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Ecology and Conservation of the Cactus Ferruginous Pygmy-Owl in Arizona

Abstract

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This report is the result of a cooperative effort by the Rocky Mountain Research Station and the USDA Forest Service Region 3, with participation by the Arizona Game and Fish Department and the Bureau of Land Management. It assesses the state of knowledge related to the conservation status of the cactus ferruginous pygmy-owl in Arizona. The population decline of this owl has been attributed to the loss of riparian areas before and after the turn of the 20th century. Currently, the cactus ferruginous pygmy-owl is chiefly found in southern Arizona in xeroriparian vegetation and well-structured upland desertscrub. The primary threat to the remaining pygmy-owl population appears to be continued habitat loss due to residential development. Important information gaps exist and prevent a full understanding of the current population status of the owl and its conservation needs.

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Cover photo—Clockwise from top: photograph of fledgling in Arizona by Jean-Luc Cartron, photograph of adult ferruginous pygmy-owl in Arizona by Bob Miles, photograph of adult cactus ferruginous pygmy-owl in Texas by Glenn Proudfoot.

Ecology and Conservation of the Cactus Ferruginous Pygmy-Owl in Arizona

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Stephen M. Russell received a degree in Biology from Virginia Polytechnic Institute and then earned a Ph.D. at Louisiana State University, where he did dissertation studies in British Honduras (Belize). He taught at the University of New Orleans before joining the faculty at the University of Arizona. Recently, he retired to emeritus status after 32 years at Arizona, where he taught, did research, and investigated the birds of Sonora. He has served as President of the Arizona-Sonora Desert Museum and the Cooper Ornithological Society and was Secretary of the American Ornithologists' Union for several years. He is currently Chair of the North American Banding Council. Current research interests focus upon the behavior and ecology of hummingbirds.

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Contents

Jean-Luc E. Cartron
Deborah M. Finch

Introduction

In March 1997, the U.S. Fish and Wildlife Service listed the Arizona population of the cactus ferruginous pygmy-owl (*Glaucidium brasilianum cactorum*) as endangered under the Endangered Species Act (U.S. Fish and Wildlife 1997). Federal listing for the owl in Arizona resulted from a petition submitted in 1992 to the U.S. Fish and Wildlife Service (Galvin et al. 1992, U.S. Fish and Wildlife 1994). It was finalized based on historical and current evidence suggesting a significant population decline of this subspecies had occurred in Arizona and the owl population in this state was now nearly extirpated (see Phillips et al. 1964, Johnson et al. 1979, Monson and Phillips 1981, Rea 1983: 65-66, Hunter 1988, Millsap and Johnson 1988, U.S. Fish and Wildlife 1997). The loss and alteration of the owl's habitat was identified as the primary threat to the remaining population (e.g., Johnson et al. 1979, Millsap and Johnson 1988, Hunter 1988, U.S. Fish and Wildlife 1997). In July 1999, critical habitat for the cactus ferruginous pygmy-owl was also designated on 296,240 ha (731,712 acres) of federal, state, and private lands in Pima, Pinal, and Maricopa counties.

The primary goal of this report is to document and explore the conservation needs of the cactus ferruginous pygmy-owl in Arizona. Although it is intended for a broad audience, one specific objective of this conservation assessment is to provide the U.S. Forest Service and other agencies and stakeholders with the information necessary to ensure the conservation of the owl and its critical habitat. In 1996, the Southwest Region of the U.S Forest Service requested assistance from the Rocky Mountain Research Station in developing a conservation assessment for the pygmy-owl. Because historical owl habitat existed on national forests of southern and central Arizona, the region believed an analysis of owl status and habitat would be of benefit in managing habitats to recover owls on national forests. Our product is the outcome of this original request. Experts from state and federal agencies, universities, and other institutions were invited to participate in writing the report. For more information about individual authors, see the *Authors* section of this report.

A recovery team for the cactus ferruginous pygmy-owl was appointed by the U.S. Fish and Wildlife Service in 1998. Its function is to develop a recovery plan that identifies delisting criteria and recommends a course of action to restore sufficient, stable, and self-maintaining population levels of the owl. Thus, another objective of the conservation assessment is to assist the recovery team by providing information for use in the development of the recovery plan while also discussing important issues and suggesting research needs.

The conservation assessment for the cactus ferruginous pygmy-owl is primarily a literature review, yet original data are presented in several chapters. It relies extensively on information gathered in Arizona by the Arizona Game and Fish Department since 1995 and in Texas by researchers from the Cesar Kleberg Wildlife Research Institute since 1992. In Arizona, efforts focused initially on population surveys but have also recently included nest monitoring, habitat sampling, and telemetry (Abbate et al. 1996, Richardson pers. comm.). In Texas, where a sizeable population of the owl has been located (Wauer et al. 1993, Mays 1996), research continues to document the natural history of the owl and determine demographic parameters and habitat use in this state (Proudfoot 1996, Proudfoot and Beasom 1997, Proudfoot and Radomski 1997). Unquestionably, the research in Arizona and Texas has provided some important information. Yet, at the same time, many questions remain unanswered.

Chapter 1 focuses on the taxonomy, distribution, and natural history of the cactus ferruginous pygmy-owl. In particular, this chapter consolidates an important amount of published and unpublished data on the breeding biology and diet of the owl. As indicated, behavioral observations suggest that much of the biology of the owl revolves around an opportunistic hunting strategy and on predator avoidance. Observed and potential causes of owl mortality are described; they include predation, parasites, and human-related factors. Throughout the chapter, the authors outline areas of uncertainty, such as genetic relatedness of the Arizona and Texas populations, habitat requirements, competition for cavities with other species, demographic parameters, and seasonal movements.

The ferruginous pygmy-owl (*Glaucidium brasilianum*) reaches the northern edge of its distribution in the southwestern U.S. Early studies establish the presence of the owl along rivers and streams of central and south Arizona around the turn of the 20th century (Bendire 1888, 1892, Breninger 1898). The owl population decline in Arizona, which is the focus of Chapter 2, has been reported to have occurred around 1950 (see Monson and Phillips 1981). Using both the existing literature and museum specimen records, the authors indicate that a sharp decrease in the number of owls probably began earlier, at least in central Arizona. Chapter 2 also examines the possible effects of biogeography and habitat loss on the population decline.

Chapter 3 is a review of the current survey effort in Arizona, with sections on the survey protocol, survey results, and habitat description in survey areas. Population surveys have become a priority for federal and state agencies, as well as private development interests. An initial survey protocol was developed by the Arizona Game and Fish Department. It provided recommendations on the timing of surveys, distance between call points, and broadcast and listening times at each call point. Due to changes in management needs and the results of ongoing research, the initial survey protocol has been revised and will likely be revised in the future in order to maximize survey effectiveness. The present distribution of the cactus ferruginous pygmy-owl in Arizona is not well understood, but in the last two years, much information has been obtained. Although more owls have been located due to the increased survey effort, population size still appears to be small.

Chapter 4 explores habitat preferences and requirements of the ferruginous pygmy-owl using descriptions of vegetation types that are reportedly associated with higher densities of the owl in various parts of its range. Because an essential conservation issue is whether the owl should be managed as a riparian species or an upland species, the authors also examine the possible respective roles and importance of these two vegetation types. As indicated in Chapter 2, the owl was historically reported chiefly from riparian woodlands and thickets in Arizona. Recently, however, it has been primarily found in desertscrub (e.g., Lesh and Corman 1995, Abbate et al. 1996, Chapter 3). Despite the persistence of what seems like suitable riparian habitat, there are few owl records from riparian areas in recent years.

Several attributes of the cactus ferruginous pygmy-owl make this bird difficult to detect and study. With the use of broadcasted conspecific calls, however, population surveys have located a higher number of owls than previously estimated, both in Texas and Arizona. In Texas, tools such as radiotransmitters, video cameras, and nest boxes have also proven valuable for conducting studies on this bird (Proudfoot 1996, Proudfoot and Beasom 1996, 1997). Chapter 5 is a description of the equipment selected for research on the cactus ferruginous pygmy-owl in Texas, along with a review of the methodology and applications for the use of that equipment.

Chapter 6 concludes the conservation assessment and reviews research needs for the conservation of the cactus ferruginous pygmy-owl in Arizona. The recent increase in the number of pygmy-owls located (Chapter 3) indicates surveys are key to a better understanding of the size, distribution, and structure of the Arizona owl population. Demographic and habitat use studies are also needed. One management issue discussed in the chapter and tied to research is the possible use of nest boxes in some riparian areas. Nest boxes may be useful to 1) locate more owls, 2) conduct habitat studies, and 3) improve habitat quality where nest sites may be limited.

The historical range of the owl in Arizona represents only the northern edge of the species' wide distribution. In the tropics, the ferruginous pygmy-owl is one of the most common birds of prey (Chapter 1). In contrast to the California condor (*Gymnogyps californianus*) or the whooping crane (*Grus americana*), the fate of the Arizona owl population likely does not condition the viability of the entire species. Yet, it should also be noted that in recent times species have often become extinct or endangered as a result of human activities leading to incremental range contractions. An important provision of the Endangered Species Act is to list those disappearing populations whose loss would lead to a significant gap in the range of the species. Throughout the conservation assessment, no attempt is made to rank the need to preserve the Arizona population of the cactus ferruginous pygmy-owls among other conservation demands. With the federal listing comes a legal obligation to develop and implement a plan for the conservation of this owl.

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Chapter 1:

The Cactus Ferruginous Pygmy-Owl: Taxonomy, Distribution, and Natural History

The cactus ferruginous pygmy-owl (*Glaucidium brasilianum cactorum*) is a small, cryptic owl that is often difficult to observe. Its natural history and conservation needs are poorly understood. Despite ongoing research in Texas and Arizona, the available information remains limited. In addition, factors influencing demographics (e.g., habitat configuration, causes of mortality and reproductive failure, and prey availability) may vary geographically, increasing the need for information from all parts of the range. Without a significant commitment to additional research, management and recovery strategies will be difficult to develop. This chapter first describes the taxonomy and distribution of the ferruginous pygmy-owl (*G. brasilianum*). It then discusses the known ecology of *cactorum*.

1. Taxonomy and distribution

The taxonomy of the genus *Glaucidium* (order Strigiformes, family Strigidae) is a topic of debate among authorities, at both the species and subspecies levels. Both Johnsgard (1988) and Sibley and Monroe (1990) list 12 species of owlets and pygmy-owls occurring worldwide, including the ferruginous pygmy-owl. However, recent molecular and vocalization studies distinguish a number of additional mainland New World species of pygmy-owls (Vielliard 1989, Robbins and Howell 1995, Howell and Robbins 1995, D. Holt pers. comm.). The austral pygmy-owl, sometimes considered a separate species, *G. nanum* (e.g., Meyer de Schauensee 1970), has recently been treated as a morph of *G. brasilianum* (Marín et al. 1989, Stoltz et al. 1996). Conversely, the pygmy-owl of southwest Ecuador and northwest Peru, once treated as *G. brasilianum* (Meyer de Schauensee and Phelps 1978), has been proposed as a distinct species, *G. peruanum,* by König (1991) and Stoltz et al. (1996).

The ferruginous pygmy-owl, also called the ferruginous owl, is considered abundant or extremely abundant throughout most of its range, which is centered on the Neotropics (Fig. 1-1) (Phillips et al. 1964, Johnsgard 1988, Terres 1991). In Mexico, this species was the one most often collected between 1840 and 1991 (Enriquez-Rocha et al. 1993). To the south, the ferruginous pygmy-owl's distribution extends to central Argentina, even to Tierra del Fuego if *nanum* is treated as conspecific (Johnsgard 1988, König and Wink 1995). At the northern edge of its geographic range, the ferruginous pygmy-owl reaches central Arizona and extreme southeast Texas (Fig. 1-2). Since 1937, the form found from central Arizona south to Michoacan in western Mexico (see Johnsgard 1988) has been recognized as the subspecies *cactorum* (van Rossem 1937, Friedmann et al. 1950, Blake 1953, Sprunt 1955, Phillips et al. 1964, Monson and Phillips

Figure 1-1. Geographic range of the ferruginous pygmy-owl (adapted from Johnsgard 1988). The distribution includes *nanum* (Marín et al. 1989, Stoltz et al. 1996) but not *peruanum* (Meyer de Schauensee and Phelps 1978). The distribution of the recently described subspecies *stranecki* (König and Wink 1995) is not included.

1981, Millsap and Johnson 1988, Binford 1989). Whether the ferruginous pygmy-owl which ranges from southeastern Texas to Tamaulipas and Nuevo Leon in northeastern Mexico (see Johnsgard 1988) is also *cactorum* has not been resolved. Peters (1940) refers to the ferruginous pygmy-owl of Texas as *ridgwayi* and to the ferruginous pygmy-owl of Arizona as *cactorum*. Since Friedmann et al. (1950), however, both forms have been treated as *cactorum*. Molecular analyses are currently in progress to decide whether the two owls should be taxonomically divided (Proudfoot et al. unpubl. data). Pending the results of these analyses, we follow the currently accepted taxonomy (Johnsgard 1988, U.S. Fish and Wildlife 1997, American Ornithologists' Union 1998) and consider the ferruginous pygmy-owl of Texas and northeastern Mexico as *cactorum*.

In southern Mexico and throughout Central America *cactorum* is replaced by *G. b. ridgwayi*. In South America, several subspecies have been described. One is the widely distributed *G. b. brasilianum* (Fisher 1893, van Rossem 1937, Friedmann et al. 1950, Schaldach 1963, Phillips et al. 1964, Meyer de Schauensee 1966, Karalus and Eckert 1974, Oberholser 1974, Johnsgard 1988, Sick 1993). Another subspecies recently described from central Argentina is *G. b. stranecki* (König and Wink 1995). The austral pygmy-owl of Tierra del Fuego may represent the southernmost subspecies of the ferruginous pygmy-owl.

Two populations of *cactorum* are generally recognized (e.g., Burton 1973, Johnsgard 1988, but see comments above) (Fig. 1-2). In the west, the cactus ferruginous pygmy-owl ranges north to central and southern Arizona. The historical boundaries of its distribution in Arizona are New River in the north, the confluence of the Gila and San Francisco rivers to the east, and the desert of southern Yuma County to the west (Fisher 1893, Phillips et al. 1964, Monson and Phillips 1981, Hunter 1988). This western population extends south along the Pacific slope of the Mexican Plateau, where it is common in lowlands and foothills (Peterson and Chalif 1973). The eastern population occurs from extreme southeastern Texas south to Tamaulipas and Nuevo Leon in northeastern Mexico. In Texas, it occurs in the live oak (*Quercus virginiana*)-honey mesquite (*Prosopis glandulosa*) forest of the historical Wild Horse Desert in Brooks and Kenedy counties (Mays 1996). Historically, it was also often reported along the Rio Grande in Star and Hidalgo counties (Oberholser 1974, Texas Ornithol. Soc. 1984, Proudfoot in press).

The eastern and western populations are separated over most of their ranges by a series of biogeographic barriers: the United States' Chihuahuan desert basins and associated mountain ranges and Mexico's Sierra Madre Occidental and Oriental and Mexican Plateau. These barriers may prevent contact between the two populations. There is no record of the cactus ferruginous pygmy-owl in any U.S. location between Arizona and south Texas (Bailey 1928; Phillips et al. 1964, Oberholser 1974, Williams 1997). In Mexico, it is rarely encountered on the Mexican Plateau above 1200 m on the west side and 300 m on the east side (Friedman et al. 1950). At the southern tip of the Mexican Plateau, however, the two ranges may merge (Johnsgard 1988, but see Burton 1973 for a different opinion).

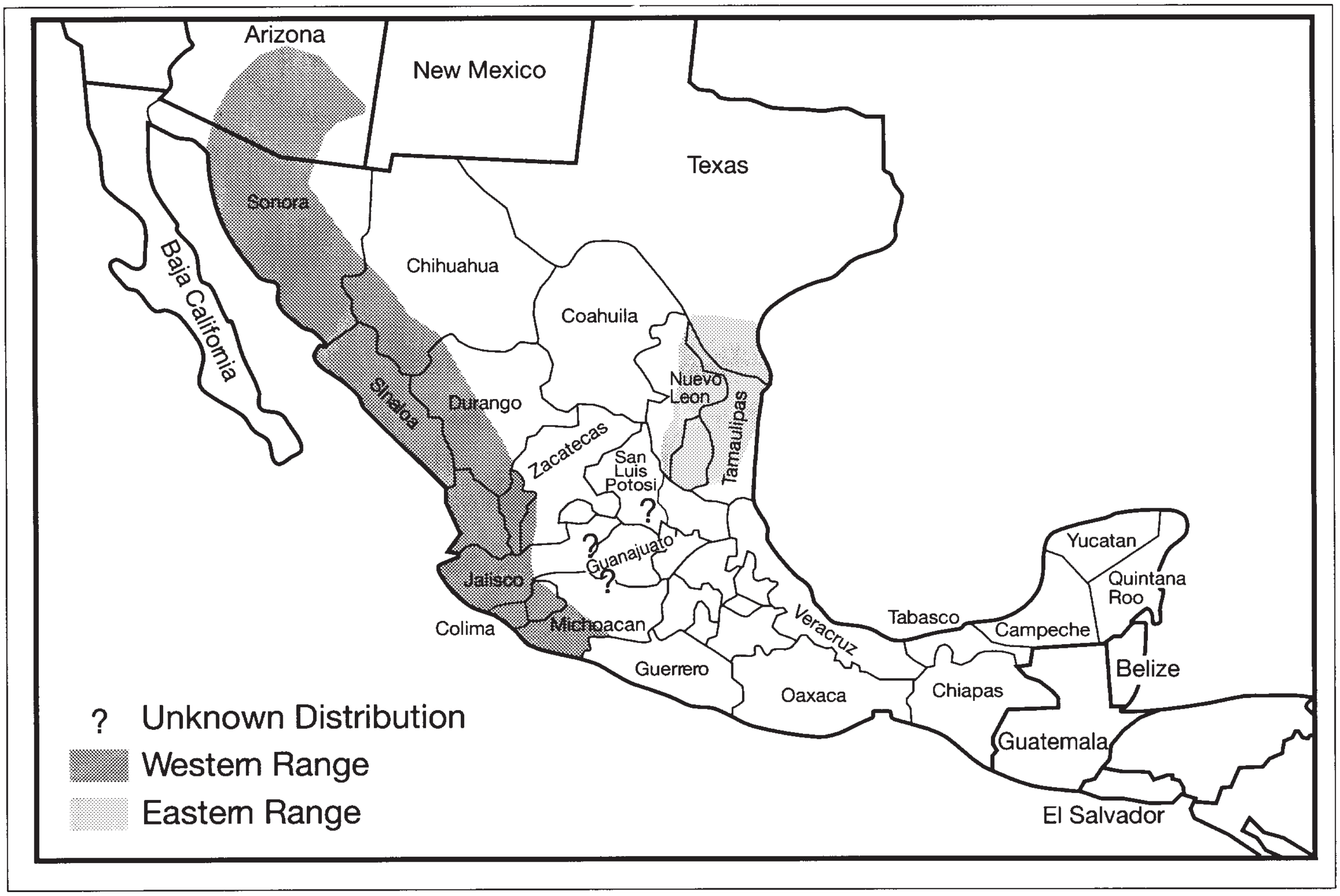

Figure 1-2. Geographic range of the cactus ferruginous pygmy-owl (adapted from U.S. Fish and Wildlife 1994). Whether the eastern and western parts of the range are completely disjunct is unknown. The eastern population is currently treated as the subspecies *cactorum*, but its taxonomic status remains uncertain.

2. Description

The cactus ferruginous pygmy-owl is a small gray-brown or rufous-brown owl, approximately 16.5 to 18 cm long. In comparison with *G. b. brasilianum* and *G. b. ridgwayi*, this subspecies exhibits shorter wings, a longer tail, and generally lighter coloration (van Rossem 1937, Phillips et al. 1964, Proudfoot 1996). The head is relatively small and without ear tufts. The eyes are lemon yellow and the crown is finely streaked with flecks of buff. On the nape, a pair of conspicuous black patches outlined in white is suggestive of eyes. The back is not spotted as in the northern pygmy-owl (*G. gnoma*), but plain, rusty brown (Robbins et al. 1966). The white breast shows well-defined streaks of brown. The tail is long compared to other small owls and is rufous in color with seven or eight darker brown cross bars. Although no true seasonal changes in plumage coloration are documented, Breninger (1898) reported that the rufous coloring of the tail and upper body becomes less noticeable through the spring months. According to Ridgway (1914), the Arizona and Texas populations of cactus ferruginous pygmy-owls exhibit slightly distinct color forms, the latter occurring with a more rufous plumage. A gray-brown phase with white tail bands has been described in other parts of the species' distribution (Edwards 1972).

As is typical in owls, the female is larger, weighing around 75 g while the male averages 64 g (Proudfoot unpubl. data) (Fig. 1-3). Additionally, subtle differences in plumage exist between the sexes, at least in the United States (Abbate et al. 1996, Proudfoot 1996). Compared to males, females display a more pronounced cinnamon-rufous color tone on their coverts, remiges, occipitals, and scapulars (Proudfoot 1996). Overall, juveniles are similar to adults but are distinguished for the first few weeks by their shorter tails and by well-contrasted white, tear-drop-like feather ends that form a broken line running from shoulder to rump when the birds are perched. Other characteristics of fledglings include lighter, less distinct eye patches on the nape, the lack of buff on their crowns, and more white on their underparts

Figure 1-3. Sexual dimorphism in the cactus ferruginous pygmy-owl. Note the difference in color tone and the larger size of the female, right. Photograph by Glenn Proudfoot.

(Abbate et al. 1996). Fledglings in Arizona also exhibit a more chocolate brown color, lacking any real rufous coloration except on their tails.

The vocal repertoire of the cactus ferruginous pygmy-owl comprises several calls, some of which appear to be specific to age or sex of the owl. The advertising call of the adult male is heard primarily at dawn and dusk but also during daylight and even moon rise, especially during the courtship period. It is ventriloquial (Sprunt 1955) and consists of a prolonged and monotonous series of clear, mellow, whistling notes uttered at approximately 1400 Hz (Stillwell and Stillwell 1954). During the breeding season, females utter a rapid chitter, possibly a contact call with the male and juveniles and also for food begging (Abbate et al. 1996, Proudfoot and Johnson in press). When the female receives food from the male, the same chitter may be used to signal her position to the fledglings (Abbate et al. 1996). Two additional female calls have been recorded; the "chirp," sometimes repeated with short pauses in between, may be used to signal distress or for warning (Abbate et al. 1996). The other call is similar to the territorial vocalization of the male, only at a higher pitch and slower beat (Phillips et al. 1964, Abbate et al. 1996). The specific function of this latter call is not well understood. The fledglings' primary vocalization is a chitter similar to the female's but at a higher pitch. When they are flushed from a perch, fledglings also produce a high-pitched chirp-like call (Proudfoot and Johnson in press, Richardson unpubl. data).

Like other species in the genus *Glaucidium*, the ferruginous pygmy-owl is reported to hunt both day and night (Oberholser 1974, Sick 1993). Yet, except during nestling development, *cactorum* is primarily diurnal (Proudfoot and Johnson in press). Although the ferruginous pygmy-owl is generally quite cryptic, it is sometimes seen during the day perched on exposed branches (Sutton 1951, Oberholser 1974). The tail, often cocked at an angle with the body, is jerked from side to side when the owl is agitated (Sprunt 1955, Oberholser 1974). Unlike many owl species, the ferruginous pygmy-owl flies with audible wingbeats due to reduced numbers, lengths, and surface area coverage of the barbs and barbules (D. Holt, pers. comm.). The ferruginous pygmy-owl's flight is generally short and consists of quick sallies from one lookout point to another. It has been compared to that of a shrike (e.g., Sprunt 1955).

3. Habitat

Across its range, the ferruginous pygmy-owl occurs in many distinct environments, such as scrublands, forests, cerrados (i.e., a neotropical type of open woodlands), and towns (Meyer de Schauensee 1966, Davis

1972, Meyer de Schauensee and Phelps 1978, Hilty and Brown 1986). Partly because of this species' plasticity and partly due to the lack of detailed habitat studies, the habitat requirements of *cactorum* remain poorly understood. The following section profiles habitat occupied by the cactus ferruginous pygmy-owl and discusses some potentially important habitat characteristics (Fig. 1-4). This topic is addressed in more detail in Chapter 4.

In the eastern part of the range, plant communities supporting the cactus ferruginous pygmy-owl are coastal-plain oak associations, mesquite bosques, and Tamaulipan thornscrub in south Texas (Tewes 1993, Wauer et al. 1993, Mays 1996), lowland thickets, thornscrub associations, riparian woodlands and second-growth forests in northeastern Mexico (van Rossem 1945, Enriquez-Rocha et al. 1993, Tewes 1993).

In western Mexico, the owl may occur in Sonoran desertscrub, Sinaloan thornscrub, Sinaloan deciduous forest, riverbottom woodlands, cactus forests, and thornforests (Enriquez-Rocha et al. 1993, U.S. Fish and Wildlife 1997). In Arizona, the owl is historically associated with cottonwood (*Populus fremontii*) and mesquite (*Prosopis velutina*) riparian woodlands (Bendire 1888, Breninger 1898, Phillips et al. 1964), and Sonoran desertscrub (Johnson and Haight 1985). Recently, cactus ferruginous pygmy-owls have been chiefly reported from Sonoran desertscrub (see Chapter 3).

