Lower Colorado River Multi-Species Conservation Program

Balancing Resource Use and Conservation

Yellow-billed Cuckoo Distribution, Abundance, and Habitat Use on the Lower Colorado River and Tributaries

2008–2012 Summary Report

May 2013

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BUREAU OF RECLAMATION

May 2013

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Multi-Species Conservation Program

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Multi-Species Conservation Program
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May 2013

Acronyms and Abbreviations

AIC	Akaike's information criterion
ANOVA	analysis of variance
ASY	after-second-year
BLM	Bureau of Land Management
BWR	Bill Williams River
CI	confidence interval
cm	centimeter(s)
COB	confirmed
CRIT	Colorado River Indian Tribe
CVCA	Cibola Valley Conservation Area
DBH	diameter breast height
DPS	distinct population segment
ESA	Endangered Species Act
g	gram(s)
GPS	Global Positioning System
ha	hectare(s)
KDE	kernel density estimate
km	kilometer(s)
LCR	lower Colorado River
LCR MSCP	Lower Colorado River Multi-Species Conservation Program
m	meter(s)
m^2	square meter(s)
MCP	minimum convex polygon
mHz	megahertz
n	site sample size
NWR	National Wildlife Refuge
PCoA	Principle Coordinate Analysis
POS	possible
PRB	probable
PVER	Palo Verde Ecological Reserve

Reclamation	Bureau of Reclamation
RH	relative humidity
SD	standard deviation
SE	standard error
SRA	State Recreation Area
SSRS	Southern Sierra Research Station
SY	second year
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
UTM	Universal Transverse Mercator
VWC	volumetric water content
WMA	Wildlife Management Area
YBCU	yellow-billed cuckoo

Symbols

γ	colonization
p	cuckoo detection probability
°	degrees
°C	degrees Celsius
°F	degrees Fahrenheit
ε	extinction
ψ	habitat use
%	percent

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EXECUTIVE SUMMARY

The western yellow-billed cuckoo (*Coccyzus americanus*) population has declined dramatically over the past century following extensive riparian habitat loss. In 2005, the Lower Colorado River Multi-Species Conservation Program (LCR MSCP) was created to protect, maintain, and create wildlife habitat for yellow-billed cuckoos, and other threatened and near-threatened species occurring within the historic lower Colorado River flood plain. This report details a 5-year project to assess the response of yellow-billed cuckoos to ongoing riparian habitat restoration and guide future habitat creation planned within the LCR MSCP boundary.

Between June and August 2008 to 2012, we conducted yellow-billed cuckoo call broadcast surveys at sites along the Muddy, Virgin, lower Colorado, Bill Williams, and Gila Rivers, covering approximately 1,900 hectares (ha) of potentially suitable breeding habitat (41 to 62 sites per year, chapter 2). Survey sites included 15 LCR MSCP restoration sites (within 6 conservation areas), 14 non-LCR MSCP restoration sites, 16 Bill Williams River (BWR) sites, and 32 other natural riparian sites. We recorded 1,052 total survey detections (210 annual average). Within LCR MSCP restoration habitat, survey detections increased 437 percent (%) over the 5 years as new planted habitat became available (up from 24 detections in 2008 to 129 detections in 2012). At the BWR National Wildlife Refuge (NWR), survey detections initially increased by 38%, from 103 in 2008 to 142 in 2010, and then declined 46% from this peak to 76 detections in 2012. Detection counts should be interpreted with caution, however, because they are not relative indices of abundance (chapter 2). Detection data are still valuable though, as the data can offer insights into broad trends (such as large annual changes) across sites and survey areas.

Detection probability varied over the season and was highest each year in July (51–62%) and lowest in June and August (42% and 20–35%, respectively). From 2008 to 2012, the estimated proportion of used LCR MSCP restoration habitat gradually increased (from 84 to 99%) in contrast to the steady decline in use estimated at the BWR (from 95 to 85%). Habitat use was lowest at non-BWR natural areas (estimated at 54% per year) where yearly cuckoo use was irregular and random.

To assess the efficacy of the survey methodology, in 2011 and 2012 we compared the accuracy and precision of habitat use estimates based on the Halterman et al. (2009a) western cuckoo survey protocol (surveys every 12 to 20 days, including two in July) and a modified protocol in which three surveys were conducted every 10 days in July during the peak of cuckoo detectability in this region (chapter 3). Overall, we found the Halterman et al. (2009a) protocol to work well for its intended purpose to assess cuckoo habitat use within surveyed habitat. The modified survey protocol did not yield definitive gains in estimating the proportion of habitat used or increasing the precision of our territory estimates.

We also assessed the detectability of breeding cuckoos (chapter 4) and found that the probability to detect cuckoos on our surveys appears to be related to cuckoo density, nest stage, and breeding phenology (the timing of their breeding cycle). Surveys in confirmed breeding habitat detected cuckoos on an average of three survey visits. We found that if no cuckoos were detected in an area across four surveys, it could be stated with 95% confidence that cuckoos were not breeding in that location.

From 2008 to 2012, the estimated maximum number of breeding territories in the study area increased by 70%, from 47 in 2008 to 80 in 2012 (chapter 5) due to the addition of newly available (LCR MSCP restoration) habitat during the study period. Estimated breeding territory abundance increased by over 1000% at LCR MSCP restoration sites (from 5 in 2008 to 54 in 2012). Palo Verde Ecological Reserve (PVER) exceeded all other LCR MSCP restoration sites in breeding territory annual abundance (average 12.8 territories, range 1–39), 5-year total abundance (64 total breeding territories), and annual rate of increase (average 155% territory abundance increase over the previous year, range 100–240% increase per year); PVER was also the only area where new breeding habitat became available each year of the study (becoming the largest restoration site in 2012). Most declines in breeding territories occurred at the BWR (down from 37 territories estimated in 2008 to 19 in 2012). Across all years, we confirmed 83% more breeding territories at LCR MSCP restoration (64 total confirmed territories) sites than at BWR sites (35 total confirmed territories); we confirmed just one breeding territory at non-LCR MSCP restoration sites and none at non-BWR natural sites.

We analyzed vegetation data collected during the 2006–2012 field seasons (2006–2007 data collected by the U.S. Geological Survey under a separate contract) at two spatial scales: site- and plot-level analyses (chapter 6). A total of 834 plots were sampled during the 7-year period, including 92 cuckoo nests. Increased total canopy height and forb ground cover were positively associated with site occupancy. Area (site size) was also a predictor of site occupancy to a lesser degree; the median size of occupied sites (37.2 ha) was almost three times as large as unoccupied sites (12.8 ha). Increased native small tree stem density and total canopy closure were important in cuckoo nest site selection. Total canopy closure showed a weak positive relationship to cuckoo nest success ($p = 0.078$); however, no measured habitat characteristics were statistically significant predictors of nest fate.

From 2008 to 2012, we compared microclimate (temperature and relative humidity [RH]) between occupied and unoccupied sites, and between nests and available habitat within occupied sites, by placing data loggers at 70 nests and 607 random locations within 59 sites (chapter 7). We found no significant differences in RH or temperature between occupied and unoccupied sites. Within occupied sites, we found nests were more likely to be located in areas with higher diurnal and nocturnal RH and lower diurnal and nocturnal temperatures compared to available habitat. We also found canopy closure to be negatively associated with diurnal temperature and positively associated with diurnal RH. Additionally, soil moisture was negatively associated with diurnal and nocturnal temperature and positively associated with diurnal RH.

We confirmed breeding in five LCR survey areas, including two areas with nests confirmed each of the 5 years (BWR and Cibola Valley Conservation Area [CVCA]), two with nests during each of the last 4 years (PVER and Cibola NWR), and one with confirmed nesting in 2010 and 2011 (Havasu NWR). We found a total of 87 nests during the 5-year period (chapter 8). The number of nests found increased each year in restoration habitat, which we attribute to the increased area of available breeding habitat each year of the project. Most nests were active between early July and mid-August, with the highest number of active nests occurring July 22–28. Clutch size ranged from two to five eggs and averaged 2.8 (site sample size [n] = 72), increasing during the last 2 years (from 2.3 ± 0.5 in 2008–2010 to 3.0 ± 0.8 in 2011–2012). Of 83 nests with known fate, 61 successfully fledged at least one young. Mayfield nest success averaged 51% (in restoration sites), with depredation the main cause of nest failure. Productivity averaged 1.6 young fledged per nest. We found evidence of possible interspecific nest parasitism in 2011, and intraspecific nest parasitism in both 2011 and 2012, identified by large gaps in laying dates, unusually large clutch sizes, and relatively high proportions of unhatched eggs. We also confirmed multiple double-brooding events in 2012, all occurring at PVER, and we saw a gradual extension of the nesting season over the 5 years, which continued into September in 2012 at PVER.

Between June and August 2008 to 2012, we captured and color banded 93 adult and 90 hatch-year cuckoos from Havasu NWR to Quigley Wildlife Management Area (WMA) (chapter 9). Most were banded at CVCA or PVER (62 and 61 birds, respectively), followed by the BWR NWR (31) and Cibola NWR (17). During 2009–2012, we recaptured or re-sighted 13 cuckoos we had banded in a previous year of the project; altogether, these returns amounted to 15 dispersal events: 10 breeding dispersal by 8 individuals and 5 natal dispersal events. Returning males showed high site fidelity; among returning adults, all males returned to their original breeding site, dispersing a median distance of 252 meters (m) between breeding locations (range 48–1,389 m, n = 8), while two females dispersed 128 m and 37,360 m. Three returning young males dispersed a median distance of 133 m from their natal nest to breed (range 30–205 m); two returning young females dispersed 1,781 m and 33,315 m.

From 2009 to 2012, we attached radio transmitters to 79 captured adults, radio tracking 70 for at least 1 day and 44 for at least 7 days (chapter 9). Approximately one-half of all tracked birds were confirmed breeders in the study area; the rest (mostly captured during the first half of the season, before July 24) appeared to be transient and were either migrating through the sites or unsuccessful at finding mates or establishing breeding territories. Confirmed breeders spent a significantly longer time at their capture site (mean = 37 days) compared to apparent non-breeding birds (mean = 10 days). Home range estimates (95% kernel density estimates) for birds tracked at least 7 days averaged 20.3 ha, but were significantly smaller for breeding (mean = 18.1 ha) compared to non-breeding birds (mean = 26 ha). Our main results and management recommendations are summarized in chapter 10.

Chapter 1 – Introduction and Project Background

YELLOW-BILLED CUCKOO HISTORY AND BIOLOGY

The western yellow-billed cuckoo (cuckoo, YBCU) population has declined dramatically over the last 100 years due to extensive loss or degradation of suitable breeding habitat, primarily riparian forests and associated bottomlands dominated by willow (*Salix* spp.), cottonwood (*Populus* spp.), or mesquite (*Prosopis* spp.) (Gaines and Laymon 1984; Laymon and Halterman 1987; Hughes 1999; Halterman et al. 2001). Historically, Mearns (1907) estimated there were 160,000–200,000 hectares (ha) of alluvial flood plain within the lower Colorado River (LCR) Valley between Fort Mohave and Yuma, which was densely wooded throughout (Grinnell 1914). At that time, cuckoos were thought to have been fairly common, although few early records exist (Gaines and Laymon 1984).

Over the past century, the LCR was transformed by dams to a string of storage pools, and vast areas of flood plain were converted to agricultural fields and urban settlements (Stromberg 2001). Grinnell and Miller (1944) noted an extensive range reduction of western cuckoos due to wide-scale habitat loss. By 1980, only 32,678 ha of riparian woodland remained in the LCR Valley (Hunter et al. 1988). In the 1970s, the regional cuckoo population was estimated at 358 individuals: 244 between Davis Dam and the Mexican border, plus another 114 at the mouth of the BWR (Gaines and Laymon 1984). Much of the LCR flood plain is now dominated by arrowweed (*Pluchea sericea*) and non-native tamarisk (*Tamarix ramosissima*) (Ohmart et al. 1988). The current expanse of woody riparian vegetation within the LCR Multi-Species Conservation Program (LCR MSCP) boundary is estimated at 50,990 ha, of which just 18 percent (%) is native (LCR MSCP 2004a).

The taxonomic status of the western cuckoo remains unclear; whereas some researchers support a distinct western subspecies *occidentalis* (Ridgeway 1887; Franzreb and Laymon 1993; Pruett et al. 2001), others find no basis for subspecies separation of eastern and western cuckoos (Banks 1988, 1990; Fleischer 2001; Farrell 2006). In 2001, the U.S. Fish and Wildlife Service (USFWS) determined that western yellow-billed cuckoos represent a distinct population segment (DPS), becoming a candidate species for listing for protection under the Endangered Species Act (ESA) (USFWS 2001). In 2002, the western DPS listing was determined to be warranted, but precluded by higher priority listing actions (due to limited resources) (USFWS 2002). Yellow-billed cuckoos are listed as endangered in California (California Department of Fish and Game 1978), a species of special concern in Arizona (Arizona Game and Fish Department 1988), and a sensitive species on U.S. Forest Service lands within Arizona and New Mexico (U.S. Department of Agriculture 1988).

Yellow-billed cuckoos are among the latest-arriving neotropical migrants, beginning to arrive in Arizona and California in late May to June (Bent 1940). Their diet during the breeding season consists primarily of large insects, such as grasshoppers, katydids, caterpillars, mantids, and cicadas, as well as tree frogs and small lizards (Bent 1940; Hamilton and Hamilton 1965; Nolan and Thompson 1975; Laymon 1980; Laymon et al. 1997; Hughes 1999). Nesting usually occurs between late June and late July, but can begin as early as late May and continue until late September (Hughes 1999). The main nest tree species in this region are Goodding's willow (*S. gooddingii*), Fremont cottonwood (*P. fremontii*), and tamarisk, though other trees or large shrubs, such as mesquite and seep willow (*Baccharis salicifolia*), may be used (McNeil et al. 2012). Nests consist of a loose platform of twigs, which are built by both sexes and take 1 to 2 days to build, though occasionally the nest of another species is used (Jay 1911; Bent 1940; Payne 2005; McNeil et al. 2011). Clutch size is 1–5 (Payne 2005), usually 2–3 (Laymon 1998), though eight eggs have been found in one nest due to more than one female laying in the nest (Bent 1940). Eggs are generally laid daily until clutch completion (Jay 1911), and incubation begins once the first egg is laid, lasting 9–11 days (Potter 1980, 1981; Hughes 1999). Young hatch asynchronously and are fed small to large insects (Laymon and Halterman 1985; Laymon et al. 1997; Halterman 2009). After fledging at 5 to 9 days, young may be dependent on adults for at least 2 (Laymon 1998) to 3-1/2 weeks (McNeil et al. 2012).

Fall migration is thought to begin in late August, with most birds gone by mid-September (Hughes 1999); however, on the LCR, some individuals appear to begin migrating in early August (McNeil et al. 2011, 2012). Little information exists on their migration routes and non-breeding range in South America where they can be confused with the endemic pearly-breasted cuckoo (*C. euleri*), their closest relative (Payne 2005). One middle Rio Grande-captured cuckoo wintered in central South America in the region where Bolivia, Brazil, Paraguay, and Argentina meet (Sechrist et al. 2012).

LOWER COLORADO RIVER MULTI-SPECIES CONSERVATION PROGRAM

The LCR MSCP is a coordinated, comprehensive, long-term, multi-agency effort, with goals that include conserving habitat, working toward the recovery of threatened and endangered species, and reducing the likelihood of additional species being listed (LCR MSCP 2004b). The LCR MSCP covers areas within the historical flood plain of the Colorado River from Lake Mead to the United States-Mexico Southerly International Boundary, a distance of about 400 river miles (LCR MSCP 2004b). Developed between 1996 and early 2005, the 50-year LCR MSCP includes the creation of more than 3,278 ha of riparian, marsh, and backwater habitat for six federally (or ESA) listed species, 20 other covered species, and 5 evaluation species native to the LCR, including at least 1,639 ha of habitat for the riparian obligate yellow-billed cuckoo (LCR MSCP 2004b).

