YELLOW-BILLED CUCKOO DISTRIBUTION AND HABITAT ASSOCIATIONS IN ARIZONA, 1998–1999: FUTURE MONITORING AND RESEARCH IMPLICATIONS

Matthew J. Johnson, Robert T. Magill, and Charles van Riper III

ABSTRACT

In 1998 and 1999, we surveyed throughout Arizona areas of suitable habitat in all known riparian drainages historically occupied by Western Yellow-billed Cuckoos (*Coccyzus americanus occidentalis*). Of the 30-odd drainages identified with historical Yellow-billed Cuckoo detections, 26 drainages had at least one Yellow-billed Cuckoo detection during the 1998–1999 surveys. In 1998 we completed 97 individual surveys resulting in 166 Yellow-billed Cuckoo detections within 22 drainages. Yellow-billed cuckoos were detected in that field season were mainly located along 5 drainages: Cienega Creek, Sonoita Creek, San Pedro River, Bill Williams River, and the Verde River. In 1999, our survey effort increased, and we completed 169 individual surveys resulting in 404 Yellow-billed Cuckoo detections within 47 drainages. The majority of Yellow-billed Cuckoo detections in 1999 were along the San Pedro River, Verde River, and Cienega Creek. Although the Agua Fria River was not surveyed in 1998, we detected a high number of Yellow-billed Cuckoos there in 1999. Sonoita Creek had a high number of Yellow-billed Cuckoo detections in 1998, whereas in 1999 it only accounted for 6 percent of all detections. In 1999, we had 14 drainages with no Yellow-billed Cuckoo detections. To evaluate our Yellow-billed Cuckoo survey method, we visited sites either once, twice, or three times. During the 1998 and 1999 Yellow-billed Cuckoo breeding season, we found that if a Yellow-billed Cuckoo was detected during the first survey, the probability of detecting Yellow-billed Cuckoos during the second and third surveys was very high.

During both years of this study we found 85 percent of all Yellow-billed Cuckoo detections in native habitat (>75% native species), dominated by cottonwood (*Populus* spp.), willow (*Salix* spp.), and mesquite (*Prosopis* spp.). Yellow-billed cuckoo detections in the mixed native habitat (51–75% native species) were dominated by cottonwood, mixed with willow and tamarisk (*Tamarix* spp.). A smaller percent of Yellow-billed Cuckoo detections (5%) occurred in the mixed-exotic category (51–75% exotic species), which was dominated by tamarisk; however, cottonwood was present at all but two Yellow-billed Cuckoo detection sites within this category. In addition, riparian habitat at sites with Yellow-billed Cuckoo detections of >5 had a greater surface area (100 m wide) at its widest point of the drainage than did sites with <5 cuckoo detections.

INTRODUCTION

The Yellow-billed Cuckoo (*Coccyzus americanus*), a neotropical migrant, spends early June through early September in northern Mexico, the United States, and southern Canada and winters primarily in South America (Hughes 1999). Yellow-billed cuckoos begin arriving in Arizona in late May

and early June with the majority arriving in mid to late June (Bent 1940, Hughes 1999, Cormon and Wise-Gervais 2005). Nesting activities usually occur between late June and early July, but can begin as early as late May and continue through late September (Hughes 1999, Laymon et al. 1997). In Arizona, nesting peaks between mid July and early August, later than for most co-occurring bird species (Cormon and Wise-Gervais 2005). The timing of nesting may be triggered by an abundance of cicadas (Cicadidae), katydids (Tettigoniidae), caterpillars (Lepidoptera), and other large prey items (e.g., tree frogs [*Hyla* spp.]), which are the bulk of the species' diet (Hamilton and Hamilton 1965, Rosenberg et al. 1982, Hughes 1999).

Western Yellow-billed Cuckoos (*C. a. occidentalis;* i.e., populations west of the continental divide) 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 historical and current information suggest the Yellow-billed Cuckoo's range and population numbers have declined substantially across much of the western United States over the past 80 years (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 historical habitat distribution indicate that western populations were once substantially larger than they are today (USFWS 1985, USFWS 2002).

In a 25 July 2001 finding by the U.S. Fish and Wildlife Service (USFWS), the western Yellow-billed Cuckoo was declared to represent a distinct population segment, and as such warranted protection under the Endangered Species Act as "threatened." However, the Yellow-billed Cuckoo was classified as a Candidate Species under the Endangered Species Act, because there was "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). The Arizona Game and Fish Department (AGFD) has designated the Yellow-billed Cuckoo as Wildlife of Special Concern in the state (AGFD 2002), and the U.S. Forest Service Regional Forester designated it a Sensitive Species on National Forests (USDA 2000) within Arizona. In addition, the species is considered likely to become an endangered species throughout its range on the Navajo Nation (Navajo Nation 2005).