The physical settings and vegetation compositions of southern Texas and Arizona have very little in common. However, the frequent association between *G. brasilianum* and thickets and edges, and its regular use of densely foliated exotic landscape trees in Arizona (Chapter 4) suggests that vegetation structure is more important to this owl than vegetation composition. Similarities between currently occupied habitat in Arizona and Texas include the presence of thorny bushes: ironwood (*Olneya tesota*) in Arizona and lime prickly ash (*Zanthoxylum fagara*) in south Texas. Results from research in Texas (Proudfoot 1996) indicate the importance of moderate (50 to 75%) to dense (76 to 100%) understory cover and trees large enough to hold cavities. Understory cover may be critical for both foraging and fledgling survival (Fig. 1-4, see also Chapter 4).

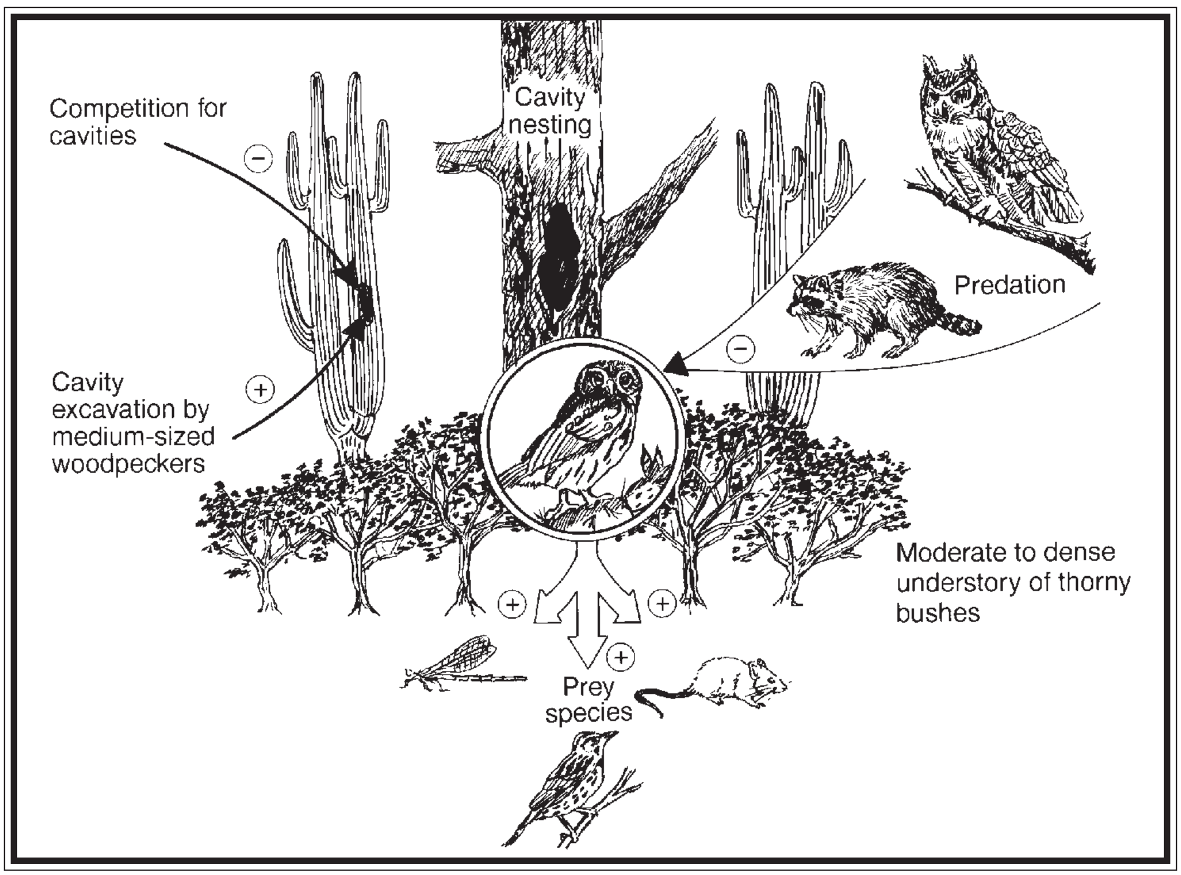

Figure 1-4. Known and hypothesized ecological relations of the cactus ferruginous pygmy-owl (+: ecological relations benefitting individual cactus ferruginous pygmy-owls; −: ecological relations with a negative impact on individual cactus ferruginous pygmy-owls). The degree of competition for nesting cavities with other species is unclear.

4. Breeding cycle

Until recently, the breeding biology of the cactus ferruginous pygmy-owl was largely undocumented. Since 1994, however, critical information has been obtained, especially in Texas, where nests have been monitored using radio telemetry and miniature video cameras with infrared-light-emanating diodes (Proudfoot 1996, Chapter 5). In Arizona, nest sites have been located and monitored since 1996 (Abbate et al. 1996, Richardson unpubl. data). These studies have provided region-specific information on the breeding chronology of the owl, habitat use by the fledglings, and adult-fledgling interactions.

Typically, the nest site is a natural cavity or an abandoned woodpecker hole in a tree or in a large columnar cactus. Nest cavities in trees have been recorded primarily in live-oak and cottonwood but also in Montezuma baldcypress (*Taxodium mucronatum*), willow (*Salix* sp.), and honey mesquite (Bendire 1892, Gilman 1909, Rea 1983: 169, Proudfoot 1996, Russell and Monson 1998). In Arizona, all nest cavities detected between 1995 and 1998 have been in saguaro cacti (*Carnegiea gigantea*) (Abbate et al. 1996, Richardson unpubl. data). Nest height varies from 2 to 12 m above ground (Breninger 1892, Gilman 1909, Oberholser 1974, Proudfoot in press). No lining material is added inside the cavity (Breninger 1898, Proudfoot 1996).

Cactus ferruginous pygmy-owl eggs are white and almost spherical and weigh approximately 8 g. They are laid at regular intervals of 32-39 hours (Proudfoot and Johnson in press). Clutch size ranges between three and seven eggs (Bent 1938, Heintzelman 1979, Proudfoot and Johnson in press). In Texas, the most commonly recorded clutch size is five (Proudfoot 1996); in Arizona, it is four (Hunter 1988); in Sonora, it is three or four (Russell and Monson 1998). In Texas, incubation is conducted solely by the female and lasts about 28 days (Proudfoot in press). However, recent observations (Richardson unpubl. data) indicate the male may play a limited role in incubation in Arizona. If the first clutch fails, a replacement clutch may be produced within 21 days (Proudfoot unpubl. data). Hatching is asynchronous, occurring every 20 to 26 hours. During the first week after hatching, the female remains with the nestlings, leaving the nest only to obtain food, cast a pellet, and/or defecate (Proudfoot and Beasom 1997). As the nestlings develop, the female spends more time outside the cavity and both adults bring food to the nest (Proudfoot unpubl. data). Intense competition for food occurs among the nestlings, occasionally resulting in siblicide (Proudfoot in press). Fledging time ranges between 21 and 30 days (Scherzinger 1977, Terres 1991, Proudfoot 1996). After fledging, both adults hunt but the female delivers most of the prey items to the juveniles. Initially, the fledglings remain near the nest, often in proximity to each other, and utilize dense, thorny shrubs and trees for cover. Over time, the size of the area the fledglings use increases while the amount of contact with the adults decreases. Approximately two months after fledging, the young disperse from the nest site (Proudfoot 1996). Preliminary data indicate that adults maintain their pair bond following the dispersal of the juveniles and appear to mate for life (Proudfoot unpubl. data).

5. Ecological relations

Hunting and prey base

Pygmy-owls are known as fierce hunters capable of killing prey twice their own size (Terres 1991, Sick 1993). Early accounts describe the cactus ferruginous pygmy-owl attacking young chickens and adult birds the size of robins (Breninger 1898, Bent 1938, Johnsgard 1988). Recently, this owl was observed killing mourning doves (*Zenaida macroura*) and large desert spiny lizards (*Sceloporus magister*) in Arizona (Richardson unpubl. data). In Texas, it feeds on large prey such as eastern meadowlarks (*Sturnella magna*) and hispid cotton rats (*Sigmodon hispidus*) (Proudfoot and Beasom 1997). When hunting, ferruginous pygmy-owls typically perch and scan their surroundings (Breninger 1898, Abbate et al. 1996). Once prey is detected, they strike it from above or engage in a short flight pursuit (Abbate et al. 1996). Sick (1993) argues that the "eye spots" of the ferruginous pygmy-owl's nape feathers trick the other birds into flying in front of it rather than behind it. The owl can then strike the unsuspecting prey in a sudden, dashing flight.

The cactus ferruginous pygmy-owl is a prey generalist (Table 1-1). Its prey base includes birds, lizards, insects, small mammals (Bendire 1888, Sutton 1951, Sprunt 1955, Earhart and Johnson 1970, Oberholser 1974), snakes (Sprunt 1955), and frogs (Proudfoot and Beasom 1997). In Texas, thirty-six prey species representing five classes have been recorded (Proudfoot and Beasom 1997). In Arizona, prey items were primarily reptiles but also included birds, mammals, and insects (Table 1-2). The cactus ferruginous pygmy-owl is an opportunistic predator: it takes advantage of seasonal opportunities such as the emergence of insects or the presence of nestlings in nearby nests (Abbate et al. 1996). After a meal, the owl may cache prey remains in a tree, cavity, or ball of mistletoe (*Phoradendron* sp.) (Sprunt 1955, Abbate et al. 1996, Proudfoot 1996).

The cactus ferruginous pygmy-owl is referred to as the "terror of small birdlife" (Sprunt 1955). Thus, it is not surprising that this owl is commonly mobbed by a wide variety of other bird species (Gilman 1909, Sutton 1951, Sprunt 1955).

Table 1-1. List of identified prey species in the diet of cactus ferruginous pygmy-owls in Texas and Arizona. The list of prey species for Texas is from Proudfoot and Beasom (1997) and for Arizona from Richardson (unpubl. data).

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

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

Table 1-2. Diet of cactus ferruginous pygmy-owls in Arizona, 1996-1998. Based on visual observations of one nesting pair in 1996, one nesting pair in 1997, and three nesting pairs in 1998. Each percentage of the diet is calculated by dividing the number of individual prey items in a taxonomic group by the total number of prey items. Data compiled from Abbate et al. (1996) and from Richardson (unpubl. data).

Prey category	1996 (% of Diet)	1997 (% of Diet)	1998 (% of Diet)
Reptiles	47 (56%)	23 (43%)	36 (35%)
Birds	7 (8.3%)	20 (38%)	28 (27%)
Mammals	4 (4.8%)	1 (2%)	7 (7%)
Insects	4 (4.8%)	1 (2%)	3 (3%)
Undetermined	22 (26.2%)	8 (15%)	28 (27%)
Total	84 (100%)	53 (100 %)	102 (100%)

Predation avoidance

Cryptic coloration, use of trees with a dense foliage and spines, a perch-and-wait hunting strategy, and a low, rapid flight may all represent predator avoidance adaptations of the cactus ferruginous pygmy-owl. In Arizona, reactions of nesting cactus ferruginous pygmy-owls to Harris's hawks (*Parabuteo unicinctus*) approaching or perching in proximity to the nest site were regularly observed. Typically, the response of the owls was to cease vocalizations and remain motionless until the hawks had left (Richardson unpubl. data).

Other ecological relations

Although many aspects of the cactus ferruginous pygmy-owl's biology are related to predator avoidance and food habits, other types of interactions with the local avifauna have also been documented (Fig. 1-4). As an obligate cavity nester, this owl is dependent on medium-sized woodpeckers such as the Gila woodpecker (*Melanerpes uropygialis*) (Gilman 1909, Rea 1983) and flickers (*Colaptes* spp.) in Arizona, and the golden-fronted woodpecker (*Melanerpes aurifrons*) in Texas. Use of cactus ferruginous pygmy-owl nest boxes by brown-crested flycatchers (*Myiarchus tyrannulus*), golden-fronted woodpeckers, eastern screech owls (*Otus asio*), and European starlings (*Sturnus vulgaris*) was documented in Texas. In Arizona, purple martins (*Progne subis*), ash-throated flycatchers (*Myiarchus cinerascens*), elf owls (*Micrathene whitneyi*), western screech owls (*Otus kennicottii*), Gila woodpeckers, northern flickers, starlings, house sparrows (*Passer domesticus*) and house finches (*Carpodacus mexicanus*) all use saguaro cavities and represent potential competitors for nest cavities. Species such as the Gila woodpecker and the greater roadrunner (*Geococcyx californianus*) have been observed raiding pygmy-owl prey caches, indicating another potential source of competition with the local avifauna (Richardson unpubl. data).

6. Mortality

Natural causes

Little is known about the rate or causes of mortality of cactus ferruginous pygmy-owls in Arizona or Texas. Due to its small size, however, the cactus ferruginous pygmy-owl may be very susceptible to predation. In Texas, several cases of mortality by a great-horned owl (*Bubo virginianus*), Harris's hawk, and Cooper's hawk (*Accipiter cooperi*) have been documented, and raccoon and bullsnake depredation of nestlings is common (Proudfoot and Johnson in press).

While the use of dense, thorny cover may reduce the threat of predation for fledglings, their initial inexperience and lack of coordinated flight leads to other types of mortality. From 1995 through 1998, 18 fledglings were monitored in Arizona. Within 24 hours of fledging, one juvenile disappeared (Abbate et al. 1996); another was rescued on the ground after being injured by a curve-billed thrasher (*Toxostoma curvirostre*) (Abbate et al. 1996); three were impaled on cholla or other cacti, but worked free or were rescued, and one was removed from a road and placed in a nearby tree (Richardson unpubl. data). In Texas, one fledgling ended up on the ground after colliding with a tree and was placed back in the tree by the observer. Mortality among fledglings before and during dispersal averaged 38% (Proudfoot unpubl. data).

Although little is known about the prevalence and impact of diseases on the survival and recruitment of the cactus ferruginous pygmy-owl, several pathogens may affect this bird. In South America, the ferruginous pygmy-owl is sometimes infected with blood parasites (hematozoa) such as *Haemoproteus* and *Leucocytozoon* (Bennett et al. 1982). One *Haemoproteus* species can be lethal in quails and one *Leucocytozoon* species has been known to kill geese, ducks, grouse, and turkeys (Clarke 1938, Fallis 1945, Cook 1971a, 1971b, Harris 1972). In owls, hematozoa are thought to be pathogenic, causing anemia, bacterial diarrhea, and septicemia (Hunter et al. 1987). Blood smears obtained from cactus ferruginous pygmy-owls did not detect the presence of hematozoa in the Texas population (Proudfoot and Radomski 1997). Samples from Arizona are under analysis (Proudfoot et al. unpubl. data).

The protozoal disease trichomoniasis represents a potential threat to the cactus ferruginous pygmy-owl in the Tucson area. The parasite is readily transmitted from prey to predator (Stabler 1951) and the owl's local prey include mourning doves and house finches (Table 1-1), both of which occur in high concentrations in urban Tucson and are known carriers of the disease. In addition, trichomoniasis has been documented in nearly every raptor in the Tucson area. In particular, it is found in other small birds of prey, such as the American kestrel (*Falco sparverius*), western screech owl, and burrowing owl (*Athene cunicularia*). High nestling mortality due to this disease has been observed in Cooper's hawks in metropolitan Tucson (Boal and Mannan 1996).

Nothing is known about the influence of starvation on the mortality of adults. As in other owl species (see Miller 1989), death by starvation probably has a higher incidence in juveniles than in adults. Finally, one dead cactus ferruginous pygmy-owl with cholla embedded in both feet was found floating in Dripping

Springs at Organ Pipe Cactus National Monument in November 1972 (T. Tibbitts pers. comm.).

Human-related deaths

The incidence and impact of direct and indirect human-related deaths among wild birds are not well known. Casualties caused by pest control, pollution, collisions with cars, TV towers, and glass windows, electrocution by power lines, and cat predation are often underestimated, although likely increasing in occurrence due to human population growth (Banks 1979, Klem 1979, Churcher and Lawton 1987). Even where human-related deaths are uncommon, they may still substantially affect populations of rare birds.

Given the propensity for cactus ferruginous pygmy-owls to occur in residential areas in Arizona, human-related factors may be a significant cause of owl mortality there. A cactus ferruginous pygmy-owl nesting near a house was rescued after colliding with an automobile window. Although it survived, it showed evidence of cranial hemorrhage (Richardson unpubl. data). Cats may be another local cause of mortality. In Texas, one adult owl and one fledgling were killed by a domestic cat. In Arizona, children were observed shooting pellet or BB guns near a nest site (Richardson unpubl. data); hence, shooting should also be considered a potential cause of owl mortality within urban areas.

7. Home range and territoriality

Estimates of both home range and territory size for the cactus ferruginous pygmy-owl are based on limited information. In other owl species, home-range and territory size may vary as much as tenfold or more among areas or individuals (Hayward 1983, Cramp 1985, Zabel et al. 1992). Initial results from ongoing research in Texas suggest that the home range of cactus ferruginous pygmy-owls may expand substantially during dry years (Proudfoot unpubl. data).

In Texas, cactus ferruginous pygmy-owls defend their territories year round. Areas used outside the breeding season varied between 19 and 116 ha (Proudfoot 1996). During incubation, adult males used 1.34 to 8.52 ha (average 4.1) (Proudfoot 1996). In Arizona, one female used an area approximately 0.2 ha in size during the prefledging period. This area increased to about 14 ha between fledging and juvenile dispersal and was also used by the fledglings (Abbate et al. 1996). Estimates of territory size in Arizona have ranged between .01 and 4 ha (Hunter 1988, Millsap and Johnson 1988, Felley and Corman 1993). In Organ Pipe National Monument, owl territories appear linear along washes (Hunter 1988). Recent studies using telemetry have begun in Arizona to gather additional information on territory and home range sizes (Richardson unpubl. data).

In south Texas, the status of the cactus ferruginous pygmy-owl as a year-round resident is clearly established (Proudfoot in press). In Arizona and western Mexico, owls are seen throughout the year (Bendire 1888, Rea 1983:169, Russell and Monson 1998). However, Russell and Monson (1998) report a larger number of sightings during the spring and summer compared to the winter in northern but not southern Sonora. Therefore, small scale migration for some individuals cannot be completely ruled out. In the last two years, telemetry has been used to study pygmy-owl movements in Arizona, but more information is needed before any conclusion regarding this issue is made.

8. Summary

Ongoing studies in Arizona and Texas have increased our understanding of the natural history of the cactus ferruginous pygmy-owl (e.g., breeding biology, prey base). However, significant gaps in the knowledge of the pygmy-owl's status and biology (i.e., demographics, seasonal movements and fledgling dispersal, habitat requirements and preferences, competition for cavities with other species, and factors influencing home-range and territory size) exist in Arizona, and the taxonomic relationship between the Arizona and Texas owl populations is uncertain. Hence, additional research is critical to the conservation of this species. The importance of research for the management and recovery of the Arizona owl population is addressed in Chapter 6.

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Chapter 2:

A Historical Perspective on the Population Decline of the Cactus Ferruginous Pygmy-Owl in Arizona

The cactus ferruginous pygmy-owl (*Glaucidium brasilianum cactorum*) was discovered in the U.S. by Bendire in 1872 in the Tucson area (Coues 1872). During the next five decades, naturalists collected many specimens of this owl and typically described the subspecies as common or fairly common along some streams and rivers of central and southern Arizona. A common view among regional ornithologists is that the cactus ferruginous pygmy-owl's Arizona population sharply declined around 1950 (see Monson and Phillips 1981). As a result of a petition (Galvin et al. 1992), the cactus ferruginous pygmy-owl became federally listed as Endangered in Arizona in 1997 (U.S. Fish and Wildlife 1997). In retrospect, however, many questions remain on the magnitude and timing of the population decline. In this chapter, we review early records of cactus ferruginous pygmy-owls from the published literature, U.S. Forest Service files, and museum specimen collections. Evidence of a sharp population decline dating back to the early 20th century exists for the Phoenix area, including the lower Salt River. Along the lower and middle Gila River Valley, a severe population decline is also apparent but its timing is uncertain. In southern Arizona, changes in the overall status of the owl are more difficult to detect in part due to the lack of baseline information. However, along Rillito Creek and the Santa Cruz River in particular, an early population decline is also probable. Along these two rivers, and along the Salt and Gila rivers, the owl's population decline could have coincided with intensive woodcutting and the construction of the first dams, causing deforestation and reduced waterflow early in the 20th century. The current status of the cactus ferruginous pygmy-owl population in Arizona is also addressed in Chapter 3.

1. A species at the edge of its range

The ferruginous pygmy-owl (*G. brasilianum*) reaches the northern edge of its distribution in Arizona and Texas. Using the scissor-tailed flycatcher (*Tyrannus forficatus*) and the indigo bunting (*Passerina cyanea*) as examples, Brown (1984) notes that the abundance of a species tends to decline from the center to the edge of the range. Towards the edge, the distribution of a species also tends to be more patchy (Brown 1984). Despite historical accounts describing the cactus ferruginous pygmy-owl as common or fairly common at various locations in Arizona (see below), it is difficult to determine what the overall status of the owl was in the state. It is unknown whether the owl was found throughout its geographic range in Arizona (Fig. 2-1), which extended north to New River, just north of Phoenix; east to Geronimo along the Gila River, and

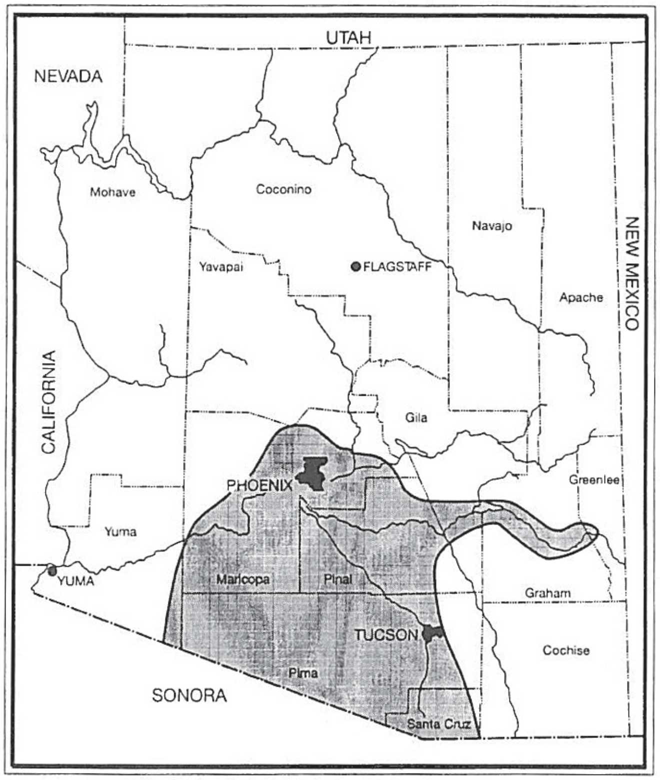

Figure 2-1. Map showing the approximate range of the cactus ferruginous pygmy-owl in Arizona (based on data from Fisher 1893, Phillips et al. 1964, Monson and Phillips 1981, Hunter 1988). Note the extended distribution to the east along the Gila River. Whether the range truly extends this far east is based on two unconfirmed reports in the 1970s and 1980s (Hunter 1988, T. Corman pers. comm.).

possibly even to the confluence of the Gila and San Francisco rivers; and west to Agua Caliente and the desert ranges of Yuma County (Fisher 1893, Gilman 1909, Swarth 1914, Aiken 1937, Phillips et al. 1964, Monson and Phillips 1981, Hunter 1988). Alternatively, this bird may have shown an insular population structure characterized by the local occurrence of distinct subpopulations, its absence in other parts of the range reflecting natural discontinuities in vegetation structure and composition and/or topographic conditions.

2. The historical importance of riparian areas

Judging from historical accounts by early ornithologists, the cactus ferruginous pygmy-owl was once frequently encountered in cottonwood (*Populus fremontii*) forests, mesquite (*Prosopis velutina*)-cottonwood woodlands, and mesquite bosques along the Gila and Salt rivers in central Arizona, and along the Santa Cruz River and Rillito Creek near Tucson (Bendire 1888, Breninger 1898, Gilman 1909, Swarth 1914). The owl was also recorded in Sonoran desert scrubland, but in this habitat it was apparently found in areas supporting pockets of xeroriparian and riparian vegetation (Fisher 1893, Howell 1916, Kimball 1921). At New River, for instance, Fisher (1893) described the cactus ferruginous pygmy-owl as "quite common" in thickets of intermixed mesquite and saguaro (*Carnegiea gigantea*) cacti. Elsewhere in the desert, the presence of this bird may have been more infrequent, as Kimball (1921) concluded that, overall, it was rare in the Santa Catalina foothills. Furthermore, Breninger (1898) differentiated the nesting habits of the elf owl (*Micrathene whitneyi*) and the cactus ferruginous pygmy-owl, the former alone, in his opinion, occupying saguaro cavities. At the same time, it should be noted that most early surveys were probably conducted along rivers, the harsh climate and limited water supply reducing coverage of surveys in the desert. Recent observations of the owl in upland desertscrub (see Chapter 3) indeed suggest that the cactus ferruginous pygmy-owl may have been overlooked in this habitat during the late 19th and early 20th centuries. Overall the owl cannot presently be considered an obligate riparian bird in Arizona, yet it seems that river valleys and washes probably were its primary habitat before the population decline occurred.

3. Population decline and local extirpations

It is generally reported that the Arizona population of cactus ferruginous pygmy-owls started to decline sharply around 1950 (Monson and Phillips 1981, Abbate et al. 1996). However, many riparian areas had already been altered before they were ever surveyed by naturalists (Phillips and Monson 1964, see also below). Other areas, where the cactus ferruginous pygmy-owl had been reported around the turn of the century, were apparently not surveyed again for decades (Johnson et al. unpubl. ms.). The lack of information means that the owl population decline could have begun earlier. By the early 1950s, the cactus ferruginous pygmy-owl was already regarded by some as rare (e.g., Brandt 1951). The apparent population decline was later also recognized by Phillips et al. (1964), Johnson et al. (1979), Monson and Phillips (1981), and Hunter (1988). The cactus ferruginous pygmy-owl was even described as extirpated "except possibly in the Organ Pipe Cactus National Monument region" (Monson and Phillips 1981). Between 1971 and 1988, fewer than 20 credible cactus ferruginous pygmy-owl sightings were recorded (Hunter 1988). Although these records showed that the owl could still be found at various locations, no persistent breeding population was known anywhere in the state.

