Yellow-Billed Cuckoo Distribution, Abundance, and Habitat Use
Along the Lower Colorado and Tributaries,
2006 Annual Report

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Executive Summary

This 2006 annual report details the first season of a 2-year study documenting western yellow-billed cuckoo (*Coccyzus americanus occidentalis*) distribution, abundance, and habitat use throughout the Lower Colorado River Multi-Species Conservation Plan boundary area. We conducted cuckoo surveys at 55 sites within 17 areas, between 11 June and 13 September. The 243 visits across all sites yielded 180 yellow-billed cuckoo detections. Cuckoos were detected at 27 of the 55 sites, primarily at the Bill Williams River National Wildlife Refuge AZ sites (n = 117 detections) and the Grand Canyon National Park–Lake Mead National Recreation Area AZ delta sites (n = 29 detections). There were also cuckoos at the Gila River–Colorado River Confluence, AZ (n = 9), Overton Wildlife Management, NV area (n = 7), and Limitrophe Division North, AZ (n = 6); however, at these sites the numbers were much lower and very few of these birds were considered to be paired or breeding. The greatest number of detections (n = 79) occurred during the second survey period (3–23 July). In 2006, we confirmed five breeding events, including one nesting observation and sightings of four juveniles; all confirmed breeding was at the Bill Williams River NWR and Grand Canyon NP–Lake Mead NRA delta sites. The breeding status of most of our detections were unknown, however, we observed 17 adult cuckoos carrying nest material or food and 40 cuckoo detections were detected while counter-calling occurred in same area during repeated surveys.

We used playback recordings to survey for western yellow-billed cuckoos. Compared to simple point counts or surveys, this method increases the number of detections of this secretive, elusive species. It has long been suspected that cuckoos have a fairly low response rate, and that the standard survey method of using playback recordings may fail to detect all birds present in an area. In 2006, we found that the majority (72%) of cuckoo detections were solicited through playback at all study sites. The number of solicited detections peaked during the first half of July and then declined as the breeding season progressed, while the number of unsolicited detections (cuckoos heard calling before playback was initiated) remained fairly constant. The majority (64%) of cuckoo detections, solicited or unsolicited, were aural; 27 percent were both heard and seen and nine percent were visual detections only. Cuckoos in areas with the largest populations had the highest rate of vocalizations before playback or after the first broadcast. In contrast, more than half the responses at sites with fewer cuckoos (with < 10 detections per site) first occurred after three or more playback recordings. This type of baseline information will be used to help refine the survey protocol for 2007, and to create hypotheses that can serve as the foundation for a full-scale evaluation and optimization of this survey technique.

Our preliminary analysis of vegetation data from occupied and unoccupied sites in 2006 focused on general patterns in the distribution and abundance of woody species. The density and composition of woody riparian vegetation varied considerably among the study areas. Much of the variation in tree density was due to the patterns of abundance of trees in the smallest size class (< 8 cm dbh). The dominant tree species at the cuckoo survey sites were cottonwood, willow, and tamarisk. Tamarisk was the most common tree, due to the abundance of small (< 8 cm dbh) individuals. When occupied and unoccupied sites were compared, occupied sites tended to have higher average canopy cover, attributable to higher average cover of the mid and low canopy. The dominant canopy at occupied sites most often consisted of cottonwood or willow trees. In addition, occupied sites in most areas had lower than average total tree density whereas unoccupied sites were denser than average. When densities of trees in different size classes were compared between occupied and unoccupied sites within areas, it appeared that cuckoos did not use areas with the highest density of small trees (< 8 cm dbh), mostly tamarisk.

We also measured microclimate variables (temperature, relative humidity, soil moisture) at occupied and unoccupied sites. Microclimate sampling in 2006 was delayed due to equipment procurement difficulties, so our preliminary conclusions are based on late-year data only; conclusions and patterns may change as new data (especially from the early season) are collected in 2007. Microclimate measurements at Grand Canyon NP–Lake Mead NRA and Bill Williams River NWR showed that locations occupied by yellow-billed cuckoos were generally slightly cooler and more humid than unoccupied sites. This was not true at Cibola NWR, where only mean nocturnal temperature was lower at occupied sites. On average, soil moisture was slightly higher at occupied cuckoo locations. Although microclimate conditions may play a significant role in cuckoo habitat selection or breeding ecology, the factors underlying the microclimate conditions in riparian patches are not currently known.

Chapter 1. Introduction

The Lower Colorado River Multi-Species Conservation Plan

The Lower Colorado River Multi-Species Conservation Program (LCR MSCP 2004) is a coordinated, comprehensive, long-term multi-agency effort to conserve native species, work towards the recovery of endangered species, and protect and maintain wildlife habitat on the lower Colorado River. The LCR MSCP's purposes are to (1) protect the lower Colorado River environment while ensuring the certainty of existing river water and power operations, (2) address the needs of threatened and endangered wildlife under the Endangered Species Act, and (3) prevent the listing of additional species on the lower Colorado River.

The MSCP covers areas up to and including the full-pool elevations of Lakes Mead, Mohave, and Havasu and the historical floodplain of the Colorado River from Lake Mead to the United States–Mexico Southerly International Boundary, a distance of about 400 river miles. Conservation measures currently focus on the area from Hoover Dam to the border, but may include the Grand Canyon in the future.

The LCR MSCP Habitat Conservation Plan (HCP) measures are designed to meet the biological goals for 26 covered species, including the western yellow-billed cuckoo (*Coccyzus americanus occidentalis*). On 25 July 2001 the U.S. Fish and Wildlife Service (USFWS) found that the western yellow-billed cuckoo (i.e., populations west of the continental divide) represents a distinct population segment and warrants protection under the Endangered Species Act as "threatened," but precluded. Thus, it became a Candidate Species under the Endangered Species Act (USFWS 2002a). The HCP requires the Bureau of Reclamation to restore 5,940 acres of cottonwood (*Populus* spp.)–willow (*Salix* spp.) habitat, including 4,050 acres specifically for the yellow-billed cuckoo. The Science Strategy is designed to provide Reclamation with a science-based process for ensuring that relevant new information generated over the 50-year term of the LCR MSCP (2004) is used to guide implementation of HCP conservation measures. The restoration goals are to create native cottonwood-willow habitat that promotes yellow-billed cuckoo conservation and recovery. Additionally, Reclamation plans to establish a standardized survey protocol and to monitor yellow-billed cuckoos at each restoration site and along the entire lower Colorado River to evaluate long-term trends and the effects of HCP conservation measures.

Specifically, the MSCP conservation measures relative to yellow-billed cuckoos include the following:

1. Conduct surveys and research, as appropriate, to collect information necessary to better define the yellow-billed cuckoo's habitat requirements and to design and manage fully functioning habitats.
2. Monitor and adaptively manage created habitat and evaluate the habitat needs of yellow-billed cuckoos. Reconstructed habitats covered under the MSCP will be managed to maintain their functions as habitat over the term of the LCR MSCP (2004). Created habitat will be monitored and adaptively managed over time to determine the types and frequency of management activities that may be required to maintain created cottonwood-willow and honey mesquite (*Prosopis* spp.) as habitat for yellow-billed cuckoos.
3. Create 1,639 ha (4,050 acres) of yellow-billed cuckoo habitat. Of the 2,404 ha (5,940 acres) of created cottonwood-willow, at least 1,639 ha (4,050 acres) will be designed to provide breeding and migration habitat for cuckoos along the lower Colorado River. A total of 1,093 ha (2,700 acres) will be designed and managed to provide habitat for both yellow-billed cuckoos and southwestern willow flycatchers (*Empidonax traillii extimus*); 546 ha (1,350 acres) will be geared specifically toward the cuckoo.

Breeding Biology, Habitat, Distribution, and Status

Breeding Biology

The yellow-billed cuckoo (*Coccyzus americanus*), a neotropical migrant, summers in northern Mexico, the United States, and southern Canada from early June through early September, and winters primarily in South America (Hughes 1999). Cuckoos begin arriving in Arizona in late May and in California in late May–early June (Bent 1940, Hughes 1999). Nesting activities usually take place between late June and late July, but can begin as early as late May, and continue through late September (Hughes 1999, Laymon et al. 1997, Halterman 2003). Nesting peaks in mid-June through August, later than most co-occurring bird species. The timing of nesting may be triggered by an abundance of cicadas, katydids, caterpillars, and other large prey items, which are the bulk of the species' diet (Hamilton and Hamilton 1965, Rosenberg et al. 1982, Hughes 1999).

Nest building takes 1–2 days. Incubation begins as soon as the first egg is laid, and lasts for 11 days (Hughes 1999). Clutch size in western populations averages just over two eggs, ranging up to four (Laymon et al. 1997). Both adults incubate the eggs and brood the young, and approximately one-third of nests have a third adult assisting with care of the young. Eggs hatch asynchronously, and nestlings are fed large food items such as katydids (*Tettigoniidae*), tree frogs (*Hylidae*), large caterpillars (*Lepidoptera*), and cicadas (*Cicadidae*; Laymon et al. 1997). After fledging at 5–7 days, young are dependent on the adults for approximately 3 weeks (Laymon and Halterman 1985). The number of broods reared per breeding season is unclear. Western populations were thought to be single-brooded (Hamilton and Hamilton 1965, Hughes 1999) but recent observations confirm that at least some individuals are double-brooded (M. Halterman, pers. comm.). Although it is not possible to differentiate between the sexes of cuckoos in the field, it is possible to identify second-year birds (one-year-olds) by their yellow orbital skin (Pyle et al. 1997).

Cuckoos do not exhibit classic territorial behavior, and the behaviors and vocalizations of unpaired birds are unknown (Hughes 1999, Laymon et al. 1997, Halterman 2002). Cuckoos can also move broadly throughout riparian and adjacent habitats, especially early in the season and post-breeding. Such cuckoos may be foraging or evaluating potential breeding sites for the current or subsequent breeding seasons. Similarly, migrating cuckoos can be found in habitats that may not have the same vegetation types or characteristics as those in which they breed. As a result, cuckoos are sometimes detected in non-riparian habitats or within riparian habitats that are not suitable for breeding, so not every location at which a cuckoo is detected can necessarily be considered breeding habitat. The level of adult breeding site fidelity is not well known, but may it be relatively low, based on large yearly fluctuations in cuckoo detections at some sites. These natural history traits complicate the determination and characterization of breeding habitat.

Habitat Requirements

Western yellow-billed cuckoos require structurally complex riparian habitats with tall trees and a dense woody vegetative understory (Halterman 1991, Hughes 1999). They breed in large blocks of riparian habitat, particularly woodlands with cottonwoods and willows (Ehrlich et al. 1988, USFWS 2002a). Nesting cuckoos along the Sacramento River in California were estimated to need riparian habitat patches ranging from 10 to 40 ha (Gaines 1974, Laymon et al. 1997, Halterman 1991). In California, dense riparian understory foliage appears to be an important factor in nest site selection, while cottonwood trees are an important foraging habitat (Laymon et al. 1997, USFWS 2002a). Nesting in the West occurs almost exclusively close to water and many researchers have hypothesized that the species may be restricted to nesting in moist river bottoms because of humidity requirements for successful breeding (Hamilton and Hamilton 1965, Rosenberg et al. 1991).

Much of what is known about yellow-billed cuckoo habitat use in Arizona is the result of surveys conducted by the Arizona Game and Fish Department (AGFD) and the U.S. Geological Survey's Colorado Plateau Research Station (CPRS) in 1998 and 1999 (Corman and Magill 2000). The AGFD-CPRS surveys show that cuckoo detection rates were highest in cottonwood-willow-ash (*Fraxinus* spp.) and mesquite bosque–hackberry (*Celtis* spp.) habitats. Yellow-billed cuckoos were much less common in Arizona sycamore (*Platanus wrightii)*–cottonwood habitat, sycamore-alder (*Alnus* spp.) habitat, and areas with more than 75 percent tamarisk (*Tamarix* spp.) cover.

Historic Abundance and General Breeding Distribution

Western yellow-billed cuckoos have historically bred in riparian zones from western Washington to northern Mexico, including Oregon, southwestern Idaho, California, Nevada, Utah, western Colorado, Arizona, New Mexico, and western Texas (American Ornithologists' Union 1983, 1998). Comparisons of historic and current information suggest that the yellow-billed cuckoo's range and population numbers have declined substantially across much of the western United States over the past 50 years (USFWS 2002a). Analysis of population trends is difficult because quantitative data, including historic population estimates, are generally lacking. However, rough extrapolations based on both observed densities of yellow-billed cuckoos and historic habitat distribution indicate that western populations were once substantial (USFWS 1985, USFWS 2002a).

Cuckoo populations have suffered severe range contractions during the last 80 years, and have been extirpated from British Columbia, Washington, Oregon, and possibly Nevada (Hughes 1999). Currently, western populations of the yellow-billed cuckoo breed in localized areas of California, Arizona, New Mexico, extreme western Texas, Sonora, Chihuahua, and south irregularly to Zacatecas, Mexico (Howell and Webb 1995, Russell and Monson 1998, Hughes 1999). Local breeding is irregular in Utah (J. Parrish pers. comm., Johnson and O'Brien 1998) and western Colorado (Kingery 1998). The yellow-billed cuckoos found in California, Arizona, and southern Nevada are western yellow-billed cuckoos; we use the two names interchangeably when discussing any yellow-billed cuckoo west of the continental divide.

Current Conservation Status in the Western United States

Yellow-billed cuckoo populations have declined throughout the species' range (Hughes 1999); western populations, in particular, have decreased and suffered range reductions during the last 80 years (Laymon and Halterman 1987a, Hughes 1999). In 1986, a petition was filed to establish the western yellow-billed cuckoo as endangered in the states of California, Washington, Oregon, Idaho, and Nevada (Manolis et al. 1986). The published 12-month finding determined that the petitioned action was not warranted, because the petitioned area did not encompass either a distinct subspecies or a distinct population segment. Another petition was filed, resulting in a 25 July 2001 finding by the USFWS that the western yellow-billed cuckoo (i.e., populations west of the continental divide) represents a distinct population segment and warrants protection under the Endangered Species Act as "threatened," but precluded. Thus, it became a Candidate Species under the Endangered Species Act; it is a species for which the Fish and Wildlife Service "has sufficient information on their biological status and threats to propose them as endangered or threatened under the ESA, but for which development of the proposed listing regulation is precluded by other higher priority listing activities" (USFWS 2002a). Candidate species receive no statutory protection under the ESA. However, the Fish and Wildlife Service "encourages the formation of partnerships to conserve these species because they are by definition species that may warrant future protection under the ESA" (USFWS 2002a).

Probable factors believed to have contributed to population declines in the West are the loss, fragmentation, and alteration of native riparian breeding habitat, the possible loss of wintering habitat, and pesticide use on breeding and wintering grounds (Gaines and Laymon 1984, Franzreb 1987, Laymon and Halterman 1987a, Hughes 1999). Local extinctions and low colonization rates may also have contributed to the declines (Laymon and Halterman 1989). Populations may be further limited by food availability for the young; they may not nest if the food supply at the breeding grounds is inadequate (Veit and Petersen 1993) and food availability is likely affected by drought conditions (Newton 1980, Durst 2004, Scott et al. 2004).

The early literature documents dozens of locations in California where the species was reported and/or collected historically, sometimes in apparent abundance, but where they have not been found subsequently (Gaines 1974, Gaines and Laymon 1984, Hughes 1999). During the late 19th century, the California breeding population was estimated to be at least 15,000 pairs (Hughes 1999). However, Gaines (1974) believed that predevelopment cuckoo populations in California were even greater than implied by the early literature, due to the species' inconspicuous behavior and the fact that large tracts of floodplain riparian habitat had already been lost to development before the first records and before accounts of the species began appearing in the literature. Grinnell (1915) described yellow-billed cuckoos as a common breeder, widely distributed in suitable river bottom habitats, but by 1940 the cuckoo was much reduced in population due to declines in the amount and suitability of habitat (Grinnell and Miller 1944, Small 1994). Many modern investigators have concluded that there was a catastrophic decline of the cuckoo in California following the start of the major era of development, beginning about the mid-1800s (Gaines and Laymon 1984, Laymon and Halterman 1987b, Launer et al. 1990). The species was listed as threatened in California in 1971, and was listed as endangered in 1987. Statewide surveys in 1986–87 found that only three areas in California supported more than about five breeding pairs on a regular basis: the Sacramento River between Colusa and Red Bluff, the South Fork of the Kern River, and the lower Colorado River (Laymon and Halterman 1987a).

In Arizona, the yellow-billed cuckoo was once considered a fairly common breeding species within riparian forests dominated by cottonwood, willow, and/or mesquite throughout the state (Stephens 1903, Swarth 1905, 1914, Visher 1910, Phillips et al. 1964, Corman and Magill 2000). A 1977 statewide Arizona survey of suitable habitat found an estimated total of 205–214 pairs, with more than half of these along the lower Colorado River (Gaines and Laymon 1984). Past estimates suggested that fewer than 200 pairs remained in 1986 (Layman and Halterman 1987a), and that fewer than 50 pairs were present 5 years later (Ehrlich et al. 1992). Prompted by continued concern regarding severe population declines, habitat loss, and the lack of statewide data, the USFWS initiated yellow-billed cuckoo surveys in 1998 and 1999. Cuckoos were documented along 25 drainages; an estimated 73 pairs were detected in 1998 and 172 pairs in 1999. The primary concentrations in the state were along the major drainages of the Agua Fria, San Pedro, and Verde Rivers, Cienega and Sonoita Creeks, and the Bill Williams River tributary along the lower Colorado River (Corman and Magill 2000). The Arizona Game and Fish Department has designated the yellow-billed cuckoo as Wildlife of Special Concern in Arizona, and the U.S. Forest Service Regional Forester designated it a Sensitive Species on National Forests within Arizona (AGFD 2002). In addition, it is considered likely to become an endangered species throughout all or a significant portion of its range on the Navajo Nation (Navajo Nation 2005).

Until recently, there were few details about cuckoo distribution and abundance in Nevada. From 2000 to 2004, the Nevada Division of Wildlife (NDOW) coordinated surveys at selected riparian areas in southern Nevada, with results varying greatly by year and site. For example, detections at Warm Springs Ranch and Moapa NWR varied from 19 individuals (4 pairs and 11 single cuckoos) in 2001 (Furtek et al 2002) to just a single bird in 2003 (Braden et al. 2005a) and in 2004 (Braden et al. 2005b). The number of detections at Mormon Mesa Littlefield North and Mesquite Bridge also varied: there were 8 in 2000, 6–10 in 2001, 0 in 2002, and 1 in 2003 (Braden et al. 2005a). From 2000 through 2002, the Southern Sierra Research Station (SSRS) also surveyed four sites in southern Nevada: Clover Creek at Caliente, Upper Pahranagat Lake, the Virgin River at Littlefield, and Meadow Valley Wash from river miles 39 to 57. SSRS detected one mated cuckoo at Pahranagat and one individual at Littlefield in 2000 (Halterman 2001), and four pairs and five single cuckoos in 2001 (Halterman 2002); SSRS and NDOW detected one or two pairs in 2002 (Halterman 2003). The Nevada Natural Heritage Program ranks the western yellow-billed cuckoo as critically imperiled (Nevada Natural Heritage Program 2004)

Historic Population Status along the Lower Colorado River

Yellow-billed cuckoos were once considered abundant throughout the riparian floodplain along the lower Colorado River. Grinnell and Miller (1944) cited only Stephen's (1903) observations of several cuckoos near Needles in 1902. Surveys in mid-June 1964 along the lower Colorado River near Laguna Dam indicated that the density of yellow-billed cuckoos was similar to, and possibly higher than, that on the San Pedro River in southeastern Arizona (Hamilton and Hamilton 1965).

A substantial population of cuckoos was detected north of Laguna Dam during the 1960s and 1970s, suggesting that the Colorado River above Laguna Dam may have been the last stronghold for the yellow-billed cuckoo in California (Gaines and Laymon 1984). Four to twelve cuckoos per season were reported from 1964 to 1975 near Laguna Dam in June and July (Gaines and Laymon 1984). Then using species-specific protocols, Gaines (1977) detected 65 cuckoos along the lower Colorado River on the California side of the river. During surveys in the 1970s and 1980s a dramatic decline of the species was noted along the lower Colorado River. In both Arizona and California, the lower Colorado River and its tributaries supported an estimated 180–240 pairs in 1976–77, a number that had declined by an estimated 80–90 percent by 1986 (Laymon and Halterman 1987a). Rosenberg et al. (1991) estimated a decline of 93 percent along the lower Colorado River between 1976 and 1986, coinciding with habitat loss from high water levels of long duration in 1983–84 and 1986 (Laymon and Halterman 1987b, Rosenberg et al. 1991). In 1998, no pairs were found in the parts of California west of the Colorado River that had been occupied in 1976–77 (Halterman 1998). Losses have been greatest at lower elevations, below 900 m (3000 ft) along the lower Colorado River and its major tributaries, which have been strongly affected by upstream dams, flow alterations, channel modifications, and clearing of land for agriculture (Groschupf 1987).

The Bill Williams River National Wildlife Refuge (NWR), a tributary of the lower Colorado River, has had the largest known population of yellow-billed cuckoos since the 1960s. The refuge consists primarily of riparian habitat along the Bill Williams River from Lake Havasu upstream to Planet Ranch, approximately 16 km (10 miles). The riparian habitat is dominated by a cottonwood and willow overstory with a dense understory of cottonwood, willow, and tamarisk. The Bill Williams River NWR riparian habitat is the most continuous unfragmented habitat of its kind in the lower Colorado River basin.

The Bill Williams River NWR cuckoo population was surveyed in 1993, 1994, and 1997–2004 (Halterman and Laymon 1994, 1995; Halterman 1998, 2001, 2002, 2003, 2004). Despite repeated surveys, trends in abundance are difficult to detect from these survey results because the amount of survey effort varied annually, and prior to 2001 survey results were given in terms of estimated numbers of pairs rather than numbers of detections. Estimated pairs ranged from 28 to 30 in 1993, 26 in 1994, 12 in 1997, and 6 to 9 in 1999. A total of 11 nests were found in 1993, 1994, and 1997. Then starting in 2001, results were reported as numbers of detections, which varied from 78 in 2001 to 34 in 2002 and 42 in 2003.

Prior to the 2006 field season, the most recent yellow-billed cuckoo surveys along the lower Colorado River were from 2005 (Johnson et al. 2006). The area of focus began at Cibola NWR and progressed south to San Luis, Arizona, at the United States–Mexico Southerly International Boundary. Additional surveys were conducted along the lower Gila River, at historical detection sites and locations that had appropriate yellow-billed cuckoo habitat. Across all sites and visits, there were 33 cuckoo detections during the 2005 breeding season, with most during July. The survey included behavioral observations and searching for nests in the sites with cuckoo detections; only one pair of cuckoos was confirmed. Breeding was not confirmed, and other detections were of unpaired cuckoos.

Project Objectives

The objectives of this project, initiated in 2006 as part of the LCR MSCP, were to document the distribution, abundance, and habitat use of yellow-billed cuckoos in riparian areas of the lower Colorado River, and to provide information relevant to the Habitat Conservation Plan measures. Yellow-billed cuckoo surveys provide information on their status and distribution, and establish baseline data that can be used for continued monitoring of cuckoo populations and riparian vegetation under the MSCP. There are four specific project objectives.

1. Conduct comprehensive, repeatable surveys in all potentially suitable habitat types within the MSCP project boundary. This work contributes to baseline information on yellow-billed cuckoo populations within these areas. All other avian species encountered within riparian habitats are also recorded.

2. Determine breeding habitat selection and preferences in the areas of concern. This includes identifying the characteristics of habitats used during the breeding season, and comparing characteristics between occupied and unoccupied sites to identify factors that may influence habitat selection by cuckoos.

3. Identify core yellow-billed cuckoo breeding habitat to use as a basis for future habitat expansion through restoration efforts.

4. Evaluate the effectiveness of the current yellow-billed cuckoo breeding season survey protocol (Halterman et al. 2006) and refine it to use over the term of the Multi-Species Conservation Plan.

Document Organization

This document is organized into six chapters. Chapter 2 (Yellow-billed Cuckoo Breeding Surveys) describes the survey design, survey effort, and results of the yellow-billed cuckoo surveys conducted during the 2006 breeding season. Chapter 3 (Survey Methodology) provides descriptive information about how cuckoos responded to our survey methodology. It also poses hypotheses and questions that may prove useful in further optimizing the cuckoo survey protocol. Chapter 4 (Yellow-billed Cuckoo Habitat Vegetation) describes the riparian vegetation sampling design, provides preliminary results on vegetation characteristics in the study areas, and compares characteristics of occupied and unoccupied sites. Chapter 5 (Microclimate Analysis) describes the design and results of microclimate sampling in occupied and unoccupied patches of riparian habitat. Chapter 6 (Riparian Habitat and Yellow-billed Cuckoo Distribution and Status in the Lower Colorado River Basin) describes the history of change in riparian habitat, how this may have contributed to changes in the yellow-billed cuckoo’s status and distribution within the region, and the potential effects on the cuckoo of riparian conservation and restoration under the LCR MSCP.

Chapter 2: Yellow-Billed Cuckoo Breeding Surveys

The Lower Colorado River Multi-Species Conservation Plan of 2004 calls for surveys to identify areas that cuckoos use and to collect information necessary to better define the species' habitat requirements. This information will then be used to design and maintain riparian habitat suitable for yellow-billed cuckoos in the LCR MSCP planning area, which should help reduce the likelihood of future federal listing of this species. This project was initiated in the spring of 2006, and cuckoo surveys were conducted, using standardized methodologies, throughout the breeding season.

Survey Location and Selection of Study Sites

The MSCP boundary covers areas up to and including the full-pool elevations of Lake Mead, Lake Mohave, Lake Havasu, and the historical floodplain of the Colorado River from Lake Mead to the United States–Mexico Southerly International Boundary, a distance of about 644 river km (400 river miles). To examine historic yellow-billed cuckoo breeding range and to determine the current range throughout the lower Colorado River basin, we expanded surveys in 2006 to include sites along the Gila River near Yuma, Arizona, the Virgin and Muddy Rivers in Southern Nevada, and Pahranagat National Wildlife Refuge in the White Water River drainage, Nevada (Figure 2.1).