Factors that probably 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 1987, Hughes 1999). Local extirpations and low colonization rates may have contributed to the declines (Laymon and Halterman 1989). Populations may be further restricted by limited food availability, and birds may not nest if food supply at the breeding grounds is inadequate (Veit and Petersen 1993). Food availability for the Yellow-billed Cuckoo is likely affected by drought conditions (Newton 1980, Durst 2004, Scott et al. 2004).

Western Yellow-billed Cuckoos require structurally complex riparian habitats with tall trees and a multi-storied vegetative understory (Hughes 1999, Johnson et al. 2008). This bird is known to breed in large blocks of riparian habitat (5–20 ha), particularly in woodlands dominated by cottonwoods (*Populus* spp.) and willows (*Salix* spp.) (Ehrlich et al. 1988, USFWS 2002a, Johnson et al. 2008).

Arizona Historical Abundance

In Arizona, the Yellow-billed Cuckoo was once considered a fairly common species throughout the state, breeding within riparian forests that were dominated by cottonwood, willow, and/or mesquite (*Prosopis* spp.) (Stephens 1903, Swarth 1905, Swarth 1914, Visher 1910, Phillips et al. 1964). A 1977 statewide Arizona survey of suitable habitat found an estimated 205–214 pairs, with more than half of these along the lower Colorado River (Gaines and Laymon 1984). Past estimates suggested that <200 pairs remained in 1986 (Layman and Halterman 1987) and that <50 pairs were present five years later (Ehrlich et al. 1992).

Prompted by continued concern regarding severe population declines, habitat loss, and the lack of statewide data, the USFWS asked the U.S. Geological Survey, in conjunction with the AGFD, to initiate Yellow-billed Cuckoo surveys to (1) determine statewide distribution of Yellow-billed Cuckoos in Arizona on public lands and (2) identify habitats associated with the presence of Yellow-billed Cuckoos.

METHODS

Study Site Selection

We selected 107 specific Yellow-billed Cuckoo survey sites prior to the initial survey season using an *a priori* knowledge of the bird, including habitat preferences, expert opinion, and basic biology of this species. This survey method identifies suitable habitats before conducting surveys (Bibby et al. 1992). We selected sites primarily where historical detections occurred prior to 1998, which is a preferred method for surveying rare birds (Dawson 1981) when resources (e.g., time) are limited. To help identify riparian areas where potentially suitable Yellow-billed Cuckoo habitat might occur we used information from the AGFD's Habitat Data Management System.

Because breeding Yellow-billed Cuckoos require large continuous areas of intact habitat (Laymon et al. 1997), we focused our 107 survey efforts within 29 large drainages (>0.2 ha) with dense broadleaf deciduous vegetation or large intact mesquite bosques. However, because of the fragmented nature of many Arizona riparian zones and because there are records of Yellow-billed Cuckoos occupying smaller patches (Johnson et al. 2008), smaller areas were also considered. We did not survey areas smaller than two ha, as this was considered an absolute minimum size for Yellow-billed Cuckoo occupancy; no Yellow-billed Cuckoos have been detected attempting to nest in patches that size or smaller in Arizona or California (Laymon et al. 1997). Dominant broadleaf deciduous species of interest included Fremont cottonwood (*Populus fremontii*) and Goodding willow (*Salix gooddingii*). Co-dominant species included Arizona sycamore (*Plantanus wrightii*), velvet ash (*Fraxinus pennsylvanica* ssp. *velutina*), seep willow (*Baccharis salicifolia*), netleaf hackberry (*Celtis reticulata*), Arizona alder (*Alnus oblongifolia*), and Arizona walnut (*Juglans major*). Exotic species included tamarisk (*Tamarix* spp.) and Russian olive (*Eleagnus angustifolia*). We identified survey sites using topographical maps and aerial photography.

A museum and literature search was conducted to determine where Yellow-billed Cuckoos had been historically documented. Curators of museum and university collections throughout the United States were contacted for information on Yellow-billed Cuckoo specimens collected in Arizona.

Yellow-billed Cuckoo Survey Methods

We modified a survey protocol used in California (Laymon, S. A., Yellow-billed cuckoo survey and monitoring protocol for California, unpublished report, 1998) to determine the statewide distribution of Yellow-billed Cuckoos in Arizona. We reduced the number of within-site surveys (three surveys per site) at some of the sites

to increase the number of overall locations that could be surveyed within such a large geographic area and because our study was basically designed to collect baseline data. Surveys were conducted along 29 drainages historically associated with the presence of Yellow-billed Cuckoos in addition to those with no records of previous historical surveys. All counts were conducted between 31 May and 29 August 1998, and between 5 June and 2 September 1999. The timing of the surveys coincided with the peak of the Yellow-billed Cuckoo's breeding season in Arizona (Hamilton and Hamilton 1965, Nolan and Thompson 1975, Hughes 1999). Surveyors were trained prior to the breeding season to standardize field techniques.

