05-07

Heritage Fund

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Yellow-billed Cuckoo Distribution, Abundance, Habitat Use, and Breeding Ecology in the Verde River Watershed of Arizona, 2004-2005 Final Report

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2008

Funded by Arizona Game and Fish Department Heritage Grant I04006

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Summary

This final report details the objectives, methods, results, and recommendations of a study documenting the distribution and abundance, habitat requirements, and breeding ecology of the yellow-billed cuckoo in the Verde River watershed of Arizona. We conducted breeding season cuckoo surveys at 37 sites within the Verde River watershed, including the Verde River from the upper river to below the confluence with West Clear Creek, and the Oak Creek, Dry Beaver Creek, Wet Beaver Creek, and West Clear Creek tributaries. Within this broader study area, we conducted surveys at two types of study sites, "historic" sites (sites in which yellow-billed cuckoos were detected during the AGFD/CPRS 1998-1999 surveys), and "random" sites, located in areas with riparian forest patches on National Forest, National Park, and state lands. Twenty-four sites were surveyed during each of two years (2004 and 2005), and each site was surveyed three times throughout the breeding season. In the two years, of the 37 sites surveyed, yellow-billed cuckoos were detected in 22 (59%) sites; 12 of the 16 (75%) historic sites, and 10 of the 21 (48%) random sites had detections. Occupancy rates (i.e., the proportion of surveys during which at least one cuckoo was detected at a site) ranged from 100% (at six sites) to 0 (at 14 sites).

We mapped all survey sites, and the location of yellow-billed cuckoo detections, to aid in estimating the minimum number of individuals using the site during a given survey visit, and to assess patterns in the distribution of cuckoos within the site, across each survey season and across the two years. The largest number of individuals detected per survey period, across all sites combined, was 31, and occurred during the second survey period. As expected, the larger sites generally had more cuckoos.

We found evidence of breeding by cuckoos at 14 sites and confirmed breeding by cuckoos at five sites. The four active nests we found were located in four different tree species, Goodding willow, boxelder, Arizona alder, and Fremont cottonwood. All of the nests were located in a patch of native trees, within 11 m of surface water, and were well-hidden by vegetative cover.

The majority of our survey sites were classified as "Native Habitat", sites containing > 75% native tree species. Fremont cottonwood was the dominant tree species in the majority of occupied sites (i.e., sites where a cuckoo was detected during at least two of the three survey periods per year; 64%). Arizona sycamore was the dominant tree species at 35% of the sites, and 85% of these were unoccupied. The five most common tree species in occupied sites were Arizona alder, Arizona sycamore, velvet ash, Goodding willow, and Fremont cottonwood. Occupied sites had a higher density of trees, in every size class, than unoccupied sites. In particular, sapling trees were considerably more common in occupied sites, and included cottonwood, willow, alder, and sycamore, and large cottonwoods had higher densities in occupied sites. In addition, occupied sites had, on average, more riparian habitat than unoccupied sites. Riparian habitat at all occupied sites was at least 100 m wide at its widest point and in the majority of occupied sites (79%), riparian habitat was over 200 m wide.

We also mapped areas of mesquite habitat, and calculated the total area of mesquite at each site. We found that within the Verde River watershed, it appears that cuckoos select deciduous riparian habitat that also has adjacent areas of mesquite at least 5 ha in size.

This project provides information on the distribution, abundance, and habitat use of the yellow-billed cuckoo that is needed to make informed management decisions regarding the species conservation. The results are directly applicable to the implementation of the Arizona Bird Conservation Plan, and Arizona's Comprehensive Wildlife Conservation Strategy.

Introduction

The Arizona Game and Fish Department's (AGFD) Heritage Grant project, *Yellow-billed cuckoo distribution and abundance, habitat requirements, and breeding ecology in the Verde River watershed of Arizona* (Project I04006), was initiated in August 2003. Field surveys for the yellow-billed cuckoo (*Coccyzus americanus*) and habitat characteristics were conducted in 2004 and 2005, and riparian habitat mapping was conducted during 2005 to 2007. This report constitutes our final report for this project.

The overall goal of this project is to meet the need for a better understanding of the factors contributing to the decline of yellow-billed cuckoos by examining the distribution and abundance, habitat requirements, and breeding ecology of the yellow-billed cuckoo in the Verde River watershed. This included inventorying the riparian habitat on which the cuckoo depends, including mesquite habitats. Our purpose is to provide meaningful information that will enable land management agencies and the public to make informed management decisions regarding yellow-billed cuckoos, riparian wildlife, and riparian habitats. Additionally, the information gathered during the riparian inventory and the yellow-billed cuckoo surveys can be used as baseline data for continued monitoring of cuckoo populations and of riparian vegetation in the Verde River watershed.

Project Objectives

This project was designed to address the 2003 Sensitive Elements for IIAPM (Identification, Inventory, Acquisition, Protection, and Management) projects. Specifically, our objectives for this project were:

Objective 1. Inventory riparian habitat, including Sonoran Riparian Forest, Mesquite Series (224.52) on federal and state lands in the Verde River watershed (Community Element: Sonoran Riparian Forest, Mesquite Series (224.52), Objective A. of the Sensitive Elements List: Inventory, map, and assess conservation needs of mesquite bottomland forests).

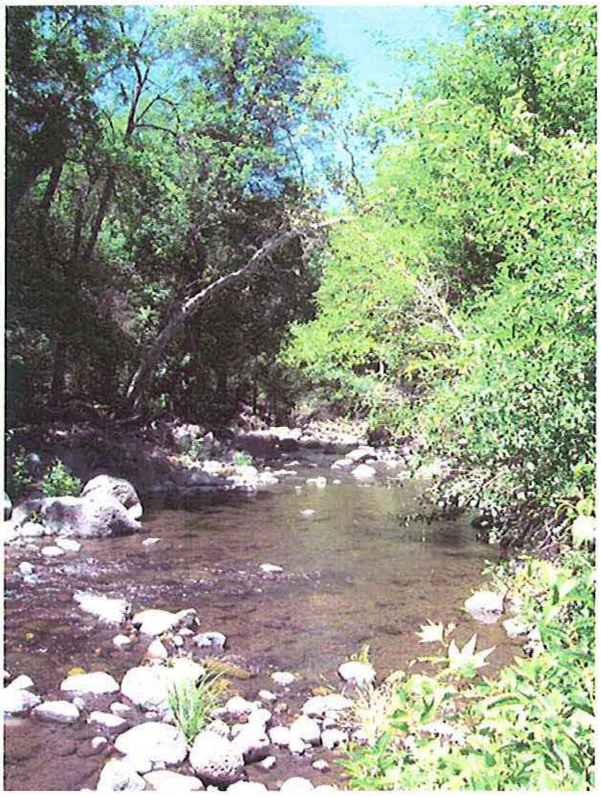
Objective 2. Conduct repeatable, randomized surveys on federal and state lands in the Verde River watershed to determine distribution and abundance of yellow-billed cuckoos (Wildlife Element: Cuckoo, Yellow-billed, Objective A. (1) of the Sensitive Elements List: Conduct repeatable, randomized surveys to determine distribution and abundance).

Objective 3. Determine yellow-billed cuckoo breeding habitat selection and preference, including patch size requirements, and identify habitat requirements on migratory routes, within the Verde River watershed. (Wildlife Element: Cuckoo, Yellow-billed, Objective A. (2): Determine breeding habitat selection and preference, including patch size requirements; *and* Wildlife Element: Cuckoo, Yellow-billed, Objective A (3) of the Sensitive Elements List: Identify habitat requirements on migratory routes and wintering grounds).

Objective 4. Conduct nest searching and monitoring to determine reproductive success. Compare reproductive success among different habitat types and identify what habitat and microhabitat features may contribute to nest success (Wildlife Element: Cuckoo, Yellow-billed, Objective B. (1) of the Sensitive Elements List: Compare reproductive success among different habitat types).

Background

Historic Abundance and General Breeding Distribution



Western yellow-billed cuckoos (*Coccyzus americanus occidentalis*) are a riparian obligate species, in that they depend on riparian habitats for breeding. They 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 western yellow-billed cuckoo's range and population numbers have declined substantially across much of the western United States over the past 50 years (United States Fish and Wildlife Service (USFWS) 2002). 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 Arizona are western yellow-billed cuckoos; we use the two names interchangeably when discussing any yellow-billed cuckoo west of the continental divide.

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 survey of suitable habitat in Arizona found an estimated total of 205 to 214 pairs, with more than half of these along the lower Colorado River (Gaines and Laymon 1984). Subsequent estimates suggested that fewer than 200 pairs remained in 1986 (Layman and Halterman 1987), 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 suitable habitat, mainly on

public lands, 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).

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 (ESA) as "threatened," but precluded. Thus, it became a Candidate Species under the ESA; 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 2002). 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 2002).

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).

Conservation Status of the Yellow-billed Cuckoo in Arizona

The Arizona Game and Fish Department has designated the yellow-billed cuckoo as "threatened" in the state, and a "wildlife species of special concern" in Arizona (AGFD 2002). Arizona's Comprehensive Wildlife Conservation Strategy (AGFD 2006) considers it to be a "species of greatest conservation need", and a community focal species. The U.S. Forest Service Regional Forester designated it a "sensitive species" on National Forests within Arizona (AGFD 2002), and 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). The Arizona Bird Conservation Plan (Latta et al. 1999) lists the western yellow-billed cuckoo as a "priority species" for the low elevation riparian priority habitat.

Yellow-billed Cuckoo Breeding Habitat

Relatively little is known about the western yellow-billed cuckoos' specific breeding requirements in Arizona; much of the quantitative information available on their breeding habitat characteristics 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 2002). 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 2002).

Cuckoo surveys in Arizona from 1998 and 1999 (Corman and Magill 2000) found that the percentage of survey sites where cuckoos were detected were highest in cottonwood (*Populus* spp.) -willow (*Salix* spp.) -ash (*Fraxinus* spp.) -mesquite (*Prosopis* spp.) habitat with less than 75 percent tamarisk (*Tamarix* spp.). Mesquite bosque–hackberry (*Celtis* spp.) habitat also had a relatively high percentage of sites with detections. Yellow-billed cuckoos were much less common in sycamore (*Platanus* spp.) -cottonwood sites (detections at 46% of sites), sycamore-alder sites (*Alnus* spp.; 33%), and habitats comprised of more than 75 percent tamarisk (33%). 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 (*Populus fremontii*), willow, velvet ash (*Fraxinus velutina*), Arizona walnut (*Juglans major*), mesquite, and tamarisk.

Riparian Habitats in Arizona

The conservation value of riparian areas is disproportionate to their spatial extent, particularly in arid and semi-arid environments (Miller et al. 2003). Riparian areas comprise less than 1% of the western landscape, but provide habitat for the majority of breeding bird species of the West.

They harbor some of the most diverse avian assemblages in North America (Johnson et al. 1977, Ohmart 1994) and some species completely depend on riparian habitats; 51% of all bird species in southwestern states require this vegetation type (Johnson et al. 1977). Birds that rely on riparian vegetation in the arid southwestern United States may be particularly vulnerable to population declines because their habitats often comprise <0.5% of the landscape, yet support disproportionately high bird diversity and abundance (Szaro 1980, Rosenberg et al. 1991, Powell and Steidl 2000). Riparian areas also provide critical resources for migrating birds (Skagen et al. 1998, AGFD 2006). In particular, riparian corridors facilitate faunal mixing on a broad, regional level (Knopf and Samson 1994), especially at the interface of different biomes or ecoregions (Sogge et al. 2005).

Riparian habitats are among the most modified habitats in the West (Krueper 1993). An estimated 95% of the riparian habitats in the West have been either altered, degraded, or destroyed in the last 100 years (Ohmart 1994); an estimated 91% of the free flowing perennial waterways on Arizona's big rivers, including the Verde, have been lost (Marshall et al. 2004). Arizona's riparian woodlands are among the most severely threatened habitats (Latta et al. 1999) and maintaining these habitats is critical to maintaining the biodiversity of the region.

