DRAFT

MEMORANDUM

Date: July 5, 2000

To: The Honorable Chair and Members
Pima County Board of Supervisors

From: C.H. Huckelberry
County Administrator

Re: **Cactus Ferruginous Pygmy-Owl Investigations in Pima and Pinal County, 1997-1999**

Background

Pima County contracted with the Arizona Game and Fish Department to conduct telemetry analysis and gather information that would lead to effective conservation and recovery initiatives for the cactus ferruginous pygmy-owl. Questions posed as part of the study include:

- *Is there exchange between pygmy-owl populations?*
- *Are pygmy-owls residents of specific areas, rather than migratory?*
- *Where do pygmy-owls go upon dispersal and how far do they travel?*
- *How tolerant are pygmy-owls of various urban occurrences? How adaptable?*

The attached studies entitled *Cactus Ferruginous Pygmy-Owl Investigations* provide observations related to these and other questions about the behavior of pygmy-owls. During 1997, banded birds were monitored. Beginning in 1998 and during 1999, pygmy-owls were radio-marked with backpack transmitters and followed on foot, by vehicle, and on two occasions aerial location of dispersing pygmy-owls took place using the Arizona Game and Fish aircraft. This memorandum provides a summary of highlights from these reports which collectively represent three years of field observations.

Study Area

Pages 2 through 7 of the 1999 report, and pages 2 through 6 of the 1997-1998 report, describe the study area covered by scientists from the Arizona Game and Fish Department.

- Cienega Creek Preserve (1997-1998)
- Pichacho Peak / Suizo Mountains (1999)
- Marana / Redrock (1997-1998, and 1999)
- Northwest Tucson (1997-1998, and 1999)
- Organ Pipe Cactus National Monument (1999)
- Saguaro National Park (1997-1998, and 1999)
- Tucson Mountain Foothills (1997-1998, and 1999)
- Santa Catalina Mountain Foothills (1997-1998, and 1999)
- Altar Valley (1999), Buenos Aires (1999), and Sopori Wash (1997-1998)

Results and Discussion

Following a section on methods used for surveys, monitoring, capture techniques, banding, radio-marking and telemetry, pages 12 through 31 of the 1999 report, and pages 13 through 60 of the 1997-1998 report, describe the results of field efforts during the past three years. A few highlights are reproduced below:

- "Arizona Game and Fish Department (AGFD) survey and monitoring efforts in 1999 resulted in confirmation of 25 occupied territories prior to dispersal of young." [Page 13, 1999 study]
- "In cooperation with U.S. Fish and Wildlife Service contract biologists and National Park Service biologists at Organ Pipe National Monument, we located 11 active pygmy-owl nests. Five other territories were believed occupied by unpaired males due to sustained and vigorous territorial calling throughout the nesting season." [Page 13, 1999 study]
- "After dispersal of young, we identified three newly occupied territories defended by pygmy-owls that were tracked using radio telemetry. We recognized 28 total territories when pre and post-dispersal sites are combined." [Page 13, 1999 study]
- During 1999, eleven pygmy-owl nests were located and monitored in Pima and Pinal counties. From these nests, 32 young fledged (average of 2.9 per nest), and 16 were known to survive dispersal. [Page 17, 1999 study]

Table: Nest Productivity in Pima and Pinal Counties, 1999

AREA	# NESTS	# FLEDGED	AVERAGE/NEST
Marana / Redrock	2	5	2.5
Altar Valley	4	11	2.75
Northwest Tucson	4	16	4.0
Organ Pipe National Monument	1	?	?
Totals	11	32	2.9

- During 1998, three nests fledged a total of 11 young (average of 3.66 per nest).
- During 1997, one nest produced 4 young; all 4 fledged and survived dispersal.
- Between 1996 and 1998, 19 of 22 fledglings survived dispersal, whereas in 1999, only 16 of 32 fledglings were known to survive dispersal.

- The 1997-1998 report describes fledgling interactions: "Fledglings maintained a relatively close association from the time of fledging until near dispersal. ... We were not able to characterize any juvenile interactions as overtly aggressive, but did observe position swapping, pushing, and following each other from perch to perch. During prey deliveries and feeding, fledglings would tend to congregate closer to each other, but frequently on separate perches. While intently watching the adult feeding prey to one or two siblings, the remaining young appeared to simply wait their turn and allow the adult to bring prey to them. In contrast, observations of young being fed by adults in Texas suggest greater aggression or squabbling between siblings over prey." [Pages 24-25]

- The 1997-1998 report also describes aggressive defense of young: "When observers searched for recently fledged young during 1997 and 1998, one or both adults would frequently fly to a nearby perch to investigate ... and often use the alarm call. When searching for fledglings at two different nest sites in 1998, three observers were struck on the back of the head during three separate incidents. During searches we would sometimes get very close to fledglings and would not be aware of their presence until hearing adult alarm calls. Adults swooped on observers shortly after the calls were heard. This very aggressive behavior by adults seemed to decrease as young matured." [P. 25]

- Mobbing episodes are described in the 1997-1998 report: "The noise and movement of mobbing birds often attracted our attention and resulted in detections of pygmy-owl adults and young that may otherwise have gone unseen. Sixteen different species were observed engaging mobbing behaviors. These birds ranged in size from hummingbird species to as large as greater roadrunners." [Page 26]

- "The reaction of pygmy-owls to mobbing birds was variable. Sometimes pygmy-owls appeared to ignore the harassment and remained on their perch until the offenders stopped and moved away. In 1998, a recent fledgling appeared stunned or indifferent while being attacked and struck on the head repeatedly by a black-tailed gnatcatcher. On other occasions, owls simply flew off to escape their tormentors, though often were followed from perch to perch." [Page 26, 1997-1998 report]

- Nesting chronology, from the 1997-1998 report

ACTIVITY	APRIL	MAY	JUNE	JULY	AUGUST
Incubation	mid April	to mid May			
Hatching		early - mid			
Nestling/Fledging		early May to	first of June		
Dispersal				start late July	earlyAugust

- The report from 1997-1998 provides observations of nestlings, fledging, and first flights:

  Nestlings: "Our first direct observations of nestlings were approximately one week prior to fledging, after down was lost and feathers were nearly grown in. ... One nestling would work its way up to the cavity entrance and we could observe its head, neck and breast. Remaining near the entrance appeared difficult at first and may have been the result of several nestlings jostling for position or poor strength and balance. ... One characteristic behavior of both nestlings and fledglings is circular or bobbing head movements which assist the observer in distinguishing perched adults from young."

  Fledging: "As nestlings become stronger and balance is increased, they begin to spend more time in the cavity entrance, standing on the bottom ledge of the entrance opening. Older nestlings have been observed leaning their entire bodies outside the cavity opening and almost falling. ... Just prior to fledging, both male and female adults with prey in their possession, appear to increase their time calling from perches, instead of going directly to the cavity. ... We suspect this adult behavior is an attempt to entice the nestlings to leave the cavity in order to obtain the prey."

  First flights: "The first flights for all directly observed fledglings during 1997 and 1998 were free of injury and entanglement. Most fledglings traveled successfully to the nearest tree or large shrub and began moving to different perch positions. Subsequent flights were more problematic with some birds landing near or on the ground, others became briefly entangled in branches and one was found a few feet from a road. One fledgling in 1997 was rescued from a cholla where it was unable to extract itself. Observations of distances traveled during initial flights at one nest site in 1998 were surprising as all three fledglings reached a patch of paloverde trees approximately 25 meters away from the nest cavity. Flights were high, floating or bobbing similar to the flight of butterflies, rather than the direct level flights of adult birds. Once a fledgling arrived at its first perch, it was immediately joined by the adults on nearby perches. One nestling fledged directly toward the perched and calling adult female." [Pages 51-52, 1997-1998 study]

- Providing observations about flight patterns and dispersal during 1997 and 1998, the report states at page 54:

  Road crossing: "Radio-marked pygmy-owls crossed several two-lane roads with vehicle traffic that ranged from light to moderately heavy in areas with trees and large shrubs on both sides of the road."

  Flight style: "The pygmy-owl flight style is typically two or four feet off the ground or just over the tops of shrubs and ground cover plants. It may fly in short hops of several meters in distance and up to 50 meters, as it moves from one tree or shrub to another within desert scrub communities. This flight pattern was also observed during dispersal." Collisions with cars and structures (such as a fence) have been observed.

- In 1999, 11 juveniles were captured and equipped with backpack style radio transmitters. Eight juvenile owls were tracked through dispersal, and the dispersal routes are found on pages 24 and 25 of the report.

  A few notes from the report include:

  Juvenile 1 dispersed on July 28, 1999, 61 days after fledging, and traveled 24.4 miles during 41 days of monitoring. A new territory was established when the dispersing owl paired with a resident male, 13 direct linear miles from the dispersal site.

  Juvenile 2 dispersed between July 27 and July 30, 1999, and traveled 10.95 miles during a 39 day monitoring period. The last radio location site of the owl on September 27, 1999 was 3.14 direct linear miles from the dispersal site.

  Juvenile 3 dispersed on July 31, 1999, only 49 days after fledging, and traveled 18.68 miles during 17 days of monitoring. A total of 6.15 direct linear miles separated the new territory from the juvenile's nest site.

  Juvenile 4 dispersed on July 30, 1999, and traveled 1.93 miles in 17 days of monitoring. Direct linear distance to the last know detection area was about 1.5 miles from the nest site.

  Juvenile 5 dispersed on July 30, 1999, from the same nest site as Juvenile 4. Monitoring during 33 days reflects that the owl traveled 11.26 miles, leaving it 5.3 direct linear miles from the fledge location, when the last detection was recorded.

  Juvenile 6 dispersed between July 22 and July 26. After six days of monitoring the signal was lost but a distance of 9.85 miles, or 9.45 direct linear miles, was covered in that time.

  Juvenile 7 dispersed late in the season (September 9), but early in its life (48 days after fledging). Monitoring efforts were complicated and after three days of tracking, observers lost the signal for the juvenile. An aerial survey took place on the 13th of September and then the owl was lost again after the fifth day of tracking. Total distance covered was 6.27 miles, or 4.35 miles direct linear distance from the nest site.

  Juvenile 8, the even-more-daring sibling of Juvenile 7, took off between September 4th and 7th, only 43 to 46 days after fledging. It took three days to lose the observers, and aerial surveys relocated this owl for another two days of data gathering before the signal was lost again. During six days of observation, Juvenile 8 covered 7.89 miles, or 6.37 direct linear miles.

Conclusions Following the 1999 Survey Season

In pages 27 through 31 of the 1999 report, the authors offer some insights and conclusions based on field investigations of the past years, including:

- Altar Valley: "Fourteen new territories that included at least 4 nest sites were documented in the Altar Valley in 1999. Most territories were located in mesquite-grassland and Sonoran desertscrub transition areas near mountain foothills. These detections reveal an important new component of the known population of pygmy-owls in southern Arizona and may represent the largest known concentration of pygmy-owl activity in Pima and Pinal counties." [Page 27]

- Telemetry: "As dispersal information is recorded over consecutive years, annual use patterns of certain dispersal routes are beginning to emerge. One explanation for these common dispersal routes, at least in the developed parts of northwest Tucson, is that areas of open, undeveloped desertscrub are limited. Pygmy-owls do not disperse with long distance flights, but rather make short flights from tree to tree, foraging and using the habitat as they go. Connected, undisturbed vegetation facilitates such dispersal. Monitoring has indicated that dispersing juveniles often choose to move through undisturbed desert areas and go around, rather than over high density residential developments. Such developments appear to present barriers to dispersal while open desert with natural washes and mature native vegetation, provide unobstructed and less hazardous dispersal routes. Radio telemetry during 1998 and 1999 has shown these limited habitat connections are being used annually by dispersing juveniles in northwest Tucson." [Page 28-29]

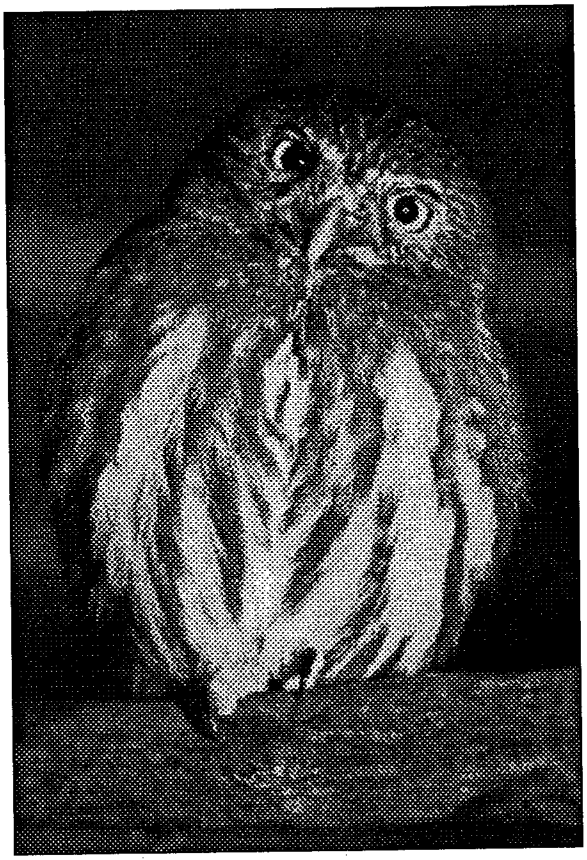
- Population Segments: "Currently, there are four distinct pygmy-owl population segments in Arizona. These are Pinal County, NW Tucson, Altar Valley and Organ Pipe Cactus National Monument. No exchange between these segments has been documented with [one] exception. An additional population segment is known to occur on the Tohono O'odham [Nation], but no species specific surveys, banding or radio-marking has been done in that area. ... Overall CFPO population viability in Arizona will be very dependent on exchange of pygmy-owls between these population segments. Barriers and habitat fragmentation which may prevent this should be considered hurdles to recovery of pygmy-owls in Arizona." [Page 30]

Recommendations from the Studies

Three recommendations for land managers are found on page 31 of the 1999 study: (1) protect remaining dispersal corridors in northwest Tucson; (2) identify and protect an interconnected system of habitat to facilitate exchange between population segments. "The identification of some of these areas has been done by the establishment of critical habitat (by USF&W), ... however, further efforts need to occur in conjunction with local planning efforts by federal agencies and local municipalities; and (3) work with the Tohono O'odham Nation.

CACTUS FERRUGINOUS PYGMY-OWL INVESTIGATIONS IN PIMA AND PINAL COUNTIES, ARIZONA 1999

Dennis Abbate, Wildlife Assistant
Scott Richardson, Urban Wildlife Specialist
Renee Wilcox, Wildlife Assistant
Sarah Lantz, Wildlife Intern



Region V Wildlife Program
Program Manager: Ronald J. Olding
Arizona Game and Fish Department

June, 2000

CACTUS FERRUGINOUS PYGMY-OWL INVESTIGATIONS IN PIMA AND PINAL COUNTIES, ARIZONA 1999

Dennis Abbate, Wildlife Assistant
Scott Richardson, Urban Wildlife Specialist
Renee Wilcox, Wildlife Assistant
Sarah Lantz, Wildlife Intern

Region V Wildlife Program
Program Manager: Ronald J. Olding
Arizona Game and Fish Department

June, 2000

RECOMMENDED CITATION

Abbate, D. J., W.S. Richardson, R. L.Wilcox and S. Lantz. 2000. Cactus ferruginous pygmy-owl investigations in Pima and Pinal Counties, Arizona: 1999. Region V Wildlife Program. Arizona Game and Fish Department, Tucson, Arizona. 37 pp.

ACKNOWLEDGMENTS

Most of the field investigations of cactus ferruginous pygmy-owls during 1999 were conducted on private properties and we are extremely indebted to the landowners for their cooperation. The owners of these private parcels not only granted access, but also demonstrated their support and enthusiasm for our efforts by providing information on the activities of the owls, and spending time orienting us to their pets and property. We are especially grateful to those landowners with properties containing nest sites that granted us almost unlimited access during all times of the day or evening. In order to protect the privacy of these residents and sensitive site specific information they are not recognized here by name, but without their contribution, our work would not be possible and we extend our deepest appreciation.

We also want to thank all Region V Arizona Game and Fish Department (AGFD) personnel who assisted with this project through consultations, office and field support. Ron Olding provided advice on data collection and logistics, participated in early habitat measurements and located radio-marked birds during aerial surveys when we lost radio signals from the ground. Marty Teugel provided data analysis advice and computer support and instruction and assisted with capture attempts. Mike Pruss also assisted with capture attempts, offered advice on field techniques, conducted surveys, attempted to confirm detections by private contractors and helped radio track an adult in the Altar Valley. Sherry Ruther conducted nest monitoring, assisted during early habitat measurements, conducted radio-tracking and helped to monitor young during the fledging period.

Aaron Flesch, contractor for the U.S. Fish and Wildlife Service, conducted extensive surveys and located a number of new territories in the Altar Valley. Aaron provided us with location data, nest monitoring information and general orientation to Altar Valley sites and landowners.

We thank Glenn Proudfoot from Texas A&M University for providing expert consultations and guidance, conducting nest cavity inspections and participating in trapping and banding efforts. Tim Tibbits, from the National Park Service, shared his field observations and provided updates on pygmy-owl activity in Organ Pipe National Park. He provided orientation to territories and participated in trapping adults. Tom Skinner from the U.S. Forest Service supported the project through coordination and implementation of cost share agreements.

PROJECT FUNDING

Collection Agreement No. 20-30-S-126015.0699 with Pima County provided the primary funding for this project. Additional funding for this project was provided by AGFD Region 5 base budgets, and a US Forest Service (Coronado National Forest) Challenge Cost Share Agreement.

AMERICANS WITH DISABILITIES ACT COMPLIANCE

The Arizona Game and Fish Department complies with all provisions of the Americans with Disabilities Act. If you need this material in an alternative format or believe you have been discriminated against, contact the Deputy Director, Arizona Game and Fish Department, 2221 West Greenway Road, Phoenix, Arizona 85023-4399; Telephone (602) 942-3000.

TABLE OF CONTENTS

Table of Contents (continued).

LIST OF FIGURES

LIST OF TABLES

CACTUS FERRUGINOUS PYGMY-OWL INVESTIGATIONS IN PIMA AND PINAL COUNTIES, ARIZONA: 1999

Dennis J. Abbate, W. Scott Richardson, Renee L. Wilcox, Sarah J. Lantz

INTRODUCTION

The cactus ferruginous pygmy-owl (*Glaucidium brasilianum cactorum*) is the northernmost subspecies of *G. brasilianum* , which occurs from southern Arizona and southern Texas through parts of Mexico and throughout Central and South America. This small owl has a long, rufous-colored tail with dark brown bands. This unique tail and a pair of conspicuous dark brown or grayish "eye spots" (often appearing black) on the nape distinguish this owl from the smaller elf owl, which is sympatric with the cactus ferruginous pygmy-owl in Arizona. The cactus ferruginous pygmy-owl (hereafter "pygmy-owl" or "CFPO") has bright yellow eyes and a rounded head that lacks visible ear tufts. More detailed accounts of CFPO physical characteristics can be found in Abbate et al. 1996 and USFWS 1997.

Historical records from Arizona have indicated *G.b. cactorum* inhabited riparian woodlands and mesquite thickets (Rea 1983, Bent 1938). However, the most recent records for this subspecies are from Sonoran desertscrub (Abbate et al. 1999, Brown 1994), with a few observations from riparian woodlands surrounded by semidesert grassland (Harris and Duncan 1998). Detailed descriptions of the habitat, range, and type localities are found in Cartron and Finch 2000, Proudfoot et al. 1999, US Fish and Wildlife 1997, Proudfoot 1996, Abbate et al. 1996, Johnsgard 1988 and Millsap and Johnson 1988. A recent search of museum collections, agency and library records and a compilation of personal observations and anecdotal information has provided the most exhaustive documentation of known Arizona specimens, location descriptions and record related notes prior to 1993 (Duncan and Harris, in press).

Field investigations of the cactus ferruginous pygmy-owl in Arizona during 1999 were a continuation of work begun by the Arizona Game and Fish Department (AGFD) in 1993. Early work was restricted to surveys to begin documentation of recent distribution and population size in response to apparent population declines in the state (Phillips et al. 1964, Monson and Phillips 1981, Rea 1983, Johnson and Haight 1985, Hunter 1988, Millsap and Johnson 1988). Survey efforts and related activities increased from 1995 through the present with the exception of the 1997 breeding season, when funding reductions limited research activities to nest monitoring and only select surveys. A summary of specific activities for each year's field season can be found in AGFD annual and technical reports: Felly and Corman 1993, Collins and Corman, 1994, Lesh and Corman 1995, Abbate et al. 1996, Abbate et al. 1999).

The US Fish and Wildlife Service (USFWS) determined endangered status for the pygmy-owl in Arizona in March 1997, but did not identify critical habitat at that time (USFWS 1997). USFWS proposed designation of approximately 730,565 acres (295,650 hectares) as critical habitat for pygmy-owls in Arizona in December 1998 (USFWS 1998) and designated 731,712 acres

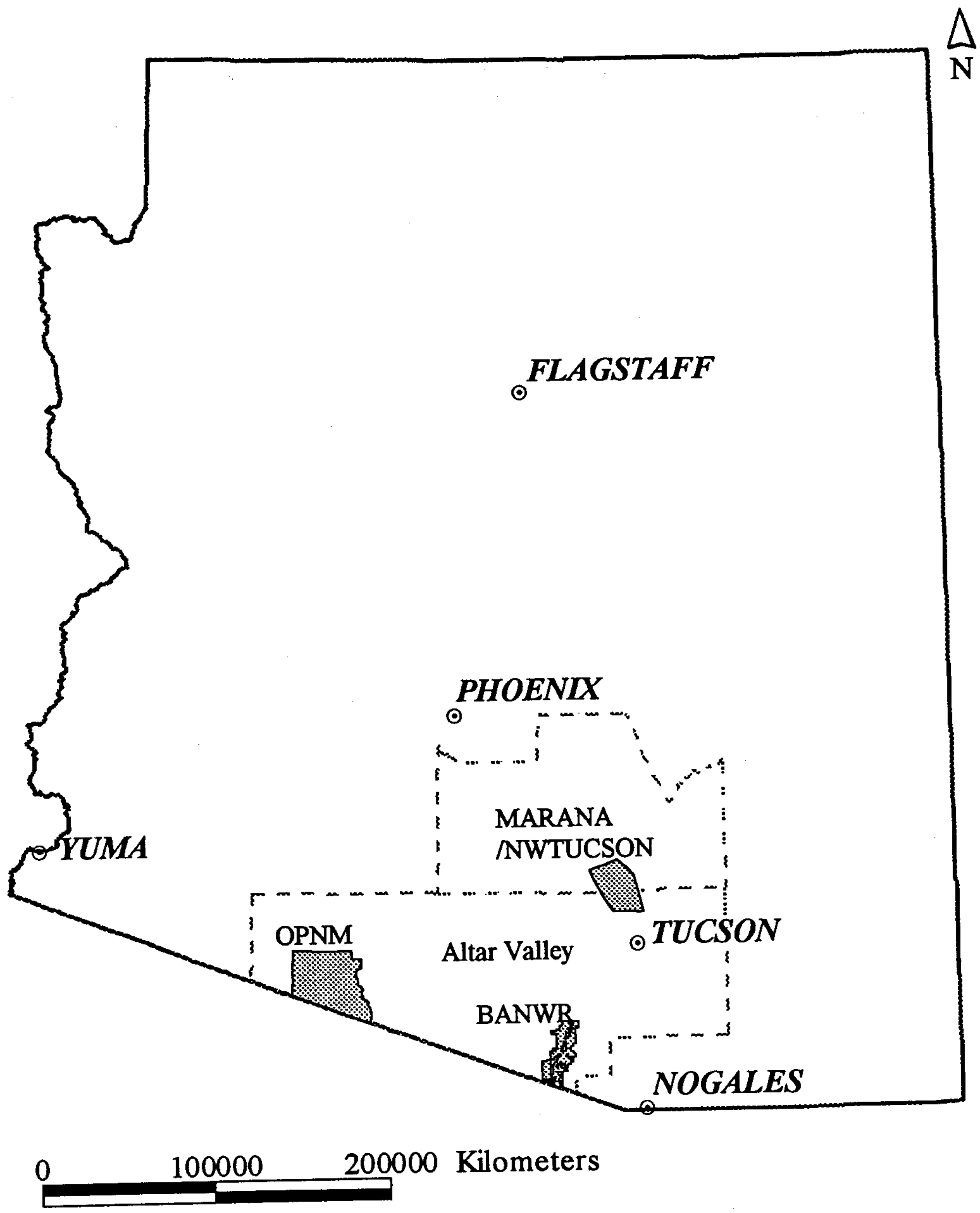


Figure 1. Study area includes parts of northwest Tucson (NWTUCSON), Marana, Altar Valley, Buenos Aires National Wildlife Refuge (BANWR), and Organ Pipe National Monument (OPNM) within Pima and Pinal Counties.

(296,240 hectares) in 1999 (USFWS 1999). A recovery team was appointed by the USFWS in 1998 to develop a Recovery Plan for the CFPO. A draft recovery plan is due out in the fall of 2000.

With the listing of the CFPO as an endangered species, agencies, municipalities and the general public initiated efforts to address potential impacts to the owl resulting from a variety of ongoing and proposed land use activities. Pima County, as a local government entity, permits and engages in activities that have the potential to impact CFPOs and their habitats. In order to address potential conflicts with the Endangered Species Act, Pima County has initiated development of a county-wide Habitat Conservation Plan (HCP) which would put into place actions and activities to avoid, reduce and mitigate potential impacts to the CFPO resulting from their permits or projects. In an effort to begin gathering important data and background for development of this HCP, Pima County entered into a Collection Agreement with the AGFD to conduct telemetry and habitat assessment studies on CFPOs in the planning area. The objective of these studies was to gather information on CFPO dispersal, use areas and habitat selection, all factors necessary for the development of an HCP. Despite the fact that more CFPOs and nest sites were located in 1999 than any previous year of this project, owl numbers and nest sites remain limited and these studies represent a preliminary effort in documenting life history requirements.

STUDY AREA

AGFD field investigations during the 1999 breeding season began with population surveys to locate pygmy-owls that were previously detected and monitored from 1996 to 1998. These early surveys focused on privately owned land and residential areas in northwest Tucson and on Arizona State Trust Lands (AST) in the Marana/Red Rock area. Additional surveys were conducted in some of these same areas along specific routes that were never surveyed or where surveys in previous years were unsuccessful. Several areas where new pygmy-owl detections and nest sites were discovered in 1999 were formally investigated and monitored by AGFD after initial detections during formal surveys conducted by USFWS contract biologists (Flesch, 1999). These new areas generally lie within the Altar Valley and include federally managed lands within the Buenos Aires National Wildlife Refuge (BANWR), Arizona State Trust Lands in the vicinity of the Sierrita , Coyote and Baboquivari Mountain ranges. One additional nest site was located on a private parcel near the Pozo Verde Mountains.

Pygmy-owl surveys and detections by employees and contract biologists for the USFWS, Bureau of Land Management (BLM), US Forest Service (USFS), the National Park Service (NPS) and Pima County permitted AGFD biologists to increase nest monitoring, banding of adults and young and tracking radio-marked pygmy-owls within nest territories and throughout dispersal in northwest Tucson, Marana/Redrock , Altar Valley, and Organ Pipe National Monument (OPNM). Habitat surveys were also conducted in northwest Tucson, Marana/Redrock, BANWR, Altar Valley, and OPNM.

Northwest Tucson

The northwest Tucson study area is semi-rural but rapidly changing due to residential and commercial development. Surveys were conducted primarily along public roads and rights of way and mostly near privately owned parcels with residences. These areas were zoned as "Suburban Ranch" (SR in Pima County) and often contained horse stables, arenas and corrals. Parcels range in size from 3.3 to 40 acres with the majority under 10 acres in size. Despite home construction and some clearing for livestock use, much of the vegetation and wash areas (we estimate 30 to 90 percent) within these private parcels remain natural and relatively undisturbed. In addition, some of the disturbed locations near residences have been landscaped with both native and non-native vegetation. A network of public access roads service the area with many remaining unpaved, but periodically maintained by grading. Larger tracts (one or more topographic sections) in surrounding areas are owned by development corporations and are currently being developed or are in the planning stages as high density residential projects and golf courses.

The survey area falls within the Sonoran desertscrub biotic community and is considered an upland subdivision characterized mostly as Paloverde-Cacti-Mixed Scrub Series (Brown, 1994). The topography is gently sloping, influenced by numerous large dry washes and smaller tributaries. Elevations range from 671 to 854 m (2200 to 2800 ft). Dominant vegetation includes saguaro (*Carnegiea gigantia*) , ironwood (*Olneya tesota*), foothill paloverde (*Cercidium microphyllum*), velvet mesquite (*Prosopis velutina*) and blue paloverde (*Cercidium floridum*). Catclaw acacia (*Acacia greggii*) and whitethorn acacia (*Acacia constricta*) can also be found in locally large numbers. A number of species of cholla and prickly pear (*Opuntia* spp.) as well as fishhook barrel cactus (*Ferocactus wislizenii*) and Fendler hedgehog (*Echinocereus fendleri*) are common. Larger shrub species include greasewood (*Larrea tridentata*), desert hackberry (*Celtis pallida*) and graythorn (*Zizyphus obtusifolia*). Triangle leaf bursage (*Ambrosia deltoidea*) is the most abundant small shrub over most of the terrain.

Marana/Redrock

Marana/Redrock identifies those lands south of Park Links Drive, west of the Tortolita Mountains, north of Tangerine Road and east of I-10. This area contains BLM and AST lands interspersed with private holdings that are clustered in some locations, but widely scattered in others. The region contains a number of small and large ranches with areas of private and public lands used for open range livestock grazing. Rural private residences on 3 to 40 acre parcels are increasing in number throughout the area and larger scale development pressures are occurring along the southern and eastern edges. The vegetation is characterized as Sonoran desertscrub habitat, but is generally more open in character than northwest Tucson. Saguaro and foothill paloverde are dominant and can occur in locally dense stands. Ironwood is common and can also become a dominant species in some localities while completely absent in others. A variety of cholla, prickly pear, hedgehog, and fish hook barrel cacti are representative of the understory with creosote bush increasing at lower elevations. Similar to the northwest Tucson survey area, the most abundant small shrub is triangle leaf bursage. Velvet mesquite and acacia species increase in numbers along the many smaller dry washes. Desert willow appears in the larger washes that drain the foothills to the east. Elevations within the survey locations ranged from 664 to 762 m (2180 to 2500 ft).

Picacho Peak/Suizo Mountains

The Picacho Peak /Suizo Mountains area includes mostly AST and BLM lands north of Park Links Drive west of the Suizo Mountains, east of the Picacho Mountains and south of Tom Mix Wash. It is largely open Sonoran desertscrub uplands containing large dry washes with old growth ironwood, blue paloverde and velvet mesquite along their banks. Saguaros and foothills paloverde increase away from the washes. Shrubs and ground cover species are very similar to the Marana/Redrock sites with some localized areas becoming more open with few trees and increasing densities of greasewood especially in lower elevations. Most areas have historically been used for cattle grazing and some are currently grazed. Recreational offroad vehicle use appears to be increasing along washes and two-track roads. Elevations in survey areas ranged from 561 to 823 m (1840 to 2700 ft).

Tucson Mountain Foothills East and West/Saguaro National Park

Surveys within the east and west foothills of the Tucson Mountains, the Tucson Mountain District of Saguaro National Park (SNP) and adjacent areas were conducted along roads and major washes. These areas include some state and private lands west of Sandario Road. Elevations range from 668 to 914 m (2190 to 3000 ft). SNP locations are almost entirely natural desert with few roads and some visitor and employee facilities. This Sonoran desertscrub community contains a very high density of saguaros. Velvet mesquite, foothill paloverde and ironwood are common tree species. Ironwood also occur at high densities in some localized areas. The shrub layer includes acacia, a variety of cacti, ocotillo, greasewood, hackberry and jojoba (*Simmondsia chinensis*) with triangle leaf-bursage the most frequently encountered groundcover.

Private lands adjacent to the park contain moderate to low density housing, small ranches and horse properties on 1 acre lots or larger. These properties often retain native species similar to those described above. Non-native species such as Aleppo pine and palm trees are common close to residences.

Tucson Mountain Foothills South

Regular surveys for CFPOs were conducted for the first time in this area in 1999. The area is characterized by similar topography and vegetation as the Tucson Mountains, which border this area to the north and east. The area extends as far west as Sandario Road and to Valencia Road on the south. Low density residential development (3 – 10 acre lots) dominate this area, but there are higher density developments of manufactured homes and trailers in portions of the survey area. Typical vegetation is saguaro, paloverde, and mesquite associated with triangle leaf bursage, cholla and prickly pear. There are some scattered patches of ironwoods on some of the southern and western exposures. As with other residential areas, exotic vegetation is commonly used for landscaping.

Organ Pipe Cactus National Monument

Trapping, banding and nest monitoring was conducted in the northwest region of OPNM by AGFD in cooperation with NPS biologists. The research area was along a major dry wash south of highway 86. Dense stands of mature ironwood, blue paloverde and mesquite occur along the wash banks. Saguaros, foothill paloverde and half shrubs increase away from the wash, but these areas are very open in character. Elevation ranges from 549 to 640 m (1800 to 2100 ft).Except for a few dirt roads leading to access areas and highway 85 bisecting the wash at one point, this area can be considered wilderness with minimal impact by human activities.

Santa Catalina Mountain Foothills

Three surveys were conducted in the north Tucson area. This is generally rolling hill or sloping bajada terrain at the base of the south facing slopes of the Santa Catalina Mountains with elevations ranging from 847 to 878 m (2780 to 2880 ft). It has been shaped by major washes and tributaries that drain the mountain slopes and canyons. The elevation changes, mountain views and varied habitats have created scenic qualities that attracted intensive residential development on the slopes and along the washes. While most areas contain one house per acre, there is an extensive network of roads and larger intersections that have attracted commercial development and high density housing in recent years. Despite these impacts, development within many residential areas has been designed around washes allowing the natural water courses and the associated natural vegetation to remain relatively intact. In addition, many residences have utilized native vegetation in landscaped areas. These factors have created a patchwork of connected natural areas.

The foothills are considered Sonoran desertscrub and contain many of the species and vegetation structure found in northwest Tucson. However, ironwood trees do not grow here naturally. Saguaro and foothill paloverde are dominant on the hills and slopes while velvet mesquite and acacia species increase nearer the washes. The specific survey sites were adjacent to washes that contained hackberry, desert willow (*Chilopsis linearis*) and ocotillo (*Foquieria splendens*) in addition to the species already mentioned.

Altar Valley

The Altar Valley lies southwest of Tucson and south of highway 286. It is largely defined by the Coyote, Baboquivari and Pozo Verde Mountains to the west and the Sierrita, Cerro Colorado, Las Guijas, and San Luis Mountains to the east. It joins the Avra Valley to the north near the south end of the Roskruge Mountains and Three Points, Arizona. Many large washes drain the east and west mountain ranges and empty into the Puertocito, Altar and Brawley washes which comprise the main drainage north along the valley floor. The valley is generally characterized as semidesert grassland or a mesquite grassland biotic community (Brown 1994). However, Sonoran desertscrub habitat characterizes many of the foothill areas in the Altar Valley. These desertscrub habitats are generally have less dense vegetation and fewer saguaros than areas of desertscrub farther north. A number of medium and large ranch operations are actively grazing cattle in many areas.