We used a taped recording of the Yellow-billed Cuckoo's *kowlp* call (Hughes 1999) during surveys. Playback equipment was capable of projecting this call at least 100 m with a minimum of distortion. Surveys were conducted from half an hour before sunrise until 11:00 a.m., and were terminated if shade temperatures exceeded 41° C or during steady rainfall. One transect (i.e., a series of points, 100 m apart, from which the tape was broadcast) was made through the habitat for every 200 m of habitat width. We bypassed areas of unsuitable habitat (e.g., a monoculture of young, short tamarisk, or an extensive cobble bar) between patches. To be excluded from the survey, unsuitable habitat had to be at least 300 m in length.

The surveyor initially stopped at a survey point and remained quiet for one minute to acclimate to the ambient noise. If no Yellow-billed Cuckoos were heard in this one-minute period, the surveyor then played the *kowlp* call once, followed by one 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 along the transect (by foot or by boat) and repeated the playback-listen protocol.

At each of the 107 survey sites we recorded Universal Transverse Mercator coordinates of the survey site boundaries (including start and stop points) and provided a description of the habitat and surrounding area. When a Yellow-billed Cuckoo was detected, the surveyor recorded its location and its use of the habitat patch, types of vocalization, and any apparent presence of nesting, and, if so, the stage of nesting. The surveyor also attempted to observe and record any other Yellow-billed Cuckoos present, possible interactions between individuals, and any apparent breeding behavior (e.g., nest building, active nest, food delivery to young). The interpretation of these behaviors was later used to ascertain breeding status.

Habitat Measurements

Visual estimates of the dominant vegetation and habitat class along the survey site were made at the time of the Yellow-billed Cuckoo survey to identify associations between the habitat type and presence of Yellow-billed Cuckoos. Habitats were classified according to the percentage of native and exotic dominant tree species: native habitats contained >75 percent native species; mixed native had 51–75 percent native species; mixed exotic habitats had 51–75 percent exotic species; and exotic habitats had >75 percent exotic species. In addition, vegetation classification according to the dominant tree species com-prising the canopy and sub-canopy were recorded.

RESULTS

Museum and Literature Search

Museum and literature searches identified a number of major drainages in Arizona where Yellow-billed Cuckoos had been detected prior to the initiation of this study (Table 1). The majority of the records documented Yellow-billed Cuckoos in the central, western, and southeastern portions of the state along perennial drainages below the elevation of 1,500 m. Of the drainages with historically known detections of Yellow-billed Cuckoos, only the Teec Nos Pos

Table 1. Yellow-billed cuckoo historical (prior to 1998) detection locations along riparian corridors in Arizona. This information was compiled from the published literature and museum records.

Historical location	Historical location
San Juan River	Gila River - upper cont.
Colorado River – above Lake Mead	Pima
Colorado River – below Lake Mead	Ft. Thomas
Bill Williams River	Geronimo
Big Sandy River	San Francisco River
Santa Maria River	San Pedro River – lower
Hassayampa River	Bass Canyon
Agua Fria River	Cascabel
Verde River	lower Aravaipa Canyon
Oak Creek	San Manuel Crossing
Wet Beaver Creek	Aravaipa Creek confluence
Tonto Creek	Cook's Lake
Little Colorado River	PZ Ranch
Salt River	Dudleyville Crossing
Gila River – lower	San Pedro River – upper
Salt confluence	Garden Canyon
Agua Fria confluence	Ramsey Canyon
W. of Airport Road	Palominas
Buckeye	Hwy. 92 – Hereford
W. of Hwy. 85	Hwy. 90
Hassayampa confluence	Lewis Springs
Gila Bend	Charleston
Painted Rock Dam	Boquillas Ranch
Dome Valley	Curtis Windmill
W. of Fortuna Wash	Saint David
Gila River – middle	Cave Creek Canyon
Winkelman	San Bernardino Valley
near Grayback Mtn.	Sulphur Springs Valley
Whitlow Dam – Queen Cr.	Babocomari River
Picacho Reservoir	Sonoita Creek
Sacaton	Sycamore Canyon
Santa Cruz confluence	Altar Valley
Gila River – upper	Arivaca Cienega
Bonito Creek	Arivaca Creek near Arivaca
Sanchez Road	Arivaca Creek
Safford	Santa Cruz River
Thatcher	Cienega Creek

Wash and Sulphur Springs Valley were not surveyed, since we determined that they lacked adequate Yellow-billed Cuckoo habitat. Of the 30-odd major drainages identified with historical Yellow-billed Cuckoo detections, 26 had at least one Yellow-billed Cuckoo detection during our 1998–1999 surveys.