Specific yellow-billed cuckoo survey sites were selected prior to the initial survey season, using the "look see" method. This method, which was employed during previous AGFD-CPRS surveys (see Bibby et al. 1992), calls for identification of suitable habitats before conducting surveys. It relies on prior knowledge of possible habitat preferences, expert opinion, and knowledge of the basic biology of the species in question (Halterman et al. 2006). We also selected sites based on historical detections, which is a preferred method for surveying rare birds (Dawson 1981) when the goal is detection of all occurrences of a species within constraints such as time. Many of the yellow-billed cuckoo survey sites selected in 2006 overlap with Southwestern willow flycatcher surveys sites, which have their own site names (Table 2.1). Some of these site names we adopted for the 2006 cuckoo survey, however a number of our sites encompass a much larger area than the flycatcher sites or do not overlap at all, and therefore many names that were established during cuckoo surveys in 2005 (Johnson et al. 2006) remained the same.

Table 2.1. Yellow-billed cuckoo (YBCU) and Southwestern willow flycatcher (SWIFL) 2006 sites names in the Lower Colorado River watershed along the Muddy, Virgin, and White Rivers in Nevada, and the Colorado, Bill Williams, and Gila Rivers in Arizona and California.

YBCU 2006 Site Name	SWIFL 2006 Site Name
Littlefield Bridge	Littlefield North
Mesquite Bridge	Mesquite East
Pahranagat NWR-Pahranagat North	Pahranagat North
Pahranagat NWR-Pahranagat East	Pahranagat Maps to the southwest
Pahranagat NWR-Pahranagat South	Pahranagat South
Pahranagat NWR-Pahranagat West	Pahranagat Maps & Pahranagat West
Overton WMA-Honeybee Pond	Overton WMA to the south
Overton WMA-Overton North	None
Overton WMA-Overton Tamarisk	Overton WMA
Overton WMA-Overton Wildlife	Overton WMA
Grand Canyon NP/Lake Mead NRA-Spencer Canyon	None
Grand Canyon NP/Lake Mead NRA-RM 274.5	RM 274.5N
Grand Canyon NP/Lake Mead NRA-River Delta/RM 285.3N	RM 285.3N
Grand Canyon NP/Lake Mead NRA-Cuckoo Beach	Kowlp Corner, RM 286N, Twin Coves

Table 2.1 (continued)

YBCU 2006 Site Name	SWIFL 2006 Site Name
Grand Canyon NP/Lake Mead NRA-Iceberg Ridge	Bradley Bay
Grand Canyon NP/Lake Mead NRA-Chuckwalla Cove	Chuckwalla Cove
Lake Mohave-Waterwheel Cove	None
Lake Mohave-Mohave Patch	None
Havasu NWR-Pintail Slough	None
Havasu NWR-North Dike	None
Havasu NWR-Topock Marsh Restoration	None
Havasu NWR-Sacramento Wash	None
Havasu NWR-Havasu Tamarisk	None
Havasu NWR-Topock Tamarisk	None
Bill Williams River NWR-Cave Wash	Site 8
Bill Williams River NWR-Mineral Wash	Beaver Pond, Site 8
Bill Williams River NWR-Big Bend	Mineral Wash & Beaver Pond
Bill Williams River NWR-Gibraltar Rock	None, Site 5 near
Bill Williams River NRA-Sandy Wash	Site 5
Bill Williams River NWR-Fox Wash	Site 5
Bill Williams River NWR-Mosquito Flats	Site 3 & Site 5
Bill Williams River NWR-Saguaro Slot	Site 1, Site 2, Site 3, Site 4, Site 11
Bill Williams River NWR-Bill Williams River Marsh	Site 1, Site 2, Site 4, Site 11
Cibola NWR-Cibola North Restoration	None
Cibola NWR-Cibola Nature Trail Restoration	Cibola Nature Trail
Cibola NWR-Cibola Eucalyptus Restoration	None
Cibola NWR-Cibola South Restoration	None
Cibola NWR-Cibola Cross River	Cibola Site 2
Cibola NWR-Cibola East Side	Cibola Site 1
Picacho SRA	Picacho NW
Imperial NWR-Imperial Paradise	Paradise
Imperial NWR-Imperial South Restoration	Imperial Nursery, Nursery NW
Mittry Lake WMA/Pratt Restoration	Mittry South
Gila/Colorado River Confluence-Colorado River	Gila Confluence North, Gila Confluence West
Gila/Colorado River Confluence-Gila River	Gila Confluence North, Gila Confluence West
Yuma West Wetlands	None
Limitrophe Division-Limitrophe Division North	Morelos Dam
Limitrophe Division-Limitrophe Division South	Gadsden, Hunters Hole
Gila River Highway 95-Gila 95 Bridge	None
Gila River Highway 95-Gila 95 Canal	None
Gila River Highway 95-Gila 95 Tall Tamarisk	None
Gila River/Ligurta	None
Gila River/Wellton	None
Gila River/Quigley Pond WMA	None

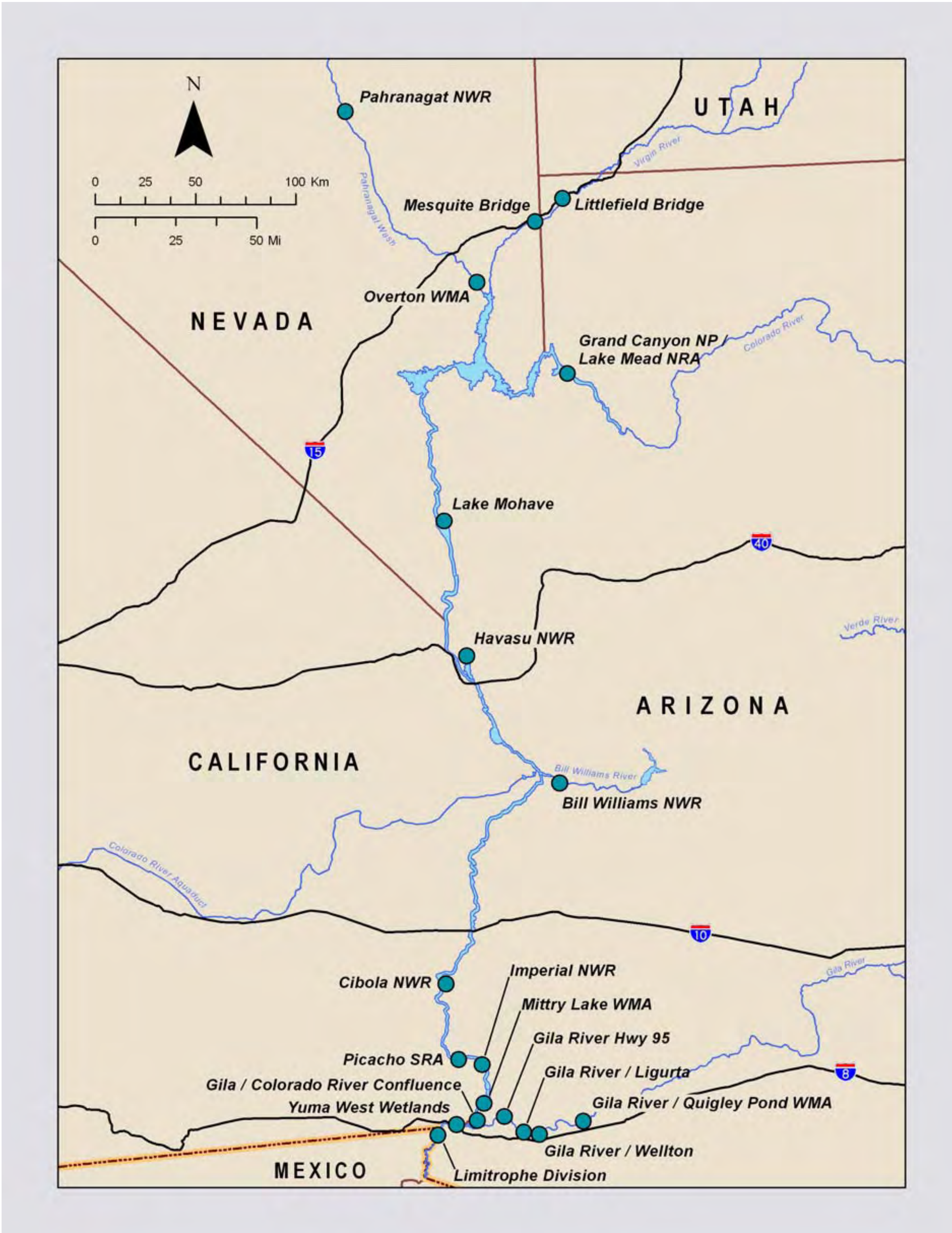

Figure 2.1. Yellow-billed cuckoo survey areas along the Virgin and Muddy Rivers, Nevada and lower Colorado, Bill Williams and Gila Rivers in Arizona and California, 2006.

Survey Methods

Surveys for presence/absence of cuckoos were conducted following established methodologies (Laymon 1998a, 1998b, Halterman et al. 2006, Johnson et al. 2006) that involve a minimum of four surveys distributed throughout the four survey periods between 10 June and 15 September (Table 2.2). Surveys at each site are conducted 10–14 days apart to assure visits throughout the potential breeding season and to increase the likelihood of detecting nesting cuckoos. If cuckoos were detected during the fourth survey period, which may indicate that they may still be breeding at that site, a fifth survey is then recommended. Previous surveys on the Bill Williams River NWR, conducted in mid August, detected several new pairs (Halterman 2002).

Table 2.2. Number of visits and yellow-billed cuckoo detections per survey period in 2006 at sites in the Lower Colorado River watershed along the Muddy, Virgin, and White Rivers in Nevada, and the Colorado, Bill Williams, and Gila Rivers in Arizona and California.

Survey Period	Survey Dates	No. of Visits (n = 243)	Detections (n = 180)
1	6/11–7/02	65	46
2	7/03–7/23	67	79
3	7/24–8/10	67	36
4	8/11–9/13	44	19

We used a taped recording of the yellow-billed cuckoo's *kowlp* call (Hughes 1999) during survey. Playback equipment was capable of projecting this call at least 100 m (328 ft) with a minimum of distortion. Surveys were conducted from half an hour before sunrise until 11:00 a.m., and were terminated if shade temperatures exceeded 41° C (110° F) or during steady rainfall. One transect (i.e., a series of points from which the tape was broadcast) was made through the habitat for every 200 m (656 ft) of habitat width. Two hectares is considered an absolute minimum size for cuckoo occupancy, as no cuckoos have been detected attempting to nest in patches that size or smaller in Arizona or California (Corman and Magill 2000, Halterman et al. 2006). Because the playback vocalizations are broadcast loudly enough to cover a large area, surveys do not need always to be conducted within the habitat; however, surveyors should be no more than 15 m (49 ft) from the habitat edge. Choosing a survey point that is not surrounded by dense vegetation provides a better view of a larger swath of the riparian habitat, making it easier to detect cuckoos that respond by flying closer but do not vocalize. Broadcasting the *kowlp* recording from the edge of the habitat enables the call to be broadcast to a larger area. Being on the edge also allows the surveyor to see cuckoos coming in silently to the observer. Areas with small narrow stringers of habitat, steep banks, and backwater sloughs can be surveyed by playing the tape from a boat. We bypassed areas of unsuitable habitat (e.g., a monoculture of young tamarisk or an extensive cobble bar) between patches (i.e., the unsuitable habitat is at least 300 m in extent).

The surveyor initially stopped at a survey point and remained quiet for 1 minute to acclimate to the ambient noise and to listen for spontaneously calling cuckoos. If no cuckoos were heard in this 1-minute period, the surveyor then played the *kowlp* call once, followed by 1 minute of silence to listen for a response. If no detections occurred, this playback-listen sequence was repeated an additional four times. The surveyor then moved 100 m (328 ft) along the transect (by foot or by boat) and repeated the playback-listen protocol. If a cuckoo was detected at the survey point, the surveyor moved 300 m (984 ft) before resuming survey playbacks to reduce the probability of re-detecting or attracting the same bird.

At all survey points we recorded UTM coordinates (using GPS), estimated number of individual cuckoos detected, and estimated distance and direction (i.e., the compass bearing) from the surveyor to the detected cuckoo. At each survey site we also recorded the UTM coordinates of the survey site boundaries (including start and stop points) and provided a description of the habitat and surrounding area.

If a cuckoo was detected, the surveyor attempted to also observe the estimated number of individuals in the habitat patch, the appearance of a nesting pair, the stage of nesting, the cuckoo's use of the habitat patch, possible interactions between individuals, any apparent breeding behavior (e.g., food carry), and types of vocalization The interpretation of these behaviors was later used to help determine breeding status.

Survey Site Classifications

Based on survey results across all four visits, sites were classified as either unoccupied (a site with no yellow-billed cuckoo detections), detected (a yellow-billed cuckoo had been detected at a site during one visit, occupied (a yellow-billed cuckoo had been detected at a site during at least two survey periods). The presence of a cuckoo at a site does not necessarily equate to pairing and breeding at that location. So at sites with one or more cuckoo detections, breeding was considered "confirmed" only if an attended cuckoo nest was found, copulation was observed, and/or recently fledged young were seen. The detection of multiple cuckoos during a single survey or throughout the season, or of cuckoos carrying food or nesting material, is suggestive of pairing and breeding, but was not considered confirmation.

Nest Searching and Monitoring

Nest searching was conducted either when we detected a cuckoo during a survey or after surveys were completed. To get a vantage point of the possible nesting area, surveyors would move about 100 m (328 ft) back and search every tree for nests (Martin and Geupel 1993). Alternatively, two to three people would work together, triangulating on vocalizations of nesting cuckoos. When a nest was located, we took a GPS reading approximately 10 m (33 ft) from the nest to avoid disturbance; a more accurate reading was taken later when the nest was inactive. Nests were monitored every 5–8 days, and were checked from a distance of 20 m (66 ft) to avoid disturbing the birds. Nest contents were only checked if the adult was not on the nest, at which time we documented the number of eggs and young and estimated nestling age. Determining whether or not a nest actually fledged young can be difficult. In the absence of other cues, we assumed that chicks had fledged successfully if the median date between the last nest check during which the nest was active and the final nest check when the nest was empty was within 2 days of the predicted fledging date (Martin and Geupel 1993).

Spatial Data

From orthorectified color aerial photography provided by the Bureau of Reclamation, we produced digital orthophoto quarter quads (DOQQs) to create aerial maps of study sites (Appendix 4). These maps were overlain with survey points (the coordinate point from which a playback survey was conducted) and cuckoo detections (the coordinate point at which the surveyor estimated the cuckoo to be located). The GIS themes are projected in UTM Zone 11 north; the datums are NAD 1983 (horizontal) and NGVD 1929 (vertical), and the spheroid is GRS 1980. The software used to compile the maps, in meters, was ArcView GIS Version 3.3 (ESRI Corp.).

Survey Results

During the 2006 field season, we surveyed 55 sites between 10 June and 15 September, for a total of 521 survey hours (Appendix 1). The number of surveys varied per site due to the restructuring of survey sites. The 243 visits across all sites resulted in 180 yellow-billed cuckoo detections. The greatest number of detections occurred during the second survey period (3–23 July). At all sites, detections fell off sharply during the fourth breeding-season surveys in late August and early September (Appendices 2 and 3). Cuckoos were detected in 27 of 55 sites (49%), with the highest number at the Bill Williams River NWR area and Lake Mead NRA–Grand Canyon NP area (Figure 2.2; Appendix 2).

Survey sites and results are listed below beginning with the most upstream locations and progressing downstream; this is true both within the entire study area and for each side drainage. Additional details on each site and the associated surveys and detections are presented in Appendix 4.

Figure 2.2. Yellow-billed cuckoo survey areas and number of cuckoo detections along the Virgin and Muddy Rivers, Nevada and lower Colorado, Bill Williams and Gila Rivers, Arizona and California, 2006.

Littlefield Bridge, NV (Virgin River, Beaver Dam Wash)

Littlefield Bridge lies along the Virgin River paralleling U.S Highway 91 within the town of Littlefield, approximately 15 km (9.3 miles) northeast of Mesquite, Nevada (Figure 2.1; Appendix 4). The Littlefield Bridge is the only site in this area. It consists of one large patch along the Beaver Dam Wash tributary, and another smaller patch that starts at the bridge and extends 500 m (1,640 ft) downstream along the Virgin River. The habitat consists of Fremont cottonwood (*Populus fremontii*) and Goodding's willow (*Salix gooddingii*), with large tamarisk patches intermixed. Stands of cattail (*Typha* spp.) and arrowweed (*Pluchea sericea*) are also present. Canopy height is 10–14 m (32–46 ft). In 2006, standing water was not present within the site, which is surrounded by urban development and desert upland scrub. Site elevation is 500 m (1,804 ft). Although two cuckoos were detected at this site in 2000 (McKernan and Braden 2001), no cuckoos were detected during the five surveys conducted in 2006 (Table 2.3).

Table 2.3. Dates (2006) for yellow-billed cuckoo surveys along the Virgin River at the Littlefield Bridge site.

Geographic Area	Site Name	Survey Period 1	Survey Period 2	Survey Period 3	Survey Period 4
Littlefield Bridge	Littlefield Bridge	6/20	7/03, 7/15	7/28	9/09

Mesquite Bridge, NV (Virgin River)

The Mesquite Bridge site lies along the Virgin River where Highway 170 crosses the river about 1.3 km (0.8 miles) south of Mesquite, Nevada (Figure 2.1; Appendix 4). The Mesquite Bridge is the only site in this area. The habitat consists of a dense stringer of Fremont cottonwood, Goodding's willow, and tamarisk, mainly along the south side of the Virgin River. Canopy height is 12–14 m (39–46 ft) and site elevation is 465 m (1,526 ft). Standing water was not present within this site in 2006. It is surrounded by agricultural and urban development on both sides of the river. Disturbance due to construction (home sites) has eliminated habitat on the north side of the river.

Cuckoos were detected at this site in 2000 and 2003 (McKernan and Braden 2001, Braden et al. 2005a). We conducted five surveys in 2006 (Table 2.4), and detected a cuckoo at the Mesquite Bridge site during the second survey period. This cuckoo responded immediately and aggressively to the tape playback and it was seen and heard by two observers (Appendix 2). Breeding of this individual cuckoo was not confirmed, and no cuckoos were detected during later surveys.

Table 2.4. Dates (2006) for yellow-billed cuckoo surveys along the Virgin River at the Mesquite Bridge site.

Geographic Area	Site Name	Survey Period 1	Survey Period 2	Survey Period 3	Survey Period 4
City of Mesquite	Mesquite Bridge	6/20	7/03, 7/15	7/28	9/09

Pahranagat National Wildlife Refuge, NV (White River Drainage)

The entire Pahranagat National Wildlife Refuge encompasses 2,177 ha (5,380 acres) in southern Nevada, approximately 15 km (9.3 miles) northwest of Las Vegas (Figure 2.1; Appendix 4). All surveys were conducted at upper Pahranagat Lake, the only site in the refuge with appropriate cuckoo habitat. The habitat consists of patches of native willow and cottonwood at the inflow and outflow of upper Pahranagat Lake, which is fed by Pahranagat Springs just north of the lake. The upland habitat adjacent to the lake is Mohave Desert consisting of creosote and desert scrub. We divided this area into four survey sites (see below), covering the lake perimeter where cuckoo habitat exists.

Yellow-billed cuckoos were detected in 2000 at Pahranagat NWR (Halterman 2001). We conducted 17 surveys in 2006 (Table 2.5), and detected a single cuckoo at the Pahranagat North site during the third survey period; no other cuckoos were detected in this area. Breeding of this individual cuckoo was not confirmed, and no cuckoos were detected during later surveys. This bird responded immediately after the first playback with *cooing* and *kowlping* that lasted about an hour (Appendix 2).

Table 2.5. Dates (2006) for yellow-billed cuckoo surveys conducted at Pahranagat National Wildlife Refuge sites.

Geographic Area	Site Name	Survey Period 1	Survey Period 2	Survey Period 3	Survey Period 4
Pahranagat NWR	Pahranagat North	6/27	7/14	7/27	8/12, 8/25
	Pahranagat East	6/27	7/14	7/27	8/12
	Pahranagat South	6/27	7/14	7/27	8/12
	Pahranagat West	6/27	7/14	7/27	8/11

Pahranagat North (Elevation 1,026 m; 3,366 ft)

The north end of the lake is the best quality cuckoo habitat at the upper Pahranagat Lake. It consists of Fremont cottonwood and Goodding's willow. Canopy height is 15–18 m (49–59 ft). In 2006, standing water was not present within this site; however, refuge personnel reported that standing water was present in May. This site is surrounded by marsh along the lake's edge, which consists mainly of lizard tail (*Yerba manza*).

Pahranagat East (Elevation 1,015 m; 3,330 ft)

Pahranagat East consists of a thin stringer of Fremont cottonwoods and Goodding's willow along the shore of the lake, with intermittent marsh understory. Canopy height is 13–15 m (43–49 ft). Standing water was not present within this site in 2006. The upland habitat adjacent to this site consists of creosote and desert scrub. A dirt road with a number of individual campsites surrounds the patch.

Pahranagat South (Elevation 1,020 m; 3,346 ft)

Pahranagat South consists of a relatively small stringer of Goodding's willow, coyote willow (*Salix exigua*), and Fremont cottonwood lining a developed channel that carries the outflow from upper Pahranagat Lake. The site is bordered by open marsh on the lake side. Tamarisk and Russian olive (*Elaeagnus angustifolia*) form a sparse understory. Canopy height is 16–18 m (52–59 ft). Standing water was not present within this site in 2006. The upland habitat adjacent to this site is creosote and desert scrub. There are extensive trails and campsites in and around this site, with attendant impacts to the riparian vegetation.

Pahranagat West (Elevation 1,020 m; 3,346 ft)

Pahranagat West consists of thin stringers of Fremont cottonwoods that are pocketed between marsh areas, mainly along the lake shore. Canopy height is 14–16 m (46–52 ft). Standing water was not present within this site in 2006. The adjacent upland habitat is creosote and desert scrub. A dirt road intersects the site.

Overton Wildlife Management Area, NV (Muddy River)

The Overton Wildlife Management Area (WMA) consists of 7,146 ha (17,657 acres) located at the inflow of the Muddy River into the Overton Arm of Lake Mead (Figure 2.1; Appendix 4). The habitat comprises seasonally flooded marshes, dense tamarisk, willow patches, scattered mesquite thickets, and isolated stringers of Fremont cottonwood. There are agricultural fields and ponds throughout the WMA, which are managed for waterfowl. Numerous roads intersect the refuge, for easy access to all sites. Four survey sites were established (see below) within Overton WMA. Cuckoos were detected at Overton WMA at the Honey Bee Pond site in 2000 and 2002 (McKernan and Braden 2001, Rathbun and Braden 2003).

We conducted 16 surveys at four sites within the management area (Table 2.6). Two sites, Honeybee Pond and Overton Wildlife, were considered adequate yellow-billed cuckoo habitat and were surveyed throughout the breeding season. Sites with lower quality habitat, Overton North and Overton Tamarisk, were surveyed fewer times due to time constraints.

We detected four cuckoos at the Honeybee Pond site, and three at the Overton Wildlife site during the second and third survey periods (Table 2.7). No cuckoos were detected at either the Overton North site or Overton Tamarisk site. We did not confirm breeding at Honeybee Pond or the Overton Wildlife site (Appendix 2). However, the two cuckoos detected at the Overton Wildlife site during the second survey period were observed counter-calling within the site.

Table 2.6. Dates (2006) for yellow-billed cuckoo surveys in the Overton Wildlife Management Area.

Site Name	Survey Period 1	Survey Period 2	Survey Period 3	Survey Period 4
Honeybee Pond	6/21	7/03, 7/15	7/28, 8/10	8/27
Overton North	6/21	no survey	7/28, 8/10	no survey
Overton Tamarisk	no survey	no survey	8/10	no survey
Overton Wildlife	6/21	7/03, 7/15	7/28, 8/10	8/27

Table 2.7. Yellow-billed cuckoo detections in 2006 in the Overton Wildlife Management Area.

Site Name	Survey Period 1	Survey Period 2	Survey Period 3	Survey Period 4	Total Detections
Honeybee Pond	0	3	1	0	4
Overton North	0	no survey	0	no survey	0
Overton Tamarisk	no survey	no survey	0	no survey	0
Overton Wildlife	1	2	0	0	3
Total Detections	1	5	1	0	7

Honey Bee Pond (Elevation 375 m; 1,230 ft)

This is the largest pond in the management area. The site has tamarisk, young coyote willow, and a few scattered California fan palms (*Washingtonia filifera)*. Canopy height is 4–8 m (13–26 ft). In 2006, standing water was present within this site. A dense stand of tamarisk surrounds the pond area.

Overton North (Elevation 373 m; 1,223 ft)

This site consists of a stringer of large Fremont cottonwoods that have been planted in rows. It lacks understory because the site is mowed. Canopy height is 12–14 m (39–46 ft). In 2006, standing water was not present within the site. A canal runs along its east side, with many housing structures within the site.

Overton Tamarisk (Elevation 368 m; 1,207 ft)

This is a small patch of older tamarisk within a dense patch of younger tamarisk. Canopy height is 4–10 m (13–33 ft). Standing water was not present within the site in 2006. The site is surrounded by a large area of younger tamarisk.

Overton Wildlife (Elevation 371 m; 1,217 ft)

This is a small isolated site with multi-structured vegetation including coyote willow and tamarisk, as well as a re-vegetation site that consists of dense even-aged coyote willow. Canopy height is 4–8 m (13–

26 ft). In 2006, standing water was not present within this site except for the canal, which has water all year. The canal separates the two main parts of this patch. Most of the site is surrounded by an impenetrably dense thicket of tamarisk.