Buenos Aires National Wildlife Refuge

BANWR covers approximately 45,540 ha and is located in the southern half of the Altar Valley. It encompasses much of the bottomland areas with some upland locations. Elevations range from 925 to 1400 m (3034 to 4593 ft), but most of the refuge occurs between 950 to 1100 m (3116 to 3608 ft) (McLaughlin 1992). As with other areas in the Altar Valley where pygmy-owls have been located, the drainages on the Refuge contain mesquites, hackberry and ash trees, while the uplands lack large trees and are dominated by grasses, low shrubs and scattered mesquites. Cattle grazing ended on these lands when the refuge was created in 1985. Controlled burns are used to control invading mesquite and other shrub species while helping to restore native grasses.

METHODS

Survey Overview

Surveys to locate pygmy-owls and identify use areas in 1999 were conducted from the courtship period (January), through post-dispersal (August). Most surveys were conducted by a field biologist walking along transect routes of varying length with multiple calling stations at specific intervals. Occasionally, "spot surveys" using one or two call points at specific locations were also used to attempt location of previously detected or suspected owls. Survey transect routes followed existing public roads, utility rights of way servicing private residential properties, along washes and unpaved access roads on federal and state lands and on private properties when land owners granted permission for access.

Survey Protocol and Equipment

Population surveys were conducted using the formal protocol developed in 1993 (Felly and Corman 1993) and revised by AGFD in 1996 (Abbate et al. 1999). We also used an informal approach (modification of the formal survey protocol) tailored to specific sites where pygmy-owl nesting or other activities had been detected during previous breeding seasons. If the informal approach was unsuccessful during the initial survey for the current year, additional formal protocol surveys were conducted during subsequent visits. Both survey techniques were employed primarily during high activity periods; one hour before sunrise until two hours after sunrise and two hours before sunset until one hour after sunset.

A survey consisted of broadcasting a taped male pygmy-owl territorial call and then listening for a response. Taped calls were broadcast using a Johnny Stewart Game Caller (Model MS - 240) , a portable cassette player, or a portable cassette player connected to an amplified speaker (Radio Shack Power Horn). Less frequently, a surveyor may choose to imitate a call by whistling instead of using a broadcast tape. The sequence is repeated for up to 10 minutes and a final listening period up to five minutes completes the calling station. The surveyor then moves to the next calling station and begins the sequence again. If a pygmy-owl responds to the broadcast by vocalizing or flying in view of the surveyor, the broadcast sequence is ended immediately and observations are recorded. Surveys were documented on Population Survey Forms (Abbate et al. 1999). The first detections of pygmy-owls for the current survey year were recorded on Initial Detection Forms (Abbate et al. 1999) and all detection locations were plotted on 7.5 minute USGS topographical quadrangle maps.

Strong mobbing behavior by small birds may also indicate the presence of a pygmy-owl. If mobbing was observed, broadcasting was ceased until the area was inspected. When possible, visual confirmation and the exact location of a calling pygmy-owl is attempted by walking in the direction of the call for closer examination of potential perches and birds in the area. Additional broadcasts may be used to help locate pygmy-owls that are well hidden or when they cease calling. The distance between calling stations ranged from 100 m in areas where pygmy-owls were previously detected to 400 m along new survey routes. Length of survey routes ranged from a single call point to over 4 km with most being less than 2 km. We estimated the area of calling coverage for each survey by multiplying number of call points by the area covered at each point. Area covered at each call point was calculated by using a radius equal to one-half the distance between call points.

Detection Defined

Detection of a pygmy-owl is defined as a confirmed aural or visual observation of one or more individuals during a formal protocol survey, a monitoring visit, or an observation by a resident that has demonstrated identification skills. A detection is considered confirmed when: a) a pygmy-owl is seen and positively identified by an experienced surveyor, b) territorial calling is vigorous with at least one calling sequence of 10 notes or two or more sequences of at least 5 notes, and c) a second experienced observer is able to confirm the detection. Locations with suspected, but unconfirmed pygmy-owl presence were revisited at later times to attempt confirmation. Additional visits may include tape broadcast surveys or stop and listen surveys at one specific location or along a survey route. Repeated visits of detection locations to monitor occupancy, nesting status and to conduct other research activities resulted in multiple detections of the same individual, pair or offspring. Therefore, the total number of detections does not represent the number of individual pygmy-owls within the study area.

Detection Site Monitoring

Once an individual or pair of pygmy-owls was detected, the site was generally visited at 5 to 10 day intervals to monitor movements, behavior and nesting status during the early part of the breeding season. Detection site monitoring included listening for spontaneous calling during morning or evening high activity periods and at times, conducting a limited (5 - 15 minute) tape-broadcast survey when no activity was observed during the listening period (5 - 30 minutes). Similar to initial surveys, we attempted to identify exact locations of calling pygmy-owls and document vegetation or structures being used by walking in the direction of the vocalizations. These searches continued unless private property boundaries were encountered or the pygmy-owl flew off repeatedly during several approaches. If permission to access the private property was secured and the detected pygmy-owl remained in one area, we resumed our search until the location could be confirmed. Monitoring visits continued until we were unable to obtain additional detections and extended surveys in adjacent areas were unsuccessful. When a pygmy-owl was not detected after multiple visits and searches, we assumed it moved away from the area or was simply unresponsive. All observations were recorded on Post-Detection Site/Territory Visit Forms (Abbate et al. 1999). If breeding activity was observed or a nest site was confirmed, we began intensive monitoring and attempted to make at least 1 or more visits each week.

Nest Site and Productivity Monitoring

Confirmation of nesting and identification of nest site locations were obtained through intensive searches, regular observations and cavity inspections. Nest searches began shortly after behavioral observations indicated a pair of pygmy-owls was present. Documentation of pygmy-owls repeatedly visiting the same site, delivering prey to a cavity, or prolonged use of a cavity by the female were considered indicators of nesting.

Cavity inspections were also used by AGFD for the first time to confirm nest site locations, clutch size and hatching efficiency. Several individual cavity inspections were conducted using a remote miniature 9 volt camera mounted on a telescoping aluminum pole (Wilco Precision Inc., Morris, MN) connected to an 8 mm video camera recorder (Model CCD-FX510, Sony Corp.). Most inspections however, were conducted by Glenn Proudfoot (Texas A&M University) by climbing a 7.3 m aluminum ladder and using a hand held fiberoptic scope (Model FS-490) with illuminator (Model 1188, Schott Fiber Optics, Inc., Southbridge, Mass.).

Intensive nest monitoring was begun after a nest cavity was identified. Nest monitoring was usually conducted by one or two observers from distances between 30 and 80 meters from the nest saguaro or tree. Binoculars and spotting scopes (15 - 60 power) were used from observation points located to provide a direct frontal or side view of the nest cavity opening. No blinds were used, but natural vegetation or other structures sometimes produced partial concealment during observation sessions. We documented specific adult and juvenile behaviors and interactions, prey deliveries, potential predators, nest productivity, vocalizations, use of structures and vegetation, reactions to disturbance and nesting chronologies. Observations were recorded on Post-Detection Site/Territory Visit Forms, Nest Site Monitoring and Observation Forms and Nest Site Prey Delivery Log and Summary Forms (Abbate et al. 1999).

Minimizing Survey and Monitoring Impacts

In order to reduce possible negative impacts from repetitive surveys at known pygmy-owl locations, we limited the use of tape broadcasts mostly to initial surveys and early monitoring efforts to identify use areas and nesting status. When a pygmy-owl detection occurred during a survey session, tape broadcasts were ended immediately unless the location was undetermined. Once a location estimate was determined, broadcasts were stopped. Follow-up monitoring visits emphasized stop and listen surveys during high activity periods. When a pair of owls or a nest site was discovered, tape broadcasts were no longer used within that territory, or were used on a very limited basis. Most monitoring efforts at nest sites were conducted by listening, through direct observation, or use of radio telemetry. Any time research activities caused noticeable agitation in the owls, we ceased conducting that activity and increased our distance from the owls. We also provided regular reports of survey locations and results to the USFWS Ecological Services Office and supported USFWS coordination of survey efforts by agency and private surveyors to eliminate field work duplication and reduce excessive survey impacts to specific areas.

Capture Techniques and Color Banding

We attempted to capture adult and juvenile pygmy-owls using a baited bow net, mist nets or hand net. Prior to fledging, we assisted Glenn Proudfoot (Texas A&M University) in climbing to the nest cavity entrance and extracting nestlings while viewing the cavity interior with a scope. This initial capture method enabled us to band and measure all nestlings without risk of losing them in desert vegetation during or after fledging, or missing a capture due to advance flight skills. Select young of the year were captured by hand after fledging for radio-marking. The bow net (Skach, Willowbrook, Ill.) is constructed with a metal rod (40 x 45 cm) frame and covered with a cotton netting. The top and bottom mesh size was 19 and 30 mm respectively. The bow was activated by a tripline trigger across the frame width and a central spring hinge closed the net. Once a pygmy-owl was located, one worker slowly approached and placed the trap within 15 m and in an unobstructed location. The trap was baited with a live tethered house sparrow.

A second capture method erected from one to three mist nets between favored trees or smaller trees with a suitable location and structure for trapping. We trapped most often using a taped broadcast of a pygmy-owl and without the use of lures or live prey. However, sometimes a pygmy-owl sized, plastic owl or captured fledgling along with a broadcast of various pygmy-owl vocalizations were used to entice an adult pygmy-owl into the net. During one trap outing we were able to use a live, tethered great-horned owl near a captured fledgling. While standing close to the net with the large owl and near the fledgling pygmy-owl, we were able to invoke a defensive response from the adult pygmy-owls for a successful capture.

Pygmy-owls were usually captured in the net when flying between perches, investigating inadvertently entangled song birds, investigating or attacking the plastic owl or attempting to defend young. Mist nets were 5.5 and 9.1 m in length with 5 cm^2 mesh size. Most fledglings were captured directly by hand soon after leaving the nest cavity, but a 36 cm diameter hand net (5 cm^2 mesh) attached to a telescoping pole was used to capture a few that were harder to reach.

All captured pygmy-owls were marked with USFWS aluminum bands on the left leg and anodized aluminum color bands (ACRAFT, Alberta, Canada) engraved with a letter or number character on the right. Color bands were modified with a hand file and sand paper to reduce width and smooth sharp edges for improved fit. Rivets were used to secure the color band. Using binoculars and spotting scopes, color bands can readily identify previously encountered pygmy-owls, indicate their age and origin, and reduce time and labor for recaptures while minimizing potential stress on captured individuals.

Radio Marking and Telemetry

Backpack-style 9 volt 1.85 gram radio transmitters (Model BD-2G, Holohil Systems Ltd., Carp, Ontario, Canada) were used to mark one or two juvenile pygmy-owls captured from each nest in 1999 to investigate habitat use, monitor movements during the breeding season, identify when dispersal occurs and monitor the directions, distances, and use areas during dispersal. Three adult male pygmy-owls were also radio-marked in an attempt to monitor their movements during the breeding season and to help determine the size of area used during this period. Radio-marked individuals were monitored using portable radio receivers (Model TR-2 receiver, Telonics, Inc., Mesa AZ, Model TRX-2000S receiver, Model F148/3FB Antenna, Wildlife Materials, Inc., Carbondale, Ill). We also mounted a magnetic CB antenna (Model 21-972, Radioshack) to the roof of a vehicle and attached it to a receiver using an RF adapter (Model 278-120, Radioshack) inside the vehicle, when long distance pygmy-owl movements required searches by vehicle. Once a strong signal was received, we resumed searching with directional antennas on foot. We attempted to locate marked pygmy-owls almost daily until the transmitters no longer worked due tracking sessions. All post-dispersal relocations and observations were recorded on Radio-Marked Owl Detection/Location Forms (Abbate et al. 1999).

Prior to dispersal, radio-marked juveniles were easily tracked on foot. Vehicles were used when we could not pick up a signal from the ground and dispersing individuals were moving long distances. After receiving an initial radio signal, we used compass bearings from known locations to estimate the pygmy-owl's direction and distance. When possible, we attempted to get visual confirmation of the location and identify the vegetation or structures being used. When ground searches were unsuccessful, we used an AGFD fixed wing aircraft (single-engine Cessna) equipped with a belly-mounted 2 element Yagi antenna connected to a receiver (Telonics scanner) for aerial locations. All known and estimated locations were recorded on USGS 7.5 minute topographical maps using triangulation, pacing, known visual locations or hand held Global Positioning System units (Geoexplorer II, Model 17319, Trimble). Universal Transverse Mercator (UTM) coordinates were determined and recorded for each location.

RESULTS

Survey Effort

Pygmy-owl population surveys were conducted by AGFD during the breeding season from 4 January to 23 June 1999. We completed 116 surveys during 58 field days. Fifteen routes and associated call points were surveyed more than once. These are included in the distance, call point and coverage totals. Survey efforts by month are summarized in Table 1. A total of 655 call points covering a distance of 153 km (95 mi.) were surveyed in 1999. We estimated calling coverage at approximately 2900 ha. (7366 ac.). Table 2 summarizes survey effort by area. Seventy-four (63 percent) of the surveys were conducted during the early morning activity period (1 hour before sunrise to 2 hours after sunrise) and 34 (29 percent) were completed during the evening activity period (2 hours before sunset to 1 hour after sunset). While detection locations by other agencies and biologists contracted by the USFWS were investigated and monitored by AGFD, initial population surveys by workers outside AGFD are not summarized in this report.

Detections

Population survey efforts by AGFD using tape broadcast and look and listen type surveys resulted in 21 initial detections from 4 January to 23 June 1999. Eighteen were territorial males calling in response to a tape broadcast or calling spontaneously during the surveyor's visit. Two females were detected in the vicinity of their mates calling in response to the tape broadcast or reacting to the male's response. One detection appeared to be a female using the one-pitch territorial call and other sounds, but this was not confirmed. Three additional detections were reported, but could not be confirmed and are not included in our total. A detection is classified as unconfirmed when reported by an inexperienced surveyor, and attempts by experienced surveyors to locate an owl during follow-up visits are unsuccessful. Initial detections of the year are distinguished from those documented during a territory monitoring visit which are considered separately.

Ten detections were from eight known territories. Five of these territories contained successful nesting pairs in previous years. Three other territories were established by dispersing juveniles at the end of the 1998 breeding season. The remaining eleven detections are considered separate territories and were located for the first time during 1999. We defined a territory as an area that is defended through territorial calling or aggressive behavior by a resident individual or pair of pygmy-owls for at least a two week period. This defensive behavior may occur spontaneously during a surveyor's monitoring visits or the response may be elicited by a surveyor's whistle or taped broadcast that imitates an intruder.
Follow-up-visits in response to owl reports by other agencies and contract biologists resulted in confirmation of 12 additional detections. These included 7 territorial males responding to tape broadcasts. Five of these males were eventually found to be paired with females after multiple monitoring visits and capture attempts. Two additional detections were reported by experienced surveyors and though not confirmed by AGFD, are considered reliable. AGFD confirmed a total of 35 initial detections of pygmy-owls during 1999.

Territory Occupation

AGFD survey and monitoring efforts in 1999 resulted in confirmation of 25 occupied territories prior to dispersal of young (Table 3). Territory occupation was confirmed when a nest was identified, a pygmy-owl was detected while conducting at least 2 surveys or monitoring visits in the same area, or a pygmy-owl was captured when defending its territory in response to a taped broadcast. In cooperation with US Fish and Wildlife Service contract biologists and National Park Service biologists at OPNM, we located 11 active pygmy-owl nests. Five other territories were believed occupied by unpaired males due to sustained and vigorous territorial calling throughout the nesting season and multiple attempts to locate a female were unsuccessful. We suspected nesting may have occurred at two territories in OPNM due to behavioral observations and vocalizations, but these were not confirmed. The nesting status of the four remaining territories was also unknown. After dispersal of young, we identified three newly occupied territories defended by pygmy-owls that were tracked using radio telemetry (see Radio-Marking, Telemetry and Dispersal). We recognized 28 total territories when pre and post-dispersal sites are combined (Table 3).

Table 1. CFPO breeding season population survey effort by month in Pima and Pinal Counties, Arizona, 1999.

Month	Hours	Days	Routes	Points	Distance Km	Coverage ha.	Initial Detections
January	4.25	5	10	12	1.9 km	52.5	4
February	18.75	11	14	94	23.6 km	411.2	1
March	31.25	15	26	90	22.9 km	393.7	5
April	40.25	11	26	159	39.3 km	695.5	1
May	58.25	12	29	275	57.2 km	1202.9	3
June	7.00	4	11	31	8.0 km	135.6	7
Totals	159.75	58	116	661	152.9	2891.4	21

Table 2. CFPO breeding season population survey effort by area in Pima and Pinal Counties, Arizona, 1999. NWT = Northwest Tucson, PP/SM = Picacho Peak/Suizo Mountains, TMF(S) = Tucson Mountain Foothills South, TMF/SNP = Tucson Mountain Foothills/Saguaro National Park, M/R = Marana/Redrock, AV = Altar Valley, SCMF = Santa Catalina Mountain Foothills, TMF(E) = Tucson Mountain Foothills East, ET = East Tucson

Survey Area	Hours	Days	Routes	Points	Distance km	Coverage Ha	Detections
NWT	49.50	27	42	175	34.55	309.2	8
PP/SM	34.25	16	22	117	35.70	1470.3	0
TMF(S)	26.00	11	13	114	35.80	201.4	0
TMF/SNP	24.50	10	12	170	29.90	300.4	0
M/R	14.00	10	11	34	10.90	427.3	3
AV	2.75	3	9	9	0.00	113.1	10
SCMF	5.25	3	4	33	6.20	58.3	0
TMF(E)	2.50	2	2	5	2.00	8.8	0
ET	1.00	1	1	4	0.80	7.1	0
Totals	159.75	83	116	661	155.85	2895.9*	21

*Total coverage does not equal total coverage in Table 1 because an average distance between call points was used in Table 1 rather than the actual distance between call points. This was necessary because survey protocol dictates using 150 m call points in some areas and 400 m call points in others.

Table 3. CFPO occupation history of known territories in Pima County, Arizona, 1993-1999.[a]
1 = occupation confirmed, 0 = occupation not detected, male = unpaired male, nest = nesting confirmed, pair = 2 birds observed-nesting status unknown, unk - unknown sex, 2 = late occupation by dispersing juvenile, und = nesting status undetermined, ----- = no survey completed

Site	1993	1994	1995	1996	1997	1998	1999	Total Yrs Checked	Total Yrs Occupied
93SN	1 - male	1 - male	1 - male	1 - male	0	2 - male[b]	1 – nest	7	5
94CM	-----	1 - male	1 - male	1 - male	0	0	0	6	3
95S	-----	-----	1 - nest	1 - male	0	0	0	5	2
95B	-----	-----	1 - male	0	1- nest	1 - nest	1 – nest	5	4
96T	-----	-----	0	1 - nest	1- male	1 - male	1 – nest	5	4
96L	-----	-----	0	1 - male	2 - male	1 - nest	0	4	2
96SB	-----	-----	-----	1 - pair	1 - male	0	0	4	2
98DM	-----	-----	0	0	-----	1 - nest	1 – nest	4	2
98SR	-----	-----	-----	-----	-----	2 - male	1 – nest	2	2
98CC	-----	-----	-----	-----	-----	2 - unk	2 – unk	2	2
98CF	-----	-----	-----	-----	-----	2 - male	1 – male	2	2
99GR	-----	-----	1 - male	0	0	0	2 - male	5	2
99LB	-----	-----	-----	-----	-----	0	2 - male	2	1
98GW	-----	-----	-----	-----	-----	1 - male	1 – nest	2	2
98PW	-----	-----	-----	-----	-----	1 - male	1 – nest	2	2
99SJW	-----	-----	-----	-----	-----	-----	1 – male	1	1

Table 3. CFPO occupation history (continued).

99SJE	-----	-----	-----	-----	-----	-----	1 – male	1	1
99CP	-----	-----	-----	-----	-----	-----	1 – male	1	1
99CT	-----	-----	-----	-----	-----	-----	1 – nest	1	1
99SLW	-----	-----	-----	-----	-----	-----	1 – nest	1	1
99RDO	-----	-----	-----	-----	-----	-----	1 – nest	1	1
99KE	-----	-----	-----	-----	-----	-----	1 – male	1	1
99KM	-----	-----	-----	-----	-----	-----	1 – male	1	1
99KW	-----	-----	-----	-----	-----	-----	1 – nest	1	1
99MWS	-----	-----	-----	-----	-----	-----	1 – und	1	1
99MWM	-----	-----	-----	-----	-----	-----	1 – und	1	1
99MWN	-----	-----	-----	-----	-----	-----	1 – und	1	1
99MWE	-----	-----	-----	-----	-----	-----	1 – und	1	1
99MWNW	-----	-----	-----	-----	-----	-----	1 – und	1	1
99MWNE	-----	-----	-----	-----	-----	-----	1 – und	1	1
99IT	-----	-----	-----	-----	-----	-----	1 – und	1	1

[a] Occupation histories are based on present understanding of territory boundaries. Future observations may change territory sizes and occupation records. A territory is considered occupied when a pygmy-owl is detected in the same area on at least two different occasions or strong territorial defense through vocalizations and behavior is observed.

[b] This territory appeared unoccupied during regular breeding season surveys, but a dispersing juvenile arrived and remained within the territory in August.

Nest Productivity and Known Number of Pygmy-Owls in Pima and Pinal Counties

Eleven pygmy-owl nests were located and closely monitored by AGFD in Pima and Pinal counties during 1999. All eleven nests were successful in fledging at least 2 young, but one nest failed after its young fledged (see Mortalities). A total of 32 young successfully fledged from all nests combined. Fecundity (mean number of young fledged per nest site) for all sites was 2.90. When we determined productivity within each study area (Marana/Redrock, Altar Valley and Northwest Tucson), fecundity was 2.50, 2.75 and 4.00 respectively. Productivity from one nest in Organ Pipe National Monument was unknown. The known number of young surviving through dispersal for all sites was 16 (dispersal efficiency = 50 percent). Table 4 summarizes productivity by area.

AGFD population surveys, nest monitoring and general observations of pygmy-owl paired adults, surviving offspring and unpaired adults, resulted in confirmation of 55 individual pygmy-owls in Pima and Pinal counties, Arizona during 1999. These included 15 young of undetermined sex, 1 confirmed female offspring, 11 nesting females, 11 nesting males, 7 males that appeared unpaired, 9 males with unknown status and 1 adult with undetermined sex and nesting status.

Table 4. CFPO nest productivity by area in Pima and Pinal Counties, Arizona 1999.
M/R = Marana/Redrock, AV = Altar Valley, NWT = Northwest Tucson, OPNM = Organ Pipe National Monument, unk = unknown.

Area	Total Nests	Total Fledged	Fecundity
M/R	2	5	2.50
AV	4	11	2.75
NWT	4	16	4.00
OPNM	1	unk	unk
Totals	11	32	2.90

Mortality and Predation

We were able to detect mortality of both adult and juvenile pygmy-owls during 1999. Two adult mortalities were confirmed and a third was suspected. Eleven juvenile mortalities were documented and all occurred close to or after fledging. Radio-marked juveniles monitored during post-dispersal had no documented mortality during the time we were able to locate them. Table 5 summarizes known mortality by territory.

Adults. One paired, radio-marked male was found dead next to a woven wire fence. When examined, this adult was in full tail molt. No visible external wounds were observed and it appears the owl collided with the fence and broke its neck. It is possible that it was pursuing prey and hit the fence due to diminished maneuverability without its tail feathers.

A second adult mortality was documented when a breeding female was found dead in the tree containing the nest cavity. The owl had been dead for several days and we suspect it may have been killed by another raptor, but this was not confirmed. The carcass was generally intact and may have been cached. This female successfully hatched offspring, which were still alive at the time it was killed.

A third adult mortality is suspected, but also unconfirmed. We arrived at a nest site to band young that we estimated were old enough to have recently fledged. However, we were unable to locate any young or the adult female. The adult male was in the area, but he was vocalizing in a manner consistent with an unpaired male. Earlier visits documented a pair of ravens nesting in the area and it is suggested that the vulnerable young and the defending female fell prey to the ravens (T. Tibbitts - personal communication).

Juveniles. A total of 11 offspring were confirmed dead or were missing shortly after fledging and therefore presumed dead. One recent fledgling appears to have been the victim of avian predation. While monitoring this transmittered juvenile, we were unable to pick up the signal at the nest site only 10 days after it had fledged. Searching the general area, we were able to locate the signal and found the transmitter approximately one mile from the nest site. The transmitter was sitting on top of a saguaro with a few feather remains, but no owl carcass was recovered. A pair of red-tailed hawks (*Buteo jamaicensis*) was defensive on approach in this same area and we suspect one of the hawks killed the pygmy-owl. Raptors generally take prey to a preferred perch to pluck and eat it. The location of this transmitter on top of a saguaro is consistent with this type of behavior.

All three juveniles from another nest site perished within a few days of each other, probably due to natural causes. The arm of the saguaro where the nest cavity was located broke off during a windstorm. One young was found dead on the ground near the broken arm. The other two were located in a nearby tree and appeared to be uninjured. We captured and banded these two young and placed a transmitter on one. While attempting to relocate them two days later, we found both young dead, inside a pack rat midden. The carcasses were submitted for necropsy, which indicated they had died from blunt force trauma. It is possible that these owls ultimately succumbed to injuries sustained from a fall when the saguaro arm broke, but necropsy notes indicated the injuries were sustained the day of death. The ultimate cause of death remains unclear.

A fifth fledgling was found dead near its nest in the Altar Valley. We were unable to document the cause of this juvenile's mortality. The remaining 6 young disappeared shortly after fledging and were never found again despite multiple searches and close monitoring of adults during prey deliveries and feeding.

Trapping and Banding

We captured and banded 27 individual adults and 32 offspring during 1999. Twenty-one adults were encountered for the first time and 6 were recaptures of pygmy-owls that were first captured as fledglings in 1998. Twenty-six of the captured adults are known or believed to have survived through dispersal of young while only 16 juveniles survived through dispersal. Appendices 1 and 2 summarize adult and juvenile capture and banding information.

Table 5. Productivity, dispersal and mortality for individual CFPO nests in Pima and Pinal Counties, Arizona, 1999. M/R = Marana/Redrock, NWT = Northwest Tucson, AV = Altar Valley, OPNM = Organ Pipe National Monument, unk = unknown.

Territory	Area	Fledge Date	Number Fledged	Number Dispersed	Known Mortalities
98GW	M/R	28 May	3	3	0
98PW	M/R	17 June	2	0	3
95BR	NWT	26 May	5	4	1
96TL	NWT	2 June	3	2	1
98DM	NWT	29 May	4	1	3
98SR	NWT	12 June	4	3	1
99CT	AV	12-13 June	3	unk	unk
99SLW	AV	23 July	2	2	0
99AW	AV	7-9 July	2	1	1
99RDO	AV	11-14 June	4	unk	1
99KW	OPNM	unk	unk	unk	unk
TOTALS	11 nests	26 May - 23 July	32	16[a]	11[b]

[a] The number of young that dispersed from their natal area is probably higher, but we only reported the number that we could confirm.

[b] We suspect mortality at nest site 99KW occurred and that the nest failed, but this was not confirmed. The fate of young at nest site 99CT was also undetermined.

Incest

While monitoring a male juvenile that was radio-marked after fledging in 1998, we documented territory establishment in the fall of the same year. Monitoring efforts in the same area during spring of 1999 indicated that this male had paired with a female and nesting activity was in progress. Observation of the color band on the female owl revealed that she was the sibling of the male with which she was paired. This becomes even more significant when we consider these two owls were the offspring of another incestuous pair that were siblings from a 1998 nest.

Radio-Marking, Telemetry and Dispersal

Eleven juveniles from eight different nests were equipped with backpack style radio transmitters during 1999. Working transmitters allowed us to locate the carcass of one juvenile and a few feather remains near another radio, after each pygmy-owl had died from predation or other natural causes (see Mortality). We believe a third juvenile was killed by a predator, but the transmitter stopped working after only a few days and was never relocated. A fourth radio-marked bird was also lost after the transmitter stopped working within one week of marking. We were able to follow two other juveniles with the aid of aerial flight surveys, but both were lost when they moved out of detection range or radios failed after only five post-dispersal locations. These are included in the review of juvenile dispersal below. In all, we were able to follow the dispersal movements of a total of eight radio-marked juveniles during 5 to 41 radio-tracking days. The known total dispersal distances ranged from 3.10 to 39.24 km (1.93 to 24.40 mi). The mean total dispersal distance was 18.34 km (11.4 mi). We believe five of the eight radio-marked juveniles were tracked from their natal areas until reaching new territories where they were detected repeatedly. The total direct linear dispersal distance for these juveniles ranged from 2.5 to 20.91 km (1.55 to 13.00 mi). Limited movement locations were obtained when radio transmissions ceased or were out of range, before the remaining three juveniles could be detected on new territories. Figures 3 and 4 show the dispersal routes for monitored juveniles.

Juvenile Dispersal. Juvenile 1 from nest 99GW, dispersed 61 days post-fledge on 28 July 1999. Our first relocation was 1.77 km (1.1 mi) southwest at bearing 212 degrees from its nest location. We tracked this pygmy-owl over 41 days and recorded a total known distance traveled of 39.24 km (24.40 mi). From 10 August to 23 September 1999, this dispersing juvenile remained in one general area where it was recaptured and outfitted with a new radio. It then continued dispersing until arriving at its new territory where it was found paired with a resident male. The last radio-detection for this pygmy-owl was 27 September. Its direct linear dispersal distance was 20.91 km (13.00 mi) at bearing 161 degrees southeast from where it fledged. It was last detected when it vocalized in December 1999 from the same area.

Juvenile 2 from nest 98DM began dispersing between 27 to 30 July 1999. Its first dispersal movement was detected 62 days post-fledge on 30 July 1999. The first relocation was 3.00 km (1.84 mi) east at bearing 64 degrees from its nest location. We tracked Juvenile 2 for 39 days and recorded a total distance traveled of 17.61 km (10.95 mi). From 1 August to 25 September this juvenile remained in one general area where its longest movement was 0.80 km (0.5 mi). It was recaptured on 15 September and outfitted with a new radio. The last radio location was on 27 September 1999. Its direct linear dispersal distance was 5.05 km (3.14 mi) east at bearing 90 degrees from where it fledged.

Juvenile 3 from nest 98SR began dispersing on 31 July 1999 at 49 days post-fledge. Its initial dispersal movement was 1.81 km (1.13 mi) at bearing 10 degrees north from where it fledged. The total distance traveled was 30.05 km (18.68 mi) during 17 days of tracking. The last radio location was on 21 August 1999. Juvenile 3 direct linear dispersal distance from its nest site to a new territory was 9.89 km (6.15 mi) at bearing 158 degrees south.

Juvenile 4 and 5 from nest 95BR dispersed between 22 and 30 July 1999 at 57 to 65 days post-fledge. Our first radio location for juvenile 4 was on 30 July at a distance of 2.42 km (1.51 mi) at bearing 73 degrees east. We tracked juvenile 4 over 17 days and attempted to recapture it for a new radio without success. However, we confirmed this pygmy-owl in the general area of its last radio location for an extended time when it vocalized during a number of visits and trap attempts. The total known distance traveled was 3.10 km (1.93 mi). The direct linear dispersal distance to it last detection area was 2.50 km (1.55 mi) at bearing 71 degrees northeast.

The first radio location for juvenile 5 during dispersal was also on 30 July 1999 at a distance of 9.42 km (5.86 mi) and a bearing of 27 degrees north. We tracked juvenile 5 for 33 days. It dispersed a total distance of 18.11 km (11.26 mi). The last radio detection for this pygmy-owl was on 29 September 1999. The direct linear dispersal distance from its fledge location was 8.52 km (5.3 mi) at bearing 25 degrees north.

Juvenile 6 from nest 96TL dispersed between 22 and 27 July 1999 at 50 to 55 days post-fledge. The first radio location was on 3 August during a morning aerial survey and confirmed from a ground survey that evening. We were unable to locate this juvenile for several days until the aerial survey was completed. Initial dispersal distance based on our first radio detection was 11.00 km (6.85 mi) at 337 degrees north of the nest location. This juvenile was tracked for a total of 6 days until its signal was lost and relocation attempts were unsuccessful. The total dispersal distance we were able to observe was 15.84 km (9.85 mi). The direct linear dispersal distance from the fledge location to the last radio location was 15.2 km (9.45 mi) at a bearing of 71 degrees east.

Juvenile 7 from nest 99SLW dispersed on 9 September 1999 at 48 days post-fledge. The initial dispersal distance was 1.12 km (0.7 mi). We were able to track this juvenile for 3 days and then lost its signal. After ground searches proved unsuccessful in relocation, an aerial survey was conducted on 13 September. One additional ground radio location was made after several days of searching. We lost the signal again after a visual detection on the fifth tracking day. We suspect the transmitter battery was no longer functioning at this time. The total dispersal distance we were able to observe was 10.08 km (6.27 mi). The direct linear distance from the nest site to the last radio location was 7.00 km (4.35 mi) bearing 114 degrees southeast.

Juvenile 8 was also from nest 99SLW, but dispersed between 4 and 7 September 1999 at 43 to 46 days post-fledge. The initial dispersal distance based on our first radio location was 2.41 km (1.5 mi) at bearing 314 degrees from the nest. We tracked this juvenile for 3 days and then lost the signal. An aerial survey on 13 September relocated juvenile 8 and we were able to track its movements for 2 more days (6 total days) before its signal was lost again. As with juvenile 7, we suspect the transmitter battery had stopped functioning. The total dispersal distance from the nest site to the last radio location was 12.70 km (7.89 mi). The direct linear distance from the nest site to the final radio location was 10.24 km (6.37 mi) bearing 327 degrees northwest.

Adult Telemetry. Three adult males were radio-marked with the same model transmitters used on juveniles. We tracked adult movements to monitor general activities, interactions with juveniles and females, identify specific structures utilized during their daily routine, identify general use areas during the breeding season, and to estimate the size of the area used. Two of these adults were paired and produced fledglings during 1999, and were from the northwest Tucson area. The third adult was an unpaired male from the Altar Valley. Both paired males were radio-marked after young of the year had fledged and were from nests where one juvenile was also radio-marked.

Adult 1 from nest 95BR was initially radio-marked on 27 May 1999. This individual was recaptured and equipped with a second radio only 45 days later, when we discovered the harness was coming apart and allowing the radio to move out of proper position. We monitored its movements during 35 days and 38 radio-tracking sessions. This male was initially radio-marked one day after young had fledged and we continued tracking through 10 days post dispersal, until it was confirmed dead on 5 August 1999 (see Mortality). All radio locations during the tracking period were within 200 m (656 ft) of the nest saguaro.

Adult 2 from nest 98SR was radio-marked on 17 June 1999. Radio-tracking began 5 days after young had fledged and continued 38 days post dispersal of young, ending 8 September when transmitter battery stopped working. We tracked this male pygmy-owl during 33 days and 34 tracking sessions. All locations documented during this tracking period were within 400 m (1312 ft) of the nest saguaro and the greatest linear distance between locations was 700 m (2296 ft).

Adult 3 from territory 99CP was captured and radio-marked on 31 May 1999. We tracked this individual's movements during 15 field days and 19 tracking sessions. The last location was on 12 September 1999. During our tracking sessions, this male was found within 500 m (1640 ft) of a large saguaro that he appeared to defend and from which it advertised. He used several cavities in this saguaro while vocalizing and escaping from our approach. The greatest linear distance between two radio- locations during this period was 600 m. However, we documented a location for this male prior to radio-marking that was approximately 1 km (0.62 mi) from the saguaro it defended later in the season.