With the use of broadcast surveys in recent years, more owls have been recorded in northwestern Tucson and elsewhere in southern Arizona (see Chapter 3). Several nesting pairs were identified chiefly in the Tucson area (Abbate et al. 1996, Wilcox et al. 1999). Thus, new questions arise concerning the true magnitude and long-term significance of the population decline reported earlier. However, a sharp population decline ultimately resulting in the extirpation of the owl appears certain for two general areas: the Phoenix area, including the lower Salt River and New River, and the lower and middle Gila River. Elsewhere, the magnitude of any population decline is confounded by the lack of baseline information, especially in desertscrub, and the recent increase in sampling effort resulting in more detections (see Chapter 3).

Central Arizona

The cactus ferruginous pygmy-owl was once a common inhabitant of the cottonwood groves in the Salt River Valley (Breninger 1898). As previously mentioned, it was also "quite common" at New River (Fisher 1893). On several occasions between 1892 and 1905, Breninger collected skins and eggs in the Phoenix area. Additional specimens were secured during that period by Fisher, Lusk, Campbell, and Bennett (Johnson et al. unpubl. ms.).

Only three specimens of cactus ferruginous pygmy-owls were collected along the Salt River after 1905. Initially, the decline in the number of specimens collected in the Phoenix area may be in part attributed to the fact that soon after the turn of the century, and until about 1930, ornithologists shifted their attention toward Tucson (Johnson et al. unpubl. ms.). However, the decline becomes especially revealing after 1930, when several resident ornithologists began to collect and publish work conducted near Phoenix. Mostly during the 1930s and 1940s, Lyndon Hargrave studied the birds of the Salt River Valley, publishing occasional notes and collecting specimens from the region (Johnson et al. unpubl. ms.). During that same period, Allan Phillips and Lewis Yaeger collected in the area. Vic Housholder worked in the area from the 1930s through the 1950s.

The small number of specimens collected, despite the presence of increasing ornithological activity after 1930, suggests a sharp, early population decline of the cactus ferruginous pygmy-owl in the Phoenix area, including the lower Salt River (Johnson et al. unpubl. ms.). The specimen of cactus ferruginous pygmy-owl that Hargrave collected in 1933 below Stewart Mountain Dam proves that the owl still occurred locally at this time. Later, when Phillips and Yaeger worked in the region, they collected owl specimens in 1949 and 1951, which are among the last known collected in the state. As late as 1964, the owl was reported as still occurring at the mouth of the Verde River and eastward along the Salt River (Phillips et al. 1964). However, at that second location it had in fact not been recorded for more than a decade (Johnson et al. unpubl. ms.).

Following Phillips, Johnson and Simpson (1971) started intensive record keeping and specimen collection at one location near the mouth of the Verde River along the Salt River, known as Blue Point Cottonwoods (BPC). The work of all these ornithologists along the Salt River was nearly continuous over seven decades, and it shows the extirpation of the owl from that location by the early seventies (Millsap and Johnson 1988). After the last record in 1971, numerous attempts to find another owl even using playback recordings have been unsuccessful.

The cactus ferruginous pygmy-owl was also "common" along the lower and middle Gila River (Breninger 1898). Breninger encountered enough individuals of this species to notice its gradual expansion along irrigation canals. Writing about owl species he recorded along the lower and middle Gila River at Agua Caliente, Sacaton, and Blackwater, Gilman (1909) later described the cactus ferruginous pygmy-owl as "fairly numerous." Although Agua Caliente alone is mentioned in his account of this owl, Gilman also collected specimens at the other two locations (Johnson et al. unpubl. ms.). At Blackwater, he collected two females, one in January 1908, the other in March of that same year. The dates given for those specimens, together with information contained in two written accounts by Gilman (Gilman 1909, Rea 1983) indicate that he encountered the cactus ferruginous pygmy-owl in all seasons. In retrospect, his work strongly suggests that the cactus ferruginous pygmy-owl was present along an extensive stretch of the lower and middle Gila River. Besides the three specimens Gilman collected and the nesting pair he described from Agua Caliente, one specimen had earlier been secured by Judson (Johnson et al. unpubl. ms.).

Unfortunately, the population status of the cactus ferruginous pygmy-owl along the middle and lower Gila River was not assessed again until 1963, at which time Rea (1983) began to survey the avifauna of the Gila River Indian Reservation, including Sacaton and Blackwater. Rea's work showed that the owl was now extirpated on the reservation. Interestingly, none of his Native American consultants recognized this bird from specimens, thus suggesting that the extirpation had occurred long before his study.

Southern Arizona

Records of cactus ferruginous pygmy-owls in southern Arizona exist for the Tucson area and, after 1949, for Organ Pipe Cactus National Monument as well (Hensley 1954). Due to the lack of baseline information, recent owl records from other locations, such as Sycamore Canyon in Santa Cruz County or the Tohono O'odham Reservation (Stejskal 1981, Taylor 1995, Johnson et al. unpubl. ms.), are difficult to interpret.

After Bendire's discovery of the cactus ferruginous pygmy-owl in 1872 and his description of this bird as common at Fort Lowell (now Tucson) along Rillito Creek, there were specimens collected at that same location on several occasions between 1872 and 1916 (Brewster 1883, Howell 1916, Johnson et al. unpubl. ms.). One specimen was also collected along the Santa Cruz River (Brown 1884). Scott (1886) referred to the owl as a bird "not uncommon about Tucson." However, from the 1920s through the 1940s, with two possible exceptions - skins collected in 1922 by Kimball and a reported observation in 1949, both at an unspecified location in the Tucson area (Johnson et al. unpubl. ms.)-, the owl was not mentioned from Rillito Creek or the Santa Cruz River in the literature, nor was any specimen collected. For example, Brandt (1951) worked in southeastern Arizona between 1935 and 1948, but he found no cactus ferruginous pygmy-owl along Rillito Creek. We are not aware of any record showing the presence of the owl along Rillito Creek or the Santa Cruz River since the 1940s.

While an early extirpation seems probable along Rillito Creek and the Santa Cruz River, the owl continued to be recorded in Sabino Canyon and elsewhere in the Santa Catalina Mountains at regular intervals through the 1970s (e.g., Kimball 1921, Brandt 1951, Davis 1974, Demaree 1976, Johnson et al. unpubl. ms.). Phillips et al. (1964) reported a population decline near Tucson but this population decline is not well documented. In recent years, broadcast surveys have led to the discovery of a breeding population of owls in the Tucson area (see Chapter 3). The fact that pygmy-owls are now found in desertscrub rather than riparian areas further confounds any effort to evaluate the magnitude and timing of a population decline in the Tucson area.

4. Habitat loss and alteration along floodplains

Reasons for the population decline and local extirpations of the cactus ferruginous pygmy-owl have been called speculative by some (Rea 1983, Hunter et al. 1987). Peripheral populations may be at a higher risk of sporadic local extinction. In birds, there is evidence suggesting that after periods of environmental stress, population density declines proportionally more at the edge of the range (Mehlman 1997). Furthermore, the contraction or expansion of the range documented for several North American birds of prey (e.g., Phillips et al. 1964, Weidensaul 1989, Williams 1997) underscores the dynamic nature of geographic boundaries. The relative instability of peripheral populations may help explain why the largely tropical ferruginous pygmy-owl seemingly experienced a population decline in Arizona, at the very northern edge of its distribution.

While biogeography may have played an important role, it is generally recognized that loss of habitat was one, if not the, primary causal factor (Johnson et al. 1979, Johnson and Haight 1985, Hunter 1988, Millsap and Johnson 1988). The coincidental occurrence of habitat loss and population decline was witnessed both in Texas and in Arizona (see Oberholser 1974, Johnson et al. unpubl. ms.). Where the pygmy-owl's habitat has been preserved in Texas, a sizeable population still occurs (Mays 1996).

The history of riparian habitats in Arizona has been called one of "destruction" (Phillips and Monson 1964) and "desertification" (Johnson and Simpson 1988). Indeed, it is now estimated that since the end of the 19th century, at least 90% of all the original vegetation along Arizona's rivers has disappeared due to human activities (Johnson and Carothers 1982, Fleishner 1994). Some rivers which once had a perennial flow of water are now dry over the lower part of their course. In many areas, their banks are lined with exotic tamarisk (*Tamarix* spp.) or are almost devoid of vegetation (Hastings and Turner 1965, Johnson 1979, Rea 1983, Tellman et al. 1997). The severe population decline of several bird species, such as the southwestern willow flycatcher (*Empidonax traillii extimus*) (Unitt 1987, Taylor and Littlefield 1986, U.S. Fish and Wildlife 1995, Sogge et al. 1997) and the yellow-billed cuckoo (*Coccyzus americanus*) (Laymon and Halterman 1987) over the entire Southwest has been linked to the disappearance of riparian habitat. In parts of their range, Lucy's warblers (*Vermivora luciae*) have clearly suffered from the loss of mature bosques caused by woodcutting and diminishing water tables (Rea 1983, Johnson et al. 1997).

In modern times, the growth of cities throughout the Southwest has been placing increasing demands on regional watersheds (Tellman et al. 1997). Groundwater pumping and water diversion in particular represent important threats to riparian woodlands (e.g., Johnson and Carothers 1982, Tellman et al. 1997). Yet, although some riparian landscapes have been drastically altered during the last several decades, many others were lost around the turn of the 20th century. The history of southwestern rivers is indicative of early human-related changes that caused severe deforestation and reduced waterflow. An early population decline of the cactus ferruginous pygmy-owl along the Gila, Santa Cruz, and Salt rivers would have coincided with a severe loss of riparian areas.

Gila River

During the first half of the 19th century, the flow of water was perennial along most of the Gila River's course (Dobyns 1981). Below its confluence with the Salt River, the river reached 200 yards in width (see Tellman et al. 1997). The banks were described as supporting tall cottonwoods and willows (*Salix* spp.) as well as abundant wildlife that included "flights of white brant [snow goose] . . . geese, and ducks, with many signs of deer and beaver" (Emory 1848). Javelinas, otters, turkeys, and mountain lions were also described (Tellman et al. 1997). Islands in the middle of the river sheltered numerous beaver; fish were abundant (Tellman et al. 1997). Some fish, such as the Colorado squawfish (*Ptychocheilus lucius*), weighed nearly 50 pounds, and, along with the razorback sucker (*Xyrauchen texanus*) in the Salt River, supported commercial fishing (Minckley 1973).

While the Pima and Maricopa Indians who lived along the banks of the Gila must have somewhat affected this river, drastic changes in the surrounding vegetation and the flow of water did not occur until the arrival of the first Anglo-Americans (Dobyns 1981, Tellman et al. 1997). The activities of the newcomers included intensive beaver trapping, cattle grazing, and mining. Beaver trapping caused the many pools behind their dams to disappear along with the wildlife they had supported. Overgrazing led to the loss of vegetation and an increase in soil erosion. Mining caused water pollution and diversion, as well as deforestation in order to produce fuel and mine timbers. In 1876, for instance, untold miles of mesquite thickets were harvested to produce charcoal (Tellman et al. 1997). The water table dropped substantially due to diversion and groundwater pumping. A canal built by farmers in 1887 at Florence significantly reduced waterflow downstream. Beginning in 1921, several dams were built that further reduced waterflow and ended seasonal flooding, thus preventing the regeneration of native vegetation (Tellman et al. 1997). Rea (1983) describes riparian areas along the Gila River during Gilman's time as already affected by humans and "rapidly deteriorating."

The Santa Cruz River and Rillito Creek

Historically, the flow of water in the Santa Cruz River was mostly perennial from the river headwaters in the San Rafael Valley to north of the Tucson Mountains (Tellman et al. 1997). Early accounts describe a river lined with cottonwood trees, willows, and walnuts (*Juglans major*), and occasional forests of huge mesquite trees (Froebel 1859, Swarth 1905, Willard 1912). Swamps created by springs occurred at several locations and supported lush vegetation (Dobyns 1981). Wildlife was abundant and diverse with the local occurrence of tortoises, waterfowl, beaver, muskrats, and large mammals such as grizzly bears and bobcats (Tellman et al. 1997).

The banks of Rillito Creek, historically a main tributary of the Santa Cruz River, supported large cottonwoods (Surgeon General's Office 1875). There was a marsh near Fort Lowell. Evidently, the vegetation along the Santa Cruz was lush in 1872 when Bendire (1888) collected his first cactus ferruginous pygmy-owl specimens. In his succinct description of the habitat, he refers to the presence of "heavy mesquite thickets."

During Bendire's time, the banks of the Santa Cruz River and Rillito Creek were already beginning to change (see Tellman et al. 1997). As trees were cut to provide domestic and industrial fuelwood for the growing city of Tucson, the banks of the Santa Cruz River suffered heavy deforestation. Swarth (1905) and Willard (1912) both describe giant mesquite trees, many of them sixty feet high, with a thick understory of hackberry (*Celtis* spp.) and other thorny bushes, along the Santa Cruz on the Papago Indian Reservation (now known as the San Xavier District of the Tohono O'odham Reservation), but Swarth adds that the location of the mesquite grove on the reservation "is the only reason for the trees surviving as long as they have, since elsewhere every mesquite large enough to be used as firewood has been ruthlessly cut down, to grow again as a straggly bush."

Salt River

In the absence of drought, the flow of the Salt River was once perennial, with pools created by beaver dams (B. Foltz, pers. comm.). The river banks were lined with cottonwood, mesquite, and willow trees (Tellman et al. 1997). Humans first impacted the river system with woodcutting and water diversion for agricultural needs. Initially, human-caused changes in the vegetation along the Salt River may have been less dramatic than on the Gila and Santa Cruz rivers. Yet, during the first decade of the century, the Salt River Project was initiated and the construction of the first of four dams on the Salt River east of its confluence with the Verde River was completed as early as 1911 (Tellman et al. 1997). By the end of the 1930s, the other three dams had been built. Together, those dams turned the lower Salt River into a string of lakes and prevented the regeneration of the native vegetation (Tellman et al. 1997).

5. Blue Point Cottonwoods: a glimpse of the past

BPC occurs on the Tonto National Forest between Stewart Mountain Dam (Saguaro Lake) and Granite

Reef Dam. Located approximately 50 km upstream from downtown Phoenix and 3 km upstream from the confluence of the Verde and Salt rivers, the area extends for nearly 2 km and supports the most extensive native cottonwood-mesquite habitat remaining along the lower Salt River. In a preliminary report, Johnson and Simpson (1971) describe a large stand of mature cottonwoods with mesquite understory and a marsh of open water located in an abandoned meander of the Salt River and lined with arrowweed *(Pluchea sericea*) and tamarisk. In the marsh, dense stands of cattail (*Typha domingensis*) grow along with duckweed (*Lemna* sp.) and a rare water fern for the region (*Azolla* sp.). On the desert hills and flats immediately adjacent to the riparian and aquatic habitats is semiarid Arizona Upland and Lower Colorado River Valley vegetation that includes washes lined by xeroriparian habitat (Brown et al. 1980, Johnson et al. 1984). Despite the presence of a dam upstream to control flooding, the area is thought to resemble many riparian habitats of the past (Johnson and Simpson 1971, Rea 1983).

To study the local bird community, Johnson and Simpson delineated a 250 acre (100 ha) plot that extended 1.6 km along the marsh with a maximum width of .8 km. The study area consisted of seven basic habitats (Table 2-1) which together contributed to the diversity and complexity of the habitat. The study area was surveyed from 1969 until the early 1980s. Of 208 avian species recorded within the plot's boundaries, 69 were breeding (Table 2-2). Among them, the least bittern (*Ixobrychus exilis*), Cooper's hawk (*Accipiter cooperii*), elf owl (*Micrathene whitneyi*), black-chinned hummingbird (*Archilocus alexandri*), brown-crested flycatcher (*Myiarchus tyrannulus*), vermilion flycatcher (*Pyrocephalus rubinus*), common raven (*Corvus corax*), and blue grosbeak (*Guiraca caerulea*) also once bred along the Gila River on the Gila River Indian Reservation (Rea 1983). Presumably, the extirpation of these species on the reservation coincided with the loss of their habitat (e.g., the tall stands of cottonwood or willow trees with well developed understory for the Cooper's hawk and the brown-crested flycatcher, and the marshy areas for the least bittern). At BPC, where these same habitat types have persisted, the birds mentioned above still occurred when the study ended. Even so, some species, including the common black-hawk (*Buteogallus anthracinus*) and the cactus ferruginous pygmy-owl, ceased to occur on the study plot, arguably as a result of the more general loss of riparian vegetation statewide.

Although total ecological losses due to human activities since the arrival of European settlers will never be fully known, the long-term study conducted at BPC, together with historical descriptions of riparian landscapes, offers a glimpse of past riverine conditions. The history of BPC between 1969 and 1995 also provides insight on the fragile nature of riparian habitats and the associated impact of human activities. During that period, grazing by cattle and horses had a sometimes deleterious effect on the native ecosystem. Cattails in the marsh were devoured by cattle during some years, leaving no cover for several species of aquatic and marsh birds (e.g. pied-billed grebe [*Podilymbus podiceps*], least bittern, common moorhen [*Gallinula chloropus*], American coot [*Fulica americana*], and common yellowthroat [*Geothlypis trichas*]). Permittee grazing was removed from the plot in 1977-1978 (Goldfield allotment permit canceled permanently in 1981) but trespass grazing continued into the 1990s. During the 1970s, the area was fenced, but fences to the north were destroyed by recreationists and fences to the south were destroyed by floods.

The pulsing action of flooding alternating with periods of non-flooding is an essential process in maintaining natural riparian ecosystems in the Southwest (e.g., Molles et al. 1998). However, when these natural processes are interrupted by dams, such as those along the Salt River, floods may then become destructive to riparian ecosystems (Johnson and Carothers 1982). Such is the case with BPC. During the late 1970s and early 1980s, several years of heavy winter rains resulted in large spring-water releases by the Salt River Project from upstream dams. During the

Table 2-1. Habitat types on the Johnson-Simpson study plot.

Type	Acres	Hectares
Closed canopy mesquite bosque	80	32
Open canopy mesquite bosque	45	18
Mesquite bosque w/ cottonwood overstory	15	6
Old river bed (sand, rocks, scattered mesquites, shrubs, cacti, and other perennials)	50	20
River and banks	25	10
Marsh	7	3
Upland (ridges dissected by washes w/ xeroriparian vegetation)	28	11
Total	250	100

Table 2-2. Breeding birds on the study plot at Blue Point Cottonwoods (data from Phillips et al. 1964, Johnson and Simpson 1971, Johnson et al. 1987, Johnson unpubl. data, and L. L. Hargrave & A. R. Phillips unpubl. field notes).

Species common name[a]	Breeding habitat[b]	Local status[c]	Riparian dependency[d]	Number of breeding pairs on plot
Pied-billed grebe	M	SR	OBL	1 (some years)
Least bittern	M	SR	OBL	2
Great blue heron[e]		PR	OBL	1
Green heron	CE	SR	OBL	3
Osprey[e,f]		WR	OBL	1 (extirpated)
Bald eagle	C	ON	OBL	1 (winters 71-72, 88-89)
Cooper's hawk	C	PR	OBL	1
Common black-hawk	C	SR	OBL	1 (extirpated)
Harris's hawk	C	PR	PREF	1 (some years)
Red-tailed hawk	C	PR	FAC	1
American kestrel	CF	PR	PREF	2
Gambel's quail	DFW	PR	PREF	Fluctuates, 1-7 coveys
Sora	M	ON	OBL	1 (summer 1951)
Common moorhen	M	SR	OBL	Varies, up to 4
American coot	M	SR	OBL	Varies, up to 6
Killdeer	E	ON	PREF	2
White-winged dove	CWF	SR	PREF	74±
Mourning dove	CWF	PR	PREF	99±
Yellow-billed cuckoo	C	SR	OBL	3
Greater roadrunner	ACDFW	PR	PREF	3
Barn-owl	C	PR	PREF	1
Western screech-owl	CW?[g]	PR	PREF	230±
Great-horned owl	C, Cliffs	PR	PREF	2
Ferruginous pygmy-owl	CW	PR	PREF	Extirpated
Elf owl	F	SR	NON	7
Lesser nighthawk	F	SR	NON	10+
Common poorwill	F	SR	NON	4+
Black-chinned hummingbird	CW	SR	OBL	11±
Costa's hummingbird	DF	SR	NON	2+
Gila woodpecker	CFDW	PR	PREF	16
Ladder-backed woodpecker	CW	PR	OBL	16
Gilded flicker	CD	PR	FAC	5
Black phoebe	ERM	PR	OBL	3
Vermilion flycatcher	CW	SR	OBL	1[h]
Ash-throated flycatcher	CFW	PR	PREF	24
Brown-crested flycatcher	C	SR	OBL	15
Western kingbird	C	SR	OBL	2
Northern rough-winged swallow	R	SR	OBL	7
Cliff swallow	R	SR	OBL	Remains of 33 old nests
Common raven	R	PR	PREF	1
Verdin	DW	PR	PREF	109±
Bushtit	D	Vagrant		1 (nested 1973)
Cactus wren	F	PR	FAC	9
Rock wren	F	PR	NON	2
Bewick's wren	C	PR	OBL	2
Black-tailed gnatcatcher	D	PR	FAC	5
Curve-billed thrasher	CFW	PR	PREF	4
Crissal thrasher	W	PR	OBL	7
Phainopepla	DW	WR	PREF	19
European starling	CF	WR	PREF	26
Bell's vireo	EW	SR	OBL	14
Lucy's warbler	CW	SR	OBL	510±
Yellow warbler	C	SR	OBL	3
Common yellowthroat	M	SR	OBL	6
Yellow-breasted chat	E	SR	OBL	4

(con.)

Table 2-2. Con.

Species common name[a]	Breeding habitat[b]	Local status[c]	Riparian dependency[d]	Number of breeding pairs on plot
Summer tanager	C	SR	OBL	4
Northern cardinal	DW	PR	OBL	11
Blue grosbeak	E	SR	OBL	3
Canyon towhee	F	PR	NON	1+
Abert's towhee	CW	PR	OBL	25±
Black-throated sparrow	F	PR	NON	2
Song sparrow	EM	PR	OBL	20
Red-winged blackbird	E	PR	OBL	15±
Bronzed cowbird	CW	SR	OBL	2+
Brown-headed cowbird	ALL	SR	PREF	10± females
Hooded oriole	CW	SR	OBL	Extirpated[i]
Bullock's oriole	CW	SR	OBL	12±
House finch	CDW	PR	FAC	30±
Lesser goldfinch	C	SR	OBL	18
Totals: 69 species				1,527+ pairs

[a]After 7th ed. A.O.U. Checklist (1998).

[b]Breeding Habitat: A=Abandoned river channel of sand and rock with sparse desertscrub; C=Fremont cottonwood (*Populus fremontii*)-Goodding willow (*Salix gooddingii*); D=desert washes; E=water edge, including mesquite (*Prosopis velutina*), arrowweed (*Pluchea sericea*) & seepwillow (*Baccharis salicifolia*) [see R]; F=foothills, largely saguaro (*Cereus giganteus*)-palo verde (*Cercidium* sp.)-bursage (*Ambrosia* sp.) and mixed cacti; M=marsh vegetation, largely cattails (*Typha domingensis*), bulrushes (*Scirpus* spp.), common reed (*Phragmites*), water fern (*Azolla* sp.), duckweed (*Lemna minor*); R=riverbank and cliffs (sand, soil & rocks in contrast to vegetation in E); W=mesquite woodland (bosque), including *Acacia* spp.

[c]Status on study plot, may differ from Salt River Valley in general: ON=occasional nester; PR=permanent resident; SR=summer resident; WR=winter resident.

[d]After Johnson et al. 1987.

[e]Feeding territory only, nesting off of study plot.

[f]Last seen nesting in this area by Werner, summer 1951 (not Johnson, as stated by Phillips et al. 1964). Hargrave (pers. comm.) knew it as a relatively common nester on transmission lines along the Salt River between Roosevelt Dam and Mesa and Robinson (1930) recorded a pair nesting at Canyon Lake.

[g]Extrapolation from random censusing of displaying pairs in open and closed-canopy mesquite and cottonwood gallery forest with mesquite understory (Johnson et al. 1981).

[h]Vermilion flycatchers (*Pyrocephalus rubinus*) were here in numbers during the 1940s and 1950s but after 1 pair bred in 1969, they disappeared from the plot until after a large burn in the late 1980s or early 1990s when at least 2 pairs returned.

[i]Earlier records showed the hooded oriole (*Icterus cucullatus*) more common than the Bullock's oriole (*I. bullockii*). In 1969, the last pair of hooded orioles was recorded nesting at BPC (Johnson unpubl. data). Phillips suggests that this may be largely due to an increase in brood parasitism by the bronzed cowbird on hooded orioles. This would not, however, explain the increase in the Bullock's oriole population.

early spring of 1978, 1979, and 1980, flows of 2.5 m to 3.5 m or more in depth flooded most of the Hargrave-Phillips-Johnson study area. Although mesquite trees were rarely damaged, some mature cottonwoods and many of the seepwillow (*Baccharis salicifolia*), arrowweed, and other riparian shrubs were uprooted. The marsh was greatly damaged from scouring of cattails, common reeds (*Phragmites australis*), bulrushes (*Scirpus* spp.), and other herbaceous or semi-woody plants. However, the receding water also left seed beds and many cottonwood and willow seedlings later grew into medium-sized trees during the 1980s.