Grand Canyon National Park/Lake Mead National Recreation Area, AZ (Colorado River and Lake Mead)

Where the Colorado River emerges from the Grand Canyon and flows into the northern end of Lake Mead, deposited sediments have been exposed by a 27 m (89 ft) drop in lake levels since 2000. Large tracts of riparian habitat have developed on these formerly inundated areas, with patches of willow, cottonwood, tamarisk, and arrowweed. The habitat extends from the river's edge to the edges of the floodplain at the inflow. We surveyed much of the new riparian habitat, and divided the area into six survey sites (Figure 2.1; Appendix 4).

We made 19 visits to the Grand Canyon/Lake Mead sites (Table 2.8). Low lake levels that resulted in shallow sandbars and other obstructions in the lower reaches of the river prevented us from accessing the Spencer Canyon site early in the season, so it was surveyed only during periods three and four. During the first visit to the River Delta/RM 285.3N site (see below) we determined it to be unsuitable cuckoo habitat and conducted no further surveys there.

We detected 29 yellow-billed cuckoos, most during the first survey period (Table 2.9). Most detections were at Chuckwalla Cove and Cuckoo Beach; no cuckoos were found at Spencer Canyon or River Delta. We confirmed yellow-billed cuckoo breeding during the first survey period at Chuckwalla Cove. After surveys were completed, a juvenile cuckoo was seen in the presence of three adult cuckoos. The habitat at this sighting was a multi-layered canopy structure consisting mainly of coyote willow intermixed with young tamarisk. Canopy height within the patch was 6–8 m (20–26 ft) with the taller trees (10 m; 33 ft) toward the back of the patch. We also detected cuckoos at Cuckoo Beach during visits later in the season. Breeding was not confirmed at Cuckoo Beach, but counter-calling between two cuckoos was heard (Appendix 2). Cuckoos were also detected at Iceberg Ridge, also during later surveys, but breeding was not confirmed. One individual cuckoo was detected at RM 274.5 in late July. Breeding of this individual cuckoo was not confirmed, and no cuckoos were detected there during later surveys (Appendix 2).

Table 2.8. Dates (2006) for yellow-billed cuckoo surveys in Grand Canyon National Park and Lake Mead National Recreation Area.

Site Name	Survey Period 1	Survey Period 2	Survey Period 3	Survey Period 4
Spencer Canyon	no survey	no survey	no survey	8/11, 8/27
RM 274.5	6/29	7/13	8/10	8/26
River Delta/RM285.3N	6/29	no survey	no survey	no survey
Cuckoo Beach	6/29–6/30	7/12	8/10	8/25
Iceberg Ridge	6/29	7/12	8/10	8/25
Chuckwalla Cove	6/29–6/30	7/12	8/09	8/25

Table 2.9. Yellow-billed cuckoo detections in 2006 at Grand Canyon National Park/Lake Mead National Recreation Area.

Site Name	Survey Period 1	Survey Period 2	Survey Period 3	Survey Period 4	Total Detections
Spencer Canyon	no survey	no survey	0	0	0
RM 274.5	0	0	1	0	1
River Delta/RM285.3N	0	no survey	no survey	no survey	0
Cuckoo Beach	6	3	0	1	10
Iceberg Ridge	2	1	0	0	3
Chuckwalla Cove	13	2	0	0	15
Total Detections	21	6	1	1	29

Spencer Canyon (Elevation 359 m; 1,179 ft)

Spencer Canyon is a narrow canyon with steep walls and a perennial creek, approximately 47 km (29 miles) upstream from the Canyon Mile 274 site (Appendix 4). At the mouth of the canyon where the creek intersects the Colorado River, the habitat consists mainly of dense tamarisk approximately 4 m (13 ft) tall. About 70 m (230 ft) up the canyon, there are stringers of willow with tamarisk understory. Canopy height within the site is 8–10 m (26–33 ft). Except for the creek running through the canyon, standing water was not present within this site in 2006. The adjacent habitat is desert upland and canyon walls.

RM 274.5 (Elevation 360 m; 1,181 ft)

RM 274.5 is approximately 19 km (11.8 miles) upstream from the Cuckoo Beach site (Appendix 4). It comprises mainly dense coyote willow and tamarisk, with many seeps and small creeks; one larger creek divides the patch in half. Canopy height within the site is 8–10 m (26–33 ft). Standing water was present during all surveys in 2006. The site is bordered by desert upland and canyon walls.

River Delta/RM 285.3N (Elevation 367 m; 1,204 ft)

River Delta/RM 285/3N is 4 km (2.5 miles) upstream of Cuckoo Beach. This site is a canyon delta dominated by tamarisk, with one narrow stringer of willow surrounded by tamarisk. Canopy height within the site is 3–5 m (10–16 ft). Except for the creek running through the canyon, standing water was not present during surveys in 2006. The adjacent habitat is desert upland. This site was surveyed once and rated as poor yellow-billed cuckoo habitat, and was not surveyed later.

Cuckoo Beach (Elevation 340 m; 1,115 ft)

Cuckoo Beach lies approximately 1.5 km (0.9 miles) upstream from the Iceberg Ridge site, and extends on both sides of the river (Appendix 4). It consists of stringers of coyote willow lining the river's edge and extending inland approximately 100 m (328 ft). Limited tamarisk is present toward the back of the site. Canopy height is 8–10 m (26–33 ft), with the taller trees toward the back of the site. In 2006, standing water was not present within this site. The adjacent habitat is desert upland.

Iceberg Ridge (Elevation 345 m; 1,132 ft)

Iceberg Ridge is a crescent-shaped patch within a cove approximately 300 m (984 ft) upstream from Chuckwalla Cove on river left (Appendix 4). This site consists of large patches of willow and tamarisk. The upstream portion is more sparsely vegetated, with open spaces between the willows and tamarisk. The middle section consists of dense coyote willow of various ages and size. The downstream end has dense coyote willow approximately 4–5 m (13–16 ft) tall. Canopy height is 8–10 m (26–33 ft). Most of this site is underlain with standing water that supports reeds (*Phragmites* spp.) and cattails (*Typhus* spp.). The site is bordered by desert upland habitat.

Chuckwalla Cove (Elevation 340 m; 1,115 ft)

Chuckwalla Cove is the first delta site on the river upstream from Lake Mead proper, located on river right approximately 14.5 km (9 miles) from the South Cove boat ramp (Appendix 4). Low water levels in the past 6 years have allowed the development of suitable yellow-billed cuckoo habitat, consisting of large patches of willow and tamarisk. The habitat exists throughout the entire floodplain, approximately 250 m (820 ft) from the river's edge. Canopy height is 8–10 m (26–33 ft). In 2006, standing water was not present within this site. The adjacent habitat is desert upland.

Lake Mohave, AZ (Colorado River)

Lake Mohave is a 107 km (66 miles) long reservoir created by Davis Dam, at the southern end of Lake Mead National Recreation Area (Figure 2.1; Appendix 4). The Lake Mohave surveys were conducted at two sites: Mohave Patch and Waterwheel Cove. Each site was surveyed three times, and no cuckoos were detected (Table 2.10).

Table 2.10. Yellow-billed cuckoo surveys in 2006 at sites adjacent to Lake Mojave along the Colorado River.

Site Name	Survey Period 1	Survey Period 2	Survey Period 3	Survey Period 4
Waterwheel Cove	7/02	no survey	7/25, 8/10	no survey
Mohave Patch	7/02	no survey	7/26, 8/10	no survey

Waterwheel Cove (Elevation 192 m; 630 ft)

The Waterwheel Cove site is a series of coves along the lake's edge approximately 29 km (18 miles) upstream of Davis Dam (Appendix 4). The habitat consists of large tamarisk interspersed among young tamarisk, with some scattered willows that appear stressed from being partially submerged in the reservoir. Canopy height is 4–6 m (13–20 ft). Most of the site was partially submerged in 2006. Waterwheel cove is bordered by desert upland habitat.

Mohave Patch(Elevation 198 m; 650 ft)

The Mohave Patch site lies along the edge of the lake approximately 1 km (0.6 miles) downstream of Waterwheel Cove, 28 km (17 miles) upstream of Davis Dam (Appendix 4). Most of the site consists of young tamarisk interspersed with larger tamarisk, with some scattered willows that are stressed from being partially submerged. There are also a number tamarisk snags throughout this site. Canopy height is 13–20 ft (4–6 m). In 2006, standing water was present in sections of the site. There is desert upland habitat adjacent to the site.

Havasu National Wildlife Refuge, AZ (Colorado River)

The Havasu National Wildlife Refuge, which is 15,181 ha (37,515 acres), includes approximately 45 river km (28 river miles) of the Colorado River (Figure 2.1; Appendix 4). Topock Marsh is an old marsh within the existing river meander, which covers approximately 1619 ha (4000 acres) of the refuge, and contains most of the riparian habitat in the refuge. It is maintained through a dike system that was created upon the implementation of the refuge. Topock Marsh presently comprises 40 percent of all backwater habitat on the entire Colorado River system. We divided the Havasu National Wildlife Refuge area into six (see below) yellow-billed cuckoo survey sites (Appendix 4).

We conducted 29 survey visits to the Havasu National Wildlife Refuge sites (Table 2.11). A single cuckoo was detected at the Pintail Slough site during the first survey period. Breeding of this individual cuckoo was not confirmed, and no cuckoos were detected during later surveys (Appendix 2). No cuckoos were detected at the five other survey sites within the refuge.

Table 2.11. Dates (2006) for yellow-billed cuckoo surveys at the Havasu National Wildlife Refuge.

Site Name	Survey Period 1	Survey Period 2	Survey Period 3	Survey Period 4
Pintail Slough	6/15, 6/29	7/11	7/26, 8/09	9/06
North Dike	6/15, 6/29	7/11	7/26, 8/09	no survey
Topock Marsh Restoration	6/15, 6/28	7/10	7/25, 8/10	9/05
Sacramento Wash	6/18, 6/30	7/12	7/29	no survey
Havasu Tamarisk	6/18, 6/30	7/12	7/29	no survey
Topock Tamarisk	6/14, 6/28	7/10	7/24	no survey

Pintail Slough (Elevation 135 m; 443 ft)

Pintail Slough is a re-vegetation site that consists of young Fremont cottonwood, with a small area of large cottonwoods just north of the re-vegetation plot (Appendix 4). This site was planted only 3 years ago and therefore lacks an understory or multi-structure canopy. Current canopy height is 4–6 m (13–20 ft). In 2006, standing water was not present within this site. It is surrounded by large swaths of tamarisk.

North Dike (Elevation 137 m; 449 ft)

North Dike is a re-vegetation site about 300 m (984 ft) east of Pintail Slough, with large Fremont cottonwoods along the edge and some mesquite along the border (Appendix 4). Canopy height is 8–10 m (26–33 ft). There was no standing water within this site in 2006, except for the surrounding canals. There is also a large patch of monotypic tamarisk and arrowweed surrounding the site.

Topock Marsh Restoration (Elevation 136 m; 446 ft)

The restoration site in Topock Marsh, adjacent to the Colorado River, consists of 5-year-old Fremont cottonwoods intermixed with 2-year-old cottonwoods and willow, with an adjacent mesquite re-vegetation plot (Appendix 4). Canopy height is 5–7 m (16–23 ft). There was no standing water within this site in 2006. A large patch of monotypic tamarisk and arrowweed surrounds the site.

Sacramento Wash (Elevation 142 m; 466 ft)

Sacramento Wash is mostly an Athel tamarisk (*Tamarix aphylla*) forest that is completely devoid of young recruitment (Appendix 4). The understory consists of a thick duff layer with many downed trees. Canopy height is 8–10 m (26–33 ft). In 2006, standing water was not present within this site. Mesquite, acacia (*Acacia* spp.), and creosote (*Larrea* spp.) surround the site.

Havasu Tamarisk (Elevation 150 m; 492 ft)

This site is an Athel tamarisk forest mostly devoid of young recruitment and surrounded by mesquite, acacia and creosote. The understory consists of a thick duff layer with many downed trees. Canopy height is 8–10 m (26–33 ft). In 2006, standing water was not present at the site.

Topock Tamarisk (Elevation 143 m; 469 ft)

This is an Athel tamarisk forest that borders the Topock Platform site (Appendix 4). A thick understory of young tamarisk occurs in some portions, while others have no understory at all, only a thick duff layer mixed with many downed trees. A small stringer of tall cottonwoods runs along a section of road that borders the site. Canopy height is 8–10 m (26–33 ft). In 2006, standing water was not present at this site. It is bordered by a large patch of young monotypic tamarisk and arrowweed.

Bill Williams River National Wildlife Refuge, AZ (Bill Williams River)

The Bill Williams River, a tributary of the Colorado River, runs 64 km (40 miles) from Alamo Dam to the confluence of the Colorado and Bill Williams Rivers (Figure 2.1; Appendix 4). Alamo Lake, which is behind Alamo Dam, is fed by the Big Sandy and Santa Maria Rivers. Bill Williams River National Wildlife Refuge (NWR) is a 2,489 ha (6,150 acres) area that stretches from Cave Wash downstream to the Colorado River–Bill Williams River confluence, a distance of approximately 16 km (10 miles). Bill Williams River NWR is a unique riparian system that consists of sandy washes, marsh, and riparian areas that offer some of the last naturally occurring cottonwood-willow stands along the lower Colorado River. The entire riparian area and the floodplain are flanked by Sonoran desert upland habitat.

We divided the Bill Williams River NWR into nine cuckoo survey sites (Appendix 4). The sites (see below) were picked from historic survey routes where cuckoos had been detected in 1994, 1995, 1998, and 2001–2003 (Halterman and Laymon 1994, Halterman and Laymon 1995, Halterman 1998, 2001, 2002, 2003). Routes were also added that connected each site within the refuge riparian system.

In 2006, we conducted 39 surveys (Table 2.12). Most of the 117 cuckoo detections came during the second survey period (Table 2.13). Cave Wash and Big Bend had the greatest number of detections, but each site had at least one detection during the 2006 field season.

We confirmed breeding at the Big Bend and Saguaro Slot sites (Appendix 2). At Big Bend, a juvenile was observed at a territory that had been consistently occupied during all visits. Three adults were confirmed visually in this territory and a food carry was seen (Appendix 2). On a subsequent visit, adults were observed feeding a juvenile. The nest search was unsuccessful, but adults were repeatedly seen in this area where the initial food carry was taken.

The one nest located this summer was found in the Saguaro Slot site. It contained two eggs and one hatchling about 5–6 days old. The nest was located 3.4 m (11.2 ft) above the ground in an extremely dense patch of tamarisk with a 6–12 m (20–39 ft) tall overstory of Goodding’s willow. The average canopy cover was 83 percent. The nest was not monitored on a continuous basis so the fate of the nestling and eggs is unknown, but it is likely that two of the eggs never hatched (Appendix 2).

Table 2.12. Dates (2006) for yellow-billed cuckoo surveys at the Bill Williams River National Wildlife Refuge.

Site Name	Survey Period 1	Survey Period 2	Survey Period 3	Survey Period 4
Cave Wash	no survey	7/05, 7/19	8/02	8/15
Mineral Wash	no survey	7/05, 7/19	8/01	8/15
Big Bend	no survey	7/05, 7/19	8/02	8/15
Gibraltar Rock	6/17	7/04, 7/18	8/01	8/14
Sandy Wash	no survey	7/04, 7/18	7/31	8/13
Fox Wash	6/17	7/04, 7/18	8/01	8/13
Mosquito Flats	6/17	7/04, 7/18	7/30	8/13
Saguaro Slot	6/17	7/18	7/30	8/13
Bill Williams River Marsh	no survey	7/05, 7/19	7/31	8/14

Table 2.13. Yellow-billed cuckoo detections in 2006 at the Bill Williams River National Wildlife Refuge.

Site Name	Survey Period 1	Survey Period 2	Survey Period 3	Survey Period 4	Total Detections
Cave Wash	no survey	12	5	4	21
Mineral Wash	no survey	8	6	1	15
Big Bend	no survey	12	4	3	19
Gibraltar Rock	1	2	1	4	8
Sandy Wash	no survey	9	5	0	14
Fox Wash	1	0	0	0	1
Mosquito Flats	3	9	5	0	17
Saguaro Slot	2	3	5	0	10
Bill Williams River Marsh	no survey	6	4	2	12
Total Detections	7	61	35	14	117

At Cave Wash and Sandy Wash we saw cuckoos carrying food in areas where birds had been detected consistently over at least two surveys (Appendix 2). In Bill Williams River Marsh, two cuckoos were detected in the same area three times and they were counter-calling during each detection. At Mineral Wash two individual cuckoos were exhibiting agitated behavior in response to playback, and cuckoos were detected during repeated visits in the same area. At Gibraltar Rock, all individuals detected at this site were not consistently detected in the same areas and the presence of more than one individual per survey point was never confirmed. Only one cuckoo was detected in Fox Wash, and no other cuckoos were detected during later surveys.

Cave Wash (Elevation 175 m; 574 ft)

Cave Wash is located at the most eastern edge of the refuge (Appendix 4). This site is a wide floodplain consisting of young willows and cottonwoods along the river's edge. The cottonwood patches within the floodplain are well developed with very little understory. The vegetation at this site is extremely thick in some places. Canopy height is 8–10 m (26–33 ft). Similar to Mineral Wash, the river is very braided here, supporting thicker riparian patches, with some standing water away from the main river channel. This site is surrounded by Sonoran Desert upland.

Mineral Wash (Elevation 160 m; 525 ft)

Mineral Wash has dense, mature riparian vegetation lining both banks (Appendix 4). The vegetation is mixed native and exotic, with native species predominating. There are many patches with multi-tiered layers of uneven-aged cottonwood and Gooding's willow stands with a dense understory of willow, cattail, tamarisk, and other shrubs. Historical flooding is evident in this section of the river. Canopy height is 12–14 m (39–46 ft). The river is heavily braided here, causing riparian patches to be thicker, with standing water away from the main river channel. This site is surrounded by Sonoran Desert upland.

Big Bend (Elevation 165 m; 541ft)

Big Bend is a bend in the Bill Williams River that winds through Bill Williams River Canyon (Appendix 4). The canyon widens and narrows throughout the site and dense riparian vegetation lines the riverbanks throughout. The vegetation is mixed native and exotic, with native species predominating. There are many patches with multi-tiered layers of uneven-aged cottonwood and Gooding's willow stands with a dense understory of willow, cattail, and tamarisk. Canopy height is 12–14 m (39–46 ft). The river washes were dry during all surveys in 2006. This site is surrounded by sandy deltas with mesquite where the canyon floodplain exists; however, there are strips of young willow and cottonwood in areas where the sandy uplands have flooded.

Gibraltar Rock (Elevation 145 m; 476 ft)

Gibraltar Rock consists of a large sandy floodplain with much cobble. This washed-out section of the river is straddled at either end by two healthy riparian patches consisting of mature and young cottonwoods, and young willows (Appendix 4). Throughout the wash portion there are many tamarisk stringers, and thicker tamarisk patches running into the upland desert habitat. Canopy height is 10–12 m (33–39 ft). The river washes were dry during all surveys in 2006. The site is bordered by Sonoran Desert upland habitat.

Sandy Wash (Elevation 146 m; 473 ft)

Researchers Trail Site has lush riparian habitat on either side of sandy braids of river washes. In this site, the river runs up against a cliff face on the northern side of the patch, well away from the main part of the riparian habitat (Appendix 4). The patches consist of large cottonwoods and willows, with a thick understory dominated by tamarisk with some younger cottonwood and willows evident. Canopy height is 12–14 m (39–46 ft). The river washes were dry during all surveys in 2006. The site is surrounded by patches of mesquite, paloverde (*Parkinsonia microphylla*), and arrowweed.

Fox Wash (Elevation 145 m; 476 ft)

Fox Wash is the most northern survey site on the refuge (Appendix 4). It is extremely diverse, consisting of desert washes lined with tamarisk stringers, old growth tamarisk patches with some mixed native old growth components, and a very unique section of mainly large cottonwood and willow with very little understory except for large patches of young tamarisk dispersed throughout this site. Canopy height is 12–14 m (39–46 ft). There were pools of standing water within this site during all 2006 surveys. The site is surrounded by patches of mesquite, paloverde, and arrowweed.

Mosquito Flats (Elevation 140 m; 459 ft)

Mosquito Flats is the broadest riparian area on the refuge; it is approximately 500 m (1640 ft) wide (Appendix 4). Our survey focus was on the southern edge of the site, where trails provide easy access. However, sections of this patch were too remote to survey without a large amount of trail clearing, which we did not do. The patch consisted of native and non-native vegetation in multiple stages of growth. Large cottonwoods and willows are predominant throughout the site. Canopy height is 12–14 m (39–46 ft). There was standing water within this site during all 2006 surveys. The site is bordered by large patches of mesquite, paloverde, and arrowweed.

Saguaro Slot (Elevation 135 m; 443 ft)

Saguaro Slot is an extremely thick and virtually impenetrable native and exotic mixed site that is roughly 100 m (328 ft) away from the river at its farthest edge (Appendix 4). The overstory includes many large willows and some cottonwoods, with an understory of many thick clumps of small-diameter tamarisk. There are numerous downed logs in this portion of the site and a thick decomposing layer of duff on the floor. Canopy height within the site is 12–14 m (39–46 ft). There were pools of standing water during all 2006 surveys. The site is surrounded by an impenetrable thicket of dense mesquite.

Bill Williams River Marsh (Elevation 133 m; 436 ft)

Bill William River Marsh was accessible by boat by paddling across Lake Havasu to the confluence of the Bill Williams River. Surveyors continued upriver approximately 1.6 km (0.9 miles), to the beginning of the site (Appendix 4). Habitat consisted mainly of Fremont cottonwood and willow along the river's edge and throughout the floodplain, with large patches of tamarisk and willow making up most of the understory. The habitat was extremely dense in some areas due to the thick tamarisk understory. Canopy height is 12–14 m (39–46 ft). Marsh vegetation is abundant along the banks, and stagnant pools of water are present just beyond the river's edge within the riparian area.

Cibola National Wildlife Refuge, AZ (Colorado River)

The Cibola National Wildlife Refuge (NWR) encompasses 6,729 ha (16,627 acres) in the floodplain of the lower Colorado River (Figure 2.1; Appendix 4). The primary flow of the river through the refuge is via a channelized section constructed in the late 1960s, while the original river channel forms the western boundary of the refuge at the California border. Approximately 809 ha (2000 acres) of the refuge is farmed to produce forage for migratory waterfowl, and 318 (785 acres) consists of desert. Most of the alluvial river bottom is dominated by tamarisk, mesquite, and arrowweed. Most cuckoo survey sites were located at riparian restoration sites planted within the past 10–15 years. Two fires occurred on the refuge during the 2006 field season, the first on 17 July and the second on 10 August. The second fire burned part of the Cross River site described below. We established six cuckoo survey sites at Cibola National Wildlife Refuge (see below). In 2005, two cuckoos were detected at the Cibola South Restoration site, and one was detected at the Cibola Cross River site (Johnson et al. 2006)

We conducted 32 survey visits (Table 2.14), resulting in cuckoo detections at the Cibola Nature Trail Restoration and Cibola South Restoration sites (Table 2.15); these sites were revisited during the fourth survey period because cuckoos were detected in these plots earlier in the season.

The individual yellow-billed cuckoo detected at the Cibola South Restoration site was only detected during one survey, it did not respond to playback, and no other individuals were seen or heard in this area during later surveys (Appendix 2). At the Cibola Nature Trail Restoration site, at least one cuckoo was detected in the same area during two consecutive survey periods (aural detection during the first survey period, visual detection during the second); no breeding behavior was observed and only one cuckoo was confirmed per detection.

Table 2.14. Dates (2006) for yellow-billed cuckoo surveys at the Cibola National Wildlife Refuge.

Site Name	Survey Period 1	Survey Period 2	Survey Period 3	Survey Period 4
Cibola North Restoration	6/20	7/03, 7/17	7/31	8/12
Cibola Nature Trail Restoration	6/20	7/03, 7/17	7/31	8/12, 9/10
Cibola Eucalyptus Restoration	6/20	7/03, 7/17	7/31	8/12
Cibola South Restoration	6/20	7/03, 7/17	7/31	8/12, 9/08
Cibola Cross River	6/20	7/03, 7/17	7/31	8/12
Cibola East Side	6/20	7/03, 7/17	7/31	8/12

Table 2.15. Yellow-billed cuckoo detections in 2006 at Cibola National Wildlife Refuge.

Site Name	Survey Period 1	Survey Period 2	Survey Period 3	Survey Period 4	Total Detections
Cibola North Restoration	0	0	0	0	0
Cibola Nature Trail Restoration	1	1	0	0	2
Cibola South Restoration	0	1	0	0	1
Cibola Eucalyptus Restoration	0	0	0	0	0
Cibola Cross River	0	0	0	0	0
Cibola East Side	0	0	0	0	0
Total Detections	1	2	0	NA	3

Cibola North Restoration (Elevation 68 m; 223 ft)

The Cibola North Restoration site lies approximately 500 m (1640 ft) north of Cibola Nature Trail (Appendix 4). It is a younger restoration site composed almost entirely of young (2–3 years old) cottonwoods. This restoration site is square in shape, since it was planted within the area of one abandoned agricultural field. Canopy height is 4–6 m (13–20 ft). In 2006, standing water was not present within the site. It is bordered by agriculture lands, with a paved road on the north side.

Cibola Nature Trail Restoration (Elevation 74 m; 243 ft)

The Cibola Nature Trail Restoration site was planted in 1999. It is dominated by cottonwood planted in a horseshoe-shaped ring (Appendix 4). Within the ring of cottonwoods, the north part is dominated by a lower canopy of willows and the south part is dominated by mesquite with a tall grass understory. A public nature trail passes through the site. Canopy height is 10–12 m (33–39 ft). The Colorado River is approximately 2 km (1.2 miles) away, and the restoration site is periodically irrigated by refuge staff, however in 2006 standing water was not present. The site is surrounded on all sides by agriculture.

Cibola Eucalyptus Restoration (Elevation 71 m; 233 ft)

The Cibola Eucalyptus Restoration site was managed as a eucalyptus restoration site, but also contains numerous cottonwoods (Appendix 4). Other tree species include tamarisk, mesquite, and paloverde. A refuge levee road bisects the site, which extends for 1 km (3.3 ft) in a north-south orientation. Canopy height is 10–12 m (33–39 ft). The Colorado River lies 328 ft (100 m) to the east, and in 2006 there was no standing water within this site. It is bordered by dense stands of tamarisk, mesquite, and arrowweed.

