the average population size of the cactus ferruginous pygmy owl in the state of Arizona, within the first 5 years of plan. Camera traps will be added to each nest site located from nest search/ point counts in the years prior.

No Action:

Removed from the Endangered Species Act in 2006, limited information on exact population numbers for the pygmy owl is known. Prior to delisting, population surveys occurred frequently (Flesch and Steidl. 2007). We can't be certain that no action will lead to extinction. Without obtaining this data, management decisions or lack thereof will be made on a false basis until collected.

Assessment for Objective 1:

The level of success in determining the average pygmy owl population size will increase as we acquire more data each year. Assessment of objective one should be conducted yearly after the first year of management. Using the number of pygmy owl sightings from our camera traps and nest search/ point counts per transect from each year, pygmy owl abundance can be calculated (Flesch and Steidl. 2006). After the first year of data collection, assessment of objective one will begin using a regression to find trends in abundance on each transect against each year.

Following the regression, a univariate repeated – measures ANOVA, with the year considered a fixed effect and transect abundance as a random effect (Flesh and Steidl. 2006). Camera trap points assessed as no success will be relocated to new randomly selected points near transects assessed at greater than 25% trend in abundance. Transects assessed as no success will be removed from further efforts, to focus on more successful transects.

- Highly Successful: All individuals (75-100% trend in abundance) within the state of Arizona are counted for.
- Moderately Successful: Most individuals (50-74% trend in abundance) within the state of Arizona are counted for.
- Low Success: Few individuals (25-49% trend in abundance) within the state of Arizona are counted for.
- No Success: Less than 24% trend in abundance, of individuals within the state of Arizona are counted for.

Objective 2:

Increase public cooperation and knowledge of pygmy owl conservation efforts by 50% within ten years.

Action 1.2:

Create and release a survey to the public in Arizona whose property lies on pygmy owl habitat. To find out public interest in the conservation of the pygmy owl and the willingness of the public to install artificial nest structures on their own property. The survey will be conducted every 2

years to determine if the public's knowledge, perceptions, and participation have positively changed.

Action 2.2:

Host community events promoting and educating the public on pygmy owl conservation efforts. Events will be held on a bi-monthly basis, specifically promoting the community to get involved in the conservation for pygmy owls on their personal properties.

Action 3.2:

Restricting a 50-meter radius around known pygmy owl nest from public access, during the nesting season throughout the management project.

Final Course of Action:

Action 1.2 and 2.2, emphasize the importance including social values in the efforts of conservation. Areas of habitat for pygmy owls occurring on private property previously have prevented us from performing conservation efforts without permission from the property owners first. These actions will help us to assess public opinion, increase community involvement, and potentially raise pygmy owl survivorship, depending on public participation in using nest boxes on their properties with pygmy owl habitat (Table 2.). Action 3.2 will be considered in future management plans, as legal efforts in property restriction will take longer than 10 years.

No Action:

No action might not directly influence recovery of the pygmy owl. However, by using social values of the community, we can gain data which can help throughout different stages of management (Manfredo et al. 2021). Understanding how the public feels about conserving the pygmy owl could prevent us from implementing ineffective management which the public won't participate/ adhere to.

Assessment for Objective 2:

Objective 2 will be assessed every two years on the participation rate increase for our survey. If assessment reports no success than public conservation forums will begin to be held on a bi-monthly basis. If public forum attendance and survey participation rate are further assessed at no success than legal/ regulatory efforts might be more successful.

- Highly Successful: 75-100% participation rate increase for pygmy owl conservation.
- Moderately Successful: 50-74% participation rate increase for pygmy owl conservation.
- Low Success: 25-49% participation rate increase for pygmy owl conservation.
- No Success: Less than 24% participation rate increase for pygmy owl conservation.

Objective 3:

Decrease amount of habitat loss by 5% yearly, occurring near areas of known owl populations.

Action 1.3:

Establish strict zoning regulations for private property, protecting the modification/alteration of the land from purchase.

Action 2.3:

Conduct yearly search and removal of buffelgrass in areas of pygmy owl habitat. Additionally, doing the same on participating landowners' property.