In the Southwest, the lack of regular natural flooding also contributes to the accumulation of debris and an increase in both frequency and intensity of fire in riparian areas (Crawford et al. 1993, Stuever 1997). At BPC, fire is presently one of the most damaging factors. Several fires of 25 acres or more during the mid to late 1980s burned much of the study area. Although many of the mesquites recovered, or partially recovered, several small stands of cottonwoods disappeared. As shown by recent visits, the larger stands along the marsh escaped damage and continue to thrive.

Most lowland riparian habitats in Arizona have suffered a substantial loss in biological diversity and a reduction in the population density of native plants and animal species. In the past, many riparian areas apparently shared the same habitat complexity and bird species richness of BPC. Even the documented changes in the local vegetation at BPC due to grazing, fires, and human-caused flooding serve as a reminder of the potential magnitude of human impacts on riparian habitats. The population decline of the cactus ferruginous pygmy-owl and other species associated with riverine ecosystems in Arizona may be viewed as symptoms of this broader problem created by human interruption of natural riparian processes along southwestern lowland river systems.

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Chapter 3

The Status of the Cactus Ferruginous Pygmy-Owl in Arizona: Population Surveys and Habitat Assessment

In 1993, the Arizona Game and Fish Department (AGFD) began formal population surveys in an attempt to document the numbers and distribution of cactus ferruginous pygmy-owls (*Glaucidium brasilianum cactorum*) in Arizona. Surveys were initiated to gather information on this little-known subspecies which was considered for listing at the time. Prior to 1993, birders and avian biologists had conducted many informal surveys in a sporadic and opportunistic fashion. However, the information derived from those surveys was limited and often inaccessible, and contributed little to the overall understanding of the distribution and abundance of the species. From 1993 to 1997, even the more formal cactus ferruginous pygmy-owl surveys were limited in number and area covered and resulted in only a handful of cactus ferruginous pygmy-owl detections. With the listing of the cactus ferruginous pygmy-owl as an endangered species, significantly more surveys were conducted in 1998 and 1999 by the AGFD, licensed consultants, land management agencies, and agency contractors. The increased number of pygmy-owl detections during those two years resulted from this additional survey effort.

While there is a considerable amount of potentially suitable cactus ferruginous pygmy-owl habitat that remains unsurveyed, we have learned the following information about the distribution of cactus ferruginous pygmy-owls within Arizona: 1) despite increased survey efforts and an increased number of cactus ferruginous pygmy-owl detections, the Arizona population of cactus ferruginous pygmy-owls still appears small; 2) the currently known population of cactus ferruginous pygmy-owls occurs chiefly in desertscrub habitats rather than riparian habitats reported in historical accounts (see Chapter 2); 3) the population of cactus ferruginous pygmy-owls appears patchily distributed across suitable habitat with population pockets occurring in northwest Tucson, southern Pinal County, the Altar Valley, Organ Pipe Cactus National Monument, and the Tohono O'odham Reservation.

In this chapter, we discuss some of the difficulties and challenges of developing an effective and practical survey protocol including results and insights from previous surveys. We then describe important riparian and desertscrub habitats which represent occupied cactus ferruginous pygmy-owl habitats or habitats presumed suitable for cactus ferruginous pygmy-owls. We then briefly describe initial agency efforts to better characterize and describe suitable cactus ferruginous pygmy-owl habitat. Finally, we present our recommendations for future survey efforts.

1. Survey Protocol

In the last two decades, broadcast surveys have been promoted as a reliable and effective technique to study the distribution and size of many small owl populations (Johnson et al. 1981, Lynch and Smith 1984, McGarigal and Fraser 1985, Smith et al. 1987, Ganey 1990, Stahlecker and Rawinski 1990, Noon et al. 1992, Wauer et al. 1993). Because of the lack of adequate information regarding the numbers and distribution of cactus ferruginous pygmy-owls in Arizona, the AGFD developed a broadcast survey protocol as they initiated formal cactus ferruginous pygmy-owl population surveys in 1993 (Felley and Corman 1993). This original protocol was developed based on the little information known at that time about the biology of cactus ferruginous pygmy-owls and similar survey protocols employed for other small owl species. As surveys progressed and the effectiveness of the protocol was evaluated, a revision of the AGFD protocol took place in 1996 (Abbate et al. 1996). The 1996 revisions included increasing the distance between call points and increasing the amount of time spent at each call point. Other slightly different protocols were utilized by contractors surveying for special projects in 1998. Adjustments to the original protocol were in response to changes in research objectives, management needs, and experience gained from previous survey experience.

Protocol development attempts to maximize cactus ferruginous pygmy-owl response to tapes by directing surveys to be performed during the highest known activity periods (i.e., dawn and dusk), and at the appropriate time of year (i.e., the courtship and nesting season) (Gilman 1909, Terres 1991, Wauer et al. 1993). There has been considerable discussion about the effectiveness of surveys outside the peak breeding season. The original survey protocol defined a survey season extending from September to April (Felley and Corman 1993) but, while there appears to be some calling activity in the early fall, the vast majority of recent cactus ferruginous pygmy-owl detections have occurred during the spring courtship and nesting period, with a decrease in calling and responsiveness observed through the remainder of the year (Richardson unpubl. data).

Another debated issue has been the recommended distance between calling stations for a survey. Results of initial response distance testing in Texas indicate that owls will respond to a taped call from a distance of at least 700 m (Chapter 5). However, current protocols for surveying in Arizona recommend call point distances ranging from 150 m to 400 m. While shorter distances between call points decrease survey coverage and thus present some logistical and economic concerns, they do address reduced responsiveness or ability to detect owls because of local demographic and physical factors. Many of the cactus ferruginous pygmy-owls found in Arizona occur in urbanized areas with significant background noises from automobiles, humans, dogs, etc. which reduce a surveyor's ability to detect an owl. Additionally, it has been suggested that, at least for the boreal owl (*Aegolius funereus*), the physiological state of individual owls, the amount of competition among males for nest sites, and mating success can all influence rates of detection (Hayward et al. 1992). In Arizona, low population densities of cactus ferruginous pygmy-owls, and perhaps reduced competition for nest sites, may be associated with lower rates of responsiveness. Thus, if call points are too far apart and/or the time spent at each point is too short, some owls may escape detection. The challenge has been to develop a protocol which balances the significant repercussions of not detecting an owl, when it could potentially be impacted by some activity, with increased costs and logistical difficulties resulting from a conservative survey protocol. Direct costs are associated with actually conducting surveys; there are also indirect costs if the protocol results in the delay of project implementation. Another question considered is the need for two protocols, one dealing with project clearance and another for population assessment and research activities.

In an effort to address issues regarding survey protocol and associated management issues, the U.S. Fish and Wildlife Service (USFWS) and the AGFD developed a survey protocol that was released for public comment in late 1998 (Appendix 3-1). This proposed survey protocol received significant review by a wide variety of public interests. Public comment is currently being evaluated and a finalized protocol is expected sometime in 1999. While economic interests such as development, grazing, and mining may be best served by a stable protocol that can be considered in long-term planning efforts, the cactus ferruginous pygmy-owl survey protocol must be adaptive enough to incorporate advances in our understanding of this species. For example, it is only within the past two years that radio telemetry has been utilized to help us understand aspects of cactus ferruginous pygmy-owl biology such as home range, territoriality, and habitat use. Telemetry will also allow us to test responsiveness of known owls to tape broadcasts. This new information must be utilized in order to develop the most effective survey protocol.

2. Responses of other bird species to broadcast surveys

The ferruginous pygmy-owl is known as the "terror of small birdlife" (Sprunt 1955). Judging from the numerous accounts describing the owl as mobbed by songbirds and hummingbirds (Gilman 1909, Sprunt 1955, Tyler and Phillips 1978, Abbate et al. 1996, Russell and Monson 1998), the occurrence of this owl is likely perceived as a threat by the local avifauna.

Mobbing is a behavior specifically directed against potential enemies during the reproductive season (Kruuk 1964, Hoogland and Sherman 1976, Shields 1984) and raids of neighboring songbird nests by cactus ferruginous pygmy-owls have been documented in Texas and Arizona (see Chapter 1). Mobbing was observed at all nest sites monitored in Arizona and involved a wide variety of species (Abbate et al. 1996, Richardson unpubl. data).

In addition to mobbing, birds also respond to pygmy-owls with vocalizations (i.e., alarm calls), movements, agitation, or some combination of the three. In the Tucson area, where cactus ferruginous pygmy-owls have been found, 25 species (14 of which are year-round residents) responded to broadcast calls with agitated behavior and/or alarm calls (Table 3-1). Among those species, the verdin (*Auriparus flaviceps*), Gila woodpecker (*Melanerpes uropygialis*), and black-tailed gnatcatcher (*Polioptila melanura*) were described as the birds most often reacting to cactus ferruginous pygmy-owls (Abbate et al. 1996). In the Coronado National Forest, where no pygmy-owl was found, several bird species responded with movement, vocalization, and/or agitation during 1997 surveys (Table 3-2). Of these, however, only two identified species exhibited agitated behavior and the bushtit (*Psaltriparus minimus*) alone is a local year-round resident.

If bird responses were species specific, they could indicate whether cactus ferruginous pygmy-owls are in the surveyed area. However, using these responses during broadcast surveys as an indicator of recent or present exposure to cactus ferruginous pygmy-owls in the area is tenuous. The residency status of responding birds is the first important consideration, as the owl is abundant in the tropics (see Chapters 1 and 4). For migratory species, such as most hummingbirds and warblers, agitated behavior or alarm calls in response to tape playing may only reflect exposure to

Table 3-1. List of species responding to broadcast calls of cactus ferruginous pygmy-owls with distress/alarm calls and/or agitated behavior in the Tucson area during surveys from 1994 to 1997 (data compiled from Collins and Corman 1995, Lesh and Corman 1995, Abbate et al.1996, Proudfoot and Beasom 1997, and Skinner unpubl. data).

Bird species	Local status (<4,000 ft elevation)	Documented predation by ferruginous pygmy-owls
Anna's hummingbird	Year-round resident	—
Ash-throated flycatcher	Summer resident	—
Bewick's wren	Winter resident [a]	Yes (Texas)
Bell's vireo	Summer resident	—
Black-tailed gnatcatcher	Year-round resident	—
Bridled titmouse	Year-round resident	—
Broad-billed hummingbird	Summer resident	—
Bushtit	Year-round resident	—
Cactus wren	Year-round resident	Yes (Arizona)
Cassin's kingbird	Summer resident	—
Curve-billed thrasher	Year-round resident	—
Gila woodpecker	Year-round resident	—
House finch	Year-round resident	Yes (Arizona)
House sparrow	Year-round resident	—
Hooded oriole	Summer resident	—
Lucy's warbler	Summer resident	—
Northern cardinal	Year-round resident	Yes (Texas)
Northern mockingbird	Year-round resident [b]	Yes (Texas)
Phainopepla	Year-round resident	—
Pyrrhuloxia	Year-round resident	Yes (Texas)
Ruby-crowned kinglet	Winter resident	—
Summer tanager	Summer resident	—
Verdin	Year-round resident	Yes (Arizona)
Vermilion flycatcher	Summer resident [c]	—
Western kingbird	Summer resident	—

[a] During the summer, the Bewick's wren occurs at higher elevations.
[b] As seasonal dispersal occurs, breeding populations may differ from winter populations below 4,000 ft (1,220 m). Many breeding individuals that breed below 4,000 ft may have wintered south of the Arizona border.
[c] During the winter, the vermilion flycatcher is local and sparse.

Table 3-2. List of species responding to broadcast calls of cactus ferruginous pygmy-owls during surveys at various locations on the Coronado National Forest during the spring of 1997.

Location of survey(s)	Type of habitat	Species responding	Type of response[a]
Providencia Canyon	Xeroriparian	ash-throated flycatcher	M, V
		Bewick's wren	M, V
		broad-billed hummingbird	M
		house finch	M?, V
		vermilion flycatcher	M
Finger Rock Canyon	Xeroriparian with occasional cottonwoods	ash-throated flycatcher	M, V, A
		broad-tailed hummingbird	M
Agua Caliente Canyon	Xeroriparian	flycatcher sp.	M, V
		gnatcatcher sp.	M
		hummingbird sp.	M?
		phainopepla	M?
		Wilson's warbler	M?
Sabino Canyon	Riparian	ash-throated flycatcher	A
		bushtit	M, A
		northern cardinal	M
		gnatcatcher sp.	A
		hummingbird sp.	M
Pima Canyon	Xeroriparian	hummingbird sp.	M
Sycamore Canyon	Riparian	broad-tailed hummingbird	M
		northern pygmy-owl	V
Santa Catalina State Park	Riparian	black-tailed gnatcatcher	M
		flycatcher sp.	V
		verdin	M, V
		common poorwill	V?

[a] M = response with movement towards the observer, V = response with vocalizations, A = response with agitated behavior, ? = movement or vocalization recorded, but not in obvious response to tape playing.

the owl in the tropics during the non-breeding season. Even when responding birds are year-round residents, however, it is not known whether they are reacting specifically to the owl's call based on personal exposure or if they simply perceive the call as fitting the characteristics of a potential predator.

Despite the questions surrounding the use of bird responses during unsuccessful surveys as an indication of owl presence, mobbing in particular is valuable to locate cactus ferruginous pygmy-owls. In fact, mobbing response is the primary tool used to detect cactus ferruginous pygmy-owls during research when the owls are not vocalizing or if a radio transmitter is not attached. Prior to the use of telemetry, most cactus ferruginous pygmy-owl locations associated with nest monitoring were the results of investigating areas where mobbing behavior by songbirds was observed. While monitoring owls during research, it is also very rare to go through a session without recording mobbing behavior. Therefore, mobbing response during broadcast surveys is a good tool to help locate this very cryptic species.

3. Population Surveys

As listed by Hunter (1988), detections of cactus ferruginous pygmy-owls during the 1970s and 1980s were scattered in various parts of south and central Arizona, occurring in both riparian and in desertscrub/ xeroriparian habitats (Table 3-3). However, the survey effort of the last five years suggests a somewhat different pattern of distribution, with few owls detected in meso-riparian habitat. Cactus ferruginous pygmy-owls have been found in association with desertscrub and xeroriparian vegetation in four general areas: Organ Pipe Cactus National Monument, northwest Tucson/southern Pinal County, the Tohono O'odham reservation, and the Altar Valley. The only

Table 3-3. General location of detections from 1971 to 1988 (adapted from Hunter 1988).

Location	Time of documented presence	Status of individuals located
Northwest Tucson and Marana/Red Rock	1976	individual
	1980-1987	pair with young
Tanque Verde Ranch	1975	individual
Sabino Canyon Visitor Center	1971, 1976	pair with young
OPCNM	1977-1985	2+ pairs
	early 1980s	individual
	early 1980s	individual
lower San Pedro watershed	1985-1987	pair
	1987	individual
Salt River	1971	individual?
Gila River watershed	1978 [a]	individual
	1985 [a]	individual
Upper Santa Cruz watershed	mid-1970s [b]	individual
	1975 [c]	individual
Lower Sycamore Canyon	1986 [d]	individual

[a] Sightings of cactus ferruginous pygmy-owls at the Bonita Creek-Gila River confluence and Gila River-San Francisco River confluence may be questionable (T. Corman, pers. comm.). There are no historical (pre-1970) records even close to this area. One owl sighted is only described as a "small, tuftless owl at the entrance to a tree cavity." In retrospect, this bird could have been an elf owl (*Micrathene whitneyi*).

[b, c] These two records are from elevations reaching approximately 4,000 ft.

[d] The owl reported may have been a northern pygmy-owl (*Glaucidium gnoma*) (T. Corman, pers. comm.).

owls found in meso-riparian areas occurred in the Altar Valley. Surveys completed from 1993 through 1996 were conducted primarily by the AGFD. Survey areas were selected based on historic occurrences and thus focused primarily on riparian areas. Some historic locations, however, occurred in desertscrub and were surveyed. In addition, some desertscrub areas on Breeding Bird Atlas blocks were also surveyed. A few surveys were conducted by federal agencies within their jurisdictions including Organ Pipe Cactus National Monument and Saguaro National Park. These surveys detected very few owls (Table 3-4).

With the listing of the cactus ferruginous pygmy-owl as an endangered species in 1997, agencies and consultants increased the cactus ferruginous pygmy-owl survey effort significantly. Surveys were still focused on areas where owls had been detected in the past, but expanded to include areas of potentially suitable desertscrub where projects were planned to occur. In conjunction with the increased survey effort, experience gained by researchers and increased public awareness have resulted in more owls being found in recent years (Table 3-4). Even with the increased survey effort, there are still large areas of potentially suitable habitat that remain unsurveyed and, although we have detected an increasing number of birds, information on the natural history, distribution and habitat requirements of cactus ferruginous pygmy-owls still remains limited. The results of population surveys do not yet allow for an estimate of population size. For these reasons, surveys should remain a high priority in the next few years.

4. Description of Important Habitat Areas and Survey Effort

The cactus ferruginous pygmy-owl in Arizona has been documented in a variety of riparian and desertscrub habitats (Bendire 1888, Breninger 1898, Gilman 1909, Phillips et al. 1964, Hunter et al. 1987, Hunter 1988, Abbate et al. 1996). Some of the historic locations, particularly those in riparian habitat, have undergone considerable alteration since the time of

Table 3-4. Number of cactus ferruginous pygmy-owls detected (including young of the year) resulting from surveys conducted from 1993 to 1999 (data compiled from Felley and Corman 1993, Collins and Corman 1995, Lesh and Corman 1995, Abbate et al. 1996, Richardson unpubl. data, and T. Tibbitts pers. comm.).

	Year						
Location	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
Northwest Tucson/southern Pinal County	1	2	6	12	10	20	39
Organ Pipe Cactus National Monument	1	0	1	3-6	2	9	8
Silverbell and Tucson mountains	ND	ND	0	0	0	1	0
Buenos Aires National Wildlife Refuge[b]	ND[a]	ND	0	ND	ND	3	10
Altar Valley (except Buenos Aires National Wildlife Refuge)	ND	ND	ND	ND	ND	0	21
Total	2	2	7	15-18	12	33	78

[a] No data.
[b] The Buenos Aires National Wildlife Refuge and the rest of the Altar Valley are distinguished.

noted pygmy-owl occurrence (see Chapter 2). Other areas, though, have developed or maintain potentially suitable habitat characteristics, such as vegetation structural diversity and nesting substrates. The following is a description of some of the important habitat areas that remain in Arizona and an indication of survey efforts in those areas. Due to limited manpower or inaccessibility, some of these areas have not yet been surveyed adequately, while others -not all of these are described here- have not yet been surveyed at all.

A map (Fig. 3-1) is included with the location of all survey areas. For several of these, information is provided in the text on recent vegetation changes and outstanding threats to the habitat. When determined by surveyors, qualitative estimates of cavity availability and woodpecker abundance are also reported.

Lower San Pedro

Lands considered to be suitable for cactus ferruginous pygmy-owl occupancy in the lower San Pedro River drainage (Fig. 3-1) primarily consist of a mixture of cottonwood (*Populus fremontii*), Goodding willow (*Salix gooddingii*), velvet mesquite (*Prosopis velutina*) and exotic tamarisk (*Tamarix* spp.)-dominated riparian vegetation.

The riparian habitat along the lower San Pedro River varies from vast expanses of gallery cottonwood/willow forest with a dense understory of tamarisk to decadent stands of cottonwood interspersed with monotypic stands of tamarisk. Extensive mesquite bosques are found in several areas near Cascabel and Mammoth and to the north around Cook's Lake. Located near the confluence of Aravaipa Creek and the San Pedro River, Cook's Lake is a 270-acre wetland surrounded by dense stands of cottonwoods, Goodding willow, netleaf hackberry (*Celtis laevigata* var. *reticulata*), buttonbush (*Cephalanthus occidentalis*), velvet mesquite, and velvet ash (*Fraxinus velutina*) and bordered on its eastern side by upland Sonoran desertscrub (Lesh and Corman 1995). The local occurrence of one of the largest breeding populations of the Southwestern willow flycatcher (*Empidonax traillii extimus*) for the state of Arizona (Sferra et al. 1997) is notable, since this endangered bird may be viewed as an indicator of riparian habitat health (S. Stoleson, pers. comm.). Bingham Cienega, another wetland near the town of Redington, is bordered by large cottonwoods, Goodding willows, Mexican elderberry (*Sambucus mexicana*), netleaf hackberry, and velvet ash. It is adjacent to a mesquite bosque and surrounded by hills supporting Sonoran desertscrub vegetation (Lesh and Corman 1995). Historic records of pygmy-owl occurrence (Hunter 1988, Table 3-3) have come from the lower San Pedro River in the vicinity of Dudleyville and from the mesquite bosques near the mouth of Aravaipa Canyon. The former location had a dense understory of tamarisk with a dispersed canopy of cottonwood trees. The latter habitat was dominated by large mesquite bosques. Elevation ranges from 1,920 ft (585 m) at Winkelman to 3,040 ft (927 m) at Cascabel.

Most of the area along the lower San Pedro River is privately owned with significant portions of Arizona State Trust Land in adjacent Sonoran Desert uplands. The Bureau of Reclamation and the Arizona Chapter of The Nature Conservancy currently administer large blocks of dense riparian habitat within the lower San Pedro near Dudleyville. Public lands administered by the Bureau of Land Management (BLM) along the river total approximately 2000 acres, including several hundred acres under conservation easements. In 1993, surveys were conducted near Winkelman, Mammoth, San Manuel, and Redington (Felley and Corman 1993). Area coverage totaled 59.1 km^2. Additional surveys were conducted in 1994 from Winkelman south to Aravaipa Creek, near Mammoth, and along

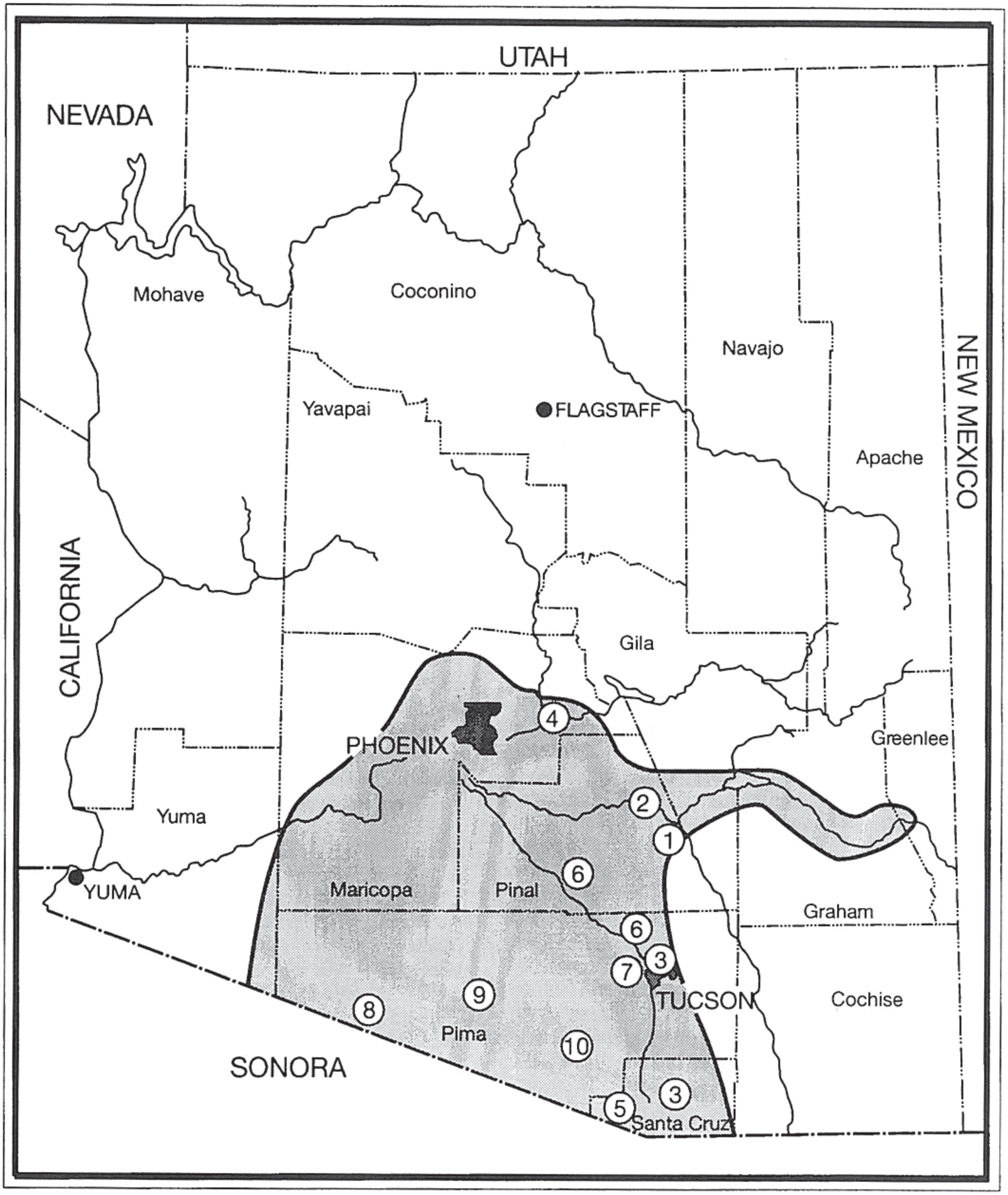

Figure 3-1. Location of survey areas. 1: lower San Pedro River, 2: middle Gila River, 3: Santa Cruz and tributaries, 4: Salt and Verde rivers, 5: Sycamore Canyon, 6: northwest Tucson and southern Pinal County, 7: Silverbell and Tucson mountains, 8: Organ Pipe Cactus National Monument, 9: Tohono O'odham Reservation, and 10: Altar Valley, including Buenos Aires National Wildlife Refuge. The shaded area corresponds to the distribution of the cactus ferruginous pygmy-owl in Arizona (Chapter 2).