Cibola South Restoration (Elevation 62 m; 203 ft)

The Cibola South Restoration site is dominated by rows of planted cottonwoods interspersed with willows (Appendix 4). The understory of the restoration site is mostly open. This site lies about 300 m (984 ft) west of the Colorado River, and is irrigated by refuge staff (Appendix 4). A fuel break was bulldozed along the southeast edge of the site to successfully protect it from the 10 August 2006 fire. Canopy height is 10–15 m (33–49 ft). In 2006, standing water was not present within this site. It is bordered by monotypic tamarisk and dense stands of mesquite with arrowweed in the understory.

Cibola Cross River (Elevation 65 m; 268 ft)

The Cibola Cross River site is near the East Side survey site in the southern section of the refuge (Appendix 4). Half of the site is located on the east side of the river, and the other half lies on the west side. The vegetation is very similar to the East Side survey site, with several large cottonwoods and willows spread amongst a thick understory of tamarisk, mesquite, and arrowweed. Canopy height is 10–12 m (33–39 ft). In 2006, there was no evidence of standing water within this site. On 10 August 2006 a lightning-ignited wildfire burned the entire western portion of this site, killing all native riparian trees.

Cibola East Side (Elevation 66 m; 271 ft)

The Cibola East Side site is located in the southern section of the refuge, and is dominated by several large cottonwoods and willows (Appendix 4). The understory is primarily tamarisk, mesquite, and arrowweed with a small patch of died-off marsh vegetation. Canopy height is 10–12 m (33–39 ft). A levee road borders the west side of the site, which is approximately 25 m (82 ft) from the Colorado River. In 2006, there was no evidence of standing water within this site. It is surrounded by a low-canopy monotypic stand of tamarisk.

Picacho State Recreation Area, CA (Colorado River)

This 46 ha (120 acre) recreation area is located on the California side of the Colorado River, within the Imperial National Wildlife Refuge (Figure 2.1; Appendix 4). Most of the park is dominated by desert scrub and washes, but it includes a riparian restoration area adjacent to the park headquarters and the river. Large cottonwoods dominate the canopy, but a small number of willows contribute to the high canopy. Willow, mesquite, and arrowweed make up the understory. The riparian area surrounding the restoration site consists almost entirely of non-native vegetation dominated by tamarisk. Canopy height is 12–14 m (39–46 ft). In 2006, there was no evidence of standing water within this site. The elevation of the park is 52 m (171 ft). This entire site is surrounded by desert upland habitat. Historically no yellow-billed cuckoos have been detected at this site.

We established only one survey site, which was reached by boat from Imperial NWR. This area was surveyed five times (Table 2.16), and a single yellow-billed cuckoo was detected during survey period three. This cuckoo was seen and heard by the observer. It was only detected once, and responded eagerly to playback (Appendix 2). One cuckoo was heard vocalizing on 5 July by a SWCA Willow Flycatcher Project employee near where our individual was detected (Appendix 3).

Table 2.16. Dates (2006) for yellow-billed cuckoo surveys at the Picacho State Recreation Area.

Site Name	Survey Period 1	Survey Period 2	Survey Period 3	Survey Period 4
Picacho State Park	6/21	7/03, 7/17	8/02	8/11

Imperial National Wildlife Refuge, AZ and CA (Colorado River)

The Imperial National Wildlife Refuge encompasses 10,428 ha (25,768 acres), including an unchannelized 50 km (31 miles) stretch of the original Colorado River (Figure 2.1; Appendix 4). The refuge borders Cibola NWR to the south. It is dominated by desert ridges, and by riparian vegetation along the Colorado River. Native riparian vegetation is rare, and most of the habitat is dominated by exotic tamarisk and reeds (*Phragmites* spp.). We searched for yellow-billed cuckoos at two sites within the refuge. In 2005, a single cuckoo was detected during two visits at the Imperial South Restoration site (Johnson et al. 2006).

We conducted 10 survey visits (Table 2.17), and made two cuckoo detections at the Imperial South Restoration site (Table 2.18). No cuckoos were found at the Imperial North Site. The cuckoo detected at Imperial South Restoration on 15 July was heard outside of a formal survey, and was observed carrying food (Appendix 2). Later in the season, two cuckoos were confirmed at the South Restoration site because vocalizations were heard simultaneously in two different areas of the refuge. The nest search was unsuccessful but a vocalization was solicited from a cuckoo in the area where the food was carried to—a tall stand of tamarisk in the middle of the marsh. The area is a matrix of marsh vegetation, roads, and stringers of cottonwoods, ponds and waterways. The cuckoos were detected in a small even-aged cottonwood restoration stand with sparse understory vegetation. This area borders extensive upland desert with mesquite, and one cuckoo was seen in a mesquite tree approximately 900 m (2953 ft) from the cottonwood restoration stand near the refuge residential buildings (Appendices 2 and 3).

Table 2.17. Dates (2006) for yellow-billed cuckoo surveys at Imperial National Wildlife Refuge.

Site Name	Survey Period 1	Survey Period 2	Survey Period 3	Survey Period 4
Imperial Paradise	6/21	7/03	8/02	8/11
Imperial South Restoration	6/19, 7/02	7/15	7/30	8/12, 9/13

Table 2.18. Yellow-billed cuckoo detections in 2006 at Imperial National Wildlife Refuge.

Site Name	Survey Period 1	Survey Period 2	Survey Period 3	Survey Period 4	Total Detections
Imperial Paradise	0	0	0	0	0
Imperial South Restoration	2	1	0	0	3
Total Detections	2	1	0	0	3

Imperial Paradise (Elevation 60 m; 197 ft)

This remote site on the California side of the river is approximately 25 km (15.5 miles) northwest of the Imperial NWR headquarters (Appendix 4), and is accessible only by boat. It is dominated by mature cottonwoods and smaller patches of coyote willow, with dense thickets of tamarisk. The understory is composed of ravennagrass (*Saccharum ravennae)*, phragmites, cattails, tamarisk, and arrowweed. Suitable cuckoo habitat runs in a north-south orientation, with trail access. Canopy height within the site is 12–14 m (39–46 ft). During heavy rains, portions of the site had standing water. West of the site is desert scrub and east is the Colorado River.

Imperial South Restoration (Elevation 56 m; 184 ft)

The Imperial South Restoration site consists of a restoration plot that was planted in 1993 (Appendix 4). The canopy is dominated by cottonwoods, with small but dense stands of willows in the understory. The canopy is 12–14 m (39–46 ft) tall. The Colorado River lies 200 m (656 ft) to the west, and the restoration site is periodically flooded by refuge staff. However, in 2006, there was no evidence of standing water within this site. Marsh habitat occurs to the north and east of the restoration site. To the south and west, the Bureau of Reclamation is currently funding additional restoration of both riparian and fish habitats.

Mittry Lake State Wildlife Management Area/Pratt Restoration Area, AZ (Colorado River)

The Mittry Lake State Wildlife Management Area consists of the Pratt Restoration Area and the adjacent Betty's Kitchen, a small recreation site managed by the Bureau of Land Management (Figure 2.1; Appendix 4). The Pratt Restoration Site is dominated by a tall canopy of cottonwoods (12–14 m; 39–46 ft), with small numbers of willows in the understory. Most of the restoration site has an open understory covered only by leaf litter. However, the southern part of the restoration site is now dominated by a dense growth of baccharis (*Baccharis* spp.) with scattered young cottonwoods. The habitat at Betty's Kitchen is mostly exotic, dominated by 8–10 m (26–33 ft) tall Athel tamarisk, but large mesquite trees are also present. The rest of the survey area is open water or marsh. In 2006, there was no evidence of standing water within the Pratt Restoration site. The elevation is 52 m (171 ft). This entire site is surrounded by agriculture fields and desert upland habitat.

In 2005, one yellow-billed cuckoo was detected at the Pratt Restoration area (Johnson et al. 2006). We conducted five survey visits in 2006 (Table 2.19), but no yellow-billed cuckoos were detected.

Table 2.19. Dates (2006) for yellow-billed cuckoo surveys at the Mittry Lake State Wildlife Management Area.

Site Name	Survey Period 1	Survey Period 2	Survey Period 3	Survey Period 4
Mittry Lake/Pratt Restoration	6/14, 6/26	7/11	7/25, 8/07	no survey

Gila–Colorado River Confluence Area, AZ (Gila and Colorado Rivers)

This confluence area, located 10 km (6.2 miles) east of Yuma, is primarily managed by the Bureau of Land Management (Figure 2.1; Appendix 4). Most riparian habitat in this area is dominated by exotic vegetation and bordered by agriculture. Only the habitat upriver from the confluence on both rivers was surveyed for cuckoos. This area was divided into two survey sites based on the dominant drainage (Appendix 4). In 2005, two cuckoo detections occurred at the Colorado River confluence site and five at the Gila River site (Johnson et al. 2006).

We conducted 10 survey visits at the Gila River–Colorado River confluence sites (Table 2.20). There were nine cuckoo detections (Table 2.21), mainly in extensive habitat patches along the Colorado River, and two detections in small patches along the Gila River.

In 2006, two cuckoo detections occurred at the confluence over two visits in July (Appendix 2). During the first visit, two birds were confirmed in the same patch as they were counter-calling. At another patch, upstream of the confluence, two birds were also confirmed in the same area. All other cuckoos found along the Colorado River confluence, and those on the Gila River, were detected only during the first survey period and were not detected during later survey periods (Appendix 2).

Table 2.20. Dates (2006) for yellow-billed cuckoo surveys at the area of the Gila River–Colorado River confluence.

Site Name	Survey Period 1	Survey Period 2	Survey Period 3	Survey Period 4
Colorado River	6/16, 7/01	7/14	7/27, 8/08	no survey
Gila River	6/16, 7/01	7/14	7/27, 8/08	no survey

Table 2.21. Yellow-billed cuckoo detections in 2006 at the area of the Gila River–Colorado River confluence.

Site Name	Survey Period 1	Survey Period 2	Survey Period 3	Survey Period 4	Total Detections
Colorado River	5	2	0	no survey	7
Gila River	2	0	0	no survey	2
Total Detections	7	2	0	0	9

Colorado River (Elevation 39 m; 128 ft)

Most of the suitable riparian habitat at this site is on the north side of the river (Appendix 4), which we surveyed entirely by kayak. Thin patches of cottonwood and willow occur sporadically, close to the river; habitat north of the river's edge is not suitable for cuckoos. As the Gila–Colorado confluence is approached, the riparian habitat on the north side abruptly transitions into a citrus orchard. On the south side of the river, only a thin belt of riparian vegetation exists between the river and agricultural fields. It is almost entirely composed of exotic tamarisk, with very little native riparian vegetation. Canopy height is 8–10 m (26–33 ft). In 2006 there was no evidence of standing water within this site. This entire site is surrounded by agriculture fields.

Gila River (Elevation 39 m; 128 ft)

The Gila River site is dominated by exotic tamarisk with very few native riparian trees. The few small patches of native cottonwood and coyote willow are interspersed with large stretches of unsuitable habitat. Canopy height within the site is 8–10 m (26–33 ft). Initially we used kayaks to cover all habitat along the river. However, this approach was abandoned after we determined that suitable habitat for cuckoos along the river itself was very limited. There is some riparian vegetation close to the river, but much of what remains is distant with broad expanses of tamarisk and arrowweed in between. Canopy height is 8–10 m (26–33 ft). In 2006, there was no evidence of standing water within this site. Agricultural fields border the Gila River on both the north and south sides. In late August, one of the best remaining patches of native cottonwoods was disturbed by heavy machinery at the edge of a farm field.

Yuma West Wetlands, AZ (Colorado River)

This park is surrounded by urban housing tracts on the edge of Yuma (Figure 2.1; Appendix 4), and is managed by the city of Yuma. Most of the park is a riparian restoration area that borders the Colorado River on one side and a levee on the other. The vegetative composition here is almost all native, with cottonwood, willow, and mesquite stands that are approximately 8–10 years old. Canopy height is 8–10 m (26–33 ft). The entire site is regularly irrigated and invasive exotic species are controlled. The southern edge of the park is bordered by a railroad right-of-way; the northern edge is bordered by a housing park, Interstate 10, and a large expanse of low desert scrub. The elevation is 36 m (118 ft).

Historically, yellow-billed cuckoo had not been surveyed at this site. We conducted six surveys (Table 2.22), but no yellow-billed cuckoos were detected.

Table 2.22. Dates (2006) for yellow-billed cuckoo surveys in Yuma West Wetlands along the lower Colorado River.

Site Name	Survey Period 1	Survey Period 2	Survey Period 3	Survey Period 4
Yuma West Wetlands	6/21, 6/01	7/16	7/29, 8/09	no survey

Limitrophe Division, AZ (Colorado River)

The Limitrophe survey area is the last stretch of the Colorado River before the river passes into Mexico (Figure 2.1; Appendix 4). It starts at the Northerly International Border by Morales Dam and ends at San Luis, Arizona, at the Southerly International Border with Mexico. Only the riparian habitat on the east side of the river was surveyed, since the western riverbank is in Mexico. The habitat, which is enclosed by a series of tightly controlled gates, was actively patrolled by border security personnel. Permission to enter was requested from the Border Patrol prior to each survey due to border security issues. Agricultural fields border the riparian habitat on both sides. The habitat was divided into north and south survey sections, above and below the Cocopah Indian Reservation. In 2005, six cuckoo detections occurred at Limitrophe Division North, and one detection occurred at Limitrophe Division South (Johnson et al. 2006).

We made nine survey visits to the Limitrophe Division sites (Table 2.23). The survey conducted in late July was partitioned over 2 days due to high heat, and a scheduled survey at Limitrophe Division South during the second period was cancelled due to high winds (constant winds over 15 mph with gusts to 35 mph). No surveys were conducted during survey period four because the last surveys on 10 August did not result in a cuckoo detection (Table 2.24).

In 2006, six yellow-billed cuckoos were detected in the area, all at Limitrophe Division North (Table 2.23). Two individuals were confirmed in areas along the river within a large patch of old-growth cotton-woods surrounded by strips of multi-tiered riparian vegetation. The birds were never detected in this patch during later surveys. Further north, near the Morelos Dam, cuckoos were detected during three surveys. The first detections were unsolicited birds that were heard giving *knocking* calls, the next was a visual detection of a silent bird, and the third was auditory only. The cuckoos detected at Morelos Dam were detected in the same patch until 28 July. This patch at Morelos Dam was also occupied by a single cuckoo in 2005 (Johnson et al. 2006). Some portions of the habitat were not searched due to border security issues (see Appendix 2). The SWCA Willow Flycatcher Project crew detected a yellow-billed cuckoo vocalizing at the northern edge of the Limitrophe Division South site, near the border with the

Cocopah Reservation (see Appendix 3). At least one individual cuckoo was heard vocalizing on 20 June, and two individuals were heard counter-calling and one cuckoo was seen on 1 July.

Table 2.23. Dates (2006) for yellow-billed cuckoo surveys in the Limitrophe Division area along the lower Colorado River.

Site Name	Survey Period 1	Survey Period 2	Survey Period 3	Survey Period 4
Limitrophe Division North	6/18, 6/28	7/16	7/28, 7/29, 8/10	no survey
Limitrophe Division South	6/17, 6/27	no survey	7/28, 8/10	no survey

Table 2.24. Yellow-billed cuckoo detections in 2006 in the Limitrophe Division area along the lower Colorado River.

Site Name	Survey Period 1	Survey Period 2	Survey Period 3	Survey Period 4	Total Detections
Limitrophe Division North	4	1	1	no survey	6
Limitrophe Division South	0	no survey	0	no survey	0
Total Detections	4	1	1	NA	6

Limitrophe Division North (Elevation 36 m; 118 ft)

This site starts at the Northerly International Border by Morales Dam and extends to the northern border of the Cocopah Indian Reservation (Figure 2.1; Appendix 4). The riparian habitat here transitions frequently from mostly native vegetation with a canopy of cottonwood and willow to mostly exotic dominated by tamarisk. In some places, riparian vegetation becomes very sparse and is dominated by a low-stature monotypic arrowweed scrub. Canopy height within the site is 4–10 m (13–33 ft). In 2006, there was no evidence of standing water within this site. There are agricultural fields adjacent to the site.

Limitrophe Division South (Elevation 33 m; 108 ft)

This site starts at the southern border of the Cocopah Indian Reservation and continues south to San Luis, Arizona, the Southerly International Border with Mexico (Figure 2.1; Appendix 4). As with the Limitrophe Division North site, the habitat here also transitions frequently between dense riparian vegetation and sparse scrub. However, Limitrophe Division South has two main patches of suitable riparian habitat that are separated by more than 2 km (1.2 miles) of sparse scrub dominated by arrowweed. The southernmost of these patches is primarily a mix of native riparian trees and marsh, whereas the northern patch lacks the marsh component. Canopy height within the site is 4–10 m (13–33 ft). In 2006, there was no evidence of standing water within this site. There are agricultural fields adjacent to the site.

Gila River Highway 95, AZ (Gila River)

This area is located where Highway 95 crosses the Gila River (Figure 2.1; Appendix 4). In addition to riparian vegetation along the river itself, survey sites also included habitat adjacent to irrigation canals and agricultural fields. Most of the habitat occurs as thin strips of trees in an otherwise human-modified landscape. We divided this area into three cuckoo survey sites (Appendix 4).

In 2005, one cuckoo detection occurred in this area of the Gila River Highway 95 Bridge site (Johnson et al. 2006). We made 15 survey trips to the Gila River Highway 95 sites in 2006 (Table 2.25); no yellow-billed cuckoos were detected.

Table 2.25. Dates (2006) for yellow-billed cuckoo surveys at sites near the junction of the Gila River Highway 95 Area.

Site Name	Survey Period 1	Survey Period 2	Survey Period 3	Survey Period 4
Gila 95 Bridge	6/13, 6/27	7/13	7/24, 8/07	no survey
Gila 95 Canal	6/13, 6/27	7/13	7/24, 8/07	no survey
Gila 95 Tall Tamarisk	6/13, 6/27	7/13	7/24, 8/07	no survey

Gila 95 Bridge (Elevation 44 m; 144 ft)

The Gila-95 Bridge site also borders the Gila River itself but it is on the west side of Highway 95 (Appendix 4). We surveyed the area from a dirt road with an agricultural field on one side and riparian habitat on the other. A large abandoned steel bridge crosses the river midway through the site. Habitat here is mostly tamarisk, but scattered cottonwoods and coyote willows form the top of the canopy. Canopy height is 10–12 m (33–39 ft). In 2006, there was no evidence of standing water within this site. This entire site is surrounded by desert upland habitat.

Gila 95 Canal (Elevation 54 m, 177 ft)

The Gila 95 Canal site is on the east side of Highway 95 and borders the Gila River on one side and a large citrus orchard on the other (Appendix 4). Parts of the site also lie adjacent to an intricate network of irrigation canals, although much of this habitat is monotypic tamarisk. Native riparian vegetation is fairly sparse, with mostly young cottonwoods and coyote willows. Canopy height is 8–12 m (26–39 ft). In 2006, there was no evidence of standing water within this site. It is entirely surrounded by desert upland habitat.

Gila 95 Tall Tamarisk (Elevation 45 m; 148 ft)

The Gila 95 Tall Tamarisk site runs parallel to Highway 95 and is approximately 300 m (984 ft) east (Appendix 4). It is composed entirely of tall tamarisk growing in a long narrow strip 8–12 m (26–39 ft) wide. The site is bisected by 3rd Street, which provides access to Dome Valley. Canopy height is 8–10 m (26–33 ft). In 2006, there was no evidence of standing water within this site. It is bordered by an irrigation canal on one side and sparse desert scrub on the other.

Gila River/Ligurta, AZ (Gila River)

The Gila River/Ligurta site is a very small patch of native riparian trees located approximately 35 km (22 miles) west of the Gila River/Quigley Pond Wildlife Management Area (WMA) and about 2 km (1.2 miles) north of the town of Ligurta (Figure 2.1; Appendix 4). It contains a small number of large cottonwood trees and a few large Goodding's willows with a dense understory of arrowweed. Canopy height is 8–10 m (26–33 ft). In 2006, there was no evidence of standing water within this site. It is surrounded on all sides by agricultural fields. Site elevation is 197 ft (60 m).

There have been no previous surveys of yellow-billed cuckoos at this site. We conducted four survey visits to the site in 2006 (Table 2.26); no yellow-billed cuckoos were detected.

Table 2.26. Dates (2006) for yellow-billed cuckoo surveys at the Gila River/Ligurta, Gila River/Wellton and Gila River/Quigley Pond Wildlife Management Area.

Site Name	Survey Period 1	Survey Period 2	Survey Period 3	Survey Period 4
Gila River/Ligurta	6/26	7/11	7/30	8/11
Gila River/Wellton	6/26	7/11	7/30, 8/11	8/11
Gila River/Quigley Pond WMA	6/14, 6/26	7/11	7/30, 8/11	no survey

Gila River/Wellton, AZ (Gila River)

The Gila River/Wellton site is a small patch of native riparian trees located approximately 25 km (16 miles) west of the Gila River/Quigley Pond WMA, about 5 km (3 miles) northwest of the town of Wellton (Figure 2.1; Appendix 4). The canopy is dominated by large mature cottonwoods and Goodding's willows, with a dense understory of tamarisk and arrowweed. Canopy height is 8–10 m (26–33 ft). In 2006, there was no evidence of standing water. The site is surrounded on all sides by agricultural fields. The elevation of this site is 64 m (210 ft).

There have been no previous surveys of yellow-billed cuckoos at this site. We conducted four survey visits to the site (Table 2.26), and detected a single cuckoo during the first survey period (Appendix 2). No cuckoos were detected during later surveys.

Gila River/Quigley Pond Wildlife Management Area, AZ (Gila River)

The Gila River/Quigley Wildlife Management Area, located in the Gila River floodplain approximately 6 km (4 miles) south of the U.S. Highway 8 Tacna exit (Figure 2.1; Appendix 4), is managed by the Arizona Game & Fish Department as wildlife habitat. The site includes a riparian restoration plot dominated by cottonwoods with a small number of willows in the understory. Adjacent to this is a larger section of mixed native-exotic habitat with a canopy of mostly young cottonwoods and willows, and a dense understory of arrowweed. Approximately 500 m (1640 ft) to the north is the Gila River itself, which is mostly dominated by tamarisk, with very few native trees. Canopy height is 8–14 m (26–46 ft). The Arizona Game & Fish Department routinely floods the restoration site; however, in 2006 there was no evidence of standing water within this site. The surrounding landscape consists of an intensively managed mosaic of agricultural fields. The elevation of this site is 67 m (220 ft).

In 2005, eight yellow-billed cuckoo detections occurred at this site. A pair was detected during one survey, with one cuckoo carrying nest material, but breeding was not confirmed (Johnson et al. 2006). We conducted six survey visits to the site in 2006 (Table 2.26), and detected a single cuckoo during the first survey period. This cuckoo was seen foraging in a cotton field on the edge of the restoration area (Appendix 2). Subsequent surveys yielded no further detections.

Summary of Cuckoo Breeding Status Results

Of our 180 yellow-billed cuckoo detections, we confirmed five breeding events by locating an active nest or observing juveniles (Table 2.27). The juveniles we found could not be easily linked to any particular adult parental birds. Yellow-billed cuckoos show evidence of cooperative breeding, so the mere presence of adults nearby does not confirm that these are the parents of a given juvenile. At the Cave Wash site in Bill Williams River NWR, a juvenile cuckoo was detected but no adults were found nearby; therefore, we cannot rule out the possibility that this juvenile hatched and fledged from a different site.

As noted in Chapter 1, cuckoos are secretive, difficult to detect, move over large areas, and can sometimes be found in areas outside of breeding habitats. Verifying that cuckoos are breeding in a particular patch thus requires finding young or a nest; most of our detections could not confirm breeding status. Cuckoos we detected were frequently only heard, and it was unclear on subsequent surveys if the same birds were being detected. In some cases cuckoos were detected in the same spot on subsequent surveys, but even then the two detections may represent different birds (especially at sites with larger or denser populations). It is likely that at least some individual birds were detected on multiple surveys. Given all of these confounding realities, the detections summarized in Table 2.26 should not be interpreted as a count of the number of birds present or the number of birds breeding at a site.

Table 2.27. Summary of breeding classifications for yellow-billed cuckoo detections in 2006 at all areas and sites along the Muddy, Virgin and White rivers in Nevada and the Colorado, Bill Williams, and Gila Rivers in Arizona and California.