Action 3.3:

Establish regulation for properties used for agriculture, tourism, and hospitality on pygmy owl habitat, requiring nest boxes installed on their grounds.

Final Course of Action:

2.3 and 3.3, Buffelgrass should be continuously monitored and removed from critical habitat of the pygmy owl. Habitat change has played a major role in this species decline with anthropogenic alterations being made to landscape for urbanization and water management (U.S. Fish and Wildlife Service. 1998). Buffelgrass is considered the most pervasive ecological threat to the Arizona Upland subdivision of the Sonoran Desert (Van Devender, and Dimmitt. 2006). While using nest boxes can increase fecundity of the pygmy owl by 20% (Table 2.).

No Action:

No action will lead to the continued decline of the pygmy owl in Arizona. This is because habitat loss has one of the largest effects on the observed decline of pygmy owls in the state of Arizona (Fish and Wildlife Service. 2021).

Assessment for Objective 3:

Using satellite imagery, we can create a landcover class of the owls known range for the first year. Each year after we will collect new satellite imagery of the same area and calculate the change between each year landcover. If no success, then management toward reestablishing pygmy owl populations might be impossible.

- Highly Successful: The percent change in landcover is $\leq 4\%$ loss in this owl's range.
- Moderately Successful: The percent change in landcover is 5-24% loss in this owl's range.
- Low Success: The percent change in landcover is 25-74% loss in this owl's range.
- No Success: The percent change in landcover is $\geq 75\%$ loss in this owl's range.

Conclusion

The Cactus Ferruginous Pygmy Owl management plan for the state of Arizona could potentially increase fecundity from 2.6 to 2.8 young fledged per nest attempt. Critical habitat should be protected and managed on public and private land, with participation of landowners of private property. Buffelgrass should be continuously monitored and removed from critical habitat of the pygmy owl. Habitat change has played a major role in this species decline with anthropogenic alterations being made to landscape for urbanization and water management (U.S. Fish and Wildlife Service. 1998). Buffelgrass is considered the most pervasive ecological threat to the Arizona Upland subdivision of the Sonoran Desert (Van Devender, and Dimmitt. 2006). The combination of our current knowledge of the pygmy owl preferred habitat, reproductive data, and previous actions is sufficient to begin management for this species in

Arizona. However, due to its small size and low population numbers, little is known about this owl in Arizona. More research is required to create a more realistic population model (Cartron et al. 2000). Conservation issues such as habitat loss from human interference, invasive species, and small population size can affect the management plan of this pygmy owl (Fish and Wildlife Service. 2021). According to the sensitivity matrix management, adults (.33) and fledging's (.30) have the greatest effect on the management of these populations. Managing for adult staged pygmy owls is difficult, as important data related to adult survivorship, mortality, and causes is still widely unknown (Cartron et al. 2000). Management for egg, hatchling, and juvenile stages will be most effective because they will be found on the breeding grounds of the parents for up to 3 months before dispersing (Proudfoot et al. 1999). This management plan aims to conserve and improve pygmy owl habitat, reestablish populations in Arizona where fewer than 20 known individuals were found in the nineties (U.S. Fish and Wildlife Service. 1998). This small cryptic owl needs a successful management plan, which will re-establish pygmy owl populations in Arizona.

Acknowledgements:

Thank you to my peers, and professors for the words of encouragement throughout this entire process. Additionally, all the revisions which helped mold this into the paper it is today.

Literature Cited:

Arizona Department of Transportation. 2007. Association between Roadways and cactus ferruginous pygmy-owls (*Glaucidium brasilianum*) in Northern Sonora, Mexico. Arizona Department of Transportation, Environmental Planning Group, Tucson, AZ.