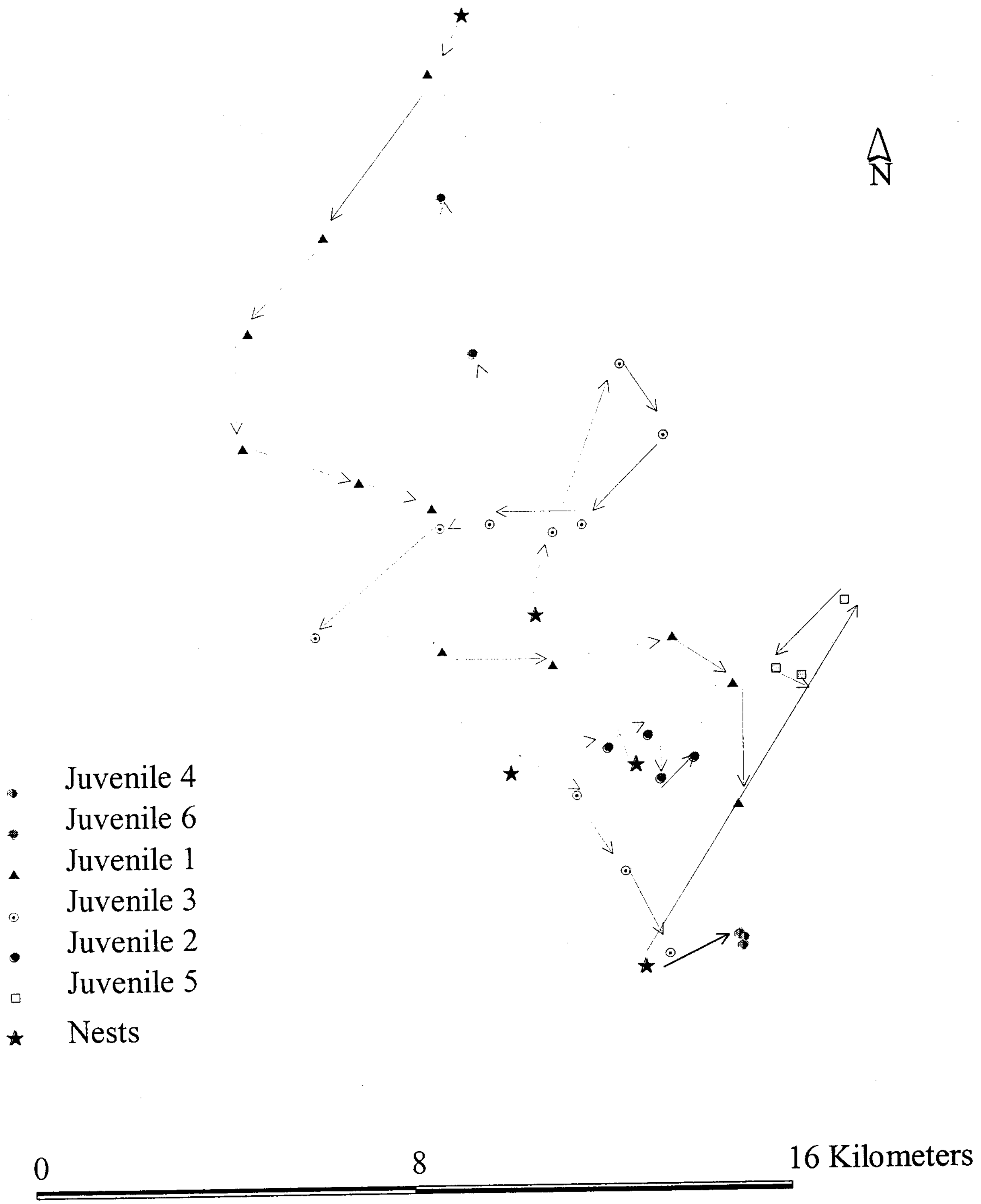


Figure 3. Dispersal routes of radio-marked juvenile pygmy-owls in northwest Tucson and Marana/Redrock areas of Pima and Pinal Counties, Arizona, 1999.

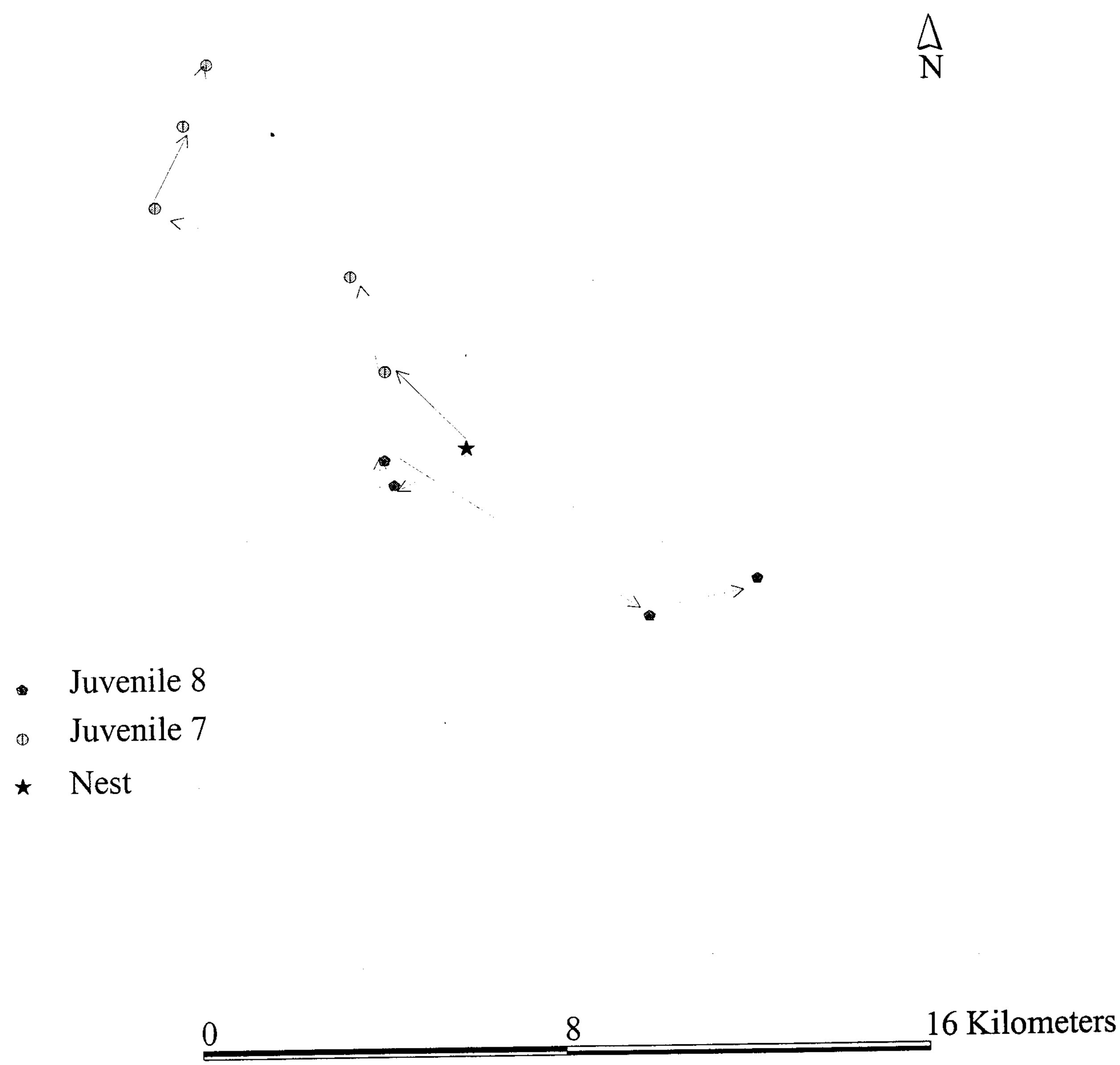


Figure 4. Dispersal routes of radio-marked juvenile pygmy-owls in the Altar Valley area of Pima County, Arizona, 1999.

DISCUSSION AND CONCLUSIONS

Survey Effort, Detections and Monitoring

Population survey efforts by AGFD during 1999 were focused in areas where owls were detected in previous years, near locations where residents reported possible pygmy-owl activity and in areas that contained suitable habitat, but were not surveyed in previous years. Surveys and monitoring by contract biologists with USFWS and Bureau of Land Management, volunteers with AGFD and short-term assistance by Phoenix-based AGFD biologists, permitted project researchers to field check more resident reports, survey new areas and increase monitoring and radio-tracking efforts that were not possible in previous years with fewer field workers.

Unsuccessful Relocation Attempts. Several pygmy-owls were observed or detected by both experienced contract biologists and AGFD project biologists during surveys, but were detected only once. Multiple return visits to the areas of detection were unsuccessful in locating them again. In addition, one nest territory that was successful in producing young in 1998, appeared vacant this season. We know that pygmy-owls from established territories have high site fidelity (G. Proudfoot - personal communication and Abbate et al. 1999). However, it appears that some pygmy-owls in the known population are still moving between areas well into the breeding season and do not defend territories, while some established pairs may become difficult to detect, or are more vulnerable to predation than we previously suspected.

Altar Valley. Fourteen new territories that included at least 4 nest sites were documented in the Altar Valley in 1999. While three of these territories were historical locations for pygmy-owls, annual monitoring was not done prior to this year. Most territories were located in mesquite-grassland and Sonoran desertscrub transition areas near mountain foothills. These detections reveal an important new component of the known population of pygmy-owls in southern Arizona and may represent the largest known concentration of pygmy-owl activity in Pima and Pinal counties.

Occupancy and Productivity. The addition of the Altar Valley pygmy-owl detections produced the highest number of occupied territories (28) since AGFD surveys began in 1993. We expect the number of detections to increase as survey efforts increase and larger areas of potentially suitable habitat are sampled.

During the 1999 season, we documented the largest number of active pygmy-owl nests and banded the greatest number of offspring (32) since AGFD began population surveys. Despite these apparent successes, we also documented a high number of mortalities and young of the year that disappeared prior to dispersal.

Mortality. The only documented mortality of pygmy-owls monitored by AGFD from 1996 to 1998 was three juveniles that were lost after fledging and before dispersal. We believe mortality detections increased in 1999 due to the use of radio-marking, more observers at nest sites and increased opportunities from the discovery of more nests with greater numbers of offspring. We were able to increase the number of nests monitored in 1999 by 300 percent. The increased mortality we observed does not necessarily mean that more owls died than in previous years. Rather, an increase in sample size simply allowed us to document what is likely, a more realistic rate of mortality and that low mortality in the early part of our project, was probably the result of low sample size. We should emphasize, that when dealing with such a small, cryptic owl, telemetry allows us to locate and document behaviors and events such as mortality that would otherwise be impossible to detect.

We suspect that relatively high mortality of recent fledglings occurs when poorly flighted juveniles encounter cacti. They may become trapped in the needles and die of exposure or succumb to injuries from needle wounds. We rescued a number of juveniles that had impaled themselves on cholla cactus or prickly pear. We observed others with cactus spines in various parts of their bodies. Some of these juveniles would certainly have died if we had not been able to remove them from the cactus.

Incest. The documentation of second generation incest in northwest Tucson raises some questions regarding the numbers and movements of pygmy-owls in this population segment. Documenting two consecutive years of incestuous breeding, coupled with the presence of unpaired male owls each year, seems to indicate that the number of female owls available for breeding may be limiting population growth in northwest Tucson. It may also indicate that habitat connections are lacking and that the females may be present, but unable to encounter unpaired males.

Banding. Increased banding efforts this year will improve our ability to document movements, site fidelity and population numbers. Already in the spring of 2000, banding efforts are yielding information on dispersal of 1999 offspring, mortality and replacement of adults on breeding territories.

Telemetry

Juvenile radio-tracking. We are only able to monitor dispersing juveniles for the 12 week battery life of a radio transmitter due to the fact that the owls are often difficult to recapture. Because of this, we have only been able to document behaviors and events associated with nesting, fledging , early dispersal initiation of territory establishment. We are lacking information about what happens following territory establishment in the late fall and winter periods.

As dispersal information is recorded over consecutive years, annual use patterns of certain dispersal routes are beginning to emerge. One explanation for these common dispersal routes, at least in the developed parts of northwest Tucson, is that areas of open, undeveloped desertscrub are limited. Pygmy-owls do not disperse with long distance flights, but rather make short flights from tree to tree, foraging and using the habitat as they go. Connected, undisturbed vegetation facilitates such dispersal. Monitoring has indicated that dispersing juveniles often choose to move through undisturbed desert areas and go around, rather than over high density residential developments. Such developments appear to present barriers to dispersal while open desert with natural washes and mature native vegetation, provide unobstructed and less hazardous dispersal routes. Radio telemetry during 1998 and 1999 has shown these limited habitat connections are being used annually by dispersing juveniles in northwest Tucson.

Dispersal Corridors. At present, it is too early and sample size is too small, after only two years of radio-marking dispersing juveniles, to draw any solid conclusions about dispersal corridors. However, a few areas are beginning to emerge as potentially important corridors of dispersal due to the consistent use of specific routes during consecutive years.. These areas are located in NW Tucson. During both years of radio-tracking, juveniles from the southern most nest in NW Tucson have followed the same route north and other juveniles from this same nest site have followed a similar route to the northeast. While these juveniles have ultimately ended up in different locations, they do end up in the same general area and initial dispersal paths are very similar. One exception is described in the Results section above (see Incest).

Additionally, two juveniles from two different nest sites during different years ended up on the exact same parcel on the west side of the Tortolita Mountains. Both owls eventually moved on, so they did not encounter each other, but this is additional evidence to support the possibility of common dispersal routes or route portions used over time.

Possible Exchange Between Population Segments. Use of radio telemetry allowed us to document exchange between pygmy-owl population segments in Arizona. A young of the year from a nest site in NW Tucson dispersed north for approximately 12 miles crossing into Pinal County. The transmitter failed at this point and it is unknown if the juvenile continued to disperse. The final location we recorded for this juvenile was in the general vicinity of an occupied pygmy-owl nesting territory. Coincidentally, another young of the year from the nest in Pinal County dispersed south into NW Tucson, ending up approximately 13 miles from its nest site. During 1999, we were not aware of any territorial pygmy-owls located between the nesting owls in Pinal County and the nesting owls in NW Tucson, and we currently consider these two separate population segments. This exchange of dispersing juveniles between population segments indicates that juveniles can disperse relatively long distances through unfragmented, suitable habitat.

Post Dispersal Monitoring and Pair Formation. Extended telemetry monitoring allowed us to document fall pair formation for the first time. A female young of the year had dispersed for approximately 40 days before settling into an area where it stayed through December 1999 when it was detected vocalizing in a territory held by a male from the previous year. We were able to recapture this owl (2 September) while it resided in an area for an extended period and replace the transmitter. The new radio prolonged potential monitoring for 12 more weeks. On approximately 24 September, this owl left the area it had been using and dispersed to the southeast bringing it into the territory of an established, unpaired male CFPO. The dispersing juvenile female halted additional movement and remained in the territory of this resident male until her transmitter stopped functioning in December 1999. Monitoring while the transmitter was functional resulted in several observations of this female juvenile and the resident male together or in close proximity, indicating that pair formation had occurred. Monitoring during the spring of 2000 showed that this pair successfully nested and produced three young.

We have detected several juvenile males using the territorial call both spontaneously and in response to a taped broadcast or whistle in 1998 and 1999. This occurred after long range (dispersal) movements had ceased. These regular and strong vocalizations appear to indicate that advertising and territory defense may occur in the fall of the year and that pair formation for dispersing juveniles or established unpaired owls may also occur during this time.

We were able to conduct extended telemetry monitoring through recapture and replacement of the radio transmitter on only one other pygmy-owl 1999. Coincidentally, this happened to be a male juvenile that had established a territory in the dispersal path of the above-described female juvenile. As the female juvenile passed through the juvenile male's territory, it followed her for approximately 0.6 miles over two days until they entered the resident, unpaired adult male's territory. Although not directly observed, telemetry locations seem to indicate that all three owls were briefly in the same area at the same time. Following this encounter, the male juvenile returned to its original territory suggesting that the resident adult male drove the male juvenile out of its territory. Extended telemetry monitoring allowed this documentation of likely competition for the dispersing juvenile female.

Adult Telemetry. Radio-marked adults often provided the opportunity to not only locate the adult male, but also its mate or offspring, during interactions such as feeding or prey exchanges. Identification of increased numbers of prey items was also made possible when males holding prey were located. With a few exceptions, movements by paired males were most often restricted to visual or aural contact distances from nests and mates, during the tracking period. Locations for the unpaired male also indicated movements that were relatively near the saguaro from which it advertised. We recognize our relocation sample size for all radio-marked adults is small, and those greater movements may have gone undetected. Future sample sizes will be increased to more accurately estimate the size of areas used from the time when females are incubating until young disperse.

Population Segments

Currently, there are four distinct pygmy-owl population segments in Arizona. These are Pinal County, NW Tucson, Altar Valley and Organ Pipe Cactus National Monument. No exchange between these segments has been documented with the exception of the incident described above. An additional CFPO population segment is known to occur on the Tohono O'odham Reservation, but no species specific surveys, banding or radio-marking has been done in that area. Therefore, some undocumented exchange could be occurring with CFPOs on the Reservation. Overall CFPO population viability in Arizona will be very dependent on exchange of pygmy-owls between these population segments. Barriers and habitat fragmentation, which may prevent this, should be considered hurdles to recovery of pygmy-owls in Arizona.

Finally, we recognize our research efforts in 1999 were aided significantly by an increased number of pygmy-owl detections and nest site locations. Increased sample size of nests monitored and radio-marked individuals began to reveal aspects of CFPO natural history of which we were previously unaware or had different perceptions. New information regarding pygmy-owls in Arizona continues to accumulate as new owls are found and added to this project's investigations. Answers to questions regarding important use areas, preferred habitat types, dispersal, immigration, population stability and species recovery will depend on continued financial and manpower support of research efforts such as banding, radio-marking and telemetry and habitat sampling studies.

MANAGEMENT RECOMMENDATIONS

1. Protect remaining dispersal corridors in NW Tucson – NW Tucson continues to support the highest breeding densities of CFPOs in Arizona. This area is potentially a source population for adjacent population segments of pygmy-owls. This area is also experiencing the most development pressure and, thus, higher potential for habitat fragmentation and barriers to dispersal. Remaining areas of undeveloped desert are being used on an annual basis as dispersal routes by juvenile CFPOs. It is important that these routes remain viable to allow for movement into and out of this area.

2. Identify and protect an interconnected system of habitat to facilitate exchange between population segments – Long-term viability of the Arizona CFPO population hinges upon the exchange of pygmy-owls between population segments within the state. This is necessary to maintain genetic diversity and to allow owls to repopulate areas of their historic range where they are no longer found or areas where some stochastic event may cause local extirpation. The identification of some of these areas has been done by the establishment of Critical Habitat (USFWS 2000), which also provides protection in some circumstances. However, further efforts need to occur in conjunction with local planning efforts by federal agencies and local municipalities.

3. Work with the Tohono O'odham Nation to gather information on that CFPO population segment- Very little is known about this CFPO population segment. Yet, it has the potential to contribute significantly through both numbers of owls and acres of suitable habitat. Gathering information on these pygmy-owls must consider both the social and political constraints presented by working on the Nation. The initiation of a cooperative working relationship with the Nation to facilitate information gathering would contribute significantly towards our understanding of CFPOs in Arizona.

RESEARCH NEEDS

1. Additional juvenile dispersal monitoring, especially in population segments other than NW Tucson – We have gained significantly in our understanding of CFPO dispersal behavior over the past two years. However, these efforts represent only a small number of individuals and nesting areas. It is important to gather additional information on other population segments, particularly those areas near the Mexican border and in Pinal County. This will help us document potential movement and exchange with the Mexican population, as well as expansion into the northern parts of the historic range in Arizona.

2. During 1999, we were able to follow two young of the year into the late fall period and for the first time, detected behavior that indicated pair formation and interspecific competition for mates. Future research efforts need to focus on gathering data during the fall and winter time periods to round out our understanding of the year-round activities and requirements of both adult and dispersing juvenile pygmy-owls.

3. Dispersal habitat selection study – Dispersing juveniles represent the opportunity for genetic exchange and repopulation of unoccupied habitat, both factors which could contribute to the ongoing viability of the Arizona CFPO population. It is important to identify any habitat requirements, selection characteristics and habitat patterns that are contributing to the successful dispersal of juvenile CFPOs.

4. Roads as barriers to dispersal – With increasing development in areas containing active CFPO nests, roads have the potential to fragment dispersal habitat and cause barriers or hazards for dispersing juveniles. We have documented dispersing pygmy-owls crossing certain types of roads, but have little or no data with regard to CFPOs' ability to cross major highways or multi-lane roads. As the human population expands and grows, so will the size and extent of our road system. We need to increase our understanding of how this will affect CFPOs, particularly their ability to successfully disperse.

5. Additional telemetry to better document mortality factors – Because CFPOs are so small and cryptic, it is very difficult to conduct extended monitoring without the aid of telemetry. The documentation of mortality is almost impossible without this tool. Pygmy-owls that have been killed by predators, disease, or man-made obstacles are very difficult to find. Telemetry allows us to locate carcasses or other evidence the may reveal the cause of mortality. Causes and rates of mortality are critical components to conducting population viability analysis, a tool that can help us quantify what needs to be done for recovery CFPOs in Arizona.

6. Continue to band all known adult and juvenile CFPOs – It is only through a long-term banding program that we can begin to gather information on survival, life expectancy, site fidelity, and movements. Again, this is all information needed to describe CFPO population characteristics.

7. Continue nest monitoring to assess productivity and mortality factors, especially comparisons between urban and non-urban sites – Our nest monitoring activities have contributed more than anything else to our understanding of CFPO productivity, food habits, mortality, habitat use and behavior. While telemetry and specific habitat studies will do more in the future, nest sites still provide the only consistent opportunity to observe and record CFPO life history elements.

LITERATURE CITED

Abbate , D.J, W.S. Richardson, R.L. Wilcox, M.J. Terrio and S.M. Belhumeur. 1999. Cactus ferruginous pygmy-owl investigations in Pima and Pinal Counties: 1997 – 1998. Region V Wildlife Program, Arizona Game & Fish Department, Tucson, Arizona. 83 pp.

Abbate, D.J., A. Ditty, S. Richardson and R.J. Olding. 1996. Cactus ferruginous pygmy-owls surveys and nest monitoring in the Tucson Basin area, Arizona – 1996. Urban Wildlife Enhancement Final Report #U95503. Arizona Game and Fish Department, Phoenix, Arizona.

Bent, A.C. 1938. Life histories of North American birds of prey. Part 2. U.S. Natl. Mus. Bull. 170

Brown, D.E. (ed.) 1994. Biotic communities: southwestern United States and northwestern Mexico. University of Utah Press, Salt Lake City.

Cartron, J.L. and D.M.Finch (eds.) 2000. Ecology and conservation of the cactus ferruginous pygmy-owl in Arizona. General Technical Report RMRS-GTR-43. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, 68 p.

Collins, M.D. and T.E. Corman. 1994. Cactus ferruginous pygmy-owl survey in Arizona: 1993-1994 season. Nongame and Endangered Wildlife Program Technical Report 37. Arizona Game & Fish Department, Phoenix, Arizona

Felly, D.L.and T.E. Corman. 1993. Spring 1993 cactus ferruginous pygmy-owl surveys in Arizona. Nongame and Endangered Wildlife Program Technical Report. Arizona Game & Fish Department, Phoenix, Arizona.

Flesch, A.D. 1999. Cactus ferruginous pygmy-owl surveys and nest monitoring on and around the Buenos Aires National Wildlife Refuge, Altar Valley, Arizona. U.S. Fish and Wildlife Service Cooperative Agreement #1448-00002-99-G943. U.S. Fish and Wildlife Service, Buenos Aires National Wildlife Refuge, Sasabe, Arizona.

Harris, L.K. and R.B.Duncan. 1998. Cactus ferruginous pygmy-owl 1998 survey of southern Arizona. FWS Grant Agreement #1448-20181-98-G915. U.S. Fish and Wildlife Service, Phoenix, Arizona.

Hunter, W. C. 1988. Status of the cactus ferruginous pygmy-owl (Glaucidium brasilianum cactorum) in the United States and northern Mexico. USDI Fish and Wildlife Service, Phoenix, Arizona.

Johnsgard, P.A. 1998. North American owls: biology and natural history. Smithsonian Institution Press. Washington and London.

Johnson, R.R. and L.T. Haight. 1985. Status of the ferruginous pygmy-owl in the southwestern United States. Abstracts, 103rd stated meeting of the American Ornithologist's Union, Arizona State University, Tempe, Arizona.

Lesh, T.D. and T.E. Corman. 1995. Cactus ferruginous pygmy-owl surveys in Arizona: 1993 – 1995. Nongame and Endangered Species Program Technical Report 76. Arizona Game & Fish Department, Phoenix, Arizona.

Millsap, B.A. and R.R. Johnson. 1988. Ferruginous pygmy-owl. Pages 137-139 in R.L. Glinski et al. (eds.) Proceedings of the southwest raptor management symposium and workshop. National Wildlife Federation, Washington, D.C.

Monson, G. and A. R. Phillips. 1981. Annotated checklist of the birds of Arizona. The University of Arizona Press, Tucson.

Phillips, A., J. Marshall and G. Monson. 1964. The birds of Arizona. The University of Arizona Press, Tucson.

Proudfoot, G.A., S.L. Beasom and F. Chavez-Ramirez. 1999. Biology of ferruginous pygmy-owls in Texas and application of artificial Nest Structures. Wildlife Management Bulletin of the Caesar Kleberg Wildlife Research Institute No. 5. Texas A&M University-Kingsville.

Proudfoot, G.A. 1996. Natural history of the cactus ferruginous pygmy-owl. Thesis, Texas A&M University, Kingsville.

Rea, A.M. 1983. Once a river. University of Arizona Press, Tucson. 285 p.

U.S. Fish and Wildlife Service. 1997. Determination of endangered status for the cactus ferruginous pygmy-owl in Arizona. Federal Register 62: (46) 10730-10747.

________. 1998. Endangered and threatened wildlife and plants; proposed determination of critical habitat for the cactus ferruginous pygmy-owl. Federal Register 63: (250) 71820-71838.

_______. 1999. Endangered and threatened wildlife and plants; determination of critical habitat for the cactus ferruginous pygmy-owl (Glaucidium brasilianum cactorum). Federal Register 64: 37419-37440.

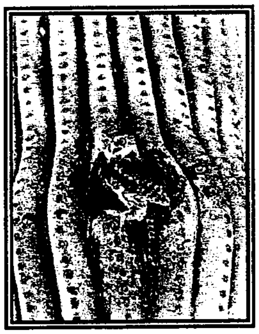
Appendix 1. FEPO adult capture and banding summary, Pima and Pinal Counties, AZ 1999. M/R = Marana/Redrock, NWT = Northwest Tucson, AV = Altar Valley, OPNM = Organ Pipe National Monument, 1 = first capture, 2 = recapture.

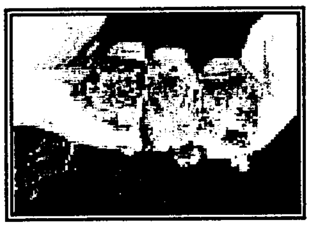
Site	Area	Sex	Color Band Description	USFWS Band #	Status	Capture Date
GW	M/R	M	Blue – I	1443-89875	1	4 April
PW	M/R	M	Blue - A	1443-89881	1	5 April
PW	M/R	F	Green – A	1443-89880	1	5 April
PW	M/R	F	Green – O	1443-89880	2	20 June
BR	NWT	F	Green – D	1443-89873	1	8 April
BR	NWT	M	Blue	1443-89874	2	8 April
BR	NWT	M	Blue - H	1443-89874	2	27 May
BR	NWT	F	Green – H	1443-89873	2	31 May
CA	NWT	M	Blue – B	1443-89882	2	6 April
DM	NWT	M	Blue – E	1443-89872	1	7 April
DM	NWT	F	Green – C	1443-89871	1	7 April
SR	NWT	M	Blue – C	1443-89883	2	6 April
SR	NWT	M	Blue – W	1443-89883	2	17 June
SR	NWT	F	Green – I	1493-28934	2	12 June
TL	NWT	F	Green – B	1443-89885	2	7 April
TL	NWT	M	Blue – D	1443-89884	2	7 April
CP	AV	M	Blue – U	1493-28922	1	31 May
AW	AV	F	Green – M	1493-28927	1	3 June
AW	AV	M	no color	1493-28928	1	3 June
CT	AV	F	Green – K	1493-28926	1	2 June
CT	AV	M	Blue – K	1443-89876	1	10 April
RDO	AV	F	Green – E	1443-89879	1	11 April
RDO	AV	M	Blue – N	1443-89878	1	11April
MWS	AV	M	Blue – V	1493-28936	1	22 June
MWM	AV	M	Blue – Y	1493-28937	1	22 June
MWN	AV	M	Blue – Z	1493-28938	1	23 June
MWNW	AV	M	Blue – X	1493-28939	1	23 June
SL	AV	M	Blue – M	1443-89877	1	10 April
KE	OPNM	M	Blue – O	1363-79777	1	12 April
KM	OPNM	M	Blue - P	1363-79778	1	12 April
KW	OPNM	M	Blue – R	1363-79779	1	13 April

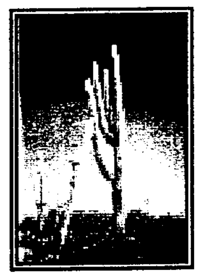
Appendix 2. FEPO juvenile capture and banding summary, Pima and Pinal Counties, AZ 1999

Site	Area	Color Band	USFWS Band #	Capture Date
BR	NWT	Black - A	1493-28903	26 May
BR	NWT	Black - B	1493-28904	26 May
BR	NWT	Black - C	1493-28905	26 May
BR	NWT	Black - D	1493-28906	27 May
BR	NWT	Black - E	1493-28907	27 May
DM	NWT	Black - M	1493-28913	30 May
DM	NWT	Black - N	1493-28911	29 May
DM	NWT	Black - O	1493-28912	30 May
DM	NWT	Black - P	1493-28914	30 May
SR	NWT	Black - V	1493-28918	31 May
SR	NWT	Black - W	1493-28919	31 May
SR	NWT	Black - X	1493-28921	31 May
SR	NWT	Black - Y	1493-28920	31 May
TL	NWT	Black - R	1493-28915	30 May
TL	NWT	Black - S	1493-28916	30 May
TL	NWT	Black - U	1493-28917	30 May
GW	M/R	Black - H	1493-28909	28 May
GW	M/R	Black - I	1493-28908	28 May
GW	M/R	Black - K	1493-28910	28 May
PW	M/R	Copper - B	1493-28935	20 June
PW	M/R	Copper - A	1493-28940	20 June
AW	AV	Black - 9	1493-28942	23 June
AW	AV	Copper - C	1493-28941	23 June
CT	AV	Black - 2	1493-28924	1 June
CT	AV	Black - 3	1493-28925	1 June
CT	AV	Black - Z	1493-28923	1 June
RDO	AV	Black - 4	1493-28930	3 June
RDO	AV	Black - 5	1493-28931	3 June
RDO	AV	Black - 6	1493-28932	3 June
RDO	AV	Black - 7	1493-28933	3 June
SLW	AV	Copper - D	1493-28944	18 July
SLW	AV	Copper - E	1493-28943	18 July

CACTUS FERRUGINOUS PYGMY-OWL INVESTIGATIONS IN PIMA AND PINAL COUNTIES, ARIZONA 1997-1998







DENNIS ABBATE
SCOTT RICHARDSON
RENEE WILCOX
MICHAEL TERRIO
STACEY BELHUMEUR

REGION V WILDLIFE PROGRAM
ARIZONA GAME AND FISH DEPARTMENT
DECEMBER, 1999

CACTUS FERRUGINOUS PYGMY-OWL INVESTIGATIONS IN PIMA AND PINAL COUNTIES, ARIZONA 1997-1998

Dennis Abbate, Wildlife Assistant
Scott Richardson, Urban Wildlife Specialist
Renee Wilcox, Wildlife Assistant
Michael Terrio, Wildlife Intern
Stacey Belhumeur, Wildlife Intern

Region V Wildlife Program
Program Manager: Ronald J. Olding
Arizona Game and Fish Department
555 N. Greasewood Road
Tucson, Arizona 85745

December, 1999

RECOMMENDED CITATION

Abbate, D.J., W.S. Richardson, R.L.Wilcox, M.J. Terrio and S.M. Belhumeur. 1999. Cactus ferruginous pygmy-owl investigations in Pima and Pinal Counties, Arizona: 1997-1998. Region V Wildlife Program. Arizona Game and Fish Department, Tucson, Arizona. 83pp.

ACKNOWLEDGMENTS

Most of the field investigations of cactus ferruginous pygmy-owls during 1997 and 1998 were conducted on private properties and we are extremely indebted to the landowners for their cooperation. The owners of these private parcels not only granted access, but demonstrated their support and enthusiasm for our efforts by providing information on the activities of the owls, and spending time orienting us to their pets and property. We are especially grateful to those land owners with properties containing nest sites that granted us almost unlimited access during all times of the day or evening. In order to protect the privacy of these residents and sensitive site specific information they are not recognized here by name, but without their contribution, our work would not be possible and we extend our deepest appreciation.

We also want to thank all Arizona Game and Fish Department (AGFD) personnel who assisted with this project through consultations, office and field support. Ron Olding provided advice on data collection and logistics, participated in early habitat measurements and located radio-marked birds during aerial surveys when we lost radio signals from the ground. Marty Teugel provided data analysis advice and computer support and instruction and assisted with capture attempts. Mike Pruss also assisted with capture attempts, offered advice on field techniques, conducted surveys and attempted to confirm detections by private contractors. Glenn Frederick and Terry Frederick helped conduct nest monitoring. Sherry Ruther conducted nest monitoring, assisted during early habitat measurements and conducted radio-tracking. Sandy Ditty participated in surveys and nest monitoring. Joe Pinto participated in radio-tracking and nest monitoring. Jennifer Cordova, Joshua Mehlum, Dean Whittle, Ken Jacobson helped to monitor nests during the fledging period. We recognize the inter-agency cooperation and contributions of Joan Scott, Jon McGehee, Rick Gerhart, Dan Smith, Mike Pruss, Ron Olding, Randy Wilson, Sylvia Harris, Bill Burger, David Krueper, T. Hildebrandt, Brian Mihlbachler, Jack Whetstone, Karen Simms and Susan Bernal during a group survey effort.

We thank Glenn Proudfoot from Texas A&M University for providing expert consultations and guidance. Tim Tibbits from the National Park Service shared his field observations and provided updates on pygmy-owl activity in Organ Pipe National Park. Natasha Kline from Saguaro National Park helped secure permission for surveys on park lands and alerted field personnel to our activities. Tom Skinner from the U.S.Forest Service supported the project through coordination and implementation of cost share agreements.

AMERICANS WITH DISABILITIES ACT COMPLIANCE

The Arizona Game and Fish Department complies with all provisions of the Americans with Disabilities Act. If you need this material in an alternative format or believe you have been discriminated against, contact the Deputy Director, Arizona Game and Fish Department, 2221 West Greenway road, Phoenix, Arizona 85023-4399; Telephone (602) 942-3000.