The riparian areas of the Verde River watershed of central Arizona are typical of Arizona's riparian habitats. Development within the watershed has increased dramatically in recent years, with populations of the cities and towns within the watershed more than doubling within the last 20 years (Verde Watershed Research and Education Program 2002). Yet, native riparian habitat persists within the Verde River watershed and the area provides a good setting for studying the impacts of human development and natural impacts such as drought on riparian habitats and the species dependent upon them. For this project, we surveyed select areas of riparian habitat within the Verde River watershed, on public land (e.g., US Forest Service, National Park Service, and State Park lands). Habitat types included in our surveys consisted mainly of Cottonwood-Willow Series (223.21), Mixed Broadleaf Series (223.22), and Mesquite Series (224.52; Brown 1994).

Yellow-billed Cuckoo Breeding Biology

The yellow-billed cuckoo, 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 (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 2005). 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 (*Orthoptera*: *Tettigoniidae*), treefrogs (*Hylidae*), large caterpillars (*Lepidoptera*), and cicadas (*Homoptera*: *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 2005). 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 be relatively low, based on large yearly fluctuations in cuckoo detections at some sites. These natural history traits can complicate the determination and characterization of breeding habitat (Johnson et al. 2007).

Methods

Study Area and Selection of Study Sites

The project study area encompasses much of the Verde River watershed, including the Verde River from the upper river to below the confluence with West Clear Creek, and the Oak Creek, Dry Beaver Creek, Wet Beaver Creek, and West Clear Creek tributaries (Figure 1). Within this broader study area, we selected two types of study sites: 1) sites in which yellow-billed cuckoos were detected during the AGFD/CPRS 1998-1999 surveys (Corman and Magill 2000), which we call "historic" sites; and 2) "random" sites, located in areas with riparian forest patches on National Forest, National Park, and state lands, with an emphasis on the drainages in which yellow-billed cuckoos were detected during the AGFD/CPRS 1998-1999 surveys (Corman and Magill 2000)

We selected historic sites to survey because Corman and Magill (2000) recommend that, to help track trends in abundance, surveys should be continued on sites where known populations of yellow-billed cuckoos exist. It had been 6 and 7 years since surveys were conducted (in 1998 and 1999), and yellow-billed cuckoos were detected at the 16 historic sites (Table 1). So little is known about yellow-billed cuckoo habitat use and distribution patterns that there is considerable value in knowing if cuckoos occupy these same sites 6 to 7 years later. Consequently, we surveyed all 16 of these sites during the initial field season (2004). All of these sites were located on public land and the size of the area surveyed was constrained by this requirement, both during the 1998 and 1999 surveys and during this project. Historic sites where we found that suitable yellow-billed cuckoo habitat no longer existed when we conducted surveys in 2004 were not surveyed again in 2005; these included Sullivan Lake Historic, Dry Beaver Creek Historic, Red Tank Draw Historic, and Walker Creek Historic. We mistakenly classified Midgley Bridge as an historic site; it was surveyed during the 1998-1999 surveys, but no cuckoos were detected. Thus, although we conducted surveys there in 2004, it was not surveyed in 2005.

In addition to historic study sites, we randomly selected study sites. First, using maps, we identified all areas within the Verde watershed that 1) contained a creek or river and 2) were located on National Forest, National Park, and state lands, with an emphasis on the drainages in which yellow-billed cuckoos were detected during the AGFD/CPRS 1998-1999 surveys (Corman

and Magill 2000). Then, using maps of these areas, we demarcated segments of riparian habitat into sampling units, based on the criterion that each sampling unit consist of an area that is no larger than can be surveyed for yellow-billed cuckoos within a single morning; based on prior experience in similar habitats, we estimated this to be 1 km. Many sites were further constrained in size due to the requirement that we conduct surveys exclusively on public land. We then drew a random sample (using GIS tools) from the pool of sampling units to obtain a list of sites to be surveyed, regardless of habitat classification or patch size. This random sample consisted of 38 sampling units (survey sites). From these, we rejected sites that could not be accessed (either due to road conditions or lack of public right-of-way). We ended up with a total of 21 random sites; eight random sites were surveyed in 2004 and 14 were surveyed in 2005. One random site, Wet Beaver Creek Random #16, where cuckoos were consistently detected in 2004 was also surveyed in 2005. Two other 2004 random sites, the Upper Verde River Random #1 and Oak Creek Random #12, with detections across all three surveys, were not surveyed again in 2005. Between the 2004 and 2005 field season, the Upper Verde River Random #1 site experienced heavy flooding which scoured most of the riparian trees to the point that it was no longer suitable cuckoo habitat and was not surveyed in 2005. We did not resurvey at the Oak Creek Random #12 site because, after the 2004 field season, we mapped our survey endpoints and discovered that some of the site was on private land (there were no indications of this in the field). A total of 37 sites were surveyed during the project, including 16 historic sites and 21 random sites (Table 1).

The method used to randomly select sites differs from the previous AGFD/CPRS surveys that employed the "look see" method for selection of survey sites. That method, as described by Bibby et al. (1992), calls for identification of suitable habitats prior to conducting surveys. It relies on prior knowledge of possible habitat preferences, expert opinion, and knowledge of the basic biology of the species in question (Corman and Magill 2000). It is a preferred method for surveying rare birds (Dawson 1981, Corman and Magill 2000) when the goal is detection of all occurrences of a species within constraints such as time. Yet, it has a disadvantage in that the resulting surveys are not random, resulting in biased estimators of population parameters and limiting the ability to draw inferences from the data. By sampling from all potential riparian types and patch sizes, we hoped to examine patterns of distribution and abundance of cuckoos across all riparian habitats of the study area, for the years of the study.

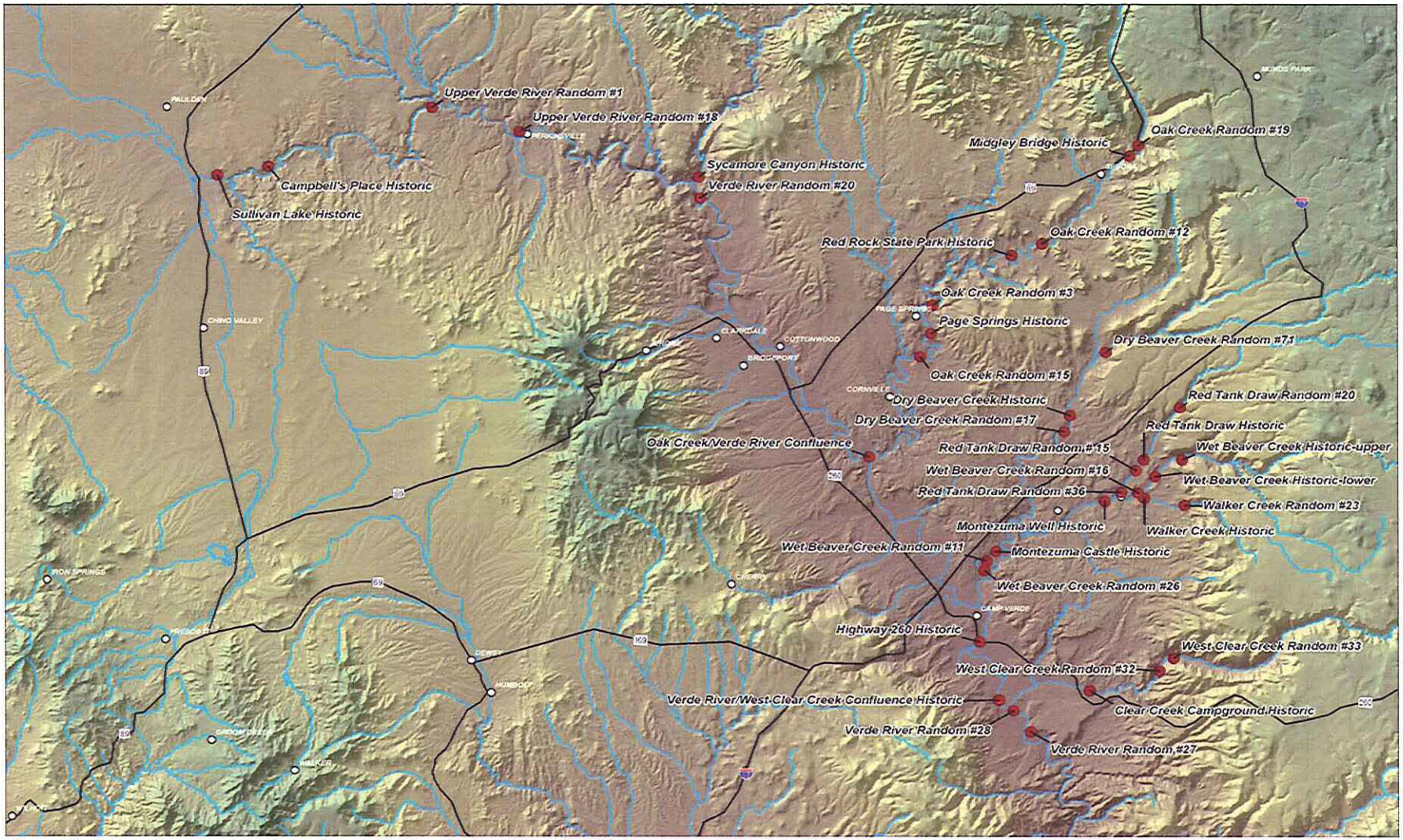


Figure 1. Map of study sites for yellow-billed cuckoo surveys in 2004 and 2005, Verde River watershed.

Table 1. Survey sites for yellow-billed cuckoo surveys in 2004 and 2005, listed from upstream to downstream in each drainage. Historic sites are shaded.

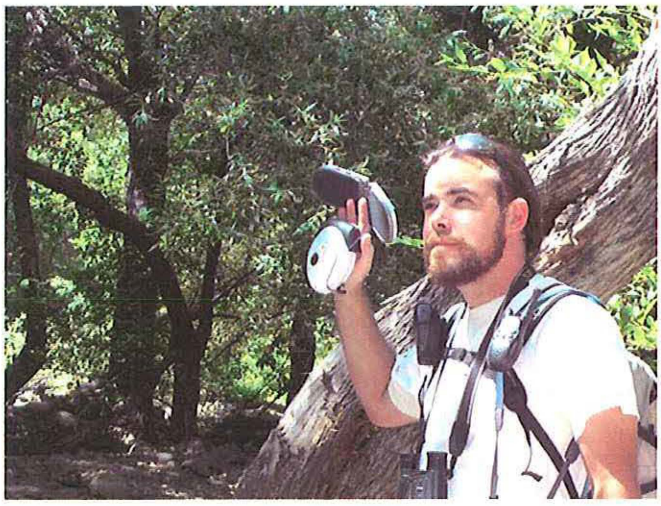
Drainage	Survey Site Name
VERDE RIVER	Sullivan Lake Historic
	Campbell's Place Historic
	Upper Verde River Random #1
	Upper Verde River Random #18
	Sycamore Canyon Historic
	Verde River Random #20
	Highway 260 Historic
	Verde River/West Clear Creek Confluence Historic
	Verde River Random #28
	Verde River Random #27
OAK CREEK	Oak Creek Random #19
	Midgley Bridge Historic
	Oak Creek Random #12
	Red Rock State Park Historic
	Oak Creek Random #3
	Page Springs Historic
	Oak Creek Random #15
	Oak Creek / Verde River Confluence
BEAVER CREEK	Dry Beaver Creek Random #71
	Dry Beaver Creek Historic
	Dry Beaver Creek Random #17
	Red Tank Draw Random #20
	Red Tank Draw Historic
	Red Tank Draw Random #15
	Red Tank Draw Random #36
	Wet Beaver Creek Historic - Upper
	Wet Beaver Creek Historic - Lower
	Wet Beaver Creek Random #16
	Walker Creek Random #23
	Walker Creek Historic
	Montezuma Well Historic
	Montezuma Castle Historic
	Wet Beaver Creek Random #11
	Wet Beaver Creek Random #26
WEST CLEAR CREEK	West Clear Creek Random #33
	West Clear Creek Random #32
	Clear Creek Campground Historic

Yellow-billed Cuckoo Surveys

Survey Methods

Surveys for yellow-billed cuckoos were conducted following established methodologies (Laymon 1998a, 1998b, Halterman et al. 2002). This methodology addresses the observation that cuckoos do not always respond to a single broadcast of their call, by requiring multiple playback surveys to be conducted within the area (every 100 m) on a survey morning, and across the field season, with a minimum of three surveys conducted between 25 May and 31 August to detect migrants and birds that were present but not detected during previous surveys. 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.