OBJECTIVES

The objectives of this project are as follows:

(1) Conduct comprehensive, repeatable yellow-billed cuckoo surveys in all potentially suitable habitat types within the LCR MSCP project boundary, including habitat creation sites.

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

(3) Evaluate the effectiveness of the current breeding season survey methodology (Halterman et al. 2008) and refine it to use over the term of the LCR MSCP.

Surveys conducted to meet objective 1 are discussed in chapter 2. Objective 2, breeding habitat selection and preferences, are discussed in chapters 5–9. Objective 3, evaluating the effectiveness of the survey protocol, is addressed in chapters 3 and 4.

STRATIFICATION OF SITES BY MANAGEMENT TYPE

A main objective of this study was to identify factors influencing cuckoo habitat selection. However, inherent differences may exist among riparian habitat patches within the study area based on their current or historical level of management; in particular, hydrological regimes are strong determinants of riparian vegetation structure (Stromberg et al. 2007). Similarly managed sites are expected to be somewhat homogeneous, having habitat characteristics more similar to each other than sites with different hydrological management histories. These inherent management differences may confound the identification of habitat characteristics that are important to cuckoos. Including site management type as a blocking factor in cuckoo habitat, selection analysis controls for management-related habitat differences as a source of variation in the dataset.

Comparing results by management type should result in less variability within the dataset and may reveal disparate habitat use and breeding occupancy patterns.

Additionally, we wished to assess the response of cuckoos to LCR MSCP habitat creation over the 5-year period by comparing cuckoo population trends at LCR MSCP sites to other (*de facto* control) sites within the study area, such as the BWR, where in recent history the highest numbers of cuckoos have occurred.

We identified four categories of sites within the study area based on each site's historical or current level of hydrological management (table 1-1 at the end of this chapter): LCR MSCP restoration sites are under active LCR MSCP management and are typically flood irrigated regularly during the breeding season; non-LCR MSCP restoration sites are generally older planted riparian sites irrigated in previous years (during establishment), but have mostly stopped receiving irrigation; BWR natural sites are all within the active lower BWR flood plain, which receives managed releases (simulating stochastic spring flood events) from Alamo Dam; and non-BWR natural sites are all other unrestored, naturally occurring woody riparian areas on dam-regulated intermittent reaches persisting under no active habitat management.

Using Principle Coordinate Analysis (PCoA), we found that all four management types had significantly different habitat characteristics from each other (table 1-1; see attachment A for analysis and results). Throughout this report, we stratified our results by the four management types for comparisons, and we included site management type in habitat selection analyses to control for inherent differences among sites managed differently.

Table 1-1.—Site management types within the LCR study area

Site type	Description and management	Vegetation characteristics (PCoA)
LCR MSCP restoration	Relatively young (since 2000) planted areas (old agricultural fields) of varying sizes with regular, though varying amounts of, flood irrigation, ensuring high water availability and establishment of fast-growing (primarily cottonwood-willow) vegetation.	Increased canopy closure and green ground cover, mainly grasses and forbs.
Non-LCR MSCP restoration	Generally older, previously managed planted woody riparian patches with little to no current hydrological management and rarely any current irrigation. Most sites are maintained by their connection to the water table or active flood plain (though with low possibility of natural flooding due to multiple upstream dams).	Greatest variability in vegetative composition. Generally, most similar to non-BWR natural plots, but with more green ground cover (mainly grasses).
BWR natural	All sites are within the active lower BWR flood plain. Flow is hydrologically managed in part for riparian conservation. Perennial flow is retained at the east end of the BWR National Wildlife Refuge due to shallow bedrock forcing water to the surface, which enables the continued dominance of cottonwood-willow, the historical southwestern pioneer riparian trees (though tamarisk occurs at increased densities in the intermittent reaches). Occasional pulse releases from Alamo Dam upstream are timed to simulate natural spring floods; vegetation turnover occurs after floods. We distinguish this area from other natural areas due to its distinct management regime and perennial flow.	Increased canopy closure and ground debris (leaves and brush) and less bare ground compared to other management types.
Non-BWR natural	Generally small, remnant woody riparian patches with variable connectivity to the water table with no active hydrological management. Dam-regulated reaches with intermittent flow; an altered flow regime creates conditions favoring the more stress-adapted tamarisk, which is indicated by the dominance or co-dominance of tamarisk at many of these sites.	Greater variability in vegetative composition, but overall similar to BWR in brush, litter, and bare ground cover, with lower amounts of grass and forbs than BWR.

Chapter 2 – Presence-Absence Surveys, Detection Probability, and Habitat Use

INTRODUCTION

Long-term monitoring programs focus on the status and trends of species distribution and can effectively document a species' annual state and changes in their condition through time (LaRoe et al. 1995). Through repeated surveys, the annual status of populations can be assessed by examining within-season distribution, habitat use, and abundance patterns, both spatial and temporal, across the landscape. The analysis of multi-year datasets can reveal emergent trends in a number of population parameters, including fluctuations and responses to environmental changes such as habitat restoration or creation.

We present the results of the 2008–2012 yellow-billed cuckoo surveys within the study area to provide a multi-year status assessment of the species and to identify trends in cuckoo population parameters, in particular the cuckoos' response to LCR MSCP habitat restoration. From repeated surveys conducted annually from 2008 to 2012, we estimated cuckoo detection probability and numerous habitat use probabilities. We hypothesized that, from 2008 to 2012, different LCR site management exhibited mild to substantial differences in cuckoo detection, habitat use, colonization, and extinction probabilities. This hypothesis is based on disparate observations of cuckoos across these habitats (McNeil et al. 2010, 2011, 2012) and a recognition of vegetative differences among management types (chapter 1 and attachment A). Stratified management type analysis also maximizes our power to detect responses to LCR MSCP habitat restoration and enables comparisons with natural and non-LCR MSCP restoration habitat (*de facto* control sites). While surveys designed to monitor a species can uncover patterns of distribution and habitat use, the mechanisms behind these patterns are often better discerned through supplemental research, such as habitat analyses, nest monitoring, and radio telemetry, described in chapters 5–9.

METHODS

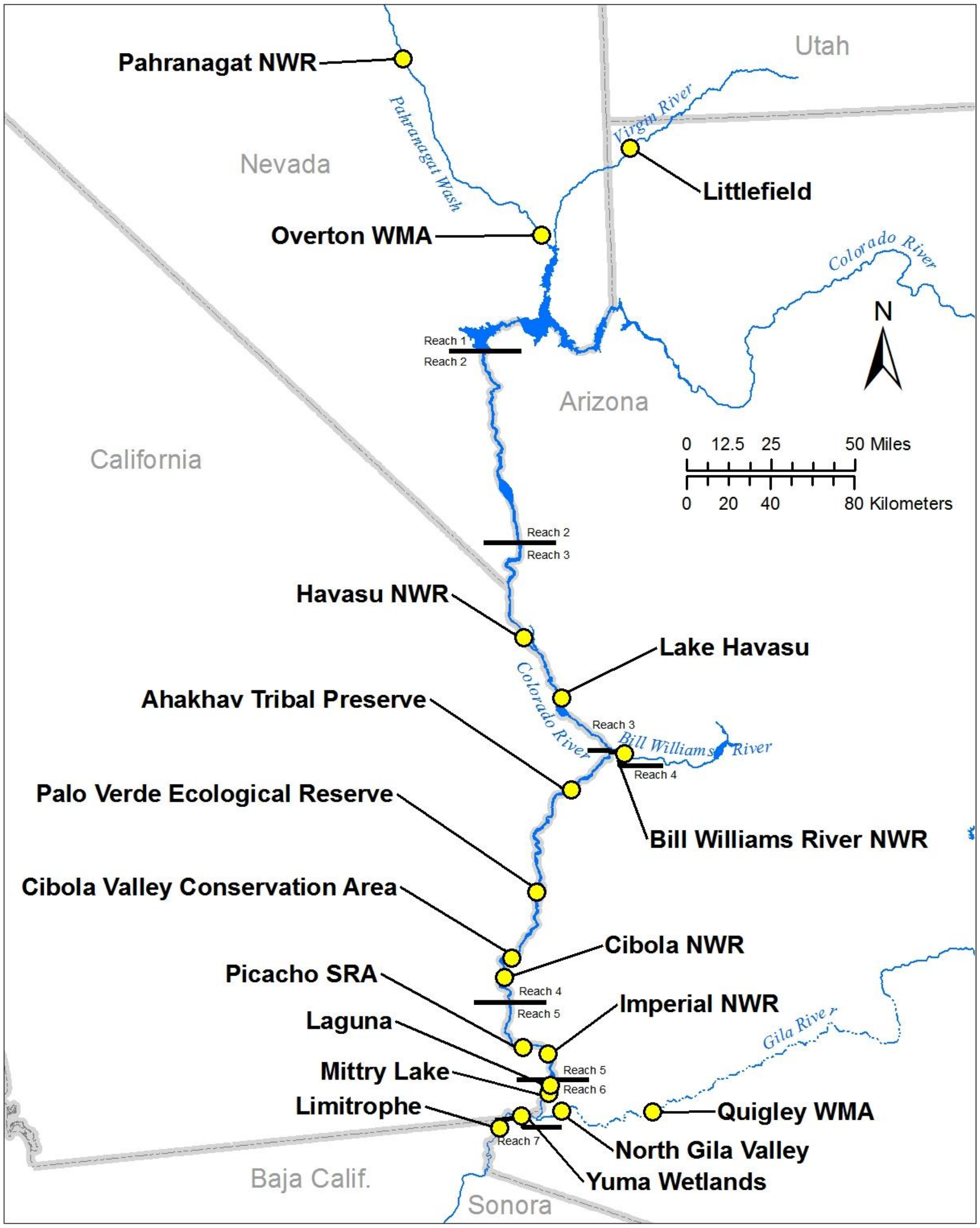
Study Area and Survey Site Selection

From 2008 to 2012, we conducted yellow-billed cuckoo surveys along a 400-river-mile stretch of the LCR and tributaries (Muddy, Virgin, Bill Williams, and Gila) from Pahranagat National Wildlife Refuge (NWR) to the United States-Mexico Southerly International Boundary (the study area) (Halterman et al. 2009b; McNeil et al. 2010, 2011, 2012; 2013, in review). The study area encompassed the LCR MSCP management boundary and included a few additional adjacent habitat patches with historical cuckoo use (e.g., Pahranagat NWR, Quigley Wildlife Management Area [WMA]). Within this area, all potentially suitable habitat patches were considered for inclusion. Potentially suitable habitat consisted of early to mature native or mixed native/exotic riparian forest with woody riparian land cover structural types I–III, at least 4–5 meters (m) in height (Anderson and Ohmart 1984). A habitat patch was defined as an area of potentially suitable habitat 2 ha or greater in extent that was separated from another patch of potentially suitable habitat by at least 300 m. Although habitat patches at least 2 ha were considered, cuckoos have not been found breeding in patches this small (Halterman et al. 2009a), and ideally they should be greater than 40 ha (Laymon and Halterman 1989) because they can support more than one breeding territory. A survey site was defined as part of a patch, an entire patch, or a collection of patches of potentially suitable habitat treated as one site. We assessed sites both by aerial (2008–2010) and ground (2008–2012) reconnaissance. Sites were selected based on past cuckoo detections (Johnson et al. 2007, 2008; Halterman et al. 2009b; McNeil et al. 2010, 2011, 2012), patch size, plant species composition, and habitat structure. Sites were delineated by walking the boundaries with a Global Positioning System (GPS) unit. Where site boundaries were inaccessible (such as areas of the BWR), boundaries were estimated in ArcGIS 9.3 using georeferenced 2004 or 2010 aerial imagery. Each site's size (ha) was estimated in ArcGIS.

We annually surveyed 41 to 62 sites between 2008 and 2012 (map 2-1 and tables 2-1 to 2-3), consisting of LCR MSCP restoration, non-LCR MSCP restoration, BWR natural, or non-BWR natural riparian habitat (chapter 1 and attachment A). Between years, the amount of surveyed area at some sites increased or decreased due to changes in habitat suitability or access. In general, BWR natural and LCR MSCP restoration sites were surveyed annually when possible, whereas non-BWR natural and non-LCR MSCP restoration sites were surveyed less regularly, with marginal sites – typically small patches often dominated by tamarisk and/or with a sparse density of native trees – surveyed less frequently than those deemed more suitable for breeding cuckoos. Site descriptions (attachment B) describe each site and any circumstances leading to survey changes.

Presence-Absence Surveys

The primary survey objective was to assess yellow-billed cuckoo habitat use within the study area. Cuckoos are inherently secretive, evade detection, and call infrequently (Hamilton and Hamilton 1965). The use of multiple call broadcast surveys during the breeding season is the standard method used to increase the probability of detecting cuckoos and determine habitat use (Johnson et al. 1981; Gaines and Laymon 1984; Halterman et al. 2008). However, their furtive nature coupled with their somewhat transitory behavior lead to imperfect detection of the



Map 2-1.—LCR yellow-billed cuckoo study area, including river reach boundaries. Survey areas shown by yellow circles. Sites listed in tables 2-1 through 2-3 are clustered in these survey areas.

Table 2-1.—Northern (Reaches 1–3) yellow-billed cuckoo survey sites, 2008–2012
(Survey areas are shown on map 2-1.)

Survey area	Site name	Site code	Size (ha) (2012 area)	Site management type	River reach	Year surveyed				
						2008	2009	2010	2011	2012
Pahranagat NWR	Key Pittman WMA	KEYPIT	1.9	Non-BWR natural	1		X			
	Pahranagat NWR North	PAHNTH	18.6	Non-BWR natural	1	X	X			X
	Pahranagat NWR South	PAHSTH	9.0	Non-BWR natural	1	X	X			X
Littlefield	Littlefield Bridge	LITBR	39.9	Non-BWR natural	1		X	X		
Overton WMA	Honeybee Pond	OVRHP	3.6	Non-BWR natural	1	X	X			
	Overton Residential	OVRR	2.8	Non-BWR natural	1		X			
	Overton Wildlife	OVRW	10.1	Non-BWR natural	1	X	X	X		X
	Overton Wilson Pond	OVRWP	22.8	Non-BWR natural	1		X	X		X
	Smelly Jelly	SMJE	28.6	Non-BWR natural	1			X		
Havasu NWR	Beal Restoration	HAVBR	21.3	LCR MSCP restoration	3	X	X	X	X	X
	Farm Ditch Road	HAVFDR	6.9	Non-BWR natural	3		X			
	Glory Hole	HAVGH	13.2	Non-BWR natural	3		X	X	X	
	Lost Lake	HAVLL	4.0	Non-BWR natural	3			X		
	Havasu Levee Road	HAVLR	3.2	Non-BWR natural	3	X	X	X		
	North Dike	HAVND	5.1	Non-LCR MSCP restoration	3	X	X	X	X	X
	Pintail Slough	HAVPS	11.7	Non-LCR MSCP restoration	3	X	X	X	X	X
	Topock Platform	HAVTPR	9.3	Non-LCR MSCP restoration	3	X	X	X	X	X
Lake Havasu	Desilt Wash	DSWA	3.4	Non-BWR natural	3		X			
	Falls Spring Wash	LHCFSW	6.8	Non-BWR natural	3		X			
	Lake Havasu Willow Patch	LHCWP	5.0	Non-BWR natural	3		X			
BWR NWR	Bill Williams Marsh	BWMA	19.7	BWR natural	3	X	X	X	X	X
	Borrow Pit	BWBP	33.6	BWR natural	3	X	X	X	X	X
	Cave Wash	BWCW	36.4	BWR natural	3	X	X	X	X	X
	Cottonwood Patch	BWCP	38.2	BWR natural	3	X	X	X	X	
	Cougar Point	BWPT	43.1	BWR natural	3	X	X	X	X	X
	Cross River	BWCR	30.2	BWR natural	3		X	X	X	X
	Esquerra Ranch	BWER	40.2	BWR natural	3	X	X	X	X	X
	Fox Wash	BWFW	62.5	BWR natural	3	X	X	X	X	X
	Gibraltar Rock	BWGR	66.5	BWR natural	3	X	X	X	X	X
	Honeycomb Bend	BWHB	29.6	BWR natural	3	X	X	X	X	X
	Kohen Ranch	BWKR	37.1	BWR natural	3	X	X	X	X	X
	Middle Delta	BWMD	25.2	BWR natural	3		X	X	X	X
	Mineral Wash	BWMW	49.8	BWR natural	3	X	X	X	X	X
	Mosquito Flats	BWMF	37.1	BWR natural	3	X	X	X	X	X
	North Burn	BWNB	30.0	BWR natural	3	X	X	X	X	X
	Sandy Wash	BWSW	50.9	BWR natural	3	X	X	X	X	X

Table 2-2.—Southern (Reach 4) yellow-billed cuckoo survey sites, 2008–2012
(Survey areas are shown on map 2-1.)