Survey Area/Site	Breeder	Juvenile	Unknown	Total
Littlefield Bridge	0	0	0	0
Mesquite Bridge	0	0	0	1
Pahranagat NWR				
Pahranagat North	0	0	1	1
Pahranagat East	0	0	0	0
Pahranagat South	0	0	0	0
Pahranagat West	0	0	0	0
Total	0	0	1	0
Overton WMA				
Honeybee Pond	0	0	4	4
Overton North	0	0	0	0
Overton Tamarisk	0	0	0	0
Overton Wildlife	0	0	3	3
Total	0	0	7	7
Grand Canyon NP– Lake Mead National Recreation Area				
Spencer Canyon	0	0	0	0
RM 274.5	0	0	1	1
River Delta/RM 285.3	0	0	0	0
Cuckoo Beach	0	0	10	10
Iceberg Ridge	0	0	3	3
Chuckwalla Cove	2	1	12	15
Total	2	1	26	29
Lake Mohave Sites	0	0	0	0
Havasu NWR				
Pintail Slough	0	0	1	1
North Dike	0	0	0	0
Topock Marsh Restoration	0	0	0	0
Sacramento Wash	0	0	0	0
Havasu Tamarisk	0	0	0	0
Topock Tamarisk	0	0	0	0
Total	0	0	1	1

Table 2.27 (continued)

Survey Area/Site	Breeder	Juvenile	Unknown	Total
Bill Williams River NWR				
Cave Wash	0	1	26	27
Mineral Wash	0	0	15	15
Big Bend	2	1	16	19
Gibraltar Rock	0	0	8	8
Sandy Wash	0	0	14	14
Fox Wash	0	0	1	1
Mosquito Flats	0	0	17	17
Saguaro Slot	1	1*	8	10
Bill Williams River Marsh	0	0	12	12
Total	3	3	117	123
Cibola NWR				
Cibola North Restoration	0	0	0	0
Cibola Nature Trail Restoration	0	0	2	2
Cibola Eucalyptus Restoration	0	0	0	0
Cibola South Restoration	0	0	1	1
Cibola Cross River	0	0	0	0
Cibola East Side	0	0	0	0
Total	0	0	3	3
Picacho SRA	0	0	1	1
Imperial NWR				
Imperial Paradise	0	0	0	0
Imperial South Restoration	0	0	3	3
Total	0	0	3	3
Mittry Lake WMA/Pratt Restoration	0	0	0	0
Gila/Colorado River Confluence				
Colorado River	0	0	7	7
Gila River	0	0	2	2
Total	0	0	9	9
Yuma West Wetlands	0	0	0	0
Limitrophe Division				
Limitrophe Division North	0	0	6	6
Limitrophe Division South	0	0	0	0
Total	0	0	6	6
Gila River/Hwy 95	0	0	0	0
Gila River/Ligurta				
Gila River/Wellton	0	0	1	1
Gila River/Quigley Pond WMA	0	0	1	1
Total All Areas	5	4	171	180

Discussion

Yellow-billed cuckoos have historically been considered a common breeding species within extensive riparian forests throughout the lower Colorado River basin (Swarth 1905, Visher 1910, Phillips et al. 1964). In 1976, the estimated number of breeding cuckoo pairs along the lower Colorado River and its five tributaries was 846 (Groschupf 1987). Later studies found a 93 percent decline along the lower Colorado River between 1976 and 1986 and an estimated 71 to 75 percent decline on the Bill Williams River delta during the same period (Rosenburg et al. 1991).

Our yellow-billed cuckoo surveys in 2006 included most areas that were surveyed historically throughout the lower Colorado River basin; we recorded only 180 cuckoo detections. The vast majority of detections were from the Bill Williams River NWR and Grand Canyon NP/Lake Mead NRA; these two areas accounted for 100 percent of the confirmed breeders in 2006 (Table 2.26). The exact number of individuals in these areas is unknown, but these two areas clearly had the most yellow-billed cuckoos and, presumably, more and/or better breeding habitat. Both sites consist of extensive native riparian vegetation, although the Grand Canyon NP/Lake Mead NRA area habitat is much younger. The available habitat at the Cibola NWR, Imperial NWR, Mittry Lake WMA/Pratt Restoration, Gila River, and Limitrophe Division Area, where cuckoos were absent, few, or solitary, lacked multi-structure canopy, was dominated by exotic vegetation, had no standing water, or was noticeably fragmented or influenced by adjacent land practices (e.g., agriculture, urbanization).

Because of differences in survey methods, specific areas surveyed, and probable differences in the criteria used to estimate the number of individuals, it is not possible to make direct comparisons between our results and previous estimates of cuckoo numbers. Any declines that may have occurred are likely due to habitat alteration in the area, including the loss of riparian habitat, invasion of exotic species, and changes in adjacent land practices. See Chapter 6 for a discussion of some of the factors that may affect yellow-billed cuckoo distribution, abundance, and breeding along the lower Colorado River, as well as options to enhance cuckoo habitat in this region.

There were several patterns in our detections that reinforce the idea that cuckoos within the study area can readily move between sites and outside of breeding habitat, such that not every location where a cuckoo is found should be considered a breeding site. For example, the habitats at several sites where cuckoos were detected were far outside the range of normal within this region and were probably not suitable for nesting; birds found there were likely non-breeding “wanderers” or birds breeding elsewhere but foraging within the patch. Also, we had several one-time detections of single cuckoos at smaller sites—where we were unlikely to have missed a cuckoo that was present during the other surveys. We believe these cuckoos did not attempt to breed within these patches, but instead were either migrants or non-breeding individuals who were visiting the patch only temporarily.

Other Riparian Bird Detections

We detected and documented 190 additional species during our surveys in 2006, including local breeders and many neotropical migratory birds (Appendix 5). These species were observed before, during, or after our cuckoo surveys. Because the focus of our efforts was on detecting cuckoos, no effort was made to quantify the abundance of these additional species, nor to track down and verify any species that were not readily identifiable or obvious to the surveyors.

Chapter 3: Survey Methodology

The basic approach of this survey protocol—the use of broadcast vocalizations to elicit a response by resident yellow-billed cuckoos—was established in California in 1965 (Hamilton and Hamilton 1965). Since then the protocol has evolved as biologists have learned more about the cuckoo's breeding biology and behavior (Gaines 1974, Gaines 1977, Gaines and Laymon 1984, Laymon and Halterman 1985, 1987a, 1987b, 1989, Halterman 2005, Halterman et al. 2006). Refinements to the protocol have helped to maximize the likelihood of detecting cuckoos while minimizing survey time and costs. Although our current project was not intended to serve as a full evaluation and test of the cuckoo survey protocol, our results may be used to help further refine and develop specific hypotheses that can be tested in the future.

Tape playback survey techniques have proven advantageous in eliciting responses from many bird species, especially those that are secretive or nocturnal. It often increases the total number of birds seen or heard for a given species in comparison to a conventional census (Johnson et al. 1981), especially for species with low song activity (Robbins 1978). Playback has also been helpful in estimating population size and investigating avian social behavior and territoriality. Playback surveys have been used primarily during the breeding season to study the presence and distribution of many species (Glahn 1974, Griese et al. 1980, Sogge et al. 1997), but they have also been employed on wintering grounds (Koronkiewicz et al. 2006).

The use of playback recordings can however sometimes have unexpected consequences. Robbins (1978) found that the use of tape recordings during repeated visits over the breeding season can bias results, as birds may alter their habits or their territorial boundaries if they believe that there are competing members of the same species holding a territory nearby. Studies of the use of playback recordings to survey spotted owls (*Strix occidentalis)* suggest that if surveyed too often, some individuals and/or species may become less responsive (Forsman et al. 1977). Also, the use of playback recordings can attract some individuals away from their territories, as in elegant trogons (*Trogon elegans;* Taylor 1978), resulting in inflated population density estimates. As with other monitoring techniques, playback surveys assume a constant probability of detection over time and space (Pollock et al. 2002), and frequent violation of this assumption can bias efforts to compare results among different areas or studies.

The use of playback recordings in surveys of western yellow-billed cuckoos has increased the number of detections of this elusive and easily overlooked species (Hamilton and Hamilton 1965, Halterman et al. 2006). Cuckoos do not sing territorially, and they vocalize relatively infrequently. Little is known about the functions of the cuckoo's various calls, but it has been suggested that the *kowlp* call (used in playback surveys) may function as a spacing mechanism, and to communicate between mated individuals (Hughes 1999). Studies, mostly of eastern yellow-billed cuckoos (*Coccyzus americanus americanus*), have found that calls are most frequent during pair formation and nest building; calls continue through nesting, then become infrequent after the last young fledge (Hughes 1999). Unfortunately, little is known about whether cuckoos call more frequently when paired or unpaired, or if they call more frequently when solitary versus when they occur in higher densities. This lack of information complicates the interpretation of survey results.

Assessing the use of playback recordings for surveys to determine the presence and distribution of yellow-billed cuckoos can be challenging, especially due to the difficulty in finding and following individuals. As with any field survey protocol, there is no way to be absolutely certain that an area with no detections is unoccupied. This may be a particular challenge with yellow-billed cuckoos, which we have long suspected have a fairly low response rate; the standard survey method of using playback recordings may fail to detect all birds present in an area. In fact, it has been observed that some individuals known to be present in the area sometimes do not respond to the recordings (Halterman 2004, Johnson et al. 2004, 2005). During a test of playback survey methods using adult cuckoos with radio transmitters, Halterman (2004) found that only 30–50 percent (depending on breeding season stage) of the birds responded to the playback recordings.

Methods

To gain a better understanding of the efficacy of the yellow-billed cuckoo survey protocol, we compared patterns of cuckoo responses among sites and across the season to the number of playbacks, detection rates, and types of detections. We also examined whether the number of surveys conducted in an area increases the overall probability of detecting cuckoos at a site.

Our survey method involves broadcasting five consecutive playbacks of the cuckoo *kowlp* call spaced one minute apart. Cuckoo detections were categorized as either "unsolicited" if birds called before initiation of the playback or "solicited" if they occurred after a playback (i.e., in response to the playback). Cuckoo detections were also classified as "aural" if individuals were heard calling but were never seen, "visual" if birds were seen but not heard, or "both" if birds were heard and seen. See Chapter 2 for a complete description of the methods used to survey for yellow-billed cuckoos during this study.

Results

In 2006, across the lower Colorado River study region, the highest percentages of initial responses were either unsolicited or occurred after the first playback (Figure 3.1). The percentage of first responses decreased as the number of playbacks increased. However, most of the unsolicited responses occurred in the two areas with the largest number of yellow-billed cuckoos (Figure 3.2). Almost 65 percent of the unsolicited responses were in the Bill Williams River NWR, and 26 percent were in the Grand Canyon NP/Lake Mead NRA. The other unsolicited responses occurred at Imperial NWR, the Limitrophe North Site near Morelos Dam, and Cibola NWR.

The Bill Williams River NWR and Grand Canyon NP/Lake Mead NRA areas differ from other areas in the lower Colorado River region (Figure 3.3). Most detected responses in these two areas were unsolicited or took place after the first playback. In contrast, the initial responses of cuckoos in areas with apparent lower densities (totaling < 10 detections) tended to occur after more playbacks (Figure 3.3). We are limited in how these data can be analyzed because the actual density of cuckoos per area is unknown, but it appears that cuckoos are calling unsolicited or responding after one playback more often at sites where there are more cuckoos present. Presumably, the birds vocalize more frequently when conspecific neighbors are nearby, and rarely engage in spontaneous calling when few or no cuckoos are in the proximity.

Overall, the majority of cuckoo detections (72%) were solicited through playback at all study sites (Figure 3.4). The number of solicited detections peaked during the first half of July and then declined as the breeding season progressed; the number of unsolicited detections remained fairly constant.

Sixty-four percent of cuckoo detections (solicited and unsolicited) were aural (Figure 3.5), 27 percent were both heard and seen, and 9 percent were visual only. The ratio of aural to visual detections was similar during the early and middle part of the breeding season, but the proportion of aural detections declined substantially in August.

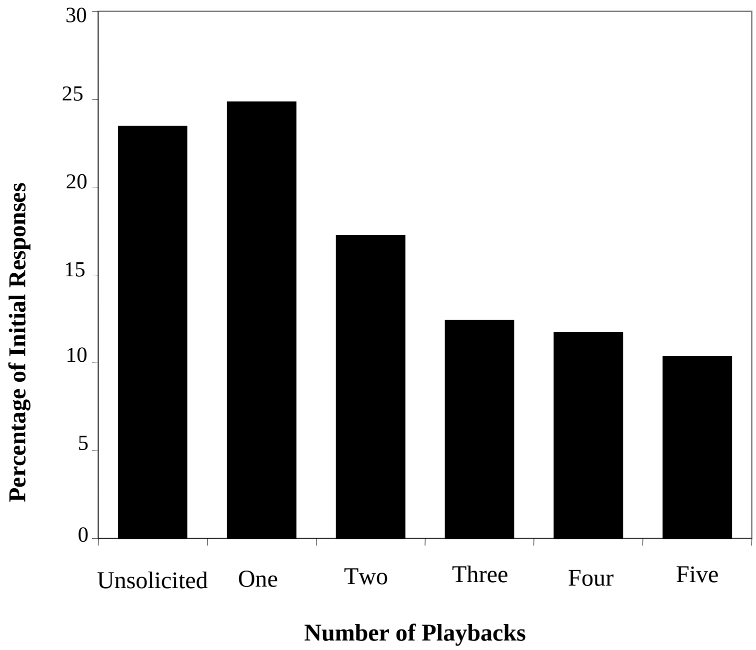

Figure 3.1. Percentage of times that yellow-billed cuckoos first responded to survey vocalization playbacks, based on sequential order of broadcast (180 total responses).

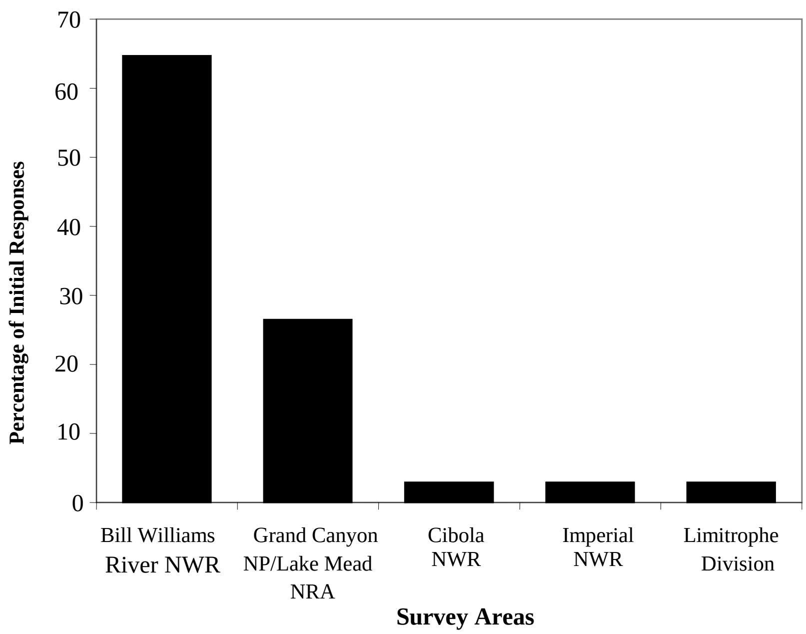

Figure 3.2. Percentage of unsolicited responses by yellow-billed cuckoos at individual survey areas (180 total responses). An unsolicited response is one in which the cuckoo vocalized prior to the first tape playback recording.

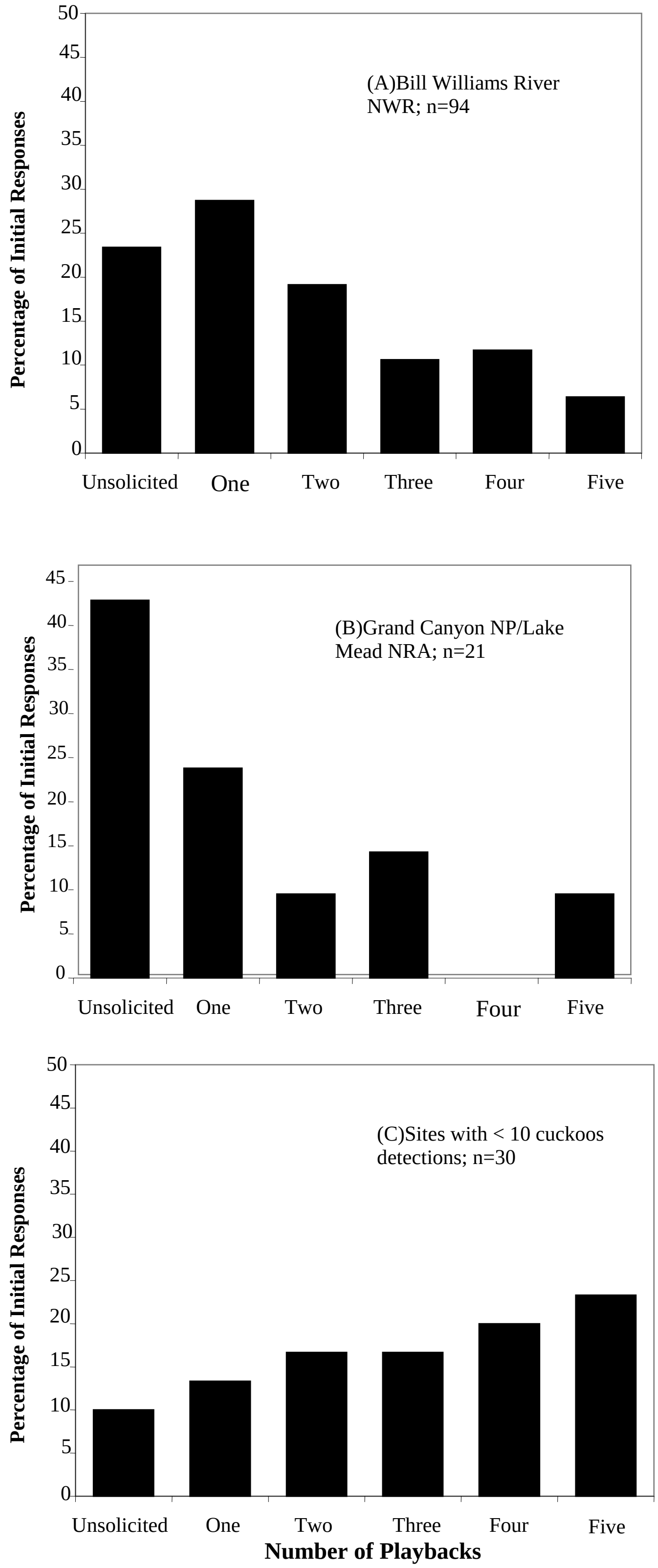

Figure 3.3. Percentage of times that yellow-billed cuckoos first responded to survey vocalization playbacks at (A) Bill Williams River NWR, (B) Grand Canyon NP/Lake Mead NRA and all sites with <10 detections, based on sequential order of response and detection types by season.

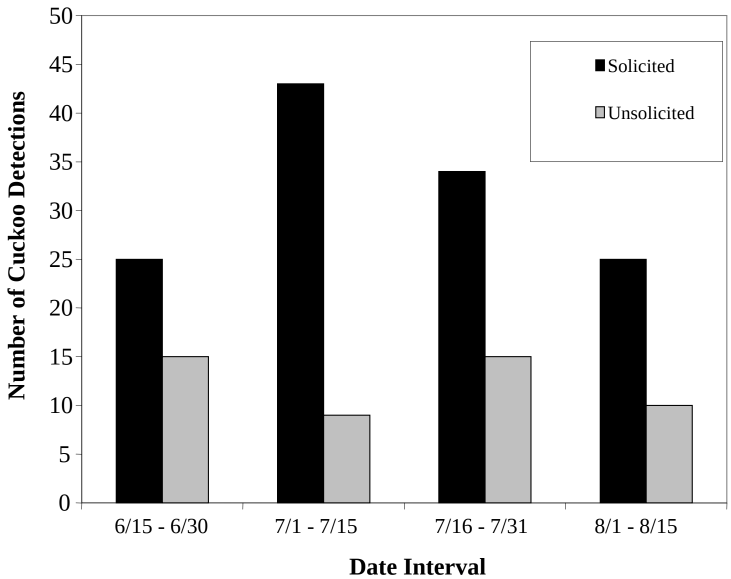

Figure 3.4. Number of yellow-billed cuckoo detections (solicited vs. unsolicited) by time period, from 15 June to 15 August 2006.

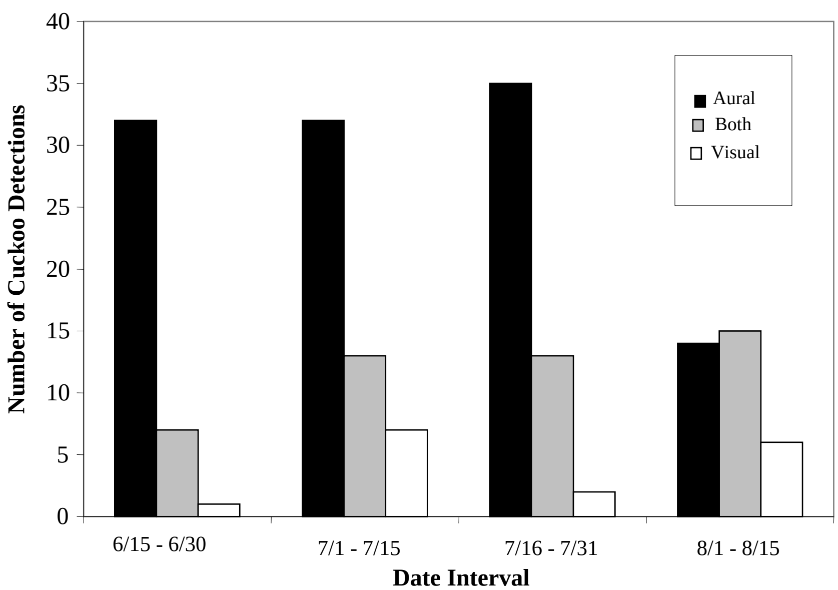

Figure 3.5. Number of yellow-billed cuckoo aural, visual, or both aural and visual detections by time period, from 15 June to 15 August 2006.

Discussion

Song playback is commonly used to survey for bird species that are not readily detected visually and to increase response rate compared to passive surveys. With secretive species, song playback is often the only way to survey efficiently, especially if natural rates of vocalization are low (Legare et al. 1999). The method is thus appropriate for yellow-billed cuckoos, which are secretive and not readily detected visually, and vocalize infrequently, especially in areas with low cuckoo densities (as evidenced during this study). We had difficulty detecting cuckoos when we tried to locate them without the use of playback, even during attempts to relocate recently detected cuckoos immediately after surveys were finished.

The number of playbacks required to solicit a response, which was variable, may be influenced by the abundance of cuckoos in an area. Nearest-neighbor distance has been shown to influence call response and duration in other species (Penteriani et al. 2002). In areas where we had the most detections (and presumably higher densities of cuckoos), cuckoos tended to call unsolicited or be first detected after the initial playback. In contrast, in areas with fewer cuckoos (< 10 detections), more detections were made after the third, fourth and final playback (Figure 3.3c). Repeated broadcasts at each point, at least up to the five playbacks we conducted, therefore increased the probability of a cuckoo being detected.

The probability of detecting secretive species such as the yellow-billed cuckoo may depend on season, stage of nesting, and sex of the bird(s) present. In a study of Bicknell's thrushes (*Catharus bicknelli*), birds called and sang consistently during the day in early to mid-June, but later in the season songs were infrequent and calls were concentrated at dawn and dusk (Rimmer et al. 1996). Some researchers have found that birds may be less likely to vocalize in response to playback after nesting has started (Sogge et al. 1997, Legare et al. 1999, Bogner and Baldassarre 2002), however Halterman (2005) found no noticeable decrease in vocalization frequency after nesting for two yellow-billed cuckoos that she tracked via telemetry throughout their nesting cycles. In contrast, we found that aural detections (both solicited and unsolicited) peaked somewhat during the middle of the breeding season, but dropped off across the season (Figure 3.4).

Even though broadcasting vocalizations generally increases cuckoo detections, no survey methodology can guarantee a detection probability of 1.0, especially on any given survey. Evidence that birds may be present but not responding includes our observation that on some occasions, no detections were made at a survey point during the broadcast and listening period but a cuckoo vocalized several minutes after a surveyor left a point (but was still close enough to detect the bird calling). Also, Halterman (2003, 2005) conducted a test of the playback survey method where a researcher carried out a normal survey while another researcher with telemetry equipment located and monitored the response of birds to playback. Only 50 percent of birds responded to the broadcast calls, suggesting that any single survey may miss half the birds present at a site.

The type of song a bird uses may vary through the season or throughout the year (Ritchison et al. 1988), and it may be possible to increase detection probabilities on any given survey by using different calls to elicit a response. The yellow-billed cuckoo has a diverse repertoire, which most commonly includes the *kowlp* call but also a variety of *kuks*, *coos*, and *rattles*. Playback during our surveys only used recordings of the *kowlp* call, and although this helps to ensure consistency across survey areas, it may fail to elicit responses in some birds.

Even though the probability of detection on any given survey of a site is less than 1.0, our data confirm that conducting multiple surveys within an area increases the probability of detecting resident cuckoos (i.e., individuals that are consistently in an area throughout the breeding season) as the breeding season progresses. Also, the more cuckoos present at a site the more likely that surveyors will correctly determine that the site is occupied.

Our technique of spatially mapping detections across multiple surveys allowed us to use the spatio-temporal pattern of detections to infer the probable status of the detected cuckoo(s). For example, a clump of detections, which includes confirmation of two individuals during at least one survey period, may be interpreted as belonging to a pair of cuckoos.

Survey Methodology Modifications for 2007

Based on our experience during the 2006 breeding season, cuckoos may be more responsive to playback during the second and possibly third survey periods. Therefore, in 2007 we will attempt (dependent upon logistical constraints) to increase the number of second and third period visits to selected sites to determine if this increases the probability of detecting cuckoos during the peak period of breeding. To initiate efforts at determining the relative effectiveness of “edge-based” surveys compared to those conducted from within a habitat patch, we will conduct comparative surveys of each type at several of our existing survey sites and quantify the cuckoo response under each approach. Due to logistical considerations, this can be done at only a few sites in 2007; however, it will allow us to begin building the sample size needed for a more robust comparison of the influence of survey point location.

Chapter 4. Habitat Vegetation Characteristics

To design an effective habitat restoration program under the Lower Colorado River Multi-Species Conservation Program, more information is needed regarding yellow-billed cuckoo habitat characteristics in this region. We currently know relatively little about the cuckoos' specific breeding requirements along the Colorado River; much of the quantitative information available on breeding habitat characteristics of western yellow-billed cuckoos comes from studies conducted in California (e.g., Gaines 1974, Laymon et al. 1997, Halterman 1991), where riparian habitat can be considerably different from Arizona. In the arid Southwest, yellow-billed cuckoos are primarily restricted to densely wooded rivers and streams and damp thickets with relatively high humidity (Corman and Wise-Gervais 2005).

Western yellow-billed cuckoos generally breed in large blocks of riparian habitat, particularly woodlands with cottonwoods and willows (Ehrlich et al. 1988, USFWS 2002a). Nesting cuckoos along the Sacramento River in California were estimated to need riparian habitat patches ranging from 10 to 40 ha (Gaines 1974, Laymon et al. 1997, Halterman 1991). Within riparian patches in California, dense understory foliage appears to be an important factor in cuckoo nest site selection, while cottonwood trees are an important foraging habitat (Laymon et al. 1997, USFWS 2002a).