PROJECT FUNDING

Funding for this project was provided by AGFD Region 5 base budgets, US Fish and Wildlife Service - Section 6 and Special Grant Funds, US Forest Service (Coronado National Forest) Challenge Cost Share, Federal Aid Enhancement and The Arizona Game and Fish Department Heritage Fund.

TABLE OF CONTENTS

Table of Contents (continued)

Table of Contents (continued)

LIST OF FIGURES

LIST OF TABLES

CACTUS FERRUGINOUS PYGMY-OWL INVESTIGATIONS IN PIMA AND PINAL COUNTIES, ARIZONA: 1997-1998

Dennis J. Abbate, William S. Richardson, Renee L. Wilcox, Michael J. Terrio, Stacey M. Belhumeur

INTRODUCTION

The cactus ferruginous pygmy-owl (*Glaucidium brasilianum cactorum*) is the northernmost subspecies of *G. brasilianum* which occurs from southern Arizona and southern Texas through parts of Mexico and throughout Central and South America. This small owl has a long, banded, rufous colored tail, bright yellow eyes and a pair of conspicuous dark "eye spots" on the back of the head. The head is rounded in appearance and lacks visible ear tufts. Historical records have indicated *G.b. cactorum* inhabited riparian woodlands and mesquite thickets (Rea 1983, Bent 1938). However, the most recent records for this subspecies are from Sonoran desertscrub (Brown 1994), with a few observations from riparian woodlands surrounded by semidesert grassland (Duncan and Harris, in press). Detailed descriptions of the range, type localities and physical characteristics of the cactus ferruginous pygmy-owl are reported in US Fish and Wildlife 1997, Proudfoot 1996, Abbate et al. 1996, Johnsgard 1988 and Millsap and Johnson 1988. A recent search of museum collections, agency and library records and a compilation of personal observations and anecdotal information has provided the most exhaustive documentation of known Arizona specimens, location descriptions and record related notes prior to 1993. (Duncan and Harris, in press).

Field investigations of the cactus ferruginous pygmy-owl (hereafter "pygmy-owl" or "FEPO") in Arizona during 1997 and 1998 were a continuation of work begun by the Arizona Game and Fish Department (AGFD) in 1993. Early work was restricted to surveys to begin documentation of recent distribution and population size in response to apparent population declines in the state (Phillips et al. 1964, Monson and Phillips 1981, Rea 1983, Johnson and Haight 1985, Hunter 1988, Millsap and Johnson 1988). Survey efforts and related activities increased in 1995 through the present with the exception of the 1997 breeding season, when funding reductions limited field personnel to nest monitoring and select surveys. A summary of specific activities for each year's field season can be found in AGFD annual and technical reports: Felly and Corman 1993, Collins and Corman, 1994, Lesh and Corman 1995 and Abbate et al. 1996.

The US Fish and Wildlife Service (USFWS) determined endangered status for the pygmy-owl in Arizona in March 1997, but did not identify critical habitat at that time (USFWS 1997). USFWS proposed designation of approximately 730,565 acres as critical habitat for pygmy-owls in Arizona in December, 1998 (USFWS 1998). The listing of the pygmy-owl limited AGFD research activities to surveys and nest monitoring during 1997. After a series of interagency discussions and clarification of federal banding permit administration, AGFD was permitted by USFWS to include capture of adults and young, color banding and radio marking in pygmy-owl field research.

STUDY AREA

During the 1997 breeding season, population surveys were focused where pygmy-owls were detected in previous years in the Tucson Basin (Figure 1). Nest monitoring was conducted in northwest Tucson. Some additional surveys were completed in 1997 primarily on Bureau of Land Management (BLM) lands and near private and Arizona State Trust Land in the Marana/ Red Rock area. We surveyed a few areas in the Santa Catalina foothills in response to several recent reported sightings of pygmy-owls. During late summer and fall of 1997 survey efforts shifted to Cienega Creek Preserve, a location where we installed nest boxes designed for pygmy-owls during January 1998. We also conducted surveys during this time within Saguaro National Park Tucson Mountain District and selected nearby locations, the east foothills of the Tucson Mountains and along access roads and washes near the Silverbell Mountains. A single survey in Sopori Wash near Arivaca Junction was conducted at the request of landowners.

Survey efforts and nest monitoring focused on northwest Tucson during the 1998 breeding season where most recent (1990's) pygmy-owl activity was observed (Figure1). Additional surveys were conducted in Marana/Redrock locations, Saguaro National Park Tucson Mountain District, and the east foothills of the Tucson Mountains. Juvenile radio-marked birds were tracked during dispersal for the first time throughout northwest Tucson and monitored on newly established territories.

Northwest Tucson

The northwest Tucson study area is semi-rural but rapidly changing due to residential and commercial development. Surveys were conducted primarily along public roads and rights of way and mostly near privately owned parcels with residences. These areas were zoned as "Suburban Ranch" (SR in Pima County) and often contained horse stables, arenas and corrals. Parcels range in size from 3.3 to 40 acres with the majority under 10 acres in size. Despite home construction and some clearing for livestock use, much of the vegetation and wash areas (we estimate 30 to 75 percent) within these private parcels remain natural and relatively undisturbed. In addition, some of the disturbed locations especially near residences have been landscaped with both native and non-native vegetation. A network of public access roads service the area with many remaining unpaved, but periodically maintained by grading. Larger tracts (one or more topographic sections) in surrounding areas are owned by development corporations and are currently being developed as high density residential projects and golf courses or are in the planning stages.

The survey area falls within the Sonoran desertscrub biotic community and is considered an upland subdivision characterized mostly as Paloverde-Cacti-Mixed Scrub Series (Brown, 1994). The topography is gently sloping, influenced by numerous large dry washes and smaller tributaries. Elevations range from 671 to 854 m (2200 to 2800 ft) Dominant vegetation includes saguaro (*Carnegiea gigantia*) , ironwood (*Olneya tesota*), foothill paloverde (*Cercidium microphyllum*), velvet mesquite (*Prosopis velutina*) and blue paloverde (*Cercidium floridum*). Catclaw acacia

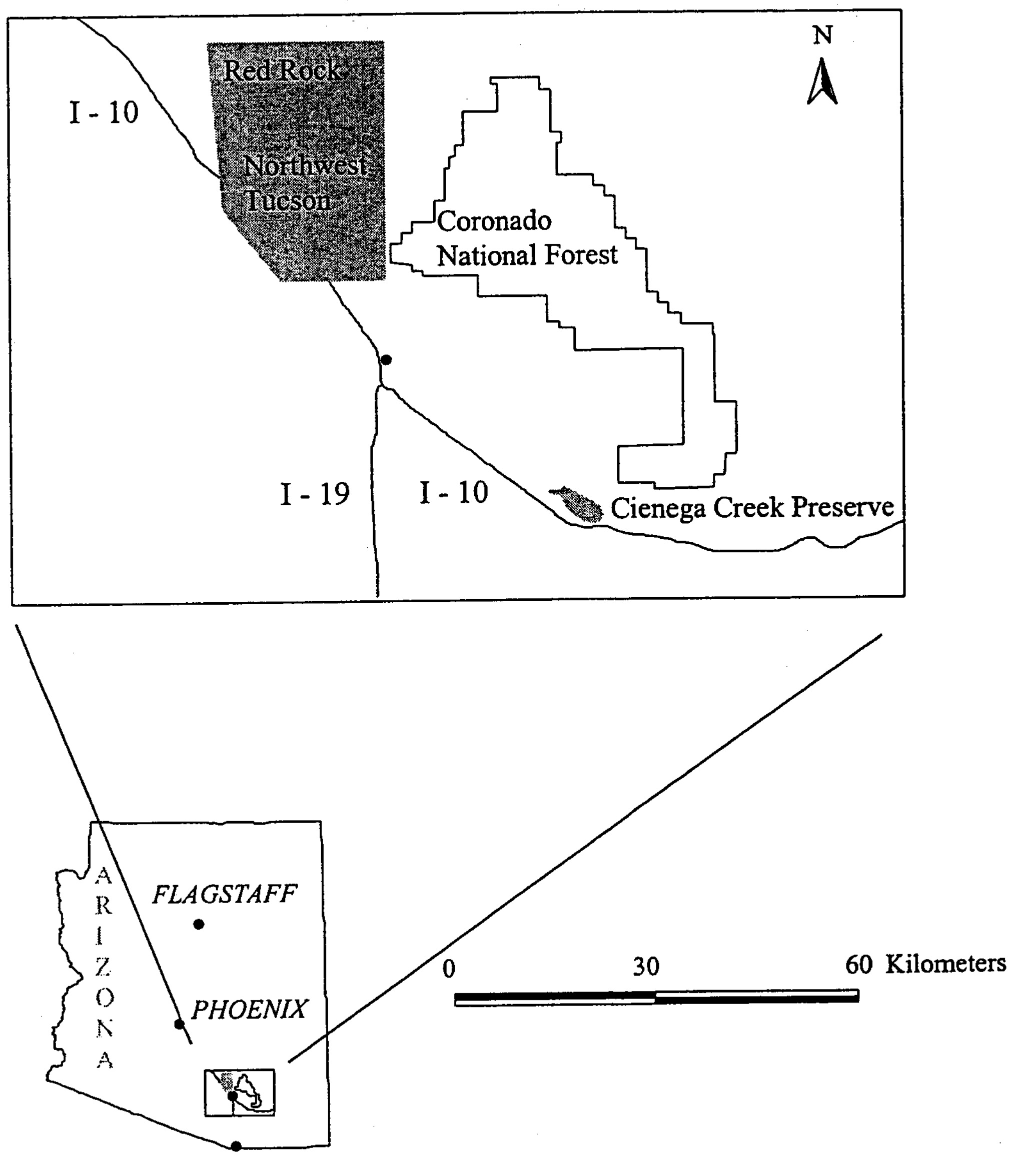


Figure 1. Study area location map.

(*Acacia greggii*) and whitethorn acacia (*Acacia constricta*) can also be found in locally large numbers. A number of species of cholla and prickly pear (*Opuntia* spp.) as well as fishhook barrel cactus (*Ferocactus wislizenii*) and Fendler hedgehog (*Echinocereus fendleri*) are common. Larger shrub species include creosote bush (*Larrea tridentata*), desert hackberry (*Celtis pallida*) and graythorn (*Zizyphus obtusifolia*). Triangle leaf bursage (*Ambrosia deltoidea*) is the most abundant small shrub over most of the terrain.

Marana/Redrock

Marana/Redrock identifies those lands south of Park Links Drive, west of the Tortolita Mountains, north of Tangerine Road and east of I-10. This area contains BLM and State Trust lands interspersed with private holdings which are clustered in some locations, but widely scattered in others. The region contains a number of small and large ranches with areas of private and public lands used for open range livestock grazing. Rural private residences on 3 to 40 acre parcels are increasing in number throughout the area. The vegetation is characterized as Sonoran desertscrub habitat, but is generally more open in character than northwest Tucson. Saguaro and foothill paloverde are dominant and can occur in locally dense stands. Ironwood is common and can also become a dominant species in some localities while completely absent in others. A variety of cholla, prickly pear, hedgehog, and fish hook barrel cacti are representative of the understory with creosote bush increasing at lower elevations. Similar to the northwest Tucson survey area, the most abundant small shrub is triangle leaf bursage. Velvet mesquite and acacia species increase in numbers along the many smaller dry washes. Desert willow appears in the larger washes that drain the foothills to the east. Elevations within the survey locations ranged from 664 to 762 m (2180 to 2500 ft).

Santa Catalina Mountain Foothills

This north Tucson location is the rolling hill terrain at the base of the south facing slopes of the Santa Catalina Mountains with elevations ranging from 847 to 878 m (2780 to 2880 ft). It has been shaped by major washes and tributaries that drain the mountain slopes and canyons. The elevation changes, mountain views and varied habitats have created scenic qualities that attracted intensive residential development on the slopes and along the washes. While most areas contain one house per acre, there is an extensive network of roads and larger intersections which have attracted commercial development and high density housing in recent years. Despite these impacts, development within many residential areas has been designed around washes allowing the natural water courses and the associated natural vegetation to remain relatively intact. In addition, many residences have utilized native vegetation in landscaped areas. These factors have created a patchwork of connected natural areas.

The foothills are considered Sonoran desertscrub and contain many of the species and vegetation structure found in northwest Tucson. However, ironwood trees do not grow here naturally. Saguaro and foothill paloverde are dominant on the hills and slopes while velvet mesquite and acacia species increase nearer the washes. The specific survey sites were adjacent to washes which contained hackberry, desert willow (*Chilopsis linearis*) and ocotillo (*Foquieria splendens*) in addition to the species already mentioned.

Cienega Creek Preserve

The Cienega Creek Preserve is a stretch of Sonoran riparian habitat (Brown, 1994) initially set aside for flood control and natural open space. It is one of the few areas remaining in the greater Tucson area with riparian habitat similar to that described for historical pygmy-owl locations. Desert willow, Fremont cottonwood (populus fremontii), Gooding willow (*Salix goodingii*) and other broadleaf riparian species were dominant in some locations, but intermixed with extremely dense mesquite bosque along other sections of the creek bank. Perennial water flows through a major portion of this stretch of the Preserve supporting grasses, sedges, and other strictly water dependent species. Railroad lines located on the upper slopes roughly follow the creek's course. The still higher rolling hill terrain in the surrounding area is relatively open and is a Sonoran desertscrub transition area with grasses and shrubs increasing while large cacti decrease in abundance. Saguaros in these adjacent areas were uncommon except for small patches. This area is used for occasional livestock grazing with sparse development of private residences outside the Preserve and active gravel operations occur nearby. Elevations range from 976 to 1036 m (3200 to 3400 ft).

Saguaro National Park Tucson Mountain District

Surveys within the Tucson Mountain District of Saguaro National Park (SNP) and adjacent areas were conducted along roads and major washes. This area is west of the Tucson Mountains and includes some state and private lands west of Sandario Road. Elevations range from 668 to 914 m (2190 to 3000 ft). SNP locations are almost entirely natural desert with few roads and some visitor and employee facilities. This Sonoran desertscrub community contains a very high density of saguaros. Velvet mesquite, foothills paloverde and ironwood are common tree species. Ironwood also occur at high densities in some localized areas. The shrub layer includes acacia, a variety of cacti, ocotillo, greasewood, hackberry and jojoba (*Simmondsia chinensis*) with triangle leaf-bursage the most frequently encountered groundcover.

Private lands adjacent to the park contain moderate to low density housing, small ranches and horse properties on 1 acre lots or larger. These properties often retain native species similar to those described above. Non-native species such as Aleppo pine and palm trees are common close to residences.

Tucson Mountain Foothills

The rolling hill terrain sloping east from the Tucson Mountains is similar to the Santa Catalina Mountain foothills. Elevations of survey areas range from 701 to 869 m (2300 to 2850 ft). This area is west of Silverbell Road, south of Avra Valley Road and north of Anklam Road. Mountain views, proximity to downtown Tucson as well as SNP, and Pima County Mountain Park lands have attracted significant residential development to this area with most parcels at 1 to 3.3 acres in size. Larger tracts to 40 acres or more are not uncommon, especially near the mountains. Commercial projects and high density housing are increasing with the addition of a resort hotel, apartment complexes and single homes on small lots. The biotic community is Sonoran desertscrub with saguaro and foothills paloverde dominant in most areas. The general character of the vegetation is open when compared to northwest Tucson, except along washes or near residences where non-native shade and ornamental species have been added. Ironwood join the dominant species in localized areas and both velvet mesquite and acacia species increase along washes. Common shrubs include: jojoba, creosote bush, desert broom (*Baccharis sarothroides*), desert hackberry and ocotillo. A variety of cacti together with smaller shrubs such as triangle-leaf bursage create substantial ground cover.

Silverbell Mountains Area

The gently sloping terrain and low lying areas between Ragged Top and Wolcott Peaks to the south, the Samaniego Hills to the north, Malpais Hill to the west and Waterman Mountain Road to the east define the Silverbell Mountain survey area. Elevations range from 609 to 716 m (2000 to 2350 ft). Most of the land within the survey area is owned by the BLM with substantially smaller state and private holdings. Private parcels of 5 acres and larger contain low density housing. One rock and gravel mine was observed on BLM land within the survey area and an unknown number of acres were staked for future rock extraction operations. Most of this area has a long history of cattle grazing and there was evidence of recent cattle operations along the survey routes. Several major well maintained dirt roads and a number of secondary routes provide access to most areas. The biotic community is identified as Sonoran desertcrub. Dense vegetation occurs in localized areas along washes and on private parcels, while other large areas are open in character. Saguaro, ironwood and foothills paloverde are dominant species. A variety of cacti are common along with larger shrubs such as creosote bush, ocotillo, hackberry and acacia. Triangle-leaf bursage is a common ground cover species.

Sopori Wash

A single survey was conducted along Sopori Wash just south and west of Arivaca Junction. This site is a Sonoran riparian community at approximately 3300 ft (1006 m) elevation. It is characterized by large cottonwood and willow trees and also has extensive areas covered by velvet mesquite. Development in the area was limited to large ranches at the time of the survey, but subdivision for residential development is proposed. Some sand and gravel operations also exist near the site.

METHODS

Survey Overview

Surveys to locate pygmy-owls and identify use areas in 1997 and 1998 were conducted from the courtship period (January), through post-dispersal (August). In addition, we surveyed during fall and winter (September to December) of 1997 to test survey effectiveness outside the breeding season. A limited number of fall and winter surveys during 1998 were also completed. Most surveys were conducted by a field biologist walking along transect routes of varying length with multiple calling stations at specific intervals. Occasionally, "spot surveys" using one or two call points at specific locations were also used to attempt location of previously detected or suspected owls. Most survey transects followed existing public roads and rights of way servicing private residential properties. Other surveys were conducted along washes and unpaved access roads on federal and state lands and on private properties when land owners granted permission for access.

Survey Protocol and Equipment

Population surveys were conducted using the formal protocol developed by AGFD (Felly and Corman 1993) and later revised (Abbate et al. 1996)[Appendix A]. We also used an informal approach (modification of the formal survey protocol) tailored to specific sites where pygmy-owl nesting or other activities had been detected during previous breeding seasons. If the informal approach was unsuccessful during the initial survey for the current year, additional formal protocol surveys were conducted during subsequent visits. Both survey techniques were employed primarily during high activity periods; one hour before sunrise until two hours after sunrise and two hours before sunset until one hour after sunset.

A survey consisted of broadcasting a taped male pygmy-owl territorial call and then listening for a response. Taped calls were broadcast using a Johnny Stewart Game Caller (Model MS 240) , a portable cassette player, or a portable cassette player connected to an amplified speaker (Radio Shack Power Horn). Less frequently, a surveyor may choose to imitate a call by whistling instead of using a broadcast tape. The sequence is repeated for up to 10 minutes and a final listening period up to five minutes completes the calling station. The surveyor then moves to the next calling station and begins the sequence again. If a pygmy-owl responds to the broadcast by vocalizing or flying in view of the surveyor, the broadcast sequence is ended immediately and observations are recorded. Surveys were documented on Population Survey Forms (Appendix B). The first detections of pygmy-owls for the current survey year were recorded on Initial Detection Forms (Appendix C) and all detection locations were plotted on 7.5 minute USGS topographical quadrangle maps. Strong mobbing behavior by small birds may also indicate the presence of a pygmy-owl. If mobbing was observed, broadcasting was ceased until the area was inspected. When possible, visual confirmation and the exact location of a calling pygmy-owl is attempted by walking in the direction of the call and examining potential perches. Additional broadcasts may be used to help locate pygmy-owls that are well hidden or when they cease calling. The distance between calling stations ranged from 100 m in areas where pygmy-owls were previously detected to 400 m along new survey routes. Length of survey routes ranged from 0.8 to 3.2 km. We estimated the area of calling coverage for each survey by multiplying the length of the route by 0.65 km (0.4 mi) [Felly and Corman 1993].

Detection Site Monitoring

Once an individual or pair of pygmy-owls was detected, the site was generally visited at 5 to 10 day intervals to monitor movements, behavior and nesting status during the early part of the breeding season. Detection site monitoring included listening for spontaneous calling during morning or evening high activity periods and at times, conducting a limited (5 - 15 minute) tape-broadcast survey when no activity was observed during the listening period (5 - 30 minutes). Similar to initial surveys, we attempted to identify exact locations of calling pygmy-owls and document vegetation or structures being used by walking in the direction of the vocalizations. These searches continued unless private property boundaries were encountered or the pygmy-owl flew off repeatedly during several approaches. If permission to access the private property was secured and the detected pygmy-owl remained in one area, we resumed our search until the location could be confirmed. Monitoring visits continued until we were unable to obtain additional detections and extended surveys in adjacent areas were also unsuccessful, indicating the owl was possibly no longer in the area. All observations were recorded on Post-Detection Site/Territory Visit Forms (Appendix D). If breeding activity was observed or a nest site was confirmed, we began intensive monitoring with visits every 1 to 3 days.

Detection Defined

Detection of a pygmy-owl is defined as a confirmed aural or visual observation of one or more individuals during a formal protocol survey, a monitoring visit, or an observation by a resident that has demonstrated identification skills. A detection is considered confirmed when: a) a pygmy-owl is seen and positively identified by an experienced surveyor b) territorial calling is vigorous with at least one calling sequence of 10 notes or two or more sequences of at least 5 notes, c) a second experienced observer is able to confirm the detection. Locations with suspected, but unconfirmed pygmy-owl presence were revisited at later times to attempt confirmation. Additional visits may include tape broadcast surveys or stop and listen surveys at one specific location or along a survey route. Repeated visits of detection locations to monitor occupancy, nesting status and to conduct other research activities resulted in multiple detections of the same individual, pair or offspring. Therefore, the total number of detections does not represent the number of individual pygmy-owls within the study area.

Nest Site Monitoring

Confirmation of nesting and identification of nest site locations were obtained through intensive searches and observations. Nest searches began shortly after detection of 2 owls in close proximity or observations of copulations. Documentation of pygmy-owls repeatedly visiting the same site, delivering prey to a cavity, or prolonged use of a cavity by the female were considered indicators of nesting. Intensive nest monitoring was begun after a nest saguaro or cavity was identified by at least two observers. In addition to Post-Detection Site/Territory Visit Forms, observations were recorded on Nest Site Monitoring and Observation Forms (Appendix E). Nest monitoring was conducted by one or two observers from distances between 30 and 80 meters from the nest saguaro. Binoculars and spotting scopes (15 - 60 power) were used from observation points located to provide a direct frontal or side view of the nest cavity opening. No blinds were used, but natural vegetation or other structures sometimes produced partial concealment during observation sessions. The immediate area (within 25 m) surrounding the nest saguaro and favored perches were avoided by observers until after fledging to minimize disturbance. Nest monitoring documented life history information that included, specific adult and juvenile behaviors and interactions, prey deliveries, potential predators, nest productivity, vocalizations, use of structures and vegetation, reactions to disturbance and nesting chronologies.

In order to reduce possible negative impacts from repetitive surveys at known pygmy-owl locations, we limited the use of tape broadcasts mostly to initial surveys and early monitoring efforts, to identify use areas and nesting status. When a pygmy-owl detection occurred during a survey session, tape broadcasts were ended immediately unless the location was undetermined. Once a location estimate was determined, broadcasts were stopped. Follow-up monitoring visits emphasized stop and listen surveys during high activity periods. When a pair of owls or a nest site was discovered, tape broadcasts were no longer used within that territory, or were used on a very limited basis. Most monitoring efforts at nest sites were conducted by listening, through direct observation, or use of radio telemetry. We also provided regular reports of survey locations and results to the USFWS Ecological Services Office and supported USFWS coordination of survey efforts by agency and private surveyors to eliminate field work duplication and reduce excessive survey impacts to specific areas.

Capture Techniques and Color Marking

Adult and juvenile pygmy-owls were captured using a baited bow net, mist nets or hand net. Recently fledged birds were also captured directly by hand. The bow net (Skach, Willowbrook, Ill.) is constructed with a metal rod frame (40 x 45 cm) and covered with a cotton netting. The top and bottom mesh size was 19 and 30 mm respectively. The bow was activated by a tripline trigger across the frame width and a central spring hinge closed the net. Once a pygmy-owl was located, one worker slowly approached and placed the trap in an unobstructed location and within 15 m. The trap was baited with a live tethered house sparrow.

A second capture method erected one to three mist nets between favored trees and perches. No lures or live prey were used for enticement. Pygmy-owls were captured in the net when flying between perches or investigating inadvertently entangled song birds. Mist nets were 5.5 and 9.1 m in length with 5 cm^2 mesh size. Most fledglings were captured directly by hand soon after leaving the nest cavity. A 36 cm diameter hand net (5 cm^2 mesh) attached to a telescoping pole was used to capture a few fledglings that were hard to reach.

All captured pygmy-owls were marked with uniquely colored celluloid leg bands [Avinet (Hughes) Dryden, NY] to identify individuals. The band was 5.5mm in diameter and was secured only by the overlapping coil. Banding and capture information was recorded on Capture Forms (Appendix F).

Radio-Marking and Telemetry

Backpack-style 9 volt 1.85 gram radio transmitters (Model BD-2G, Holohil Systems Ltd., Carp, Ontario, Canada) were used to mark selected pygmy-owls captured in 1998 to investigate habitat use, monitor movements during the breeding season, identify when dispersal occurs and monitor the directions, distances, and use areas during dispersal. Radio-marked individuals were monitored using portable radio receivers (Model TR-2 receiver, Telonics, Inc., Mesa AZ, Model TRX-2000S receiver, Model F148/3FB Antenna, Wildlife Materials, Inc., Carbondale, Ill). We also mounted a magnetic CB antenna (Model 21-972, Radioshack) to the roof of a vehicle and attached it to a receiver using an RF adapter (Model 278-120, Radioshack) inside the vehicle, when long distance pygmy-owl movements required searches by vehicle. Once a strong signal was received, we resumed searching with directional antennas on foot. We attempted to locate marked pygmy-owls almost daily from 1 June 1998 until the transmitters no longer worked due to battery failure. During dispersal, we frequently located birds during both morning and evening tracking sessions. The last transmitter stopped working on 2 October 1998. All relocations after dispersal were recorded on Radio-Marked Owl Detection/Location Forms (Appendix G).

Prior to dispersal, radio-marked individuals were easily tracked on foot. Vehicles were used when we could not pick up a signal from the ground and dispersing individuals were moving long distances. After receiving an initial radio signal, we used compass bearings from known locations to estimate the pygmy-owl's direction and distance. When possible, we attempted to get visual confirmation of the location and identify the vegetation or structures being used. On two occasions we used an AGFD fixed wing aircraft (single-engine Cessna) equipped with a belly-mounted 2 element Yagi antenna connected to a receiver (Telonics scanner) to aerial locate two dispersing individuals. Miles from their previous location, these pygmy-owls began using terrain that prevented signal reception from the ground, or were located on private land with difficult access. All known and estimated locations were recorded on USGS 7.5 minute topographical maps using triangulation, pacing and known visual locations. Universal Transverse Mercator (UTM) coordinates were determined and recorded for each location.

Prey Identification and Small Mammal Trapping

Prey items were identified during 1997 and 1998 through direct observations during nest monitoring using binoculars and spotting scopes from distances of 100 m or less. Observations of captured prey were recorded on Nest Site Prey Delivery Log and Summary Forms (Appendix J). Most often, observers were alerted to prey deliveries when specific vocalizations by adults were detected. When prey items could not be identified to class, they were documented as "undetermined". In addition to direct observations in the field, we collected regurgitated pellets from beneath known perches for future lab analysis.

We also conducted small mammal trapping near one nest site in 1997 to sample potential prey items which were rarely detected through direct observations of prey deliveries. Trapping was completed over 6 days from 2 to 11 July 1997 at two locations. The distance between sample locations was approximately 300 m. Two parallel transects 27.4 m apart were arranged with 12 stations each at both sample sites. One small and one large Sherman box trap was placed at each station. Stations were spaced approximately 15 m apart. Traps were baited initially with peanut butter and oat mixture, but this bait was changed to commercial bird seed which was less attractive to ants. Traps were set and checked 3 times at 1830 to 2100 hrs, 2100 to 0500 hrs and 0500 to 0830 hrs.

Habitat Measurements

We began quantitative measurements of pygmy-owl habitat characteristics in December 1997. Sample plot locations were identified using nest sites, territories held by individual males, areas used by dispersing juveniles, and detection sites where a pygmy-owl was found only once, from 1995 to 1998. Detection locations were considered for sampling only when the pygmy-owl's position was spontaneous (not influenced by tape broadcasts) and exact locations were known through visual observation. Historical locations prior to the 1990's were not included due to inadequate location data and a variety of disturbances causing habitat loss or changes.

Habitat sample plots were 0.5 ha and centered at a tree or saguaro cactus (*Carnegiea gigantea*) where a pygmy-owl was observed. Four 50 m transects were randomly placed by spinning a pencil in the air to determine the direction and compass bearing of the first transect from the center point. The three remaining transects were determined using successive 90 degree intervals. We identified vegetation species and non-vegetative components along each transect using the point-intercept method. Vegetation and other components were identified and categorized every two meters according to size, when intercepting (hitting) a 2 m long pole held perpendicular to the transect. The pole was 3.1 cm (1.24 in.) in diameter, and divided into decimeters to determine vegetation height. Hits were identified and recorded at ground level (where the bottom of the decimeter pole contacts the ground - 0.0), level 1 (0 - 0.4 m), level 2 (0.4 - 2m), and level 3 (> 2m). Vegetation exceeding 2m in height was examined for cavities large enough for use by pygmy-owls and the DBH of the largest stem was measured. All saguaros (>2m) within the plot boundaries were counted to derive a saguaro density measure within the sample plot.

In addition to the transect vegetation sampling, we randomly established a 100 m^2 (10 m x 10 m) quadrat along each transect. This plot was oriented so that 2 opposite corners were bisected by the transect and the remaining two plot corners were perpendicular to the transect. All plant species within the quadrat were identified and counted. We estimated mean height by measuring all individuals or a sample of individuals when numbers were large, and computing the average height. An estimate of ground cover for each species was also recorded using 5 cover classes: 1 = (0 - 5 %), 2 = (6 - 25 %), 3 = (26 - 50 %), 4 = (51 - 75 %), 5 = (76 - 95 %), 6 = (96 - 100 %). Cover estimates for combined ground structures including logs, rocks, branches and pack-rat middens were also recorded. Finally, we estimated the percentage of bare ground occurring within the quadrat. In an effort to compare vegetative cover values in Arizona to pygmy-owl habitat in Texas, we constructed cover boards according to specifications developed during work done through Texas A&M University (Proudfoot 1996). A cover board measuring 205 cm x 8.9 cm x 1.9 cm was divided into 8 equal sized panels of alternating colors (white and orange). The cover board was placed at the sample plot center and alternately oriented to each of the 4 previously established transects. Cover estimates were read while standing at 11.3 m from the board location looking down the transect line toward the plot center.

We completed our habitat measurements at each sample plot by identifying, measuring and describing non-vegetative components. These included distances from the plot center to: permanent water, dry washes, bird feeders, nearest dirt road, nearest paved road and nearest man-made structure (e.g. houses, barns, etc.). We also included a description of human activities, recorded livestock grazing, listed other wildlife species known or suspected in the area and indicated the nearest neighboring pygmy-owl distance and location. All habitat measurements and observations were recorded on Habitat Characterization Forms (Appendix I).

Nest Saguaro and Cavity Measurements

We described and measured nest saguaros and the cavities used for nesting at all nest sites from 1995 to 1998. Saguaros were characterized by measuring heights of the main stem and arms when they contained the nest cavity, using a clinometer (Suunto Co., Finland). We counted the number of cavities and the number of primary and secondary arms and measured distances to features such as the nearest building. Nest cavities were accessed using a 7.3 m aluminum ladder adapted for secure use on trees and saguaros. Cavity heights and diameters and were measured and aspects were determined. All observations and measurements were recorded on Saguaro and Cavity Measurement Forms (Appendix J).

Nest Box Installation and Inspection

Fifteen nest boxes with specifications (13 x 13 x 44 cm and 5.1 cm diameter entrance hole) and orientation designed to target pygmy-owls (Proudfoot 1996) were installed in 3 segments of the Cienega Creek Preserve using a 7.3 m aluminum ladder on 20 January 1998. Boxes were clustered in groups of three and six. We selected trees we could access with at least one vertical stem that would permit the nest box to be secured perpendicular to the ground at a minimum of 3 m or above in height. We also considered the amount of shade provided to the nest box, the relative density of vegetation in the area and obstructions to the entry hole. Five species of trees were used for nest box support. These included Fremont cottonwood (*Populus fremontii*), velvet mesquite (Prosopis velutina), velvet ash (*Fraxinus velutina*), Gooding willow (*Salix goodingii*) and Arizona walnut (*Juglans major*). Most boxes were installed on Fremont Cottonwood.

We inspected nest boxes using a remote miniature 9 volt camera mounted on a telescoping aluminum pole (Wilco Precision Inc., Morris, MN) connected to an 8mm video camera recorder (Model CCD-FX510, Sony Corp.). This system was first used with pygmy-owls and described by Proudfoot, (1996b). Fourteen nest box inspections were completed on 17 and 18 June, 1998. The last box was inspected on 23 June 1998.

RESULTS

Survey Effort

Pygmy-owl population surveys were conducted during the breeding season from 3 January to 20 August 1997 and 9 January to 29 May 1998. We completed 102 surveys during 75 field days for both years combined. Survey efforts by month are summarized in Tables 1 and 2. A total of 365 call points covering an overall distance of 70.23 km (43.67 mi) were surveyed in 1997 and 292 call points along a total distance of 74 km (45.98 mi) were sampled in 1998. We estimated the area of calling coverage for 1997 and 1998 at 45.61 km^2 (17.47 mi^2) and 48.10 km^2 (18.30 mi^2) respectively. Nine routes and call points in 1997 and 7 in 1998 were surveyed more than once and are included in the distance, point and coverage totals. Ninety-three percent of the surveys completed during 1997 were during the early morning activity period (1 hour before sunrise to 2 hours after sunrise) and in 1998, 91 percent of the surveys were completed during the same period.

We also conducted population surveys from 2 September to 30 December 1997. This post-breeding period began after the young had dispersed and ended prior to what is considered the beginning of the new breeding season in January. These additional surveys were conducted in an effort to locate new territories held by recently dispersed pygmy-owls, to locate previously undetected owls, and to test responsiveness to taped call broadcasts during the post-breeding season. Ninety-four surveys during 64 field days were completed during this time. We sampled 543 call points along a total distance of 129.66 km (80.61 mi). Our calling coverage estimate was 88.16 km^2 (33.75 mi^2). Survey efforts in specific areas during the post-breeding season are reviewed in Table 3.

Detections

During breeding season population surveys we recorded six detections in 1997 and six in 1998. All of these initial detections were territorial males calling in response to taped call broadcasts. Initial detections resulting from broadcast surveys are considered formal survey detections and are distinguished from additional monitoring detections derived from follow-up visits to the same areas. Monitoring detections are considered separately. In 1997, all formal survey detections occurred in the northwest Tucson area and represented four different territories. We included one detection from a known nesting territory in the total because it occurred after the young had dispersed and represented occupation of the area outside the breeding season. A second detection was also included in the total because we could not determine it was a previously detected pygmy-owl. It was located in an area believed to be in a known territory, but its specific location was significantly different from any previously recorded for known pygmy-owls in that area.