Survey area	Site name	Site code	Size (ha) (2012 area)	Habitat type	River reach	Year surveyed				
						2008	2009	2010	2011	2012
‘Ahakhav Tribal Preserve	‘Ahakhav Tribal Preserve	CRIT	59.6	LCR MSCP restoration	4	X	X		X	X
Cibola NWR	Cibola Crane Roost	CIBCR	48.0	LCR MSCP restoration	4			X	X	X
	Cibola Eucalyptus[1]	CIBEUC	29.4	Non-LCR MSCP restoration	4	X	X	X	X	X
	Cibola Island Perri Marsh	CIBIPM	88.3[2]	Non-LCR MSCP restoration	4	X	X	X	X	
	Cibola Island South	CIBSTH	17.8[2]	Non-LCR MSCP restoration	4	X	X	X	X	
	Cibola Mass Planting	CIBMP	23.7	LCR MSCP restoration	4	X	X	X	X	X
	Cibola Nature Trail	CIBCNT	14.4	LCR MSCP restoration	4	X	X	X	X	X
	Cibola North	CIBNTH	7.2	LCR MSCP restoration[3]	4	X	X	X	X	X
Cibola Valley Conservation Area (CVCA)	Cibola Valley Phase 1	CVCA1	34.8	LCR MSCP restoration	4	X	X	X	X	X
	Cibola Valley Phase 2	CVCA2	24.7	LCR MSCP restoration	4		X	X	X	X
	Cibola Valley Phase 3	CVCA3	37.0	LCR MSCP restoration	4		X	X	X	X
Palo Verde Ecological Reserve (PVER)	Palo Verde Phase 1	PVER1	8.3	LCR MSCP restoration	4	X	X	X	X	X
	Palo Verde Phase 2	PVER2	24.2	LCR MSCP restoration	4		X	X	X	X
	Palo Verde Phase 3	PVER3	19.8	LCR MSCP restoration	4			X	X	X
	Palo Verde Phase 4	PVER4	35.8	LCR MSCP restoration	4			X	X	X
	Palo Verde Phase 5	PVER5	73.7	LCR MSCP restoration	4					X

[1] Cibola Eucalyptus is adjacent to Cibola NWR.
[2] Area for CIBIPM CIBSTH are pre-fire August 2011.
[3] Cibola North was treated as non-LCR MSCP restoration for analysis.

Table 2-3.—Southern (Reaches 5–6) yellow-billed cuckoo survey sites, 2008–2012
Survey areas are shown on map 2-1.

Survey area	Site name	Site code	Size (ha) (2012 area)	Habitat type	River reach	Year surveyed				
						2008	2009	2010	2011	2012
Imperial NWR	Imperial NWR 20A	IMP20A	2.0	Non-LCR MSCP restoration	5	X	X		X	X
	Imperial NWR 50	IMP50	4.2	Non-LCR MSCP restoration	5				X	X
	Imperial NWR South	IMPSTH	13.0	Non-LCR MSCP restoration	5	X	X	X	X	X
	Imperial Martinez Lake	IMPAST	6.8	Non-BWR natural	5		X		X	
Picacho State Recreation Area (SRA)	Picacho SRA	PICSRA	14.8	Non-LCR MSCP restoration	5	X	X	X	X	X
Laguna	Laguna 1	LAG1	0.9	Non-BWR natural	6		X			
	Laguna 2	LAG2	3.9	Non-BWR natural	6		X	X		X
	Laguna 3	LAG3	3.8	Non-BWR natural	6		X	X		X
	Laguna East	LAGE	13.9	Non-BWR natural	6				X	
	Laguna West	LAGW	1.0	Non-BWR natural	6				X	
	Laguna “A”	LAGTA	10.1	Non-BWR natural	6				X	
	Laguna “D”	LAGTD	14.4	Non-BWR natural	6				X	
Mittry Lake	Mittry Lake-Pratt	MLPR	13.0	Non-LCR MSCP restoration	6	X		X	X	X
	Mittry Lake East Rd	MLEA	10.1	Non-BWR natural	6				X	
Gila River	Colo/Gila Confluence	YUCC	67.7	Non-BWR natural	6	X	X			
	Gila Confluence	GRGC	26.8	Non-BWR natural	6	X			X	
	North Gila Valley “A”	GRNVA	3.6	Non-BWR natural	6		X			X
	North Gila Valley “B”	GRNVB	4.7	Non-BWR natural	6		X			
Quigley WMA	Quigley WMA	GRQP	10.6	Non-LCR MSCP restoration	6	X	X	X	X	X
Yuma Wetlands	Yuma East Wetlands	YUEW	9.0	Non-LCR MSCP restoration[1]	6		X	X	X	X
	Yuma West Wetlands	YUWW	25.5	Non-LCR MSCP restoration	6	X	X	X	X	X
Limitrophe	Limitrophe North	LIMNTH	164.5	Non-BWR natural	6	X	X			
	Limitrophe South “A”	LIMSTA	8.3	Non-BWR natural	6	X	X			
	Limitrophe South “B”	LIMSTB	8.1	Non-BWR natural	6	X	X			

[1] YUEW became an LCR MSCP restoration site toward the end of the study and was treated as a non-LCR MSCP site for analysis.

species (McNeil et al. 2010, 2011). Also, the use of call broadcasts can attract cuckoos from neighboring habitat into the surveyed habitat. Given these behaviors, the surveys are not designed to determine the absolute number of cuckoos within an area, to determine breeding status, or be used to assess small-scale habitat preferences.

Cuckoo presence-absence surveys were conducted at survey sites along point transects on foot or by kayak, between sunrise and 10:30 a.m., or until temperatures exceeded 40 degrees Celsius (°C) (104 degrees Fahrenheit [°F]). Whenever possible, adjacent sites were surveyed on the same day to minimize the possibility of double counting the same cuckoo moving between adjacent sites. On these occasions, surveyors used radios to communicate with each other to avoid double counting. Each site contained one or more transects with parallel transects spaced approximately 200 to 250 m apart. Survey points were spaced every 100 m along transects. Most transects traversed through the habitat patches. However, some transects ran along habitat edges or adjacent roads to take advantage of greater visual detectability from these locations or because the interior of the habitat was inaccessible. Survey points were located using Garmin GPS units (±6 m horizontal accuracy), and at each point, we recorded the Universal Transverse Mercator (UTM) location, time, habitat type and structure, and live cicada index (in 2010 and 2011, we also recorded temperature and humidity at each survey point).

Upon arriving at a survey point, surveyors listened and watched for cuckoos for 1 minute. If none were detected, surveyors used an MP3 player and hand-held speaker to broadcast a 5-second yellow-billed cuckoo contact call (the "kowlp" call) (Hughes 1999) at approximately 70 decibels, once per minute for 5 minutes. A 5-second contact call was followed by 55 seconds of active observation and listening. If a cuckoo was detected, call playbacks were discontinued immediately, and all pertinent data were recorded (see below). Following a detection, surveyors progressed along the point transect 300 m from the estimated location of the detected cuckoo to avoid additional disturbance and duplicate detections of the same bird.

For each detection, the surveyor recorded the estimated true bearing and distance from the surveyor to the cuckoo, time of detection, number of call broadcasts played, response type, behavior, vocalizations, vegetation type, presence of other cuckoos, interactions, and the presence and/or color combination of leg bands. Any observed breeding evidence was also recorded, including carrying food or nesting material, copulation, the presence of a juvenile, or a nest. An individual cuckoo visually observed or heard during a survey, including one detected while traveling in between survey points, was recorded as a survey detection. If the same individual cuckoo was detected more than once during a single survey, only the initial detection was used in calculating the survey detection total and in habitat use analysis. Cuckoos detected greater than approximately 300 m apart during a single survey were counted as separate individuals and, therefore, separate survey detections. Repeated detections of a cuckoo and cuckoos encountered before or after a survey were classified as non-survey or incidental detections. Information collected for incidental detections was the same as that collected for survey detections. Additionally, we recorded all avian species encountered during surveys (attachment C). Terms related to surveys are summarized in table 2-4.

Table 2-4.—Summary of definitions for site management type, study area, river reach, survey area, survey site, and survey point

Term	Definition
Site management type	The historical or current hydrological management of each survey site affecting vegetation/habitat characteristics (chapter 1 and attachment A). Four types are identified: LCR MSCP restoration, non-LCR MSCP restoration, BWR natural, and non-BWR natural.
Study area	All potentially suitable cuckoo habitat along a 400-river-mile stretch of the LCR and tributaries from Pahranagat NWR to the United States-Mexico Southerly International Boundary (map 2-1).
River reach (Reach)	A discrete watershed segment used by the LCR MSCP for the analysis of impacts and conservation measures (LCR MSCP 2004a). Reach boundaries are shown on map 2-1. Sites are grouped by reach (tables 2-1 to 2-3).
Survey area	A collection of clustered survey sites (tables 2-1 to 2-3).
Survey site (Site)	A location consisting of an entire patch, a part of a patch, or a collection of patches of potentially suitable habitat (tables 2-1 to 2-3) surveyed in one morning. To adequately survey a site, one or more survey transects traversed each site.
Survey point	Spatially explicit points spaced 100 m apart along transects within a survey site where cuckoo call broadcasts (up to five broadcasts per point) were conducted.

Five surveys were conducted at most sites, once per survey period (table 2-5). However, over the course of the 5 years, the survey period dates changed. In 2008, surveys were conducted following the recommended protocols at the time (Halterman et al. 2007 and table 2-5). In 2009, we followed updated survey period dates recommended by Halterman et al. (2008, 2009a). In 2011, as part of our assessment of survey protocol effectiveness (study objective 3, chapter 3), we changed our survey period frequency to determine if an additional peak-season survey would increase the likelihood of detecting breeding cuckoos or increase our accuracy in determining habitat use. With this change, the majority of surveys (three of five) in 2011 and 2012 were conducted in July, during the peak of cuckoo detectability, site use, and breeding activity on the LCR based on our 2009 and 2010 data (McNeil et al. 2010, 2011). To standardize the 2008 to 2012 survey data for the 5-year analysis, we reassigned the survey periods in the 2008, 2011, and 2012 datasets to the 2009–2010 survey periods (table 2-5). This

Table 2-5.—LCR YBCU survey period dates 2008–2012. 2008–2010 surveys were conducted every 12-20 days. 2011-2012 surveys were conducted every 10–12 days
Between years, survey period dates changed due to recommendations by the western cuckoo working group (2008–2009) and to assess protocol efficacy (2010–2011). For the 5-year analysis, 2008, 2011, and 2012 surveys were reassigned based on the 2009–2010 survey periods.

Survey period	2008	2009–2010	2011–2012
1	June 4 to June 30	June 15 to June 30	June 15 to June 30
2	July 1 to July 21	July 1 to July 15	July 1 to July 10
3	July 22 to August 11	July 16 to July 31	July 11 to July 21
4	August 12 to September 2	August 1 to August 15	July 21 to July 31
5	September 3 to September 22	August 16 to August 31	August 1 to August 15

resulted in two surveys having been conducted within one survey period, at all sites in 2011 and 2012, and three sites in 2008. When this occurred, we randomly removed the data from one of the two conflicting surveys, with the remaining dataset now conforming to the 2009–2010 survey periods.

Surveys were not always conducted during all survey periods in all years. In 2008, surveys were initiated in early June and repeated every 12 to 20 days (usually every 20 days), which resulted in few surveys in the first half of July (during the 2009–2010 survey period 2). In all years, surveys were not always conducted during survey period 5 (past August 15) at all sites. Late August surveys result in few detections and, as such, are considered optional (Halterman et al. 2007, 2008, 2009a). Sites with no detections in the first four surveys were generally not surveyed during the fifth survey period.

Detection Probability and Habitat Use

On the LCR, cuckoos reside in an open population; individual cuckoos have been observed moving out of the study area or exhibiting large pre-breeding movements across sites during the breeding season (chapter 9) and prior to the completion of the last round of surveys. In contrast, in a closed population study, individuals do not enter or leave the study area until all surveys have been completed. As such, the detection of a cuckoo in an area only once is an unreliable indicator that the area was used for more than a few days, let alone being occupied for breeding. The alternative, which we adopted for select analyses in this report (chapters 2–4), is to consider these areas as "used" rather than "occupied" (MacKenzie et al. 2006), as cuckoos may have spent only a short time within the habitat during a migratory stopover point or during a brief foraging foray from an adjacent territory. For our presence-absence analyses, we took this more conservative approach and calculated annual habitat use estimates based on one or more survey detections in one or more survey periods. Regarding the distinction between habitat use and occupancy, we believe that within the LCR study area, multiple detections spread across several survey periods are a more likely indication of breeding occupancy. As done previously (McNeil et al. 2010, 2011, 2012), in chapter 5, we calculated the proportion of sites occupied by breeding cuckoos based on two or more detections in two or more survey periods. Subsequent habitat (chapter 6) and microclimate (chapter 7) analyses also use this site occupancy definition (table 2-6).

Table 2-6.—Summary of definitions for occupancy estimation terms

Term	Definition
Habitat use	Cuckoo use of an area based on one or more survey detections. The habitat deemed “used” may have held cuckoos for a day or for the duration of the breeding season. Habitat use estimates are used in chapters 2–4.
Habitat occupancy	Occupancy is based on two or more total detections during two or more survey periods. Multiple detections over several survey periods in an area suggest that the area was inhabited for an extended period of time and may have been used as breeding habitat. Habitat occupancy estimates are used in chapters 5–7.
Sample unit	The territory-sized spatial unit **used solely** to estimate cuckoo detection probability and habitat use (in analysis prior to 2011, site boundaries were used as the sample units for detection probability and habitat use estimation).
Used sample unit	A sample unit with at least one survey detection during one or more survey periods.
Unused sample unit	A sample unit with no survey detections in all survey periods.

During surveys, it is possible that a cuckoo is present, but remains undetected. As a result, an area may be incorrectly classified as unused, which can result in underestimating true habitat use (MacKenzie et al. 2006). To account for this situation, we incorporated cuckoo detection probability (the probability of detecting one or more cuckoos within a surveyed area). We analyzed cuckoo presence-absence data from our repeated surveys using the program PRESENCE v 5.5 (Hines 2006) to calculate detection probabilities and habitat use estimates (for surveyed areas) at BWR natural, non-BWR natural, LCR MSCP restoration, and non-LCR MSCP restoration habitat.

To estimate detection probability and the proportion of habitat used across a study area, the area is subdivided into defined areas or sample units; detection probability and use estimates are derived from (and therefore describe) the presence, absence, and detectability of a species within these sample units

(Williams et al. 2002; MacKenzie et al. 2006). Sample units should be similar in size and sized to be both meaningful to the management of, and biologically relevant to, the species of interest (MacKenzie et al. 2006; Bart 2011). In the past, (Johnson et al. 2007, 2008; Halterman et al. 2009b; McNeil et al. 2010, 2011), the sample units used for detection probability and habitat use (referred to as occupancy in previous reports) analyses for this project were defined as the site boundaries; these are both arbitrary (such as at the BWR) and discrete in delineation (most other sites), with considerable size variation (ranging from 2-ha patches to the extensive riparian forest of the BWR [> 600 ha divided into arbitrary sites ~20–90 ha each]). Using a standardized sample unit size provides increased accuracy and decreased bias in habitat use and detection probability estimates, and by controlling for the effects of sample unit size, the estimates are more comparable across the entire study area (Williams et al. 2002).