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 during steady rainfall; (surveys would also have been terminated if shade temperatures exceeded 41° C (110° F), but we did not encounter this.) 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. Because the playback vocalizations are broadcast loud enough to cover a large area, surveys did not need to be conducted directly within the habitat; however, surveyors were no more than 15 m (49 ft) from the habitat edge. In some cases, 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. Established methodologies state that areas with small narrow stringers of habitat, steep banks, and backwater sloughs can be surveyed by playing the tape from a boat and, in the second year of the project, we conducted surveys at two sites along the Verde River (Verde River Random #27, and #28) using canoes. Two canoes with two people each floated the river, and pulled up to the bank at each survey point for one person to conduct the survey.



To conduct a survey, 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 endpoints).

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.

Spatial Analyses of Survey Results

We mapped all survey sites, and the location of yellow-billed cuckoos, to aid in estimating the number of individuals using the site during a given survey visit, and to assess patterns in the distribution of cuckoos within the site, across each survey season (2004 and 2005) and across the two years. We created ArcGIS (ESRI 2007) point shapefiles using coordinate data (UTM coordinates) collected from hand-held global positioning system (GPS) units. Corresponding maps were developed from these data for: (1) sites surveyed in 2004 and 2005, showing surveyor location points, detection location points, and the endpoints that demarcate the start and stop of the survey; and (2) sites surveyed in 2004 or 2005 where there were no cuckoo detections and showing only the endpoints of the survey. We generated 35 maps of those survey sites where yellow-billed cuckoos were detected in either 2004, 2005, or detected in both 2004 and 2005. These maps consist of five main layers: 1) digital orthoimagery; 2) a point layer of all surveyor locations (i.e., the point from which a playback survey was conducted); 3) a point layer of cuckoo detections (i.e., a point derived from the estimated distance and bearing from the surveyor location); 4) a line layer representing the bearing and distance from the surveyor location to the estimated yellow-billed cuckoo detection location, and; 5) a point layer of the survey endpoints (i.e., the start and stop points of the survey). Also, we generated 15 maps of those study sites where there were no yellow-billed cuckoo detections. These maps consisted of two main layers: 1) digital orthoimagery, and; 2) a point layer of the survey endpoints (i.e., the start and stop points of the survey). Digital orthoimagery for the entire study area was acquired from the Arizona Imagery Server (http://sco.az.gov/imagery.htm) and provided by the Arizona State Cartographer's office. This imagery is 1-meter resolution orthoimagery and the datum is NAD83, and was photographed in 2005. The standard map unit is meters and the projection and datum are UTM, Zone 12, NAD83. GIS databases will be submitted to the AGFD Heritage Program with this final report.

We estimated the numbers of individuals detected during each survey at each site using the site maps of detections and the descriptions of detections (Appendix A). Detections were counted as individual cuckoos when they were a minimum of 300 m from any other detection during that survey, and/or when multiple cuckoos were detected at a survey point. For example, when one cuckoo was detected at a survey point, and then two cuckoos were detected at the subsequent survey point, and were within 300 m of the location of the last detected cuckoo, we estimated there were two cuckoos total. Thus, our estimates of the number of cuckoos at a site during a particular survey can be considered as the minimum number of cuckoos detected during that survey.

Documenting Breeding by Yellow-billed Cuckoos in the Verde River Watershed

Surveyors recorded the behavior of the cuckoos they were able to observe during surveys. In addition, after surveys were complete, surveyors returned to the areas where cuckoos were

detected and attempted to re-sight them, and search for nests. Using these observations, breeding was classified according to the criteria in Table 2.

Table 2. Yellow-billed cuckoo breeding classifications and the criteria used to determine them (adapted from Corman and Wise-Gervais 2005).

Breeding Classification	Description
Unlikely	Cuckoo(s) detected at the site during only one survey per year.
Possible	Cuckoo(s) detected at the site on at least two of three surveys within a year.
Probable	Pair observed in suitable nesting habitat; courtship behavior between two individuals or copulation, includes display or food exchange; visiting probable nest site, but no further evidence obtained; agitated behavior or anxiety calls of adults indicating nest site or young in vicinity.
Confirmed	Nest building or adult carrying nesting material; recently fledged young, with limited mobility, including of sustained flight; occupied nest indicated by adult entering or leaving nest site in circumstances indicating occupied nest; feeding young, including recently fledged young; adult carrying a fecal sack; nest with eggs; nest with young seen or heard.

Measuring Habitat Vegetation Characteristics

We measured habitat characteristics at two spatial scales: the survey site - level, and at the within-site – level. We measured a suite of habitat variables at all the sites surveyed, including both occupied and unoccupied sites, as described below.

Site-level Habitat Measures

At the survey site - level, we measured the size of the riparian habitat and classified the habitat of sites according to the composition of the canopy cover. We originally proposed measuring riparian patch size by delineating riparian patch boundaries in the field, with a patch defined as an area of contiguous riparian habitat that includes the appropriate riparian tree species and is separated by at least 300 m from the nearest contiguous riparian habitat. In practice, we were unable to measure patch size in this way, as our survey sites were restricted to public lands, and we were unable to access private lands to delineate habitat patches that extended beyond the survey site boundaries. Therefore, we used the width of the riparian habitat at its widest point within a site as our measure of the area of riparian habitat at each site. Deciduous riparian area at the local scale is a function of the width of the riparian corridor (Tewksbury et al. 2002), and recent research has focused on the width of riparian zones rather than area because of difficulties associated with defining area when riparian habitat is interconnected (Kilgo et al. 1998). We measured the maximum width of the riparian habitat within each site using GIS tools and the maps we generated for each site (as described above).

To further describe site-level habitat characteristics of each site, we recorded a site description that included: A) the habitat class, based on the percent canopy cover contributed by native and exotic tree species (Table 3); B) an estimate of percent cover of each dominant and/or codominant plant species; C) the average canopy height; D) the composition and cover of understory vegetation; E) the presence of surface water and pools of standing water; and F) the levels and causes of any disturbance. Additionally, we photographed sites.

Table 3. Riparian habitat classifications for yellow-billed cuckoo survey sites in the Verde River watershed, based on percent canopy cover contributed by native and exotic trees.

HABITAT CLASS	DEFINITION
Native Habitat	Sites containing > 75% canopy cover comprised of native tree species
Mixed Native Habitat	Sites containing 51-75% canopy cover comprised of native tree species
Mixed Exotic Habitat	Sites containing 51-75% canopy cover comprised of exotic tree species
Exotic Habitat	Sites containing > 75% canopy cover comprised of exotic tree species

Within-Site Habitat Measures

We conducted vegetation sampling at points within each site in order to characterize the vegetation structure and composition of the site. These habitat measures are adapted from the Field Protocols of BBIRD, a national program for monitoring breeding productivity and habitat conditions for nongame birds using standardized sampling protocols (Martin et al. 1997). Within a survey site a series of sampling points were established to sample vegetation at the patch level. We used orthorectified aerial photos to locate the initial sampling point, which was established in the middle of the survey site, directly adjacent to the stream or river. Two additional points were located in the bottom of the drainage, one 200 m upstream, and one 200 m downstream. Then three points were established perpendicular to these points (across the drainage), 100 m away. At each point, nested 5 and 11.3 m radius circular plots were sampled for vegetation. The plots of 5 m radius were used to count shrub and sapling stems < 2.5 cm diameter at breast height (DBH) and 2.5-8 cm DBH. At the 11.3 m plot we counted the number of small (8-23 cm DBH), medium (23-38 cm DBH), and large trees (>38 cm DBH) of each species, and the number of small (< 12 cm DBH) and large snags (>12 cm DBH). Additional measures recorded within the 11.3 m plot, while standing at the center of the plot, included average canopy height, estimated canopy cover, estimated percent total canopy cover above 5 m, dominant plant species, and each dominant species' percent cover, and the aspect and slope of the site. Species dominance was determined visually; dominance was defined as those species that account for at least 40% of the canopy cover.

In order to identify factors that may influence habitat selection by cuckoos, and identify habitat characteristics they may require for breeding, we compared characteristics between occupied and unoccupied sites. We used the survey results across all three visits within a year to classify sites as either occupied (a yellow-billed cuckoo had been detected at a site during at least two survey periods), or unoccupied (sites with no yellow-billed cuckoo detections, and sites where a cuckoo had been detected during only one survey period). We developed these criteria because individual cuckoos are known to wander, even within the breeding season, and there are numerous examples of cuckoos observed in obvious non-breeding habitat (Johnson et al. 2006, 2007). Consequently, a single detection of a cuckoo at a site does not indicate settling, pairing, or breeding at that location, and we only classified sites as occupied if cuckoos were detected there during two or more survey periods within a year.

We also characterized nest sites of all nests found (four), after the nest cycle was concluded (the nest had failed or the young had fledged). Measures at the nest sites included the UTM coordinates of the nest, the nest substrate species (what plant species the nest was placed in), height of the substrate, DBH of the nest substrate, the number of support branches and their size,

density estimate of foliage reflecting concealment, nest height above the ground, height from the top of the nest tree or shrub down to the nest, distance from the bole of the tree or the center of the bush to edge of the nest, distance from the edge of the nest to the nearest outside edge of the tree or shrub, and orientation of the nest according to the nest substrate, and the distance from the nest to the nearest water. Detailed drawings, depicting the location of the nest within the riparian patch, and within the nest tree were made for each site.

Inventory of Mesquite Habitat

In order to map the distribution of mesquite within our survey sites, we made maps of each study site using digital orthoimagery (photographed in 2005) acquired from the Arizona Imagery Server (http://sco.az.gov/imagery.htm) and provided by the Arizona State Cartographer's office. These maps were used in the field to delineate patches of mesquite within the survey sites. We then generated 32 maps where mesquite vegetation polygons were delineated. These maps consist of three main layers: 1) digital orthoimagery; 2) a point layer of the survey endpoints (i.e., the start and stop points of the survey), and; 3) a polygon layer of the mesquite vegetation. The digital orthoimagery is 1-meter resolution orthoimagery and the datum is NAD83. The standard map unit is meters and the projection and datum are UTM, Zone 12, NAD83. GIS databases will be submitted to the AGFD Heritage Program with this final report.

Results

Yellow-billed Cuckoo Distribution and Abundance in the Verde River Watershed

We conducted yellow-billed cuckoo surveys at a total of 37 sites within the Verde River watershed (Figure 1); 24 sites were surveyed each year (2004 and 2005). Three surveys were conducted at each site, within the survey periods listed in Table 4. The specific dates on which surveys were conducted at each site are listed in Appendix A.

Table 4. Yellow-billed cuckoo survey periods for 2004 and 2005.

Year	Survey 1	Survey 2	Survey 3
2004	6/15 – 6/30	7/1 – 7/22	7/27 – 8/17
2005	6/9 – 6/23	6/26 – 7/10	7/19 – 8/19

In 2004, of the 24 sites surveyed, 16 were historic sites (i.e., where cuckoos had been detected during the AGFD/CPRS surveys in 1998 and 1999), and 8 were random sites (see Methods). In 2005, 24 sites were surveyed; 10 of these were historic sites and 14 were random. Eleven of the 37 sites were surveyed in both years; 10 were historic sites in which cuckoos were detected during the initial year (2004). The remaining site that was surveyed in both years was Wet Beaver Creek Random #16, a randomly selected site in 2004 which had consistent detections across the season and was easily accessible (Table 5).