During formal surveys in 1998, four detections represented four known territories in northwest Tucson and included the territory held by a dispersing juvenile of the previous breeding season. Two other detections were recorded from the Marana/Redrock area where we located two new territories with the help of private consultant biologists (Harris Environmental Group, Inc., Tucson). During the post-breeding season (September to December) of 1997, we recorded 10 detections from three known territories representing three individual pygmy-owls in northwest Tucson (Table 4). We recorded only one detection each in September and November while eight detections were recorded in October. Surveys in December did not result in any detections. The rate of response for all three defensive pygmy-owls during the 4 month period was 26 percent, but when we considered October alone, the response rate increased to 42 percent for the three sites combined. During four visits to a successful nest site during the same year's breeding season, the male pygmy-owl's response rate was 50 percent overall and 100 percent during three visits in October. In contrast, the response rate of another adult male at a previous year's nest site was only 22 percent and a dispersing juvenile at a new territory responded 37 percent of the time (Table 5).

Table 1. FEPO breeding season population survey effort by month in Pima and Pinal Counties, Arizona, 1997.

Month	Hours	Days	Routes	Points	Distances km	Distances mi	Coverage km^2	Coverage mi^2	Detections
January	5.00	3	4	13	2.81	1.75	1.82	0.70	0
February	9.50	5	10	33	6.43	4.00	4.17	1.60	1
March	20.00	9	11	58	16.49	10.25	10.71	4.10	1
April	34.25	5	18	183	31.77	19.75	20.65	7.90	0
May	10.75	5	5	48	8.44	5.25	5.48	2.10	1
June	0.00	0	0	0	0	0	0	0	0
July	0.00	0	0	0	0	0	0	0	0
August	12.75	6	8	30	4.29	2.67	2.78	1.07	3
Totals	92.25	33	56	365	70.23	43.67	45.61	17.47	6

Table 2. FEPO breeding season population survey effort by month in Pima and Pinal Counties, Arizona, 1998.

Month	Hours	Days	Routes	Points	Distances km	Distances mi	Coverage km^2	Coverage mi^2	Detections
January	20.25	9	9	60	14.90	9.26	9.70	3.70	2
February	20.25	9	11	53	12.10	7.52	7.90	3.00	4
March	28.75	11	11	79	20.60	12.80	13.40	5.10	0
April	12.25	5	5	36	9.40	5.84	6.10	2.30	0
May	21.00	8	8	64	17.00	10.56	11.00	4.20	0
Totals	102.50	42	44	292	74.00	45.98	48.10	18.30	6

Table 3. FEPO post-breeding season population survey effort by area in Pima and Pinal Counties, Arizona, 1997.[a]

Survey Area	Hours	Days	Routes	Points	Distances km	Distances mi	Coverage km^2	Coverage mi^2	Detections
Cienega Creek	41.75	14	14	108	28.60	17.77	18.59	7.10	0
Silverbell Mountains	17.00	6	6	48	12.8	7.95	8.32	3.20	0
Northwest Tucson	57.25	23	52	204	38.46	23.93	28.88[d]	11.07[d]	10
Tucson Mtn. Foothills	13.50	5	5	41	11.4	7.10	7.41	2.84	0
Saguaro N. P. West[b]	48.25	16	17	142	38.4	23.86	24.96	9.54	0
Totals	177.75	64	94	543	129.66	80.61	88.16	33.75	10

[a] Data include all repeat surveys and monitoring of sites with previous post-breeding detections to reflect responsiveness of known birds outside the breeding season.
[b] Saguaro National Park west includes surveys conducted near, but outside the park boundary.
[c] The number of detections includes multiple detections at each of three sites and is believed to represent one individual at each site.
[d] A number of surveys in northwest Tucson used only one call point. Though linear distance was considered 0, calling coverage was estimated at 0.259 km^2 or 0.1mi^2.

Table 4. FEPO post-breeding population survey effort by month in northwest Tucson, Pima County, Arizona, 1997.

Month	Hours	Day	Routes	Points	Distances km	Distances mi	Coverage[a] km^2	Coverage[a] mi^2	Detections
September	21.00	4	12	77	18.34	11.40	12.44	4.76	1
October	18.25	9	20	64	8.44	5.25	7.04	2.70	8
November	8.00	6	16	33	4.02	2.50	4.43	1.70	1
December	10.00	4	4	30	7.66	4.76	5.00	1.91	0
Totals	57.25	23	52	204	38.46	23.91	28.91	11.07	10

[a] A number of surveys in northwest Tucson used only one call point. Though linear distance was considered 0, calling coverage was estimated at 0.259 km^2 or 0.1mi^2. All single point calling coverage was added to the totals.

Table 5. Survey response rates of three male pygmy-owls defending territories during the post-dispersal period (September - December) in northwest Tucson, Pima County, Arizona, 1997.

Territory	Description	Total Surveys all[a]	Total Surveys Oct	Total Detections all	Total Detections Oct	Response Rates (%) all	Response Rates (%) Oct
96T	adult male at previous nest site	17	9	3	2	17.64	22.22
97FD	dispersing juvenile in vacant territory	13	7	3	3	23.07	42.85
95B	paired adult male from nest of same year	8	3	4	3	50.00	100.00
Totals	--------------	38	19	10	8	26.31	42.10

[a] all = all months surveyed.

Territory Occupation

Prior to dispersal of young, we recognized occupation of three territories in 1997 and six territories in 1998 within northwest Tucson and Marana/Redrock areas. Territories were defined as sites where nesting was confirmed or at least one pygmy-owl was detected while conducting two or more surveys or monitoring visits in the same area, during one breeding season. Two detections in the same area during different years indicated occupation of the same territory. One nest site was located in 1997 and three were found in 1998. We also recognized persistent occupation of new areas by dispersing juveniles within their first year as new territories. We confirmed a dispersing bird of the same year when its color band was resighted in 1997 (see First Year Observations of Color-Marked Juvenile Pygmy-Owls). Radio telemetry enabled us to confirm occupation of four new territories by dispersing juveniles in 1998. Known occupation history for pygmy-owl territories in northwest Tucson and Marana/Redrock from 1993 to 1998 is summarized in Table 6.

Detection Site and Nest Monitoring

In 1997, population surveys and detection site monitoring resulted in confirmation of one nest site and three other territories in northwest Tucson defended by male pygmy-owls that appeared to be unpaired. Regular monitoring of these sites resulted in 91 detections of one or more pygmy-owls.

Survey and monitoring efforts in 1998 resulted in locating three nest sites and three additional territories that appeared to be defended by unpaired male pygmy-owls during the breeding season. The number of detections for the six sites combined in 1998 was 203. All three nests were located in northwest Tucson. One of the remaining territories was in northwest Tucson and two were located in the Marana/Redrock area.

In the northwest Tucson area during 1998, three nest sites, one territory held by an unpaired male and two new territories established by dispersing juveniles occurred within relatively short distances from each other. Figure 2 shows nearest neighbor distances using nest sites and select detection sites centered within territories held by unpaired pygmy-owls. The closest distance was between a nest site and a territory held by an unpaired adult at 1.3 km. The closest nest sites were 3.3 km apart. The greatest distance between any two nearest neighbors was 3.6 km.

The nest sites were monitored intensively throughout the breeding season while the Marana/Redrock territories were visited by AGFD only once after they were initially detected by consultant biologists. The remaining northwest Tucson territory was monitored intermittently from January to July with at least one detection each month. Detection success was increased with the aid of radio transmitters placed on fledglings in June and July. Monitoring effort is summarized in Tables 7 and 8.

Table 6. FEPO occupation history of known territories in Pima County, Arizona, 1993 - 1998.[a] 1 = occupation confirmed, 0 = occupation not detected, male = unpaired male, nest = nesting confirmed, pair = 2 birds observed- nesting status unknown, unk - unknown sex, 2 = late occupation by dispersing juvenile, ----- = no survey completed

Site	1993	1994	1995	1996	1997	1998	Total Yrs Checked	Total Yrs Occupied
93SN	1 - male	1 - male	1 - male	1 - male	0	2 - male[b]	6	4
94CM	-----	1 - male	1 - male	1 - male	0	0	5	3
95S	-----	-----	1 - nest	1 - male	0	0	4	2
95B	-----	-----	1 - male	0	1- nest	1 - nest	4	3
96T	-----	-----	0	1 - nest	1- male	1 - male	4	3
96L	-----	-----	0	1 - male	2 - male	1 - nest	3	2
96SB	-----	-----	-----	1 - pair	1 - male	0	3	2
98DM	-----	-----	0	0	-----	1 - nest	1	1
98SR	-----	-----	-----	-----	-----	2 - male	1	1
98CC	-----	-----	-----	-----	-----	2 - unk	1	1
98CF	-----	-----	-----	-----	-----	2 - male	1	1
98GW	-----	-----	-----	-----	-----	1 - male	1	1
98PW	-----	-----	-----	-----	-----	1 - male	1	1

[a] Occupation histories are based on present understanding of territory boundaries. Future observations may change territory sizes and occupation records. A territory is considered occupied when a pygmy-owl is detected in the same area on at least two different occasions

[b] This territory appeared unoccupied during regular breeding season surveys, but a dispersing juvenile arrived and remained within the territory in August.

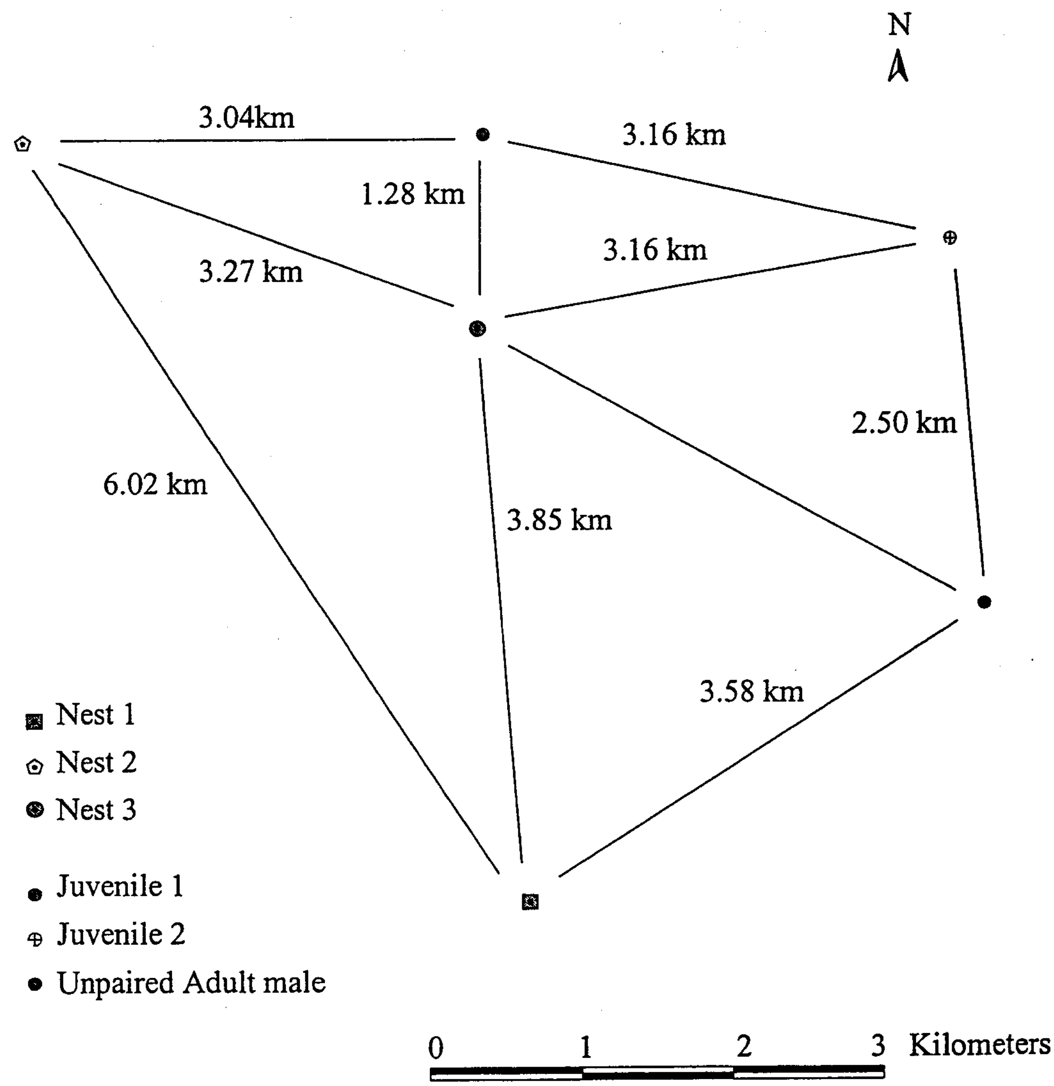


Figure 2. Cactus ferruginous pygmy-owl nearest neighbor distances including three nest sites, an unpaired male and two dispersing young of the year in northwest Tucson, 1998.

Table 7. Monitoring effort at three FEPO nest sites in northwest Tucson, Pima County, Arizona, 1998.

Nest Site	Initial Date[a] of Detection	Prior Visits[b]	Total Visits[c]	Detections	Total Days	Total Hours	Mean Hours per visit	Mean Hours per day
95B	2 February	3	65	59	61	105.00	1.61	1.72
98DM	25 February	2	74	68	66	138.25	1.86	2.09
96L	12 March	5	59	56	52	106.25	1.80	2.04
Total/Mean	Feb - March	3.33	198	183	95[d]	349.50	1.77	3.67

[a] Date when a pair of birds or nesting was confirmed.
[b] The number of visits prior to the discovery of paired birds or the nest including the discovery visit.
[c] The total number of monitoring visits during the entire breeding season.
[d] This total counts days with visits to multiple sites only once.

Table 8. Monitoring effort at FEPO territory "96T" defended by adult male in northwest Tucson, Pima County, Arizona 1997-98.

Year	Initial Date[a] of Detection	Prior Visits[b]	Total Visits[b]	Detections Total	Detections Rate[c]	Total Days	Total Hours	Mean Hours per visit	Mean Hours per day
1997	21 Aug 97	6	23	5	17.85	22	19.50	0.84	0.88
1998	9 Jan 98	1	21	15	71.42	19	18.50	0.88	0.97
Totals	Jan - Aug	7	44	20	40.81	41	38.00	0.86	0.92

[a] Date of first aural detection for the current breeding season.
[b] The number of visits prior to the first aural detection including the day of detection
[c] Rate of detection (percent) for the field season - includes all visits before and after the initial detection.

Nest Productivity and Number of Pygmy-Owls in Greater Tucson

One pygmy-owl nest in 1997 produced four young that successfully fledged and survived through dispersal. Observations of nesting adults, young and solitary birds at different territories by AGFD resulted in confirmation of eight individual pygmy-owls in 1997. Two additional individuals were detected briefly by residents at a territory where a nest was located in 1995 in the Marana/Redrock area. Though not confirmed by AGFD, these detections were by observers with extensive observation experience of pygmy-owls and their nesting behavior and are considered reliable.

In 1998, three nests closely monitored by AGFD successfully fledged a total of 11 young. Nine young (81.8% of total fledged) were regularly observed until dispersal. Fecundity (mean number of young fledged per nest site) in northwest Tucson during 1998 was 3.66. Fecundity for both 1997 and 1998 (N=4) was 3.75. When all nests with known number of fledglings were combined (1996-1998, N=5) fecundity was 3.66. The mean number fledged at the only nest site where we have productivity data for both years was 4.5 young. AGFD observations of nesting adults, surviving young and unpaired males at other territories resulted in confirmation of 20 individual pygmy-owls in 1998. Table 9 compares number of young fledged with the number surviving through dispersal (N=6) from 1996 to 1998. The combined number of fledglings for all years was 22. The known number surviving through dispersal for all sites was 19 (dispersal efficiency = 86.4%).

Mortality. We were able to monitor nine of 11 young from the time they fledged until dispersal. Two juveniles from one nest site were missing by the third week after fledging. One of these apparently sustained an eye injury during fledging and was regularly observed with one eye closed during 10 days prior to its disappearance. During most of that time, it appeared stable though frequently remaining apart from the other two fledglings. During the last few days of observation, it began to look lethargic. It was not observed on day 11 post fledging and we could not find a carcass. We suspect the eye injury may have developed a secondary infection that weakened the bird and directly caused its death or made it vulnerable to predation. The second juvenile was observed through day 23 post-fledge and then disappeared. No carcass was found. This pygmy-owl appeared extremely active and the most skilled of the three juveniles in flight and maneuverability during our observations. We suspect it was also predated, but have no evidence to support that conclusion.

Table 9. Comparison of FEPO nest productivity in Pima County, Arizona, 1996 - 1998.[a]
NWT = northwest Tucson; OPNM = Organ Pipe National Monument.

Year	Territory Name	Location	Fledge Date	No. Fledged	No. Dispersed
1996	96T	NWT	6-04-96	2	1
1997	95B	NWT	5-28-97	4	4
1998	95B	NWT	5-31-98	5	5
1998	98DM	NWT	6-01-98	3	1
1998	96L	NWT	5-31-98	3	3
1998	98OP	OPNM	5-20-98	5	5
Totals	6	_____	20 May - 6 June	22	19

[a] One nest site in 1995 was not included in this table because it was discovered late in the season and the discovery of only one fledgling may not account for the total number fledged.

Vocalizations and Behavioral Observations

Monitoring of one nest site in 1997 and three in 1998 combined with other detection site monitoring provided numerous opportunities to hear pygmy-owl vocalizations and observe behavior. We were also able to compare these observations with those from nest sites monitored in 1995 and 1996. The most familiar pygmy-owl vocalization is the single pitch, repeated note most often associated with the male. This call is the typical vocal response given by territorial males when solicited with taped-call broadcasts of the same type. Territorial calling by resident males used to defend against intruding males or to advertise their presence to females can vary in intensity, frequency and duration. A male may call just one or two notes, or many notes during one or multiple calling sequences. We have documented individual males calling 200 notes or more without a pause. Some calling may be soft and difficult for observers to hear while other calling may be loud and aggressive. Although usually softer and of shorter duration, this same call is often used by the male during nesting to announce its presence to the female or young in preparation for a prey delivery. The male's single note calling has been heard at all nest sites and is the primary evidence used to detect pygmy-owls during surveys.

The female pygmy-owl has also been heard using the single pitch repeated note call near the nest site, but its use was rare and appeared to be a form of communication with the adult male. The most familiar female call heard at all nest sites is a "chitter". This rapid "trill-like" high-pitched call is used in short sequences. The frequency and duration of chitter calls can be variable and have not been heard outside a nesting territory. The female chitter is typically associated with food-begging directed toward the male, with prey deliveries, and in communicating with fledglings to announce the presence of food. The female also chitters for extended periods of time just before and after copulations, apparently announcing her readiness to the male, and when young are about to fledge.

We recognized an alarm call at all nest sites in northwest Tucson during 1997 and 1998 which was similar to calls documented from the 1996 nest site. This call was most often associated with the female, but both male and female adults were heard using an alarm call particularly during the early fledgling period. This call was usually heard when an observer approached fledglings within 20 meters or less. The call is characterized as a chirp and was used before escape flight, in sequences while remaining at one perch, or while moving between several nearby perches. The alarm chirps were one to three single pitch notes and most often two notes in one or more sequences. Once the observer moved away, the alarm chirp ceased.

Nestlings and fledglings were heard calling at all monitored nest sites from 1996 to 1998. These vocalizations are similar to the female chitter, but at a higher pitch and lower volume. The tone can be described as a thin metallic-like or rattling sound. This call appears to be mostly associated with food-begging directed toward both the male and female. They were first heard while the young were in the nest cavity and we were able to hear them more frequently after the young had fledged. It appeared fledglings called almost constantly for the first few weeks they were outside the nest. The call seemed to be used by all fledglings and we assumed there was no difference between male and female calls at this age.

On one occasion, a "distress scream" was heard after a fledgling was captured by hand. The sound was very loud and high pitched. It was unknown prior to this event and emitted only once. It appeared this was a response to imminent danger, perhaps to distract a potential predator, and to alert adult owls. More often, recent fledglings emitted a softer trill or chirp when initially handled and then remained silent during processing.

Fledgling Interactions. Fledglings maintained a relatively close association from the time of fledging until near dispersal. This may reflect adaptive behavior to insure regular access to prey deliveries by adults and may afford some protective advantage through group warnings of nearby danger. Mobbing birds or potential predators could be more easily detected and driven off by adults supervising young that congregate in the same tree or on the same branch, instead of separating. Mutual grooming and beak rubbing was observed at all nest sites with some young engaging in these activities more frequently than others. We were not able to characterize any juvenile interactions as overtly aggressive, but did observe position swapping, pushing, and following each other from perch to perch. During prey deliveries and feeding, fledglings would tend to congregate closer to each other, but frequently on separate perches. While intently watching the adult tearing and feeding prey to one or two siblings, the remaining young appeared to simply wait their turn and allow the adult to bring prey to them. In contrast, observations of young being fed by adults in Texas suggest greater aggression or squabbling between siblings over prey (Proudfoot - personal communication). In Arizona, the adult female would sometimes feed two or three young at once when they all shared the same perch. As the young matured and became more skilled at tearing and feeding themselves, they appeared less inclined to share the prey, moving or turning away from siblings nearby.

Adult Interactions. Once incubation began, adult male and female interactions were limited almost exclusively to behaviors associated with prey deliveries and exchanges. The male would typically announce his presence by perching within sight of the nest cavity and calling. The female often would come out of the cavity, fly to the male's perch, and retrieve the prey directly from the male. Both birds are very vocal during this time. Less often, the male would deliver prey directly to the cavity and fly off almost immediately. During some prey exchanges the male would remain near the female and on the same perch for a brief time, however after most exchanges, the male would leave quickly and fly out of our sight. Rarely, we observed one adult entering the nest cavity and was quickly followed by the second. Both remained in the cavity from a few seconds to several minutes. Once the young fledged, the female appeared more aggressive toward the male and was observed on several occasions flying at him and driving him off his perch.

Aggressive Defense of Young. When observers searched for recently fledged young during 1997 and 1998, one or both adults would frequently fly to a nearby perch to investigate our activity and would often use the alarm call (see vocalizations) or sometimes chittering by the female. When searching for fledglings at two different nest sites in 1998, three observers were struck on the back of the head during three separate incidents. During our searches, we would sometimes get very close to fledglings and would not be aware of their presence until hearing adult alarm calls. Adults stooped on observers shortly after the calls were heard. This very aggressive behavior by adults seemed to decrease as young matured.

Adult pygmy-owls were also seen aggressively pursuing some birds near or threatening their young. During one of our attempts to capture a recently fledged juvenile pygmy-owl, a gila woodpecker exhibited very aggressive behavior towards the juvenile owl. The adult male pygmy-owl immediately responded by diving at the intruding woodpecker on multiple occasions, successfully driving off the woodpecker. Even non-aggressive birds such as mourning or white-winged doves were sometimes pursued or knocked off perches when they landed near young pygmy-owls.

Mobbing. We defined mobbing as the harassment or aggressive attack of pygmy-owls by two or more birds of the same or different species. This collective behavior ranged from passive alarm vocalizations while perched within a few meters of an owl to loud vocalizations and repeated jabs from a perch or during short flights, sometimes making contact. The noise and movement of mobbing birds often attracted our attention and resulted in detections of pygmy-owl adults and young that may otherwise have gone unseen. Sixteen different species were observed engaging in mobbing behaviors. These birds ranged in size from hummingbird species to as large as greater roadrunners. Birds observed mobbing pygmy-owls in the greater Tucson area from 1995 to 1998 are listed in Appendix K.

We also observed solitary birds reacting to pygmy-owl presence with aggressive or mobbing-like behaviors. Similar to groups of mobbing birds, the intensity of individual reactions was variable. During one nest monitoring session, a juvenile pygmy-owl was perched in an ironwood tree approximately 0.9 m from the ground. A female Gambel's quail (*Callipepla gambelii*) with her brood approached in close proximity to the perched owl. Upon detection of the owl, the adult female quail left her brood and flew at the owl, knocking it from its perch. The owl flew to a nearby tree and was pursued by the female quail. The quail again succeeded in chasing the owl from its perch. The owl flew out of sight of the observer and the quail returned to her brood.

Several interactions between greater roadrunners (*Geococcyx californianus*) and pygmy-owls were also observed during nest monitoring. On two occasions, a greater roadrunner was observed hopping from branch to branch around an adult pygmy-owl coming close to making contact while lunging and then moving away. While roadrunner's are certainly capable of capturing and killing recently fledged pygmy-owls, its behavior during both incidents appeared to be more harassment and similar to mobbing by songbirds (see mobbing). In both cases the owl showed little reaction to the roadrunner's activity. During a third incident in 1997, a roadrunner was suspected of trying to steal a prey item from a juvenile pygmy-owl. During the other interactions with pygmy-owls, roadrunners may have also been investigating the possibility of pirating a meal.

Mobbing Responses to Taped Broadcasts . In addition to reactions to pygmy-owl presence, mobbing-like behaviors from a variety of bird species were observed in response to taped-call broadcasts during population surveys. As with reactions to perching pygmy-owls, the level of response to broadcasts was variable. Responses included one or more birds calling from a distance away, calling birds flying back and forth between perches within a few meters of our position and their original perch some distance away, and a group of mixed species flying to a nearby tree and vocalizing loudly while moving rapidly between perches.

The reaction of pygmy-owls to mobbing birds was also variable. Sometimes pygmy-owls appeared to ignore the harassment and remained on their perch until the offenders stopped and moved away. In 1998, a recent fledgling appeared stunned or indifferent while being attacked and struck on the head repeatedly by a black-tailed gnatcatcher. On other occasions, owls simply flew off to escape their tormentors, though often followed from perch to perch. In 1997, we observed an adult female fly into a nearby saguaro cavity to escape mobbers and the same female attacked mobbers when they were harassing its young that had recently fledged. Occasionally, pygmy-owls actually made contact when chasing off mobbers, but we could not determine if this effort was a capture attempt or scare tactic.

Potential Predators and Pygmy-Owl Response

The most common potential avian predators observed near pygmy-owl nesting and detection sites were Harris hawks (*Parabuteo unicinctus*) and great horned owls (*Bubo virginianus*). Similar to pygmy-owls, both species utilize saguaro cactus and tall native and non-native trees for hunting, social interactions and nesting. In addition, unlike pygmy-owls, both species will frequently take advantage of power poles and other man-made structures often located near pygmy-owl sites.

In 1997, a pair of great horned owls nested in the vicinity of a pygmy-owl nest cavity. While the actual nest was not located, regular activity by the adults and observations of great horned owl fledglings indicated the pygmy-owl nest was within the nesting territory of these larger owls. Both great horned owls and pygmy-owls successfully fledged two and four young respectively. The disparity between high activity periods for these species (nocturnal vs crepuscular or diurnal) may account for the apparent lack of interactions or threat of predation that we observed. Regular observations of great horned owls appearing on perches near dusk to begin nightly activities, offered little evidence for the threat of predation or specific responses by pygmy-owls. Pygmy-owls were normally less vocal or silent at this time of day and were less likely to be moving from protective perch sites. However, this diminished activity was relatively consistent at all pygmy-owl nest sites regardless of great horned owl presence and we could not determine if this passivity was a response to a predatory threat.

Harris hawk activity was very common near most pygmy-owl detection or nest sites and was often observed during the early morning pygmy-owl high activity period. On 10 occasions in 1997, Harris hawks were observed perching within a pygmy-owl nest territory approximately 75 m or less from perching pygmy-owls. During eight of these events, calling adult and/or juvenile pygmy-owls ceased vocalizations and remained stationary until the hawk left the area. In contrast, during the two other events, the pygmy-owls continued their activity and did not appear to be threatened by the hawk's presence. Other large raptor species observed near pygmy-owl territories were red-tailed hawks (*Buteo jamaicensis*) and Cooper's hawks (*Accipiter cooperii*). These observations were rare however, and no interactions or pygmy-owl responses were observed.

Three smaller raptors were observed or detected sporadically near pygmy-owl use areas. These were the American kestrel (*Falco sparverius*) the western screech owl (*Otus kennicottii*) and the elf owl (*Micrathene whitneyi*). No direct interactions with these species or responses by pygmy-owls were observed. Similar to pygmy-owls, kestrels, screech owls and elf owls are cavity nesters and utilize saguaros for nesting substrate (Hardy, 1997). In addition, there is some overlap in the types of prey used by all four species. Consequently, pygmy-owls, kestrels, screech owls and elf owls may be attracted to the same areas for similar reasons and aggression may be attributed more to competition than predation. In 1997, a screech owl was observed napping in an ironwood tree approximately 30 meters from a pygmy-owl nest cavity. There was no response from pygmy-owls in the area and it is possible they may not have been aware of its presence.

Nesting Chronology

Intensive monitoring of northwest Tucson nest sites by AGFD in 1997 and 1998 and observations of another nest by the National Park Service in 1998, has provided data to support nest chronology estimates for pygmy-owls in southern Arizona (Figure 3). The first pygmy-owl detected during 1997 was on 24 February and in 1998 we confirmed the first individual on 9 January. During 1998, copulations were observed on 9 March at one site and on 11 and 19 March at a second site. No copulations were observed during 1997. Despite numerous hours of observing pygmy-owl pairs from 1996 to 1998, no other copulations were observed after March. (*1996 - copulation on 31 Mar.*). Proudfoot (1996) reports the commencement of egg-laying in Texas from 17 to 26 April and 32 to 39 hours between each egg laid. Based on these observations, we calculated the time required for clutch completion at 4.0 - 4.9 days for a clutch size of 4 eggs and 5.3 - 6.5 days for a clutch of 5. The incubation period was reported as 21 - 23 days (Proudfoot, 1996) and ranged from 25.3 - 29.5 days if we combined the egg-laying period with sustained incubation. This compares favorably with 28 - 30 day incubation periods reported by Scherzinger (1977) and Terres (1991). Hatching was reported as asynchronous with 20-26 hours between each egg (Proudfoot, 1996), and we calculated the range of time required for completion of hatching for clutches of 4 and 5 eggs at 2.5 - 4.3 days. Using egg-laying, incubation and hatching data reported for pygmy-owls in Texas and our direct observations of fledging at all nest sites during 1997 and 1998, we determined breeding chronology estimates for all pygmy-owl nest sites combined in northwest Tucson. We also assumed clutch sizes were equal to the those reported for Texas. Since actual fledging was observed from 28 May to 1 June, egg-laying was estimated to take place from 3 -15 April. We determined incubation to begin 9 - 11 April and egg-hatching at 27 April to 3 May. The nestling period occurred from 27 April to 1 June. Dispersal was detected at 56 to 62 days after fledging from 25 July to 1 August.

Captures and Color Band Marking

We captured 2 fledglings during 1997. One was captured with a hand held net and the other by hand. Each was color banded on the right leg, one with yellow and the second with a red band. During 1998, we captured all 11 fledglings from the 3 nest sites and 1 adult each from two sites. One adult was a female from a nest site and second adult was a male from a territory where nesting was not detected. Eight fledglings were captured by hand, one was trapped in a mist net, and two were obtained using a hand held net. The adult female was captured in a mist net positioned between favored perches and the adult male was trapped using a bow-trap baited with a house sparrow. All 15 pygmy-owls captured in 1997 and 1998 were marked with color bands to differentiate each individual (Appendix L).

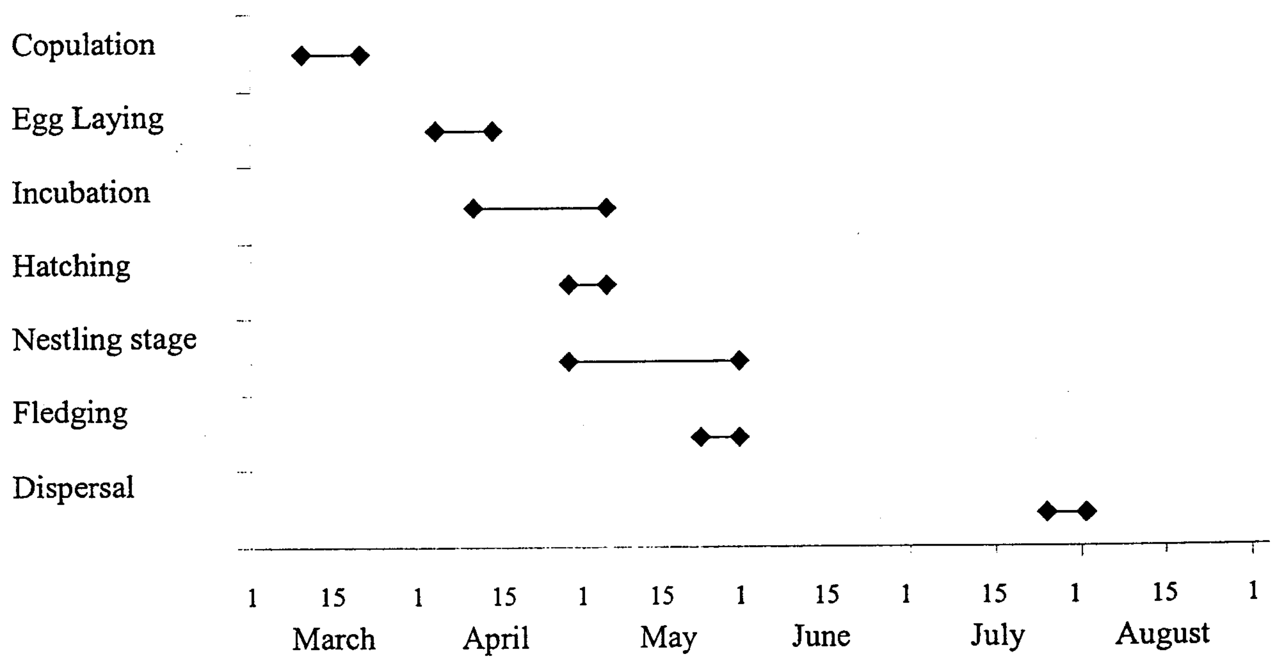


Figure 3. Breeding chronology estimates based on three pygmy-owl nest sites in northwest Tucson, Pima County, Arizona, 1998.

1997 Post-Dispersal Observations of Color-Marked Juvenile Pygmy-Owls

Dispersal. During post-dispersal surveys in 1997 we confirmed the location and distance traveled of one color-marked pygmy-owl (see Radio Telemetry and Dispersal) through visual observations of its red-color band and without the use of radio telemetry. This individual was first detected by a resident when it was calling spontaneously . Follow-up tape-broadcast surveys in the area were successful in eliciting a vocal response and we were able to observe this bird directly by following the direction from which it was calling.

Juvenile Calling and Territory Defense. The spontaneous calling and vocal responses to taped-call broadcasts were clear, vigorous, one-pitch repeated notes identical to adult male advertising and defense calls. The weak "chitter-like" vocalizations heard during nestling and fledgling stages were absent and we would not have recognized this pygmy-owl as a young of the year without seeing the color band. The strength and frequency of calling by this individual both spontaneously and in response to our broadcasts indicates defensive behavior within a newly established territory, after departure from its natal area just 3 weeks earlier.

First Year Breeder. The red-banded juvenile appeared to remain in the general area where it was detected after dispersal through the Fall. It was heard and observed in October approximately .4 km. south of the first location. It was located again in March 1998 approximately .8 km west from its last location and by the end of March we confirmed the presence of a second pygmy-owl near the red-banded individual. Prey deliveries and behavior indicated this pair was nesting.