For the habitat use and detection probability analyses, we used sample units based on the average size of a cuckoo territory instead of using site boundaries. From previous telemetry observations at LCR restoration sites, we estimated the average cuckoo territory to be between 19.8 and 21.7 ha (range 8.0–48.9 ha) (McNeil et al. 2010, 2011, 2012). Given the variation in the size of surveyed habitat patches, we included sample units with a range of sizes. At sites less than 30 ha in size, too small to break into smaller sample units, we used the natural boundaries of the site to define the sample unit. At sites containing contiguous patches of habitat of at least 30 ha (e.g., at the BWR NWR), we tessellated the habitat into a continuous grid of 1-ha hexagons in ArcGIS. We then combined adjacent hexagons into 20-ha sample units and, where possible, used knowledge of the habitat to position sample unit boundaries relative to natural habitat boundaries (Bart 2011). The territory-based sample units (table 2-7) are used solely for calculating detection probability and habitat use estimates in the program PRESENCE (chapters 2–4).

Table 2-7.—Annual sample units used in LCR YBCU habitat use analysis, 2008–2012

Site type	Number of sample units per year				
	2008	**2009**	**2010**	**2011**	**2012**
LCR MSCP restoration	8	12	15	18	21
Non-LCR MSCP restoration	13	15	20	22	13
BWR natural	35	36	36	36	34
Non-BWR natural	10	26	8	6	6
Total	66	89	79	82	74

In addition to calculating detection probabilities (*p*) and habitat use estimates (ψ), the analysis of multi-year datasets enables the estimation of local habitat colonization and extinction probabilities. The habitat colonization estimate (·)

is the probability that an unused sample unit in one year will be used by cuckoos in the following year. The local extinction probability (·) estimates the probability that a sample unit used in one year will be found unused the following year. The colonization and extinction estimates can then be used with the habitat use estimate to dynamically calculate a habitat use growth rate, lambda, and a multiplicative rate of increase or decrease in the proportion of used habitat from one year to the next. A lambda value greater than 1 indicates that from one year to the next, the sample unit use rate increased, while a value less than one indicates sample unit use declined. A value of exactly one indicates no change in sample unit probability of use between years.

The models used to estimate cuckoo habitat use (ψ), colonization (γ), extinction (ε), and detection probabilities (p) may use either a Markov or a strictly random process. Based on the best fitting model, we can then make inferences about cuckoo site fidelity (MacKenzie et al. 2006). In a Markov model, the derived use state of a sample unit in one year is related to its use state the previous year. If a model using a Markov process is selected as the top model, we can infer that cuckoos (as a species, not at the level of individuals) exhibit high site fidelity to a particular area (MacKenzie et al. 2006). Alternatively, the data can be modeled using random (non-Markov) processes in which the habitat use state in one year is independent of the previous year. These models suggest that habitat use is random and that cuckoos (as a species) exhibit low site fidelity.

We developed six different hypotheses, with six corresponding models, to estimate habitat use, extinction, colonization, and detection probability parameters (table 2-8). The processes these parameters estimate may be dynamic and exhibit annual variation or relatively stable and constant through time. The six models estimated various combinations of either dynamic or constant parameter values. Because we have repeatedly observed detection probability to vary by survey period (McNeil et al. 2010, 2011, 2012), we modeled only this relationship for the detection probability parameter (as opposed to modeling detection probability as a single rate for all survey periods or an annual rate). We applied the set of models to the entire 2008–2012 survey dataset, stratified by the four site management types.

The presence-absence survey data were analyzed using the program PRESENCE v 5.5 (Hines 2006). PRESENCE calculates detection probability estimates from the detection history of the repeated presence-absence surveys (the detection or non-detection of cuckoos from each survey) (MacKenzie et al. 2006). No additional data were incorporated into the analyses. The PRESENCE dataset is comprised of 1s and 0s for the detection or non-detection of cuckoos in each surveyed sample unit. Dashes (-) were used where no data were collected (i.e., when a site was not surveyed). If a site was not surveyed in a given year, it was assigned dashes for all five survey periods. PRESENCE ignores dashes

Table 2-8.—Model equations, hypotheses, and descriptions for the set of six competing models used to estimate cuckoo detection (*p*), habitat use (ψ), colonization (γ), and extinction (ε) probabilities

Model #	Model	Model hypothesis	Model description
1	ψ(2008) γ(·) ε(·) *p*(survey period)	Cuckoos exhibit site fidelity; therefore, sample unit habitat use is related to its habitat use state the previous year. However, habitat use at a sample unit can change and vary from year to year. Sample unit colonization and extinction rates are the same in all years, and the probability to detect cuckoos at a sample unit varies by survey period.	This model estimates habitat use (ψ) for the first year of data (2008) from the survey dataset and derives habitat use in subsequent years from dynamic processing of the model parameters. The model uses a **Markov** process to estimate sample unit habitat use for subsequent years; thus, sample unit habitat use in one year is related to its habitat use the previous year. The model assumes that local sample unit colonization (γ) and extinction (ε) probabilities are in a state of equilibrium; they are held constant (·) and estimated from the data for all years. Detection probability (*p*) varies by survey period.
2	ψ(2008) γ(year) ε(year) *p*(survey period)	Cuckoos exhibit site fidelity, and sample unit habitat use is related to its habitat use the previous year. However, habitat use at a sample unit can vary from year to year. Sample unit colonization and extinction rates vary by year, and the probability to detect cuckoos at a sample unit varies by survey period.	This model estimates habitat use (ψ) for the first year of data (2008) from the survey dataset and derives habitat use in subsequent years from dynamic processing of the model parameters. The model uses a **Markov** process to estimate sample unit habitat use; as such, sample unit habitat use in one year is related to habitat use the previous year. The model assumes that local sample unit colonization (γ) and extinction (ε) probabilities are not in equilibrium; these parameters are estimated from the data and vary by year. Detection probability (*p*) varies by survey period.
3	ψ(2008) γ(·) {ε = 1 - γ} *p*(survey period)	Cuckoos show low site fidelity or select habitat at random. As such, sample unit habitat use by cuckoos is not related to its habitat use the previous year. Habitat use at a sample unit can change and may vary from year to year. Sample unit colonization and extinction rates are the same in all years, and the probability to detect cuckoos at a sample unit varies by survey period.	This model estimates habitat use (ψ) for the first year of data (2008) from the dataset and derives habitat use in subsequent years from dynamic processing of the model parameters. The model assumes that sample unit habitat use in one year is not related to the habitat use state the previous year. The probability of a sample unit becoming used is the same as the probability that a sample unit stays used. The model assumes that local sample unit colonization (γ) and extinction (ε) probabilities are constant (·), and that they are in a state in equilibrium. The extinction probability is not estimated from the data, but is instead complementary to the estimated colonization probability (ε = 1 - γ). Detection probability (*p*) varies by survey period.

Table 2-8.—Model equations, hypotheses, and descriptions for the set of six competing models used to estimate cuckoo detection (p), habitat use (ψ), colonization (γ), and extinction (ε) probabilities

Model #	Model	Model hypothesis	Model description
4	ψ(2008) γ(year) $\{\varepsilon = 1 - \gamma\}$ p(survey period)	Cuckoos show low site fidelity or select habitat at random. Sample unit use by cuckoos is not related to its use the previous year. Habitat use at a sample unit can change and may vary from year to year. Sample unit colonization and extinction rates vary by year, and the probability to detect cuckoos at a sample unit varies by sample period.	This model estimates habitat use (ψ) for the first year of data (2008) from the dataset and derives habitat use in subsequent years from dynamic processing of the model parameters. The model assumes that sample unit use in one year is not related to the usage state the previous year. The probability of a sample unit becoming used is the same as the probability a sample unit stays used. The model assumes that local sample unit colonization (γ) and extinction (ε) probabilities are not in equilibrium and can vary from year to year. The extinction probability is not estimated from the data, but is instead complementary to the estimated colonization probability ($\varepsilon = 1 - \gamma$). Detection probability (p) varies by survey period.
5	$\psi(\cdot)$ $\gamma(\cdot)$ p(survey period)	Cuckoo habitat use, colonization, and extinction are the same in all years. Cuckoo detection probability varies by survey period.	This model assumes that cuckoo habitat use (ψ) and local colonization (γ) are constant ($\cdot$) for all 5 years. Local extinction probability (ε) is also constant; it is derived from and a complement of the colonization parameter. It is not estimated from the data and hence not shown in the model. Detection probability (p) varies by survey period.
6	$\psi(\cdot)$ p(survey period)	Cuckoo habitat use is well established and does not change from year to year. Cuckoo habitat use is static for all 5 years, and there is no local colonization or extinction at the sample unit scale. Cuckoo detection probability varies by survey period.	This model assumes that cuckoo habitat use (ψ) was constant ($\cdot$) for all 5 years. Colonization (γ) and extinction (ε) parameters are constrained to zero. Detection probability (p) varies by survey period.

when calculating probability estimates, and is thus powerful, as it can be used with incomplete datasets. The Markov models, and colonization, extinction, and growth rate estimates, only used data where surveys were conducted at least two consecutive years.

We used an information theoretic approach (Burnham and Anderson 2002) to model the data using Akaike's information criterion (AIC). For each model, we calculated the standard negative log likelihood ($-2l$), number of parameters (K), AIC values, the relative AIC difference between each model and the top model with the lowest AIC (ΔAIC_i), and the relative Akaike weights (ω_i). Models were ranked using AIC values (Burnham and Anderson 2002) and their relative strength assessed by their ΔAIC_i. Models with ΔAIC_i between 0–2 were considered to have substantial support in explaining the variation in the data, ΔAIC_i = 3–7 had less support, and models with ΔAIC_i greater than 10 had virtually no support. Akaike weights (ω_i) were derived from the AIC measure of model parsimony determined from the inclusion of the most important explanatory variables. They represent the strength of evidence of each particular model as the best from the set of models considered (Burnham and Anderson 2002).

RESULTS

Presence-Absence Surveys

From 2008 to 2012, we surveyed between 41 and 62 sites per year and annually averaged 210 survey detections (table 2-9). With the variation in the number of sites surveyed per year, especially in 2008 and 2009, the annual total detection counts should be compared with caution. Note that 2008 survey period 2 detections were low primarily as a result of following the then-current survey period dates, which resulted in relatively few surveys conducted from July 1 to July 15. Overall, most detections were made in July, in survey periods 2 and 3. August surveys had the fewest number of detections, though not all sites were surveyed during the optional fifth survey period. June detections exhibited the greatest variability, suggesting highly variable annual migratory arrival timing. Annual detection totals for all sites are listed in tables 2-10 to 2-12.

Several broad patterns are evident in the 2008–2012 detection totals. When grouped by river reach (table 2-13), the majority of detections were made in Reaches 3 and 4, at the BWR and at LCR MSCP restoration sites. Relatively few detections were made in the remaining reaches surveyed (Reaches 1, 5 and 6, mostly non-LCR MSCP restoration and non-BWR natural sites). Reach 2 had no surveys due to a lack of suitable habitat.

Table 2-9.—LCR YBCU annual number of survey detections by survey period, 2008–2012
Displayed data have been formatted to conform to the 2009–2010 survey periods listed in table 2-5.

Year	Number of sites surveyed	Survey period					Survey detection total
		1	2	3	4	5	
2008	42	45	14	47	33	11	150
2009	61	29	56	65	22	6	178
2010	49	67	85	69	38	9	268
2011	51	22	97	61	40	0	220
2012	48	41	82	57	47	9	236
Average		41	67	60	36	7	210

Overall, Reach 1 sites (table 2-10), all non-BWR natural, had 0 to 2 detections per year when surveyed (mean [μ] = 0.6 detection per year, standard deviation (SD) = 0.69, n = 20) and no evident annual detections trend. At Havasu NWR in Reach 3 (see table 2-10), annual detections at the LCR MSCP restoration site Beal (μ = 5.4, SD = 4.04, n = 5) averaged greater than non-LCR MSCP restoration sites (μ = 2.1, SD = 1.75, n = 15) and non-BWR natural sites (μ = 0.1, SD = 0.35, n = 8), which only had a single detection from 2008–2012.

Reach 3 BWR natural sites (table 2-10) exhibited an overall declining detection trend from 2008 to 2012 (2008: μ = 7.4 detections per year, SD = 4.22, n = 14; 2012: μ = 4.9, SD = 4.03, n = 15). Sites upstream of the rock formation known as Gibraltar Rock (Cave Wash, Cottonwood Patch, Cougar Point, Esquerra Ranch, Gibraltar Rock, Honeycomb Bend, Kohen Ranch, and Mineral Wash) generally had more detections (2008: μ = 9.3, SD = 4.46, n = 8; 2012: μ = 6.3, SD = 4.49, n = 7) than those downstream from Gibraltar Rock (2008: μ = 4.8, SD = 2.23, n = 6; 2012: μ = 3.6, SD = 3.11, n = 8). Only Honeycomb Bend (2008–2012: μ = 13.2 per year, SD = 1.30, n = 5) appeared not to experience the decline in detections observed at other BWR sites. This declining trend predates the 2012 Planet Ranch ownership change and subsequent loss of access to three sites (half of Cave Wash, all of Cottonwood Patch, and ~400 m of Honeycomb Bend). Cave Wash and Cottonwood Patch experienced declines starting in 2011 and the lost access was thus probably not a significant factor in the detection decline observed in this survey area.

Reach 4 includes all but two LCR MSCP restoration areas (‘Ahakhav Tribal Preserve, Palo Verde Ecological Reserve [PVER], Cibola Valley Conservation Area [CVCA], and Cibola NWR) (table 2-11). Annual detection totals at ‘Ahakhav Tribal Preserve fluctuated between 5 and 10 (2008–2012: μ = 7.3 per year, SD = 2.62, n = 4) and did not exhibit a clear increasing or decreasing trend.

Table 2-10.—Annual survey detection totals for northern (Reaches 1–3) yellow-billed cuckoo survey sites, 2008–2012
(A blank space indicates the site was not surveyed.)

Survey area	Site name	Site code	Site size (ha) (2012 area)	Habitat type	River reach	Annual survey detection total				
						2008	2009	2010	2011	2012
Pahranagat NWR	Key Pittman WMA	KEYPIT	1.9	Non-BWR natural	1		1			
	Pahranagat NWR North	PAHNTH	18.6	Non-BWR natural	1	0	1			2
	Pahranagat NWR South	PAHSTH	9.0	Non-BWR natural	1	0	0			1
Littlefield	Littlefield Bridge	LITBR	39.9	Non-BWR natural	1		0	0		
Overton WMA	Honeybee Pond	OVRHP	3.6	Non-BWR natural	1	0	0			
	Overton Residential	OVRR	2.8	Non-BWR natural	1		0			
	Overton Wildlife	OVRW	10.1	Non-BWR natural	1	0	0	1		1
	Overton Wilson Pond	OVRWP	22.8	Non-BWR natural	1		1	2		1
	Smelly Jelly	SMJE	28.6	Non-BWR natural	1			0		
Havasu NWR	Beal Restoration	HAVBR	21.3	LCR MSCP restoration	3	2	1	9	5	5
	Farm Ditch Road	HAVFDR	6.9	Non-BWR natural	3		0			
	Glory Hole	HAVGH	13.2	Non-BWR natural	3		0	0	0	
	Lost Lake	HAVLL	4.0	Non-BWR natural	3			0		
	Havasu Levee Road	HAVLR	3.2	Non-BWR natural	3	1	0	0		
	North Dike	HAVND	5.1	Non-LCR MSCP restoration	3	3	0	2	1	0
	Pintail Slough	HAVPS	11.7	Non-LCR MSCP restoration	3	0	0	4	3	0
	Topock Platform	HAVTPR	9.3	Non-LCR MSCP restoration	3	2	1	6	1	3
Lake Havasu	Desilt Wash	DSWA	3.4	Non-BWR natural	3		0			
	Falls Spring Wash	LHCFSW	6.8	Non-BWR natural	3		0			
	Lake Havasu Willow Patch	LHCWP	5.0	Non-BWR natural	3		0			
BWR NWR	Bill Williams Marsh	BWMA	19.7	BWR natural	3	7	4	2	4	3
	Borrow Pit	BWBP	33.6	BWR natural	3	2	6	5	1	2
	Cave Wash	BWCW	36.4	BWR natural	3	11	14	20	6	6
	Cottonwood Patch	BWCP	38.2	BWR natural	3	4	6	13	1	
	Cougar Point	BWPT	43.1	BWR natural	3	15	10	21	8	10
	Cross River	BWCR	30.2	BWR natural	3		8	8	3	4
	Esquerra Ranch	BWER	40.2	BWR natural	3	3	2	4	6	3
	Fox Wash	BWFW	62.5	BWR natural	3	4	4	3	0	2
	Gibraltar Rock	BWGR	66.5	BWR natural	3	8	3	6	2	1
	Honeycomb Bend	BWHB	29.6	BWR natural	3	14	14	13	11	14
	Kohen Ranchway	BWKR	37.1	BWR natural	3	7	7	7	9	2
	Middle Delta	BWMD	25.2	BWR natural	3		2	3	4	0
	Mineral Wash	BWMW	49.8	BWR natural	3	12	13	16	15	8
	Mosquito Flats	BWMF	37.1	BWR natural	3	8	7	11	6	2
	North Burn	BWNB	30.0	BWR natural	3	4	5	2	5	6
	Sandy Wash	BWSW	50.9	BWR natural	3	4	13	8	2	10

Table 2-11.—Annual survey detection total for southern (Reach 4) yellow-billed cuckoo survey sites, 2008–2012 (A blank space indicates the site was not surveyed.)