Cuckoo surveys in Arizona from 1998 and 1999 (Corman and Magill 2000) found that occupancy rates (i.e., the percentage of sites surveyed that were occupied) were highest in cottonwood-willow-ash-mesquite habitat with less than 75 percent tamarisk. Mesquite bosque–hackberry habitat also had a relatively high occupancy rate. Yellow-billed cuckoos were much less common in sycamore-cottonwood (46% occupancy), sycamore-alder (33% occupancy), and more than 75 percent tamarisk habitats (33% occupancy). Surveys conducted by the Arizona Breeding Bird Atlas (Corman and Wise-Gervais 2005) found that 68 percent of the yellow-billed cuckoo observations were in lowland riparian woodlands, often containing a variable combination of Fremont cottonwood, willow, velvet ash, Arizona walnut, mesquite, and tamarisk.

Our objective was to improve the current knowledge of yellow-billed cuckoo habitat requirements specifically within the LCR MSCP study area by characterizing riparian habitat at the survey site–patch level. We sampled occupied and unoccupied sites in order to describe vegetation composition and structure, including characteristics of the canopy, and the distribution and density of woody species.

Methods

We considered this first year of data collection to be a pilot year during which to develop, assess, and refine our vegetation sampling study design and data collection. To develop field methodologies for vegetation sampling, we reviewed the sample designs and measurement techniques typically used in previous Western riparian bird-habitat studies. The majority of these studies used point-based sampling associated with point count survey locations, songbird territories, or nest sites (e.g., James and Shugart 1970, Noon 1981, Strong and Bock 1990, Martin et al. 1997, Saab 1999, Powell and Steidl 2000, Miller et al. 2003). We then evaluated potential measurement techniques based on our understanding of cuckoo habitat use and the physical features that might be most important in characterizing breeding habitat. For example, cuckoos have been observed using fairly large areas compared to typical songbird territories, so we selected point-based sampling measures that characterize riparian habitat at the survey site–patch level. Overall, measures were selected to provide data on vegetation composition and structure, the numbers and identities of plant species present in a sample site, and the relative abundance or importance of riparian woody species. We also documented general vegetation characteristics within sites by taking photographs at each vegetation plot (Appendix 6). Landscape-level measures of habitat attributes and measurement techniques were not addressed.

Vegetation Sampling Design

During 2006 we were primarily interested in characterizing vegetation at the site level and in comparing vegetation between occupied and unoccupied sites. The survey region was stratified north to south from the Grand Canyon to the United States/Mexican International border, and 11 areas were selected (Table 4.1) from the total list based on the presence of cuckoos (in 2005) and/or the feasibility of placing the microclimate data loggers (see Chapter 5) that were co-located with the vegetation sampling locations. For the preliminary analyses presented in this report, we focused only on the Grand Canyon NP/Lake Mead NRA, Bill Williams River NWR, and Cibola NWR sites.

Within study areas, vegetation sampling plots were located in both occupied and unoccupied survey sites. Sites were initially selected and classified as occupied or not based on 2005 yellow-billed cuckoo surveys (Johnson et al. 2006); sites were then reclassified after the field season. Sites were categorized as occupied if cuckoos were detected during two or more survey periods in 2006 and unoccupied if cuckoos were detected during only one or no survey periods.

Within sites, vegetation plots were centered on microclimate sampling locations that were selected in two ways: (1) At occupied sites, vegetation sampling locations included the estimated coordinates of cuckoo detection locations (see below) and one or more GIS-generated random points. (2) At unoccupied sites, locations included one or more random UTM coordinates generated from orthorectified aerial photographs of sites. In cases where random UTM locations were inaccessible or located in inappropriate habitat such as marsh, an alternate was selected by choosing a random compass bearing and a random distance to a new location. If the random distance could not be reached, the plot was established at the first patch of riparian vegetation along that compass bearing.

The cuckoo locations used to designate sampling locations in occupied sites were of three types: (1) UTM coordinates for perches of observed cuckoos (i.e., a cuckoo was observed and a UTM was recorded in the field, from the point below the perch). (2) Detections in 2006, where a surveyor

Table 4.1. Vegetation and microclimate study areas along the lower Colorado River and tributaries, 2006. Sites whose data were analyzed and presented in this report are marked with asterisks.

Study Areas	Plots in Occupied Sites	Plots in Unoccupied Sites
Pahranagat NWR	0	12
Overton WMA	3	0
Grand Canyon NP/Lake Mead NRA*	7	5
Havasu NWR	0	3
Bill Williams River NWR*	26	2
Cibola NWR*	4	9
Imperial NWR	1	0
Mittry Lake WMA/Pratt Restoration	0	8
Gila/Colorado Rivers Confluence	7	8
Yuma West Wetlands	0	3
Gila River/Quigley Pond WMA	0	2

returned to the survey location from where the cuckoo was detected, followed the stated bearing and distance until the approximate location of the bird was reached, and recorded the UTM for the plot center. (3) GIS-based estimates of cuckoo locations from 2005 detections. For example, if a cuckoo was detected from a known location in the Cibola NWR in 2005, and estimated to be 50 m away at a 200 compass bearing, we used GIS to determine the UTM coordinates for the estimated location.

There were four sampling subplots—main, 100 m, 50 m, and 30 m (Figure 4.1)—within each vegetation sampling plot. The main subplot was located directly beneath the microclimate (HOBO) sensor coordinate. The first subplot was 100 m away from the main subplot's center, on a randomly chosen bearing (but constrained so that the subplot fell within riparian vegetation). The second subplot was 50 m away from the main subplot, on a bearing 120° from the bearing to the first subplot. The third subplot was 120° from the second subplot, and 30 m from the center of the main subplot. We sampled vegetation characteristics within both 5 m and 11.3 m radii circles (the former nested within the latter) at each of the four subplots.

Vegetation Measures and Measurement Techniques

Vegetation sampling was conducted during August and September of 2006. Within each subplot, we measured the density of woody species, canopy cover, ground cover, average top canopy height, and litter depth. We recorded the woody species density because they are functional and structural dominants in most riparian systems. We counted the stems of each species encountered (within size classes) within each 5 m and 11.3 m circle. Smaller size classes (< 2.5 cm, 2.5–8 cm at 10 cm above ground, < 8 cm dbh) were counted within the 5 m radius circle and larger size classes were counted within the 11.3 m radius circle. We also made a set of measurements based on the point-centered quarter method (Mueller-Dombois and Ellenberg 1974) for estimating densities of plants. Standing at the center of the subplot, the nearest live tree, live shrub, and snag (dead tree) were located within each of the quarters of the circle. We recorded the distance to each, the height, the maximum width and perpendicular width of the crown, the species, and canopy cover (using a spherical densiometer).

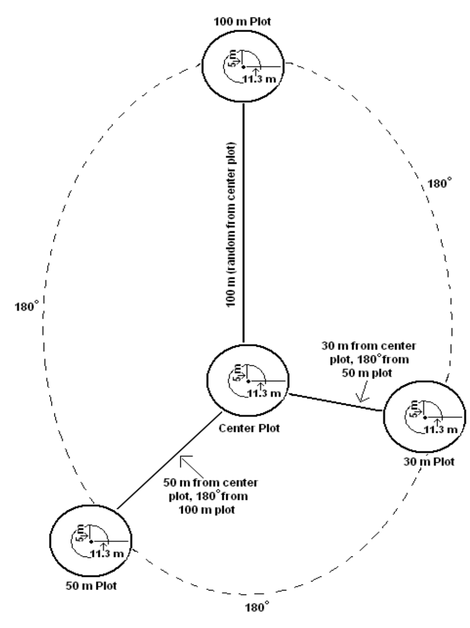

Figure 4.1. Layout of vegetation subplots used to characterize yellow-billed cuckoo habitat in occupied and unoccupied sites.

Cover was estimated as the vertical projection of vegetation from the ground, as viewed from above. We used a spherical densiometer for measuring total canopy cover (which includes the high canopy), and from that made a visual estimate of the high canopy cover (i.e., the percent total canopy cover above 5 m in height). Eight measures (four each of total canopy and high canopy) were taken at the center of each vegetation subplot, standing at the center point and facing each of the cardinal directions. Counts from the densiometer were converted, after the field season, using the formula

$$\frac{\text{number of covered dots}}{96} \times 100 = \text{percent canopy cover.}$$

We also recorded the dominant and co-dominant plant species in the canopy and the percentage of the canopy accounted for by each species. We defined a dominant species as one that accounted for at least 40 percent of the high canopy (visually estimated) within the 11.3 m radius subplot. Two species were considered co-dominant when each accounted for $\geq$ 40 percent of the high canopy present. If no single plant species comprised $\geq$ 40 percent of the high canopy, there were no dominant species.

Average top canopy height was measured using a clinometer based on a point in the canopy that represented the estimated average height of the top canopy within the 11.3 m main subplot; lone trees that emerged far above the main canopy were not considered when estimating this average.

We made ocular estimates of ground cover within each 5 m radius circle, for each of the following vegetation classes: all green vegetation, grass, sedge, shrub, dead woody vegetation, forb, cactus, moss, leaf litter, rock, log, marsh vegetation, water, and bare ground. The percent cover of each class was estimated independently of all other vegetation types (i.e., as if other vegetation types were absent). Thus, vegetative cover categories could sum to more than 100 percent because of vertical stratification of plant layers.

We measured litter depth to the nearest millimeter at 2 m intervals along ropes that divided the 5 m radius circular subplot into quadrats (one 10 m rope placed north to south, with litter depth measured at 0 m, 2 m, 4 m, 6 m, 8 m, and 10 m; one rope placed east to west). Thus, litter depth was measured at 12 points, and then averaged for the subplot.

Given that 2006 was the pilot year for this study, our preliminary analyses focused on comparing patterns in woody plant structure and density in occupied and unoccupied sites. In doing so, we combined woody species into structurally similar categories (i.e., cottonwood, willow, mesquite, and tamarisk). Within the willow category, all plants in the larger size classes (> 23 cm dbh) and most in the smaller size classes (< 23 cm dbh) were Goodding's willow; a few small coyote willow were grouped in the latter, as they are structurally similar when of this size. The mean total stem count for occupied and unoccupied sites was then calculated for each of three geographical areas: the Grand Canyon NP/Lake Mead NRA, Bill Williams River NWR, and Cibola NWR. All sampling plots were a fixed size; thus, mean abundance also represents the relative density of each area.

None of the areas included in these preliminary analyses had any woody plants in the 2.5–8 cm diameter at 10 m height category. The shrub/sapling size classes were therefore combined to examine patterns in the distribution of shrubs/saplings among the areas and within areas. Mean total shrub and sapling counts for areas were derived by summing counts in both size classes for each vegetation subplot and calculating the mean count per subplot (i.e., density) for each site, and the mean for the sites within each of the six areas. Likewise, the mean density of shrubs and saplings was calculated for occupied and unoccupied sites, for each area.

Results

The following results are based on exploratory analyses of a subset of data from the initial pilot year of the study. Therefore, these results are preliminary, and are intended for use in identifying areas for further study or refinement of our vegetation study design and sampling methods. Additional data collection in 2007 will yield further insights, and may lead to changes in the patterns described below.

Characteristics of the Canopy

Total canopy cover was higher at occupied sites than at unoccupied sites. This difference is attributed to more mid and lower canopy cover, as high canopy cover (i.e., the percent total canopy cover above 5 m in height) did not differ between the occupied and unoccupied sites (Table 4.2).

Table 4.2. Mean percent canopy cover (and standard error) at all sites sampled.

	Occupied Sites (n = 80)	Unoccupied Sites (n = 120)	p value
Total Canopy Cover	51 (3.8)*	41 (2.9)	.044
High Canopy Cover	19 (3.2)	19 (2.4)	.968

Density of Woody Species

Mean total density of trees (i.e., mean total stem count, including all tree size classes) at occupied and unoccupied sites varied across the three geographical areas (Figure 4.2). Within each area, occupied sites had lower total densities of trees than did unoccupied sites.

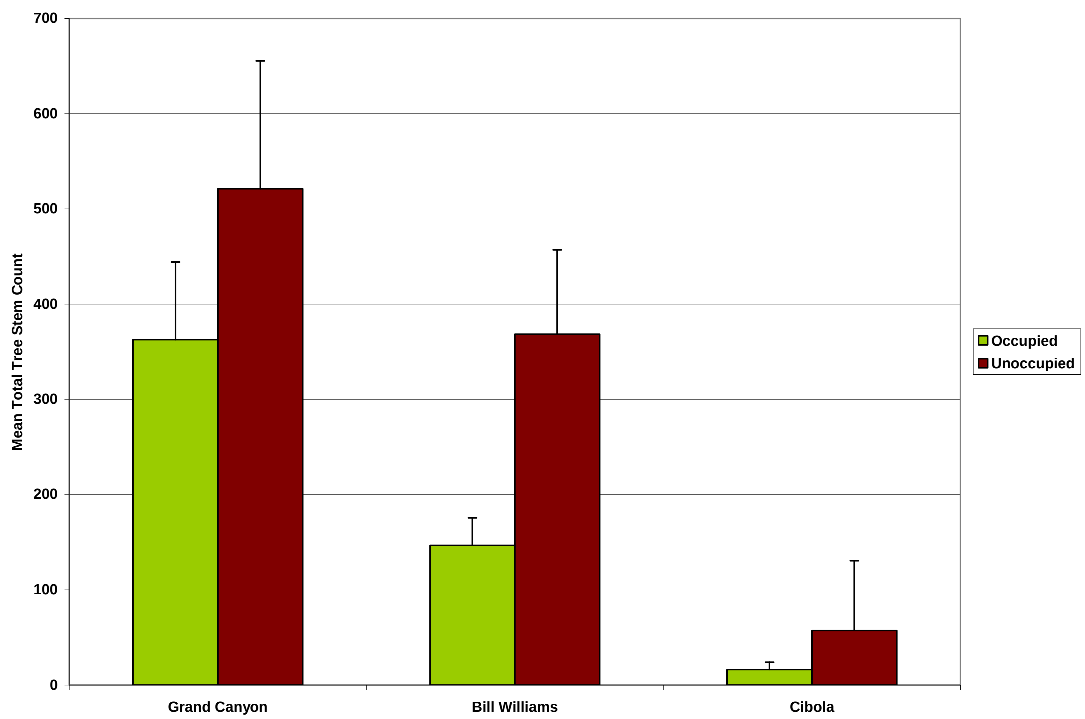

Figure 4.2. Mean tree densities for occupied (green bars) and unoccupied (red bars) yellow-billed cuckoo sites, within three geographic areas. Lines above each bar represent the standard error of each mean.

Patterns of tree abundance and size class (cm dbh) distribution in occupied and unoccupied sites differed across the areas (Figure 4.3). At all three sites, trees in the smallest size class were most abundant and there were few trees over 23 cm dbh. Small trees were particularly abundant at the Grand Canyon NP/Lake Mead NRA and Bill Williams River NWR areas, where unoccupied sites had higher tree densities than occupied sites. At the Cibola NWR, overall tree density was low; unoccupied sites were considerably denser, due almost entirely to the number of trees in the smallest size class (Figure 4.3).

The Cibola and Grand Canyon NP/Lake Mead areas were characterized by overall denser understories of shrubs and saplings than found in the Bill Williams River NWR (Figure 4.4). In the Cibola NWR cuckoos were detected in locations with relatively sparse understory, with low densities of woody species in the shrub and sapling size class. Within the other two areas, occupied sites had denser understories on average than unoccupied sites (Figure 4.4).

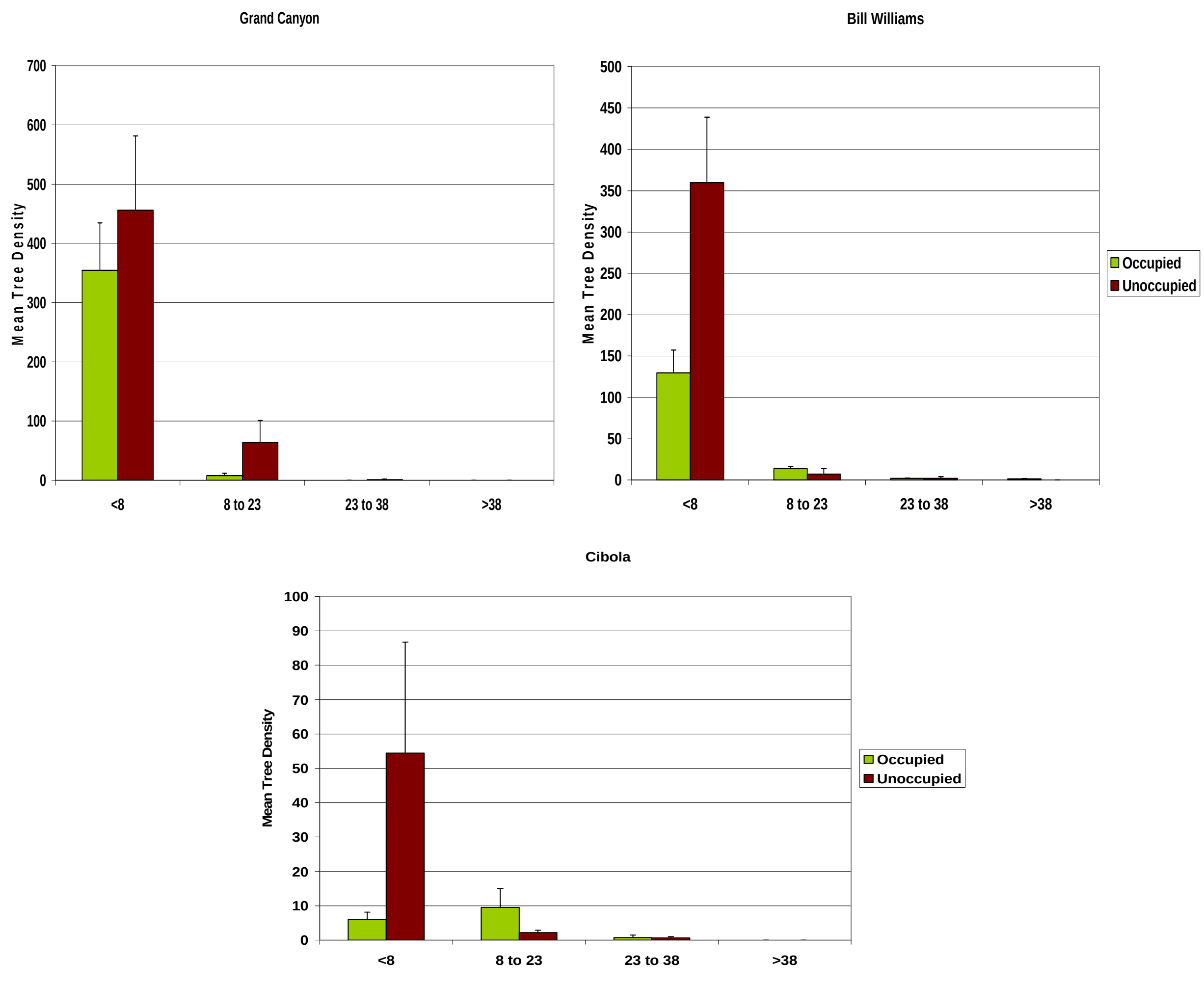

Figure 4.3. Mean tree densities in different size classes (< 8, 8–23, 23–38, and > 38 cm dbh), for occupied (green bars) and unoccupied (red bars) yellow-billed cuckoo sites within three areas. Lines above each bar represent the standard error of each mean.

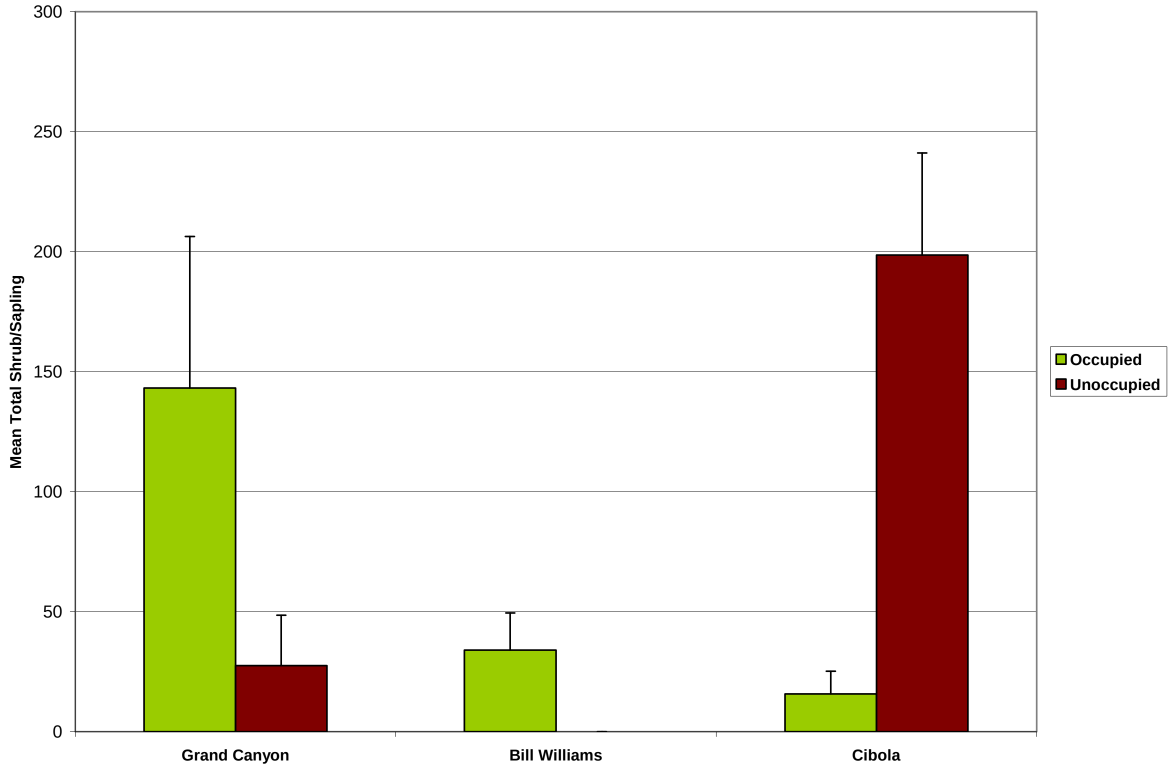

Figure 4.4. Mean shrub/sapling densities for occupied (green bars) and unoccupied (red bars) yellow-billed cuckoo sites, within three areas. Lines above each bar represent the standard error of each mean.

We also examined patterns in the distribution and abundance of the dominant trees found in the study areas (occupied and unoccupied sites combined). Among all the vegetation sampling areas, tamarisk was by far the most common tree; willow was the second most commonly recorded tree, and cottonwood and mesquite trees were encountered fairly equally during sampling. Small tamarisk trees (< 8 cm dbh) comprised the most abundant (Table 4.4) species and size class.

The distribution and abundance of woody trees within size classes varied across the study areas (Figure 4.5). The Grand Canyon NP/Lake Mead NRA sites had the densest trees, mostly tamarisk and willows in the smaller sizes. The Bill Williams River NWR area had, on average, relatively more large willows than the other areas. The Cibola NWR area is mainly tamarisks in the smallest size class and cottonwoods of 8–38 cm dbh (Figure 4.5).

Table 4.3. Number of each tree species encountered, by dbh size classes, during vegetation sampling at all yellow-billed cuckoo study areas in 2006.

	Size Class (cm dbh)				
Tree	< 8	8–23	23–38	> 38	Total
Cottonwood	264	256	58	15	799
Mesquite	771	50	4	0	781
Tamarisk	9,742	487	106	49	10,224
Willow	2,828	630	78	73	3597

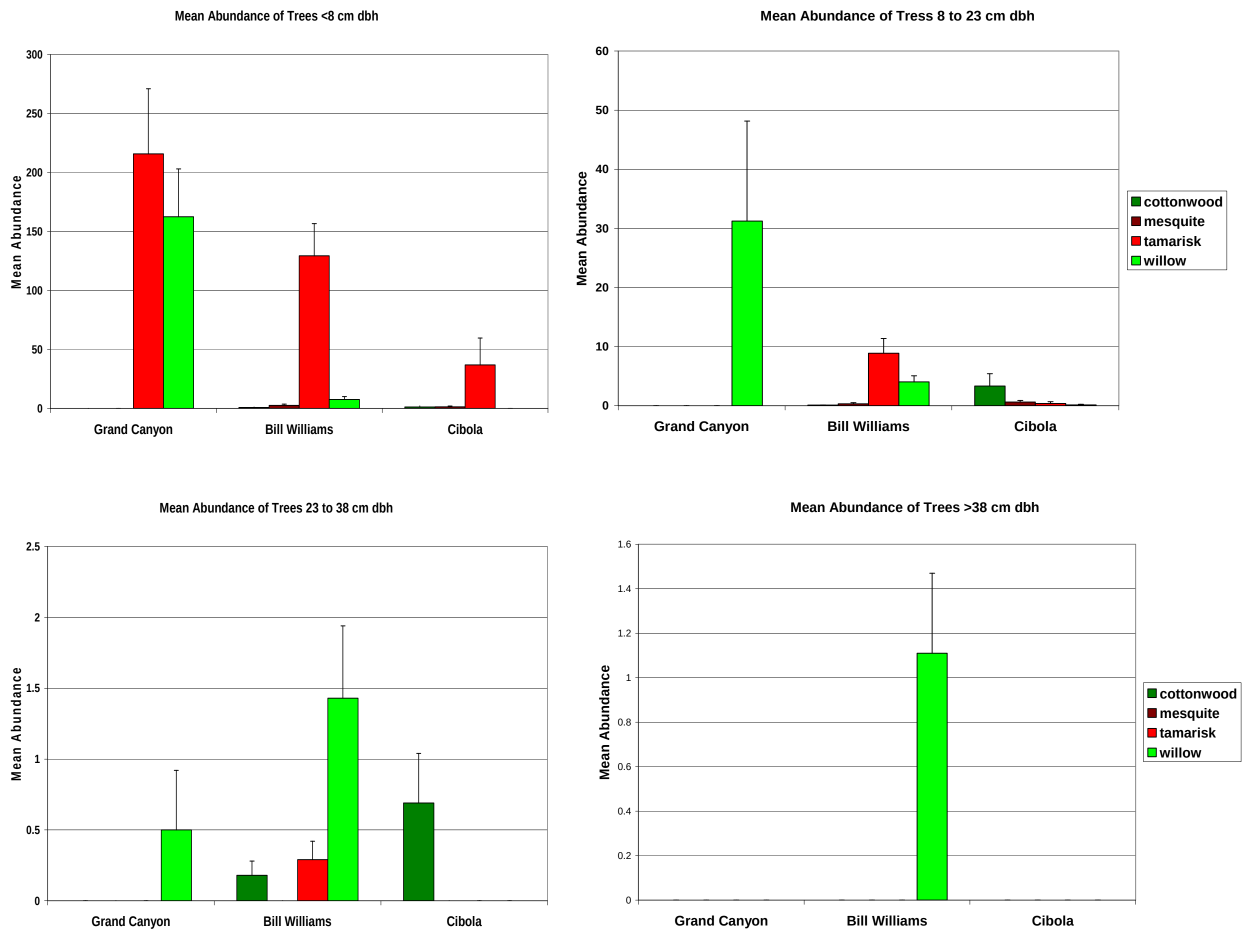

Figure 4.5. The mean abundance of trees of differing size classes at three yellow-billed cuckoo study areas, occupied and unoccupied sites combined, 2006. Note that the abundance scale (y axis) is different for each size class. Lines above each bar represent the standard error of each mean.