Yellow-billed cuckoos were detected in 16 of the 24 (67%) sites surveyed in 2004; cuckoos were detected in 12 of the 16 (75%) historic sites, and 4 of the 8 (50%) random sites. In 2005, cuckoos were detected in 16 of the 24 (67%) sites surveyed (the same proportion of sites with detections as in 2004); detections occurred in 9 of the 10 (90%) historic sites, and 7 of the 14 (50%) random sites. When both years are considered, of the 37 sites surveyed, there were detections at 22 (59%) sites, including 12 of the 16 (75%) historic sites, and 10 of the 21 (48%) random sites had detections (Figure 2).

We did not detect cuckoos at four of the historic sites, where cuckoos were found by AGFD/CPRS in 1998 to 1999. Midgley Bridge had been surveyed as part of the AGFD/CPRS project, but cuckoos had not been detected there. Thus, we mistakenly classified it as "historic" and having had a cuckoo detection. Cuckoos were detected during the AGFD/CPRS at Sullivan Lake, Highway 260, and Dry Beaver Creek, but we did not detect any at these sites during our surveys, six years later.

Table 5. Survey sites (listed from upstream to downstream in each drainage), and occurrence of detections during each survey period. X = at least one cuckoo was detected during the survey; 0 = no cuckoo was detected during the survey; -- = no survey was conducted; shaded = historic site.

		2004				2005		
Drainage	Survey Site Name	Survey 1	Survey 2	Survey 3		Survey 1	Survey 2	Survey 3
VERDE RIVER	Sullivan Lake Historic	0	0	0		--	--	--
	Campbell's Place Historic	X	0	0		X	X	X
	Upper Verde River Random #1	--	--	--		0	0	0
	Upper Verde River Random #18	X	X	X		--	--	--
	Sycamore Canyon Historic	0	X	0		X	X	X
	Verde River Random #20	--	--	--		0	0	0
	Highway 260 Historic	--	0	0		--	--	--
	Verde River/West Clear Creek Confluence Historic	X	X	X		X	X	X
	Verde River Random #28	--	--	--		X	X	X
	Verde River Random #27	--	--	--		X	X	X
OAK CREEK	Oak Creek Random #19	0	0	0		--	--	--
	Midgley Bridge Historic	0	0	0		--	--	--
	Oak Creek Random #12	X	X	X		--	--	--
	Red Rock State Park Historic	X	0	0		X	0	0
	Oak Creek Random #3	0	X	0		--	--	--
	Page Springs Historic	X	0	X		0	X	X
	Oak Creek Random #15	--	--	--		0	X	0
	Oak Creek / Verde River Confluence	--	--	--		X	X	0
BEAVER CREEK	Dry Beaver Creek Random #71	--	--	--		0	0	0
	Dry Beaver Creek Historic	0	0	0		--	--	--
	Dry Beaver Creek Random #17	0	0	0		--	--	--
	Red Tank Draw Random #20	--	--	--		0	0	0
	Red Tank Draw Historic	0	0	X		--	--	--
	Red Tank Draw Random #15	0	0	0		--	--	--
	Red Tank Draw Random #36	--	--	--		0	X	0
	Wet Beaver Creek Historic - Upper	X	X	0		X	X	X
	Wet Beaver Creek Historic - Lower	X	0	X		X	X	X
	Wet Beaver Creek Random #16	X	X	X		X	X	X
	Walker Creek Random #23	--	--	--		0	0	0
	Walker Creek Historic	0	0	X		--	--	--
	Montezuma Well Historic	0	X	X		X	X	X
	Montezuma Castle Historic	0	X	0		0	0	0
	Wet Beaver Creek Random #11	0	0	0		--	--	--
	Wet Beaver Creek Random #26	--	--	--		0	X	0
WEST CLEAR CREEK	West Clear Creek Random #33	--	--	--		0	0	0
	West Clear Creek Random #32	--	--	--		0	0	0
	Clear Creek Campground Historic	0	X	X		X	X	X

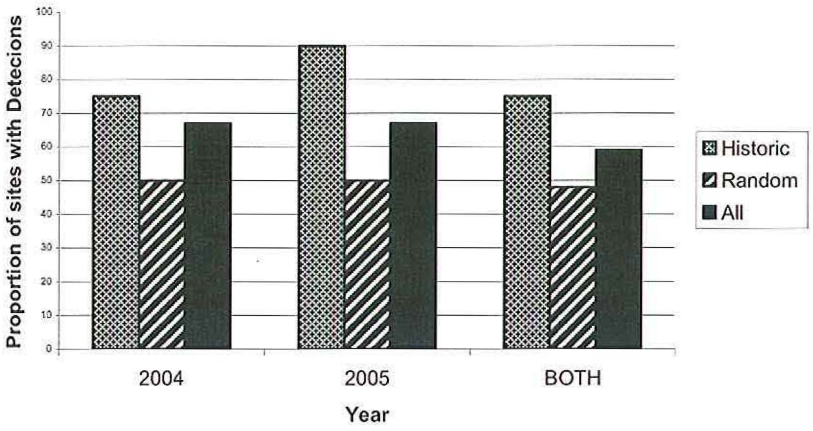


Figure 2. The proportion of historic, random, and all sites in the Verde River watershed where yellow-billed cuckoos were detected during at least one survey.

We also calculated the occupancy rate for each site (Table 6). Individual cuckoos are known to wander, even within the breeding season, and there are numerous examples of cuckoos observed in obvious non-breeding habitat (Johnson et al. 2006, 2007). Consequently, a single detection of a cuckoo at a site does not indicate settling, pairing, or breeding at that location. Therefore, we used the survey results across all three visits within a year to calculate occupancy rates for each site. Because the number of surveys conducted varied across sites, we defined occupancy rate as the proportion of surveys during which at least one cuckoo was detected. Occupancy rates for sites ranged from 100% (at six sites) to 0 (at 14 sites; Table 6).

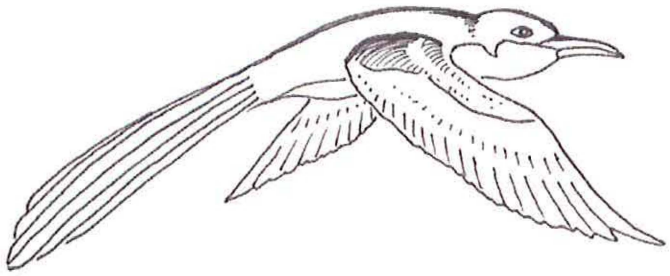


Table 6. Yellow-billed cuckoo occupancy per survey per site in the Verde River watershed, and occupancy rate.

	2004				2005			
Survey Site Name	Survey 1	Survey 2	Survey 3		Survey 1	Survey 2	Survey 3	Occupancy Rate
Upper Verde River Random #18	X	X	X		--	--	--	100
Verde River/West Clear Creek Confluence Historic	X	X	X		X	X	X	100
Verde River Random #28	--	--	--		X	X	X	100
Verde River Random #27	--	--	--		X	X	X	100
Oak Creek Random #12	X	X	X		--	--	--	100
Wet Beaver Creek Random #16	X	X	X		X	X	X	100
Wet Beaver Creek Historic - Upper	X	X	0		X	X	X	83
Wet Beaver Creek Historic - Lower	X	0	X		X	X	X	83
Montezuma Well Historic	0	X	X		X	X	X	83
Clear Creek Campground Historic	0	X	X		X	X	X	83
Campbell's Place Historic	X	0	0		X	X	X	67
Sycamore Canyon Historic	0	X	0		X	X	X	67
Page Springs Historic	X	0	X		0	X	X	67
Oak Creek / Verde River Confluence	--	--	--		X	X	0	67
Red Rock State Park Historic	X	0	0		X	0	0	33
Oak Creek Random #3	0	X	0		--	--	--	33
Oak Creek Random #15	--	--	--		0	X	0	33
Red Tank Draw Historic	0	0	X		--	--	--	33
Red Tank Draw Random #36	--	--	--		0	X	0	33
Walker Creek Historic	0	0	X		--	--	--	33
Wet Beaver Creek Random #26	--	--	--		0	X	0	33
Montezuma Castle Historic	0	X	0		0	0	0	17
Sullivan Lake Historic	0	0	0		--	--	--	0
Upper Verde River Random #1	--	--	--		0	0	0	0
Verde River Random #20	--	--	--		0	0	0	0
Highway 260 Historic	--	0	0		--	--	--	0
Oak Creek Random #19	0	0	0		--	--	--	0
Midgley Bridge Historic	0	0	0		--	--	--	0
Dry Beaver Creek Random #71	--	--	--		0	0	0	0
Dry Beaver Creek Historic	0	0	0		--	--	--	0
Dry Beaver Creek Random #17	0	0	0		--	--	--	0
Red Tank Draw Random #20	--	--	--		0	0	0	0
Red Tank Draw Random #15	0	0	0		--	--	--	0
Walker Creek Random #23	--	--	--		0	0	0	0
Wet Beaver Creek Random #11	0	0	0		--	--	--	0
West Clear Creek Random #33	--	--	--		0	0	0	0
West Clear Creek Random #32	--	--	--		0	0	0	0

Within-Site Cuckoo Detections and Estimated Numbers of Individuals

Using maps of the survey sites, with the location of detected cuckoos (derived from estimates of compass bearing and distance made in the field), for each survey period, and the descriptions of detections (Appendix A) we estimated the minimum numbers of individuals detected during each survey at each site (Table 7). These estimates do not account for cuckoos that may have been present but not responding to playback surveys.

The largest number of individuals detected per survey period occurred in 2005, during the second survey period (from 6/26 to 7/10). The survey sites varied in size, and, as expected, the larger

sites generally had more cuckoos. Cuckoos were most abundant at the Verde River / West Clear Creek Confluence site; this was also one of our larger sites (see Appendix A).

Table 7. Estimated number of yellow-billed cuckoos detected per survey at sites in the Verde River watershed.

		2004				2005		
Drainage	Survey Site Name	Survey 1	Survey 2	Survey 3		Survey 1	Survey 2	Survey 3
VERDE RIVER	Sullivan Lake Historic	0	0	0		--	--	--
	Campbell's Place Historic	3	0	0		1	3	1
	Upper Verde River Random #1	--	--	--		0	0	0
	Upper Verde River Random #18	2	1	1		--	--	--
	Sycamore Canyon Historic	0	1	0		1	1	3
	Verde River Random #20	--	--	--		0	0	0
	Highway 260 Historic	--	0	0		--	--	--
	Verde River/West Clear Creek Confluence Historic	5	4	3		1	3	4
	Verde River Random #28	--	--	--		1	3	3
	Verde River Random #27	--	--	--		4	2	5
OAK CREEK	Oak Creek Random #19	0	0	0		--	--	--
	Midgley Bridge Historic	0	0	0		--	--	--
	Oak Creek Random #12	2	1	1		--	--	--
	Red Rock State Park Historic	1	0	0		1	0	0
	Oak Creek Random #3	0	1	0		--	--	--
	Page Springs Historic	2	0	2		0	2	2
	Oak Creek Random #15	--	--	--		0	1	0
	Oak Creek / Verde River Confluence	--	--	--		3	4	0
BEAVER CREEK	Dry Beaver Creek Random #71	--	--	--		0	0	0
	Dry Beaver Creek Historic	0	0	0		--	--	--
	Dry Beaver Creek Random #17	0	0	0		--	--	--
	Red Tank Draw Random #20	--	--	--		0	0	0
	Red Tank Draw Historic	0	0	1		--	--	--
	Red Tank Draw Random #15	0	0	0		--	--	--
	Red Tank Draw Random #36	--	--	--		0	1	0
	Wet Beaver Creek Historic - Upper	4	2	0		1	1	4
	Wet Beaver Creek Historic - Lower	2	0	1		1	2	1
	Wet Beaver Creek Random #16	2	3	1		2	2	1
	Walker Creek Random #23	--	--	--		0	0	0
	Walker Creek Historic	0	0	2		--	--	--
	Montezuma Well Historic	0	3	2		2	2	2
	Montezuma Castle Historic	0	1	0		0	0	0
	Wet Beaver Creek Random #11	0	0	0		--	--	--
	Wet Beaver Creek Random #26	--	--	--		0	1	0
WEST CLEAR CREEK	West Clear Creek Random #33	--	--	--		0	0	0
	West Clear Creek Random #32	--	--	--		0	0	0
	Clear Creek Campground Historic	0	2	5		3	3	1
	Total per survey period	**23**	**19**	**19**		**21**	**31**	**27**

Evidence of Breeding

We found evidence of breeding by yellow-billed cuckoos at 14 sites. We confirmed breeding by cuckoos at five sites. We found active nests at Campbell's Place-Historic, the Oak Creek / Verde River Confluence, and the Clear Creek Campground-Historic site. We were unable to adequately

monitor nests due to logistical constraints (i.e., the nests we located were substantial distances from our scheduled survey areas), and we lacked the sample size to compare nest success in different riparian habitat types. Nevertheless, we did confirm successful breeding by yellow-billed cuckoos within the Verde River watershed, as we observed recently fledged individuals at the Verde River / West Clear Creek Confluence-Historic and Wet Beaver Creek-Historic-Upper sites. Breeding was probable, based on behavioral observations, in an additional four sites, Verde River Random #28 and #27, Oak Creek Random #12, and Page Springs-Historic. The presence of breeding cuckoos was possible at five sites, since cuckoos were detected there during at least two surveys within a year (Table 8).