Survey area	Site name	Site code	Site size (ha) (2012 area)	Habitat type	River reach	Annual survey detection total				
						2008	2009	2010	2011	2012
‘Ahakhav Tribal Preserve	‘Ahakhav Tribal Preserve	CRIT	59.6	LCR MSCP restoration	4	5	9		5	10
Cibola NWR	Cibola Crane Roost	CIBCR	48.0	LCR MSCP restoration	4			5	10	13
	Cibola Eucalyptus	CIBEUC	29.4	Non-LCR MSCP restoration	4	0	2	3	1	1
	Cibola Island Perri Marsh	CIBIPM	88.3[1]	Non-LCR MSCP restoration	4	0	3	1	13	
	Cibola Island South	CIBSTH	17.8[1]	Non-LCR MSCP restoration	4	3	1	5	2	
	Cibola Mass Planting	CIBMP	23.7	LCR MSCP restoration	4	0	0	1	2	2
	Cibola Nature Trail	CIBCNT	14.4	LCR MSCP restoration	4	1	3	7	1	5
	Cibola North	CIBNTH	7.2	Non-LCR MSCP restoration	4	1	1	1	0	0
CVCA	Cibola Valley Phase 1	CVCA1	34.8	LCR MSCP restoration	4	14	12	19	12	10
	Cibola Valley Phase 2	CVCA2	24.7	LCR MSCP restoration	4		0	13	18	9
	Cibola Valley Phase 3	CVCA3	37.0	LCR MSCP restoration	4		6	6	12	1
PVER	Palo Verde Phase 1	PVER1	8.3	LCR MSCP restoration	4	2	1	2	5	4
	Palo Verde Phase 2	PVER2	24.2	LCR MSCP restoration	4		5	8	7	9
	Palo Verde Phase 3	PVER3	19.8	LCR MSCP restoration	4			7	7	10
	Palo Verde Phase 4	PVER4	35.8	LCR MSCP restoration	4			2	16	20
	Palo Verde Phase 5	PVER5	73.7	LCR MSCP restoration	4					31

[1]Area for CIBIPM and CIBSTH are pre-fire August 2011.

Table 2-12.—Annual survey detection totals for southern (Reaches 5–6) yellow-billed cuckoo survey sites, 2008–2012
(A blank space indicates the site was not surveyed.)

Survey area	Site name	Site code	Site size (ha) (2012 area)	Habitat type	River reach	Annual survey detection total				
						2008	2009	2010	2011	2012
Imperial NWR	Imperial NWR 20A	IMP20A	2.0	Non-LCR MSCP restoration	5	3	0		0	2
	Imperial NWR 50	IMP50	4.2	Non-LCR MSCP restoration	5				1	1
	Imperial NWR South	IMPSTH	13.0	Non-LCR MSCP restoration	5	3	4	3	3	4
	Imperial Martinez Lake	IMPAST	6.8	Non-BWR natural	5		0		1	
Picacho State Recreation Area (SRA)	Picacho SRA	PICSRA	14.8	Non-LCR MSCP restoration	5	1	1	9	1	7
Laguna	Laguna 1	LAG1	0.9	Non-BWR natural	6		0			
	Laguna 2	LAG2	3.9	Non-BWR natural	6		0	0		0
	Laguna 3	LAG3	3.8	Non-BWR natural	6		0	1		3
	Laguna East	LAGE	13.9	Non-BWR natural	6				0	
	Laguna West	LAGW	1.0	Non-BWR natural	6				0	
	Laguna “A”	LAGTA	10.1	Non-BWR natural	6				1	
	Laguna “D”	LAGTD	14.4	Non-BWR natural	6				0	
Mittry Lake	Mittry Lake-Pratt Restoration	MLPR	13.0	Non-LCR MSCP restoration	6	1		4	4	6
	Mittry Lake East Rd	MLEA	10.1	Non-BWR natural	6				1	
Gila River	Colo/Gila Confluence	YUCC	67.7	Non-BWR natural	6	0	1			
	Gila Confluence	GRGC	26.8	Non-BWR natural	6	1			0	
	North Gila Valley “A”	GRNVA	3.6	Non-BWR natural	6		0			0
	North Gila Valley “B”	GRNVB	4.7	Non-BWR natural	6		0			
Quigley WMA	Quigley WMA	GRQP	10.6	Non-LCR MSCP restoration	6	0	3	3	2	1
Yuma Wetlands	Yuma East Wetlands	YUEW	9.0	Non-LCR MSCP restoration	6		0	1	0	1
	Yuma West Wetlands	YUWW	25.5	Non-LCR MSCP restoration	6	3	0	1	2	1
Limitrophe	Limitrophe North	LIMNTH	164.5	Non-BWR natural	6	0	3			
	Limitrophe South ”A”	LIMSTA	8.3	Non-BWR natural	6	0	0			
	Limitrophe South “B”	LIMSTB	8.1	Non-BWR natural	6	1	0			

Table 2-13.—LCR YBCU annual survey detection total grouped by river reach 2008–2012
(Reach 1 was not surveyed in 2011. Reach 2 did not contain suitable cuckoo habitat and was not surveyed.)

River reach	Survey detections by year				
	2008	2009	2010	2011	2012
1	0	3	3	-	5
2	–	–	–	–	–
3	111	120	163	93	81
4	26	43	80	111	125
5	7	5	12	6	14
6	6	7	10	10	11
Total	150	178	268	220	236

Cibola NWR (see table 2-11) has four LCR MSCP restoration and three non-LCR MSCP restoration sites, and two sites showed increasing annual detection trends: Crane Roost (from 5 in 2010 to 13 in 2012) and Perri Marsh (from 0 in 2008 to13 in 2011; the site was not surveyed in 2012 due to site closure [for safety] following a fire in August 2011). The remaining sites exhibited no clear trends and fluctuated between 0 and 7 detections annually (LCR MSCP restoration sites [Cibola Mass Planting and Cibola Nature Trail], 2008–2012: μ = 2.4 per year, SD = 2.24, n = 9); non-LCR MSCP restoration sites [Cibola North, Cibola Eucalyptus, and Cibola Island South] 2008–2012: μ = 1.5 per year, SD = 1.40, n = 14). On average, from 2008–2012, CVCA (three LCR MSCP restoration sites, Phases 1–3) had a relatively high average detection count (2008–2012: μ = 10.2 per year, SD = 5.74, n = 13), and the survey area as a whole had an increasing total detection count from 2008 to 2011 (14, 18, 38, 42). However, from year to year, CVCA showed an irregular up and down trend in average detections per site (2008: 14, n = 1; 2009: μ = 6.0, SD = 6, n =3; 2010: μ = 12. 7, SD = 6.50, n = 3; 2011: μ = 14.0, SD = 3.46, n = 3; 2012: μ = 6.7, SD = 4.93, n = 3). On average, PVER (five LCR MSCP restoration sites, Phases 1–5) exhibited an increasing annual detection trend (2008: 2, n = 1 site; 2012: μ = 14.8, n = 5 sites; 2008–2012: μ = 8.5 per year, n = 16).

River Reach 5 has one non-BWR natural site and four non-LCR MSCP restoration sites (see table 2-12). The non-BWR natural site (Imperial Martinez Lake) was surveyed in 2 years with zero and one survey detection. The four non-LCR MSCP restoration sites did not exhibit any increasing or decreasing annual detection trend (2008–2012: μ = 3.3 per year, SD = 3.07, n = 16).

Reach 6 includes 15 non-BWR natural sites and four non-LCR MSCP restoration sites (see table 2-12). The non-BWR natural sites had few detections and no apparent annual trend (2008–2012: $\mu = 0.5$ per year, SD = 0.90, n = 25). The non-LCR MSCP restoration sites also showed no apparent trend (2008: $\mu = 1.8$ detections per year, SD = 1.98, n = 19).

When stratified by site management type, from 2008 to 2012, we saw disparate trends in survey detections (table 2-14). At LCR MSCP restoration habitat, survey detections increased 437%, from 24 detections in 2008 to 129 detections in 2012. During this time, the number of LCR MSCP restoration sites surveyed also increased annually, from 6 in 2008 to 13 in 2012 (see tables 2-10 and 2-11) due to recently planted cottonwood-willow phases maturing into suitable habitat (generally after two growing seasons). From 2008 to 2012, the average annual total detections per site increased nearly 150%, from an average of 4 in 2008 to 9.9 in 2012 (table 2-15).

Table 2-14.—LCR YBCU annual survey detection totals stratified by site management type, LCR MSCP restoration, non-LCR MSCP restoration, BWR natural, and non-BWR natural habitat, 2008–2012

Site management type	Survey detections by year				
	2008	2009	2010	2011	2012
LCR MSCP restoration	24	37	79	100	129
Non-LCR MSCP restoration	20	16	43	35	26
BWR natural	103	118	142	83	73
Non-BWR natural	3	7	4	2	8
Total	150	178	268	220	236

Table 2-15.—LCR YBCU average annual total detections per site by site management type (LCR MSCP restoration, non-LCR MSCP restoration, BWR natural and non-BWR natural), 2008–2012

Standard deviation (in parentheses) and site sample size (n) are displayed with the site detection average. These data are a summary of tables 2-10 to 2-12.

Site management type	Annual site mean cuckoo detection total				
	2008	2009	2010	2011	2012
LCR MSCP restoration	4 (5.2) n = 6	4.6 (4.2) n = 8	7.2 (5.3) n = 11	8.3 (5.3) n = 12	9.9 (8.1) n = 13
Non-LCR MSCP restoration	1.5 (1.3) n = 13	1.1 (1.4) n = 13	3.3 (2.4) n = 13	2.3 (3.2) n = 15	2 (2.3) n = 13
BWR natural	7.4 (4.2) n = 14	7.4 (4.2) n = 16	8.9 (6.2) n = 16	5.2 (4) n = 16	4.9 (4) n = 15
Non-BWR natural	0.3 (0.5) n = 9	0.3 (0.7) n = 24	0.4 (0.7) n = 9	0.4 (0.5) n = 8	1.1(1.1) n = 7

At the BWR, the number of surveyed sites remained fairly constant at 14 to 16 per year. Here, survey detections increased by 38% from 103 detections in 2008 to 142 detections in 2010 and then declined 49% from this peak to 73 detections in 2012 (see table 2-14). A similar pattern was observed in the mean annual survey detections per site (see table 2-15), which increased by 24%, from 7.4 in 2008 to 8.9 in 2010, and then declined 45% from the 2010 peak to a mean of 4.9 in 2012.

The number of non-LCR MSCP restoration and non-BWR natural sites surveyed varied considerably between years, as these sites were often considered marginal for breeding cuckoos. Survey detections were relatively modest at non-LCR MSCP restoration sites (16 to 43 total survey detections per year) (see table 2-14), and the average annual total detections per site varied from 1.1 to 3.3 (see table 2-15). A few of these sites had regular but modest annual detection counts, including Topock Platform at Havasu NWR, Cibola Island (two sites) at Cibola NWR, Imperial South at Imperial NWR, and Mittry Lake/Pratt. Non-BWR natural sites had 2 to 8 total survey detections per year, from 7 to 24 sites surveyed annually (see table 2-14), and the average annual total detections per site varied from 0.3 to 1.1 (see table 2-15).

Detection Probability and Habitat Use

Cuckoo detection probability and habitat use, colonization, and extinction probabilities were estimated from a set of six models, for all sites (table 2-16), and by site management type (LCR MSCP restoration habitat, table 2-17; non-LCR MSCP restoration habitat, table 2-18; BWR natural habitat, table 2-19, and non-BWR natural habitat, table 2-20). The parameter estimates from the top selected models for each site management type are displayed in tables 2-21 and 2-22 and are discussed below.

Across all sites from 2008 to 2012 (table 2-16), model 2 (see table 2-8) came out on top with the lowest AIC value and highest weight ($\omega_i = 0.42$). We also found strong support for models 1 and 5 ($\Delta AIC_i < 2$). The top two are Markov models, suggesting that cuckoos (as a species) exhibited site fidelity and that overall LCR habitat use was related to habitat use during the previous year.

The top two models indicate that the proportion of habitat used during the 5 years was best modeled as annually variable. In contrast, models with random or no annual change in the proportion of habitat used had less (model 5) or no support (models 3, 4, and 6). Between the top three models, the estimated detection, habitat use, habitat colonization, and habitat extinction probabilities were similar. The colonization and extinction estimates in model 1 are more conservative than those in model 2; they are constant and estimate an average use rate of change

Table 2-16.—LCR cuckoo detection probability (p), habitat use (ψ), colonization (γ), and extinction (ε) model selection for all sites, 2008–2012

Model number, model, negative log likelihood value (-2l), number of predictor variables (K), AIC, AIC differences (ΔAIC_i), and Akaike weights (ωi) are shown. Models are ranked by their ΔAIC_i value. Models are described in table 2-8.

Model number	Model	-2l	K	AIC	ΔAIC_i	ω_i
2	ψ(2008) γ(year) ε(year) p(survey period)	1913.75	14	1941.75	0.00	0.4250
1	ψ(2008) $\gamma(\cdot)$ $\varepsilon(\cdot)$ p(survey period)	1926.09	8	1942.09	0.34	0.3586
5	$\psi(\cdot)$ $\gamma(\cdot)$ p(survey period)	1929.10	7	1943.10	1.35	0.2164
4	ψ(2008) γ(year) $\{\varepsilon = 1 - \gamma\}$ p(survey period)	1942.48	10	1962.48	20.73	< 0.0000
6	$\psi(\cdot)$ p(survey period)	1953.95	7	1967.95	26.20	< 0.0000
3	ψ(2008) $\gamma(\cdot)$ $\{\varepsilon = 1 - \gamma\}$ p(survey period)	1955.82	7	1969.82	28.07	< 0.0000

Table 2-17.—LCR cuckoo detection probability (p), habitat use (ψ), colonization (γ), and extinction (ε) model selection for LCR MSCP restoration habitat, 2008–2012.

Model number, model, negative log likelihood value (-2l), number of predictor variables (K), AIC, AIC differences (ΔAIC_i), and Akaike weights (ωi) are shown. Models are ranked by their ΔAIC_i value. Models are described in table 2-8.