Arsenault, D. P., P.B., Stacey, & G.A., Hoelzer. 2005. Mark-recapture and DNA fingerprinting data reveal high breeding-site fidelity, low natal philopatry, and low levels of genetic

- population differentiation in flammulated owls (*Otus flammeolus*). *The Auk* 122:329-337.
- Bark-Hodgins, R., and B.G., Colby. 2006. An economic assessment of the Sonoran Desert Conservation Plan. *Natural Resources Journal* 46:710-725.
- Cartron, J. L. E., W.S., Richardson, and G.A., Proudfoot. 2000. Ecology and conservation of the cactus ferruginous pygmy owl (*Glaucidium brasilianum*) in Arizona. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fort Collins, CO.
- Cohn, J. P. 2001. Sonoran Desert conservation. *BioScience* 51:606-610.
- Fish and Wildlife Service. 2021. Endangered and Threatened Wildlife and Plants; Threatened Species Status with Section 4(d) Rule for cactus ferruginous pygmy owl (*Glaucidium brasilianum*). Federal Communications Commission, Fish and Wildlife Service, Interior.
- Flesch, A. 2007. Population and demographic trends of ferruginous pygmy-owls (*Glaucidium brasilianum*) in Northern Sonora Mexico and implications for recovery in Arizona. School of Natural Resources, University of Arizona, Tucson, AZ.
- Flesch, A., R., Hutto, W., Van Leeuwen, K., Hartfield, and S., Jacobs. 2015. Spatial, Temporal, and Density-Dependent Components of Habitat Quality for a Desert Owl. *PLOS ONE* 10:1-36.
- Flesch, A. D., and R.J., Steidl. 2007. Detectability and Response Rates of Ferruginous Pygmy-Owls (*Glaucidium brasilianum*). *Journal of Wildlife Management* 71:981-990.
- Flesch, A. D., and R.J., Steidl. 2006. Population Trends and Implications for Monitoring cactus ferruginous pygmy-owls (*Glaucidium brasilianum*) in Northern Mexico. *The Journal of Wildlife Management* 70:867-871.
- Flesch, A., and R., Steidl. 2002. Nest-site Selection by Cactus Ferruginous Pygmy-owls (*Glaucidium brasilianum*) in Northern Sonora Mexico. School of Renewable Natural Resources, University of Arizona, Tucson, AZ.
- Guevara, J. N. A., and B.A., Ball. 2018. Urbanization Alters small Rodent Community Composition but not Abundance. *PeerJ* 6:1-14.

- Hong, S. Y., H.S., Lin, Z.L., Huang, W.S., Choi, W. I., Wang, & Y.H., Sun. 2022. Perch-Mounted Camera Traps Record Predatory Birds in Farmland. *Journal of Raptor Research*, 56:116-124.
- Johnson, R. R., J. L. E., Cartron, L. T., Haight, R. B., Duncan, and K. J., Kingsley. 2003. Cactus ferruginous pygmy-owl (*Glaucidium brasilianum*) in Arizona, 1872-1971. *Southwestern Naturalist* 48:390-401.
- Little, A., and S., Webb. 2013. The Wildlife Techniques Manual, Volume 2: Management. *Journal of Wildlife Management*. 7:270-292.
- Manfredo, M. J., B. E. W., Berl, T. L., Teel, and B. T., Bruskotter. 2021. Bringing social values to wildlife conservation decisions. *Frontier in Ecology and the Environment* 19:355-362.
- Office of Sustainability and Conservation. 2021. Cactus Ferruginous Pygmy-Owl (*Glaucidium brasilianum*) Monitoring and Habitat on Pima County Conservation Lands. Pima County Office of Sustainability and Conservation, Tucson, AZ.
- Pérez Granados, C., K.L., Schuchmann, and M., Marques. 2020. Vocal activity of the ferruginous pygmy-owl (*Glaucidium brasilianum*) is strongly correlated with moon phase and nocturnal temperature. *Ethology Ecology and Evolution* 32:62-72.
- Proudfoot, G. A., S. L., Beasom, and F., Chavez-Ramirez. 1999. Biology of ferruginous pygmy-owls (*Glaucidium brasilianum*) in Texas and application of artificial nest structures. *Texas A&M University-Kingsville, Wildlife Management Bulletin of the Caesar Kleberg Wildlife Research Institute* 5:1-7.
- Proudfoot, G. A., J. L., Usener, and P. D., Teel. 2005. Ferruginous pygmy-owls: A new host for *Protocalliphora sialia* and *Hesperocimex sonorensis* in Arizona. *Wilson Bulletin* 117:185-188.
- Proudfoot, G., R., Honeycutt, and R., Slack. 2006. Mitochondrial DNA variation and phylogeography of the ferruginous pygmy-owl (*Glaucidium brasilianum*). *Conservation Genetics* 7:1-12.
- Sayre, N. 2005. Interacting effects of landownership, land use, and endangered species on conservation of Southwestern U.S. rangelands. *Conservation Biology* 19:783-792.