Table 8. Yellow-billed cuckoo breeding classification at survey sites in the Verde River watershed, based on survey results and behavioral observations. Descriptions of the types of evidence used to make classifications are given in Table 2.

Drainage	Survey Site Name	Breeding Classification
VERDE RIVER	Sullivan Lake Historic	No Detections
	Campbell's Place Historic	Confirmed
	Upper Verde River Random #1	No Detections
	Upper Verde River Random #18	Possible
	Sycamore Canyon Historic	Possible
	Verde River Random #20	No Detections
	Highway 260 Historic	No Detections
	Verde River/West Clear Creek Confluence Historic	Confirmed
	Verde River Random #28	Probable
	Verde River Random #27	Probable
OAK CREEK	Oak Creek Random #19	No Detections
	Midgley Bridge Historic	No Detections
	Oak Creek Random #12	Probable
	Red Rock State Park Historic	Unlikely
	Oak Creek Random #3	Unlikely
	Page Springs Historic	Probable
	Oak Creek Random #15	Unlikely
	Oak Creek / Verde River Confluence	Confirmed
BEAVER CREEK	Dry Beaver Creek Random #71	No Detections
	Dry Beaver Creek Historic	No Detections
	Dry Beaver Creek Random #17	No Detections
	Red Tank Draw Random #20	No Detections
	Red Tank Draw Historic	Unlikely
	Red Tank Draw Random #15	No Detections
	Red Tank Draw Random #36	Unlikely
	Wet Beaver Creek Historic - Upper	Confirmed
	Wet Beaver Creek Historic - Lower	Possible
	Wet Beaver Creek Random #16	Possible
	Walker Creek Random #23	No Detections
	Walker Creek Historic	Unlikely
	Montezuma Well Historic	Possible
	Montezuma Castle Historic	Unlikely
	Wet Beaver Creek Random #11	No Detections
	Wet Beaver Creek Random #26	Unlikely
WEST CLEAR CREEK	West Clear Creek Random #33	No Detections
	West Clear Creek Random #32	No Detections
	Clear Creek Campground Historic	Confirmed

The four active nests of yellow-billed cuckoos we found were located in four different tree species, Goodding willow (*Salix gooddingii*), boxelder (*Acer negundo*), Arizona alder (*Alnus oblongifolia*), and Fremont cottonwood (*Populus fremontii*). All of the nests were located in a patch of native trees, within 11 m of surface water, and were well-hidden by vegetative cover (Table 9).

Table 9. Habitat characteristics of nest sites of yellow-billed cuckoos, found at survey sites in the Verde River watershed.

Drainage	Site	Date	Tree Species	Tree Height (m)	Nest Height (m)	DBH (cm)	Orient.	Distance to Water (m)
Verde River	Campbell's Place Historic	6/29/2005	Goodding willow	8	5.3	18.3	90	6
Oak Creek	Oak Creek / Verde River Confluence	6/27/2005	boxelder	19	12	33	55	10
West Clear Creek	Clear Creek Campground Historic	7/30/2004	Arizona alder	8	3.3	24.3	180	2
West Clear Creek	Clear Creek Campground Historic	7/9/2005	Fremont cottonwood	8	7	9.5	90	11

Yellow-billed Cuckoo Habitat Use in the Verde River Watershed

The maps of locations of yellow-billed cuckoos detected during surveys (Appendix A) show that we rarely detected cuckoos outside of the riparian habitat we surveyed. Our survey results also show that some riparian areas are not used by cuckoos. In order to identify factors that may influence habitat selection by cuckoos, and identify habitat characteristics they may require for breeding, we compared characteristics between occupied and unoccupied sites (defined under Methods).

We classified the vegetation of each survey site, using classifications described in Table 3. The majority of our survey sites (32 of 37; 86%) were classified as "Native Habitat", sites containing > 75% native tree species (detailed site descriptions are in Appendix B). Three sites were classified as "Mixed Native", two were occupied, one was not. Only two sites were classified as "Mixed Exotic" and one was occupied (Table 10).

Fremont cottonwood was the dominant tree species in the majority of occupied sites (9 of 14; 64%). Arizona sycamore (*Platanus wrightii*) was the dominant tree species in 13 sites, and the majority of these sites (11; 85%) were unoccupied. The five most common tree species (from 8 to >38 cm DBH) in occupied sites were Arizona alder, Arizona sycamore, velvet ash (*Fraxinus velutina*), Goodding willow, and Fremont cottonwood. In unoccupied sites, the most common trees were Utah juniper (*Juniperus osteosperma*), mesquite (*Prosopis* sp.), ash, Goodding willow, one seed juniper (*Juniperus monosperma*), and Arizona sycamore.

Table 10. Occupancy and vegetation classifications of yellow-billed cuckoo survey sites in the Verde River watershed.

Survey Site Name	Occupancy Classification	Vegetation Classification
Sullivan Lake Historic	Unoccupied	Mixed Native
Campbell's Place Historic	Occupied	Native
Upper Verde River Random #1	Unoccupied	Mixed Native
Upper Verde River Random #18	Occupied	Native
Sycamore Canyon Historic	Occupied	Native
Verde River Random #20	Unoccupied	Native
Highway 260 Historic	Unoccupied	Mixed Exotic
Verde River/West Clear Creek Confluence Historic	Occupied	Native
Verde River Random #28	Occupied	Native
Verde River Random #27	Occupied	Native
Oak Creek Random #19	Unoccupied	Native
Midgley Bridge Historic	Unoccupied	Native
Oak Creek Random #12	Occupied	Mixed Native
Red Rock State Park Historic	Unoccupied	Native
Oak Creek Random #3	Unoccupied	Native
Page Springs Historic	Occupied	Mixed Exotic
Oak Creek Random #15	Unoccupied	Native
Oak Creek / Verde River Confluence	Occupied	Native
Dry Beaver Creek Random #71	Unoccupied	Native
Dry Beaver Creek Historic	Unoccupied	Native
Dry Beaver Creek Random #17	Unoccupied	Native
Red Tank Draw Random #20	Unoccupied	Native
Red Tank Draw Historic	Unoccupied	Native
Red Tank Draw Random #15	Unoccupied	Native
Red Tank Draw Random #36	Unoccupied	Native
Wet Beaver Creek Historic - Upper	Occupied	Native
Wet Beaver Creek Historic - Lower	Occupied	Native
Wet Beaver Creek Random #16	Occupied	Native
Walker Creek Random #23	Unoccupied	Native
Walker Creek Historic	Unoccupied	Native
Montezuma Well Historic	Occupied	Native
Montezuma Castle Historic	Unoccupied	Native
Wet Beaver Creek Random #11	Unoccupied	Native
Wet Beaver Creek Random #26	Unoccupied	Native
West Clear Creek Random #33	Unoccupied	Native
West Clear Creek Random #32	Unoccupied	Native
Clear Creek Campground Historic	Occupied	Native

Occupied sites had a higher density of trees, in every size class, than unoccupied sites (Table 11). Sapling trees (0 to <8 cm DBH) were considerably more common in occupied sites, and saplings of cottonwood, willow, alder, and sycamore were much more common in occupied sites than unoccupied sites. Large cottonwoods (23 – 38, and >38 cm DBH) had higher densities in occupied sites.

Table 11. Mean number of trees per hectare in each size class. Z value is from a Mann-Whitney U test.

Size Class (cm DBH)	Occupied	Unoccupied	Z value	Significance
0 to <8	2,513	1,489	-1.55	0.122
8 to 23	469	336	-2.43	0.015
23-38	75	37	-2.03	0.042
>38	29	12	-1.69	0.092

We compared the area of riparian habitat (measured as the width of the riparian habitat at its widest point within each site) in occupied and unoccupied sites. We found that, on average, occupied sites were larger than unoccupied sites (mean width of occupied sites=253 m, 95% CI 206-300 m; mean width of unoccupied sites=134 m, 95% CI 101-167 m). Occupied sites were at least 100 m wide, and 79% (11 of 14) of occupied sites were over 200 m wide (Table 12).

Table 12. Area of riparian habitat per survey site, measured as the width of riparian habitat at its widest point within the site. Sites occupied by yellow-billed cuckoos are shaded.

Survey Site Name	Occupancy Classification	Width of Riparian Habitat (m)
Red Tank Draw Random #15	Unoccupied	25
Red Tank Draw Random #36	Unoccupied	34
Upper Verde River Random #1	Unoccupied	55
Dry Beaver Creek Random #17	Unoccupied	64
Sullivan Lake Historic	Unoccupied	71
Oak Creek Random #3	Unoccupied	87
West Clear Creek Random #32	Unoccupied	92
Red Tank Draw Historic	Unoccupied	96
Walker Creek Random #23	Unoccupied	111
Oak Creek / Verde River Confluence	Occupied	114
Wet Beaver Creek Random #11	Unoccupied	115
Verde River Random #20	Unoccupied	116
Oak Creek Random #15	Unoccupied	119
Red Tank Draw Random #20	Unoccupied	119
Wet Beaver Creek Random #26	Unoccupied	120
Midgley Bridge Historic	Unoccupied	137
Highway 260 Historic	Unoccupied	140
Campbell's Place Historic	Occupied	146
Oak Creek Random #19	Unoccupied	154
West Clear Creek Random #33	Unoccupied	163
Dry Beaver Creek Random #71	Unoccupied	169
Montezuma Castle Historic	Unoccupied	169
Sycamore Canyon Historic	Occupied	187
Dry Beaver Creek Historic	Unoccupied	208
Oak Creek Random #12	Occupied	241
Upper Verde River Random #18	Occupied	262
Wet Beaver Creek Historic - Upper	Occupied	267
Walker Creek Historic	Unoccupied	270
Page Springs Historic	Occupied	278
Red Rock State Park Historic	Unoccupied	285
Verde River/West Clear Creek Confluence Historic	Occupied	310
Montezuma Well Historic	Occupied	322
Wet Beaver Creek Historic - Lower	Occupied	322
Wet Beaver Creek Random #16	Occupied	357
Clear Creek Campground Historic	Occupied	400

We found evidence of impacts on riparian habitat at that the majority of our 37 study sites. Eight sites had been grazed by cattle to the extent that soil was eroded and understory vegetation was trampled. Heavy human use, evidenced by multiple trails, ORV tracks, campfire rings, and compacted soil, was evident at 17 (46%) of our study sites. ORV use was particularly evident at five sites including Campbell's Place Historic, Upper Verde Random #1 and #18, Verde River/West Clear Creek Confluence Historic, and Walker Creek Historic. A description of each study site, including evidence of impacts to riparian habitat, is given in Appendix B.