Model number	Model	-2l	K	AIC	ΔAIC_i	ω_i
1	ψ(2008) $\gamma(\cdot)$ $\varepsilon(\cdot)$ p(survey period)	403.18	8	419.18	0.00	0.3777
5	$\psi(\cdot)$ $\gamma(\cdot)$ p(survey period)	405.48	7	419.48	0.30	0.3251
3	ψ(2008) $\gamma(\cdot)$ $\{\varepsilon = 1 - \gamma\}$ p(survey period)	406.98	7	420.98	1.80	0.1536
4	ψ(2008) γ(year) $\{\varepsilon = 1 - \gamma\}$ p(survey period)	402.29	10	422.29	3.11	0.0798
6	$\psi(\cdot)$ p(survey period)	409.28	7	423.28	4.10	0.0486
2	ψ(2008) γ(year) ε(year) p(survey period)	397.59	14	425.59	6.41	0.0153

for the 5 years. The estimated detection probability and habitat parameters for model 1 are displayed in tables 2-21 and 2-22. This model and its probability estimates represent the overall cuckoo processes occurring on the LCR; however, it is apparent that cuckoos responded to the different site management types differently (tables 2-17 to 2-20).

In modeling detection probability and habitat use parameters at LCR MSCP restoration habitat from 2008 to 2012 (see table 2-17), model 1 had the best support in explaining the data. Strong support was also found for model 5, while models 2, 3, 4, and 6 offered less support. The top two models used a Markov process to determine habitat use, indicating that cuckoos showed high site fidelity toward LCR MSCP habitat, and that use of this habitat was not random. The

Table 2-18.—Detection probability (*p*), habitat occupancy (ψ), colonization (γ), and extinction (ε) model selection for non-LCR MSCP restoration habitat, 2008–2012

Model number, model, negative log likelihood value (-2*l*), number of predictor variables (K), AIC, AIC differences (ΔAIC_i), and Akaike weights (ωi) are shown. Models are ranked by their ΔAIC_i value. Models are described in table 2-8

Model number	Model	-2*l*	*K*	AIC	ΔAIC_i	ω_i
3	ψ(2008) $\gamma(\cdot)$ $\{\varepsilon = 1 - \gamma\}$ *p*(survey period)	390.38	7	404.38	0.00	0.2448
6	$\psi(\cdot)$ *p*(survey period)	390.66	7	404.66	0.28	0.2128
1	ψ(2008) $\gamma(\cdot)$ $\varepsilon(\cdot)$ *p*(survey period)	388.37	8	404.73	0.35	0.2055
5	$\psi(\cdot)$ $\gamma(\cdot)$ *p*(survey period)	390.73	7	404.73	0.35	0.2055
4	ψ(2008) γ(year) $\{\varepsilon = 1 - \gamma\}$ *p*(survey period)	385.68	10	405.68	1.30	0.1278
2	ψ(2008) γ(year) ε(year) *p*(survey period)	384.75	14	412.75	8.37	0.0152

Table 2-19.—Detection probability (*p*), habitat occupancy (ψ), colonization (γ), and extinction (ε) model selection for BWR natural habitat, 2008–2012

Model number, model, negative log likelihood value (-2*l*), number of predictor variables (K), AIC, AIC differences (ΔAIC_i), and Akaike weights (ωi) are shown. Models are described in table 2-8.

Model number	Model	-2*l*	*K*	AIC	ΔAIC_i	ω_i
1	ψ(2008) $\gamma(\cdot)$ $\varepsilon(\cdot)$ *p*(survey period)	643.43	8	959.43	0.00	0.6350
5	$\psi(\cdot)$ $\gamma(\cdot)$ *p*(survey period)	946.67	7	960.67	1.24	0.3416
6	$\psi(\cdot)$ *p*(survey period)	953.36	7	967.36	7.93	0.0120
2	ψ(2008) γ(year) ε(year) *p*(survey period)	939.49	14	967.49	8.06	0.0113
4	ψ(2008) γ(year) $\{\varepsilon = 1 - \gamma\}$ *p*(survey period)	960.35	10	980.35	20.92	< 0.0000
3	ψ(2008) $\gamma(\cdot)$ $\{\varepsilon = 1 - \gamma\}$ *p*(survey period)	969.04	7	983.04	23.61	< 0.0000

Table 2-20.—Detection probability (*p*), habitat use (ψ), colonization (γ), and extinction (ε) model selection for non-BWR natural habitat, 2008–2012

Model number, model, negative log likelihood value (-2*l*), number of predictor variables (K), AIC, AIC differences (ΔAIC_i), and Akaike weights (ωi) are shown. Models are described in table 2-8.

Model number	Model	-2*l*	*K*	AIC	ΔAIC_i	ω_i
4	ψ(2008) γ(year) $\{\varepsilon = 1 - \gamma\}$ *p*(survey period)	101.97	10	121.97	0.00	0.2677
1	ψ(2008) $\gamma(\cdot)$ $\varepsilon(\cdot)$ *p*(survey period)	106.31	8	122.31	0.34	0.2258
5	$\psi(\cdot)$ $\gamma(\cdot)$ *p*(survey period)	108.50	7	122.50	0.53	0.2053
6	$\psi(\cdot)$ *p*(survey period)	108.97	7	122.97	1.00	0.1623
3	ψ(2008) $\gamma(\cdot)$ $\{\varepsilon = 1 - \gamma\}$ *p*(survey period)	109.54	7	123.54	1.57	0.1221
2	ψ(2008) γ(year) ε(year) *p*(survey period)	99.51	14	127.51	5.54	0.0168

Table 2-21.—LCR YBCU habitat use, colonization, extinction, and growth rate for all habitats, by management type, 2008–2012

The habitat use parameter (ψ) estimates the proportion of sample units used in a given year. The colonization estimate (γ) is the probability that a sample unit unused one year will become used the following year. The extinction estimate (ε) is the probability that a used sample unit will become unused the following year. The growth rate estimate (λ) is derived from the colonization and extinction probabilities; it is a multiplicative rate of increase or decrease in the proportion of used sample units from one year to the next. Of particular interest (in **bold**) are the increasing habitat use and positive growth rates observed at LCR MSCP restoration habitat and decreasing use and negative growth rates observed at the BWR.

Habitat type	Habitat Use (ψ)					Colonization (γ)				Extinction (ε)				Growth rate (λ)			
	2008	2009	2010	2011	2012	2009	2010	2011	2012	2009	2010	2011	2012	2009	2010	2011	2012
All habitat	0.70	0.76	0.79	0.82	0.83	0.32	0.32	0.32	0.32	0.05	0.05	0.05	0.05	1.09	1.05	1.03	1.02
LCR MSCP restoration	**0.84**	**0.94**	**0.97**	**0.99**	**0.99**	0.60	0.60	0.60	0.60	**0.00**	**0.00**	**0.00**	**0.00**	**1.12**	**1.04**	**1.02**	**1.01**
Non-LCR MSCP restoration	1.00	1.00	1.00	1.00	1.00	0.88	0.88	0.88	0.88	0.12	0.12	0.12	0.12	0.88	1.00	1.00	1.00
BWR natural	**0.95**	**0.92**	**0.90**	**0.87**	**0.85**	**0.00**	**0.00**	**0.00**	**0.00**	0.03	0.03	0.03	0.03	**0.93**	**0.93**	**0.93**	**0.93**
Non-BWR natural	0.54	0.54	0.54	0.54	0.54	0.13	0.13	0.13	0.13	0.11	0.11	0.11	0.11	1.00	1.00	1.00	1.00

Table 2-22.—LCR YBCU detection probabilities with 95% confidence intervals (CI) by survey period for all habitats, by site management type, 2008–2012

Detection probability was greater at LCR MSCP restoration habitat compared to BWR natural habitat, but both types exhibited similar detection trends with a peak in July and declines in June and August. Detection probabilities for the four types are displayed on figure 2-1.

Survey period	All habitats (CI)		LCR MSCP restoration (CI)		Non-LCR MSCP restoration (CI)		BWR (CI)		Non-BWR natural (CI)	
1	0.415	(0.359–0.473)	0.426	(0.316–0.544)	0.315	(0.219–0.430)	0.420	(0.355–0.503)	0.325	(0.115–0.640)
2	0.617	(0.552–0.677)	0.781	(0.663–0.865)	0.575	(0.430–0.707)	0.604	(0.481–0.644)	0.166	(0.049–0.434)
3	0.513	(0.454–0.572)	0.721	(0.603–0.814)	0.272	(0.183–0.385)	0.522	(0.416–0.567)	0.170	(0.056–0.412)
4	0.348	(0.294–0.406)	0.462	(0.350–0.578)	0.152	(0.087–0.251)	0.415	(0.306–0.459)	0.000	(0.000–1.000)
5	0.198	(0.139–0.274)	0.170	(0.073–0.350)	0.037	(0.005–0.223)	0.262	(0.174–0.362)	0.000	(0.000–1.000)

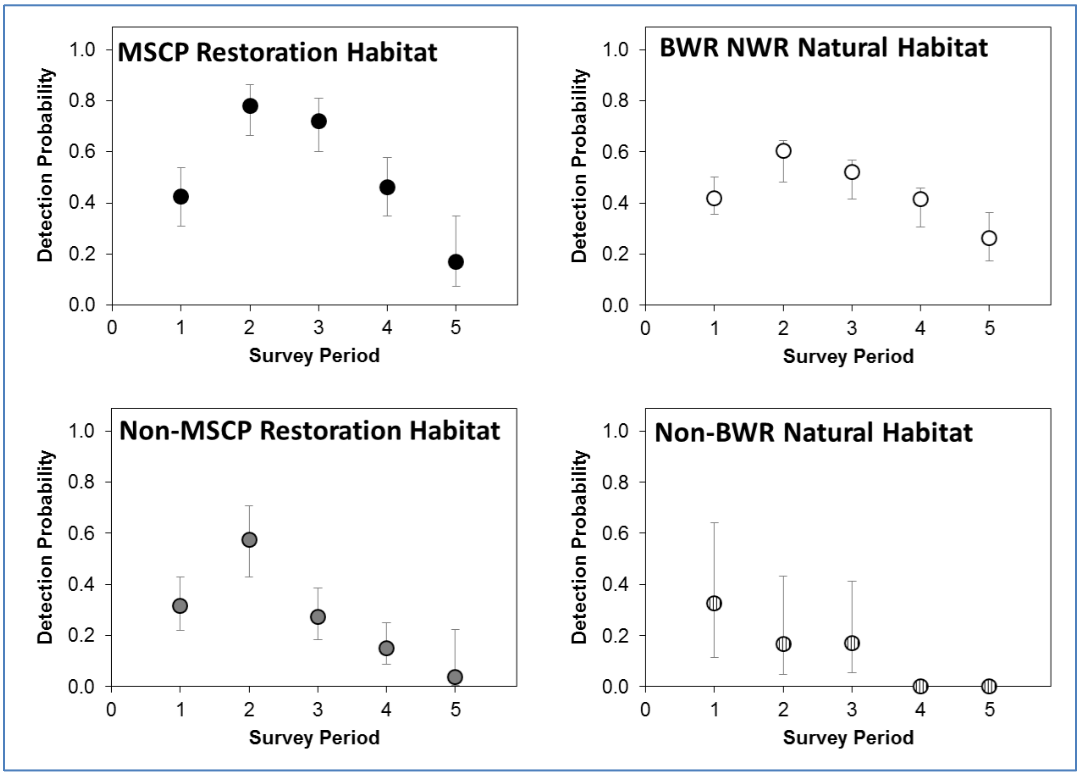


Figure 2-1.—LCR YBCU 5-year detection probabilities with 95% confidence intervals by survey period and site management type (LCR MSCP restoration [black], non-LCR MSCP restoration [gray], BWR natural [white], and non-BWR natural habitats [striped]), 2008–2012.
Detection trends were similar at LCR MSCP restoration, non-LCR MSCP restoration, and BWR natural habitats. For most survey periods, detection probability was greatest at LCR MSCP restoration habitat.

estimated detection, habitat use, habitat colonization, habitat extinction probabilities, and habitat use growth rate for the top LCR MSCP restoration habitat model are displayed in tables 2-21 and 2-22.

The top non-LCR MSCP restoration habitat model, model 3 ($\omega_i = 0.25$), indicated that cuckoo site fidelity towards this non-LCR MSCP restoration habitat was low or that habitat use here was random and not based on its use state the previous year (see table 2-18). However, there was also strong support for alternative models (models 1, 4, 5 and 6, $\Delta AIC_i < 2$, $\omega_i = 0.13$ to 0.21), and three of these models suggest that use of this habitat may instead be related to past site use by the species. Three of the top four models estimated habitat use, colonization, and extinction with a constant value, and as such, there was little evidence to suggest that these parameters varied much from year to year within this habitat. Tables 2-21 and 2-22 display the estimated detection, habitat use, habitat colonization, habitat extinction probabilities, and habitat use growth rate for the top non-LCR MSCP restoration habitat model (model 3).

In modeling cuckoo detection probability and habitat use, colonization and extinction at BWR natural habitat from 2008 to 2012 (see table 2-19), model 1 had the strongest support ($\omega_i = 0.63$). Model 5 also had support ($\omega_i = 0.34$), but there was little to no support for any other model. The top two used Markov processes to estimate habitat use, which suggests that cuckoos exhibited site fidelity to BWR habitat. Results for model 1 are displayed in table 2-21; detection probabilities are displayed in table 2-22.

Lastly, we found the best model to estimate detectability and habitat use parameters at non-BWR natural habitat (model 1 and table 2-20) was the same model predicted for non-LCR MSCP restoration habitat, suggesting that cuckoo selection of this habitat was random, or site fidelity toward these sites was low. Models 2–5 ($\Delta AIC_i < 2$) also had high support and may adequately fit the observed dataset. However, parameter estimates in the top two models that vary by year may be biased due to the low and non-random sampling of these sites. The constant colonization and extinction estimates of model 1 may be less biased. The estimated detection, habitat use, habitat colonization, habitat extinction probabilities. and habitat use growth rate for this model are displayed in table 2-21; detection probabilities are displayed in table 2-22.

Overall, across all areas (see table 2-22), the probability of detecting a cuckoo during a survey was lowest in June and August (42, 20–35%) and highest in July (51–62%). However, detection probability trends varied significantly by site management type (table 2-22 and figure 2-1). At LCR MSCP restoration habitat, detectability was on average greater than that found at other site management types, peaking in early July (78%) and declining thereafter. At BWR natural habitat, detectability trended lower, peaking in the first half of July (60%) and declining thereafter. The detection trend at non-LCR MSCP restoration habitat was similar to that observed at LCR MSCP restoration and BWR habitat, but trended even lower, with a July peak (58%) followed by a steady decline through August (4%). Detectability was lowest at non-BWR natural habitat where it declined from 33% in June to zero in August.

Across all surveyed habitats in the LCR study area (see table 2-21), we estimated that habitat use increased from 70% in 2008 to 83% in 2012 and was associated with a moderate habitat colonization probability ($\gamma = 32\%$), coupled with a low habitat extinction probability ($\varepsilon = 5\%$). The positive estimated habitat use trend resulted in positive, though annually declining, growth rates ($\lambda = 1.09-1.02$). It is important to reiterate that habitat use is triggered by a single detection within a sample unit and that this estimate can broadly refer to temporary use during one survey to occupancy for the duration of the breeding season.

LCR MSCP restoration habitat use steadily increased from 84% in 2008 to 99% in 2012, with no habitat used in one year found unused in subsequent years (see table 2-21). The near-complete habitat saturation by cuckoos coupled with a habitat extinction rate of zero resulted in an annually positive growth rate that steadily declined toward one. The opposite of this trend occurred at the BWR, where estimated habitat use declined from 95% in 2008 to 85% in 2012 (see table 2-21). The BWR habitat colonization rate was zero, indicating that no unused habitat was found used in subsequent years. Habitat extinction was estimated to be 3% annually. The remaining habitat found at non-LCR MSCP restoration sites and non-BWR natural sites appears to have reached a state of habitat use equilibrium, with a growth rate of one (table 2-21). Habitat colonization and extinction occurred in both areas, but their estimated annual use rates remained constant at 100% (non-LCR MSCP restoration habitat) and 54% (non-BWR natural habitat).