Bingham Cienega (Collins and Corman 1995). In 1995, only Bingham Cienega and Cook's Lake were surveyed (Lesh and Corman 1995). On the public lands near Cascabel managed by the BLM, no surveys were conducted prior to 1999. One survey conducted in April 1999 resulted in no detections. Despite the survey effort, much of the habitat along the lower San Pedro, especially on private lands, has not yet been surveyed.

Habitat restoration is occurring on both public and private lands within the lower San Pedro River Basin through adjustments in livestock management practices, revegetation of the floodplain with native riparian trees, and construction of erosion control structures in the uplands. The BLM is actively pursuing a land acquisition process using Land and Water Conservation funds. Land acquisition, land exchange, and conservation easements continue to be the best habitat conservation programs along the lower San Pedro River. Despite substantial recharge from side drainages north of Cascabel, however, the growth of Sierra Vista and increasing groundwater pumping (Tellman et al. 1997) represent a threat to the riparian vegetation along the San Pedro River.

Middle Gila River

Upstream from Ashhurst-Haydn Dam to near Kelvin, the banks of the middle Gila River support regenerating cottonwoods and willows intermixed with extensive mesquite bosques. In several areas, extensive stands of tamarisk line both sides of the river, forming nearly impenetrable thickets. The middle Gila River is completely dependent on water releases from Coolidge Dam which withholds water from the San Carlos Reservoir. Land ownership patterns along this reach of the river consist primarily of private, AZ State Trust Lands and Bureau of Reclamation (BoR) lands. The BLM manages the BoR lands due to a cooperative agreement with this agency. On July 12, 1999, the entire length of the middle Gila River was designated as critical habitat for the cactus ferruginous pygmy-owl. This riparian corridor, however, has not been surveyed for cactus ferruginous pygmy-owls due to funding and personnel constraints.

Santa Cruz Watershed

The cactus ferruginous pygmy-owl was once described as a resident of the riparian habitat along Rillito Creek (Bendire 1888). However, changes in the vegetation along the Santa Cruz watershed since the turn of the century have been pronounced (see Chapter 2). The perennial reaches of the Santa Cruz once found at San Xavier and Tucson are now dry and deeply entrenched (Tellman et al. 1997). In Tucson, the banks of both the Santa Cruz and Rillito Creek are soil cemented. Perennial surface water is now found only in the upper Santa Cruz River where it receives wastewater from the Nogales treatment plant and in some of the river's tributaries (Tellman et al. 1997). The remaining floodplain riparian habitat is mostly confined to narrow, linear areas along major washes such as Cañada del Oro and Sutherland Washes near the western foothills of the Santa Catalina Mountains, and along Sabino Canyon Wash, Tanque Verde, and Rincon Creek east of Tucson (Fig. 3-1).

The Cañada del Oro Wash and connecting Sutherland Wash are large, sandy washes that flow only during heavy rainfalls. They are found in part in Santa Catalina State Park (Coronado National Forest), where they were surveyed in 1994, 1995, 1997, and 1999 at an elevation ranging from 2,640 ft (805 m) to 3,200 ft (976 m). The banks of both washes support mature riparian vegetation consisting primarily of velvet mesquite trees and desert willows (*Chilopsis linearis*). The vegetation also includes some walnut (*Juglans major*), and a few small cottonwoods. The shrub layer is composed of catclaw acacia (*Acacia greggii*), graythorn (*Ziziphus obtusifolia*) and desert broom (*Baccharis sarothroides*). In the uplands, the vegetation is dominated by saguaros (*Carnegiea gigantea*) and foothill palo verde (*Cercidium microphyllum*) but also includes ocotillo (*Fouquieria splendens*), prickly pear and cholla (*Opuntia* spp.), white bur sage (*Ambrosia dumosa*) and fairy duster (*Calliandra eriophylla*).

Sabino Creek is a perennial stream which originates on the Santa Catalina District of the Coronado National Forest. Owls were detected at the Sabino Canyon Visitor Center in the 1970s (Hunter 1988). Within the Forest's boundaries, riparian habitat along the creek is thin, yet continuous, and typically consists of ash, willow, mesquite, and cottonwood. Understory plants include hackberry. Cavities are numerous and woodpeckers are common. The area is open to the public and receives approximately one million visitors every year. Near its confluence with Tanque Verde in northeast Tucson, some of the vegetation has been cleared due to urban development. Original, unimpacted habitat along Sabino Creek and Tanque Verde consists of dense mesquite bosques with patches of large Fremont cottonwoods (Lesh and Corman 1995). Lower Sabino Creek and Tanque Verde were surveyed in 1993 and 1995. Sabino Creek was also surveyed on the Coronado National Forest in 1997.

Agua Caliente originates on the Santa Catalina District of the Coronado National Forest and runs southwest beyond the limits of the forest to its confluence with Tanque Verde in northeast Tucson. It consists of a rocky and sandy wash flanked with xeroriparian vegetation and occasional, thin patches of riparian habitat. The riparian vegetation along

Agua Caliente on the Coronado National Forest includes ash, walnut, Arizona sycamore (*Platanus wrightii*), and willow. Along the wash's lower segment, the riparian vegetation is comprised of Arizona sycamore, desert willow, eucalyptus (*Eucalyptus* spp.), and Fremont cottonwood, with mesquite bosques in some areas. Agua Caliente was surveyed in 1997.

Rincon Creek was surveyed in 1993 and 1998. Along the banks of Rincon Creek is a fairly narrow strip of riparian vegetation that consists typically of cottonwood, sycamore, velvet ash, and velvet mesquite. Downstream, these trees are replaced by mesquite groves. Land use varies from light grazing to large residential subdivisions.

Cienega Creek has perennial surface waters along a segment located in the Cienega Creek Preserve at an approximate elevation of 1,000 m (Abbate et al. 1996). Dense mesquite bosques occur locally, intermixed with Fremont cottonwood, desert willow, and other broadleaf riparian species. The creek also supports grasses, sedges, and other strictly water-dependent species. On the upper slope, the vegetation includes grasses, shrubs, and large cacti. While livestock grazing has been excluded from the preserve, trespass cattle can still be found regularly in the riparian area. Development outside is sparse. Cienega Creek was surveyed in 1996, 1997, 1998, and 1999. Cactus ferruginous pygmy-owl nest boxes were placed in this drainage in 1998, but were unused by cactus ferruginous pygmy-owls.

Arivaca Creek and its tributaries are located in the Buenos Aires National Wildlife Refuge in the Altar Valley (see Altar Valley section).

Lower Salt and Verde Rivers on Tonto National Forest

The cactus ferruginous pygmy-owl was once a common resident of the Salt River Valley (Breninger 1898). Its occurrence along the Salt River was noted until 1971 (see Chapter 2). The local decline of the owl coincided with the disappearance of the original riparian vegetation due to woodcutting and the construction of dams (see Chapter 2). Along the Verde River, there is no known record of cactus ferruginous pygmy-owls, yet their historical occurrence here is certainly possible in light of records from New River (Fisher 1893), Cave Creek (Johnson et al. unpubl. ms.), and Blue Point Cottonwoods (Johnson and Simpson 1971).

In May 1997, approximately 13,000 acres on the Tonto National Forest were surveyed for cactus ferruginous pygmy-owls, chiefly along the Salt and Verde rivers (Fig. 3-1). In 1998, 12,412 acres were surveyed by a contractor. In 1997, the survey area along the Verde River was from Horseshoe Dam to three miles below the dam, along a portion of the west bank of Bartlett Reservoir, and between Bartlett Dam and the Fort McDowell Indian Reservation. Along the Salt River, surveys were conducted between Stewart Mountain Dam and Granite Reef Dam. The confluence of the two rivers, which lies at an elevation of 1,500 ft (457 m), was also surveyed in 1993 and in 1994 (Felley and Corman 1993, Collins and Corman 1995). In 1998, riparian areas and adjacent uplands were surveyed along the Verde and Salt rivers, Sycamore Canyon just upstream from Horseshoe Dam, Cave Creek, and New River. However, the topography of the latter two areas surveyed (i.e., steep canyons) suggests that the historical records from Cave Creek and New River (Fisher 1893, Johnson et al. unpubl. ms.) did not originate from within the Forest boundaries. Additional areas surveyed in 1998 included the Bulldog Canyon-Usery Pass area and Hog Canyon.

Along the Salt and Verde rivers, the vegetation is in places characterized by mesquite bosques and small patches of cottonwood-willow and sycamore. The banks of the Verde River have several marshes with cattails (*Typha domingensis*). Tamarisk dominates an area near Granite Reef Dam. The mesquite bosques lack an understory and are largely degraded by off-highway vehicle use. Riparian vegetation is flanked by Sonoran desertscrub consisting predominantly of scattered mesquite and palo verde, with associations of triangle-leaf bur sage (*Ambrosia deltoidea*), cholla cactus, prickly pear, saguaro, creosote bush (*Larrea tridentata*), and occasional ironwood (*Olneya tesota*). This habitat is mostly open, with scattered patches of dense vegetation, and little vertical structural diversity. Near the confluence of the Salt and Verde rivers, the Salt River Recreation Area includes a picnic area, nature trails, and a large parking lot. Livestock grazing has been banned from the Tonto National Forest but still occurs on the Fort McDowell Indian Reservation along the Verde River and a section of the northern bank of the Salt River. According to Johnson and Haight (1998), habitat suitability in survey areas along the Verde River seems comparable to that along the Salt River.

Blue Point Cottonwoods (see Chapter 2) was described between 1969 and the early 1980s as one of the last remnants of the original floodplain landscapes in the Salt River Valley. The area was last surveyed in 1998. It consists of a marsh of open water lined with large stands of cottonwoods and a mesquite understory. The marsh is typically dry during the winter when water is held upstream. Trespass grazing represents the primary threat to the habitat.

Sycamore Canyon in the Atascosa/Pajarito Mountains

Sycamore Canyon, located in the Nogales District of the Coronado National Forest, was surveyed in 1994 and 1997. With intermittent surface waters, it supports lowland riparian vegetation consisting primarily of Arizona sycamore, velvet ash, willow, walnut, and seepwillow (*Baccharis salicifolia*). Saguaros, junipers (*Juniperus* spp.), and oaks (*Quercus* spp.) occur on the slope of the canyon. Mesquite grows at the edges of the main drainage at the mouth of the canyon. The habitat supports a substantial number of woodpeckers while sycamores and saguaros provide many cavities.

Northwest Tucson and Southern Pinal County

This area is bounded on the south by Cortaro Farms Road, on the east by the Catalina Mountains and State Highway 79, on the west by I-10 and on the north by Florence and Coolidge (Fig. 3-1). It is a region of diverse desert scrub of varying quality. This area has been the most intensively surveyed area for cactus ferruginous pygmy-owl in the state. Surveys have been conducted formally since 1993 and have continued through 1999 (Table 3-4). The area contains most of the cactus ferruginous pygmy-owls detected since 1993. It contains a mixture of private, state, and BLM lands. Residential occupancy ranges from scattered ranches on hundreds of acres to densities as high as six residences per acre. Livestock grazing and recreational use occur throughout the area. There are large areas of natural desert characterized as Sonoran desertscrub. Density and diversity of vegetation are highest to the south. To the north, the vegetation becomes progressively more open and less diverse. Mesquite and foothill palo verde are dominant species. Saguaros and ironwoods are common and can become dominant in some localities, but are completely absent in others. The understory consists of a variety of cholla, prickly pear, hedgehog (*Echinocereus* spp.) and fishhook barrel cacti (*Ferocactus* spp.). Triangle-leaf bursage is the dominant understory shrub, but creosote and burroweed (*Isocoma tenuisecta*) are common. Desert hackberry (*Celtis pallida*), acacia species and desert willow increase along the numerous dry washes found in the region. Much of the survey work and most of the cactus ferruginous pygmy-owl detections have occurred in the bajadas of the Tortolita Mountains. Elevation ranges from 2,100 ft (640 m) to near 3,000 ft (915 m) in the areas surveyed. This site occurs in one of the fastest developing areas of the state with continued fragmentation and loss of habitat likely.

Silverbell and Tucson Mountains

The Silverbell and Tucson Mountains are located on the western edge of the Tucson Basin (Fig. 3-1). The area is characterized by the occurrence of potentially suitable desertscrub that has been surveyed for cactus ferruginous pygmy-owls in a relatively intense manner by both agency personnel and private consultants. Surveys have been conducted from 1995 through 1999. One owl was located in 1998 in the Tucson Mountains. Recreational, residential, mineral and agricultural uses all occur in the area. The density and diversity of the desertscrub vegetation vary across this region but are typical of the upper Sonoran desertscrub vegetation classification. Saguaros are common with velvet mesquite, foothill paloverde and ironwood making up the dominant tree species. A shrub species which is common in this area, but not as common in northwest Tucson, is jojoba (*Simmondsia chinensis*). The most common shrubs and cacti are the triangle-leaf bursage, creosote, acacia, prickly pear, cholla, and barrel cactus. Desert hackberry is common along the washes. Elevation ranges from 610 m to 915 m in areas surveyed. Because both county and national parks occur in this area, there is some level of habitat protection for a rather large area. However, much of the area is still subject to development and other potential impacts.

Organ Pipe Cactus National Monument

Cactus ferruginous pygmy-owls have been documented here since the late 1940s (Hensley 1954). Periodic surveys for cactus ferruginous pygmy-owls have likely occurred on the Monument since that time. More recently, annual surveys have been conducted since 1993 (Table 3-4). Owls have been detected every year since then, except 1994, and nesting was documented in 1998 and 1999. The surveyed areas are typical desertscrub in the drainages and bajadas of nearby mountain ranges. While overall precipitation is less than that of northwest Tucson and the Tucson/Silverbell Mountain areas, it is still characterized by many of the same species such as saguaro, ironwood, foothill paloverde, velvet mesquite, triangle-leaf bursage, creosote, prickly pear, and cholla. Livestock grazing no longer occurs on the Monument and recreation is the primary human activity for the area.

Tohono O'odham Reservation

Agencies and contractors have not generally been allowed on the Reservation to conduct surveys. However, some surveys have been conducted since 1997 to clear various planned and occurring projects on the Reservation. Breeding Bird Atlas surveyors have been conducting Atlas activities on the Reservation and have detected a number of cactus ferruginous pygmy-owls. The Reservation is a large block of relatively undisturbed desertscrub which is located between the two major areas where cactus ferruginous pygmy-owls have been found recently, Organ Pipe Cactus National

Monument and the Tucson Basin. Based on its proximity and the fact that cactus ferruginous pygmy-owls were detected in 1997 and 1998 (Johnson et al. unpubl. ms.), the Reservation represents a key habitat area that must be considered in the status of the cactus ferruginous pygmy-owl population in Arizona.

Altar Valley

The Altar Valley runs south from State Highway 86 to the Mexican border. It is bounded on the west by the Baboquivari Mountains and on the east by the Sierrita, Cerro Colorado and Las Guijas mountains (Fig. 3-1). The Buenos Aires National Wildlife Refuge is included in the Altar Valley and extends south to the Mexican border. It was surveyed in 1995, 1998, and 1999 (Table 3-4). The rest of the Altar Valley area was primarily surveyed only during 1998 and 1999. Owls have been detected throughout the area, the majority of which are occurring in desertscrub or desertscrub/desert grassland transition areas. Owls have also been detected in riparian habitat along Arivaca Creek and its tributaries.

The desertscrub habitat in the Altar Valley is less dense and less diverse than those previously described. There are far fewer saguaros and the tree species are primarily velvet mesquite and foothill paloverde. Existing desert grassland is characterized by scattered mesquites and Lehmann's lovegrass (*Eragrostis lehmanniana*). Most owls detected to date were found along washes lined with well-structured xeroriparian vegetation. In comparison with the uplands, vegetation diversity and density along washes with pygmy-owls are enhanced. Elevations are higher here, with owls being found right at 4,000 ft (1,220 m).

Arivaca Creek and Brown Canyon on Buenos Aires National Wildlife Refuge were surveyed in 1995 and at an elevation of 3,080 ft (939 m) to 3,980 ft (1,213 m) (Lesh and Corman 1995). Arivaca Creek and San Luis Wash were surveyed in 1998 and 1999. Along Arivaca Creek, the riparian vegetation is dominated by cottonwoods, netleaf hackberry, Arizona ash, and velvet mesquite. Vegetation in the San Luis tributary is similar, but less dense. In a few areas, mesquite form large bosques. Brown Canyon, to the north of Arivaca Creek, is lined with large Arizona sycamores, velvet mesquite, Emory oaks (*Quercus emoryi*), netleaf hackberry, and catclaw acacia. Owls were detected during surveys along Arivaca Creek in 1998, and along San Luis Wash in 1998 and 1999 (Table 3-4).

Livestock grazing and recreation are the primary human impacts, although residential development is increasing. Based on the number of owls found here in 1998 and 1999, additional survey work should be focused in this area.

5. Habitat Assessment

While we can describe, in general terms, the habitat in areas where cactus ferruginous pygmy-owls have been found in Arizona, we lack the numbers of owls and the research necessary to determine specific habitat needs. In addition, the range of vegetation types and diversity of areas where cactus ferruginous pygmy-owls are found in Arizona have made it difficult to identify what specific habitat characteristics these owls are selecting. In an effort to identify and prioritize areas for survey and management, the BLM and U.S. Forest Service, with input from the AGFD and USFWS, have developed habitat assessment protocols (see Appendix 3-2). These protocols were developed to rapidly assess habitat areas without having to conduct time-consuming, detailed habitat sampling. This type of assessment is an iterative process. Adjustments are being made based on new information gathered during ongoing research and also to address local differences in vegetative communities. Habitat assessment protocols will likely change in the future based on location and purpose, but are useful for agencies and others who need some type of quantitative assessment of cactus ferruginous pygmy-owl habitat.

5. Recommendations

Given the endangered status of the cactus ferruginous pygmy-owl and the associated regulatory requirements, as well as the urgent need to gain a better understanding of this owl's biology, survey efforts will likely continue to intensify. As a result, we will, hopefully, gain a better idea of the numbers and distribution of cactus ferruginous pygmy-owls in Arizona. Below are recommendations for future cactus ferruginous pygmy-owl survey efforts and habitat assessments:

- Ensure that all surveyors utilize the most recent approved protocol to maintain consistency and comparability of survey results. As mentioned above, a revised protocol is now being considered for release by the USFWS.
- Continue to update the survey protocol periodically with improved information on the ecology of cactus ferruginous pygmy-owls as it becomes available.
- Centralize all completed survey information from all sources, i.e., agencies, consultants, researchers, etc. Because the information is not centralized and difficult to find, it is currently not easy to assess survey coverage or intensity statewide.
- Survey potentially suitable habitat in areas around and between sites recently occupied by cactus ferruginous pygmy-owls. Some high

priority areas are northern Pima County and southern Pinal County in the Tucson Basin, the Tucson, Silverbell and Roskruge Mountain areas, the middle Gila River, the Altar Valley, BLM lands north of Organ Pipe Cactus National Monument, and the Tohono O'odham reservation.

- Conduct surveys in all suitable remaining riparian habitats in southern and central Arizona. Areas of specific potential include the Lower San Pedro River, the Gila River, the Salt River, the Verde River, Arivaca Creek, and the Santa Cruz River between Rio Rico and Amado.
- Conduct surveys (if proper vegetative components are present) within the range of potential housing development patterns (i.e., from very low density development up to high density development, in cluster and sprawl developments). Survey sites with other types and levels of human activities (recreation, livestock grazing, mining, etc.) to help clarify the levels and design of human activities tolerated by cactus ferruginous pygmy-owls.
- Continue to refine existing rapid habitat assessment protocols based on results of ongoing research.
- Conduct studies on habitat selection and use on a variety of scales.
- Investigate additional funding sources (agency, grants, foundations, etc.) to increase survey and habitat research efforts.
- Utilize telemetry to help document habitat use, dispersal parameters, broadcast responsiveness, home range size, etc. These contribute directly to developing better survey protocols and habitat assessment methodologies.

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Appendix 3-1: Proposed revised cactus ferruginous pygmy-owl survey protocols, with introduction and summary of changes since 1993. Please note that a survey protocol has been proposed for project clearance, another for large area search. The proposed protocols were developed by the Arizona Game and Fish Department (AGFD) and the U.S. Fish and Wildlife Service (USFWS).

3-1-1 Introduction and purpose of the protocols

Any survey protocol for this species must address two distinct needs. The first is the need to determine if cactus ferruginous pygmy-owls are present on those sites where an activity is proposed that would result in loss, modification, or disturbance of pygmy-owls or their habitat. The second is the need to survey the vast acreage of potential pygmy-owl habitat to gather information on distribution, occurrence, and numbers of pygmy-owls in Arizona.

A single protocol cannot address these two needs because of funding and personnel constraints, the potential ramifications if pygmy-owls are missed on project sites, and the area that can be covered by a surveyor. Therefore, we have included a separate protocol to address each need. The first is a conservative protocol developed to answer, with some degree of confidence, whether cactus ferruginous pygmy-owls occupy a project site where an impacting activity has been proposed. In Arizona, we know of so few individual pygmy-owls, that it is essential to locate and address potential impacts to any pygmy-owls that may occur on project sites.

The second protocol is to be used by researchers, land managers, and others to survey large areas of unsurveyed habitat. It is designed to allow a greater area to be surveyed with more effective use of limited manpower and funds. This will help us increase the area surveyed in order to answer key questions regarding distribution and occurrence of known and unknown cactus ferruginous pygmy-owl population centers in Arizona.

Issuance of permits by USFWS to survey for cactus ferruginous pygmy-owls is tied to appropriate use of these two protocols. Permits will be used only after attendance at a training session approved by AGFD and USFWS where the circumstances under which these protocols can be applied will be discussed.

3-1-2 Project clearance protocol

1. Permission to access a property for surveying must be obtained from all private property owners or those having management authority (public lands) prior to conducting surveys.
2. Surveys must be conducted in potential habitat from 1 hour before sunrise to 2 hours after sunrise, or from 2 hours before sunset to 1 hour after sunset, during the period of January through June. Recent data suggest peak calling activity occurs from February through April.
3. Sites must be surveyed for two consecutive years during the above protocol period. Each year, survey routes must be surveyed a minimum of 3 times, with no less than 15 days between surveys. One survey must be conducted between February 15 and April 15. These time frames are necessary to account for variations in annual weather patterns and the responsiveness of individual pygmy-owls. Surveys should not be conducted if wind or other factors reduce the detectability of calls.
4. Any acreage subjected to surface disturbance (including vegetation removal or disturbance) must have been surveyed for presence of pygmy-owls within the calendar year in which surface disturbance occurs. These surveys must have been conducted in suitable pygmy-owl habitat within 1500 ft of the acreage being disturbed.
5. Call points along a survey route in urban areas, sites with high noise disturbance (such as along roads or highways), or in riparian areas (due to tree density and noise) must be no more than 150 meters apart. In more remote areas that do not have the above types of disturbance, the distance between call points may be extended up to 400 meters, so long as complete coverage is maintained. Distance between survey transects must be no more than twice the distance between call points.
6. Conduct a 1-minute listening period at each call point prior to broadcasting any calls. This will allow the surveyor to detect any spontaneous calling and also to become familiar with features at the call point, such as large trees or saguaros, residences, water sources, etc., that may affect pygmy-owl presence or observation.
7. Following the initial listening period, broadcast calls for 30 seconds and follow this with a 90 second listening and observation period. Broadcast the call in all directions. Set the volume at an adequate level to get complete coverage along a survey route without causing distortion of the

call. Equipment used must be able to produce a minimum of 100 dB at 1 m from the speaker without distortion.

8. Repeat the calling/listening sequence for at least 10 minutes. Extend this sequence if disturbances such as dogs, air traffic or vehicles disrupt your call point.
9. Observe and listen for an additional 2-3 minutes before proceeding to the next call point.
10. If a cactus ferruginous pygmy-owl is heard or seen:

    a) End broadcasts unless additional responses are needed to pinpoint the location.
    b) Observe the pygmy-owl as long as possible without disturbing it (i.e. do not chase the bird or harass it with calls). Record all observations, use of cavities and prey observations are especially important. Listen for female or fledgling vocalizations or other evidence that there may be other pygmy-owls in the area.
    c) Flag the location of the bird, or your best estimate of where the bird was, with surveyor's tape and record the location on a map (tape will be removed when follow-up visits are completed).
    d) Record the date, time, type and duration of response (aural or visual), habitat characteristics of the site, and detailed directions to the site.

11. Complete the attached survey data forms for each route each time it is surveyed. Be sure to record survey date, time, weather conditions, moon phase, and responses of other birds. If a cactus ferruginous pygmy-owl is located, please fill out a detection form.
12. If an owl is located, fax a copy of your detection form and map to AGFD and USFWS within 24 hours of the detection. No later than 10 days after the completion of the 3rd survey, return all survey forms and detection forms to AGFD and USFWS:

    Arizona Game and Fish Department
    Nongame Branch
    2221 West Greenway Road
    Phoenix, Arizona 85023-4399
    (602) 789-3500 Fax (602) 789-3926

    United States Fish and Wildlife Service
    Arizona Ecological Services Field Office
    2321 W. Royal Palm Road, Suite 103
    Phoenix, Arizona 85021-4951
    (602) 640-2720 Fax (602) 640-2730

It is important that we receive all completed data forms, whether a pygmy-owl is detected or not. AGFD and USFWS will respect the rights of private property owners throughout implementation of this protocol.