Inventory of Mesquite Habitat and Yellow-billed Cuckoo Site Occupancy

We mapped areas of mesquite habitat within our survey sites, and calculated the total area of mesquite at each site (Appendix C). We were unable to map two sites (Verde River Random # 27, Verde River Random # 28) because the river is bordered by private land. We accessed these areas by canoe to conduct yellow-billed cuckoo surveys, and we could not access them in order to delineate mesquite areas.

Preliminary exploratory analyses of the area of mesquite per site showed three outliers, with exceptionally large amounts of mesquite habitat, including Wet Beaver Creek Random #26, Montezuma Castle-Historic, and Wet Beaver Creek Random #11. These sites are also outliers in the sense that they differ from the majority of study sites in several aspects. They are adjacent to each other, and are located in an area that is fairly atypical of our sites in that there are extensive patches of mesquite, comprised of sparsely distributed small to mid-sized mesquite trees, that extend a considerable distance from the deciduous riparian habitat in these sites. These sites are also fairly unique because the amount of deciduous riparian vegetation within them is relatively limited (the average maximum width of deciduous habitat is 98 m), the stream has been dry during our surveys, and the deciduous habitat is sparse and stressed (Appendix B). Considering these factors, and using our knowledge of cuckoo habitat use in the area, we expect that mesquite habitat with these characteristics would not likely be used by yellow-billed cuckoos in the study area. When we removed these outliers from analysis, we found that occupied sites had more mesquite than unoccupied sites (Mean area of mesquite in occupied sites = 17.6 ha, 95% CI 9.0-26.3 ha; mean in unoccupied = 9.3, 95% CI 4.9-13.7 ha; $Z = -2.06$; $p = .039$).

All occupied sites had adjacent mesquite, 92% had at least 5 ha of mesquite. Eleven sites had less than 5 ha of mesquite, and only one was occupied (Oak Creek Random #12). Of the 10 sites with over 24 ha of mesquite, five (50%) are occupied sites. If we remove the three outliers (described above), 71% (5 of 7) of the sites with the largest areas of mesquite are occupied by yellow-billed cuckoos (Table 13).

Table 13. Area of mesquite (ha) per survey site in the Verde River watershed. Sites occupied by yellow-billed cuckoos are shaded.

Survey Site Name	Occupancy Classification	Area of Mesquite (ha)
Midgley Bridge Historic	Unoccupied	0.0
Oak Creek Random #3	Unoccupied	0.0
Oak Creek Random #19	Unoccupied	0.0
Sullivan Lake Historic	Unoccupied	0.6
Dry Beaver Creek Random #17	Unoccupied	1.0
Red Rock State Park Historic	Unoccupied	2.4
Oak Creek Random #12	Occupied	2.9
Red Tank Draw Random #20	Unoccupied	3.2
Red Tank Draw Random #36	Unoccupied	3.3
Walker Creek Random #23	Unoccupied	3.4
Upper Verde River Random #1	Unoccupied	4.5
Page Springs Historic	Occupied	5.4
West Clear Creek Random #32	Unoccupied	5.5
Clear Creek Campground Historic	Occupied	5.7
Upper Verde River Random #18	Occupied	7.2
Oak Creek Random #15	Unoccupied	8.8
Wet Beaver Creek Historic - Upper	Occupied	10.7
Oak Creek / Verde River Confluence	Occupied	11.0
Dry Beaver Creek Random #71	Unoccupied	11.3
West Clear Creek Random #33	Unoccupied	13.6
Dry Beaver Creek Historic	Unoccupied	14.0
Wet Beaver Creek Random #16	Occupied	15.3
Highway 260 Historic	Unoccupied	16.9
Red Tank Draw Historic	Unoccupied	18.9
Red Tank Draw Random #15	Unoccupied	23.9
Walker Creek Historic	Unoccupied	24.1
Verde River/West Clear Creek Confluence Historic	Occupied	24.6
Sycamore Canyon Historic	Occupied	25.3
Wet Beaver Creek Historic - Lower	Occupied	26.5
Campbell's Place Historic	Occupied	27.6
Verde River Random #20	Unoccupied	30.8
Montezuma Well Historic	Occupied	50.0
Wet Beaver Creek Random #11	Unoccupied	72.4
Montezuma Castle Historic	Unoccupied	78.4
Wet Beaver Creek Random #26	Unoccupied	88.2

Discussion

The Arizona Game and Fish Department has designated the yellow-billed cuckoo as "threatened" in the state, and a "wildlife species of special concern" in Arizona (AGFD 2002). Arizona's Comprehensive Wildlife Conservation Strategy (AGFD 2006) considers it to be a "species of greatest conservation need", and a community focal species. The Arizona Bird Conservation Plan (Latta et al. 1999) lists the western yellow-billed cuckoo as a "priority species" for the low elevation riparian priority habitat. The plan (Latta et al. 1999) has an objective to achieve 25 self-sustaining populations (with a population defined as 25 pairs of cuckoos), with 3 populations (75 pairs) in the Verde River area, from the Verde/Salt confluence to Cottonwood. The plan's habitat strategy is to maintain or increase yellow-billed cuckoo habitat.

Knowledge of habitat selection patterns and identification of potential breeding habitat is essential to guide conservation efforts (Laymon 1998, Hughes 1999). Our study shows that yellow-billed cuckoos are found throughout the Verde River watershed in sites that contain relatively large areas of deciduous riparian habitat, at least 100 m wide, with dominant tree species comprised of mainly Fremont cottonwood, Goodding willow, Arizona alder, and Arizona sycamore. In addition, yellow-billed cuckoos seem more likely to occupy riparian habitat that has adjacent patches of mesquite over 5 ha in size.

In order to identify specific areas to meet the habitat strategy to maintain areas of habitat for yellow-billed cuckoos (Latta et al. 1999), we propose using occupancy rate as a measure of habitat quality. In a review of 22 studies of territory occupancy in 17 species, Sergio and Newton (2003) found that occupancy was always correlated with productivity and/or with some other measure of territory or habitat quality. They suggest that occupancy may be a reliable method of habitat quality assessment, especially for populations in which not all territories are always occupied, and for species in which checking occupancy is easier than finding nests. Yellow-billed cuckoos are just such a species. Although they are not territorial, our survey results show that we detected cuckoos occupying some sites (e.g., Verde River / West Clear Creek confluence, Wet Beaver Creek-Historic) within the Verde River watershed throughout the breeding season, and across years, while other sites were not always occupied, and were used for short durations. Using occupancy rate as an indication of habitat quality, the areas with the highest occupancy rates is expected to provide the greatest conservation benefit for yellow-billed cuckoo populations (Table 14). Areas with lower occupancy rates (33-17) likely provide habitat for migratory and/or wandering cuckoos, and are also important to consider for conservation. Our results indicate that native, multi-layered riparian habitat, including areas of mesquite, are important to cuckoos. We noted impacts to some of these sites from cattle grazing and ORV use, and effective conservation of these areas may require management of these impacts.

Table 14. Priority areas for the maintenance of yellow-billed cuckoo habitat within the Verde River watershed.

Survey Site Name	Occupancy Rate	Survey Site Name	Occupancy Rate*
Upper Verde River Random #18	100	Sycamore Canyon Historic	67
Verde River/West Clear Creek Confluence Historic	100	Page Springs Historic	67
Verde River Random #28	100	Oak Creek / Verde River Confluence	67
Verde River Random #27	100	Red Rock State Park Historic	33
Oak Creek Canyon Random #12	100	Oak Creek Canyon Random #3	33
Wet Beaver Creek Random #16	100	Oak Creek Canyon Random #15	33
Wet Beaver Creek Historic - Upper	83	Red Tank Draw Historic	33
Wet Beaver Creek Historic - Lower	83	Red Tank Draw Random #36	33
Montezuma Well Historic	83	Walker Creek Historic	33
Clear Creek Campground Historic	83	Wet Beaver Creek Random #26	33
Campbell's Place Historic	67	Montezuma Castle Historic	17

However, managing these areas to maintain cuckoo habitat is unlikely to be sufficient to achieve the targeted 75 pairs, and 150 individuals in the Verde River watershed. We surveyed a majority of the riparian habitat on public land in the area, from just below the Verde River / West Clear Creek confluence to the upper Verde River; our estimates of the number of cuckoos in a site are conservative, and do not account for individuals that may have been present but did not respond during playback surveys. Nevertheless, the number of individual cuckoos occupying our study sites falls short of the targeted 75 pairs, and 150 individuals. This suggests that it will be necessary to manage additional riparian areas to support cuckoo populations in the Verde River watershed, and that some of these areas will likely be private land. Our findings suggest that areas selected for increasing yellow-billed cuckoo habitat, and increasing cuckoo populations in the area, should be, or should have the potential to become, multi-storied riparian habitat dominated by native trees, especially Fremont cottonwood and Goodding willow, and should have adjacent areas of mesquite that are 5 ha or larger.

We recommend that a new statewide inventory of yellow-billed cuckoos be conducted using our modified survey methods, discussed below. Data from this inventory could then be used as baseline data for long term monitoring. Data on cuckoo abundance and distribution could also be used to reassess the Arizona Bird Conservation Plan (Latta et al. 1999) population objectives for Arizona and to identify priority areas for maintaining or increasing yellow-billed cuckoo habitat.

Established methodologies for conducting yellow-billed cuckoo surveys (Laymon 1998a, 1998b, Halterman et al. 2006) address our observations that cuckoos do not always respond to a single broadcast of their own call, therefore requiring multiple playback surveys to be conducted within the survey area. Broadcasts are conducted every 100 m, with a minimum of three surveys conducted between 25 May and 31 August. 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. We found that these methodologies are adequate in determining cuckoo presence/absence. However, they do not provide adequate data for estimating the number of cuckoos at a site.

To enable estimating cuckoo abundance from survey data, we modified the survey methodologies. When we detected a cuckoo during a survey, we recorded the UTM coordinates of the surveyor's location (as per Halterman et al. 2006). In addition, we estimated the distance and compass bearing to the detected cuckoo. We then mapped these detections and used these maps, with the descriptions of detections, to estimate the numbers of individuals detected during each survey at each site. Detections were counted as individual cuckoos when they were a minimum of 300 m from any other detection during that survey, and/or when multiple cuckoos

were detected at a survey point. For example, when one cuckoo was detected at a survey point, and then two cuckoos were detected at the subsequent survey point, and were within 300 m of the location of the last detected cuckoo, we estimated there were two cuckoos total. Thus, our estimates of the number of cuckoos at a site during a particular survey can be considered as the minimum number of cuckoos detected during that survey. We suggest using these methods to estimate the number of cuckoos at a site using survey data.

Alternatively, for long term monitoring of yellow-billed cuckoos in Arizona's riparian habitats, estimating trends in site occupancy may be a suitable and effective approach, as many species that are rare or difficult to detect are monitored by estimating trends in site occupancy as opposed to trends in numbers of animals detected (MacKenzie et al. 2002). Particular sites would be classified based on their duration of occupancy (i.e., occupancy rate, as described above), and particular sites would be monitored across years.

As part of this study, we conducted surveys at sites where cuckoos were detected during the AGFD/CPRS 1998-1999 surveys (Corman and Magill 2000), which we call "historic" sites. We detected cuckoos in all but 3 of the 16 historic sites with detections during the 1998-1999 surveys. We were unable to make direct comparisons of site conditions between years, as there is limited information on the habitat characteristics of these sites at the time of the previous surveys. Nevertheless, the three sites that no longer had cuckoos in 2004 or 2005, Sullivan Lake Historic, Highway 260 Historic, and Dry Beaver Creek Historic, did not appear to have suitable cuckoo habitat. At the Sullivan Lake site, the lake appeared to have receded considerably, and the site had only sparse pockets of riparian vegetation consisting mainly of young Fremont cottonwoods, desert willow, and tamarisk, with very little understory. The maximum width of riparian habitat was 71 m. At the Highway 260 Historic site, we found evidence of heavy human traffic, which appeared to be affecting tree regeneration in the understory. Also, in 2005, a large flood swept through this area, scouring out much of the vegetation. The Dry Beaver Creek Historic site also had noticeably high human use, and impacts from cattle grazing.