DISCUSSION

The probability to detect cuckoos was not constant throughout the breeding season (Whitfield and Stanek 2011; McNeil et al. 2012) or across the study area. It varied through time and by site management type. This variation appeared to be related to migration arrival and departure timing, cuckoo density, and breeding stage (chapter 4). Average cuckoo detectability was low in June, peaked in July, and then dropped again in August. In June, not all cuckoos may have arrived to their breeding destinations (Halterman et al. 2009a). This has been observed through consistently greater numbers of survey detections in July over those in June. Also, migratory arrival timing appears to fluctuate annually. From 2008 to 2012, June detections varied widely, even during the years with relatively uniform sampling effort (2010–2012, 48–51 sites surveyed annually). For example, cuckoos were unusually abundant in June 2010, indicating that they arrived earlier than normal. However, June detections were below average in 2011, when most cuckoos, along with many migratory U.S. songbirds (Arizona Field Ornithologists 2011), arrived around 2 weeks later than normal.

The July detectability peak and subsequent August decline appears to be partly related to their response behavior during the nesting cycle (chapter 4). Breeding cuckoos respond well to survey broadcasts until their nestlings fledge (generally through late July), after which they become less responsive, and detections significantly decline (typically in August, chapter 4). Dispersal and departure from the study area in late July and August (chapter 9) also contributes to the diminished August detection probability.

In addition to varying through time, detection probability trends varied by site management type; on average, they were greatest at LCR MSCP restoration habitat, followed by BWR natural habitat, non-LCR MSCP restoration habitat, and finally non-BWR natural habitat. We hypothesize that these differences were at least partly density dependent and breeding-stage related (as opposed to inherent variation in vocalizations and behaviors among cuckoos in different habitat types). The probability to detect the presence of cuckoos within a sample unit is density dependent, increasing with greater cuckoo abundance (chapter 4). The increased probability to detect cuckoos at LCR MSCP restoration sites was likely affected by later year observations of asynchronous breeding (chapter 4, chapter 8), and high abundances of cuckoos and breeding territories (chapter 4, chapter 5). The synchronous breeding observed at the BWR (McNeil et al. 2011, 2012), coupled with fewer breeding territories relative to LCR MSCP restoration habitat, likely contributed to its lower detection probability (chapter 4, chapter 5), particularly in August. In contrast, poor detectability in non-BWR natural habitat likely resulted from a dearth of cuckoos using these areas. The strongly declining trend in June and July and lack of August detections suggest that birds were continually leaving these areas during the breeding season (MacKenzie et al. 2006) and may indicate that this habitat is more likely used for migratory refueling than breeding. The relatively low detection trend at non-LCR MSCP restoration habitat shared a mix of characteristics observed at other sites, suggesting that this habitat may have supported a few nests (up to 4–8 territories per year, chapter 5), but was mostly used as stopover habitat.

Overall annual detection totals and site averages increased over the 5 years, with significant increases at LCR MSCP restoration habitat, mixed trends at non-LCR MSCP restoration habitat, little change at non-BWR natural habitat, and declines at the BWR. The steady rise in average detections at LCR MSCP restoration habitat indicates that use of this habitat increased with the increasing amount of available habitat. By 2012, PVER far exceeded all other LCR MSCP areas in detections, rivaled the BWR in detections (even though its total area was approximately one-fifth in size), and also exceeded the BWR in the proportion of available habitat used. Relative to other areas, causes for the increases observed at PVER are likely related to its large contiguous area and the continual addition of new suitable habitat each year; by 2012, the total (contiguous) area of habitat at PVER, over 160 ha, exceeded that found in any other area outside the BWR, and it was the only area where available habitat was added each year (discussed further in chapter 5). Additional information on the vegetation and habitat differences found at LCR habitat, nest locations, and occupied sites can be found in chapter 6.

The survey data afford insight into broad detection trends at sites and survey areas. However, although we standardized the data to the 2009–2010 survey periods, comparing year-to-year detection totals are confounded by behaviors that we cannot control for, specifically annual variation in migratory arrival and dispersal (chapter 9), and within-season variation in detection probability of breeding cuckoos over time and space (chapter 4). These likely affect our frequency of detecting these birds, the extent to which remains unclear, thus confounding between-year and within-year detection comparisons to an unknown extent. Drawing conclusions from detection comparisons (among sites, survey areas, or management types) is to use the detections, implicitly or explicitly, as a relative index of abundance. This is problematic because our detection counts violate the main assumption behind relative abundance indices – that the proportion of birds counted relative to the true abundance of birds is constant (Williams et al. 2002; Norvell et al. 2003). The relationship between cuckoo abundance and number of detections is highly variable across the different site management types, evident by the varying availability (see Diefenbach et al. 2007 for a useful discussion on a bird's availability to be detected on a survey) and probability to detect cuckoos (chapter 4). Disparate migration arrival and dispersal timing leads to between-year and within-year variation in the availability to detect cuckoos at sites. For example, a single migrating bird traveling through a non-BWR natural site may have been present and available to be detected on just one survey, whereas an individual breeding cuckoo at an LCR MSCP site may have been present and available to be detected on up to five surveys. Additionally, the probability to detect cuckoos at a site changes over time, such as in response to their nesting cycle (chapter 4). With behavioral factors adding variability to the proportion of birds counted (the relative abundance index), the value of the index diminishes (Johnson 2008). With increasing variability, it becomes progressively more difficult to distinguish whether changes in the number of detections should be attributed to changes in abundance or variation in the availability or probability to detect cuckoos. In summary, the total detection count may inaccurately represent the number of cuckoos at a site, and we believe that our territory estimates (chapter 5) provide a stronger assessment of breeding activity at a site. However, the detection data are still valuable, as the data can offer insight into broad trends (large annual changes) at sites and survey areas.

Relative to the total number of survey detections (a questionable index of abundance), presence-absence habitat use estimates may provide less information, but are more reliable and comparable from year to year, because they account for imperfect detection and are less affected by annual variation in the number of detections between survey periods (MacKenzie et al. 2006; Henneman 2009). Year after year, at LCR MSCP and BWR sites, cuckoo habitat use was generally regular and predictable, indicating that cuckoos (as a species) exhibited high site fidelity to these areas; this is supported by our observations of individual site fidelity to both BWR and LCR MSCP restoration sites (chapter 9).

From 2008 to 2012, the estimated proportion of LCR MSCP restoration habitat (sample units) used by cuckoos gradually increased (from 84% to 99%) in contrast to the steady estimated decline in habitat used at the BWR (from 95% to 85%). The regular occurrence of one or more detections at non-LCR MSCP restoration sites resulted in an estimated full use (100%) of this habitat annually, though the low detection frequency, detection probability trend, and breeding territory estimates (chapter 5) suggest that their annual occupancy for the duration of the breeding season was low. Habitat use was lowest at non-BWR natural habitat (54% per year) where cuckoo use was irregular and occurred randomly from year to year, indicating that breeding within these sites is probably rare.

Identifying the year-to-year changes in habitat use is informative; however, because cuckoos exhibit transient behavior (and therefore are an open population), the determination of habitat use based on a single detection has some limitations to how these data can be further evaluated. The assessment of an area of habitat as used (i.e., a cuckoo was detected in the area on one or more survey) should not be construed to indicate habitat quality. Species presence or density are poor indicators of habitat quality, and biological metrics, such as survivorship, nesting success rate, or average annual productivity, should be used instead (Van Horne 1983). Used habitat may harbor breeding cuckoos; alternatively, it may reflect a brief migratory presence or a bird assessing a site and then moving on to something better (Hamilton and Hamilton 1965; Stanek and Stanek 2013). This measure of habitat use is unable to either distinguish among these scenarios or identify an annual transition from one scenario to another. As such, in the LCR open cuckoo population, habitat use estimates based on the minimum of a single cuckoo detection should not be used as a measure of habitat quality or an indication of breeding.

From the onset of this study, and prior to it (Johnson et al. 2007, 2008), cuckoo detections at the BWR far exceeded those observed elsewhere in the study area. Within the refuge, detections were consistently greatest in the habitat east and upstream of the cliff formation known as Gibraltar Rock. Here, the refuge is largely confined within a narrow, rugged rock canyon that experiences habitat succession from periodic flooding originating from surrounding watersheds and releases from Alamo Dam upstream. Downstream from Gibraltar Rock, in the western section of the refuge, the canyon widens, and the bedrock is deeper. Flooding creates fewer disturbances here, and the riparian habitat appears less structurally diverse and more decadent than the habitat found upstream. From 2008 to 2012, detection declines were observed across the refuge, but were greatest in the eastern section that has historically supported most breeding territories (chapter 5).

In conclusion, we saw cuckoo habitat use at LCR MSCP restoration areas exceed that of all other areas. LCR MSCP habitat is currently relatively young, and newly available LCR MSCP habitat was colonized annually. Once used, cuckoos were continually detected at these sites annually; no used habitat was found unused in subsequent years. Over time, the proportion of habitat used and the average detections per site increased at LCR MSCP habitat and decreased at BWR habitat; these trends may be related (discussed further in chapter 5). If so, this does not necessarily indicate that BWR habitat declined in quality over the course of the study. Much of the BWR habitat may still be suitable, but cuckoos may currently prefer the younger habitat presently found at LCR MSCP sites. Continued cuckoo population monitoring, nest monitoring, and habitat assessment will be required to determine the correlation of these two trends (discussed further in chapter 5). In comparison, at the remaining habitat within the study area (non-BWR natural and non-LCR MSCP restoration), the habitat use estimates and detection trends suggest that the majority of this habitat was used temporarily and not occupied for the duration of the breeding season. However, these habitat patches likely provide vital migratory stopover habitat that aid in the successful reproduction of cuckoos at other locations. Many neotropical migrants stop frequently to rest and refuel to ensure a successful migration (i.e., survival and timely arrival to their breeding grounds) (Mehlman et al. 2005). Cuckoos appear to follow this strategy and have been observed using habitat briefly before moving on (chapter 9). These habitat patches may enable greater connectivity between larger breeding areas (Gustafson and Gardner 1996). Riparian habitat in the Southwest is scarce (< 1% of the landscape), with relatively few historical patches remaining, prompting researchers to argue for the protection of desert riparian habitat regardless of its size or isolation (Skagen et al. 1998, 2005). Restoration efforts that create or improve the current migratory stopover habitat would likely benefit cuckoos even if they choose not to breed at these sites. Further study on the migratory behavior and dispersal capabilities of cuckoos would increase our understanding of migratory stopover habitat use and the habitat connectivity required by cuckoos.

Chapter 3 – Survey Protocol Assessment I: Survey Frequency

INTRODUCTION

The current yellow-billed cuckoo survey methodology was originally developed in collaboration with the Arizona Game and Fish Department and the U.S. Geological Survey (USGS) Colorado Plateau Research Station in Flagstaff, Arizona (Halterman et al. 2009a). Having been adopted by the Western Cuckoo Working Group and permitting agencies, it has become the recommended method to follow when surveying for western yellow-billed cuckoos and is now used to monitor cuckoos in California, Arizona, Nevada, Utah, New Mexico, and Colorado. Over the course of this study, the survey protocol was revised. Changes in survey visit dates (survey periods) are the relevant alterations pertinent to this analysis and are described in chapter 2. Through 2010, we followed the protocols recommended at the time (Halterman et al. 2007, 2008, 2009a). In 2011, as part of our assessment of the survey protocol effectiveness (study objective 3) we changed our survey period frequency to determine if an additional July survey would increase the likelihood of detecting breeding cuckoos or our accuracy in determining habitat use. Halterman et al. (2009a) recommend that five surveys be conducted every 12 to 20 days from mid-June through August (the first four are required, the last is considered optional): one survey in June, two in July, and two in August. We shifted our survey periods so that the majority of surveys, three of five, were in July, with three main objectives in mind:

(1) This action was taken to increase the likelihood of detecting breeding cuckoos which, in turn, could increase the accuracy and precision in estimating habitat use. The additional July survey could also yield a more precise detection probability trend through time and hopefully lead to finding more breeding territories.

(2) With three surveys in July, the majority of our survey effort coincided with the peak in cuckoo detectability, site occupancy, and breeding activity (McNeil et al. 2011, 2012; 2013, in review). The probability of detecting a cuckoo during the times preceding and following the July peak of activity has been observed to be relatively lower on the LCR (Johnson et al. 2007, 2008; Halterman et al. 2009b; McNeil et al. 2010), and in other areas throughout their western breeding range (Henneman 2009; Ahlers and Moore 2010; Dettling and Howell 2011a; Whitfield and Stanek 2011). June and August surveys may be less valuable in assessing breeding habitat use than an additional July survey.

(3) We hoped to identify and sufficiently survey during a window of residency where the LCR population was largely closed to movement (MacKenzie et al. 2006). Relative to an open population, analysis of a closed population yields more accurate detection probability estimates and allows for more tangible inference of these estimates, allowing us to estimate habitat occupancy instead of habitat use based on a single survey detection.

An objective of this study was to evaluate the current survey protocol in an effort to improve the efficacy of surveys within the LCR MSCP study area. Here we compare and contrast habitat use and detection probability estimates derived from presence-absence survey data collected in 2011 and 2012 (analyzed in the program PRESENCE) using three versus two July surveys. In addition to analyzing the PRESENCE results, we also analyzed the behavior and vocalization responses of cuckoos to survey broadcast calls to gain insight into responsiveness to our survey point playbacks. In the discussion, we draw on results and observations throughout this report to make survey protocol recommendations.

METHODS

Two Versus Three July Surveys

To assess the impact of an increased number of peak-season surveys, we compared the 2011 and 2012 survey data using the two different survey protocols. We refer to the 2009–2010 survey protocol (Halterman et al. 2009a) using two July surveys as the "Halterman et al." protocol and our 2011–2012 survey protocol using three July surveys as the "modified" protocol (see chapter 2 for details on annual survey protocols). Next, we compared detection and habitat use probabilities and their precision (standard errors) from the 2011 and 2012 presence-absence survey datasets analyzed using two versus three July surveys. The data were collected across five survey visits following the modified survey protocol (McNeil et al. 2013, in review), with one survey conducted in June, three in July, and one in August. We compared the data collected with the modified survey protocol to a subset of the same data reformatted to fit the 2009–2010 survey periods (see chapter 2 for the reassignment of data to the 2009–2010 survey periods). After reassignment, the reformatted dataset was comprised of data collected across four survey periods, with one survey in June, two in July, and one in August. The original 2011 and 2012 datasets and the reformatted datasets were analyzed using the program PRESENCE v5.5 (Hines 2006) to calculate detection probabilities and habitat use estimates (for surveyed areas) at LCR MSCP restoration, non-LCR MSCP restoration, and natural (BWR and non-BWR) habitat (see chapter 2 for a description of these methods). Due to the small sample size for non-BWR natural habitat, we pooled these data with the BWR natural habitat data.

To assess the efficacy of the two survey protocols, we examined the relative differences between detection probability and habitat use estimates derived from them. We hypothesized that the precision of the modified protocol estimates would be greater (i.e., the standard errors would be smaller) than those derived from the Halterman et al. protocol due to the increased number of peak-season surveys (MacKenzie and Royle 2005). If the modified protocol's habitat use estimates were found to be consistently greater than those estimated from the Halterman et al. protocol, we would conclude that the extra July survey may be warranted. However, support for recommending the extra July survey would also depend on other factors, such as the identification of a closed breeding period, and cost effectiveness.

Survey Detections

As part of our survey protocol review, we examined how cuckoos responded to our survey playbacks through time. We analyzed 1,052 survey detections from the 2008–2012 dataset formatted for the 2009–2010 survey periods (see chapter 2). For these comparisons, we first calculated annual detection proportions by call broadcast number and by survey period. The annual calculations were then averaged to derive estimates of responsiveness to playback surveys.

To assess the value of completing five broadcast calls per survey point, we compared the proportion of unsolicited and solicited detections by call broadcast number. Unsolicited detections were those made at survey points prior to broadcasting recorded calls or those made while travelling between survey points. We deemed the frequency of unsolicited detections to be a mixture of a cuckoo's natural calling rate and a delayed response to recently played call broadcasts. To determine if response behavior varied by density, we examined these same solicited and unsolicited calls between high- and low-density sites. Site density was roughly estimated as high or low based on the total number of detections made at each site (Johnson et al. 2007, 2008), where low-density sites had zero to 10 total detections, and high-density sites had more than 10 detections. We also examined unsolicited calls and "coo" calls by survey period to explore the possibility that they may be related to movement or breeding. For example, unsolicited calls may be given more frequently early in the breeding season as birds assess the occupancy state of their selected habitat patch, while the "coo" call is suspected to be a mate attraction call (Hughes 1999; Payne 2005) and may be given more frequently prior to nesting.