Sinden, A. 2004. The economics of endangered species: why less is more in the economic analysis of critical habitat designations. *Harvard Environmental Law Review* 28:129-214.

Taylor, M. F. J., K.F., Suckling, and J.J., Rachlinski. 2005. The effectiveness of the endangered species act: a quantitative analysis. *BioScience* 55:360-367.

U.S. Fish and Wildlife Service. 1998. Cactus ferruginous pygmy owl in Southern Arizona. U.S.F.W.S. Ecological Services Field Office, Phoenix, AZ.

U.S. Fish and Wildlife Service. 2017. Population Trends, Extinction Risk, and Conservation Guidelines for ferruginous pygmy owls (*Glaucidium brasilianum*) in the Sonoran Desert. Arizona Ecological Service Field Office, Tucson, AZ.

Van Devender, and Dimmitt. 2006. Conservation of Arizona Upland Sonoran Desert Habitat. Status and Threats of Buffelgrass (*Pennisetum ciliare*) in Arizona and Sonora. Arizona-Sonora Desert Museum, Tucson, AZ.

Weiss, J. L., J.T., Overpeck. 2005. Is the Sonoran Desert losing its cool? *Global Change Biology* 11:2065-2077.

Appendix A: Population Model

.78 eggs hatched/laid: With limited information on the survival rates of this owl in Arizona. The number of all eggs that will hatch (Eggs hatched/laid=78%) in natural cavities is from research conducted in Texas (Proudfoot et al. 1999).

.70 (# hatched/fledged): This is the number of all hatched divided by the number of them which fledged based of data collected on this owl in Texas (Proudfoot et al. 1999).

1 (# hatch 1/ hatch 2): Since my owl only has 4 life stages for the model to work, I had to include an additional life stage. This is a repeat of hatch 1 so all individuals that survive hatch 1 will also survive hatch 2.

.62 (adults/fledged): It is estimated that fledgling mortality is 38% in Arizona, which means that .62 of fledglings will survive to become adults (Cartron et al. 2000).

.55 of adults will survive the year: The maximum life span of this owl is 5 years, while it takes a year for this owl to become an adult (Fish and Wildlife Service. 2021). Plus, our known number of owls in Arizona is 20 individuals (U.S. Fish and Wildlife Service. 1998). With this information I was able to calculate that .55 of all individuals would survive each year, because at this survivorship rate the population would be extinct after five years their maximum lifespan.

Fecundity of adults is 2.6: This is based off research done in Texas on this species which found that 2.6 of fledged per nest attempt (Proudfoot et al. 1999).

Population vector: Due to its small size and low population numbers, little is known about this owl in Arizona. The rate and cause of mortality, particularly. More research is required to create a more realistic population model (Cartron et al. 2000). As a result, my population vector will only begin with 25 individuals in the adult stage (Egg: 0, Hatchling 1: 0, Hatchling 2: 0, Fledging: 0, and Adult: 25). I extrapolated this number using multiple sources. In the mid-90's populations were near twenty individuals in Arizona (U.S. Fish and Wildlife Service. 1998). Additionally, 33 were recorded during nest surveys in Arizona (Office of Sustainability and Conservation. 2021). Since adult survivorship is .55, after one year the population of 20 adult owls would decrease to 11. While the 33 hatchlings will become 14 adults after one year. After adding these groups of individuals together, I had my value for adult owls in the population vector.

Table 3. Stage based sensitivity and elasticity matrix (no management).

Sensitivity matrix					
	F(e)	F(h1)	F(h2)	F(f)	F(a)
Egg	0.1703	0.1170	0.0734	0.0657	0.0719
Hatch_1	0.2397	0.1675	0.1050	0.0940	0.1029
Hatch_2	0.3823	0.2671	0.1675	0.1500	0.1642
Fledging	0.4269	0.2982	0.1870	0.1675	0.1833
Adults	0.7687	0.5370	0.3367	0.3016	0.3301
Elasticity matrix					
	F(e)	F(h1)	F(h2)	F(f)	F(a)
Egg	0	0	0	0	0.167477403
Hatch_1	0.167476772	0	0	0	0
Hatch_2	0	0.1674767	0	0	0
Fledging	0	0	0.167476772	0	0
Adults	0	0	0	0.167477403	0.162611712

0.999996764

Table 4. Stage based sensitivity and elasticity matrix (with implementation of management plan).