Acknowledgements

We would like to thank the Arizona Game and Fish Department Heritage Program, the Western National Parks Association, and the USGS Southwest Biological Science Center for providing funding for the project. Terry Arundel, USGS Southwest Biological Science Center conducted GIS-related tasks and created the maps presented in this report. The National Park Service, Montezuma Castle National Monument generously provided field housing. We would also like to thank the USGS Southwest Biological Science Center, Colorado Plateau Research Station, the Center for Sustainable Environments, and Northern Arizona University, who all provided valuable administrative assistance. The project would not have been possible without the dedication of our field staff, and we thank Emily Nelson, Dean Pokrajac, and Ken Etzel for their assistance. Also, thanks to Patty Gunnison for help with surveys at Red Rock State Park. Robert Weber, Pinnacle Mapping Technologies, Flagstaff AZ created the initial survey maps and assisted in the selection of study sites. Several agencies allowed us access to the lands they manage; especially we thank Janie Agyagos, Coconino National Forest, Susan Schuhardt, Prescott National Forest, and Kathy Davis, National Park Service for their time and assistance. Christopher Calvo created the illustrations. An anonymous reviewer provided helpful suggestions on the draft report.

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05-07 Addendum

Assessing Yellow-billed Cuckoo habitat requirements at Montezuma Castle National Monument and Montezuma Well

Western National Parks Association Grant No. : 05-07

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Explanation of WNPA Research Committee Concerns for Release of Final Payment

September 12, 2008

This report is an explanation addressing the concerns by the Western National Park Association research committee for the WNPA project 05-07, "*Assessing Yellow-billed Cuckoo Habitat Requirements through the use of Radio-telemetry at Montezuma Castle National Monument*". Below we give a brief introduction of the project and the species studied. We then explain the methods used during the project and then address the first and second questions submitted by the WNPA research committee (1. Was the telemetry used in this study? If not, why? What problems were encountered? 2. How was $4890 given to the Co-Principle Investigators used?) We then discuss the results of the project we modified since we were unsuccessful with our initial objectives, and how we continued to use the funding received for this grant. And finally we address the third question submitted by the WNPA research committee; (3. In what specific ways can this information be used by park staff to 1) better manage habitat at Montezuma Well and or improve habitat near Montezuma Castle and 2) share this information with park visitors through educational media and interpretive programs.).

Introduction

Western populations of the Yellow-billed Cuckoo (*Coccyzus americanus occidentalis*), a riparian habitat obligate, have decreased and suffered catastrophic range reductions in the twentieth century and its future is uncertain. The Yellow-billed Cuckoo recently became a Candidate Species under the Endangered Species Act and it is ranked as the third highest Priority Species (with an overall score of 35) in the list of Priority Species in the Arizona Partners in Flight Bird Conservation Plan. Despite concern over the fate of this species, few aspects of Yellow-billed Cuckoo life history have been adequately studied. Particularly in the Southwest, the basic habitat requirements of this species are largely unknown. For example, the extent to which Yellow-billed Cuckoos depend on native riparian vegetation, as opposed to exotics such as salt cedar (*Tamarix* sp.), is unclear. Additionally, the extent to which vegetation surrounding the riparian corridor influences cuckoo occupancy and productivity is unknown.

Little is known about the Western Yellow-billed Cuckoo's habitat requirements, hindering the ability to make informed management decisions regarding the cuckoo's conservation, including the ability to predict the effects of management options such as riparian habitat protection and restoration. To help meet these information needs, we were awarded an Arizona Game and Fish Department (AZGFD) Heritage Fund grant to inventory riparian habitat and conduct Yellow-

billed Cuckoo surveys in riparian areas of the Verde River watershed, including Montezuma Castle National Monument (MOCA), and Montezuma Well (MOWE), a unit of MOCA, in 2004 and 2005. In addition, we received funding from the Sonoran Joint Venture (SJV) to acquire the equipment needed to use radiotelemetry to track individual Yellow-billed Cuckoos and determine their movements and habitat use. The SJV did not provide funds for personnel to conduct this work, and the Western National Parks Association (WNPA) provided funds to attempt to use radiotelemetry to track individual Yellow-billed Cuckoos in order to better determine cuckoo breeding habitat and food requirements. The results of the AZGFD Heritage project are reported in Holmes et al. (2008). Here, we describe the study conducted with funding from the WNPA, to provide information on Western Yellow-billed Cuckoo habitat use at MOCA, and MOWE.

Methods

Surveys for Western Yellow-billed Cuckoos were conducted at Montezuma Castle and Montezuma Well as part of the AZGFD Heritage project, listed above. The Heritage project study area encompassed much of the Verde River watershed, including the Verde River from the upper river to below the confluence with West Clear Creek, and the Oak Creek, Dry Beaver Creek, Wet Beaver Creek (which runs through Montezuma Well and Montezuma Castle), and West Clear Creek tributaries. Surveys were conducted three times across the breeding seasons, in 2004 and 2005 (Table 1). For a complete description of survey methods, including selection of study sites, please see Holmes et al. (2008).

Table 1. Yellow-billed cuckoo survey dates for 2004 and 2005, at MOCA and MOWE.

Site	Year	Survey 1	Survey 2	Survey 3
MOCA	2004	6/16	7/1	7/27
	2005	6/11	7/5	7/26
MOWE	2004	6/18	7/9	8/4
	2005	6/21	7/5	7/28

Explanation:

1. **Was the telemetry used in this study? If not, why? What problems were encountered?**
2. **How was $4890 given to the Co-Principal Investigators used?**

At MOWE, where surveys suggested cuckoos were nesting, we attempted to trap and fit Yellow-billed Cuckoos with radios for tracking their movements. This involved attempting to capture Yellow-billed Cuckoos by placing mist nets within known home ranges and playing various call notes to entice adults into the net. Captured cuckoos were to be outfitted with Holohil LB-2N radio transmitters that have a life span of approximately 13-22 days. These transmitters weigh 0.42g, well below the maximum of 3% of total body weight recommended for birds. They are attached to the tail, according to methodologies refined by M. Halterman. A Wildlife Materials International, Inc. TRX 100s receiver with a 3-element Yagi antenna is then used to locate and follow radioed birds. Handheld GPS units are used to mark the position of located cuckoos.

The Co-Principal Investigators (Matthew Johnson and Jennifer Holmes) and one biological technician (Christopher Calvo) spent considerable time attempting to capture cuckoos, however, we were unsuccessful. We believe the main reason we failed to capture cuckoos was due to the structure of the habitat at our sites in the Verde Watershed, and the limited number of cuckoo pairs at Montezuma Castle (n = 1 unpaired cuckoo) and Montezuma Well (n = 3 cuckoo pairs).

Western Yellow-billed Cuckoos have been successfully captured in the past in areas typified by large areas of dense, large mesquite trees adjacent to deciduous riparian. In these areas, nets are placed out in the mesquite, at a distance that basically forces a cuckoo to come out of the tall deciduous riparian trees and into the lower-level of mesquite to investigate the source of the cuckoo call (the speaker near the net). Cuckoos typically move in slowly to net level when the vegetation is dense and provides enough cover for them to feel secure. Then, they can be chased into the net. We found, at MOCA, that we could not place the nets a sufficient distance from the tall deciduous riparian trees to lure the cuckoos down. Also, the mesquite may not have provided enough cover. The cuckoos would remain calling and apparently reacting to the call from the speaker, from the tops of the tall trees; they would not approach the net area.

Failing to capture and radio-tag cuckoos, we modified our methods in order to record habitat use, and attempt to observe foraging and record cuckoo prey items. We conducted observational surveys two ways. First, when conducting formal surveys for cuckoos, when cuckoos were detected during surveys, one person would continue to conduct the survey for cuckoos (the "surveyor"), while the second person (the "observer") would walk in the direction of the detection, attempt to observe the cuckoo, record all observations, and attempt to follow it, or relocate the cuckoo by following vocalizations. The observer used a handheld GPS to record the location of Yellow-billed Cuckoo observations. The observer did not use call playback to attempt to locate individual cuckoos by getting them to call, in order to not interfere with the surveyor and the formal survey. We also conducted observational surveys on days when formal surveys were not conducted. On these days, the observer would occasional broadcast a call (1 to 2 times) in an attempt to locate cuckoos. From these observations, we examined patterns in the location and movement of cuckoos and estimated the location of individual home ranges of cuckoos at MOWE.

At each study, we completed a site description that included: A) the habitat class; B) an estimate of percent cover of each dominant and/or co-dominant plant species; and C) the levels and causes of any disturbance. We also proposed to measure microhabitat features associated with any nests found at Montezuma Castle or Montezuma Well. No nests were found, but we did conduct vegetation measurements to describe the structure and composition of riparian habitat at MOCA and MOWE, at random points located within the riparian habitat. We also mapped and measured deciduous riparian patch size and the amount of mesquite habitat adjacent to deciduous riparian habitat (see Holmes et al. 2008).

We created ArcGIS (ESRI 2007) point shapefiles using coordinate data (UTM coordinates) collected from hand-held global positioning system (GPS) units. Corresponding maps were developed from these data for Montezuma castle and Montezuma Well, surveyed in 2004 and 2005. These maps consist of five main layers: 1) digital orthoimagery; 2) a point layer of all surveyor locations (i.e., the point from which a playback survey was conducted); 3) a point layer of cuckoo detections (i.e., a point derived from the estimated distance and bearing from the surveyor location); 4) a line layer representing the bearing and distance from the surveyor location to the estimated yellow-billed cuckoo detection location, and; 5) a point layer of the survey endpoints (i.e., the start and stop points of the survey). Digital orthoimagery for the study area was acquired from the Arizona Imagery Server (http://sco.az.gov/imagery.htm) and provided by the Arizona State Cartographer's office. This imagery is 1-meter resolution orthoimagery and the datum is NAD83, and was photographed in 2005. The standard map unit was meters, and the projection and datum are UTM, Zone 12, NAD83. GIS databases were submitted to the AZGFD Heritage Program with the Heritage Project final report (Holmes et al. 2008).

Results of Modified Telemetry Study at MOCA and MOWE

Using survey data, we calculated the occupancy rate for MOCA and MOWE (Table 2). Individual cuckoos are known to wander, even within the breeding season, and there are numerous examples of cuckoos observed in obvious non-breeding habitat (Johnson et al. 2006, 2007). Consequently, a single detection of a cuckoo at a site does not indicate settling, pairing, or breeding at that location. Therefore, we used the survey results across all three visits within a year to calculate occupancy rates for each site. We defined occupancy rate as the proportion of surveys during which at least one cuckoo was detected.

Table 2. Yellow-billed cuckoo occupancy per survey per site in the Verde River watershed, and occupancy rate.

	2004				2005			
Survey Site Name	Survey 1	Survey 2	Survey 3		Survey 1	Survey 2	Survey 3	Occupancy Rate
Montezuma Castle Historic	0	X	0		0	0	0	17
Montezuma Well Historic	0	X	X		X	X	X	83

In 2004 and 2005, Yellow-billed Cuckoos were not breeding at MOCA. Only one Yellow-billed Cuckoo was detected there in the two years, and this individual's behavior indicated it was a wanderer, as it flew in towards the call from a distance, then left, flying out a sight. In contrast, Yellow-billed Cuckoos were repeatedly detected at MOWE during surveys.

We used our survey detections, and our observations to delineate the areas cuckoos were using in MOWE, as shown in Figure 1. We estimate that three pairs of cuckoos have home ranges that include riparian habitat at MOWE, at least in part. Yellow-billed Cuckoos using the upstream portion of MOWE were also heard across the park boundary, in riparian habitat on private land. The cuckoos observed near the downstream boundary of the park were also repeatedly heard outside the park, on private land.