1998–1999 Yellow-billed Cuckoo Detections

During the 1998 field season, 72 sites in 22 drainages were surveyed between 31 May and 29 August (Table 2; Figure 1). We completed 97 individual surveys resulting in 166 Yellow-billed Cuckoo detections at 46 of the 72 sites (64%). The mean detection

Table 2. Total number of yellow-billed cuckoos detected during 1998–1999 surveys along riparian corridors in Arizona (NS = No survey conducted).

Drainage	1998	1999	Total
San Pedro River	28	86	114
Cienega Creek	35	39	74
Verde River	20	40	60
Agua Fria River	NS	45	45
Sonoita Creek	20	15	35
Gila River	5	28	33
Bill Williams River	21	11	32
Clear Creek	3	20	23
Hassayampa River	NS	23	23
Big Sandy River	5	11	16
Wet Beaver Creek	2	11	13
Arivaca Creek	1	11	12
Santa Cruz River	NS	10	10
Santa Maria River	5	2	7
Arivaca Cienega	NS	6	6
Roosevelt Lake	NS	6	6
San Bernardino Valley	NS	6	6
Penitas Wash	NS	5	5
Picacho Reservoir	NS	4	4
San Luis Wash	NS	4	4
Lower Colorado River	3	1	4
San Francisco River	4	0	4
Babocomari River	4	NS	4
Oak Creek	1	2–23	3
O'Donnell Creek	3	NS	3
Sycamore Canyon	NS	3	3
Granite Creek	NS	2	2
Pajarito Canyon	NS	2	2
Champurrado Wash	0	2	2
Lindberg Tank Wash	NS	2	2
Blue River	2	NS	2
Little Colorado River	NS	2	2
Salt River	NS	2	2
Burro Creek	1	NS	1
Bitter Well Wash	NS	1	1
Tonto Creek	1	0	1
Pinal Creek	1	NS	1
Virgin River	1	NS	1
Huachuca Creek	NS	0	0
Red Tank Draw	NS	0	0
Fossil Creek	NS	0	0
Waddell Dam	NS	0	0
Queen Creek	NS	2	2
Cerro Prieto Wash	NS	0	0
Sabino Creek	NS	0	0
Sawmill Canyon	NS	0	0
Date Creek	NS	0	0
Leslie Canyon	NS	0	0
Chevelon Crossing	NS	0	0
Cave Creek, Chiricahuas	NS	0	0
Seven Springs	NS	0	0
Romero Wash	NS	0	0
Total	166	404	570