3-1-3 Large area search survey protocol

1. Permission to access a property for surveying must be obtained from all private property owners or those having management authority (public lands) prior to conducting surveys.
2. Surveys must be conducted in potential habitat from 1 hour before sunrise to 2 hours after sunrise, or from 2 hours before sunset to 1 hour after sunset, during the period of January through June. Recent data suggest peak calling activity occurs from February through April; therefore, surveys should be conducted during this period if possible.
3. Sites should be surveyed for two consecutive years during the above protocol period. Each year, survey routes must be surveyed a minimum of 3 times, with no less than 15 days between surveys. One survey must be conducted between February 15 and April 15. These time frames are necessary to account for variations in annual weather patterns and the responsiveness of individual pygmy-owls. Surveys should not be conducted if wind or other weather factors reduce detectability of calls.
4. Call points along the survey transect must be spaced at no more than 480 meters (0.3 miles), unless a bionic ear or other listening-enhancement device is used, in which case distance between call points may be extended to 800 meters (0.5 mile). Call points in riparian areas must be no more than 150 m apart due to tree density and noise. Distance between survey transects should be no more than twice the distance between call points.
5. Conduct a one minute listening period at each call point prior to broadcasting any calls. This will allow the surveyor to detect any spontaneous calling and also to become familiar with features at the call point such as large trees or saguaros, residences, water sources, etc., that may affect pygmy-owl presence or observation.
6. Following the initial listening period, broadcast calls for 30 seconds and follow this with a 90 second listening and observation period. Broadcast the call in all directions. Set the volume at an adequate level to get complete coverage along a survey route without causing distortion of the call. Equipment must be able to produce a minimum of 100 dB at 1 m from the speaker without distortion.

7. Repeat the calling/listening sequence for at least 6 minutes. Extend this sequence if disturbances such as animals, air traffic, or other noises disrupt your ability to hear responses.
8. Observe and listen for an additional 2-3 minutes before proceeding to the next call point.
9. If a cactus ferruginous pygmy-owl is heard or seen:

   a) End broadcast unless additional responses are needed to pinpoint the location.
   b) Observe the pygmy-owl as long as possible without disturbing it (i.e. do not chase the bird or harass it with calls). Record all observations, use of cavities and prey are especially important. Listen for female or fledgling vocalizations or other evidence that there may be other pygmy-owls in the area.
   c) Flag the location of the bird, or your best estimate of where the bird was, with surveyors tape and record the location on a map (tape will be removed when follow-up visits are completed).
   d) Record the date, time, type and duration of response (aural or visual), habitat characteristics of the site and detailed directions to the site.

10. Complete the attached survey data forms for each route each time it is surveyed. Be sure to record survey date, time, weather conditions, moon phase, and responses of other birds. If a cactus ferruginous pygmy-owl is located, please also fill out a detection form.
11. If an owl is located, fax a copy of your detection form and map to AGFD and USFWS within 24 hours of detection. No later than 10 days after completion of the 3d survey, return all survey forms and detection forms to AGFD and USFWS:

    Arizona Game and Fish Department
    Nongame Branch
    2221 West Greenway Road
    Phoenix, Arizona 85023-4399
    (602) 789-3500 Fax (602) 789-3926

    United States Fish and Wildlife Service
    Arizona Ecological Services Field Office
    2321 W. Royal Palm Road, Suite 103
    Phoenix, Arizona 85021-4951
    (602) 640-2720 Fax (602) 640-2730

It is important that we receive all completed data forms, whether a pygmy-owl is detected or not. AGFD and USFWS will respect the rights of private property owners throughout implementation of this protocol.

3-1-4 Summary of changes from 1993 cactus ferruginous pygmy-owl survey protocol.

1993 Protocol	Proposed protocol	Reasons for proposed changes
Call point intervals of 100-150 yards.	Call point intervals for clearance protocol 150-400 meters. Call point interval for large area search protocol 480-800 meters.	Closer call points to increase chance of detection in areas with noise disturbance. Greater call point intervals to cover larger areas in a timely fashion. Distances based on surveyor's ability to detect a pygmy-owl, not on a pygmy-owl's ability to hear call.
Calling and listening period of 6-8 minutes at each calling point.	Calling and listening period 11-12 minutes at each call point.	Field observations on this and other owls indicate longer calling and listening periods can increase detections.
Survey period September to April.	Survey period January through June, with peak from February through April.	Seasonal monitoring and survey efforts show regular, consistent calling during this time period. Fall calling is inconsistent and generally not in response to survey tapes.
Survey frequency is one survey, one year.	Survey frequency is three surveys separated by at least 15 days with one survey between February 15 and April 15.	Field observation of seasonal and individual variation in responsiveness.
No requirement for resurvey if certain time period lapses.	Acreage to be disturbed must be surveyed within the same calendar year as the disturbance; surveys must be conducted in suitable habitat within 1500 ft of the site being disturbed.	Our data indicate increased use area post-dispersal, and dispersing juveniles, as well as adults, can cause an area to be occupied one year that wasn't the previous year.

Appendix 3-2: Cactus ferruginous pygmy-owl habitat assessment protocol (key and data collection forms) used by the Bureau of Land Management in desertscrub. A similar protocol is used by the Coronado National Forest. The habitat photo guide is not included. Text in italics is added for clarity.

3-2-1 Key

VEGETATION CHARACTERISTICS

1) Is non-native woody vegetation present within the ¼ section? **Y** (yes) or **N** (no).

2) Are saguaros or trees >6" dbh with cavities present within the ¼ section? Enter the score based upon total estimated number of suitable nesting trees **PER ACRE** within the ¼ section:

Score	# per acre
0	0 (Not suitable)
1	1-5 (Poor)
2	6+ (Moderate to Good)

3) Is there a moderate to high level of woody or perennial vegetation <18" tall present within the ¼ section? (see PHOTO GUIDE for reference only)

Score
0 (No)
1 (Yes)

4) Estimate the total number of woody **SPECIES** 18" - 6' tall within the ¼ section (diversity index) (See back of data collection form—*list of vegetative species below*)

Score	# spp. w/i ¼ section
0	<5 spp.
1	5-10 spp.
2	11-15 spp.
3	>15 spp.

5) Estimate the total number of canopy **SPECIES** >6' tall within the ¼ section (see back of data collection form) **Note: do not include saguaros:**

Score	# species w/i ¼ section
0	0 (no species)
1	1-4 spp.
2	>4 spp.

6) Does the vegetation structure appear to be **relatively equally distributed** between the understory (<18"), shrub (18"-6'), and canopy (>6')layers? (i.e., is there a significant proportion of vegetative biomass in each of these 3 categories, and how are they distributed relative to each other?):

Score	Description
1	Midstory shrubs are present in low density, with understory **and** canopy layers lacking in proportion to the others
2	Midstory shrub layer well developed but lacking in **either** an overstory or understory components in proportion to the others
3	All three layers well represented

7) Utilizing the **HABITAT PHOTO GUIDE**, identify the photo set that best represents the appearance of the vegetated landscape in the ¼ section.

Score	Vegetative Density
1	Low vegetative density
3	Moderate vegetative density
5	High vegetative density

These first 7 habitat questions have been identified as the most critical factors for CFPO occupancy. Therefore, the RAW SCORES of these 7 habitat components on the data form will be totalled and then multiplied by two to achieve the FACTORED SCORE. A factored score of 15+ indicates that these habitats have some characteristics of potential CFPO habitat that MAY warrant further investigation, while a habitat score below 15 indicates low quality habitat which exhibits few characteristics of potential CFPO habitat.

OTHER HABITAT FEATURES

8) Is there any development or surface disturbance (not including livestock grazing) present within the ¼ section? (Y/N)

9) Roads within and bordering the ¼ section are:

Score	Type of Road
0	Paved
1	Graded and improved
2	No roads or dirt two-track

10) If development is present within the ¼ section, which of the following categories best describes the dominant type of land use?

Score	Description
0	Commercial/Industrial and/or >1 residence per acre
1	One residence per acre
2	One residence per 3 or more acres and/or undisturbed or essentially undisturbed open space

11) Estimate the total % of the ¼ section that is developed, altered, or has some degree of ground disturbance.

Score	% "disturbed"
0	>50% disturbed
1	25-50% disturbance
2	0-25% disturbance

12) Is there a source of free-standing perennial water present and available?

Score
0 Not present
1 Present and available

3-2-2 Data collection form

Personnel: ____________________ Survey Dates: ____________

____

Quad Name (7.5 min): ____________________ ____________

____

Legal Description: T ____ R _____ Section _____ UTM ____________

Allotment Name: ________________________________

FOR EACH ¼ SECTION, PLEASE ANSWER THE FOLLOWING USING THE HABITAT ASSESSMENT FORM KEY PROVIDED:

VEGETATION CHARACTERISTICS	**NE/4**	**NW/4**	**SE/4**	**SW/4**
1) Non-native woody vegetation?(Y/N)				
2) Suitable nesting structure				
3) Vegetation <18" present				
4) # woody species present				
5) # canopy spp. >6' tall				
6) Vegetative structure/distribution				
7) Photo guide score				
TOTALS (raw score/factored score)	/	/	/	/

HABITAT FRAGMENTATION/WATER	**NE/4**	**NW/4**	**SE/4**	**SW/4**
8) Development? (Y/N) (see below)				
9) Presence of roads				
10) Dominant type of land use				
11) % of ¼ section developed				
12) Presence of water				
TOTALS				

GRAND TOTALS				

8) If development is present w/i this ¼ section, describe: ________________________________

____

13) Describe any impacts that livestock grazing may have within this section: ____________

____

CHECK (√) IF VEGETATIVE SPECIES IS PRESENT ON ¼ SECTION

SHRUB SPECIES PRESENT (<6')	**NE/4**	**NW/4**	**SE/4**	**SW/4**
Agave (*Agave* spp.)				
Barrel cactus (*Ferocactus*)				
Brittle bush (*Encelia farinosa*)				
Buckwheat (*Eriogonum* spp.)				
Burro bush/Cheeseweed (*Hymenoclea* spp.)				
Canyon ragweed (*Ambrosia*)				
Catclaw acacia (*Acacia greggii*)				
Cholla (*Opuntia* spp.)				
Chuparosa (*Anisacanthus thurberi*)				
Creosote (*Larrea tridentata*)				
Desert broom (*Baccharis sarothroides*)				
Desert lavendar (*Hyptis emoryii*)				
Greythorn (*Condalia* spp.)				
Hackberry (*Celtis reticulata*)				
Hopbush (*Dodonaea viscosa*)				
Jojoba (*Simmondsia chinensis*)				
Jumping bean (*Sapium biuncifera*)				
Mesquite (*Prosopis* spp.)				
Mormon tea (*Ephedra* spp.)				
Ocotillo (*Fouquieria splendens*)				
Palo verde (*Cercidium* spp.)				
Prickly pear (*Opuntia* spp.)				
Range ratany (*Krameria* spp.)				
Saguaro (*Carnegiea gigantea*)				
Saltbush (*Atriplex* spp.)				
Triangle-leaf bursage (*A.tridentata*)				
White bursage (*Ambrosia dumosa*)				
Whitethorn acacia (*Acacia constricta*)				
Wolfberry (*Lycium* spp.)				
Yucca (*Yucca* spp.)				

CANOPY SPECIES PRESENT (>6')	**NE/4**	**NW/4**	**SE/4**	**SW/4**
Catclaw acacia (*Acacia greggii*)				
Cholla (*Opuntia* spp.)				
Creosote (*Larrea tridentata*)				
Cruxifixion thorn (*Canotia holocantha*)				
Desert willow (*Chilopsis linearis*)				
Graythorn (*Condalia* spp.)				
Hackberry (*Celtis* spp.)				
Ironwood (*Olneya tesota*)				
Mesquite (*Prosopis* spp.)				
Ocotillo (*Fouquieria splendens*)				
Palo verde (*Cercidium* spp.)				
Saguaro (*Carnegiea gigantea*)				
Salt cedar (*Tamarix* spp.)				
Whitethorn acacia (*Acacia constricta*)				

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Chapter 4:

The Ferruginous Pygmy-Owl in the Tropics and at the Northern End of its Range: Habitat Relations and Requirements

The habitat needs of the ferruginous pygmy-owl (*Glaucidium brasilianum*) are poorly understood. In the tropics, this common bird of prey inhabits many distinct vegetation communities or environments (e.g., Monroe 1968, Meyer de Schauensee 1970, Stiles and Skutch 1989, Sick 1993). A resident of woodlands and open forests, it is also found in the open, perched on telephone lines or fence posts (Ridgely 1976). At the northern edge of its range, the ferruginous pygmy-owl has been recorded in riparian woodlands and thickets (Bendire 1888, Breninger 1898, Oberholser 1974), live oak (*Quercus virginiana*)-mesquite (*Prosopis glandulosa*) forest (Wauer et al. 1993, Mays 1996, Proudfoot 1996), and Sonoran desertscrub (Monson and Phillips 1981, Millsap and Johnson 1988, Abbate et al. 1996). In this chapter, we describe some of the vegetation types associated with the ferruginous pygmy-owl, with an emphasis on those found to support the highest densities of the owl. We then explore key pygmy-owl habitat components suggested by descriptions of those plant communities.

1. Habitat associations and patterns of abundance

South America

Throughout the tropics, the ferruginous pygmy-owl occupies only lowlands (Meyer de Schauensee 1970, Davis 1972, Meyer de Schauensee and Phelps 1978, Hilty and Brown 1986). At higher elevations, it is replaced by congeneric species, such as least pygmy-owls (*G. minutissimum* complex), the northern pygmy-owl (*G. gnoma*), and the Andean pygmy-owl (*G. jardinii*). In South America, the ferruginous pygmy-owl occurs in a broad range of vegetation types (Table 4-1). As listed by Stotz et al. (1996: 170), vegetation types with the highest densities of pygmy-owls are arid and second-growth scrub. The ferruginous pygmy-owl is less common in forested areas, and in these areas chiefly occupies open deciduous forest, second growth, and edges (Hilty and Brown 1986, Stotz et al. 1996). Two representative examples of areas with high pygmy-owl population densities are the central llanos of Venezuela and the xeric coastal lowlands of western Ecuador.

Although they are found throughout much of Venezuela, ferruginous pygmy-owls are especially abundant in the central *llanos* (Fig. 4-1), an ecotonal area between the tropical deciduous forests to the north and the vast open savannas to the south (Troth 1979). This region consists of a mosaic of open marshes, wet meadows, and closed-canopy, partially deciduous forests along major watercourses. Much of the area is covered by an open woodland of scattered large trees, primarily of the genera *Enterolobium* and *Pithecellobium,* with a dense understory of mostly spiny shrubs including *Acacia*, *Anona*, *Mimosa*, *Randia*, and

Table 4-1. Habitat types occupied by the ferruginous pygmy-owl in some parts of its geographic range.

Geographic region	Types of habitat occupied	References
South America	"forest, scrub, arid woodland"..."towns, cerrado"	Meyer de Schauensee 1970
Brazil	"forest edges, cerrado, tree plantings"	Sick 1993
Columbia	"from dry forest and scrubby semiopen areas with trees and thickets to humid *terra firme* and *várzea* forest borders"	Hilty and Brown 1986
Panama	"scrubby and light woodland" and "open areas with scattered thickets and trees in lowlands"	Ridgely 1976
Costa Rica	"deciduous and evergreen woodland, savanna trees, semi-open, second growth, coffee plantations, suburban areas with large trees for nesting"	Stiles and Skutch 1989
Honduras	"arid woodlands," "arid interior highlands," and semiopen habitats	Monroe 1968
Mexico and northern Central America	"semiopen areas with hedges and scattered forest patches, open forest and edge, semiopen thorn forest, plantations..."	Howell and Webb 1995
Mexico	"mesquite thickets, river woods, scrubby second growth, forest edges"	Peterson and Chalif 1973

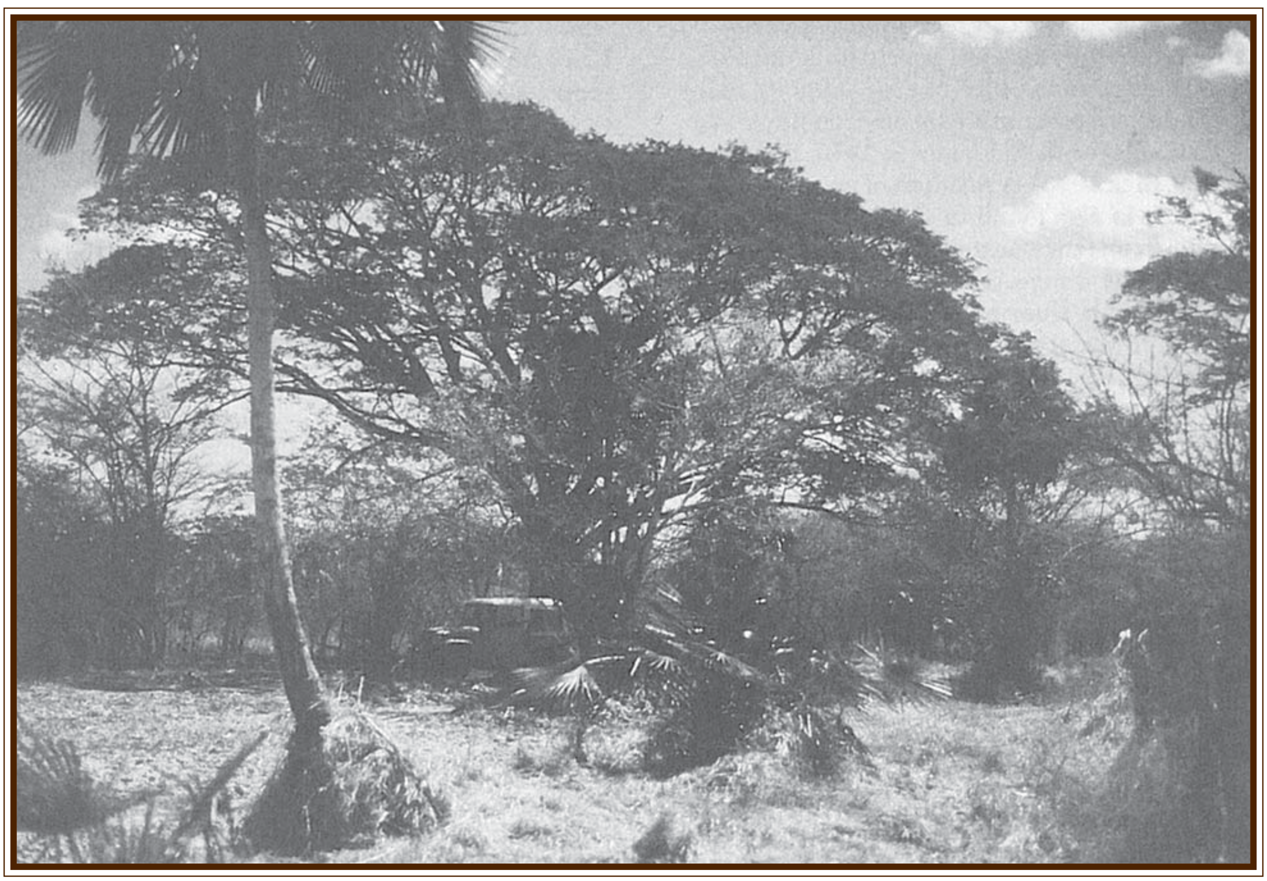

Figure 4-1. Vegetation type in Venezuela associated with high densities of ferruginous pygmy-owls. Note the open canopy and spiny thickets. Photograph by Scott Stoleson.

Zanthoxylum. These woodlands support dense populations of pygmy-owls nesting in cavities of the *Enterolobium* and *Pithecellobium* trees. Owls are also found, at lower densities, in more open areas that form seasonal marshes with emergent spiny-leafed palms (*Copernicia*), shrubby cactus (*Pereskia*) and spiny shrubs (*Anona*, *Randia*). Permanent water sources and major rivers are lined with closed-canopy forest, which tends to have a poorly-developed understory and very few pygmy-owls (Thomas 1979).

In western Ecuador, the local pygmy-owl, generally considered a morph of the ferruginous pygmy-owl (e.g., Meyer de Schauensee and Phelps 1978, but see König [1991] who treats it as a distinct species *G. peruanum*), is found most frequently in xeric coastal lowlands in riparian and arid thickets (Stotz et al. 1996). Riparian thickets in Ecuador are composed of dense stands of *Baccharis, Salix,* and *Tessaria* adjacent to watercourses. Arid thickets are dominated by spiny shrubs (*Acacia, Capparis*, *Cercidium*, *Parkinsonia, Prosopis*) and columnar cacti (*Armatocereus*, *Neoraimondea*) (Stotz et al. 1996). In both general aspect and genus-level floristics, these two habitats are very similar to riparian and xeroriparian areas historically or currently associated with ferruginous pygmy-owls in Arizona. Elsewhere in Ecuador, the pygmy-owl is chiefly associated with forest edges and shrubby second growth, but as these habitats are increasing with deforestation, the owl may be expanding its range within the country.

Western Mexico

In Sonora, the ferruginous pygmy-owl (subspecies *cactorum*) occurs in at least 50 localities, from the extreme southeastern border with Sinaloa northwest to the vicinity of Sonoita close to Organ Pipe Cactus National Monument in Arizona. The owl's altitudinal range is from near sea level to about 1,200 m; it has not been found in the extreme northeastern portion of Sonora, a region mostly above 1,200 m; nor has it been found in northwestern coastal areas or in the Gran Desierto west of Sonoita.

The ferruginous pygmy-owl is common locally in southern Sonora. Most of the records are from the tropical deciduous forest and its edges. The tropical deciduous forest extends from Costa Rica northward into Sonora in a narrow corridor predominantly at low elevations on the Pacific slope. In Sonora, this forest is characterized by deciduous trees that begin to lose their leaves in October following the summer rains. Until June of each year, the vegetation is leafless and temperatures are high. Characteristic plants include hecho (*Pachycereus pecten-aboriginum*), *Lysiloma* spp., *Pithecellobium* spp., *Tabebuia* spp., *Randia echinocarpa*, and guácima (*Guazuma ulmifolia*). Of 351 bird species recorded in the Alamos area, only 43 species have been found in more localities than the ferruginous pygmy-owl (Russell in press).

At the southwestern edge of the deciduous forest, pygmy-owls occupy tropical thornscrub, but more sparsely. At higher elevations (1,000 m to 1,200 m), where oaks may coexist with tropical deciduous forest plants, they reach their upper limits in Sonora. Cactus ferruginous pygmy-owls may also be found in riparian areas of tropical deciduous forest and in tall second growth. They are uncommon and local in desertscrub, which dominates the western half of Sonora, and in this vegetation type often occur many kilometers from water sources. Typical vegetation where the owl has been found in desertscrub includes columnar cacti, palo verde (*Cercidium*), and ironwood (*Olneya*). It is through this plant community that the ferruginous pygmy-owl ranges into Arizona.

Outside the tropical deciduous forest, the association between the ferruginous pygmy-owl and lowland riparian habitats in Sonora is somewhat uncertain. In the northern part of the state, much of the riparian habitat has disappeared but there is no historical evidence that it supported a large number of pygmy-owls. Stephens (1885) collected one owl from an organ pipe cactus near Caborca and another, presumably in desertscrub, 20 miles south of Caborca. He referred to the riparian community near Caborca as "timber," and so implied a community that no longer exists, but he did not mention *Glaucidium* in this area. Neff (1947) spent time in June and July of 1942 in the Altar-Caborca region. Although he described a "wilderness forest of giant mesquite", he did not mention the ferruginous pygmy-owl in his list of notable species seen. Throughout the rest of Sonora and at low elevations, riparian communities do not appear to support higher densities of ferruginous pygmy-owls than other vegetation types.

In Colima and Jalisco, the ferruginous pygmy-owl (subspecies *cactorum*) is described by Schaldach (1963) as abundant in low elevation thornscrub and thorn forest. Schaldach (1963) also mentions that it does not occur in the tropical deciduous forest of the region and is replaced at higher elevations by the northern pygmy-owl.

In Oaxaca, the ferruginous pygmy-owl (subspecies *ridgwayi*) is common in openings in tropical evergreen and tropical deciduous forests (Binford 1989). It is fairly common in arid tropical scrub and tropical semideciduous forests.

Texas

In southern Texas, ferruginous pygmy-owls (treated as subspecies *cactorum*, see Chapter 1) were once common along the lower Rio Grande in Tamaulipan thornscrub community with Texas ebony (*Pithecellobium ebano*), honey mesquite, and hackberry

(*Celtis* spp.) (Oberholser 1974, U.S. Fish and Wildlife 1994). However, urban and agricultural expansion from 1920 to 1970 resulted in the loss of more than 90% of this vegetation type (Oberholser 1974) and only small, possibly disjunct, populations may now exist. The largest known population is in the coastal sand plain of the historical Wild Horse Desert about 80 km south of Kingsville, with eolian sand as geologic substrate (Diamond and Fulbright 1990). The climate is "subhumid to semiarid east-coast subtropical," with rainfall peaking in May, June, September, and October and overall high humidity (Fulbright et al. 1990). The human history of the region included the establishment of large ranches under private ownership.

The coastal sand plain supports a mosaic of vegetation communities including dune fields and a prairie dotted with live oak woodlands and groves of honey mesquite trees (Fulbright et al. 1990). In Kenedy County, the once distinct live oak woodlands have merged with mesquite to form a nearly continuous patch of mixed live oak and honey mesquite forest (Wauer et al. 1993, Fig. 4-2). Within the forest boundaries, the vegetation is heterogeneous and varies from live oak with minimal ground cover to mixed live oak-honey mesquite woodland and mesquite savanna. An understory vegetation that includes thorny woody shrubs such as desert hackberry (*Celtis pallida*), catclaw acacia (*Acacia greggii*), and lime prickly-ash (*Zanthoxylum fagara*), occurs chiefly in association with mesquites (Archer 1989, 1990) and, in some areas, forms "nearly impenetrable thickets" (Wauer et al. 1993).