The average density of each of the most abundant trees (cottonwood, willow, and tamarisk) for occupied and unoccupied locations varied among study areas. Cottonwoods in the two smallest size classes were found in much greater densities in occupied sites at the Cibola NWR, compared to unoccupied sites (Figure 4.6). The Grand Canyon NP/Lake Mead NRA sites had no cottonwoods.

Occupied sites tended to have higher average densities of willows in the smallest size class. The Grand Canyon NP–Lake Mead area had many dense willows less than 8 cm dbh, particularly in occupied sites. Larger willows (> 23 cm dbh) were found only at Bill Williams River NWR (Figure 4.7).

Tamarisk, especially in the smaller size classes, was widespread and abundant across the study region. Within the three areas, occupied sites had lower densities of small tamarisk, than unoccupied sites. This pattern is particularly evident in the areas that had relatively dense small tamarisks, including Bill Williams River NWR and the Grand Canyon NP/Lake Mead areas. Larger tamarisks (> 8 cm dbh) were recorded almost exclusively in occupied sites at Bill Williams River NWR (Figure 4.8).

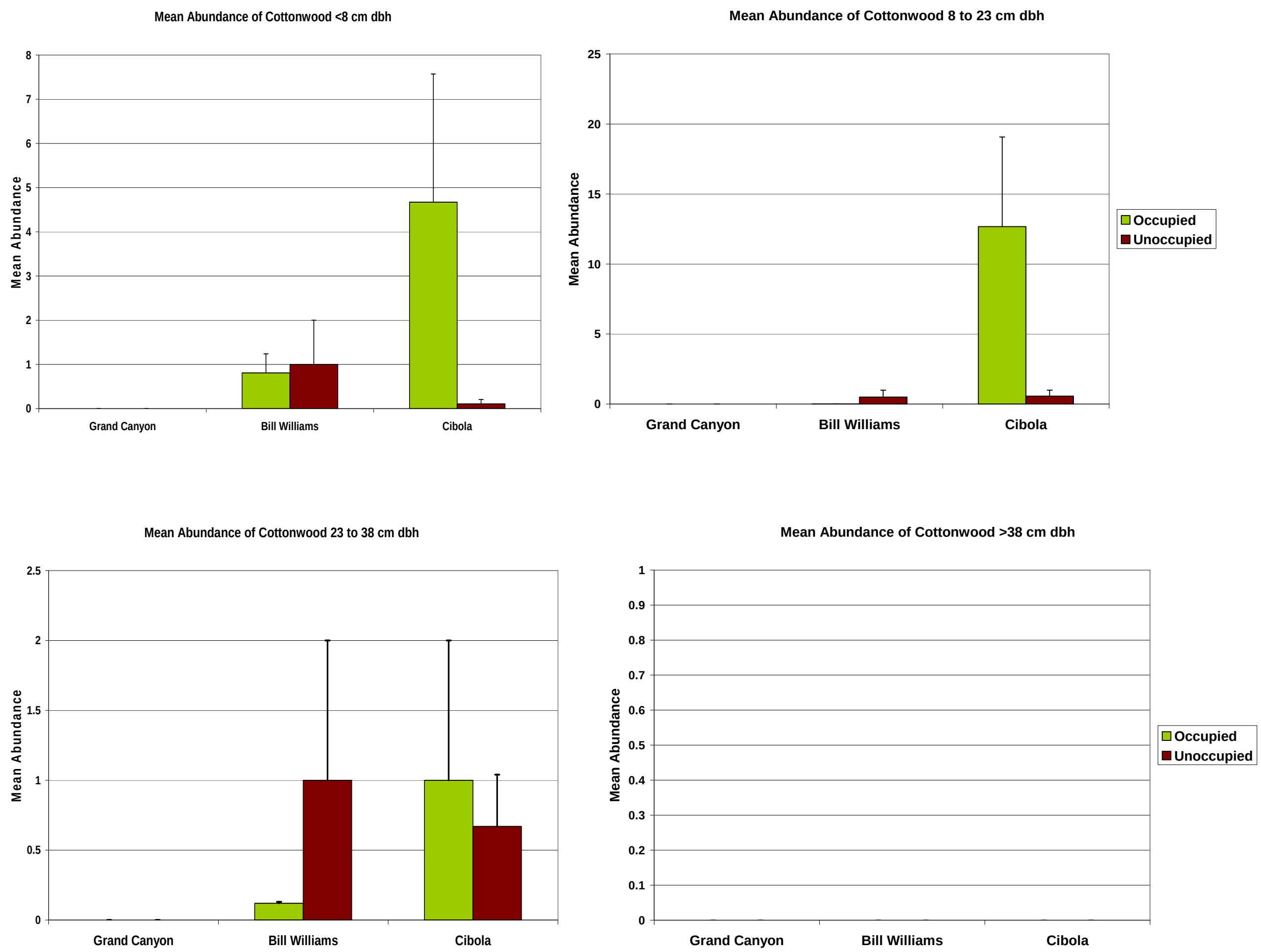

Figure 4.6. Mean cottonwood abundance, by size class (cm dbh), of occupied (green bars) and unoccupied (red bars) sites in three yellow-billed cuckoo study areas. Lines above each bar represent the standard error of each mean.

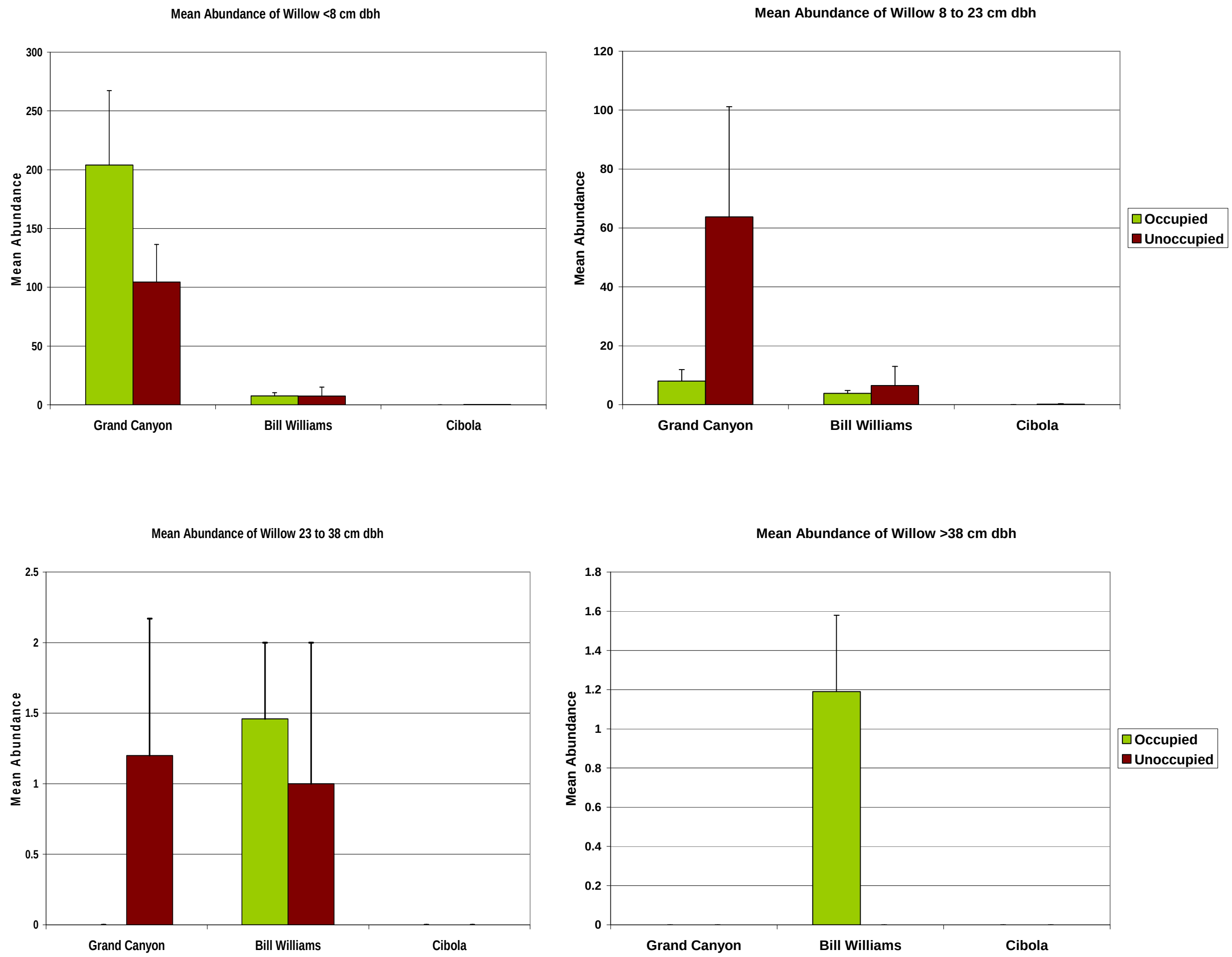

Figure 4.7. Mean willow abundance, by size class (cm dbh), of occupied (green bars) and unoccupied (red bars) sites in three yellow-billed cuckoo study areas. Lines above each bar represent the standard error of each mean.

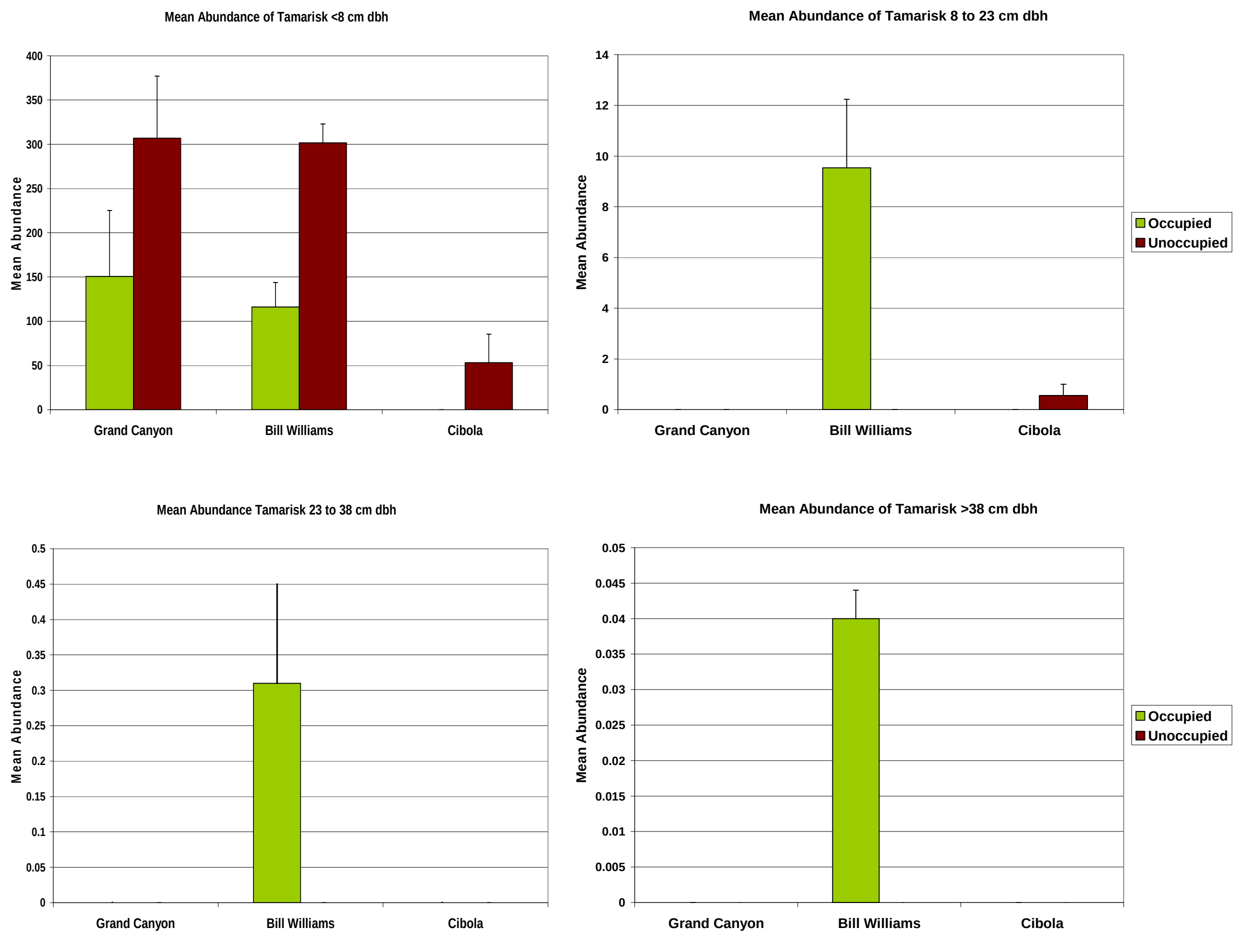

Figure 4.8. Mean tamarisk abundance, by size class (cm dbh), of occupied (green bars) and unoccupied (red bars) sites in three yellow-billed cuckoo study areas. Lines above each bar represent the standard error of each mean.

Discussion

Our preliminary analysis of the vegetation data collected in 2006 focused on general patterns in the distribution and abundance of woody species within riparian habitats of the study region, including comparisons of occupied and unoccupied yellow-billed cuckoo survey sites. As noted earlier, this is a pilot year for vegetation analysis and the patterns observed in 2006 are preliminary; data from the upcoming 2007 season will provide additional insights.

The density and composition of woody riparian vegetation varied considerably among the study areas. Much of the variation in tree density was due to the patterns of abundance of trees in the smallest size class (< 8 cm dbh). Differences in the woody plant species composition and vegetation physiognomy between native cottonwood/willow- and tamarisk-dominated habitats can lead to fundamental differences in structure, such as gallery forests versus riparian scrub or thicket habitats (Busch and Smith 1995).

The dominant tree species at our cuckoo survey sites were cottonwood, willow, and tamarisk. Tamarisk was the most common tree, due to the abundance of small (< 8 cm dbh) individuals. Larger trees were usually cottonwoods or willows, probably due to their morphology. Mesquite was not regularly encountered because most sampling occurred within riparian vegetation, with very few samples from adjacent habitat types, including mesquite.

The Bill Williams River NWR sites have relatively more large willows. The Grand Canyon NP/Lake Mead NRA sites had the densest trees, mostly tamarisk and willows in the smaller size classes. The Cibola NWR is primarily a restoration site with planted native trees, and in general it does not resemble a “natural” riparian area (e.g., the cottonwoods were planted in rows). The area supports primarily tamarisks in the smallest size class and cottonwoods of 8–38 cm dbh.

When occupied and unoccupied sites were compared, occupied sites tended to have higher average canopy cover, attributable to higher average cover of the mid and low canopy. The dominant canopy at occupied sites was most often primarily cottonwood or willow trees. In addition, occupied sites in most areas had lower than average total tree density whereas unoccupied sites were denser than average. When densities of trees in different size classes were compared between occupied and unoccupied sites within areas, it appeared that cuckoos did not use areas with the highest density of small trees (< 8 cm dbh), mostly tamarisk.

These results correspond with those of Corman and Magill (2000), who found that western yellow-billed cuckoo occupancy rates in Arizona were highest in sites dominated by native tree species, including cottonwood, willow, ash, and mesquite. Yellow-billed cuckoos were much less common in habitats with more than 75 percent tamarisk cover. Other studies of the western yellow-billed cuckoo in California found that dense understory foliage appears to be an important factor in nest site selection (Laymon et al. 1997, USFWS 2002a), and this may be an important factor in habitat selection in our study sites as well. In addition, there may be a threshold of tree density, beyond which cuckoos select less dense sites. The influence of understory density and overall tree density will be further examined following the 2007 field season.

Chapter 5: Microclimate Analysis

Large-scale transformation of the riparian ecosystem along the lower Colorado River has produced extensive areas that are no longer suitable for breeding yellow-billed cuckoos. Because of this, previous surveys (e.g., Corman and Magill 2000, Johnson et al. 2006) were conducted only in habitat that initially appeared suitable for cuckoos. Within suitable sites, however, occupation likely depends on both the presence of appropriate habitat structure and suitable microclimatic conditions. The Lower Colorado River Multi-Species Conservation Program calls for the creation of 4,050 acres of yellow-billed cuckoo breeding habitat, including 1,350 acres created specifically for cuckoos (Lower Colorado River Multi-Species Conservation Program 2004). Characterization of vegetation within currently occupied sites will help guide cuckoo habitat restoration and creation; however, cuckoos may select breeding habitat or nest sites based on specific microclimatic conditions (Hamilton and Hamilton 1965). Therefore, we designed a method to characterize the microclimate at occupied and unoccupied yellow-billed cuckoo survey sites, and collected preliminary data during the 2006 season.

Although factors such as nest predation and food limitation undoubtedly affect nest site selection (Martin 1995), the non-random distribution of nests in dense vegetation highlights the possible importance of microclimate, as nest placement will determine the extent of protection from wind and excess diurnal heat gain from solar radiation (Walsberg 1985, Gloutney and Clark 1997). Hamilton and Hamilton (1965) suggested that yellow-billed cuckoo nests in the Southwest are restricted to river bottoms because these areas are humid. Walsberg (1985) noted that egg dehydration is sensitive to the hydric microclimate to which the egg is exposed, and is primarily determined by nest humidity. Ultimately, factors such as predation, foraging sites, and favorable microclimate are not mutually exclusive and may interact in the selection of nest sites (Holway 1991).

In developing our methodology, all of the bird microclimate studies that we reviewed focused on characterizing the microclimate at nest locations rather than at the habitat patch level. Because yellow-billed cuckoo nests are very hard to find, and the focus of our 2006 surveys was on finding cuckoos rather than nests, we knew that a nest-based approach would not be feasible. However, given that there have been virtually no quantitative studies of even the most basic aspects of yellow-billed cuckoo habitat microclimate, a logical and useful starting point was to work at the habitat patch scale. It is reasonable to hypothesize that microclimate may differ between riparian habitats that are used or not used by cuckoos, so we focused in 2006 on comparing occupied and unoccupied cuckoo habitat is a first step towards understanding how microclimate affects habitat use within the riparian matrix.

Ambient shade temperature is the most logical variable to measure in relation to occupied and unoccupied habitat. Summer temperatures along the lower Colorado River may approach 50° C (122° F), which can subject birds to severe heat loading. Other key microclimate properties are wind, radiation, and humidity. We examined how temperature and relative humidity varied between occupied and unoccupied sites, and we compared soil moisture at these same locations since this may affect the presence of cicada nymphs (Andersen 1994), which can be a very important food resource for cuckoos (Rosenberg et al. 1982). Finally, vegetation measurements (described in Chapter 4) were taken at microclimate sampling locations in order to relate microclimate variables to vegetation structure and species composition.

Methods

We conducted microclimate analyses to investigate the correlation between cuckoo presence and microclimatic conditions. Due to logistical considerations, we stratified our LCR MSCP survey region from north to south and selected 11 areas from the total list based on the presence of cuckoos and/or feasibility for the placement of microclimate data loggers (Table 5.1).
We collected microclimate data at both occupied and unoccupied study sites. Sites were initially selected and classified as occupied or not based on 2005 yellow-billed cuckoo surveys (Johnson et al. 2006); sites

were then reclassified after the field season. Sites were classified as occupied if cuckoos were detected during two or more survey periods in 2006 and unoccupied if one or fewer cuckoos were found. For microclimate analysis purposes, sites with only a single detection were categorized as unoccupied because we believe that the cuckoos found at these sites were likely foraging away from their breeding sites, or were migrants or "wanderers" that do not breed within the detection area. Also, these single detections frequently occurred at sites where the habitat did not have the general characteristics considered important for breeding cuckoos.

Loggers were placed in the field during July and August and were removed during September and October. Our intended deployment in June did not occur due to delays in equipment purchases. Each logger was programmed to record an event (T/RH reading) every 6 minutes for 90 days. Twenty-five microclimate data loggers were deployed from the Bill Williams River NWR north, and 35 were deployed to the south, for a total of 60. Data loggers were placed in occupied or unoccupied patches within the 10 microclimate data collection areas as described below.

At unoccupied sites, loggers (n = 38) were typically placed in mixed native-exotic habitat or exotic habitat, but still within the riparian floodplain. Aerial photographs for each study site were used to identify habitat boundaries, and data logger locations were assigned to random UTM coordinates. These coordinates were located in the field with GPS, and a logger with housing was then deployed within vegetation at 3 m high (the mean nest height for yellow-billed cuckoos in this habitat; Halterman 2003). In cases where random UTM locations were inaccessible or located in inappropriate habitat such as marsh, an alternate was selected by choosing a random compass bearing and a random distance to a new location. If the random distance could not be reached, the data logger was deployed at the first suitable patch of vegetation along that compass bearing.

At occupied sites, loggers (n = 22) were initially deployed based on estimates of cuckoo locations from surveys conducted in 2005. We deployed data loggers as new cuckoos were detected throughout the 2006 field season. For both 2005 and 2006 detections, loggers were placed at the approximate locations of detected cuckoos, based on the estimated bearing and distance from a surveyor to the cuckoo. As with the unoccupied locations, loggers (HOBOs) in occupied locations were hung at a height of 3 m.

Table 5.1 Microclimate study areas along the lower Colorado River and adjacent locations (2006). Sites whose data were analyzed and presented in this report are marked with asterisks.

Study Areas	Plots in Occupied Sites	Plots in Unoccupied Sites
Pahranagat NWR	0	12
Overton WMA	3	0
Grand Canyon NP/Lake Mead NRA*	7	5
Havasu NWR	0	3
Bill Williams River NWR*	26	2
Cibola NWR*	4	9
Imperial NWR	1	0
Mittry Lake WMA/Pratt Restoration	0	8
Gila/Colorado Rivers Confluence	7	8
Yuma West Wetlands	0	3
Gila River/Quigley Pond WMA	0	2

Temperature and Relative Humidity

Temperature (T) and relative humidity (RH) were both recorded with HOBO Pro RH/Temp data loggers (Onset Computer Corporation, Pocasset, MA). HOBO loggers can be programmed to collect T (50° to –30° C, accurate to ± 0.2° C at 21° C) and RH (0–100%, accurate to ± 3%) data at specified intervals. To protect each data logger from direct solar radiation, HOBOs were deployed in the field using a cost-effective method developed by McLeod et al. (2005). Each logger, operating under identical field conditions, was housed in a small, inverted plastic container with a sheet of shade cloth covering the top. The open bottom of the bowl was also covered with shade cloth to ensure that the HOBO was sampling free-flowing air, and thus could accurately measure T/RH. To ensure accuracy, we compared readings from HOBOs within our housings to those from the data loggers housed within Onset's Solar Radiation Shields; we found almost no detectable difference (i.e., 0.5° C difference). Therefore, all data loggers were deployed within our homemade housings.

Soil Moisture and Canopy Cover

We measured soil moisture at each of the survey areas (listed in Table 5.1) using an ML2x ThetaProbe with a type HH2 ThetaMeter type (Delta-T Devices Ltd., Cambridge, UK). This instrument recorded percent volumetric water content to an accuracy of ± 1%. Soil moisture was recorded directly below each HOBO and also at distances of 1.0, 2.0, and 3.0 m from this spot in each cardinal direction, such that 13 soil moisture readings were associated with each location, although at some locations dense vegetation or hard soil prevented us from collecting all 13 soil moisture readings. Soil type on the ThetaMeter was set to mineral soil, and measurements were taken at a depth of 60 mm. McLeod et al. (2005) noted that for very high or very low voltage readings, the ThetaMeter reports volumetric soil moisture as above or below the table, respectively. To eliminate these qualitative readings, we recorded soil moisture in terms of voltage (mV), and later converted these values to percent soil moisture. Soil moisture was recorded at the same time that HOBO data loggers were deployed and retrieved.

We used a spherical densiometer to measure total canopy cover, defined as the vertical projection of vegetation from the ground, as viewed from above. We recorded four measures of total canopy cover (standing at the center point and facing each of the cardinal directions) at the center of the vegetation sampling main subplot at the HOBO location, and at the centers of three satellite subplots associated with the data logger. Counts from the densiometer were converted, after the field season, using the formula

$$\frac{\text{number of covered dots}}{96} \times 100 = \text{percent canopy cover}.$$

Occupied versus Unoccupied Sites

HOBO data loggers were collected from field sites during September and October. One was destroyed in a fire at Cibola NWR, two were destroyed by heavy machinery at the Gila River confluence site, and one was missing at the West Wetlands Park in Yuma. In addition, two HOBOs at the Bill Williams River NWR failed to record data for the specified period of time. Data from the remaining 54 loggers (34 unoccupied, 20 occupied) were downloaded and organized to allow comparison of occupied versus unoccupied sites for the following variables (based on McLeod et al. 2005):

- Mean diurnal and nocturnal temperatures: we used local sunrise and sunset times to delineate cutoff times between night and day.
- Mean diurnal and nocturnal relative humidity.
- Mean soil moisture: we combined moisture readings from the first measurement period when HOBOs were deployed with those from the second when HOBOs were collected; little difference was found between early and late season soil moisture measurements.