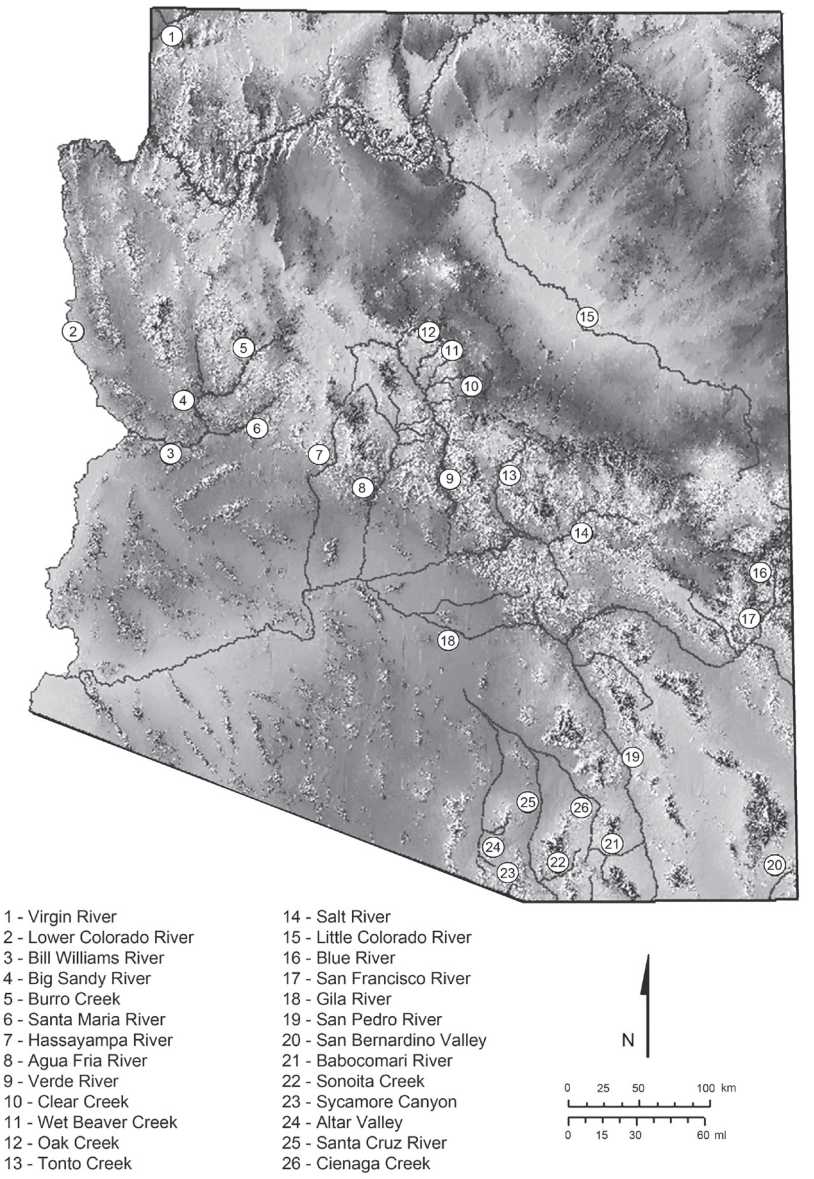

Figure 1. Yellow-billed cuckoo detection locations during 1998–1999 surveys along riparian corridors in Arizona.

date in 1998 was 26 July. The majority of Yellow-billed Cuckoos detected in 1998 were located along five drainages; Cienega Creek (22%) San Pedro River (17%), Bill Williams River (13%), Sonoita Creek (12%), and Verde River (12%). All drainages surveyed in 1998, except for Champurrado Wash, had at least one Yellow-billed Cuckoo detection.

During the 1999 field season our survey effort increased and we covered 134 sites in 46 drainages between 5 June and 2 September 1999 (Table 2; Figure 1). We completed 169 individual surveys resulting in 404 Yellow-billed Cuckoo detections

at 88 of the 134 sites (65%). The mean detection date in 1999 was 9 July. Yellow-billed cuckoo detections in 1999 were also centered along the San Pedro River (21%), Verde River (10%) and Cienega Creek (10%). Agua Fria was a site not surveyed in 1998, but in 1999 we detected a high number of Yellow-billed Cuckoos, accounting for 11 percent of all detections that year. Sonoita Creek had a high number of Yellow-billed Cuckoo detections in 1998, whereas in 1999 it only accounted for 6 percent of all Yellow-billed Cuckoo detections. In 1999, we found 14 (31%) drainages with no Yellow-billed Cuckoo detections.

Combining both 1998 and 1999, we surveyed 53 drainages of which 39 drainages had at least one Yellow-billed Cuckoo detection. During this study, 16 drainages were surveyed in both years. Of those 16 drainages, 13 had Yellow-billed Cuckoo detections in both years. Those 13 drainages accounted for 75 percent of all Yellow-billed Cuckoo detections during this study.

Yellow-billed Cuckoo Detection Rates

In our evaluation of the survey protocol, we found the majority (72%) of Yellow-billed Cuckoo detections were solicited through broadcast. The number of solicited detections peaked during the middle of July and then declined as the breeding season progressed. We found that 74 percent of Yellow-billed Cuckoo detections, solicited or unsolicited, were aural, and 26 percent were visual detections. We found that areas with the largest Yellow-billed Cuckoos populations had the highest rate of vocalizations.

During the 1998 and 1999 breeding season, we found that if a Yellow-billed Cuckoo was detected during the first survey, the probability of detecting Yellow-billed Cuckoos during the second and third surveys was high. Eighty-three percent of the sites with Yellow-billed Cuckoo detections during the first survey had Yellow-billed Cuckoos detections during the second survey, and 78 percent of those sites with detections during the first survey had detections during the third survey. In contrast, if a Yellow-billed Cuckoo was not detected during the first survey, but detected during the second survey, only 43 percent of those sites had Yellow-billed Cuckoo detections during the third survey. Overall, if detections occurred during the first visit, 71 percent of the time detections occurred during all three visits (n = 26). In general, Yellow-billed Cuckoos tend to occupy a site and remain in that location for the breeding season.