Sensitivity matrix					
	F(e)	F(h1)	F(h2)	F(f)	F(a)
Egg	0.1694	0.1067	0.0733	0.0645	0.0683
Hatch_1	0.2656	0.1684	0.1156	0.1018	0.1077
Hatch_2	0.3868	0.2452	0.1684	0.1482	0.1569
Fledging	0.4393	0.2785	0.1912	0.1684	0.1782
Adults	0.8048	0.5102	0.3504	0.3085	0.3265
Elasticity matrix					
	F(e)	F(h1)	F(h2)	F(f)	F(a)
Egg	0	0	0	0	0.168380223
Hatch_1	0.168380828	0	0	0	0
Hatch_2	0	0.168381521	0	0	0
Fledging	0	0	0.168380828	0	0
Adults	0	0	0	0.168380223	0.158091653

0.999995275

Appendix B: Survey

This survey was created with the management of the cactus ferruginous pygmy owl in mind. In particular, the focus of this survey is to find out the willingness of community members to assist in the conservation of this owl on public and their own personal land. Additionally, determining the level of support we have from the communities which lie on the pygmy owl's habitat. In fulfillment of objective 2.

- 1.) Is your land located in Maricopa, Yuma, Graham, Greenlee, Gila, Santa Cruz, Pima, Cochise, and Pinal Counties?
 - a. Yes, seasonal/ part-time in _____ county
 - b. Yes, full time in _____ county

- c. No, property isn't within any of the listed counties
- 2.) Is your property located below 4000 feet in elevation?
 - a. Yes, below 4000 feet in elevation
 - b. No, above 4000 feet in elevation
- 3.) If seasonal/ part-time resident, when do you visit?
 - a. Spring (March - May)
 - b. Summer (June – August)
 - c. Fall (September – October)
 - d. Winter (November – February)
- 4.) Are you familiar with the bird species, Cactus Ferruginous Pygmy Owl?
 - a. Yes
 - b. No
 - c. Unsure
- 5.) Did you know that this species was listed as endangered under the Endangered Species Act up until 2006?
 - a. Yes
 - b. No
 - c. Unsure
- 6.) How knowledgeable are you on the conservation and management of wildlife?
 - a. Very familiar
 - b. Familiar
 - c. Moderate
 - d. Unfamiliar
 - e. Zero knowledge
- 7.) How supportive are you of species conservation efforts on public property?
 - a. Highly supportive
 - b. Supportive
 - c. Moderate
 - d. Unsupportive
- 8.) How supportive are you of species conservation efforts being conducted on your own property?
 - a. Highly supportive
 - b. Supportive
 - c. Moderate
 - d. Unsupportive

- 9.) Are you willing to install nest boxes on your own property to help reduce pygmy owl mortality?
 - a. Yes
 - b. No
 - c. Maybe
- 10.) Would you be willing to attend a free forum which informs about wildlife management and conservation?
 - a. Yes
 - b. No
 - c. Maybe
- 11.) Are you familiar with the invasive species, buffelgrass?
 - a. Yes
 - b. No
 - c. Uncertain
- 12.) Are you willing to remove buffelgrass from your property to help protect and conserve this pygmy owl's population?
 - a. Yes
 - b. No
 - c. Undecided
- 13.) How much would you be willing to donate for the management of the pygmy owl?
 - a. \$0
 - b. \$1 - \$10
 - c. \$11 - \$20
 - d. Over \$20
- 14.) What is your gender?
 - a. Male
 - b. Female
 - c. Other: _____
 - d. Not Available
- 15.) What is your individual annual gross income?
 - a. < \$20,000
 - b. \$20,001 to \$60,000
 - c. \$60,001 to \$80,000
 - d. Over \$100,001