- Mean number of 6-minute intervals above 41º C each day: 41º is a rough cutoff above which hyperthermic mortality of unattended eggs may increase (Webb 1987).
- Mean daily temperature range: daily maximum minus daily minimum.

For the preliminary analyses in this 2006 report, we restricted our investigation to the Bill Williams River NWR, the Cibola NWR, and the Grand Canyon NP/Lake Mead NRA. These three areas were selected because they are large and geographically distinct within the lower Colorado River region, and because they all had occupied sites. We placed data loggers at 8 occupied sites and 5 unoccupied sites (Table 5.2). Analyses included only data from 45 days, starting in early August and extending to mid-September, when all loggers were simultaneously active at all three areas. We examined the differences in diurnal and nocturnal relative humidity and temperature between occupied and unoccupied sites by calculating daily means per site, then calculating the overall means of diurnal and nocturnal relative humidity, and diurnal and nocturnal temperature at occupied and unoccupied sites. We used the canopy cover data collected at each data logger location to provide a broad characterization of occupied and unoccupied sites.

Table 5.2. Number of sites and number of microclimate data loggers (HOBOs) within the three survey areas (Grand Canyon NP/Lake Mead NRA, Bill Williams River NWR, and Cibola NWR) from which data were used in the preliminary analysis of microclimate data. HOBOs were placed in occupied and unoccupied survey sites within the study areas.

	Number of Sites			Number of HOBOs		
Area	Total	Occupied	Unoccupied	Total	Occupied	Unoccupied
Three Areas Combined	13	8	5	19	11	8
Grand Canyon/Lake Mead	4	3	1	6	4	2
Bill Williams River NWR	5	3	2	7	3	4
Cibola NWR	4	2	2	6	4	2

Results

The following microclimate results are based on exploratory analyses of a subset of data from the initial pilot year of the study. These results are therefore preliminary, but they may help identify aspects of our microclimate study design and sampling methods that need further study or refinement. Additional data collection in 2007 will yield further insights, and may lead to changes in the patterns described below.

Relative Humidity and Temperature

For all three microclimate areas combined, mean diurnal and nocturnal relative humidity measures were higher in unoccupied sites than in occupied sites; there were no significant differences in day or night temperatures (Table 5.3). Microclimate patterns were not consistent from area to area. For example, mean diurnal and nocturnal relative humidity values were higher in the unoccupied sites at the Grand Canyon NP/Lake Mead NRA area, lower at such sites in the Bill Williams River NWR, and not significantly different at Cibola NWR (Table 5.3).

Table 5.3. Descriptive statistics (means and standard errors, in parentheses) for microclimate data collected at Grand Canyon NP/Lake Mead NRA, Bill Williams River NWR, and Cibola NWR yellow-billed cuckoo study areas, August–September 2006. Microclimate data loggers were placed in occupied and unoccupied survey sites within the study areas. Means are given with their standard errors (±SE). Sig. is the 2-tailed p-value of independent sample T-tests for equality of means.

Variable	Occupied	Unoccupied	Sig.
Mean Diurnal Relative Humidity			
Grand Canyon/Lake Mead	32 (0.6)	44 (1.2)	0.00
Bill Williams River NWR	56 (1.3)	46 (1.0)	0.00
Cibola NWR	35 (0.6)	35 (1.0)	0.65
Three Areas Combined	39 (0.6)	43 (0.7)	0.00
Mean Nocturnal Relative Humidity			
Grand Canyon/Lake Mead	48 (1.2)	59 (1.7)	0.00
Bill Williams River NWR	69 (1.5)	65 (1.3)	0.03
Cibola NWR	56 (0.9)	55 (1.3)	0.24
Three Areas Combined	57 (0.7)	61 (0.9)	0.00
Mean Diurnal Temperature			
Grand Canyon/Lake Mead	32 (0.2)	30 (0.5)	0.00
Bill Williams River NWR	31 (0.2)	33 (0.2)	0.00
Cibola NWR	37 (0.2)	37 (0.2)	0.98
Three Areas Combined	34 (0.2)	33 (0.2)	0.14
Mean Nocturnal Temperature			
Grand Canyon/Lake Mead	24 (0.3)	22 (0.5)	0.02
Bill Williams River NWR	25 (0.2)	25 (0.2)	0.28
Cibola NWR	26 (0.2)	27 (0.3)	0.00
Three Areas Combined	25 (0.2)	25 (0.2)	0.88

Soil Moisture and Canopy Cover

When data from all sites were pooled, mean soil moisture was higher on average at occupied sites than at unoccupied sites (Table 5.4). Within individual areas, occupied sites had higher mean soil moisture when compared to unoccupied sites (though not significantly so at Cibola NWR). It is interesting that both occupied and unoccupied sites at the Cibola NWR had higher soil moisture than any Grand Canyon NP/Lake Mead NRA or Bill Williams River NWR sites.

Overall, mean percent canopy cover did not differ significantly between occupied and unoccupied sites (Table 5.5). Within the Grand Canyon NP/Lake Mead area, we sampled only one unoccupied site and three occupied sites. The unoccupied site, Canyon Mile 274, is fairly unique in that it consists of a large patch of mostly very dense, low tamarisk whereas the occupied sites were comparatively more open. These observations are supported by our measures of canopy cover within the Grand Canyon NP/Lake Mead area. The occupied and unoccupied sites in Bill Williams River NWR had higher mean canopy cover than Grand Canyon NP/Lake Mead NRA and Cibola NWR sites. Occupied sites at Cibola had slightly higher mean canopy cover than unoccupied sites, but were highly variable (Table 5.5).

Table 5.4. Descriptive statistics (means and standard errors, in parentheses) for soil moisture data collected at yellow-billed cuckoo study areas within Grand Canyon NP/Lake Mead NRA, Bill Williams River NWR, and Cibola NWR. Means are given with their standard errors (±SE). Sig. is the 2-tailed p-value of independent sample T-tests for equality of means.

	Mean Soil Moisture (%)		
Area	Occupied	Unoccupied	Sig.
Grand Canyon/Lake Mead	11 (1.1)	8 (0.8)	0.03
Bill Williams River NWR	12 (1.4)	5 (0.9)	0.00
Cibola NWR	19 (0.6)	16 (2.0)	0.11
All Areas Combined	12 (0.6)	10 (0.4)	0.03

Table 5.5. Descriptive statistics for percent canopy cover data from microclimate sampling sites in Grand Canyon NP/Lake Mead NRA, Bill Williams River NWR, and Cibola NWR yellow-billed cuckoo study areas in 2006. Means are given with their standard errors (±SE). Sig. is the 2-tailed p-value of independent sample T-tests for equality of means.

	Mean % Canopy Cover		
Area	Occupied	Unoccupied	Sig.
Three Areas Combined	52 (4.8)	49 (6.4)	0.67
Grand Canyon/Lake Mead	34 (7.9)	58 (11.7)	0.12
Bill Williams River NWR	62 (5.5)	69 (7.3)	0.48
Cibola NWR	46 (25.9)	30 (9.6)	0.59

Discussion

Our preliminary analysis of the microclimate data collected in 2006 focused on comparisons of a subset of occupied and unoccupied yellow-billed cuckoo survey sites. As noted earlier, this is a pilot year for data collection and analysis, and the patterns observed in 2006 are preliminary; data from the upcoming 2007 season will provide additional insights.

Over the three study areas examined, unoccupied sites had higher diurnal and nocturnal humidity and cooler mean daytime temperatures than occupied sites. This differs from what might be expected based on considerations of thermal tolerance and humidity as possible limiting factors in habitat use. However, at least part of our pattern may be driven by sample size and vegetation conditions at the Grand Canyon NP/Lake Mead NRA sites. There, the only unoccupied site sampled (Canyon Mile 274) consists of a large patch of mostly very dense, low tamarisk, whereas the occupied sites were comparatively more open. Occupied patches within the Bill Williams River NWR had higher mean diurnal and nocturnal relative humidity but also higher temperature; the latter runs counter to microclimate expectations. The one unoccupied site sampled here was a fairly open area with relatively sparse vegetation. Results for the Cibola NWR area are interesting in that there were no measurable differences in relative humidity and temperature between occupied and unoccupied sites with the exception of mean nocturnal temperature, which was lower at occupied sites. Overall, Cibola was also the hottest of the three areas.

Mean soil moisture was consistently higher in occupied sites compared to unoccupied sites, when all areas were combined and when areas were considered separately. Cibola NWR was particularly interesting in that unoccupied sites there had higher mean soil moisture than the occupied sites at the Grand Canyon NP/Lake Mead NRA and Bill Williams River NWR. It appears that cuckoos may be using the moistest sites within each of the areas.

Yellow-billed cuckoos have been thought to favor humid habitats and to thus be confined to river bottom habitats in the arid Southwest (Hamilton and Hamilton 1965). Our data, though preliminary, provides limited indications that yellow-billed cuckoos along the lower Colorado River and adjacent drainages are occupying sites that have relatively high mean soil moisture within the area. Higher soil moisture may contribute to conditions that would be more favorable for breeding from a microclimate standpoint. However, at this point we are unable to discern any uniform patterns in microclimate differences between occupied versus unoccupied sites. High variation in local conditions, complex local and landscape interactions, and the small sample size of 2006 data may be masking general microclimate patterns.

The reasons for differences in soil moisture between occupied and unoccupied sites are uncertain. One explanation may be moisture retention after flooding events, which may occur at Bill Williams River NWR; however, it is not a likely explanation at all other sites because they no longer receive natural flood pulses due to the altered hydrology of the Colorado River. Another possible factor may be the presence of Apache cicada (*Diceroprocta apache*) nymphs, which affect the spatial distribution of surface water by excreting unassimilated fluid obtained through feeding on xylem (Andersen 1994). However, the distribution of burrowing cicada nymphs is non-random and clustered (Ellingson and Andersen 2002), and we do not know where our soil moisture measurements were taken relative to cicada populations.

Microclimate Evaluation – 2006 and 2007

The variable patterns resulting from these preliminary microclimate analyses highlight the need to refine our microclimate sampling design and increase our overall sample sizes, in order to better compare microclimate characteristics between occupied and unoccupied sites. The 2006 evaluation of microclimate was limited by a small sample size and late deployment, and an uneven distribution of data loggers between unoccupied and occupied sites. This latter factor was due to the limited number of pre-designated "occupied" detection sites available from the 2005 field season, and no previous cuckoo presence/absence data to work with from our northern survey areas. Furthermore, many data loggers were deployed late in the summer, which restricted our analyses to time intervals in August and September. All of these problems will be corrected in 2007. We will use 2006 yellow-billed cuckoo location data, aerial photography, and GIS in order to generate new sampling locations for 2007. We will attempt to evenly pair unoccupied and occupied sites within areas, and to deploy equal numbers of HOBOs within occupied and unoccupied sites. Additionally, HOBOs will be deployed in May and retrieved in September, in order to characterize microclimatic variables during the time span that yellow-billed cuckoos are normally present in the region. This should increase the power to detect differences in the microclimate variables we measure between occupied and unoccupied sites.

Although our current project objectives do not include an analysis of cicada distribution, especially with regard to microclimate conditions, we believe this question is worth attention due to the potentially important role that cicadas may play in yellow-billed cuckoo distribution within the lower Colorado River region. Soil moisture may be an indication of the burrowing and feeding activities of cicada nymphs, and soil temperature may determine when adult cicadas emerge and are available as a food source for cuckoos. High soil temperatures may result in the earlier emergence of cicadas (Andersen 1994, Smith et al. 2006), and canopy cover affects soil temperature. Yellow-billed cuckoos arrive on their breeding grounds later than most neotropical-nearctic migrants, and high soil temperatures may increase the chance that cuckoos arrive after cicadas have emerged. Thus, further measurement of soil temperature in combination with additional vegetation analyses and examination of other microclimatic variables may provide useful information about the life cycle of this keystone resource in riparian habitat. Ultimately, soil temperature could become one of several easy-to-measure indicators of riparian restoration success.

Chapter 6. Riparian Habitat and the Status of Cuckoos in the Lower Colorado River Basin

Given the lack of consistent long-term yellow-billed cuckoo survey information and the challenges of interpreting cuckoo detection data, we cannot make precise comparisons between the historical and current numbers of breeding cuckoos with the lower Colorado River project region. However, there are probably substantially fewer cuckoos and fewer breeding sites now than occurred in the early 1900s, and possibly fewer than during the 1970s and 1980s (see Chapter 1). Assessing the factors that may have contributed to declines can provide useful insight in developing conservation and restoration actions. Declines were likely due to substantial changes that have occurred in the riparian habitats of the area, including the loss of such habitat, the invasion of exotic species, and changes in adjacent land practices.

It has been estimated that 85–98 percent of Arizona's native riparian habitat has been destroyed or severely degraded since Euro-American settlement (Noss et al. 1995, Bogan et al. 1998). By the early 1900s, extensive agriculture activities were occurring in Yuma, Arizona and in the Imperial Valley, California (Rosenburg et al. 1991), but annual flooding continued to devastate these farming efforts. To control the river for human use the U.S. Bureau of Reclamation began to develop the river for power generation, water storage, and flood control. This began with the construction of a series of dams—Laguna Dam in 1907, Hoover Dam in 1936, Parker Dam and Imperial Dam in 1938, and Davis Dam in 1954. Dam operations changed the natural flows of the lower Colorado River by ending the cycle of annual flooding, except when heavy runoff from local rains produced floods from the larger tributaries (e.g., Bill Williams River). Without these floods, new, rich alluvial seedbeds were no longer formed and the life history cycle of cottonwoods, willows, and mesquite were changed. With floods controlled and irrigation water readily available, large stands of natural floodplain vegetation were converted to agricultural uses. In the 1940s and 1950s wide portions of the floodplain near Yuma, Blythe, Parker, and Needles were cleared for agriculture. Extensive farm tracts, "clean" farming practices, and shifts to crops such as cotton and lettuce resulted in the removal of large tracts of cottonwood-willow forests and mesquite bosques and greatly reduced the extent of wildlife habitat, including habitat required by yellow-billed cuckoos to breed. The only large tracts of natural riparian vegetation that remained through the 1970s were on the five Native American reservations and the four national wildlife refuges (Pahranagat, Havasu, Bill Williams River, Cibola, and Imperial; Rosenberg et al. 1991).

In addition to reducing the amount of riparian habitat in the landscape, agricultural and urban development has also fragmented the remaining riparian areas. In this form of fragmentation, riparian forest tracts are progressively reduced to smaller and more isolated patches embedded within a relatively permanent matrix of largely unsuitable habitat (Saab 1999). Western yellow-billed cuckoos may be especially sensitive to fragmentation, as they require tracts of large contiguous and unfragmented patches. Laymon and Halterman (1989) have estimated that sites larger than 80 ha (200 acres) in extent and wider than 600 m (1950 feet) were the optimal patch size for yellow-billed cuckoos.

Agricultural lands currently continue to dominate much of the riparian landscape within the region. Of the 55 sites we surveyed for cuckoos in 2006, 65 percent are bordered on at least one side by agriculture fields; agricultural development on adjacent lands has been shown to affect riparian bird communities. While studying habitat use by breeding birds in cottonwood riparian forests at multiple spatial scales along the South Fork of the Snake River in southeastern Idaho, Saab (1999) found that riparian patches surrounded by an agriculture matrix supported different bird assemblages than did patches surrounded by a natural habitat matrix. In addition, avian nest predators, brood parasites, and exotic species all responded positively to the human-altered landscapes resulting from agricultural development, fragmentation, residential areas, or all three factors (Saab 1999).

Agriculture and urban development and their attendant water capture, control, and distribution practices represent new types, or at least new scales, of disturbance for river systems in the Southwest (Stromberg and Chew 2002). Urban and agricultural demands throughout western North America are expected to result in increasingly scarce water resources, and altered flow regimes will negatively impact riparian cottonwood ecosystems (Lytle and Merritt 2004). In addition, tail-water from irrigated fields or urban sewage treatment plants is often enriched with nutrients and salt, which can negatively impact the river reaches that receive such water (Stromberg and Chew 2002). In contrast to the generally negative affects of water diversions and modifications at the landscape level, at a localized scale these activities may help support some riparian habitat patches. For example, the southwestern willow flycatcher recovery plan (USFWS 2002b) notes that most of the riparian patches in which the flycatcher breeds are supported by various types of supplemental water, including agricultural and urban runoff, treated water outflow, irrigation or diversion ditches, reservoirs, and dam outflows. The sustainability of habitats relying on such supplemental water is questionable, and these supplemental flows likely do not provide for the full array of ecological functions that occurred before the alteration of the local hydrology.

These factors all have the potential to influence yellow-billed cuckoo habitat use. In arid regions such as those found along the lower Colorado River, yellow-billed cuckoos are restricted to river bottoms, ponds, swampy areas, and damp thickets with relatively high humidity (Gaines and Laymon 1984, Hughes 1999). Most breeding pairs of western yellow-billed cuckoos have been found nesting in riparian patches within 100 m of water (Laymon and Halterman 1987a, Johnson et al. 2005, 2006). Surface water in cottonwood-willow groves may help lower the air temperature via evaporative cooling (Laymon and Halterman 1987b, Hughes 1999). Our habitat sampling in 2006 found that occupied sites were significantly closer than unoccupied sites to surface water (mean of 98 m versus 290 m, respectively).

Changes in microclimate conditions resulting from development may also affect cuckoos. Large patches of mature cottonwood forest, with willows forming a subcanopy layer, are likely to provide the best shading of any riparian habitat. While foraging western yellow-billed cuckoos may be found in stands of smaller mesquite trees or even tamarisk, they usually do not nest there (Halterman 2004). Tamarisk and open mesquite bosques may be inadequate in buffering extreme high temperatures. Habitat attributes that provide cooler temperatures and higher humidity are likely especially important to cuckoos in the lower Colorado River basin where the cuckoo is one of the last migratory summer breeders to arrive. Cuckoos arrive in mid to late June and depart by the end of August or mid-September. Nesting cuckoos would thus be exposed to the extremely high midsummer temperatures common in this region (> 35–45° C; 100° F). In 2006 we found that locations occupied by yellow-billed cuckoos were more shaded and tended to be cooler and more humid on average compared to unoccupied locations, which tended to be more variable with respect to both temperature and relative humidity.

The factors that most drastically changed the riparian vegetation structure and composition throughout the lower Colorado River basin were the introduction of the exotic tamarisk tree and the changes in riparian ecosystem processes that initially promote its establishment and persistence. In 1894, Means (1907) estimated that native riparian vegetation covered about 160,000–180,000 ha of alluvial bottomland between Fort Mohave and Fort Yuma. As of 1986, there were only about 40,000 ha of riparian vegetation—roughly 25 percent of the bottomland estimated by Means (Anderson and Ohmart 1984, Younker and Anderson 1986). Approximately 40 percent of the area remaining in 1986 was dominated by tamarisk, 16 percent by honey mesquite and/or native shrubs, and only 0.7 percent by mature cottonwood or willow habitat (Ohmart et al. 1988).

Tamarisk and Russian olive are currently the third and fourth most frequently occurring woody riparian plants in the Southwest (Friedman et al. 2005). Although tamarisk was the most common tree in the study area, the canopy at occupied sites was usually dominated by cottonwood or willow trees. Occupied sites in most areas had lower than average total tree density, and it appears that cuckoos did not breed in areas with the highest density of small trees (< 8 cm dbh), which were mostly tamarisk. The exceptions to this pattern were the northernmost sites and the southernmost sites, where overall tree density was relatively low and cuckoos were detected in sites with higher than average tree density. These results correspond with those of Corman and Magill (2000), who found that western yellow-billed cuckoo occupancy rates in Arizona were highest in sites dominated by native tree species and lower in habitats consisting of more than 75 percent tamarisk cover. We do not know if cuckoos are generally absent from areas of denser or smaller tamarisk because of the species composition or because the trees do not have the proper structure; these two factors are likely related.

In sum, multiple factors such as water diversion and redistribution and agricultural and urban development have impacted riparian habitats and landscapes along the lower Colorado River in the previous 50–100 years. Riparian habitats have been lost, fragmented, and degraded. We found that yellow-billed cuckoos persist in the region mainly in riparian habitats with some native vegetation. Other factors such as the presence of surface water, microclimate conditions, and landscape-level habitat features may also play a role in cuckoo habitat selection.

Restoring Riparian Habitat for the Yellow-Billed Cuckoo: Additional Research Needs

Efforts to restore riparian habitats within the lower Colorado River basin have focused on the restoration of native vegetation through the removal of tamarisk and planting of native cottonwoods and willows. Revegetated stands have been established at Cibola NWR, Quigley WMA, Mittry Lake WMA/Pratt Restoration, and Imperial NWR, and in 2006 we detected unpaired non-breeding cuckoos in all of these areas. Each of the revegetated stands consists of mainly mature trees and they appear to have adequate plant species composition and structure to accommodate cuckoos. However, we observed only unpaired, presumably non-breeding cuckoos at the restoration sites, except that one cuckoo was seen carrying food within the restoration site at the Imperial NWR and flying to a nearby non-restored area, where it was likely breeding. Western yellow-billed cuckoos require large blocks of riparian habitat (Laymon and Halterman 1987a, Ehrlich et al. 1988, USFWS 2002a), and data are needed regarding the size and distribution of riparian habitat required for breeding within the lower Colorado River region. Such information is crucial for designing adequately sized riparian restoration projects that can accomplish the goal of providing breeding habitat for these birds. Additional information gaps include knowledge about habitat factors at other spatial scales, such as riparian patch connectivity, the effects of the landscape geomorphology, the amount of riparian habitat in the landscape, and the composition of the surrounding landscape matrix—all of which likely have substantial influence on yellow-billed cuckoo habitat selection.

The distribution and population dynamics of many birds cannot be understood solely by studying the processes occurring within individual habitat patches (Freemark et al. 1995). A landscape comprises a heterogeneous mosaic of patches in which individual birds live and disperse (Dunning et al. 1992); landscapes thus represent an intermediate spatial scale between local habitat patches and larger-scale regions (Freemark et al. 1995). Since patterns in the mosaic of habitat patches on the landscape influence the distribution and dynamics of individuals, populations, and communities (Kotliar and Wiens 1990, Barrett 1992, Freemark et al. 1995), a landscape perspective is needed to adequately monitor lower Colorado River cuckoos, and to properly assess the effects from the dynamics of the surrounding landscape patterns on species, biotic interactions, and ecological processes (Freemark et al. 1995).

Habitat data from multiple spatial scales could be used to construct a habitat model to determine associations between riparian habitat characteristics and yellow-billed cuckoo breeding-season occurrences, and to identify the habitat features that cuckoos require. This knowledge about habitat selection patterns and identification of potential breeding habitat is essential to establishing effective conservation efforts, including prioritization of areas for conservation and restoration and areas for monitoring changes in habitat distribution and quality over time.

Other factors to consider in designing effective riparian restoration include the effects of such restoration on avian food resources. Many bird species that breed in riparian habitats are insectivorous, and the lush vegetation associated with riparian zones provides abundant food resources, especially when compared to surrounding upland habitats (Strong and Bock 1990). The Apache cicada, in particular, has been suggested as a keystone species in the lower Colorado riverine ecosystem, due to its herbivory (Karban 1980, Andersen 1987) and role as a prey species for birds and mammals (Rosenberg et al. 1982, Krohne et al. 1991).

Yellow-billed cuckoo habitat use in the Southwest does in fact appear to be linked to cicadas. Rosenberg et al. (1982) found that in cottonwood-willow habitat in the Colorado River valley, cuckoos concentrate on cicadas, a superabundant, seasonally predictable resource (Strong and Bock 1990). The relatively late nesting period of the western population of cuckoos is thought to be an adaptation to the typical timing of cicada emergence (Rosenberg et al. 1982). In New Mexico, cuckoo nesting coincides with peak cicada (*Tibicen dealbatus*) emergence in unburned plots along the middle Rio Grande (Howe 1986). Emergence of cicadas prior to the cuckoo breeding season could be detrimental to the cuckoo's nesting success (Andersen 1994).

There is evidence in New Mexico (Smith et al. 2006) that cottonwood density and cottonwood canopy cover are important factors in cicada emergence density and phenology; the age and health of a cottonwood stand have a smaller effect on emergence density. Cottonwood canopy was also correlated with lower soil temperatures, which are associated with later emergence dates (Smith et al. 2006). These findings suggest that the recovery and sustainability of yellow-billed cuckoo populations in the Southwest may depend to some extent on sustaining cicada populations. It may be possible to design riparian restoration to promote conditions that allow cicadas to emerge at densities and times that provide the greatest benefits to cuckoos. Studies are needed to understand the relationships between vegetation associations and annual cicadas, and the effects of vegetation structure and climate on cicada emergence density and phenology in riparian habitats along the lower Colorado River.

In addition to the LCR MSCP program, several other efforts are currently underway in the lower Colorado River basin and other areas of the Southwest to restore riparian habitats; these include the Clark County Nevada Multiple Species Plan, the Western Riverside Multi-Species Habitat Conservation Plan in California, the Colorado River Indian Tribes (CRIT) 1998 revegetation plan, and the Salt River Project Roosevelt Lake Habitat Conservation Plan. All have the goal of restoring riparian habitats and thus providing assistance to riparian wildlife, including the western yellow-billed cuckoo. Additional knowledge of the yellow-billed cuckoo's habitat requirements in the Southwest, and what factors influence these habitats, can help lead to even more effective and efficient riparian restoration. Armed with this knowledge, there is great potential to restore considerable amounts of breeding habitat within the LCR MSCP region.

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