Yellow-billed Cuckoo Habitat Type

Yellow-billed cuckoos were detected primarily within three habitat classes: native, mixed native, and mixed exotic habitats. These classes were subsequently divided into 17 habitat types according to the dominant vegetation (Table 3). We combined both the 1998 and 1999 data to summarize Yellow-billed Cuckoo detections per habitat type. We found 85 percent of all Yellow-billed Cuckoo detections within the native habitat category (Table 3). Within the native habitat category, we found that habitat dominated by cottonwood with a strong association of willow and mesquite (45%) was the most common habitat composition in which Yellow-billed Cuckoo were detected, followed by cottonwood with willow, but without mesquite (17%), followed by a cottonwood-willow-ash mix (14%). We found 10 percent of all Yellow-billed Cuckoo detections were within mixed native habitats (Table 3). Within the mixed native habitat category, 89 percent of the Yellow-billed Cuckoo detections occurred in areas dominated by cottonwood with a willow and tamarisk mix. Only 5 percent of all Yellow-billed Cuckoo detections in this study occurred within mixed exotic habitats, which were dominated by tamarisk; yet cottonwood was present at all but two Yellow-billed Cuckoo detection sites within this category. No Yellow-billed Cuckoo

Table 3. Habitat classes and vegetation dominance, comprising the canopy and sub-canopy associated with Yellow-billed Cuckoo detections and cuckoo surveys with zero detections for all sites surveyed in 1998 and 1999.

Habitat Class	Yellow-billed Cuckoo Detections	Yellow-billed Cuckoo Surveys with No Detections
Native	1998–1999	1998–1999
Cottonwood-Willow-Mesquite	216 (45%)	27
Cottonwood-Willow	82 (17%)	28
Cottonwood-Willow-Ash	66 (14%)	8
Cottonwood-Willow-Sycamore	48 (10%)	12
Cottonwood Dominated Mix	23 (5%)	12
Mesquite Dominated Mix	20 (4%)	12
Willow Dominated Mix	12 (2%)	8
Ash Dominated Mix	9 (2%)	7
Sycamore Dominated Mix	7 (1%)	9
Black Walnut Dominated Mix	3 (<1%)	0
Subtotal	485 (85%)	123
Mixed Native		
Cottonwood-Willow-Tamarisk	51 (89%)	15
Cottonwood-Russian Olive	2 (3.5%)	0
Cottonwood-Willow-Mesquite-Tamarisk	2 (3.5%)	3
Willow-Tamarisk	2 (3.5%)	3
Subtotal	57 (10%)	21
Mixed Exotic		
Tamarisk-Cottonwood-Willow-Mesquite	24 (86%)	8
Tamarisk-Cottonwood	2 (7%)	0
Tamarisk-Willow	2 (7%)	0
Subtotal	28 (5%)	8
1998–1999 Total	570	152

detections occurred in exotic habitats in our 1998 or 1999 surveys. We are unable to report specific selections because we did not enumerate the availability of each habitat type.

DISCUSSION

Our 1998–1999 surveys included almost all areas historically occupied by Yellow-billed Cuckoo and other potentially suitable sites in Arizona. During these surveys we had 532 Yellow-billed Cuckoo detections along 38 drainages in Arizona. The majority of Yellow-billed Cuckoo detections were on the San Pedro River, Cienega Creek, Verde River, Sonoita Creek, and the Agua Fria River. Previous studies documented Yellow-billed Cuckoos along many of the same drainages that we surveyed (Hamilton and Hamilton 1965, Groschupf 1987, Halterman 1998, Hughes 1999); however, the detections were not all along the same reaches. Rea (1983) reported Yellow-billed Cuckoos present along the Gila River from the confluence with the Santa Cruz River to its confluence with the Hassayampa River. Groschupf (1987) reported Yellow-billed Cuckoos were present along the length of the Santa Cruz River from 1970 to 1986. Yellow-billed cuckoos were once considered abundant throughout the riparian floodplain along the lower Colorado River. Grinnell and Miller (1944) cited only Stephen's (1903) observations of several cuckoos near Needles in 1902.

Surveys in mid-June 1964 along the lower Colorado River near Laguna Dam indicated the abundance of Yellow-billed Cuckoos was similar to, and possibly higher than, that on the San Pedro River in southeastern Arizona (Hamilton and Hamilton 1965).

Given the lack of consistent long-term Yellow-billed Cuckoo survey information and the challenges of interpreting historical Yellow-billed Cuckoo detection data, we cannot make precise comparisons between the historical and current numbers of breeding Yellow-billed Cuckoos with this current study. However, there are probably substantially fewer Yellow-billed Cuckoos and fewer breeding sites (less habitat) now than what occurred in Arizona during the early 1900s, and possibly fewer than during the 1970s and 1980s.