Incest. Intensive monitoring of this nesting pair using spotting scopes revealed the identity of the female pygmy-owl as the sibling of the red-banded male. The yellow banded female was the only other pygmy-owl color-marked during previous years. This pair of birds confirmed first year reproductive success for both a male and female pygmy-owl as they fledged 3 young which survived through dispersal in 1998. These 2 siblings were last seen together prior to dispersal on 25 July 97. An observer reported a close association between these juveniles and observed them engaging in beak rubbing and mutual preening. When one moved to another perch, the second bird would follow it. It is not known if this pair remained near each other through the Fall and Winter months or if they found each other at the start of the new breeding season. The male (red-banded) pygmy-owl was observed on several occasions after dispersal, but the female (yellow-banded) was not detected until nesting was confirmed in the Spring 1998.

Juvenile Survival. The observation of these color-banded juveniles during the 1998 breeding season confirmed their place of origin and age. The same nest which produced these marked individuals successfully fledged a total of 4 young during 1997 and indicates a minimum 50 percent survival rate for this nest.

Radio-Marking, Telemetry and Dispersal

Pygmy-owls were not radio-marked in 1997. However, as indicated above, the dispersing red color-marked juvenile was relocated and confirmed as a previously encountered bird approximately 3 weeks after the last sighting near its natal area. Vocal responses to tape broadcasts in the same area suggest this individual may have been present in its new territory within 14 days of dispersal. This juvenile pygmy-owl had moved a known distance of 4.0 km (2.5 mi) at a direction of 3 degrees north.

During 1998, one unpaired adult male pygmy-owl and 4 juveniles were equipped with backpack style radio transmitters when initially captured. The adult male was tracked from 23 to 26 March, but removed the transmitter on day 4, leaving it inside a saguaro cavity. Relocations of this bird were all near the capture location and within 500 - 600 m of each other during 4.5 hrs of tracking over 6 sessions.

Two juvenile pygmy-owls from one nest site and one each from the two other nest sites in Tucson during 1998 were relocated numerous times during nest monitoring from the time of capture until dispersal. All of these early locations were within 400 m of the nest site. We continued to radio-track each individual from the first dispersal movement outside the natal area (25 July - 1 August) until radio transmissions ceased due to battery failure. Three radios failed on 27 August and the fourth ceased transmissions on the 2 October 1998. Transmissions by the last radio were extended because the bird was captured and radio-marked approximately 4 weeks later than the others. We tracked the 4 radio-marked juvenile pygmy-owls 131 hours over 55 days (Table 10.) Figure 4 compares dispersal routes and distances. Figure 5 indicates direct linear distances and directions from natal areas to new territories.

Juvenile 1 from nest 96L4 dispersed 55 days post-fledge on 25 July 1998. Our first relocation for this individual was 1.9 km (1.2 mi) southwest at bearing 259 degrees from where it fledged. We tracked this pygmy-owl over 6 days and recorded a total known distance traveled of 7.96 km (4.95 mi) until we could not detect the signal from the ground. On 3 Aug juvenile 1 was located by aerial survey and we were able to track this bird until it arrived at a new territory. The overall known distance traveled for this individual was 20.59 km (12.8 mi.) over a minimum of 11 days. This juvenile remained in its new territory through the time of its last detection of the season on 29 August 1998. The location where this bird was last detected was 6.27 km (3.9 mi.) at bearing 335 degrees from where it fledged.

Juveniles 2 and 3 from nest 95B4 dispersed 62 days post-fledge on 1 August 1998. We relocated juvenile 2 on the day it dispersed 1.52 km (0.95) mi bearing 16 degrees from the nest site. We tracked juvenile 2 a known distance of 7.24 km (4.5 mi) over 5 - 11 days until it arrived in a territory where it remained through our last detection on 1 October 1998. This location was 7.24 km (4.5 mi) at 32 degrees northeast from its natal area. Juvenile 3 was relocated for the first time after dispersal 2.0 km (1.26 mi) at bearing 84 degrees east. This individual moved a known total distance of 5.92 km (3.68 mi) over 9 days until arriving at a new territory where it remained through our last detection on 26 August 1998. The location where it was last detected was 57 degrees east and 3.62 (2.25 mi) from where it fledged.

Juvenile 4 from nest 98DM1 dispersed 57 days post-fledge on 26 July 1998. Initial dispersal at the time of our first relocation was 301 degrees northwest and 3.45 km (2.15 mi) from where it fledged. This individual flew a known total distance of 18.18 km (11.3 mi) over 5 - 7 days until arriving at a new territory where it remained through our last detection on 26 August 1998. This location was 356 degrees northwest and 10.69 km (6.65 mi) from its natal area.

Preliminary Size Estimates of Areas Used by Adult Males. The use of radio telemetry and multiple detection locations of three territorial adult male pygmy-owls provided preliminary size estimates of use areas during the early breeding season. Two males that eventually paired (both in 1998) used approximately 20 and 35 acres respectively prior to pairing. A third unpaired male (also in 1998) used approximately 40 acres. Data available for one of the paired males indicated his use area decreased to approximately 10 acres after pairing had occurred. In contrast, the unpaired male's use area actually increased later in the breeding season about the time successful pairs were fledging offspring. When all breeding season locations for this unpaired male are combined, the area used was approximately 220 acres.

Table 10. Post-dispersal radio-tracking effort for juvenile pygmy-owls in northwest Tucson, Pima County, Arizona, 1998.

Nest Site &Owl I.D.	Dispersal Date	Tracking Days	Tracking Sessions	Tracking Hours	Total Relocations	Detection Type	
95B4-4	1 Aug 98	47	63	42.00	61	54	7
95B4-6	1 Aug 98	24	36	29.25	35	31	4
98DM1-1	28 July 98	22	25	26.25	21	17	4
96L4-1	25 July 98	24	26	33.50	22	21	1
Totals	----------	55[c]	150	131	139	123	16

[a] R = radio-detection only
[b] V = visual detection
[c] This total reflects days when multiple birds were tracked.

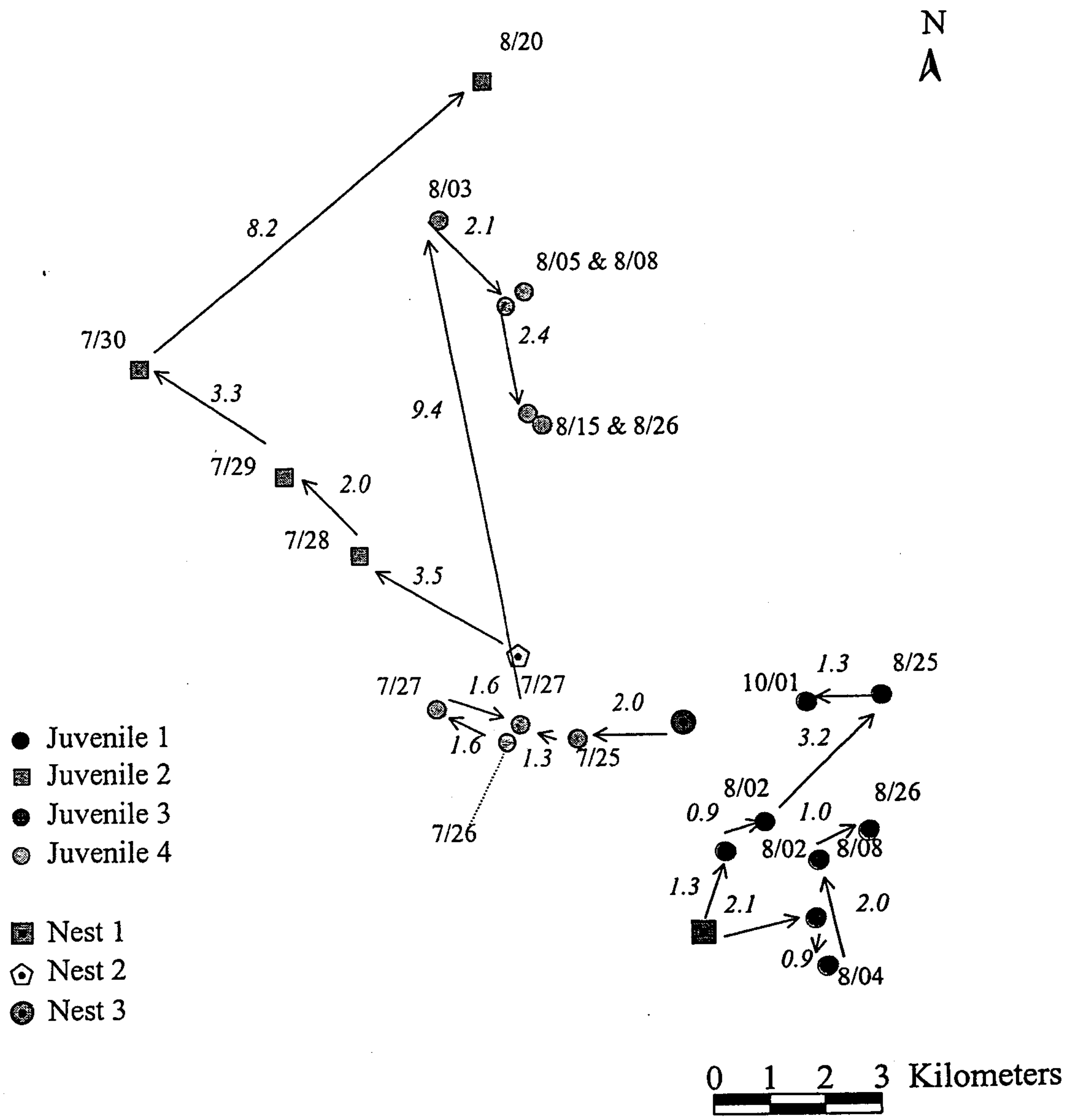


Figure 4. Dispersal routes and movement distances (kilometers) of four radio-marked juvenile pygmy-owls in Pima County, Arizona, 1998.

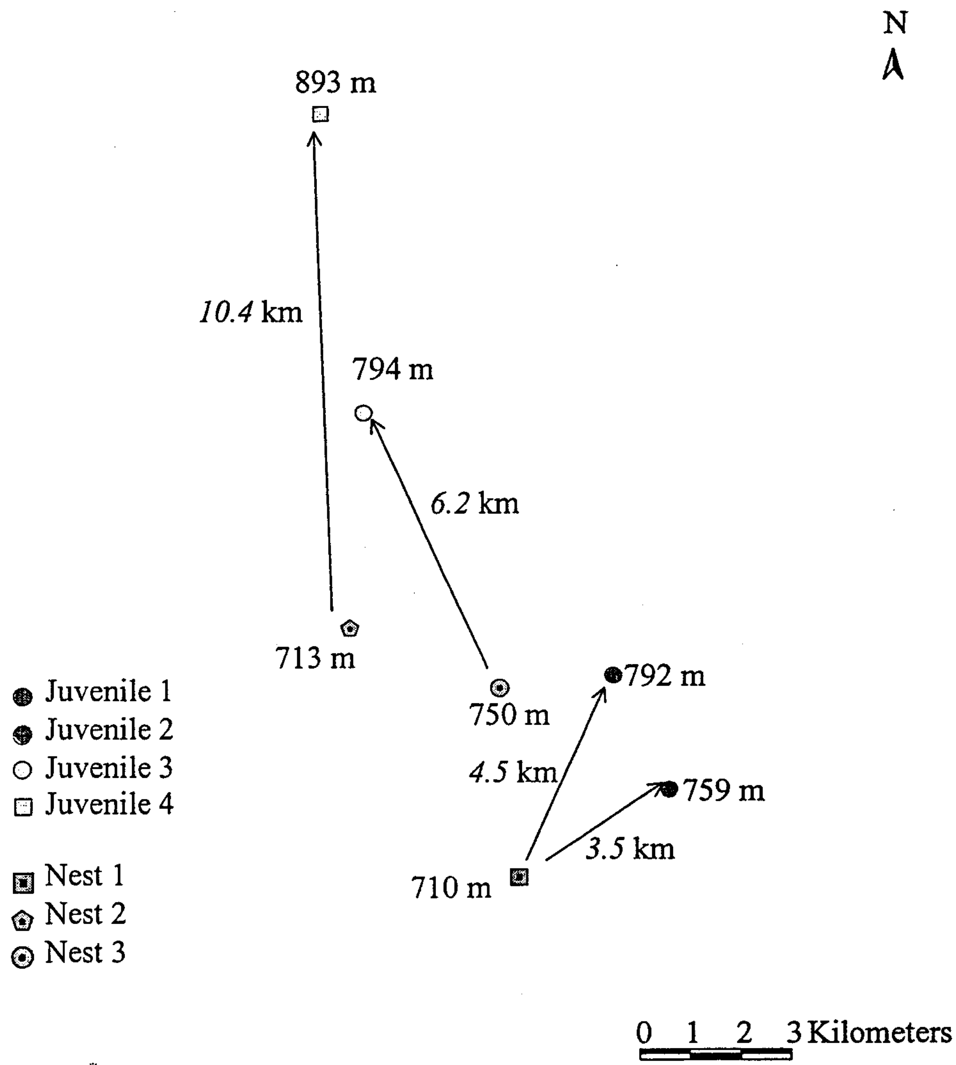


Figure 5. Direct linear distances and elevations between nest sites and newly defended territories for dispersing juvenile pygmy-owls in Pima County, Arizona, 1998.

Prey Descriptions

Direct observations of feeding events, prey deliveries, caching and associated behaviors by adult and juvenile pygmy-owls were recorded during monitoring of one nest in 1997 and three in 1998. We observed prey from 14 April to 21 July in 1997 and from 27 March to 19 July 1998. We observed 77 total prey items in 1997 with reptiles and birds making up the highest class percentages at 39 and 35 percent respectively (Tables 11 and 12). In 1998, we observed 110 total prey items at three nests combined with 37 percent reptiles and 26 percent birds. Figure 6 compares prey class percentages between three nest sites in 1998. Table 13 summarizes total number of prey items in each class at individual nests for 1998. We were able to identify most prey items (76 percent) to class during both years, with a limited number of prey items identified to species or genus. These included: verdins (*Auriparus flaviceps*), house finches (*Carpodacus mexicanus*), mourning dove (*Zenaida aurita*), Gambel's quail (*Callipepla gambellii*) western whiptail lizards (*Cnemidophorus tigris*), desert spiny lizards (*Sceloporus magister*), zebra-tailed lizards (*Callisaurus draconoides*) and a kangaroo rat (*Dipodomys* sp.). We also observed a juvenile holding a butterfly and an adult catching and eating grasshoppers. Prey items identified during nest monitoring and general observations from 1995 to 1998 are listed in Appendix M.

We observed 187 prey items from all nest sites combined during 1997 and 1998. We recognized a number of additional prey deliveries by observing specific behaviors and vocalizations, but some of these were not included in the total since interpretation of these events was often subjective. Reptiles and birds accounted for the highest percentages of prey at 36 and 30 percent respectively for both years combined. Mammals accounted for only seven percent of observations and insects represented two percent of the detections for both years combined. The smallest prey items recognized were grasshoppers and the largest was a mourning dove. Figure 7 compares yearly prey class percentages from 1996 to 1998. Figure 8 shows prey class percentages for all nest sites combined from 1996 to 1998.

Hunting and Feeding. A total of 46 feeding events (adults feeding young) were observed during both 1997 and 1998 combined. We knew many additional feeding events occurred, but were hidden from our view. Females were detected feeding young on 38 occasions (79% of observed feeding events), while males were detected feeding young only five times (13 %). The sex of adults feeding young on three other occasions was undetermined. Adult males and females were usually distinguished by behavior and vocalizations.

Hunting was done exclusively by males throughout incubation and during the early nestling period. Females hunted after this time, but appeared to remain very close to the nest site during the late nestling and early fledging periods. We recorded 127 total prey deliveries or captures for both 1997 and 1998 when the hunting adult gender could be determined. We detected 101 total deliveries (57%) by adult males and 26 total deliveries (15%) by females. We could not identify the sex of adults delivering 49 (28%) prey items. We were not able to observe any successful prey captures by juveniles, but at times, young were seen with prey late in the breeding season and we did not detect a delivery by an adult. We suspect several of these prey items were successful captures by juveniles.

Table 11. Number of FEPO prey items identified to class through direct observation at 5 nest sites in northwest Tucson, Pima County, Arizona, 1996 - 1998.

Year	Number of Nests	Total Prey Items	Total Undetermined	Total Reptiles	Total Birds	Total Mammals	Total Insects
1996	1	84	22	47	7	4	4
1997	1	77	14	30	27	5	1
1998	3	110	28	41	29	8	4
Totals	5	271	64	118	63	17	9

[a] Prey items that could not be identified to class.

Table 12. Comparison of FEPO prey class percentages for five nest sites in northwest Tucson, Pima County, Arizona, 1996 - 1998.

Year	Nest Site	Total Prey Items	Percent Undetermined	Percent Reptiles	Percent Birds	Percent Mammals	Percent Insects
1996	96T	84	26	56	8	5	5
1997	95B	77	18	39	35	6	1
1998	95B	39	26	41	23	5	5
1998	98DM	33	33	24	30	9	3
1998	96L	38	18	45	26	8	3
1998	3 nests combined	110	25	37	26	7	4
All Years	5	271	24	44	23	6	3

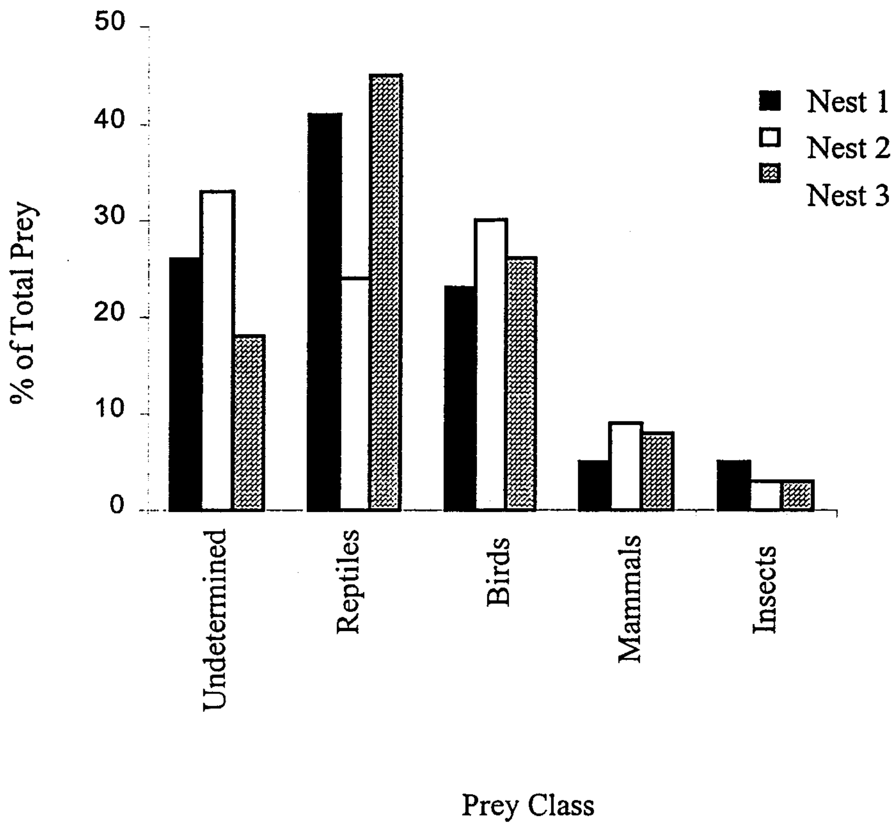


Figure 6. Comparison of prey class percentages at three pygmy-owl nest sites during the same year in northwest Tucson, Pima County, Arizona 1998.

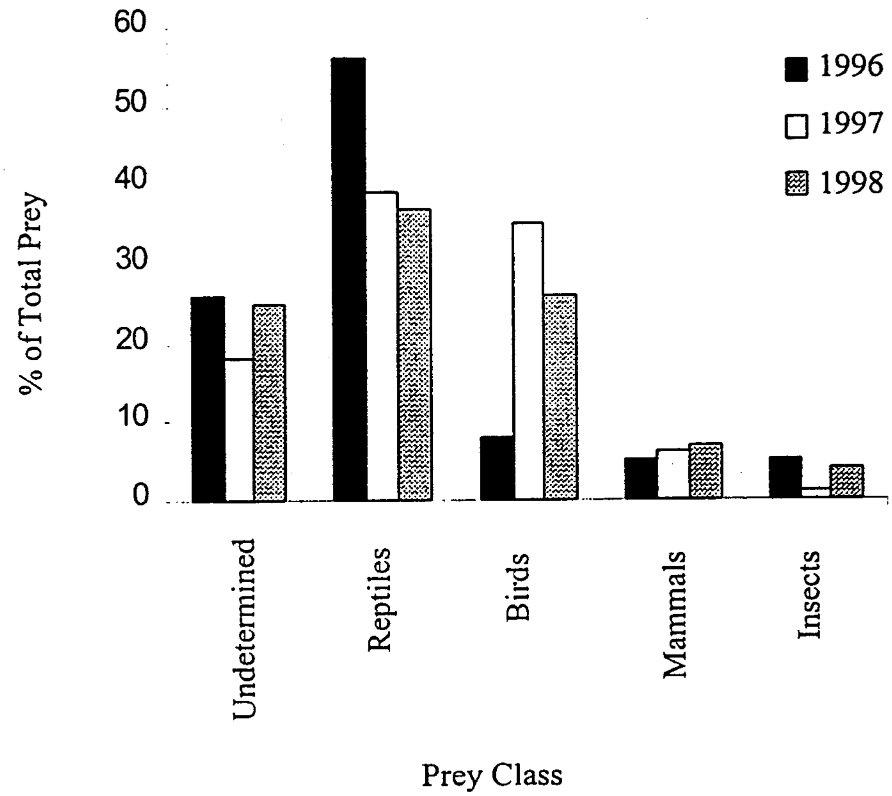


Figure 7. Comparison of prey class percentages between years (1996-1998) in northwest Tucson, Pima County, Arizona.

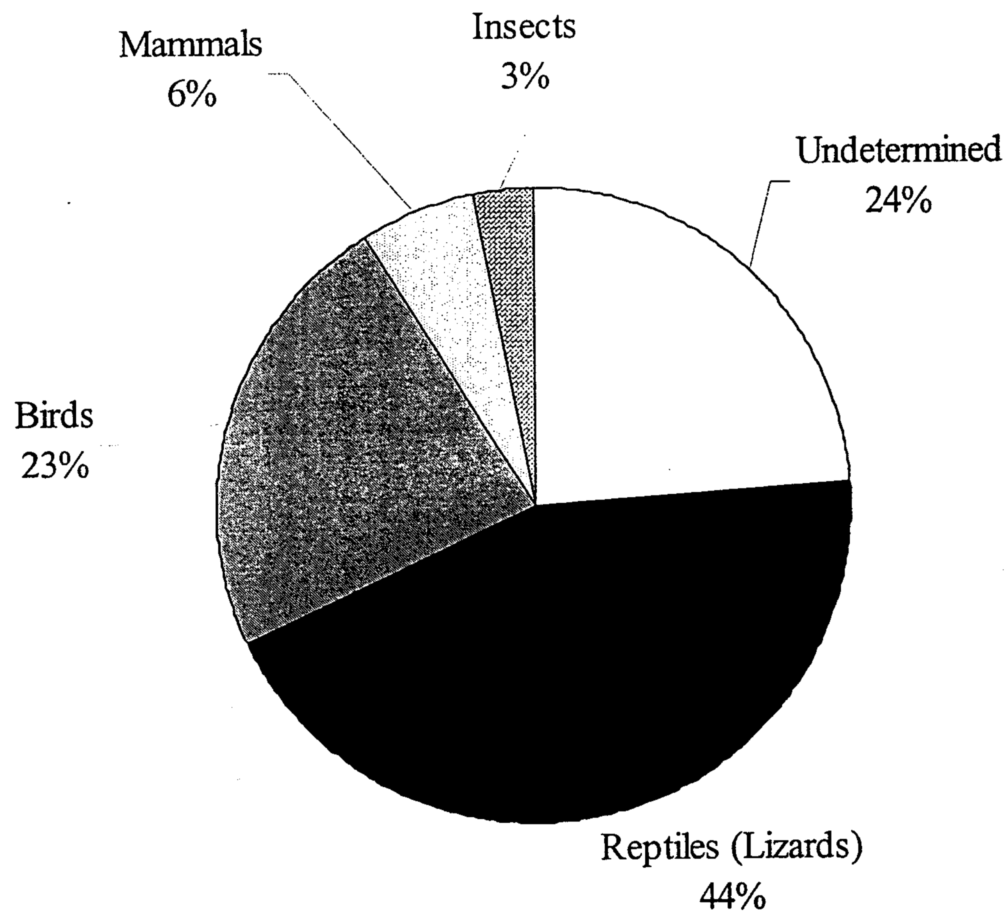


Figure 8. Pygmy-owl prey class utilization based on combined direct observation at five nest sites in northwest Tucson, Pima County, Arizona 1996-1998.

Table 13. Total FEPO prey items at three nest sites in northwest Tucson, Pima County, Arizona, 1998.

Site	Number of Hours[a]	Total Prey Items	Total Undetermined	Total Reptiles	Total Birds	Total Mammals	Total Insects
95B	105.75	39	10	16	9	2	2
98DM	138.25	33	11	8	10	3	1
96L	106.25	38	7	17	10	3	1
Total	330.50	110	28	41	29	8	4

[a] Total number of monitoring hours at each nest site.
[b] Prey items that could not be identified to class.

Small Mammal Trapping

We identified 5 rodent species near the pygmy-owl nest site in 1997 through trapping and observation. We captured 47 individuals representing 4 species. These included desert pocket mice (*Chaetodipus penicilatus* , n = 20), white-throated wood rat (*Neotoma albigula* , n = 18), Merriam's kangaroo rat (*Dipodomys merriami* , n = 3) and Harris' ground squirrel (*Ammospermophilus harrisii* , n = 6). Round-tailed ground squirrels (*Spermophilus tereticaudus*) were observed in the area, but none were captured. Most captures (72%) occurred after dark and overnight (2100 hrs to 0500 hrs). Only 28 percent of total captures were during early morning and evening hours (0500 to 0830 hrs) and (1830 to 2100 hrs).

Habitat Measurements

Habitat characteristics were measured at 21 sample plots located in areas used by pygmy-owls in northwest Tucson and Marana/Redrock (Wilcox et al. 1998). Three sample plots were at nest sites and 18 were detection locations where pygmy-owls were observed perching. All sample plots were located on private residential properties ranging from 3 to 40 acres in size. Most parcels were 3.3 to 5 acres and were generally adjacent to properties similar in size. Point-intercept transects, coverboard measurements and 10 by 10 m quadrat samples were used in an effort to identify vegetative characteristics associated with pygmy-owl use areas and to help refine the most appropriate methodology for more intensive habitat studies. In addition, we determined the numbers of saguaros over two meters in height occurring within the sample plot, examined cavity characteristics to determine if they could be used by pygmy-owls and recorded non-vegetative components of sample areas such as the distance to the nearest water source. A detailed summary of methods and results of these preliminary habitat investigations is presented in Wilcox et al. 1998.

Nest Saguaros and Nest Cavity Characteristics

The nesting substrate selected by pygmy-owls in southern Arizona during 1997 and 1998 is consistent with previous nests in 1995 and 1996. All 7 nests from 1995 to 1998 were located in large mature multi-armed saguaros. Elevations for these locations range from 411.4 m (1350 ft) in Organ Pipe National Monument (OPNM) [T. Tibbits - personal communication] to 769.6 m (2525 ft) in northwest Tucson (NWT). We found 5 nest cavities located in primary arms (saguaro branches growing directly from the main stem) and 2 within the main stem (trunk). Nest cavity aspects ranged from 340^0 northwest to 174^0 southeast. These aspects included four nest cavities facing southeast, two northeast and one northwest. Mean aspect for all nest cavities was 133^0. No west or southwest nest cavity aspects were found. Nest cavity height ranged from 3.81 m in OPNM to 6.2 m in NWT. The mean nest cavity height was 5.14 m. Nest cavity entrance vertical diameters ranged from 4.3 to 7.62 cm and the mean was 5.9 cm. Horizontal diameters ranged from 5.3 to 7.8 cm with a mean of 6.71 cm. Nest saguaro and cavity characteristics are summarized in Table 14. Figure 9 contains photographs of nest saguaros and cavities used by pygmy-owl nesting pairs from 1995 to 1998.

Nest Box Study

Of the 15 boxes erected, six boxes (40 percent) contained evidence of use by birds. However, no pygmy-owls were detected or suspected during our inspections. Five boxes (33 percent) contained well defined passerine nests and included two active flycatcher (*Myiarchus sp.*) nests, one with three eggs and the second with two eggs and one nestling. A third box contained a grass nest of an undetermined species with two broken eggs and one intact. This nest appeared to be abandoned. An unused grass nest was in the fourth box. A third active nest was found in the fifth box with two speckled eggs and a downy chick. No adults were seen and the species was undetermined. The sixth box with evidence of use contained several passerine feathers and scattered undefined debris - possibly nesting material.

Table 14 . Comparison of FEPO nest saguaro and nest cavity characteristics in Pima County, Arizona 1995 - 1998. MR = Marana/Redrock, NWT = northwest Tucson, OPNM = Organ Pipe National Monument.

Year	Site	Location	Elevation		Saguaro Height		Nest Cavity Arm Height		Cavity Height[a]		Cavity Aspect	Cavity Location[b]
			m	ft	m	ft	m	ft	m	ft		
1995	95S	MR	659.8	2165	8.83	29.0	6.09	20.0	5.25	17.2	18^0	arm
1996	96T	NWT	769.6	2525	8.07	26.5	5.33	17.5	4.26	14.0	24^0	arm
1997	95B	NWT	711.7	2335	8.38	27.5	7.01	23.0	5.40	17.7	174^0	arm
1998	95B	NWT	710.1	2330	8.22	27.0	NA	NA	6.20	20.3	126^0	main stem
1998	98DM	NWT	713.2	2340	9.14	30.0	6.09	20.0	5.30	17.3	110^0	arm
1998	96L	NWT	749.8	2460	8.53	28.0	6.70	22.0	5.80	19.0	138^0	arm
1998	98OP	OPNM[c]	411.4	1350	6.85	22.5	NA	NA	3.81	12.5	340^0	main stem
Mean	------	----------	675.0	2215	8.3	27.2	6.2	20.5	5.14	16.85	133^0	----------

[a] Cavity height is the distance from the lower edge of the cavity opening to the ground directly below.
[b] Cavity location indicates whether the nest cavity is located in the main stem of the saguaro or in one of its arms.
[c] OPNM data provided by T. Tibbitts, National Park Service, OPNM

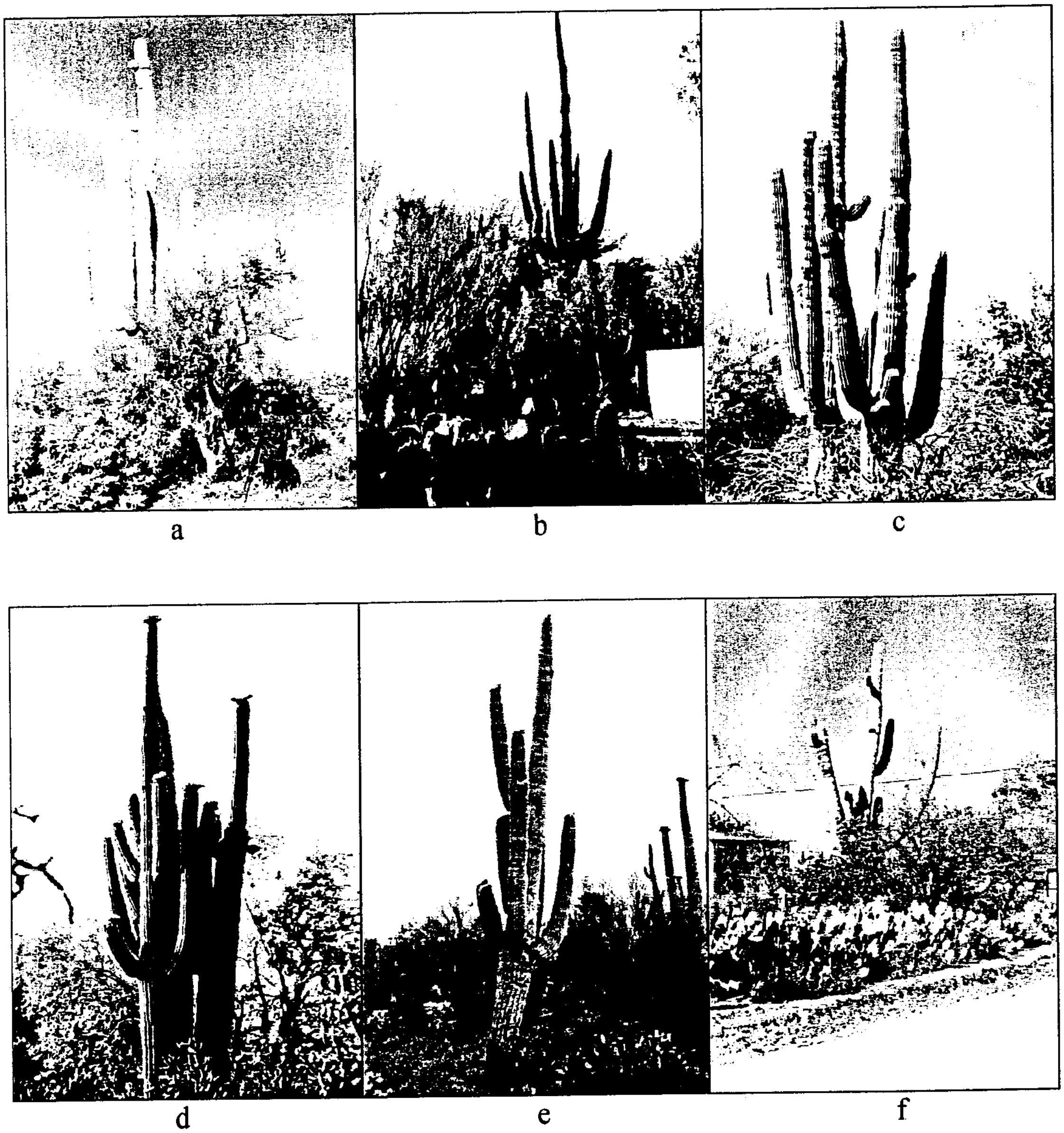


Figure 9. Photographs comparing structure of nest saguaros and cavities used by five pygmy-owl pairs nesting in Pima County, Arizona from 1995 – 1998. One pair each year 95 (a) to 97(c) and three pair in 1998(d – f). (Note: one pair nesting in 97 and 98 used a different saguaro each year (c,d).

DISCUSSION

Survey Protocol

Since 1996, AGFD has employed a pygmy-owl population survey methodology revised from the 1993 protocol (Felly and Corman, 1993). In an effort to increase the chances of detecting a pygmy-owl within a survey area, we extended both the listening and tape-broadcast time to a total of 15 minutes at each call point. This added time reduces the overall coverage during a survey session, but we believe it increases the likelihood of eliciting and hearing a response. While many pygmy-owl detections have occurred during the first 5 minutes of a broadcast and listening sequence, we have documented a number of responses that occurred 15 minutes or longer after initiating the survey at a calling point. Increased survey time for species with higher population abundance would not support the cost and effort for the limited data that would be gained. However, because pygmy-owl numbers are extremely low and every additional individual and nest located may be a significant contributor to the population, concentrated efforts using longer survey times are warranted especially in areas, or at specific sites, where pygmy-owls have been known to occur.