Wauer et al. (1993) and Mays (1996) recorded the highest numbers of ferruginous pygmy-owls in the mixed live oak-mesquite woodlands in Kenedy County. The owl also occurs, but at lower densities, in monotypic live oak forest and in the mesquite savanna. No pygmy-owl was detected on the prairie or in the pastures outside the forest (Wauer et al. 1993). Outside the continuous live oak-mesquite forest, the ferruginous pygmy-owl was recorded either in contiguous patches of forest or in mesquite bosque associated with large trees (Mays 1996).

Figure 4-2. Live oak (*Quercus virginiana*)-honey mesquite (*Prosopis glandulosa*) habitat in southeast Texas. Note the high density of understory plants and the semi-open canopy. Photograph by Jean-Luc Cartron.

Arizona

The ferruginous pygmy-owl (subspecies *cactorum*) ranges into south and central Arizona at elevations up to 1,200 m. Below 1,000 m, the dominant vegetational zone is lower Sonoran, with large cacti, velvet mesquite (*Prosopis velutina*), palo verde, and creosote bush (*Larrea tridentata*). Along rivers and creeks, floodplain riparian corridors typically consisted of cottonwood (*Populus fremontii*)-Goodding willow (*Salix gooddingii*) forests intermixed with mesquite bosques. Nearer the owl's upper elevational boundary, dominant or common riparian tree species also included walnut (*Juglans major*), sycamore (*Platanus wrightii*), and ash (*Fraxinus velutina*). Since the late 18th century, most of the original riparian vegetation has been cleared or altered by human activities (Chapter 2). At some locations, however, current vegetation structure and composition likely represent past conditions (Chapter 3).

Historical accounts suggest that the cactus ferruginous pygmy-owl was originally fairly common or common in riparian woodlands and thickets in Arizona (Bendire 1888, Fisher 1893:199, Breninger 1898, Swarth 1914:31). At present, however, this bird seems chiefly associated with Sonoran desertscrub, where it often gravitates along washes lined with dense xeroriparian vegetation composed of mesquite, palo verde, desert ironwood (*Olneya tesota*), desert hackberry, and catclaw acacia (Fig. 4-3) (Millsap and Johnson 1988, Lesh and Corman 1995). In the Altar Valley, pygmy-owls have been located in xeroriparian vegetation along washes within low-density desertscrub or mesquite grasslands (Chapter 3). In the Tucson area, which supports many of the known owls (Felley and Corman 1993, Lesh and Corman 1995), documented habitat occupancy is higher in low-density (one house per 3.3 acres or more) residential areas. While the vegetation near residences remains dominated by the native saguaro (*Carnegiea gigantea*), foothill palo verde (*Cercidium microphyllum*), ironwood, and velvet mesquite, it is often denser and more complex than on adjacent, undisturbed patches of Sonoran desertscrub due to supplemental irrigation.

Figure 4-3. Cactus ferruginous pygmy-owl habitat in Arizona: xeroriparian vegetation along a wash. On the upland, saguaros provide cavities for nesting. Photograph by Jean-Luc Cartron.

Non-native plants, such as California pepper trees, Allepo pines, citrus, eucalyptus, and mulberry trees also enhance vegetation density and diversity. Under bushes or trees, drip irrigation may create small pools of water which are used by local wildlife. The presence of some sort of free-standing water was recorded at or near all known nest sites in residential areas (Abbate et al. 1996, Richardson unpubl. data).

Recent survey efforts have resulted in an increased number of owl detection in areas with little or no residential development. Statewide, there are now more known nests in non-residential areas than in residential areas (Richardson unpubl. data). However, the vegetation of these non-residential areas (i.e., well-structured upland desertscrub and xeroriparian vegetation) resembles in structure the vegetation of low-density residential areas. The influence of residential development on the quality of cactus ferruginous pygmy-owl habitat may only be determined through additional surveys and research.

2. Habitat preferences and requirements

Because fitness is a more accurate indicator of habitat quality than population density, one must exercise caution when examining patterns of owl population density. Higher population density in an area may indicate habitat preferences and requirements, but the relationship between habitat suitability and population density can be affected by habitat connectivity at a geographic scale, site fidelity regardless of quality, and the exclusion of a large proportion of the population from high-quality sites by a few dominant individuals (Willis 1974, Lidicker 1975, Wiens and Rotenberry 1981, 1985).

Foraging, protection, and the importance of the understory

Although different observers may characterize vegetation differently or determine vegetation types at different scales, habitat descriptions above (see also Table 4-1 for more descriptions of ferruginous pygmy-owl habitat in the tropics) are typically congruent. Habitat descriptions in the tropics and in Texas suggest the importance of thickets and woodlands with a dense understory that often consists of spiny shrubs. This pattern is consistent with Proudfoot's (1996) habitat use versus availability study: ferruginous pygmy-owls nested disproportionately in areas with moderate to dense understory. Although more work is needed to better understand the significance of the association, a dense understory may benefit the ferruginous pygmy-owl by providing a shelter from climatic stresses and potential predators for the juveniles (Abbate et al. 1996, Proudfoot 1996). Greater habitat complexity may also result in more foraging opportunities for the ferruginous pygmy-owl. Where vegetation diversity and structure are reduced, the presence of water may increase habitat quality by attracting more prey to the area. In 1997, an owl pair in Texas nested on the edge of a pasture near a water tank that attracted wildlife, including song birds (Proudfoot unpubl. data). In the Tucson area, drip irrigation or water dishes close to monitored nests attracted a variety of potential prey (Abbate et al. 1996, Richardson unpubl. data).

Cavity nesting and the importance of trees or saguaros

Because the ferruginous pygmy-owl is an obligate cavity nester, it requires trees or cacti large enough to contain a cavity, as well as cavity excavators. Thus, nest location may strongly reflect nest cavity availability. Historical records suggest that in riparian areas, mesquite, a hard wood less readily excavated by Gila woodpeckers and northern flickers, was less frequently used than softwood trees (Hunter 1988). With the loss and alteration of riparian areas in Arizona, saguaros may now provide the most available source of cavities for nesting; most recent nest sites have, in fact, been located in saguaro cavities (Abbate et al. 1996, Richardson unpubl. data). However, two nests monitored in 1999 were located in a eucalyptus and an Arizona ash (Richardson unpubl. data). The eucalyptus was an integral component of an exotic landscape, but the ash was in an ephemeral wash surrounded by uplands of mesquite/grassland vegetation with no available saguaros. The only cavities in the area were in the large trees along the wash. Within certain portions of the cactus ferruginous pygmy-owl's range in Arizona, riparian and xeroriparian vegetation communities may still contain the only available pygmy-owl nest sites.

The density of trees and amount of canopy cover preferred by ferruginous pygmy-owls remains unclear. Most of the above habitat descriptions suggest that the highest owl densities are found in semi-open or open woodlands, often in proximity to forests or patches of forest. Where the owl occurs in forested areas, it is more readily observed along the edge or in openings rather than deep in the forest itself (Binford 1989, Sick 1993). Hence, at a landscape level, this bird may prefer semi-open, transitional zones between dense stands of trees and open savannas or scrublands, and semi-open habitats dotted with thickets. Additional research is needed to examine this association.

4. The importance of riparian and desertscrub habitats in Arizona

Assessing the importance of riparian areas and desertscrub for maintaining or recovering the ferruginous pygmy-owl in Arizona is essential. As indicated, the ferruginous pygmy-owl is not consistently dependent on riverine ecosystems throughout its range. In fact, where the riparian vegetation forms a closed-canopy gallery forest, owl density may be low. In Sonora, Mexico, where riparian areas closely resemble those of Arizona, the association between riparian plant communities and the owl appears weak. One potential explanation is that in Sonora, as in other parts of the pygmy-owl's range, a significant portion of the land outside of floodplains is wooded, presenting the owl with a larger choice of suitable habitats. In the southwestern United States, however, riparian floodplains support most of the low-elevation woodland vegetation. These areas attract a disproportionate amount of wildlife (Carothers and Johnson 1975, Hubbard 1977, Pase and Layser 1977). Migrating passerines, for instance, exhibit a strong preference for riparian corridors over the adjacent uplands (Stevens et al. 1977).

In general, early accounts of the original riparian vegetation and descriptions of Blue Point Cottonwoods (Chapter 2) are congruent with descriptions of habitats where ferruginous pygmy-owls are most commonly found. Riparian areas where the owl was detected often included thickets (e.g., Bendire 1888), while cottonwoods and resident woodpeckers must have provided many cavities for nesting (see Breninger 1898, Gilman 1909). Riparian areas are linear and thus tend to have a high proportion of edge. Unless they have been completely invaded by tamarisk, these areas support a higher density of breeding birds than any other low to mid elevation vegetation community in the Southwest (Carothers et al. 1974, Johnson et al. 1977, Franzreb 1987). Riparian areas of the Southwest generally support a higher average number of reptile and amphibian species than nonriparian areas (Brode and Bury 1984, Jones 1988). They may also support higher diversity and densities of mammalian species than adjacent uplands (Stamp and Ohmart 1979, Frey and Yates 1996). Such an abundance and diversity of prey may be essential for a perch-and-wait predator like the ferruginous pygmy-owl. The continuous corridors of floodplain riparian vegetation once covering hundreds of miles in the Southwest may have supported the sizable pygmy-owl population suggested by Bendire (1888) and Breninger (1898)'s accounts. The very low number of owls found in riparian vegetation in recent years may reflect loss of habitat connectivity rather than lack of suitability.

Although the majority of recent cactus ferruginous pygmy-owl detections in Arizona have occurred in desertscrub, the literature suggests that this vegetation type has always been associated with low densities of this bird, even when it was considered common in riparian areas (Breninger 1898, Kimball 1921). In large, fairly pristine, desertscrub areas (e.g., Organ Pipe Cactus National Monument), records of the owl's occurrence are infrequent (Groschupf et al. 1988). In Sonora, Mexico, limited evidence indicates that cactus ferruginous pygmy-owls are uncommon in this vegetation type (Russell and Monson 1998). One possible explanation for the seemingly rare occurrence of the owl in desertscrub is that this habitat is of marginal quality (Johnson and Haight 1985, Taylor 1986). Alternatively, the low number of historical records in desertscrub may chiefly reflect the lack of early studies in desert areas. As mentioned, xeroriparian vegetation in Arizona resembles arid thickets in Ecuador where ferruginous pygmy-owls are common, and the tall columnar saguaros of the Sonoran Desert provide cactus ferruginous pygmy-owls with nesting cavities (Abbate et al. 1996).

Desertscrub may also play an important role at another level. Habitat connectivity is greater for desertscrub than for riparian vegetation. As stated, this habitat type represents the substrate through which the owl ranges from Sonora into Arizona, perhaps at times allowing the Arizona population to be replenished. Dispersing juvenile pygmy-owls traveled more than 15 miles through desertscrub of varying quality during radio tracking in 1998 (Richardson unpubl. data). Research is needed in Arizona to better understand the size and distribution of the remaining owl population and to further explore the relative importance of desertscrub and riparian areas.

Recently, cactus ferruginous pygmy-owls have been found in areas (i.e., desert grassland communities) of Arizona where the potential to detect them was perhaps initially considered to be low (see Chapter 3). These detections were chiefly the result of an increased survey effort. They indicate that intensified survey efforts in "marginal" habitats can result in increased owl detections and change our perception of the relative importance of vegetation communities utilized by pygmy-owls. For example, the recent identified nesting of cactus ferruginous pygmy-owls in xeroriparian vegetation along washes within mesquite grasslands raises questions regarding the value of these types of areas and their contribution toward the persistence of the owl in Arizona. As with nearly all aspects of the owl's ecology, more information is needed before we have a complete understanding of cactus ferruginous pygmy-owl habitat preferences.

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Chapter 5:

Research on the Ferruginous Pygmy-Owl in Southern Texas: Methodology and Applications

Using broadcasted conspecific calls, nest boxes, miniature-video cameras, a fiberoptic stratascope, and radio-telemetry, researchers from Caesar Kleberg Wildlife Research Institute conducted studies to assess the viability and profile the natural history of ferruginous pygmy-owls in Texas (Mays 1996, Proudfoot 1996a, Proudfoot and Beasom 1996, Proudfoot and Beasom 1997, Proudfoot and Radomski 1997). Techniques used were specifically designed or adapted to address the concerns of this species (e.g., minimizing risks of nest abandonment resulting from nest inspection). In this chapter, we summarize research methods used to study ferruginous pygmy-owls in Texas and provide current information regarding its status there.

1. Status of ferruginous pygmy-owls in Texas

Prior to 1920, the ferruginous pygmy-owl was considered a common resident of riparian areas in the lower Rio Grande Valley of Texas (Figs. 5-1 and 5-2) (Oberholser 1974). However, by the early 1970s, over 90% of this habitat was cleared for urban and agricultural expansion, reducing the size of the ferruginous pygmy-owl population (Oberholser 1974). During the Texas Breeding Bird Atlas Project, 1987-1992, two confirmed nest sites were recorded below Falcon Dam in Starr County, Texas, and six probable sites were recorded between the Rio Grande River and the 27^{th} parallel (Proudfoot in press). Wauer et al. (1993) expressed concern that repeated disturbance by bird-watchers (e.g., broadcast of conspecific calls during the breeding season) may negatively affect the Falcon Dam population. In 1993, no ferruginous pygmy-owls were detected from broadcast surveys conducted along the Lower Rio Grande River and, although the absence of detection may have been influenced by bird-watchers, Tewes (1993) concluded that the cause is more likely a lack of suitable habitat. Although this information suggests ferruginous pygmy-owls are rare in Texas, recent studies have located and monitored 99 ferruginous pygmy-owl nests in Kenedy County from January 1994-June 1999 (Proudfoot unpubl. data). In addition, Mays (1996) estimated from 745 to 1,823 individuals may occur in Kenedy County, Texas and Wauer et al. (1993) estimated 1,308 ferruginous pygmy-owls may occur in the live oak (*Quercus virginiana*)-mesquite (*Prosopis glandulosa*) habitat in Brooks, Kenedy, and Willacy counties, Texas (Fig. 5-2). Hence, although the ferruginous pygmy-owl is listed as endangered in Arizona (U.S. Fish and Wildlife 1997) and was proposed for listing as threatened in Texas (U.S. Fish and Wildlife 1994), a viable population may still exist in Texas. In Texas, the ferruginous pygmy-owl has no protection under the Endangered Species Act (U.S. Fish and Wildlife 1997).

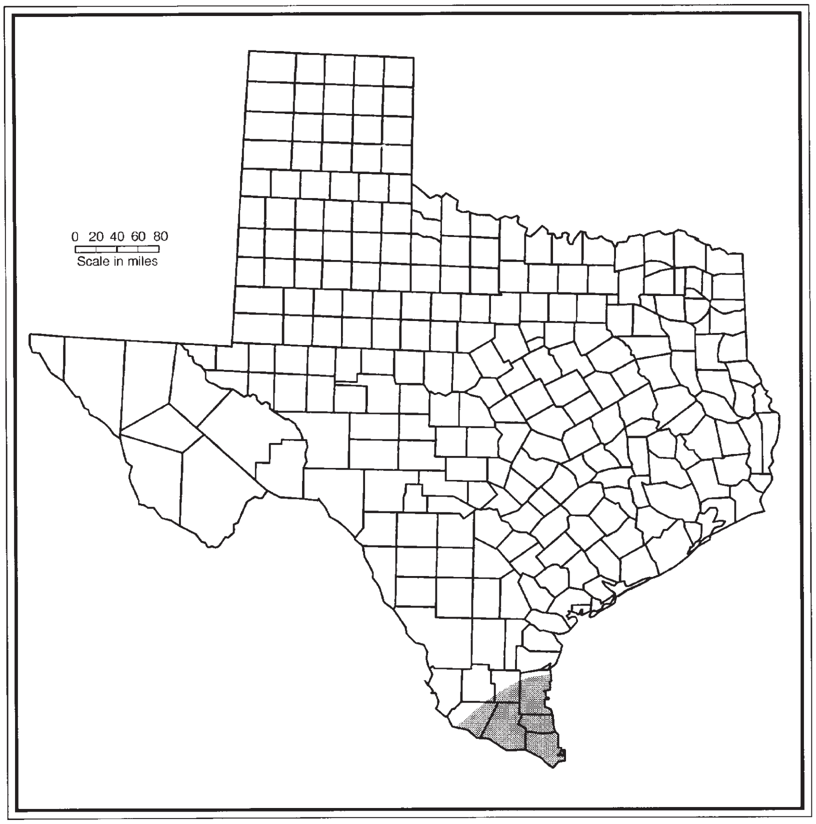

Figure 5-1. Known distribution of ferruginous pygmy-owls in Texas.

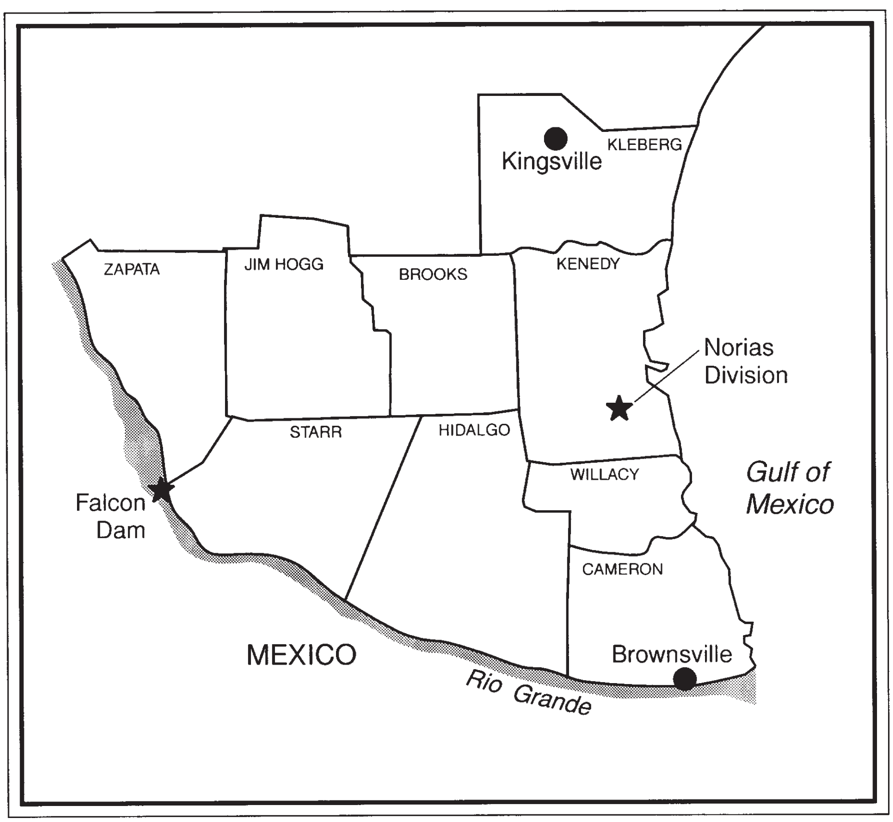

Figure 5-2. Southern tip of Texas, locations of the Norias Division and Falcon Dam.

2. Study area

The Norias Division of the King Ranch encompasses 97,877 ha of rangeland in the historical Wild Horse Desert (Fig. 5-2). The climate is subtropical with mean annual temperature of 24° C and mean annual precipitation of 68 cm. Macro-vegetation types on Norias include coastal grassland, live oak-mesquite woodland, and honey mesquite savanna. The introduction of sheep and cattle in the 18th century may have affected natural succession on Norias and contributed to an increase in the dispersal of live oak seeds, resulting in the fusion of scattered oak groves into a continuous block of live oak-mesquite forest encompassing about 30,000 ha (Johnston 1963). However, the distribution of major vegetation types on Norias has remained essentially the same for the past century (Wauer et al. 1993).

3. Materials for locating and studying ferruginous pygmy-owls

Broadcast equipment and use of parabolic microphone

Broadcasted conspecific calls are commonly used to locate and survey forest-dwelling raptors (Allaire and Landrum 1975, Johnson et al. 1981, Marion et al. 1981, Forsman 1983, Hayward and Garton 1983, Lynch and Smith 1984, McGarigal and Fraser 1985, Smith et al. 1987, Ganey 1990, Stahlecker and Rawinski 1990). To assess the effectiveness of this technique for ferruginous pygmy-owls, Proudfoot and Beasom (1996) compared elicited versus non-elicited (stop-and-listen) call-counts and recorded a >3-fold increase in detection using elicited call-counts. This study suggests the use of broadcasted conspecific calls may be a viable tool for locating and surveying ferruginous pygmy-owls in Texas. Broadcast equipment used (MS512MR Johnny Stewart Wildlife Caller, Waco, TX) for this and coexistent ferruginous pygmy-owl research (Mays 1996) is capable of producing 95-100 dB at a distance of 1 m from the speaker, which meets minimum output criteria recommended for broadcast surveys (Fuller and Mosher 1987). To maximize the effectiveness of broadcast surveys and detection of responding ferruginous pygmy-owls, recent studies (Proudfoot unpubl. data) incorporate use of a Bionic Ear (Silver Creek Industries, Manitowoc, WI) parabolic microphone. Using this system, responding ferruginous pygmy-owls were detected at distances >600 m. In addition, heretofore unreported calls of females and juveniles (e.g., alarm and distress) were recorded (Proudfoot et al. unpubl. data).

Mist nets and bow nets

Ferruginous pygmy-owls were captured using a combination of techniques, most of which are commonly used for numerous raptors (Tordoff 1954, Kenward and Marcstrom 1983, Bloom 1987). Two or three mist nets (Item No. CTX, Avinet, Inc. Dryden, NY) were placed in various configurations (e.g., V shape, triangular, or open-ended box) in proximity (e.g., <75 m) to known ferruginous pygmy-owl locations. In the center of the mist net configuration a portable tape-recorder was used to broadcast conspecific-calls. It was assumed the territorial defensive behavior of the owl would draw them into the net responding to the call. To capture responding owls that did not display enough aggressive behavior (e.g., females) to become caught in mist nets, self-triggering baited bow nets (Bird Traps, Czechoslovakia) were placed on the interior and exterior ($\leq$5 m) of the mist net configuration. Caged laboratory mice were used for bait (Proudfoot 1996a). Using these techniques, 149 adult ferruginous pygmy-owls were captured from March 1994-June 1999 (Proudfoot et al. unpubl. data).

Radiotransmitters

Radio-telemetry is considered a valuable tool for the study of elusive species (Neudorf and Pitcher 1997). From spring 1994-fall 1997, radio-transmitters were established on 28 adult and 26 juvenile ferruginous pygmy-owls. To diminish the possibility of nest abandonment, transmitters were not established on adult females prior to two-weeks posthatch. A backpack harness was used to attach the transmitters. Transmitter frequencies were from 150.00-150.40 MHz, mass was from 1.5-2.0 g, and antennae were 16 mm long. Although the use of radio-transmitters has fostered some concern (e.g., affecting behavior and foraging and reproductive success) (Ramakka 1972, Perry 1981, Kenward 1987, Massey et al. 1988, Croll et al. 1996), no difference in behavior was observed between radio-tagged and non-radio-tagged owls nor in productivity of breeding pairs (Proudfoot unpubl. data). Similar studies report comparable results (Gilmer et al. 1974, Brigham 1989, Hill and Talent 1990, Morris and Burness 1992, Neudorf and Pitcher 1997).

Nest boxes

Recent studies using artificial nest structures include economic and ethological research (Korpimaki 1985, Brawn and Balda 1988, Hayward et al. 1992). Alleviating many logistical problems (e.g., knowledge of potential nests, access to eggs, nestlings, and adults), nest boxes may aid study of nesting requirements, limiting factors, and productivity (Lack 1966, Enemar and Sjostrand 1972, Hogstad 1975, Waters et al. 1990). In addition, because artificial nest structures are mobile and associated with reduced predation (Miller 1989, Sonerud 1985, 1989), they may be established to augment recovering populations.

In October 1992, to ascertain selectivity of ferruginous pygmy-owls for specific nest-box configurations, 36 nest boxes were constructed from 14.7 x 1.9 cm rough cut cedar. Box depth varied from 31-46 cm and entrance size varied from 4.5-6.4 cm in diameter. To encourage their use, nest boxes were established in areas known to be occupied by ferruginous pygmy-owls. Four nest boxes designed for black-bellied whistling-ducks (*Dendrocygna autumnalis*) provided another variation in box depth (44 cm), floor surface area (294 cm^2), and entrance hole diameter (9.8 cm). Nest boxes were established in eight groups of five boxes, each box varying in depth and entrance size (Proudfoot 1996a).

In April 1993, three nest boxes from different groups were used by ferruginous pygmy-owls. Nest boxes used were 31, 44, and 46 cm in depth, with 4.5, 5.1, and 5.8 cm entrance diameters, respectively (Proudfoot 1996a). Expanding ferruginous pygmy-owl nest box studies to include habitat selection, nest box placement criteria, nestling development, predation, and productivity, 40 nest boxes were constructed in the mean configuration used by ferruginous pygmy-owls in 1993 and established throughout the study area (Fig. 5-3).

From 1993-1997, 15 nest boxes were used by ferruginous pygmy-owls and 21 nests were located in natural cavities. Number of young fledged/nest attempt was 3.47 and 1.96 for nest boxes and natural nest cavities, respectively. Nest depredation noticeably affected productivity of natural cavities and, at artificial nest structures, increased in association to nest box age (Proudfoot et al. unpubl. data).