Historical Water Diversion and Landscape Changes along the Lower Colorado River

Somewhere between 85 and 98 percent of Arizona's native riparian habitat has been reduced or degraded since Euro-American settlement (Noss et al. 1995). This began with the construction of a series of dams: Laguna Dam in 1907, Hoover Dam in 1936, Parker Dam and Imperial Dam in 1938, and Davis Dam in 1954. Dam operations changed the natural flows of the lower Colorado River by ending the cycle of annual flooding, except when heavy runoff from local rains produced floods from the larger tributaries (e.g., Bill Williams River). Without these floods, new, rich alluvial seedbeds were no longer formed and the replacement cycle of cottonwoods, willows, and mesquites were changed, ultimately eliminating the vast majority of Yellow-billed Cuckoo habitat. With floods controlled and irrigation water readily available, large stands of natural floodplain vegetation were converted to agricultural uses. In the 1940s and 1950s wide portions of the floodplain near Yuma, Blythe, Parker, and Needles were cleared for agriculture. Extensive farm tracts, "clean" farming practices, and shifts to crops such as cotton and lettuce resulted in the removal of large tracts of cottonwood-willow forests and mesquite bosques and greatly reduced the extent of wildlife habitat, including habitat required by Yellow-billed Cuckoos to breed (Rosenberg et al. 1991). The only large tracts of natural riparian vegetation that remained through the 1970s were in five Native American nations and four national wildlife refuges.

Historical Habitat Changes in Arizona

Knowledge of habitat-selection patterns and identification of potential breeding habitat is essential to guide conservation efforts (Laymon 1998, Hughes 1999). Our study has demonstrated that Yellow-billed Cuckoos are found in sites containing relatively large areas of native deciduous riparian habitat, at least 100 m wide, with dominant tree species comprising mainly cottonwood, willow, and mesquite. In addition, Yellow-billed Cuckoos are more likely to occupy riparian habitat with adjacent patches of mesquite (Holmes et al 2008).

Habitat within areas where Yellow-billed Cuckoos were absent, few, or solitary—such as some sites along Tonto Creek, Salt River, Gila River, and many sites along the lower Colorado River—lacked a multi-structure understory with a dominant cottonwood canopy, and were dominated by exotic vegetation, had no standing water, or was noticeably fragmented or influenced by adjacent land practices (e.g., agriculture, urbanization). Agriculture practices and urban development have greatly contributed to the fragmentation of the remaining riparian areas in Arizona (Anderson and Ohmart 1984, Younker and Anderson 1986).

Arizona's native riparian habitat has been reduced over the last century (Noss et al. 1995), resulting in the fragmentation of riparian forest tracts, which are progressively reduced to smaller and more isolated patches embedded within a relatively permanent

matrix of largely unsuitable habitat (Saab 1999). Western Yellow-billed Cuckoos may be especially sensitive to fragmentation, as it appears that they require tracts of large contiguous and unfragmented patches. In California, sites larger than 80 ha in extent and wider than 600 m were found to be the optimal patch size for Yellow-billed Cuckoos (Laymon and Halterman 1989).

Agricultural lands currently dominate much of the riparian landscape within many regions in Arizona, particularly along the lower Colorado River, and agricultural development on adjacent lands affects riparian bird communities. While studying habitat use by breeding birds in cottonwood riparian forests along the South Fork of the Snake River in southeastern Idaho, Saab (1999) found riparian patches surrounded by an agriculture matrix supported different bird assemblages than did patches surrounded by a natural habitat matrix. In addition, avian nest predators, brood parasites, and exotic species all prospered in the human-altered landscapes resulting from agricultural development, fragmentation, residential areas, or all three factors (Saab 1999). Of 55 sites we surveyed for Yellow-billed Cuckoos along the lower Colorado River in Arizona in 2006 and 2007, 65 percent were bordered on at least one side by agriculture fields (Johnson et al. 2008).

Changes to avian and vegetative communities have the potential to influence Yellow-billed Cuckoo habitat use. In arid regions, Yellow-billed Cuckoos are restricted to river bottoms, ponds, swampy areas, and damp thickets with relatively high humidity (Gaines and Laymon 1984, Hughes 1999). Most breeding pairs of western Yellow-billed Cuckoos have been found nesting in riparian patches within 100 m of water (Laymon and Halterman 1987; Johnson et al. 2006a, 2006b, 2007). Surface water in these cottonwood-willow groves may help lower the air temperature via evaporative cooling (Laymon and Halterman 1987, Hughes 1999), which provides the optimal microclimatic breeding conditions for Yellow-billed Cuckoos.