Modifications of the protocol are also necessary at times to adapt to field conditions especially in urban areas. Barking dogs, vehicle traffic noise, trains, and a variety of residential activities may interfere with the ability of the surveyor to hear. Shorter or longer call point intervals, longer calling periods, longer listening periods and skipping a call point to return when the disturbance is not present are a few modifications employed to increase survey effectiveness. In addition, most surveys were conducted during early morning sessions when noise and disruptions from human activities in urban areas tend to be lower. Morning surveys and monitoring that begin before sunrise also increase the opportunities to detect pygmy-owls during their initial contact communications and vocalizations associated with the first prey deliveries of the day.

After frequent pygmy-owl detections from distances greater than 300 m in urban areas and up to 800 m (0.5 mi) in rural areas, we also increased intervals between call points to 300 m. When physical obstacles, noise or other disturbances influenced the survey, interval distances and the length of survey time were modified even further.

Breeding Disruption and Adverse Conditioning. Increased efforts by AGFD to locate pygmy-owls using tape broadcasts during surveys and monitoring in the same areas, year after year, may present the potential for negatively impacting pair bonding and breeding activities. Responsiveness of individual territorial owls may also be reduced. In addition, private contractors have also begun intensive surveys in areas slated for development due to recommendations by the local county government and the US Fish and Wildlife Service. Surveys by both private parties and AGFD have sometimes occurred in the same or nearby locations, increasing the potential impact to a specific area. Conducting more surveys during the fall would reduce breeding season impacts (Proudfoot and Beasom 1996). However, preliminary results of fall and winter surveys in Arizona have had limited success in locating pygmy-owls and it appears responsiveness to tape broadcasts outside the breeding season is inconsistent. To date, we have not recognized any serious negative impacts to nesting.

The implementation of broadcast limitations (see Methods) are considered sufficient to address the concerns mentioned above. Responsiveness of individuals is probably influenced by many variables and some of these may be related to our survey work. We will continue to increase listening surveys especially near known detection sites and to refine our methods in order to maintain the highest response rates possible to monitor territory occupation, movements, reproduction and behavior.

Survey Effort and Detection Success

While most pygmy-owl population surveys were focused in Sonoran desertscrub upland communities of northwest Tucson and the Marana/Redrock area, we continued to expand our searches to include some locations with no known recent pygmy-owl activity. These areas contained vegetative components and natural features similar to where pygmy-owls have been found in recent years or were considered similar to historical riparian locations. We conducted surveys in some of these new areas during both 1997 and 1998 breeding seasons and also continued surveys after dispersal of young from August to December 1997.

While no pygmy-owls were detected by AGFD outside known areas of recent activity, a number of locations were surveyed only once. In addition, observations in northwest Tucson and in Texas have indicated lack of response does not prove pygmy-owls are absent (Abbate et al. 1996, Wauer et al. 1993 and Beasom et al. 1994). Promising locations containing potentially suitable habitat characteristics adjacent to pygmy-owl use areas as well as those in outlying locations have not been surveyed at all. The initiation, or increase, of survey activities by USFWS, US Forest Service, National Park Service, Bureau of Land Management and private consultant biologists in response to recent endangered status and proposed critical habitat, have begun the necessary task of inventorying previously unvisited areas and resulted in detection of several new individuals and territories in 1998, which compliments work by AGFD.

The discovery of 3 nest sites in northwest Tucson by AGFD during 1998 and the location of one nest in OPNM by T. Tibbitts (National Park Service biologist) represent the first year when more than one nest was located during the breeding season. Since raptor populations tend to rise and fall with fluctuations in prey abundance, it is unknown if this represents an actual increase in the population size and the number of nesting attempts. Increased precipitation levels and mild winters in southern Arizona during recent years may have provided sufficient prey increases to influence the number of nesting pygmy-owls. However, our increasing knowledge of subtle behaviors, vocalizations and territory locations, combined with increasing survey efforts, are just as likely to explain these recent successes.

Disturbance Factors and Survey Effectiveness. Survey efforts in urban areas were often influenced by noise and disturbances normally associated with residential and commercial activities. These included: train engines, whistle and track noises, trash trucks, heavy equipment noises from construction sites, vehicle backup warning beeps, small and large aircraft engines, truck and car traffic noises and barking dogs. Short-term modifications to the survey protocol at specific sites were used in an attempt to minimize these disruptions, but were not always successful. While pygmy-owls in northwest Tucson and the Marana/Redrock areas may generally be habituated to certain noises and human activities, the first sudden loud noises of the day occurring during early morning survey periods, may be reducing our detection success by frightening a bird away, reducing its responsiveness, or preventing the surveyor from hearing a response. Some calling pygmy-owls are known to have stopped calling in response to sudden noises and activities. Surveys may need to be repeated several times in areas that are exposed to frequent disruptions. Beginning surveys earlier in the day may provide some relief from noises and changing week day surveys to weekends may also be helpful. However, despite our best efforts, some pygmy-owls in urban areas may go undetected due to such high levels of disturbance. We recognize that this affects our ability to conclusively state the actual number of owls inhabiting these environments.

Un-paired Male Detections. Detections of territorial pygmy-owls in one location during two or more visits without detection of a second pygmy-owl (female) in the same area during the breeding season, were considered un-paired males. We recognize that this assumption only represents our current ability to detect a female or locate a nest. Though the probability appears lower, it does not mean a female or nest is absent. All initial pygmy-owl detections during 1997 and 1998 were territorial male vocalizations in response to broadcast surveys. Unpaired males tend to call for longer periods of time and with greater frequency, whether spontaneously, or in response to a survey broadcast. Detections of females and nests occurred only after multiple visits and hours of observation. Females appear to be quite secretive during the early part of the breeding season and have not been known to respond vocally to tape-broadcast surveys until after incubation. A few nest sites have been discovered only after observation of the silent female sticking her head out of a cavity and looking around, apparently curious about the source of broadcasted calls. It would be very easy to miss this subtle response.

Post-Dispersal Responses. Regular monitoring of juvenile behavior and movements shortly before dispersal resulted in intermittent detections of adult females. To avoid disturbance, we did not test for male presence by broadcasting taped-calls, but in contrast to regular observations earlier in the season, adult males appeared to be absent or spending more time away from the nest territory during the same period. Successful post-dispersal Fall broadcast surveys may suggest adult males were within or near the nesting territory not only during the late part of the nesting season, but also through the Fall and Winter. This supports observations in Texas where males remain in and defend their territory through most of the year (Proudfoot - personal communication).

Comparison of response rates and intensity by three males defending different territories during the fall post-dispersal season were variable (Table 5). A paired male that nested during the breeding season was the most consistent and aggressive responder to our broadcasts. Another adult male defending a territory where a a nest was located in 1996, but a female was not detected in 1998, responded less frequently and for shorter durations. Responses from a dispersing juvenile within a newly established territory were considered moderate and occurred over a larger area. Unpaired pygmy-owls may be using larger areas than paired males in their search for mates. Greater distances from survey transects may contribute to diminished response rates because responses were too far away to be detected by surveyors or owls were too far away to respond at all.

The number of post-breeding season detections during 1997 indicates that some birds may respond to broadcast surveys during Fall and Winter months with some regularity, while others are less consistent. In addition, systematic fall and winter sampling of sites with known occupation during the previous breeding season has been irregular and current survey results during this period are inconclusive.

Territory Occupancy and Site Fidelity

With each successive survey season, we have documented increasing numbers of detection sites in areas where pygmy-owls were previously located. Color-banding and radio-marking individuals in 1997 and 1998 have also increased our opportunity to recognize returning individuals to known territories and identify new territories established by dispersing young. Many raptor species are known to return to breeding territories and even specific nest sites from year to year (Johnsgaard 1990). Some sites are used by the same species and even the same reproductive pair for many years, while others may change individuals and sometimes species with similar nesting requirements.

Observations of pygmy-owls in Texas have indicated well defined territories with high fidelity by established pairs or individuals (Proudfoot - personal communication). Until recently, the number of pygmy-owl detections in Arizona was insufficient to estimate territory boundaries or recognize affinity by individuals toward specific areas. A number of territories are now identified due to occupation history records over several years. For example, in 1998, we documented the first nest territory to be occupied in successive years (1997-1998). The nest cavity and saguaro were different, but the nest site locations were within 300 meters of each other. A second nest site located in 1998 was occupied by an unpaired male in 1996 and appeared vacant in 1997. It is possible that nesting occurred in this territory all three years and was not discovered during the first two. In any case, pygmy-owls have returned or dispersing birds reoccupied a vacant territory, apparently attracted by favorable environmental characteristics. Another nest territory occupied and successful in fledging two young in 1996, appeared to be unoccupied in 1997 until late in the breeding season (August). At this time, a territorial male was detected during several visits. This individual may have been using the territory earlier in the season and was undetected during surveys, or it was a dispersing juvenile from a nest of the same year, establishing itself in a vacant territory. The third nest site in 1998 was considered a new territory, however nearby residents reported pygmy-owl presence in previous years and one resident showed us a photograph of a pygmy-owl taken in 1996.

Fidelity to specific sites by raptors is an indication that environmental factors such as a reliable food supply, protection from predators and superior nesting sites will contribute not only to survival, but also reproductive success. In 1996, an un-paired male defended a nesting territory that contained a successful nest in 1995. This male was observed calling from the very same cavity from which young had fledged the previous year. If a territory is vacated due to mortality, favorable environmental characteristics may serve to attract new occupants, which are often dispersing birds. In 1998, a dispersing juvenile was located within a territory with a relatively long occupation history, 1993 to 1996. The territory appeared to be vacant in 1997. Using radio telemetry, we were able to track this pygmy-owl until it arrived on the presumably vacant territory. It stayed in the area through the remaining life of the transmitter.

Nest Productivity

Direct observations of pygmy-owl nest cavity interiors were not attempted during the 1997 and 1998 breeding seasons to minimize disturbance during incubation and prevent possible damage to eggs by startled adults. Without these direct observations, actual clutch sizes were undetermined and we were not able to assess hatching or fledging efficiency. This conservative approach was based on the limited number of active nest cavities (1-3) and difficulties encountered during attempts to observe interior characteristics. Saguaro nest and general use cavities were inspected after the 1997 nesting season and before the 1998 breeding season began. Cavities tended to slope toward the center of the saguaro stem and some appeared curved or peanut shaped. When combined with substantial depth (38 cm or greater), these factors made viewing the bottom difficult or impossible with our current remote camera viewing system. The time required for observations at the cavity was also considered too long. We believe clutch size, hatching efficiency and fledging efficiency are important data and will investigate other equipment and methods that will permit more reliable and efficient cavity inspections. At present, the number of young surviving to fledge at five nest sites for 1997 and 1998 ranged from three to five (Table 9), we suspect clutch sizes in Arizona are similar or equal to those reported for Texas, at four and five (Proudfoot, 1996a).

Fecundity for Arizona nests in saguaro cavities (3.75) during 1997 and 1998 was significantly higher than Texas natural cavity nests at 2.61 from 1993 to 1999 (Proudfoot - unpublished data). Fecundity was also higher than nest box nests in Texas from 1993 to 1999 at 2.81 young per nest. While differences in productivity between natural cavities and artificial boxes in Texas (boxes were higher) were significantly different from 1993 to 1997, recent results that include a larger sample size over a longer time period indicate productivity rates for natural cavities and boxes are very similar. This may be the result of the long term memory of predators that take a few years to include nest boxes in their search image (Proudfoot - personal communication).

In contrast to suitable tree cavities, saguaro cavities in the greater Tucson area are more plentiful and provide consistent nesting substrate over long periods, since the saguaro life-span averages 125 to 175 years or more (Pierson and Turner 1998). Historically, when larger trees with suitable cavities were more common in the Tucson area, especially along larger washes and river drainages, it is possible pygmy-owls used trees for nesting more often. We recognize the present sample size of pygmy-owl nesting substrate in Arizona is small, but we suggest the selection of deep cavities inside large saguaro cacti may offer superior protection against predators during the incubation and nestling stages, especially from larger mammals such as raccoons. Except for occasional saguaro mortality from blow downs or old age, which may destroy eggs and young, and a possibly a rare predation event, known pygmy-owl pairs nesting in saguaro cavities are highly successful in fledging young. All nest sites during 1997 and 1998 not only produced multiple fledglings, but most of these young (19 of 22) survived through dispersal (86.4% dispersal efficiency). In addition, two other nests (one in 1995 and one in 1996) also successfully fledged one or more young from saguaro cavities.

Population Size. While the most recent survey efforts documented 20 surviving pygmy-owls in 1998, nine additional individuals were confirmed by AGFD after reported by T. Tibbitts (National Park Service - personal communication) and R. Duncan (R.B. Duncan and Associates). Two additional detections reported by R. Duncan are considered reliable and several detections by Breeding Bird Atlas workers were also reported to us, but are not included in our total. A total of twenty-nine individuals excludes reports of owls not confirmed by AGFD, but still represents the highest number of pygmy-owls located in one season since AGFD surveys began in 1993.

Mortality and Predation

Direct evidence to support pygmy-owl mortality rates and identification of specific predation events is arguably the most difficult life history information to collect in the field. Color marking pygmy-owls to identify individuals and the use of radio transmitters over multiple survey seasons will provide some evidence to support estimates of mortality. The ability to identify individuals holding territories or engaged in nesting will help determine survival and turnover from year to year. The detection in 1998 of the only two pygmy-owls color marked in 1997, indicates a minimum survival rate of 50 percent for this one nest alone. In addition, regular relocation of radio-marked individuals will increase the chances to detect predation and mortality.

Observations of pygmy-owl nests during the nestling periods of 1997 and 1998 indicate mortality and predation were completely absent or at extremely low levels. Fecundity for five pygmy-owl nests from northwest Tucson, Marana /Redrock and OPNM was 4.0. In a study of elf and screech owls on the Barry M. Goldwater Military Range, five of 37 elf owl nest saguaros fell down during one year (Hardy 1997). Residents in northwest Tucson near one new pygmy-owl nest site in 1998 reported the loss of a very large saguaro approximately 50 meters from early breeding season activity. Near another pygmy-owl detection site in 1997, residents living on 40 acres in a more rural area reported loss of many saguaros during a wind storm. No pygmy-owl nest losses due to saguaro mortalities have been observed, but we do know of a dead saguaro used on several occasions by a territorial male, fell down two weeks after it was first observed and we recognize this natural process as a potential cause of pygmy-owl mortality.

Small cavity entrance openings and estimated cavity depths up to 38 cm or greater exclude most larger avian and mammalian predators. The smooth surface, absence of low branches and presence of spines that characterize saguaros may also exclude some predators that are successful when raiding nests in trees or other substrates. Cavities in trees such as mesquite, cottonwood, or ash may be more accessible to predators such as raccoons and ring-tailed cats since the trees are easier to climb and cavity depths may be shallower. In Arizona, nest cavities may be more vulnerable to smaller birds such as woodpeckers and starlings, a few climbing snakes (coachwhips and gopher snakes), and opportunistic rodents such as pack-rats. Other small owls such as screech owls may also be able to access some pygmy-owl nest cavities.

As with most raptor species, pygmy-owls are most vulnerable to predation or other threats during and shortly after fledging. One fledgling disappeared within the first 24 hours out of the nest in 1996. In 1997, a fledgling was rescued after becoming entangled in a cholla cactus. In 1998, one fledgling apparently sustained an eye injury during fledging which may have been a factor in its disappearance during the following week. Another fledgling was rescued from a cholla cactus on the second day after fledging and its sibling was rescued from the side of a road after what appeared to be an unsuccessful attempt to cross it. Within three weeks of leaving the nest, a second fledgling also disappeared.

Nesting Chronology

The nesting events of four nests in northwest Tucson during 1997 and 1998 were very close in onset and duration. Using actual fledge dates as a known event reference point, all nests were within five days of each other. The nest in 1996 fledged its young one week later (4 June) than the nest in 1997 (28 May). Another nest in OPNM fledged young on 20 May 1998. By fledging young eight days sooner than the next earliest nest observed in northwest Tucson in 1997, this nest represents the earliest known nesting in Arizona since formal surveys and monitoring by AGFD began. In contrast, the discovery of a recent fledgling from a Marana/Redrock area nest on 29 July 1995, indicates very late nesting when compared with nests active from 1996 to 1998. This late nesting appears to be unusual and may be the result of a second clutch laid after the first had failed or was predated.

Breeding Event Descriptions

Courtship . The difficulty in locating pygmy-owls early in the breeding season, the secrecy and limited vocal behavior of females and private property access issues have all contributed to extremely rare opportunities to observe pygmy-owl courtship behavior. It appears that courtship begins with the advertising calls of the male to attract a female. At two nest sites we observed the male calling from several different saguaro cavities during this period. At three nest sites in 1998, males were observed calling from several potential nest cavities before one was selected. We have observed both male and female on the same perch beak rubbing and nibbling or grooming each other. On a few occasions, the female was heard chittering repeatedly, seeming to call the male to her. The male would fly to her perch briefly and while fluttering his wings for balance, would mount her. The copulations we observed were over within seconds and then the birds would separate with the male flying out of sight. No copulations were observed after the 31 March at 3 nest sites. This seems to coincide closely with the time when incubation or egg-laying has begun and advertising calls diminish.

Incubation.. Incubation is conducted primarily by the female and observers in Texas have reported incubation as the exclusive domain of the female (Proudfoot, 1996). However, in northwest Tucson, we have observed the male at different nests entering the cavity after bringing prey to the female during incubation. The male would announce the delivery and the female would leave the cavity to obtain the food. Once the exchange was made, the female would fly off or remain on the perch to eat and the male flew to and entered the cavity. The length of time he remained inside was variable and not always known, ranging from less than a minute to several minutes or more. On other occasions the identity of the adult entering the cavity was not confirmed, but suspected to be the male. During other events the male was observed entering the cavity and followed by the female. Both birds remained in the cavity together for several minutes. It is not known if the male was actually incubating during any of these visits inside the cavity and may have simply been inspecting or defending the eggs or young, but we cannot rule out limited male participation during the incubation process.

Nestlings. Our first direct observations of nestlings were approximately one week prior to fledging, after down was lost and feathers were nearly grown in. The depth and structure of cavities selected for nesting appears to be a barrier to young trying to reach the entrance until they are strong enough to climb up. Prior to this time, we occasionally could hear the young vocalizing from inside the cavity. One nestling would work its way up to the cavity entrance and we could observe its head neck and breast. Remaining near the entrance appeared difficult at first and may have been the result of several nestlings jostling for position or poor strength and balance development. We did not attempt to use our remote camera for views inside the cavity to avoid disturbance and possible injury to the young. One characteristic behavior of both nestlings and fledglings are circular or bobbing head movements which assist the observer in distinguishing perched adults from young.

Fledging. As nestlings become stronger and balance has increased, they begin to spend more time in the cavity entrance, standing on the bottom ledge of the entrance opening. Older nestlings have been observed leaning their entire bodies outside the cavity opening and almost falling. However, no nestlings were observed falling out of cavities. Mean ledge width for 5 nest cavities was 5.1 cm (2.5 - 7.6 cm) providing a substantial surface for perching and fledging. We suspect the repeated action of climbing to the cavity entrance from the bottom of the cavity and jostling with siblings for position provides exercise and development of flight muscles needed during fledging. Unlike many other young raptors using wing extensions and flapping to develop muscles in preparation for flight, pygmy-owl movements inside saguaro cavities are restricted due to relatively narrow cavity width, depth and shape as well as the absence of a platform at the cavity entrance. Instead, it appears young pygmy-owls use their wings and legs with alternating pressure behind and in front to "chimney" up the cavity to its entrance and in doing so may develop their flight muscles.

Just prior to fledging, both male and female adults with prey in their possession, appear to increase their time calling from perches, instead of going directly to the cavity. On several occasions, we observed adults fly to the cavity edge or actually enter the cavity with prey and then depart the cavity retaining the prey. We suspect this adult behavior is an attempt to entice the nestlings to leave the cavity in order to obtain the prey.

The first flights for all directly observed fledglings during 1997 and 1998 were free of injury and entanglement. Most fledglings traveled successfully to the nearest tree or large shrub and began moving to different perch positions. Subsequent flights were more problematic with some birds landing near or on the ground, others became briefly entangled in branches and one was found a few feet from a road. One fledgling in 1997 was rescued from a cholla where it was unable to extract itself. Observations of distances traveled during initial flights at one nest site in 1998 were surprising as all three fledglings reached a patch of paloverde trees approximately 25 meters away from the nest cavity. Flights were high, floating or bobbing similar to the flight of butterflies, rather than the direct level flights of adult birds. Once a fledgling arrived at its first perch, it was immediately joined by the adults on nearby perches. One nestling fledged directly toward the perched and calling adult female.

Dispersal. During 1998, dispersal was documented by locating juveniles using radio telemetry. Prior to this time, pygmy-owls were not radio-marked and with one exception, were not relocated after moving away from the natal area. Juvenile pygmy-owls were considered dispersing once they moved at least 0.8 km from the nest site and did not return to the nest territory. Dispersal was considered complete after relocations remained in the same area during multiple tracking sessions over 10 or more days. In contrast to behavior within the nest territory, when juveniles were often easily observed and could be approached within just a few meters without flushing, dispersing juveniles were skittish, easily flushed and extremely difficult to observe directly. During most relocation efforts the owls were moving between trees almost constantly as we approached. The behavior appeared to change again once juveniles had arrived on their new territory, they became more tolerant of our presence and on a few occasions allowed our approach within 25 m.

Captures and Color-Marking

Capturing adult and juvenile pygmy-owls near a nesting site is probably the most reliable approach to obtaining birds for research measurements, color-marking and radio-marking. Our 100 percent capture success clearly demonstrated that recent fledglings are relatively easy to approach and capture by hand or net with minimal risk of injury, and the investment of continuous monitoring time just prior to fledging is worth the effort. During this same period, adults are closely tied to a small area and will present opportunities for capture when defending young or investigating intruding field workers. In general, both nesting adults and their young are more tolerant of approach within relatively short distances and may also be habituated to observer presence, after repeated monitoring visits during the early part of the nesting season. Mist nets alone erected between favored perches should be tried first. If the nets are avoided, an owl decoy or tape player broadcasting calls and placed between nets may attract enough attention for capture (Proudfoot - personal communication). Fledgling development occurs rapidly and within 2 or 3 days, strength, balance and flight skills have progressed enough to prevent easy capture by hand net. Use of mist nets or other creative techniques may also prove successful until young move further away from the nest site.

Capturing unpaired territorial males is a greater challenge as these birds are less tolerant to approach and are not closely tied to a small area. We successfully captured one adult with a baited trap, but could not recapture this individual after it pulled off its transmitter. We also attempted to capture a dispersing juvenile that had arrived on a new territory. Despite the fact that it entered a bow trap, capture was avoided. Use of a variety of techniques at different times of day may increase capture success for pygmy-owls not associated with nest sites.

Color -Marking. The ability to identify individuals from a distance will provide important information necessary to understand the population dynamics and general biology of the small pygmy-owl population in Arizona. Color bands placed on 2 juveniles in 1997 have already demonstrated the power of this effort and the error of previously held assumptions (see Results - First Year Observations of Color-Marked Juvenile Pygmy-Owls). Once color-marked, the need for additional captures of the same individual is eliminated, saving time and reducing the risk of injury during handling. The increased banding effort for both juveniles and adults in 1998 is expected to help answer even more questions regarding survival, occupation, nesting pair turnover, and dispersal. More durable aluminum color bands have been selected for future efforts and a long-term study color band scheme has been planned.

Incest. Color band marking to discriminate individual pygmy-owls confirmed a successful pairing of siblings from the previous breeding season. Incest in raptors is considered rare and its occurrence has been documented in only 18 cases representing seven species (Carlson et.al. 1998). Four of the seven species are owls and include: barn owls (*Tyto alba*), burrowing owl (*Athene cunicularia*), screech owl (*Otus asio*) and spotted owls (*Strix occidentalis*). Similar dispersal direction and relatively short dispersal distances may play a role in the pairing of siblings (Carlson et al. 1998). Early results from two radio-marked dispersing juveniles from one nest site in 1998 indicated similar dispersal directions and detections within their new territories were at one time within 2.4 km. It is of interest to note that just prior to dispersal in 1997, the two siblings that later became paired were closely associated and appeared to interact with each other more than the remaining 2 siblings (see First Year Observations of Color-Marked Juvenile Pygmy-Owls). This unusual pairing may be the result of dispersal behavior or extremely low numbers of available mates within a small population. We also suggest habitat loss, fragmentation and dispersal barriers may influence dispersal of young from certain nest sites, keeping dispersing birds in closer proximity than would ordinarily occur.

Radio-Marking and Telemetry

Transmitters enabled us to locate juvenile pygmy-owls from shortly after fledging through dispersal. During the post-fledging dependency period, radio-marked individuals were relocated almost daily as they remained near the nest site. Detections of all fledglings and sometimes adults at each nest site required less time and effort because radio-marked juveniles were frequently near or interacting with unmarked family members. Prior to the use of radio-marking, significantly more time was required to detect juveniles and adults during normal monitoring and there were times when no birds were detected. Once radio-marked juveniles began to disperse, we were able to track them almost daily until they reached new territories. Two juvenile pygmy-owls were lost during ground tracking and required aerial tracking for relocation.

Shortly after attaching the transmitter, the released pygmy-owls were observed pulling at the string harness. This behavior would continue intermittently for several minutes and then seemed to diminish. All radio-marked birds appeared unimpeded during flight after release. When located the next day, occasional pulling at the harness was observed, but less frequent than the first day. During several monitoring visits, we observed a radio-marked pygmy-owl pulling out on the harness with its foot. On another occasion an individual was able to reach back and pull the antenna with its beak.

Radio-marked pygmy-owls crossed several two-lane roads with vehicle traffic that ranged from light to moderately heavy in areas with trees and large shrubs on both sides of the road. One individual dispersed almost due west toward Interstate 10. Our last detection location before it reversed its direction was 1.1 km (0.7 mi) east of the highway. The pygmy-owl flight style is typically two to four feet off the ground or just over the tops of shrubs and ground cover plants. It may fly in short hops of several meters in distance and up to 50 meters, as it moves from one tree or shrub to another within desert scrub communities. This flight pattern was also observed during dispersal. The absence of adequate trees or other vegetation along roadways and large distances across a highway may reduce the likelihood that a pygmy-owl would cross.

Surprisingly, as pygmy-owls dispersed, some areas that contained complex vegetative structure and appeared to be suitable habitat, were passed through quickly within the short time of our observations, or some time between observation sessions. In contrast, one juvenile was relocated in an ironwood tree behind a convenience store for over 2 days before moving on. Another individual was followed as it moved around the perimeter of a golf course seemingly avoiding the open non-vegetated areas.

Prey

We recognize that our direct observation identifications of prey items are limited to specific times of day and year. Prey deliveries or captures can be hidden from the view of the most attentive observer. In addition, of those items we were able to detect, 24 percent could not be identified to class. These factors may have prohibited recognition of the full range of prey species utilized and the percentages of some prey classes may be under-represented. Indeed, a superficial review of a number of regurgitated pellets indicated frequent occurrence of mammal hair, apparently indicating a higher percentage of mammals than we could detect through direct observation.
High percentages of lizards and birds were observed for all years considered (1996-1998). When we excluded unknown items, the percentages of these high use prey groups are even more pronounced. We suggest that at least some of the prey items not identified were also from the bird and reptile classes. While pygmy-owls in Arizona utilize a wide variety of prey items, these two groups appear frequently at all nest sites observed almost to the time of dispersal.

The utilization of insects in general, and the specific groups we were able to observe such as moths, grasshoppers and cicadas, appear to be opportunistic and probably short lived, coinciding with their hatching out or migration through pygmy-owl territories. Similarly, nestling songbirds and young quail are available for a limited time during spring and early summer and are more easily captured to provision developing pygmy-owl nestlings. In Texas, an analysis of pygmy-owl diets from eight nest sites (two in 1994, three in 1995 and three in 1996) indicated very high percentages of insects. Using prey remains, visual observations and video recordings during the analysis, insects made up

58, 62 and 89 % respectively, of the total prey identified (Proudfoot 1997). In the same study, the percentage of birds ranged from 2.3 to 10.5 percent and reptiles ranged from 7.1 to 22.5 percent.

Planned formal analysis of collected prey pellets will provide additional information on pygmy-owl diets in Arizona to compliment our direct observation data, but it is clear that lizards and birds are very important prey species during the nesting season and are available for extended periods of time to provision adults and young during the time when energy demands are very high.

Habitat Measurements

Measurements of habitat characteristics at known perch and nest sites during 1997 and 1998 are initial efforts to evaluate suitable pygmy-owl habitat in southern Arizona (Wilcox et al. 1998). At present, our sample size for both perch and nest sites is small. Only 3 out of seven known nest sites have been evaluated and the number of documented perch sites has more than tripled after nest monitoring and radio-tracking efforts in 1998. Nest site samples for all measurements were more variable than perch sites and probably reflect the small sample size. Current results are also biased toward use areas within the suburban/rural interface and may not represent suitable areas in natural undisturbed habitats. Habitat selection analysis is an important part of determining suitable pygmy-owl habitat, but control samples of available habitat have not been measured. Our early efforts represent the beginning of a larger study which will increase sample sizes of known use areas and include samples of randomly selected available habitat with no known use. Present results are preliminary and we emphasize caution in their interpretation.

Pygmy-owl habitat sample site locations were on private residential properties. In addition to homes, garages, gardens and enclosed pool areas, many residents own horses and have cleared sections for corrals, arenas, barns and various out-buildings. Some residents also raise a variety of animals including pigs, poultry and goats. Several owners operate small businesses from their homes that require heavy diesel trucks and equipment. Equestrian and husbandry activities require open areas with feed and water sources. The presence of these and other resources adjacent to natural vegetated areas probably contribute to increased prey abundance.

Both point-intercept transects and 10 x 10 m quadrat sample methods indicated relatively high percentages of bare ground at all sample sites, which we would expect in most desertscrub areas. Clearing of ground cover species due to landscaping, horse corrals, driveways and a variety of other uses also contributed to the "patchiness" of vegetation. The presence of these open areas interspersed with regular patches of shrubs, trees and cacti may actually be advantageous for pygmy-owls, which fly in short low sequences or hops between vegetation islands allowing unobstructed views and flight paths to easily pounce on ground dwelling prey.

Point-intercept transect measurements generally indicated more even distribution of vegetation cover at heights between 0.5 and 4.0 m, corresponding to perch locations frequently used by pygmy-owls. Denser foliage provides concealment, shade and escape areas during feeding, prey deliveries, resting, social interactions and predator avoidance or mobbing. Cover board readings at perch sites also indicate a trend toward more even distribution of vegetation at heights above 1 meter (Wilcox et al. 1998).

Many large multi-armed saguaros with cavities were observed in the vicinity of our sample areas, but few occurred within the sample itself. Our sample plots may be too small to adequately represent the number of saguaros that are actually available for pygmy-owls to use in specific territories, and we will test plot sizes to see which samples this habitat component the best.

Nest Saguaros and Nest Cavities

Pygmy-owl nest substrate records for 30 sites reported by Johnsgaard (1988) included a variety of tree species containing natural cavities, woodpecker holes and depressions or tree forks. Proudfoot (1996) also reports pygmy-owls nesting in live oak tree cavities. In Arizona, all pygmy-owl nests (n=7) monitored from 1995 through 1998 have been located exclusively in saguaro cavities. An unconfirmed report of an eight nest was also in a saguaro. Six of the seven known nests were in older large and multi-armed saguaros with several arms greater than 2 meters in length. The seventh nest saguaro had two smaller arms. Johnsgaard (1988) also reports mean height of 26 nest sites was 4.9 m , while the mean height of four natural nests monitored in Texas in 1995, was 3.7 m (Proudfoot 1996). Mean nest cavity height for Arizona was 5.3 m. Selection of cavities for nesting by pygmy-owls in Arizona is probably determined by a number of variables including surrounding habitat characteristics and internal structure and size of cavities. Nest cavity height in saguaros is directly dependent on primary cavity nesters which rarely excavate suitable nest cavities below four meters (McAuliff and Hendricks 1988). At this time, the small number of known nest cavities in both Arizona and Texas suggest caution when comparing nest cavity characteristics between the geographical areas, but structural differences between tree and saguaro nesting substrates, reports of predation incidents and lower productivity from natural cavities in Texas, may indicate saguaro cavity nest sites in Arizona could be successful due to superior protection from predators and environmental stresses.

The elf owl and the screech owl also nest in saguaro cavities in the Sonoran desert. Similar to pygmy-owls, elf owls use mostly the largest mature cactus with multiple arms (Goad and Mannan 1987). These large saguaros were characterized as class five with heights greater than five meters and with at least three arms greater than one meter in length. Mean nest cavity heights for elf owls were somewhat higher than pygmy-owls at 6.3 and 6.1 m reported from two different study sites (Goad and Mannan 1987, Hardy 1997). While screech owl nests have been reported from trees as well as saguaros in Sonoran desertscrub communities, Hardy (1997) reported 10 of 12 screech owl nests in saguaros with a mean nest cavity height of 6.2 m. To date, we have not observed any interactions between pygmy-owls and other small owl species in pygmy-owl detection areas. This may be due in part to the timing of surveys and monitoring. A few screech owls have been observed roosting and others heard calling in response to taped broadcasts of pygmy-owls. One flew to a tree within 15 m of a surveyor during broadcasts in 1996 and another flew within approximately one meter, fluttered briefly and landed nearby. Competition for nest cavities between the small owls using saguaros probably occurs on rare occasions, but appears to be minimized due to a variety of factors. These include the ability of elf and screech owls to utilize different habitat types, differences between daily activity patterns, body size differences and migratory behavior of elf owls. At least some pygmy-owls are known to remain within or near their territory year-round in Arizona. Increasing use of telemetry after the dispersal of young and through the late fall and early winter will help determine whether pygmy-owls migrate during colder periods when prey numbers are reduced.

All secondary cavity nesters in saguaros in southern Arizona are dependent on gila woodpeckers and gilded flickers to excavate cavities. Gila woodpeckers excavate smaller cavity entrance openings than gilded flickers (Kerpez and Smith 1990). Kerpez and Smith (1990) report mean horizontal and vertical diameters for gila woodpecker nest cavity entrances at 6.28 and 5.66 cm respectively, and mean horizontal and vertical diameters for gilded flickers entrances at 8.3 and 6.9 cm respectively. While there is some overlap, a preliminary review of pygmy-owl nest cavity entrance dimensions compares favorably with gila woodpecker cavities and less so with gilded flickers. We did not make a statistical comparison at this time due to small sample size. Mean vertical diameter was 5.90 cm (range = 4.3 - 7.62) and mean horizontal diameter was 6.71 cm (range = 5.3 - 7.8 cm) for seven pygmy-owl nest cavities. It has also been reported that gilded flickers usually restrict their cavities to within three meters of the saguaro main stem apex while gila woodpecker nest cavity locations are more variable (McAuliffe and Hendricks 1988). Only two of the seven pygmy-owl nest cavities monitored were in saguaro main stems, with the remaining nests located in large primary arms (branches growing directly from the main stem). McAuliffe and Hendricks did not address cavities in saguaro arms, but since pygmy-owl nest cavity entrances appear to be consistent with the size of gila woodpecker nest cavity entrances, gila woodpeckers may excavate in saguaro arms more frequently than gilded flickers.

Pygmy-owls have also been observed using cavities of varying size and height in the immediate vicinity of the nest cavity for shade, caching prey, cover from mobbing birds and hunting perches. The importance of the availability of these additional cavities and their potential influence on nest cavity selection is unknown.