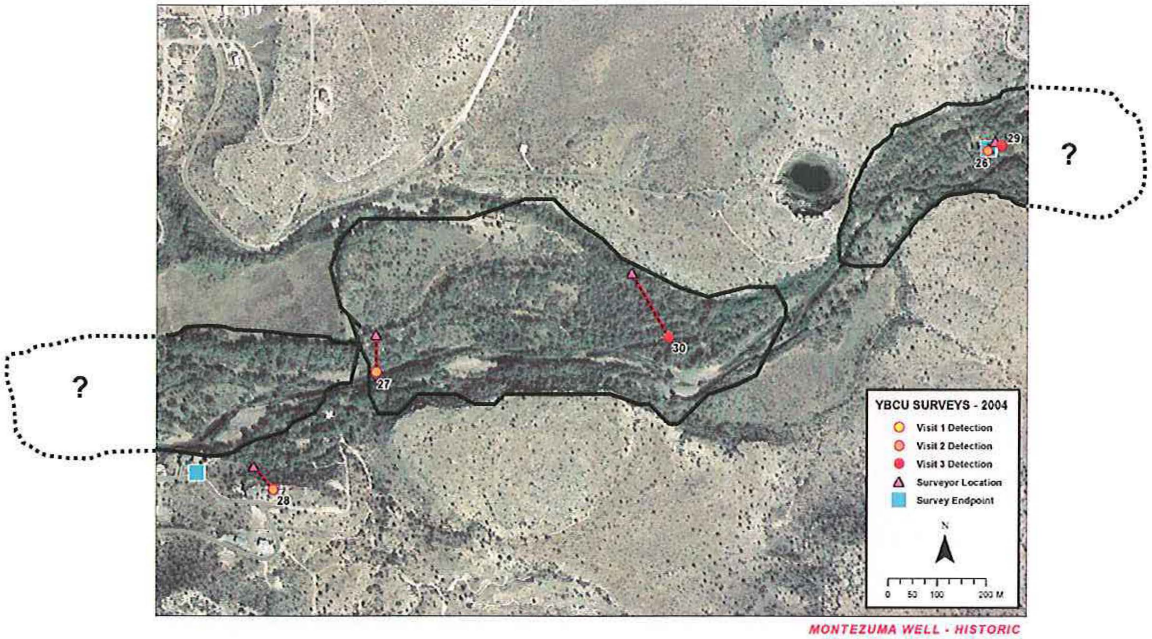

Figure 1. Map of the estimated home ranges of Yellow-billed Cuckoos at MOWE, based on observations during 2004 and 2005.

Riparian habitat at MOWE and MOCA was classified as "Native Habitat", containing > 75% native tree species. MOWE, a unit of the Montezuma Castle National Monument, is a 278 acre site of upland and riparian habitat along Wet Beaver Creek. From the north boundary to the west boundary, the entire creek was surveyed. The maximum width of deciduous riparian habitat at MOWE was 322 m (1,057 ft). The riparian area is native-dominated, multi-storied, and consists of Fremont cottonwood (*Populus fremontii*), Arizona sycamore (*Platanus wrightii*), and Arizona alder (*Alnus oblongifolia*). Some Goodding willow (*Salix gooddingii*), velvet ash (*Fraxinus velutina*), desert willow (*Chilopsis linearis*), and netleaf hackberry (*Celtis reticulate*) are also present. Tamarisk (*Tamarix* spp.) was uncommon. Canopy height is 8-15 m (26-49 ft). The understory shows considerable recruitment of the riparian trees, as well as a well established shrub layer consisting of snakeweed (*Guitierrezia* sp.), red barberry (*Berberis haematocarpa*), snowberry (*Symphoricarpos* sp.), and mimosa (*Mimosa* sp.). The surrounding upland consists mainly of juniper (*Juniperus* sp.), mesquite (*Prosopis* sp.) and mimosa, with some areas closer to the trail system exhibiting a multitude of native upland species. At the downstream portion of the site, large fields of grasses in the picnic area and near the worker's housing have some of the largest trees (mostly Fremont cottonwood) in the area, averaging 15-18 m (49-59 ft) in height. Human impact here is very low, due to the majority of the creek being outside of the trail system.

Montezuma Castle National Monument has 206 hectares (508 acres) of upland and riparian habitat along Wet Beaver Creek. The entire expanse of the creek was surveyed within the park boundaries. Though much of the creek is dry in the summer season, extremely large and long pools of stagnant and semi-flowing water exist in two main areas. The maximum width of riparian habitat at the site is 169 m (556 ft). This native dominated, multi-storied habitat consists of large Arizona sycamore, Fremont cottonwood, velvet ash, netleaf hackberry, and Goodding willow. Canopy height varied considerably, with the top canopy averaging approximately 25-30 m (82-98 ft), especially at the downstream end where extremely large sycamore and cottonwoods were present. Arizona walnut (*Juglans major*), and desert willow are also present. The understory, though lacking in large tree recruitment in many areas, was a mix of mesquite, mimosa, and juniper, and has a shrub layer consisting of red barberry, long-leaf ephedra (*Ephedra trifurca*), and four-wing saltbush (*Atriplex cabescens*). The surrounding upland consists of mesquite, mimosa, creosote (*Larrea* sp.), and juniper. Thick carpets of cheat grass (*Bromus* sp.) exists, but are patchily distributed. Human impact here is low due to the protected nature of the monument, however some cattle grazing was apparent in areas where the boundary fence was knocked down.

Across all sites included in the AZGFD Heritage project, we found that occupied sites had a higher density of trees, in every size class, than unoccupied sites (Table 3). Sapling trees (0 to <8 cm DBH) were considerably more common in occupied sites, and saplings of cottonwood, willow, alder, and sycamore were much more common in occupied sites than unoccupied sites. Large cottonwoods (23 – 38, and >38 cm DBH) had higher densities in occupied sites (Holmes et al. 2008). This same pattern was evident when we compared MOCA to MOWE, and we recorded more large sycamores in MOWE than in MOCA.

Table 3. Mean number of trees per hectare in each size class. Z value is from a Mann-Whitney U test.

Size Class (cm DBH)	Occupied	Unoccupied	Z value	Significance
0 to <8	2,513	1,489	-1.55	0.122
8 to 23	469	336	-2.43	0.015
23-38	75	37	-2.03	0.042
>38	29	12	-1.69	0.092

We mapped areas of mesquite habitat within our survey sites, and calculated the total area of mesquite at each site. We (Holmes et al. 2008) found that all occupied sites had adjacent mesquite, and 92% had at least 5 ha of mesquite. The mesquite at MOCA was fairly atypical of our sites in that it had a fairly extensive patch of mesquite, comprised of sparsely distributed small to mid-sized mesquite trees, and the patch extended a considerable distance from the deciduous riparian habitat at the site. MOCA is also fairly unique because the amount of deciduous riparian vegetation within it is relatively limited (maximum width of deciduous habitat is 169 m), portions of the stream were dry during our surveys, and the deciduous habitat is sparse and stressed. Considering these factors, and using our knowledge of cuckoo habitat use in the area, we expect that mesquite habitat with these characteristics would not likely be used by yellow-billed cuckoos in the study area. In contrast, MOWE has a relatively large area of deciduous riparian habitat (maximum width of deciduous habitat is 322 m) and a large patch of fairly dense and tall mesquite bosque situated between riparian corridors. We repeatedly detected cuckoos in, and immediately adjacent to, this mesquite patch.

Management Implications of Modified Telemetry Study at MOCA and MOWE

3. **In what specific ways can this information be used by park staff to 1) better manage habitat at Montezuma Well and or improve habitat near Montezuma Castle and 2) share this information with park visitors through educational media and interpretive programs.**

The Arizona Game and Fish Department has designated the yellow-billed cuckoo as "threatened" in the state, and a "wildlife species of special concern" in Arizona (AZGFD 2002). Arizona's Comprehensive Wildlife Conservation Strategy (AZGFD 2006) considers it to be a "species of greatest conservation need", and a community focal species. The Arizona Bird Conservation Plan (Latta et al. 1999) lists the western yellow-billed cuckoo as a "priority species" for the low elevation riparian priority habitat. The plan (Latta et al. 1999) has an objective to achieve 25 self-sustaining populations (with a population defined as 25 pairs of cuckoos), with 3 populations (75 pairs) in the Verde River area, from the Verde/Salt confluence to Cottonwood. The plan's habitat strategy is to maintain or increase yellow-billed cuckoo habitat.

Knowledge of habitat selection patterns and identification of potential breeding habitat is essential to guide conservation efforts (Laymon 1998, Hughes 1999). Our AZGFD Heritage study showed that yellow-billed cuckoos are found throughout the Verde River watershed in sites that contain relatively large areas of deciduous riparian habitat, at least 100 m wide, with dominant tree species comprised of mainly Fremont cottonwood, Goodding willow, Arizona alder, and Arizona sycamore. In addition, yellow-billed cuckoos seem more likely to occupy riparian habitat that has adjacent patches of mesquite over 5 ha in size. MOWE, which contains a relatively large areas of deciduous riparian habitat with a substantial amount of mesquite, had one of the highest occupancy rates of the 22 sites we surveyed (Holmes et al. 2008).

In order to identify specific areas to meet the habitat strategy to maintain areas of habitat for yellow-billed cuckoos (Latta et al. 1999), we proposed using occupancy rate as a measure of habitat quality (Holmes et al. 2008). In a review of 22 studies of territory occupancy in 17 species, Sergio and Newton (2003) found that occupancy was always correlated with productivity and/or with some other measure of territory or habitat quality. They suggest that occupancy may be a reliable method of habitat quality assessment, especially for populations in which not all territories are always occupied, and for species in which checking occupancy is easier than

finding nests. Yellow-billed cuckoos are just such a species. Although they are not territorial, our survey results show that we detected cuckoos occupying some sites (e.g., Verde River / West Clear Creek confluence, Wet Beaver Creek-Historic) within the Verde River watershed throughout the breeding season, and across years, while other sites were not always occupied, and were used for short durations. Using occupancy rate as an indication of habitat quality, the areas with the highest occupancy rates are expected to provide the greatest conservation benefit for yellow-billed cuckoo populations.

Management and Interpretive programs considering MOWE and MOCA, in particular:

- MOWE, with its large areas of deciduous and mesquite habitat, had a high occupancy rate and provides quality habitat for Yellow-billed Cuckoos. Yet, our observations indicate that at least some of MOWE's cuckoos also depend on the additional riparian habitat adjacent to the park, on private land, for their habitat. The persistence of cuckoos in the park may be dependent on the continued existence of quality riparian habitat at a scale larger than MOWE itself.

- MOWE contains quality mesquite habitat, bordered by deciduous riparian habitat, and used by cuckoos. Park managers could potentially increase the amount of high quality cuckoo habitat by promoting mesquite growth in the old field/open area of the western portion of the park.

- During our surveys, in 2004 and 2005, portions of the stream in MOCA were dry and the riparian vegetation was stressed. Yellow-billed Cuckoos were historically detected at MOCA, but we detected a single, apparently wandering, cuckoo during our 6 surveys over two years. Management to maintain and promote the establishment of riparian vegetation would increase the likelihood of the Yellow-billed Cuckoo again using the area in the future.

- Interpretive programs at MOCA and MOWE can convey the message to park visitors that riparian systems at both monuments are very complex and of key importance for all wildlife. The main fact that needs to be conveyed to park visitors is that Yellow-billed Cuckoos are just one of many species that depend on riparian woodlands at MOCA and MOWE. It is also important to stress that riparian zones are among the most severely threatened habitats in Arizona to point out that across the Southwest, riparian areas comprise less than 1% of the region's area, and that 75-80% of vertebrate wildlife species depend on riparian areas for food, water, cover, and migration routes. It is also important to point out that riparian zones provide other tangible benefits through improving water quality by filtering sediments and nutrients. Also, that accumulated sediments in riparian zones store large amounts of water, which helps to sustain streamflow during drier times.

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