One factor that drastically changed riparian vegetation structure and composition throughout many parts of Arizona was the introduction of exotic tamarisk, changing riparian ecosystem processes that initially promoted its establishment and persistence. In 1894, Mearns (1907) estimated that native riparian vegetation covered between 160,000 and 180,000 ha of alluvial bottomland between Fort Mohave and Fort Yuma (lower Colorado River). As of 1986, only about 40,000 ha of riparian vegetation remained (Anderson and Ohmart 1984, Younker and Anderson 1986). About 40 percent of the area remaining in 1986 was dominated by tamarisk, 16 percent by honey mesquite and/or native shrubs, and only 0.7 percent by mature cottonwood or willow habitat (Ohmart et al. 1988). Tamarisk and Russian olive are currently the third and fourth most frequently occurring woody riparian plants in the Southwest (Friedman et al. 1998). Although tamarisk was the most common tree in all of our study sites, we found that Yellow-billed Cuckoo occupancy rates in Arizona were highest in sites dominated by native tree species and lower in habitats consisting of mixed native or >75 percent tamarisk cover.

In summary, multiple factors such as water diversion and redistribution as well as agricultural and urban development have impacted riparian habitats and landscapes throughout Arizona in the previous 50 to100 years. While riparian habitats have been lost, fragmented, and degraded, we found that Yellow-billed Cuckoos persist in the region mainly in riparian habitats that are still dominated by native vegetation. Other factors, such as the presence of surface water, microclimate conditions, and landscape-level habitat features, may also play a role in Yellow-billed Cuckoo habitat selection.

Probability of Detecting Yellow-billed Cuckoos using Tape Playback Recordings

Even though the probability of detecting Yellow-billed Cuckoos on any given survey of a site is less than 1.0, our data confirm that conducting multiple surveys (3 surveys) using tape playback recordings within an area increases the probability of detecting resident Yellow-billed Cuckoos (i.e., individuals that are consistently in an area throughout the breeding season) as the breeding season progresses. Even though broadcasting vocalizations generally increases Yellow-billed Cuckoo detections, no survey methodology can guarantee an absolute determination of presence or absence, especially on any given survey. Evidence that birds may be present but not responding includes our observation that on some occasions when no detections were made at a survey point during the broadcast and listening period, a Yellow-billed Cuckoo vocalized several minutes after a surveyor left that point (but was still close enough to detect the bird calling). Also, Halterman (2005) conducted a test of the playback survey method, in which one researcher carried out a normal survey while another researcher with telemetry equipment located and monitored the response of birds to playback. Only 50 percent of birds responded to the broadcast calls, suggesting that any single survey may miss birds present at a site.

The probability of detecting secretive species such as the Yellow-billed Cuckoo may depend on season, stage of nesting, and sex of the bird(s) present. In a study of Bicknell's thrushes (*Catharus bicknelli*), birds called and sang consistently during the day in early to mid June, but later in the season songs were infrequent and calls were concentrated at dawn and dusk (Rimmer et al. 1996). Some researchers have found that birds may be less likely to vocalize in response to playback after nesting has started (Sogge et al. 1997, Legare et al. 1999, Bogner and Baldassarre 2002). We found that aural Yellow-billed Cuckoo detections (both solicited and unsolicited) peaked somewhat during the middle of the breeding season, but declined thereafter.

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

RESEARCH NEEDS

Continue Yellow-billed Cuckoo Presence-Absence Surveys

If our study were repeated at least once every 10 years the data gathered would update current knowledge on Yellow-billed Cuckoo distribution in Arizona. Including measurements on available habitat in future surveys would help identify the species' habitat selection. These data could be used to identify selected riparian habitat for Yellow-billed Cuckoos in Arizona. One way to improve the reliability of the surveys, would be to conduct three Yellow-billed Cuckoo surveys within the study year using established protocols (Halterman, M. D., et al., Western Yellow-billed Cuckoo natural history summary and survey methodology, unpublished report, 2006), including at least one survey during the August or September breeding season.

Using Occupancy Models to Identify Core Breeding Yellow-billed Cuckoo Habitat

There is a need to identify core breeding habitat areas and their characteristics for use as a basis for future habitat expansion through riparian habitat enhancement and restoration efforts. Occupancy might be a

reliable method of habitat-quality assessment (MacKenzie et al. 2002; Halterman, M. D., et al., Western Yellow-billed Cuckoo natural history summary and survey methodology, unpublished report, 2006). Particular sites could be classified based on duration of occupancy (i.e., occupancy rate) and monitored across years. Occupancy could then be correlated with productivity and/or with some other measure of site or habitat quality (Sergio and Newton 2003).

Identifying Yellow-billed Cuckoo Habitat Model Variables

Knowledge of habitat selection patterns and identification of potential breeding habitat is essential to guide conservation efforts (Laymon 1998, Hughes 1999). Including additional habitat characterization measures during future Yellow-billed Cuckoo surveys would be helpful for planning processes. Data on plant species composition, vegetation structure within riparian patches, riparian patch size, and characterization of the surrounding landscape matrix could be analyzed for selection patterns and used to develop predictive models for breeding-season habitat occupancy. This information could help predict the effects of riparian restoration and other management options.

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