Nest Box Study

Two unused nest boxes were located near active Cooper's hawk nests which were not apparent at the time of installation. One of these boxes also contained an ant colony when examined. Spaces between the box tops and side panels caused by wood warping were observed at three sites. Exposure to water entry and continued deterioration may exclude them as nesting possibilities. We recognized that 15 boxes was a small number and consider this effort a preliminary stage to test design, installation techniques and potential competitors for cavities. After one breeding season, it appears that increased numbers of boxes and yearly adjustments or maintenance will provide increased nesting opportunities for a number of species.

Potential Threats to Pygmy-Owls in Urban Areas

Wildlife in urban areas are exposed to a variety of hazards, obstacles and disturbances which may impact the ability of some localized populations to breed and survive. Increased prey abundance, greater availability of large trees for nesting and cover, complex man-made structures providing shade, escape areas, nesting locations and dependable water sources are just some of the attractions of urban environments for wildlife. However, despite these benefits, urban areas also contribute to wildlife mortality and can act as "ecological traps" (Boal 1997). Some obvious hazards such as vehicle collisions and predation by domestic animals impact many wildlife species and probably contribute to some pygmy-owl losses. Other hazards such as electrocution from power facilities (Dawson 1997) and the spread of certain diseases such as trichomaniasis (Boal 1997) are more difficult to detect and affect specific groups or species. Some of these hazards often have the greatest impact on young that are still developing strength, balance and survival skills. Observations during and shortly after fledging indicate this developmental period as a time when pygmy-owls are also highly vulnerable to a number of threats. The following paragraphs review some potential hazards to pygmy-owls.

Disease. Songbirds represent a significant percentage of the pygmy-owl diet during the nesting season (see Prey) and some species such as house finches are frequent visitors to bird feeders, a known source of disease transfer. Observations during 1997 and 1998 have also documented at least occasional use of mourning doves, another species known for high incidence of trichomaniasis. To date, we have not recorded mortalities or observed symptoms that could be related to disease. Increased observations, recovery of carcasses and collecting culture samples from live pygmy-owls will be necessary to detect any threats from disease.

Vehicle and Structure Collisions . Residents observed an adult pygmy-owl collide with a parked car and a juvenile was observed as it crashed into a window. Other observations of low flying pygmy-owls across two-lane roadways, and a recent fledgling on the ground near a road, indicate vehicle and structure collisions are a realistic hazard.

Fires. During 1998, we observed a car fire on a one lane dirt road within a few feet of dense vegetation and less than 1 km from an active pygmy-owl nest site. This fire was quickly controlled by the local fire department, but represents a realistic potential danger to pygmy-owls in the greater Tucson area. As housing densities and human activity increases in previously undisturbed desert habitats, so do the risks of wildfires. During dry and windy conditions that frequently occur during the early and mid nesting season, fires may be more difficult to control. Most recent detections of pygmy-owls have occurred on private parcels, which retain a large percentage of native vegetation with increasing patches of exotic trees, shrubs and low-lying plants, and are accessed by narrow vegetation-lined roads. Added to these potential fuels are scrap piles, yard clippings and firewood stacks. Fires can impact pygmy-owls through direct destruction of nest saguaros and loss of eggs or young as well as loss of habitat structure and foraging areas. The severe changes in pygmy-owl habitat caused by fires would create a long term loss.

Utility /Road Construction and Maintenance. One nest site that was active in 1998 was located within a few meters of a roadway and power line. Other detection locations during 1998 and in previous years were also close to roadways. The pruning or removal of trees and saguaros to accommodate road expansions, maintenance of road shoulder areas and some utility lines may impact pygmy-owls by removing cover, perch sites and nest cavities in use areas. The continued and expanded surveys along public road and utility corridors as well as private properties with proposed projects, are essential in order to reduce land use impacts by allowing opportunities to create mitigation plans when owls are found.

Pesticides and Hazardous Waste. The presence of pygmy-owls close to residences and commercial operations such as nurseries may cause direct exposure to environmental contaminants such as pesticides and herbicides. Sprays to control insects and weeds are used regularly around buildings, on fruit trees and landscaped areas and on road medians and shoulders. In addition, poisons are sometimes used to control rodents, which tend to be more abundant around horse and livestock facilities that are common in areas where pygmy-owls have been found. Pygmy-owl ingestion of prey items exposed to these chemicals may cause death from toxicity or disruption of reproduction.

Illegal dumping of waste is problematic for urban areas adjacent to natural open spaces, where this activity can be hidden by thick stands of vegetation and many low lying washes make disposal convenient. While most of this material is non-toxic such as yard waste or construction debris, a recent dumping incident involved 55 gallon drums of toxic solvents. These containers were found approximately 1.6 km from pygmy-owl detection sites and may present a potential hazard to pygmy-owls and their prey.

Habitat Loss. The primary threat to pygmy-owls in the greater Tucson area and the most urgent problem to be addressed for stabilization and recovery of the known population, is the loss and fragmentation of habitat from large scale residential and commercial development near and within use areas. The complete removal of vegetation and natural features required for many large-scale and high density projects directly and indirectly impact pygmy-owl survival. Recent occupation history records are beginning to reveal a relatively high site fidelity for pygmy-owls in Arizona, where birds remain in or return to the same areas each year. In addition, radio telemetry efforts in 1998 have indicated some dispersing birds will find and take over a vacated territory. This suggests known use areas retain environmental characteristics from year to year that are favorable for survival, mating and nesting success.

High levels of alteration or fragmentation in use areas may eliminate productive pygmy-owl territories. Removal of individual or clusters of large saguaro cactus eliminates potential nest sites and cavities used for escape and cover. Competition for the remaining sites may increase. Elimination of ground cover plant species, rodent burrows and native soils as well as loss of trees and shrubs, severely impacts local reptile and bird populations that are important to the pygmy-owl diet. Loss of complex vegetative structure forces increased energy demands on owls that must forage at greater distances and risk exposure to a variety of hazards.

When habitats are altered or destroyed by development, larger birds with the ability to fly over unsuitable or dangerous areas can establish new territories or nest sites. However, the small size of pygmy-owls, their style of flight and movements through open and unfamiliar areas present a greater risk to predation than larger raptor species. Despite many hours of observation during nesting and the tracking of dispersing juveniles, we have not observed any long sustained flights or movements at more than a few meters above the ground. Pygmy-owls tend to move in a series of shorter flights or hops just above shrub or tree levels. Patches of trees or large shrubs spaced at regular intervals during movements within their territory and during dispersal, provide concealment and protection from predators and mobbing birds as well shade and cooler temperatures.

CONCLUSIONS

Despite increased survey efforts by AGFD, other agencies and private contractors outside known areas of recent occupation, northwest Tucson , Marana /Redrock and Organ Pipe National Monument continue to support the highest known concentrations of pygmy-owl detections, nesting and dispersal activity in southern Arizona. Detection success in northwest Tucson may be due in part to multiple surveys and increased monitoring efforts in areas with previous detections since 1996. In addition, our increasing knowledge of territory boundaries through multiple detections, familiarity with habitat on localized private parcels, and increasing awareness of subtle pygmy-owl behaviors have also increased survey success.

We recognize the existence of large areas with potentially suitable pygmy-owl habitat between the greater Tucson area and OPNM. While some of these areas include Arizona State Trust, Bureau of Land Management and National Wildlife Refuge lands, large areas lie within private holdings and Tohono O'Odham Nation lands. Owner contacts and negotiations for access to conduct surveys in some of these areas have begun. Additional outlying locations and many sites in the greater Tucson area have not been surveyed or surveys were limited. These areas need further investigation. If immigration into the greater Tucson area pygmy-owl population does occur, we believe the source of immigrants would come from dispersing young produced in out-lying locations that have not been surveyed, such as the Tohono O'Odham lands southwest of the Tucson Basin.

Detection of pygmy-owl presence and nesting status often requires multiple surveys and monitoring visits during the breeding season (January to July). We believe pygmy-owls were present during a number of surveys, but went undetected due to background noise, non-aggressive or non-vocal responses. Nesting can be even more difficult to verify as adults become more secretive during incubation. Early responses of incubating females to taped-call broadcasts were non-vocal and involved poking their head out of the cavity and looking around, then disappearing back into the cavity. Males attending to incubating females appear to call less often and at lower volumes. Residential buildings and structures may compound detection difficulties by obstructing pygmy-owl activities from view and muffling vocalizations. It is also possible that some territorial males believed to be un-paired, were actually paired and nesting, but monitoring efforts were insufficient to make that determination. Detection of pygmy-owls using listening surveys often requires more time than broadcast surveys, but this technique may help to clarify nesting status in some locations. Efforts to locate adult territorial males during the post -breeding season have had mixed results and individual responsiveness to taped-call broadcasts appears to be less variable during the early part of the breeding season. Juvenile pygmy-owls are capable of producing adult-like territorial calls within weeks of dispersing from natal areas. This may explain reports of increased calling during a short period late in the breeding season in previous years. Surveys during mid-August to early September may detect dispersing juveniles defending new territories.

Predation of pygmy-owls in southern Arizona does not appear to be a serious threat to population survival. Saguaro nest cavities seem to be almost impervious to intruders since all nest sites observed from 1995 to 1998 were successful in fledging two or more young. Adult pygmy-owls are also aggressive defenders of their offspring (striking observers on the head), particularly during the early fledgling period when they are most vulnerable. Despite the frequent presence of great horned owls and Harris hawks, as well as an occasional Cooper's hawk near nesting pygmy-owls, no serious interactions were observed. Domestic cats and dogs may present more serious threats to pygmy-owls, especially during and shortly after fledging. Fledglings have been observed on the ground and entangled in low-lying vegetation where they would be vulnerable to attack. While adult pygmy-owls could easily avoid capture, recently fledged young have not developed the strength or skills for escape from domestic animals or other ground dwelling predators such as snakes, gila monsters and greater roadrunners, seen occasionally near pygmy-owl nest sites.

Recent use of color bands and radio-marking have already provided important new information about pygmy-owls in the greater Tucson area. We have learned that first year birds are sexually mature and dispersing birds will locate and defend territories within a few weeks of departing their natal area. One case of incest between siblings has been documented and all four dispersing juveniles avoided occupied territories. One juvenile has occupied a territory believed vacated by previous occupants.

Efforts to characterize suitable pygmy-owl habitat based only on breeding season detection and nesting sites may miss essential habitat elements. Since at least some pygmy-owls in the greater Tucson area appear not to migrate, survival for the population may also depend on availability of key habitat elements outside the breeding season. For example, native trees and shrubs such as mesquite and acacia, used by pygmy-owls during the breeding season, are without leaves during mid to late winter and early spring. Non-native deciduous trees also drop their leaves. Leaf loss reduces the concealment for perched pygmy-owls, and those tree species that retain the greatest cover such as ironwood, may become extremely important for predator avoidance and hunting success. Identification and measurement of fall and winter detection sites would provide a more complete habitat analysis.

In addition to random habitat sample sites in the vicinity of known use areas, a third sample group in non-use areas should be included for habitat selection analysis. While much of the greater Tucson area is characterized as Sonoran desertscrub, significant differences in species composition and density seem to occur between some areas. Locations in east Tucson for example, appear to be different in structure and composition from sites in northwest Tucson where many pygmy-owl detections have occurred. However, several historic pygmy-owl locations have been documented on Tucson's east side and therefore, habitat samples from this area should be included.

Habitat loss and fragmentation from urban growth is the most serious and immediate threat to pygmy-owl survival in the greater Tucson area. As the inventory of vacant land decreases, there is tremendous pressure to develop the remaining parcels. Many acres of suitable habitat were lost in 1997 and 1998. One of these parcels that now contains high density housing was within 400 m of a 1998 nest site. Another detection site where two pygmy-owls were observed in 1996 and one in 1997, was also developed into high density housing. A single family home and horse facilities were constructed on a third smaller site, where a juvenile male was observed a number of times during early 1998. We believe that connectivity between habitat patches within urban areas and to larger natural areas in outlying locations, is necessary to provide dispersal areas for young pygmy-owls, to allow unpaired birds to find mates, and to reduce inbreeding and promote a healthy gene flow. Continued habitat losses on a large scale will isolate existing groups of pygmy-owls into smaller areas where the outlook for long-term survival is pessimistic.

MANAGEMENT OPTIONS

We documented multiple pygmy-owl nests in one breeding season for the first time in 1998. Intensive monitoring in the late nestling stage and during the first week post-fledging enabled us to identify the exact time of fledging and the condition of the fledglings after their first flight. Close monitoring during this vulnerable period not only gave us the opportunity for easy capture, but also allowed direct intervention when fledglings were threatened with injury or death through predation or other hazards. We rescued one fledgling impaled on a cactus and moved another which landed just a few feet from a road. We recommend the following management action to reduce fledgling mortalities and increase dispersal efficiency:

1) Monitor all detection locations a minimum of three times from 1 January to 1 May to determine if pygmy-owls are paired and nesting.

2) If a pair or nest is discovered, increase monitoring to once per week to identify the nesting cavity location and nesting status.

3) We recommend a daily "nest watch" once nestlings are visible in the nest cavity (third to fourth week of May in greater Tucson area), and 2 times per day (at high activity periods) during the last week of May to detect fledging status.

4) Continue intensive monitoring through the first week after fledging or until young are flying without difficulty.

Recent use of radio-marking and color bands on individual pygmy-owls has provided crucial information for understanding the biology of this species in Arizona. We have identified and documented dispersal routes, newly established territories, previously unknown use areas, first year breeding, incest and survival rates. We recommend the continued use of these marking and tracking techniques to monitor pygmy-owls not only in the greater Tucson area, but expanded to include all known pygmy-owls in southern Arizona. The ability to identify individuals and track their movements is critical to: understanding territory and home range sizes in urban and non-urban areas, detecting immigration from outlying areas, continued identification of new territories and dispersal routes, adult turnover at nest sites and recognition of individuals.

RESEARCH NEEDS

Pygmy-owl prey analysis in Arizona is currently based on direct observations at nest sites. Regurgitated pellets have been collected for several years, but have not been evaluated. Pellet analysis will provide a more complete picture of prey utilization and dietary needs. A study plan and proposal need to be completed and funding allocated to complete this work.

Birds and lizards are important components of pygmy-owl diet in Arizona comprising 23 and 44 percent respectively of total prey observed during three successive years. Prey abundance has been suggested as a contributing factor in determining pygmy-owl territory size and nest site selection, but we have little specific information on prey abundance in pygmy-owl detection areas and non-use areas. Germaine (1995) examined general population and community descriptors by sampling breeding birds, wintering birds, lizards and rodents in the greater Tucson area across a residential gradient from undisturbed to highly developed. He was able to identify factors influencing wildlife populations in urban areas and make recommendations for maximizing abundances of native wildlife in residential areas. The study did not examine microhabitats within Sonoran desertscrub such as ironwood tree understory and overstory compared with foothills paloverde or other species. It also did not examine regional differences within the Tucson area such as northwest Tucson where pygmy-owls appear to be associated with ironwood and paloverde communities compared with east Tucson where pygmy-owls have not been detected during surveys in the 1990's. Surveys of prey species abundance and diversity within the microenvironments associated with pygmy-owl detection areas and compared with microenvironments of non-use areas may provide important information on habitat selection and pygmy-owl survival.

Pygmy-owl nest cavities observed in Arizona from 1995 to 1998 have been located exclusively in large multi-armed saguaro cactus. In addition, six of seven nests were located in the northwest Tucson and Marana/Redrock areas where development is occurring at a rapid rate. The continued existence of large saguaros with suitable cavities in these areas may be critical to pygmy-owl reproduction and survival in the greater Tucson area. In addition to general habitat studies, specific saguaro field surveys to determine abundance, physical characteristics, cavity availability and reproduction is potentially important baseline data for support of management decisions. Data on the status of saguaros in known pygmy-owl use areas and potential use areas will assist planners and managers in assessing threats to individual pygmy-owl territories and determining appropriate mitigation guidelines.

Post-breeding season surveys in Arizona have been irregular and results of surveys inconsistent. A limited extension of surveys beyond the breeding season may be warranted to increase the number of pygmy-owl detections. To establish the most effective survey periods, maximize detection success, and guide the allocation of resources, we recommend development of a post-breeding survey protocol and continued surveys during the post-breeding season. These efforts should focus in areas occupied during the same year's breeding season to test responsiveness of known birds.

LITERATURE CITED

Abbate, D.J., A. Ditty, S. Richardson and R. J. Olding. 1996. Cactus ferruginous pygmy-owl surveys and nest monitoring in the Tucson Basin area, Arizona - 1996. Urban Wildlife Enhancement Final report #U95503. Arizona Game and Fish Department, Phoenix, Arizona.

Beasom, S. L., J. L. Mays and G. Proudfoot. 1994. Evaluation of non-response bias in pygmy -owl elicited-call surveys; in Caesar Kleberg Wildlife Institute's annual report to the Caesar Kleberg Foundation for Wildlife Conservation. Texas A&M University, Kingsville.

Bent, A.C. 1938. Life histories of North American birds of prey. Part 2. U.S. Natl.Mus. Bull. 170.

Boal, C. 1997. Urban environment as an ecological trap for Cooper's hawks. Dissertation. University of Arizona, Tucson.

Brown, D. E. (ed) 1994. Biotic Communities: Southwestern United States and Northwestern Mexico. University of Utah Press, Salt Lake City.

Carlson, P.C., W.S. Lahaye and A.B. Franklin., 1998. Incestuous Behavior in Spotted Owls. Wilson Bull., 110 (4): 562-564.

Collins, M.D. and T.E. Corman. 1994. Cactus ferruginous pygmy-owl surveys in Arizona: 1993-1994 season. Nongame and Endangered Wildlife Program Technical Report 37. Arizona Game and Fish Department, Phoenix, Arizona.

Dawson, J. W. and R.W. Mannan 1994. The ecology of Harris hawks in urban environments. Final report to the Arizona Game and Fish Department. Grant # G20058A, 76 pp.

Duncan, R.B. and L.K. Harris. (in press) Historical and present day distribution of the ferruginous pygmy-owl in Arizona: abstract of presentation presented at annual meeting of the Raptor Research Foundation, Inc., Ogden Utah, October, 1998. J. Raptor Research.

Felly, D.L. and T.E. Corman. 1993. Spring 1993 cactus ferruginous pygmy-owl surveys in Arizona. Nongame and Endangered Wildlife Program Technical Report. Arizona Game and Fish Department, Phoenix, Arizona.

Goad, S.M. and R. W. Mannan. 1987. Nest site selection by elf owls in Saguaro National Monument, Arizona. The Condor 89: 659-662.

Hardy, Paul C. 1997. Habitat selection by elf owls and western screech-owls in the Sonoran Desert. Thesis, School of Renewable Natural Resources ,University of Arizona, Tucson 143pp.

Hunter, W. C. 1988. Status of the cactus ferruginous pygmy-owl (Glaucidium brasilianum cactorum) in the United States and Northern Mexico. USDI Fish and Wildlife Service, Phoenix, Arizona.

Johnsgard, P.A. 1988. North American owls: biology and natural history. Smithsonian Institution Press. Washington and London.

Johnson, R. R. and L. T. Haight. 1985. Status of the Ferruginous Pygmy-Owl in the Southwestern United States. Abstracts, 103rd Stated Meeting of the American Ornithologist's Union, Arizona State University, Tempe, Arizona.

Kerpez, T. A. and N.S. Smith. 1989. Nest-site selection and nest-cavity characteristics of gila woodpeckers and northern flickers. The Condor 92:193-198.

Lesh, T. D. and T. E. Corman. 1995. Cactus ferruginous pygmy-owl surveys in Arizona: 1993-1995. Nongame and Endangered Wildlife Program Technical Report 76. Arizona Game and Fish Department. Phoenix, Arizona.

McAuliffe, J. R. and P. Hendricks. 1988. Determinants of the vertical distributions of woodpecker nest cavities in the sahuaro cactus. The Condor 90: 791-801.

Millsap, B. A. and R.R. Johnson. 1988. Ferruginous pygmy-owl. Pages 137-139 in R.L. Glinski et al., (eds). Proceedings of the Southwest Raptor Management Symposium and Workshop. Natl. Wildl. Fed., Washington, D.C.

Monson, G. and A. R. Phillips. 1981. Annotated checklist of the birds of Arizona. The University of Arizona Press, Tucson.

Phillips, A., J. Marshall , and G. Monson. 1964. The birds of Arizona. The University of Arizona Press, Tucson, Arizona .

Pierson, E.A. and R.M. Turner. 1998. An 85-year study of saguaro (Carnegiea gigantea) demography. Ecology 79(8): 2676-2693.

Proudfoot, G. A. 1996. Natural History of the Cactus Ferruginous Pygmy-Owl. Thesis, Texas A&M University, Kingsville.

_____. 1996. Miniature video-camera used to inspect natural and artificial nest cavities. Wildl. Soc. Bull. 24:528-530.

_____ and Sam L. Beasom. 1996. Responsiveness of Cactus ferruginous pygmy-owls to broadcasted conspecific calls. Wildl. Soc. Bull. 1996, 24(2):294-297.

_____ and Sam L. Beasom. 1997. Food habits of nesting ferruginous pygmy-owls in southern Texas. Wilson Bulletin 109 (4):741-748.

Rea, A. M. 1983. Once a River. University of Arizona Press, Tucson. 285pp.

Scherzinger, W. 1977. Small owls in aviaries. Aviculture Magazine 83 (1): 18-21.

Terres, J. K. 1991. The Audubon Society Encyclopedia of North American Birds. Wings Books, Avenel New Jersey.

U.S. Fish and Wildlife Service. 1994. Proposed Rule: to list the cactus ferruginous pygmy-owl as endangered in Arizona and threatened in Texas. December 12, 1994. Federal Register 59: 63975-63986.

____. 1997. Determination of endangered status for the cactus ferruginous pygmy-owl in Arizona. Federal Register 62: (46) 10730-10747.

____. 1998. Endangered and threatened wildlife and plants; Proposed determination of critical habitat for the cactus ferruginous pygmy-owl. Federal Register 63 (250) 71820-71838.

Waur, R.H., P.C. Palmer, and A.Windham. 1993. The Ferruginous Pygmy-Owl In South Texas. American Birds: 47,(5): 1071-1076.

Wilcox, R.L., S. Richardson, and D.Abbate. Habitat characteristics of occupied cactus ferruginous pygmy-owl (*glaucidium brasilianum cactorum*) sites at the suburban/rural interface of north Tucson, Arizona (in progress), Region V Wildlife Program, Arizona Game and Fish Department, Tucson .

Appendix E. FEPO data form used to record active nest monitoring observations.

ARIZONA GAME AND FISH DEPARTMENT
CACTUS FERRUGINOUS PYGMY-OWL
NEST SITE MONITORING AND OBSERVATION FORM

Nest site name or description:______________________________
Date (D/M/Y):____________ Sunrise time:__________ Sunset time:__________
Observer (s):______________________________Affiliation:______________
Arrival Time:__________

Observation start time:_______Starting weather: Temp:_______Wind:_______Clouds:_______
end time:_______ Ending weather: Temp:_______Wind:_______Clouds:_______
Total hrs:_______

Date when nesting was confirmed:________ How nesting was confirmed:______________
____

Current estimated nesting stage: ______________________________

Today's initial detection times: adult male aural:_______ adult female aural:_______
adult male visual:_______adult female visual:_______
juvenile #1 aural:_______visual:_______
juvenile #2 aural:_______visual:_______
juvenile #3 aural:_______visual:_______
juvenile #4 aural:_______visual:_______
juvenile #5 aural:_______visual:_______

Vegetation/Structure Use (continue on back of form)

Description	Observed activity/behavior	# times used

Water use description: ______________________________
____

Female Time Budget Summary	a.m.	p.m.	total
total visual and aural observation time:			
amount of time in cavity:			
amount of time outside cavity:			

Additional Notes or Comments : ______________________________
____
____

CACTUS FERRUGINOUS PYGMY-OWL CAPTURE FORM

Date_______________ Time__________________

Weather (wind, cloud cover, temp. etc.) ____________________________________
____

Personnel ____

Location Description ____
____
____

Township _____ Range _____ Section ______ ____1/4 of ____1/4
EWUTM _____________ NSUTM ______________

Owl Information:
Age _________ Sex _________
Weight ____________
Wing Chord Length _______________ Tail Length _______________
Total Body Length _______________ Tarsus Diam. _______________

Marking Information:
Bands: Yes ___ No ___
Type _____________ Leg _______
Type _____________ Leg _______

Transmitter: Yes ____ No ____ Type ______________________________________
Frequency _________________

Other Samples:
Type ____
Vial or Bag # _______________

Comments ____
____
____
____
____

Appendix G. FEPO data form used to record radio-marked owl location data.

ARIZONA GAME AND FISH DEPARTMENT
CACTUS FERRUGINOUS PYGMY-OWL PROJECT
RADIO-MARKED OWL DETECTION/LOCATION FORM

Today's Date ______________ Frequency of transmitter: __________________.
Color Band Description:________________ USFWS Band number: __________________
Observer (s):___________________________________ Affiliation:________________________

Total number of days CFPO has been radio-marked _______

Today's detection time (*time when confirmed transmission from radio was first received*):__________

Visual detection time:_________ Aural detection time:_________ Radio detection only: ______

Legal Description for today's location (*when possible, use compass bearings and triangulation if radio or aural detection only*): Actual Estimate

T_______, R_______, _______1/4 of the______1/4 of Section______Elevation:_________

UTM Description for known or triangulated location: Easting ____________, Northing ____________

If radio detection only:

Your Location (s) — Compass Bearing to Owl

____ ____________
____ ____________
____ ____________
____ ____________

Habitat description where owl was located (*include habitat type*,dominant vegetation and general species present*):
____
____
____

Identify vegetation species or structures being used when visual detection is made:

Species	Perch height estimate	Vegetation height estimate

Identify birds species involved in mobbing or other interactions: ____________________________
____

Are other juvenile or adult pygmy-owls in the immediate area? _______ Describe location and behavior:
____
____

Describe owl behavior and general comments____
____
____

Attach photocopy of 7.5 minute USGS topo section with owl location, date, observer and affiliation, time.
* Refer to Brown, David E. (ed.) 1994. Biotic Communities: Southwestern United States and Northwestern Mexico

Appendix H. FEPO direct observation prey item records.

ARIZONA GAME AND FISH DEPARTMENT
CACTUS FERRUGINOUS PYGMY OWL
NEST SITE PREY DELIVERY LOG AND SUMMARY

Today's Date: ____________
Nest Site Name or Description: ____
Observer(s):__________________________________Affiliation:_________________________
Arrival Time: ________ Sunrise Time: ________ Sunset Time: ________
Observations Start Time:________ End Time:________ Total hrs. ________

Delivery or Capture Time	Sex of Owl Making Delivery	Item Description	Item Disposition

Prey Data Summary *(this data will assist in determining nesting stage)*

	a.m.	p.m.	total
Number of prey items delivered directly to female:	____	____	____
Number of prey items delivered to nest cavity by male:	____	____	____
Number of prey items delivered to nest cavity by female:	____	____	____
Number of prey items cached by female:	____	____	____
Number of prey items cached by male:	____	____	____
Number of prey items captured by female:	____	____	____
Total number of prey items captured by male and female:	____	____	____

Prey Item	a.m.	p.m.	Total	Notes / Comments
birds	____	____	____	________________________________
reptiles (lizards)	____	____	____	________________________________
mammals	____	____	____	________________________________
insects	____	____	____	________________________________
undetermined	____	____	____	________________________________

Appendix I. Forms used to record habitat data within FEPO use sites.

Cactus Ferruginous Pygmy Owl Habitat Characterization Form

Date: ____________________ Observer(s): ____________________
____
____

Location: T____ R____ S____ ____1/4 of the ___ 1/4 Quad:________

UTM N________ E__________ Elevation: _____________

Land Ownership: ____
____
____

Number of Times and How Bird Was Detected at this Site: ______________________
____
____

Distance to Habitat Components (Indicate how determined, i.e. map, actual measurement, estimate):

Permanent Water: ______ Ephemeral Water: ______ Bird Feeder: _____

Dirt Road: __________ Paved Road: _________

Artifical Structure: ______________ Type?: ____________________

Habitat Edge: ____________ Type?: ______________________________

Nearest Other Confirmed CFPO Location: ______________________________
____

What Types of Human Activities are Occurring on Site? ______________________
____
____

Is the Site Grazed by Livestock? __________ Type: ______________

Other Wildlife or Signs: ______________________________________
____
____
____
____

Comments: ____
____
____

Appendix I (continued)

10m X 10m Sample Plot: Count every individual of every species occurring within the plot and provide an average height and cover class for each species. For trees and saguaros over 2m, measure diameter of largest stem at breast height and count number of cavities.

Species	Number	Average Ht.	Diam./Cavit.	Cover Class
Bare Ground				
Large Ground Structures (logs,branchrocks>18in.)				

Cover Classes:

CLASS	PERCENT COVER	MIDPOINT
1	0-5%	2.5
2	6-25%	15.5
3	26-50%	38.0
4	51-75%	63.0
5	76-95%	85.5
6	96-100%	98.0

Appendix I. (continued)

50m Line Transect

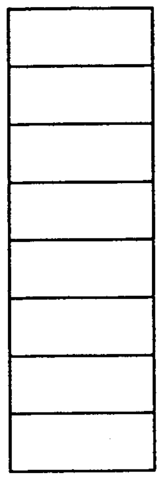
Every 2 meters, indicate every vegetation hit at each height for each point. For heights > 2 m., visually estimate whether vegetation would hit point and measure diameter of largest stem at breast height and count the number of cavities.

Point	0	0 - .4m	.4m - 2m	>2m	Diam./Cav.
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					
21					
22					
23					
24					
25					

Appendix I. (continued)

Transect #_______ Bearing(Magnetic)__________

Cover Board Reading



Cover Classes:

CLASS	PERCENT COVER	MIDPOINT
1	0-5%	2.5
2	6-25%	15.5
3	26-50%	38.0
4	51-75%	63.0
5	76-95%	85.5
6	96-100%	98.0

Appendix J. Data form used to record measurements of nest or general use saguaros and cavities.

ARIZONA GAME AND FISH DEPARTMENT
FEPO SAGUARO AND CAVITY MEASUREMENT FORM

Location ______________________ Date ______________

Surveyors ____

Saguaro Data

Main stem height_____ Nest cavity arm height_____ Total no. of arms_____
No. primary arms _____ No. secondary arms _____ No. Buds _____(*12 inches or less*)

Distance of saguaro to nearest building (main exterior wall)______to nearest road_______

Distance to nearest water source_____ Comment ______________________

Shape of water source____________Size of water source_________ Depth of water_________

Is saguaro or cavity shaded by tree or structure during: morning evening unshaded
Distance of saguaro to the nearest neighbor large saguaro with cavities____________

Distance of saguaro to nearest shade tree or shrub____________

Diameter of saguaro at center of cavity opening__________

Cavity Data

Total number of cavities on main trunk_______Total number of cavities on arms __________

Total number of cavities inspected for suitability__________number suitable ____________

Location of cavity opening used by CFPO: main trunk arm

Height of cavity opening used by CFPO _______ Aspect of cavity opening_______

Cavity used for: nesting caching cover feeding use unknown

Exterior cavity scarring description:______________________________

Cavity opening vertical diameter__________horizontal diameter_______
describe cavity shape____________________________________

Thickness of cavity opening bottom ledge__________

Distance from bottom exterior cavity edge to nearest saguaro arm (closest edge)__________

Distance from exterior of cavity opening to back wall of cavity interior _____ Cavity Depth _____

Comments____
____
____

Use back for additional comments and cavity sketch. Include photograph if possible.

Appendix K. List of songbird species observed mobbing pygmy-owls in Pima County, Arizona, 1997-1998.

Common Name	Scientific Name
Ash-throated Flycatcher	*Myiarchus tyrannulus*
Cactus Wren	*Campylorhynchus bruneicapillus*
Curve-billed Thrasher	*Toxostoma curvirostre*
Gambel's Quail	*Callipepla gambellii*
Gila Woodpecker	*Melanerpes uropygialis*
Black-tailed Gnatcatcher	*Polioptila melanura*
Greater Roadrunner	*Geococcyx californianus*
House Finch	*Carpidacus mexicanus*
House Sparrow	*Passer domesticus*
Northern Cardinal	*Cardinalis cardinalis*
Northern Flicker	*Colaptes auratus*
Northern Mockingbird	*Mimus polyglottos*
Phainopepla	*Phainopepla nitens*
Pyrrhuloxia	*Cardinalis sinuatus*
Verdin	*Auriparus flaviceps*
Hummingbirds	species undetermined

Appendix L. Color-band scheme for adult and juvenile pygmy-owls in northwest Tucson, Pima County, Arizona, 1995 - 1998.[a] MR = Marana/Redrock, NWT = northwest Tucson

Owl I.D. & Capture Site	General Location	Date of Capture	Known Age at Capture	Sex	Band Description[b]	Last Known Status
95S1-1	MR	95	fledgling	unknown	USFWS aluminum - R	released after rehab
95B3-1	NWT	2 June 97	fledgling	male	red - R	first year breeder - 98
95B3-2	NWT	2 June 97	fledgling	female	yellow - R	first year breeder - 98
96T2-1	NWT	23 March	adult	male	dark blue - R	unpaired & defending - 98
95B4-1	NWT	31 May 98	fledgling	unknown	yellow - L	dispersed in August - 98
95B4-2	NWT	31 May 98	fledgling	unknown	light blue - L	dispersed in August - 98
95B4-3	NWT	31 May 98	fledgling	unknown	dark blue - L & red - R	dispersed in August - 98
95B4-4	NWT	31 May 98	fledgling	unknown	red - L	dispersed 2.25 mi. - Aug 98
95B4-5	NWT	10 July 98	Adult	female	dark green - L	breeder in 98
95B4-6	NWT	10 July 98	fledgling	unknown	black - R	dispersed 4.5 mi. - Aug 98
98DM1-1	NWT	1 June 98	fledgling	unknown	orange - L	dispersed 6.7 mi. - August 98
98DM1-2	NWT	1 June 98	fledgling	unknown	dark green - R	presumed dead June 98
98DM1-3	NWT	1 June 98	fledgling	unknown	orange - R	presumed dead June 98
96L4-1	NWT	31 May 98	fledgling	unknown	light blue - R	dispersed 3.9 mi. August 98
96L4-2	NWT	31 May 98	fledgling	unknown	dark blue - L	dispersed - late July 98
96L4-3	NWT	31 May 98	fledgling	unknown	yellow - L & white - R	dispersed - late July 98

[a] No birds were color-marked in 1996.
[b] L = left leg, R = right leg

Appendix M. List of FEPO prey species identified through direct observations at nest sites in Pima County, Arizona 1996 - 1998.

Common Name	Scientific Name
Birds	
Black-tailed Gnatcatcher	*Polioptila melanura*
Cactus Wren	*Campylorhynchus bruneicapillus*
Gambel's Quail	*Callipepla gambellii*
House Finch	*Carpodacus mexiancus*
House Sparrow	*Passer domesticus*
Mourning Dove	*Zenaida aurita*
Verdin	*Auriparus flaviceps*
Reptiles	
Western Whiptail Lizard	*Cnemidophorus tigris*
Desert Spiny Lizard	*Sceloporus magister*
Zebra-tailed Lizard	*Callisaurus draconoides*
Mammals	
Kangaroo Rat	*Dipodomys* sp.
Insects	
Cicada	undetermined
Grasshopper	undetermined
Moths	undetermined
Butterfly	undetermined