Optic equipment

To minimize observer stress and disturbance to nest-cavity occupants, a miniature video-camera system was used to inspect natural and artificial nest cavities (Proudfoot 1996b). Containing a light source and powered by one 9 V DC battery, the camera system transferred a black-and-white image via video patch cable to a hand held monitor (Sony Watch-Cam, Sony Electronics, Inc., Itasca, IL). Mounted at the end of a 10 m telescoping aluminum pole, this system allowed observers to inspect nest cavities from the ground (see Proudfoot 1996b for detailed description). Although efficient, limitations of this system (i.e., 49 cm depth of field and 60° field of view) restricted use to cavities of cylindrical configuration <49 cm in depth. Therefore, in summer 1994, a flexible fiber optic stratascope (FS-490X108 Schott Fiber Optics Inc., Southbridge, MA) was used to complement the miniature video-camera system. The stratascope lens and light source are contained in a flexible stainless steel housing 1.3 cm in diameter x 246 cm in length. This system was used to inspect cavities that exceeded the limits of the aforementioned monitoring system and occasionally to qualify occupancy determinations made using the camera system.

To obtain information on ferruginous pygmy-owl food habits and nestling behavior, two miniature color video-cameras (XC-42 Computar, Chugai Boyeki Corp., New York, NY) were established in the top of occupied nest boxes to record nestling activity. The image was relayed via video patch cable to a cam-corder (Canon A1, Canon Inc., Japan) placed in proximity to the nest site. This system obtained about 105 hours of video footage and did not seem to affect nestling development, age of fledging, or productivity (Proudfoot and Beasom 1997).

In spring 1997, five miniature video-cameras equipped with infrared light-emanating diodes and time lapse recording units (Model AG-1070DC,

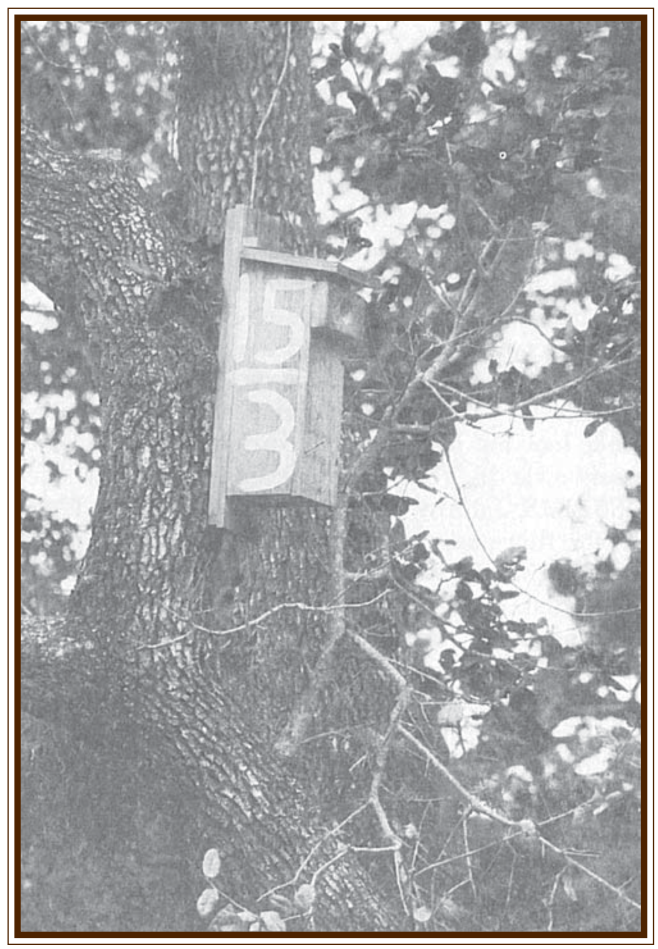

Figure 5-3. Ferruginous pygmy-owl nest box on live-oak tree in Texas. Photograph by Jean-Luc Cartron.

Panasonic Inc., Japan) were established to obtain information on ferruginous pygmy-owl nesting activity. Cameras were established ≤1.5 m from cavity entrances. Time lapse recording systems operated 24 hours/day seven days/week from incubation-fledging, obtaining >4,500 hours of information (Proudfoot unpubl. data).

4. Applications and methodology

Use of radio-telemetry for developing survey protocols

The effectiveness of broadcast surveys may be influenced by weather conditions, time of broadcast (AM, PM), physiological state of individuals being surveyed, degree of competition among males for nest sites, and mating success (Hayward et al. 1992). Other factors may include sensitivity to broadcasted or imitated calls (Tewes 1993), environmental characteristics, and effective broadcast radius (i.e., maximum distance between broadcast station and targeted individual that will invoke a response without affecting responsiveness). Therefore, it is essential to appropriately address regulatory empirical factors (i.e., time of broadcast, distance between broadcast stations, and acceptable weather conditions) before conducting surveys.

To determine the effective broadcast radius for ferruginous pygmy-owls in Texas, nine adult males (four in 1995 and five in 1996) were fitted with radio-transmitters (L. L. Electronics, Mahomet, IL) and their response distance to broadcasted conspecific calls was tested. Because spontaneous calling bouts of ferruginous pygmy-owls are usually crepuscular (Gilman 1909), testing was restricted to 30 min before and after sunset, as determined by the U.S. Naval Observatory, Washington, D.C. No testing was conducted when winds exceeded 19-24 kph (12-15 mph) or when precipitation occurred (Proudfoot 1996a).

Using a three-element Yagi antenna and portable radio-receiver (L. L. Electronics, Mahomet, IL) one observer tracked a radio-tagged pygmy-owl until obtaining visual contact and relayed its location in relation to its distance from established points (e.g., wind mills, nest trees, fences, gates, etc..) to a second observer via two-way radio. The second observer calculated distance to the owl and used compass bearings and pacing to obtain the distance desired for testing. A portable tape recorder was used by the second observer to broadcast conspecific calls toward the targeted individual. Broadcasting continued for three minutes, during which any movement toward the broadcast station or vocalization was recorded. Because the characteristic call of pygmy-owls is a simple series of interrupted single notes, continued broadcast should not hamper detectability (Proudfoot and Beasom 1996). Radio-telemetry was used to substantiate movement or vocal response of the targeted individual (Proudfoot 1996a).

In 1995, all ferruginous pygmy-owls tested at 400 and 500 m (n = 4) responded by moving toward the broadcast station and vocalizing. At 600 m, three individuals responded with movement and vocal defense; the fourth only responded vocally. Due to time constraints, only one ferruginous pygmy-owl was tested at 700 m in 1995, and it responded by moving toward the broadcast station and vocalizing (Proudfoot 1996a).

In 1996, two of five birds tested at 700 m moved toward the broadcast station and vocalized. A third bird responded vocally at 700 m with limited movement toward the broadcast station and vocalization at 600 m. The fourth bird responded vocally at 600 m and moved toward the broadcast station and vocalized at 550 m. The fifth bird responded vocally at 550 m and moved toward the broadcast station and vocalized at 250 m.

Habitat preferences

Tracking 54 radio-tagged ferruginous pygmy-owls in Texas showed preferential habitat use and seasonal variation in areal use (Proudfoot unpubl. data). To compare habitat use to habitat availability, 37 ferruginous pygmy-owls were tracked almost daily for the life of the transmitters (90+ days) and at each visual sighting, a 0.04-ha circular plot was established to determine habitat composition of areas used (Stoddard and Stoddard 1987). Trees >2 m in height and ≥2.5 cm in diameter at breast height (dbh) that occurred within the 0.04-ha plot were counted, identified according to species, and measured for dbh. Density board values were estimated to determine understory cover. A single board measuring 205 x 8.9 x 1.9 cm, with eight equal-sized panels of alternating white and orange color was placed at the center of each plot and observed from the outer edge from four cardinal directions. Each panel was rated between zero and six for percentage of the panel covered by vegetation (0 = 0%, 1 = >0-5%, 2 = 6-25%, 3 = 26-50%, 4 = 51-75%, 5 = 76-95%, 6 = 96-100%). Mean cover values, number of trees/ha, and dbh of trees within circular plots were compared to study area composition data obtained in a systematic-random sample of 219 0.04-ha plots to determine ferruginous pygmy-owl habitat selection (Stoddard and Stoddard 1987, Proudfoot 1996a). Habitat use was disproportionate to its availability. Ferruginous pygmy-owls used areas containing significantly ($P < 0.05$) fewer small trees (<25 cm dbh) and more large trees (>26 cm dbh), with moderate-dense understory (50-100% cover) (Proudfoot 1996a). Results from this study were used to gauge habitat potential for detecting ferruginous pygmy-owls during broadcast surveys and for establishment of nest boxes (Proudfoot et al. upubl. ms.).

Home range

To calculate areal use, Universal Transverse Mercator (UTM) coordinates of radio-tagged ferruginous pygmy-owls were analyzed for 95 and 100% minimum convex polygons. A TELEM88 home-range analysis program (Dept. of Fish and Wildlife, Virginia Polytechnic Institute and University, Blacksburg, VA.) was used to conduct the analysis. Starting from known UTM locations, observers tracked radio-tagged ferruginous pygmy-owls using compass bearings and pacing (Stoddard and Stoddard 1987) to calculate the geographic location of each individual detected. Owls were tracked almost daily during the lives of the transmitters (90+ days) (Proudfoot 1996a). The results of this study are in Chapter 1.

Assessment of cavity availability

Because studies on cavity nesting species may be influenced by the availability of cavities (Waters et al. 1990), observers surveyed the study area to estimate the number of natural cavities/ha. Transects (400 x 6 m) (n = 104) to locate natural cavities were established at 400-m intervals perpendicular to roads that intersect the study area. Compasses were used to orient transects and lines were laid with a topometric hip-chain (Forestry Suppliers, Inc., Jackson, MS) to establish boundaries. Trees were temporarily marked with a chalk tree marker (Forestry Suppliers, Inc., Jackson, MS) (Proudfoot 1996a, Proudfoot unpubl. data). To obtain information on possible interspecific competition, cavities with entrances >3.8 cm in diameter were inspected for occupancy with the nest box monitoring system (Proudfoot 1996b). Cavity entrance diameters were estimated by comparing the size of the entrance to the size of the camera housing (3.6 x 2.2 cm). The above ground height of cavity entrances was estimated (+ or – 15 cm) from markings placed on the telescoping pole that supported the camera. Trees containing cavities were identified to species and dbh measured. The number of cavities/ha in the study area was estimated by multiplying the mean number of cavities/ha in the area sampled by the size (ha) of the study area (Proudfoot 1996a).

Transects encompassed 24.96 ha (an estimated 13,995 trees) and contained 261 natural cavities (10.5/ha). One hundred and twenty cavities (46%) (4.8/ha) were of the entrance hole diameters used by ferruginous pygmy-owls, suggesting that the study area supports a large number of cavities. Although none of the cavities inspected contained avian occupants (Proudfoot 1996a), possibly because surveying preceded nesting for many species in the area, the potential for competition is indicated by the fact that several species were found occupying nest boxes (see Chapter 1).

Nest monitoring

Using the miniature video-camera and strata-scope, nest boxes and natural cavities occupied by ferruginous pygmy-owls were periodically inspected to obtain information on laying sequence, clutch size, incubation period, and hatching sequence (Proudfoot 1996ab). In addition, food habits and nestling activities were monitored by establishing miniature video-cameras in the top of nest boxes (Proudfoot 1996a, Proudfoot and Beasom 1997). To document nestling development, nestlings from seven nest boxes were photographed on alternating days from one day posthatch to fledging (Proudfoot 1996a, Proudfoot unpubl. data). Development information may aid conservation of this species by providing investigators an estimation of time available to conduct needed research (e.g., banding and marking [essential tools in avian management]).

Demographic study

The empiric determination of demographic parameters can be used to calculate minimum recruitment standards for a population (Gehlbach 1994). However, to obtain information for such an analysis requires long-term study, and although ongoing ferruginous pygmy-owl research is addressing the required parameters, insufficient information exists for sound analysis.

Food habit study

Analysis of prey remains, visual observation, and analysis of video footage recorded inside active nest boxes were used to obtain information on ferruginous pygmy-owl food habits. Prey remains were identified using dichotomous keys (Jones and Manning 1992, Chaney 1993) and university reference collections. Visual observations were conducted from blinds established <5 m from four nest sites; observation time was about 105 hours. Video footage, obtained from miniature video-cameras established in the top of two active nest boxes, provided images of prey items brought to the nest by adults. About 104 hours of video footage was analyzed (Proudfoot 1996a, Proudfoot and Beasom 1997).

Thirty-six prey species from five classes (i.e. Insecta, Reptilia, Mammalia, Aves, and Amphibia) were identified in the diet of ferruginous pygmy-owls from Texas. Analysis of prey remains (eight nest sites) identified more individual prey items (184) and prey species (28) than visual observations (40 individuals and 11 species), or analysis of video footage (103 individuals and 12 species). Comparison of prey items identified/prey item brought to the nest site showed analysis of video footage exceeded visual observation in prey identification by 28%.

Hematozoa study

Hematozoa may cause septicemia, marginal anemia, and neonatal bacterial diarrhea (Hunter et al. 1987), reducing survivability and recruitment. To determine presence of hematozoa from ferruginous pygmy-owls in Texas, blood smears were obtained from 63 (14 females, 45 males, four nestlings) individuals and analyzed. Results revealed no hematozoa (Proudfoot and Radomski 1997).

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Chapter 6:

Research Needs for the Conservation of the Cactus Ferruginous Pygmy-Owl in Arizona

In this chapter, we describe research needs for the conservation of the cactus ferruginous pygmy-owl (*Glaucidium brasilianum cactorum*) in Arizona. Estimates of population size, structure, and dynamics, as well as demographic data, are needed for the recovery team to formulate sound population objectives. Habitat loss due to residential development may represent the primary threat to the pygmy-owl, yet the impacts of other human activities and of disease or predation have not been evaluated. Studies of the cactus ferruginous pygmy-owl's habitat requirements are essential to determine the importance of various vegetation types to the owl, protect critical habitat on federal lands, and develop guidelines for residential development. Using annual population surveys in conjunction with continued nest monitoring, habitat sampling, and telemetry will best address Arizona's owl research needs. Habitat studies and population surveys in Sonora, Mexico may be necessary as well. The use of nest boxes in riparian areas, while presenting potential benefits for the management of the owl, may also address habitat research needs.

1. Current state of knowledge and management situation

Historical accounts and specimen records suggest that the cactus ferruginous pygmy-owl was common or fairly common in some riparian areas in the late 19th and early 20th centuries (Chapter 2). A substantial population decline may have occurred during the first few decades of the 20th century which eventually led to the extirpation of the owl along the lower and middle Gila River, the Santa Cruz River and Rillito Creek, and the Salt River in the Phoenix area (Chapter 2). The population decline along those rivers coincided with the loss and alteration of riparian areas due to human activities (Chapter 2). Although some riparian areas appear to remain suitable for pygmy-owl occupancy, very few owls have been detected in this habitat in the last decade (Chapter 3).

The recent survey effort suggests that population size of the pygmy-owl is now small (Chapter 3) and that the owl is chiefly associated with xeroriparian vegetation and dense, well-structured desertscrub (Chapters 3 and 4). In at least some areas, the remaining owl population is threatened by urban development (Chapter 3). Added to the threat of habitat loss is the risk of extinction inherent to small population size due to stochastic variation in demographic parameters, sex ratio, genetic diversity, environmental conditions, and disease (Shaffer 1981, Petterson 1985, Simberloff 1988, Clark et al. 1990).

2. Research needs

In the last two years, the need to rapidly accumulate more information on the population status and habitat needs of the cactus ferruginous pygmy-owl has led to an increased survey effort and to the use of telemetry (Chapter 3). Habitat sampling and nest monitoring have also been continued.

Additional research is needed to develop a recovery plan for the owl, to guide habitat protection and enhancement efforts on federal lands, and formulate guidelines for future residential development compatible with the persistence of the cactus ferruginous pygmy-owl. Delisting criteria typically include population objectives for ensuring the long-term viability of a species. Examples of population objectives used for other federally listed species are:

1) Minimum average number of individuals over a specified number of years (U.S. Fish and Wildlife Service 1986).
2) Maximum rate of annual population decline over a specified number of years (U.S. Fish and Wildlife Service 1986).
3) Minimum productivity per active nest (U.S. Fish and Wildlife Service 1990).
4) Minimum number of self-sustaining populations (U.S. Fish and Wildlife Service 1996).

The choice of a particular population parameter and objective requires knowledge about current population size and structure, demographics, and the cause(s) of the population decline responsible for the listing of the species. Recovery plans also list recommendations for reaching the population objective(s). Such recommendations require a good understanding of past, current, and future threats to the listed species and its habitat.

Under Section 7 of the Endangered Species Act, federal agencies are required to protect and enhance critical habitat located on federal lands. However, efforts by federal agencies regarding critical habitat may be less effective if the owl's habitat needs and preferences are not fully understood. Further, due to the lack of biological information, land managers are having difficulty developing management guidelines to reduce impacts of various activities on cactus ferruginous pygmy-owls. Developers also need development guidelines which outline appropriate development locations, densities, and patterns. The livestock industry is searching for suitable grazing systems while the recreationists ponder whether some areas may be restricted due to pygmy-owls. To answer the need for sound management guidelines, defensible, biological information has to be gathered through research.

Estimates of population size, distribution, structure, and movement

In the spring and summer of 1999, 78 owls were reported from Organ Pipe Cactus National Monument, northwest Tucson, southern Pinal County, and the Altar Valley (Chapter 3). Despite the increased number of owls located, many questions remain concerning the exact size and attributes of the Arizona population. It is only through annual population surveys that an accurate estimate of population size and population trend will become possible. In particular, the Tohono O'odham Reservation represents a key area not yet formally surveyed. In addition to its large size and the fact that pygmy-owls have been documented within its boundaries, its geographic position between the Tucson area, the Altar Valley, and Organ Pipe Cactus National Monument suggests that it could be occupied by a substantial number of pygmy-owls. Other inadequately surveyed locations where cactus ferruginous pygmy-owls may persist include the lower San Pedro River and the middle Gila River. Although some sections of the lower San Pedro River have been surveyed since 1993 (Chapter 3), the absence of detections is not reliable because most of the habitat occurs on private lands, and these have not yet been surveyed. The lower San Pedro still supports a cottonwood-willow gallery forest and mesquite bosques. A pair of cactus ferruginous pygmy-owls was detected at the Dudleyville crossing in the late 1980s (Hunter 1988). Access to private properties along the lower San Pedro was recently granted to conduct Southwestern willow flycatcher (*Empidonax traillii extimus*) surveys.

For 15 miles, the banks of the Gila River from Ashhurst-Haydn Dam upstream to near Kearny (elevation 390 m to 540 m) support thickets of exotic tamarisk (*Tamarix* spp.), but also regenerating cottonwood and willow intermixed with extensive mesquite bosques (Chapter 3).

In the last five years, cactus ferruginous pygmy-owl nest sites have been found (Chapters 1 and 4). Yet, whether the Arizona owl population is self propagating or receives a flow of recruits from Mexico is uncertain. Long-distance dispersal capabilities of individuals are unknown. In particular, northward movements of at least some cactus ferruginous pygmy-owls from across the Mexican border remain a possibility (Chapter 1). Because the recruitment of dispersing individuals can lead to the recolonization of historical habitat and thus population recovery, determining the presence or absence of long-distance dispersal is crucial. As noted in Chapter 4, the cactus ferruginous pygmy-owl seems common locally in southern Sonora, Mexico. Yet, its population status over the entire state of Sonora has not been evaluated using population surveys.

Demographic study

To maximize the chances of success of a recovery or management plan, conservation biologists have learned to rely heavily on demographic studies (Dobson and

Lyles 1989, Noon and Biles 1990, Wyllie and Newton 1991, Sjögren 1991, Noon et al. 1992, Powell and Zielinski 1994, Koehler and Aubry 1994, Donovan et al. 1995, Olmsted and Alvarez-Buylla 1995). Life history tables and demographic modeling form the basis on which population growth rates and characteristics are projected (Ricklefs 1973, 1983). Population growth rates reflect the influence of age at first breeding, the proportion of the adult population that breeds, productivity, and juvenile and adult mortality. Based on the normal ranges of these demographic parameters, it is also possible to infer optimal rates of population recovery and run sensitivity analyses, the results of which can point to the factors most responsible for limitations on population growth.

At present, it is unknown whether population size of the cactus ferruginous pygmy-owl in Arizona is chiefly limited by high adult mortality, low recruitment (i.e., low productivity or high juvenile mortality), a low proportion of breeding adults, or a combination of the three. High adult mortality and low recruitment may be caused by predation, disease, lack of food, or human-related factors. A high proportion of adults that do not breed is perhaps due to habitat fragmentation, lack of nest sites, or low owl densities. The use of banding and radiotelemetry is needed to complement nest monitoring and provide estimates of survivorship, and breeding and productivity rates. Initially, these data could be compared with the demographic data on the Texas population of ferruginous pygmy-owls.

Besides residential development, potential threats to the cactus ferruginous pygmy-owl and its current and historical habitat exist in Arizona. Among them is the possible incidence of trichomoniasis in cactus ferruginous pygmy-owls. While it has not yet been reported, owls found in the Tucson area may be at risk for contracting the disease (Chapter 1). Other potential causes of mortality, such as window strikes, fence strikes, cats, and shooting need to be evaluated. In the last five decades, wildfire frequency has increased in upland Sonoran Desert communities (Schmid and Rogers 1988, Narog et al. 1995). With their mortality reaching 80%, saguaros (*Carnegiea gigantea*) are especially vulnerable to wildfires (Wilson et al. 1996). Their numbers have been shown to decrease drastically in burned areas (Cave and Patten 1984).

Habitat study

As shown in Chapter 4, while the ferruginous pygmy-owl occurs in various low-elevation plant communities, it may exhibit a preference for semi-open habitats with large trees (or cacti) and a moderate to dense understory. Other structural attributes of preferred habitat, such as amount of edge, stand insularity, and spatial connectivity, are not well known and require additional research. Together with vegetation gap analyses and a knowledge of the population's distribution and movements, data on habitat characteristics can be used to create a map of occupied, suitable (i.e., suitable for occupancy but currently unoccupied), and potential (i.e., currently unsuitable for occupancy but with the potential to develop to a suitable condition) habitat and to assess habitat connectivity. Ultimately, such a map can provide critical insight for conservation planning (Murphy and Noon 1992).

A critical, unresolved issue, is whether the ferruginous pygmy-owl in Arizona should be managed as an upland species, a riparian species, or both. In desertscrub, pygmy-owls have been found in dense upland desertscrub or along washes lined with xeroriparian vegetation. They have also been found in low-density residential areas, often in association with artificially enhanced native or exotic vegetation (Chapter 4). Why some pairs would choose to nest near houses in this type of vegetation may be an indication of habitat preferences. Alternatively, the association may suggest human encroachment into an area historically occupied by pygmy-owls.

An essential finding of recent surveys is the observed near-absence of pygmy-owls in presumably suitable riparian areas. Possible reasons for this finding include loss of connectivity particularly in the Phoenix area where the owl was once reportedly common or fairly common. Another possible contributing factor is the lack of large trees or saguaros. In areas with dense understory, but few trees or saguaros, the use of nest boxes may help with the recovery of the owl. It may also identity nest site availability as a key habitat component currently missing, preventing recolonization of riparian areas. If nest boxes are used, they should be closely monitored for occupancy.

Human-related impacts (e.g., development, grazing, recreation) on cactus ferruginous pygmy-owl habitat represent another research priority. In semi-urban and semi-rural areas, factors such as densities of development and size of road may affect cactus ferruginous pygmy-owl movements and demographics and may best be evaluated by demographic and habitat use studies. While low-density residential areas are sometimes compatible with cactus ferruginous pygmy-owl occupancy (Chapter 4), further habitat evaluation is needed. Local extirpation can result from a reduction in total habitat area and habitat fragmentation which leads to the insularization of populations (Wilcove et al. 1986). Habitat fragmentation is often responsible for the disruption of ecological relations such as prey-predator interactions (Gilbert 1980). In populations with little or no dispersal ability, the loss of connectivity between patches of suitable habitat becomes an additional problem: as already mentioned in this chapter, small isolated populations may become extinct due to stochastic processes.

List of priorities

- Increase survey effort. Extend surveys to the Tohono O'odham Indian Reservation and the middle Gila River. Through the continued use of public education and outreach programs, enlist the cooperation of the public for reporting pygmy-owls. Where appropriate, obtain authorization of private land owners to conduct surveys on their properties.
- Conduct habitat suitability studies. Compare survivorship and productivity between nest sites in undisturbed desertscrub and low-density residential areas.
- Evaluate the impact of human-related activities (e.g., development, livestock grazing, and recreation) through demographic and habitat use studies.
- Continue to monitor all nesting pairs located.
- Continue to capture and band individual owls located. Continue using telemetry to study movements and mortality.
- In riparian areas and other habitat types, evaluate the benefits and costs of nest box use where the understory is dense but nest site availability appears limited. Give priority to areas near occupied sites.
- Conduct research in western Mexico to study population status and habitat associations and evaluate pygmy-owl population exchanges between Sonora and Arizona.
- Conduct and annually update vegetation gap analyses to assess habitat connectivity.

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Studies accelerate solutions to problems involving ecosystems, range, forests, water, recreation, fire, resource inventory, land reclamation, community sustainability, forest engineering technology, multiple use economics, wildlife and fish habitat, and forest insects and diseases. Studies are conducted cooperatively, and applications may be found worldwide.

Research Locations

Flagstaff, Arizona
Fort Collins, Colorado*
Boise, Idaho
Moscow, Idaho
Bozeman, Montana
Missoula, Montana
Lincoln, Nebraska
Reno, Nevada
Albuquerque, New Mexico
Rapid City, South Dakota
Logan, Utah
Ogden, Utah
Provo, Utah
Laramie, Wyoming

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