RESULTS

Two Versus Three July Surveys

Estimated proportions of habitat used derived using the Halterman et al. protocol were similar to those derived using the modified protocol (figures 3-1, 3-2, and tables 3-1 to 3-8). Conducting three surveys in July instead of two provided more detailed detection trends, and a slight increase in the precision and accuracy of the detection and occupancy estimates. In general, presence-absence surveys conducted using the Halterman et al. protocol (two July surveys) yielded detection probability trends with less temporal variation and detail compared to surveys conducted using the modified protocol (figures 3-1, 3-2, and tables 3-1 to 3-4). Detection probability trends derived from two July surveys appeared to be muted or averaged representations of the trends using three July surveys. They had lower (by up to 11%) estimated peaks in detectability (figure 3-2 and tables 3-3 and 3-4), and the peaks or shifts from high to low detection probability varied between the two datasets by 3 to 7 days (e.g., natural habitat on figure 3-1). In general, detection probabilities were estimated to be slightly greater using the modified compared to the Halterman et al. protocol (which affected the habitat use estimates described below). Detection estimates using the modified protocol (average standard error [SE] = 0.089) were on average 3.5% more precise than those derived from the Halterman et al. protocol (average SE = 0.093). In sum, the detection probability trends from surveys conducted using the Halterman et al. protocol were similar to those using the modified protocol, but were slightly less detailed, less precise, and appear to be less accurate.

Overall, the observed habitat use (the raw proportion of sites deemed used based on a single detection) and estimated habitat use (the PRESENCE habitat use proportion estimate that takes detection probability into account) derived from the modified protocol exhibited increased precision (decreased average SE estimates) relative to those estimated using the Halterman et al. protocol (tables 3-5 to 3-8). In comparing the observed habitat use estimates between the two protocols, we found that in 2012, the estimates from the two protocols were nearly identical, indicating that the extra July survey did not lead to more sample units being found used (tables 3-5 to 3-6). However, in 2011, the modified protocol detected cuckoos in sample units missed under the Halterman et al. protocol, leading to greater observed habitat use (tables 3-7 to 3-8).

Comparing the PRESENCE-estimated habitat use proportions in 2012, the habitat use estimate was greater using the Halterman et al. protocol than that estimated using the modified protocol (tables 3-5 to 3-6). The habitat use estimate is directly related to detection probability, and in this situation, the lower

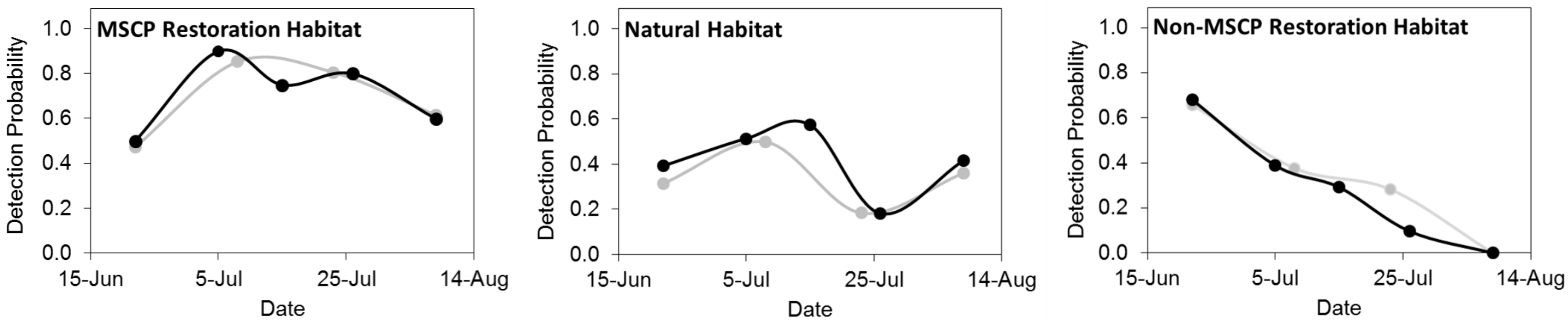


Figure 3-1.—2012 LCR YBCU detection probability comparison by site management type.
Data analyzed using Halterman et al. protocol (gray, two surveys in July) and modified protocol (black, three surveys in July). Detection probabilities (points) are displayed by survey period median date.

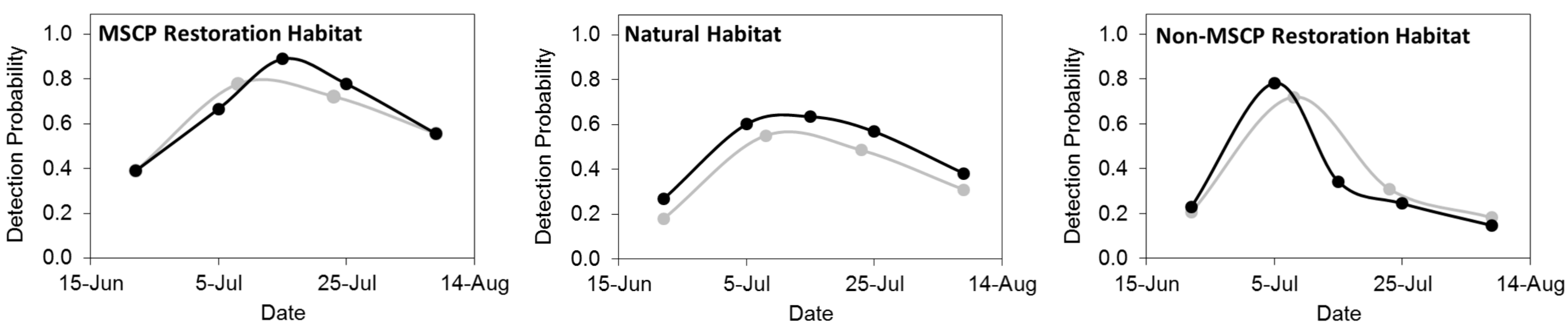


Figure 3-2.—2011 LCR YBCU detection probability comparison by site management type
Data analyzed using Halterman et al. protocol (gray, two surveys in July) and modified protocol (black, three surveys in July). Detection probabilities (points) are displayed by the survey period median date.

Table 3-1.—2012 LCR YBCU habitat detection probabilities and standard errors by site management type and for all habitats, analyzed using the original dataset reformatted to fit the Halterman et al. survey protocol

Survey dates	Detection probability estimates							
	LCR MSCP restoration habitat (SE)		Non-LCR MSCP restoration habitat (SE)		Natural habitat (SE)		All habitats (SE)	
June 15 – June 30	0.473	(0.108)	0.659	(0.191)	0.314	(0.082)	0.432	(0.064)
July 1 – July 15	0.852	(0.078)	0.377	(0.164)	0.498	(0.097)	0.602	(0.067)
July 15 – July 31	0.805	(0.087)	0.283	(0.148)	0.183	(0.065)	0.401	(0.063)
August 1–- August 15	0.615	(0.106)	0.000	(0.000)	0.360	(0.093)	0.412	(0.066)
Average		0.095		0.126		0.085		0.066

Table 3-2.—2012 LCR YBCU detection probabilities and standard errors by site management type and for all habitats using the modified protocol

Survey dates	Detection probability estimates							
	LCR MSCP restoration habitat (SE)		Non-LCR MSCP restoration habitat (SE)		Natural habitat (SE)		All habitats (SE)	
June 15 – June 30	0.500	(0.111)	0.681	(0.182)	0.392	(0.087)	0.485	(0.064)
July 1 – July 10	0.899	(0.067)	0.389	(0.164)	0.513	(0.091)	0.630	(0.063)
July 11 – July 20	0.749	(0.097)	0.292	(0.149)	0.573	(0.091)	0.598	(0.064)
July 21 – July 31	0.799	(0.089)	0.097	(0.093)	0.181	(0.067)	0.372	(0.062)
August 1 – August 15	0.599	(0.109)	0.000	(0.000)	0.416	(0.094)	0.425	(0.066)
Average		0.095		0.118		0.086		0.064

Table 3-3.—2011 LCR YBCU detection probabilities and standard errors by site management type and all habitat using Halterman et al. protocol

Survey dates	Detection probability estimates							
	LCR MSCP restoration habitat (SE)		Non-LCR MSCP restoration habitat (SE)		Natural habitat (SE)		All habitats (SE)	
June 15 – June 30	0.389	(0.114)	0.206	(0.095)	0.180	(0.069)	0.243	(0.052)
July 1 – July 15	0.778	(0.098)	0.720	(0.134)	0.552	(0.103)	0.666	(0.065)
July 15 – July 31	0.722	(0.105)	0.309	(0.111)	0.486	(0.099)	0.505	(0.064)
August 1–- August 15	0.556	(0.117)	0.182	(0.098)	0.310	(0.089)	0.352	(0.062)
Average		0.109		0.110		0.090		0.061

Table 3-4.—2011 LCR YBCU detection probabilities and standard errors by site management type and for all habitat using the modified protocol

Survey dates	Detection probability estimates							
	LCR MSCP restoration habitat (SE)		Non-LCR MSCP restoration habitat (SE)		Natural habitat (SE)		All habitats (SE)	
June 15 – June 30	0.389	(0.114)	0.229	(0.102)	0.268	(0.081)	0.485	(0.056)
July 1 – July 10	0.667	(0.111)	0.782	(0.109)	0.602	(0.092)	0.630	(0.058)
July 11 – July 20	0.889	(0.074)	0.342	(0.108)	0.635	(0.090)	0.598	(0.060)
July 21 – July 31	0.778	(0.098)	0.244	(0.096)	0.569	(0.092)	0.372	(0.061)
August 1 – August 15	0.556	(0.117)	0.147	(0.079)	0.383	(0.091)	0.425	(0.059)
Average		0.103		0.099		0.090		0.059

Table 3-5.—2012 LCR YBCU observed habitat use and estimated habitat occupancy with standard errors and 95% CIs by site management type and all habitat using the Halterman et al. protocol

Habitat type	Observed habitat use	Estimated habitat occupancy	Estimated habitat occupancy SE	Estimated habitat occupancy 95% CI
LCR MSCP restoration	0.955	0.960	0.045	(0.955–0.994)
Natural	0.775	0.955	0.110	(0.775–1.000)
Non-LCR MSCP restoration	0.692	0.816	0.188	(0.692–0.981)
All habitats	0.808	0.888	0.056	(0.808–0.959)
Average			0.100	

Table 3-6.—2012 LCR YBCU observed habitat use and PRESENCE-estimated habitat use with standard errors and 95% CIs by site management type and for all habitat using the modified protocol

Habitat type	Observed habitat use	Estimated habitat occupancy	Estimated habitat occupancy SE	Estimated habitat occupancy 95% CI
LCR MSCP restoration	0.952	0.953	0.047	(0.952–0.994)
Natural	0.775	0.828	0.074	(0.775–0.931)
Non-LCR MSCP restoration	0.692	0.791	0.170	(0.692–0.966)
All habitats	0.811	0.838	0.048	(0.811–0.911)
Average				

Table 3-7.—2011 LCR YBCU observed habitat use and PRESENCE-estimated habitat use with standard errors and 95% CIs by site management type and for all habitat using the Halterman et al. protocol

Habitat type	Observed habitat use	Estimated habitat occupancy	Estimated habitat occupancy SE	Estimated habitat occupancy 95% CI
LCR MSCP restoration	1.000	1.000	0.000	(1.000–1.000)
Natural	0.643	0.795	0.103	(0.643–0.931)
Non-LCR MSCP restoration	0.773	0.884	0.128	(0.773–0.989)
All habitats	0.756	0.852	0.057	(0.756–0.934)
Average				

Table 3-8.—2011 LCR YBCU observed habitat use and PRESENCE-estimated habitat use with standard errors and 95% CIs by site management type and for all habitat using the modified protocol

Habitat type	Observed habitat use	Estimated habitat occupancy	Estimated habitat occupancy SE	Estimated habitat occupancy 95% CI
LCR MSCP restoration	1.000	1.000	0.000	(1.000–1.000)
Natural	0.763	0.787	0.072	(0.763–0.896)
Non-LCR MSCP restoration	0.864	0.930	0.091	(0.864–0.995)
All habitats	0.846	0.870	0.043	(0.846–0.933)
Average				

2012 detection probability derived under the Halterman et al. protocol yielded a greater habitat use estimate. However, in 2011, a different pattern emerged, with the modified protocol yielding greater PRESENCE habitat use estimates relative to the Halterman et al. protocol. The greater habitat use estimate resulted from the greater number of sample units observed with cuckoos (tables 3-7 to 3-8).

Regarding the precision of the habitat use estimates under the two protocols, the PRESENCE habitat use estimates using the modified protocol (average SE = 0.068) were on average 29.2% more precise than those derived from the Halterman et al. protocol (average SE = 0.086). In summary, the habitat use estimates derived from the modified protocol were more precise; however, the overlapping CIs indicate that they were not significantly different. The results were inconclusive whether the modified protocol with the additional July survey was able to correctly identify a greater proportion of habitat used.

Survey Detections

The majority of survey detections were aural (77.7%), followed by aural and visual (16.8%), then visual only (8.7%) (figure 3-3). Solicited survey detections (72%) exceeded unsolicited survey detections (28%) by a 2.6:1 ratio (figure 3-4). Survey detections from call broadcasts 1–5 steadily declined: 21.5%, 16.4%, 12.2%, 11.1% and 10.7% respectively (figure 3-4). When these survey detections were stratified by high versus low site density, we observed that cuckoos at low-density sites responded to initial broadcasts more readily than cuckoos at high-density sites, and that high-density sites had an increased proportion of unsolicited calls (figure 3-5). Across all sites, the rate of change in unsolicited calls detected over time trended upward in July and then declined in August. The pattern was

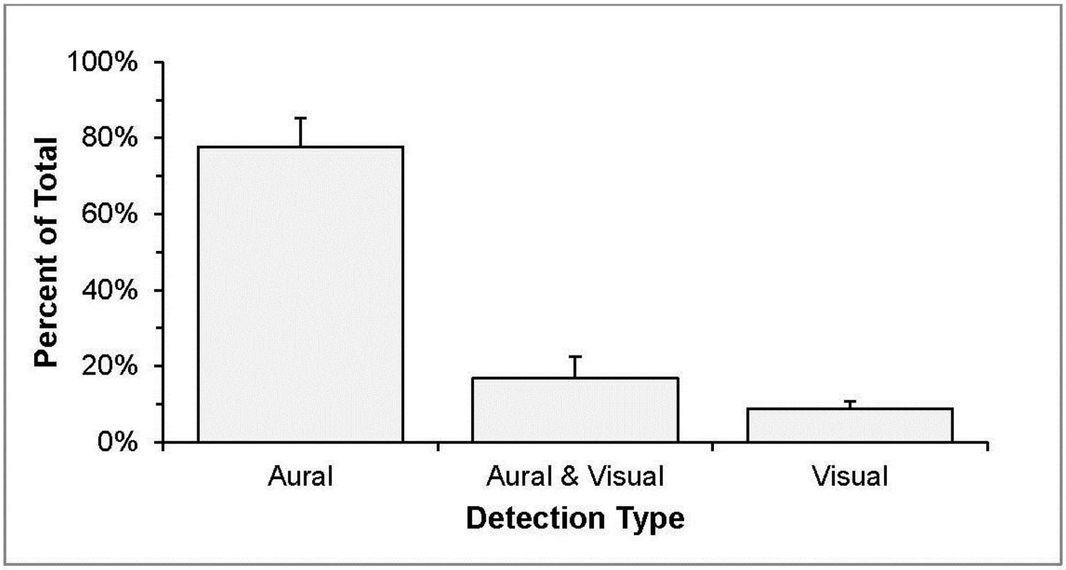


Figure 3-3.—Aural detection of cuckoos (77.7%) far exceeded that of aural and visual (14.5%) and visual only detections (7.8%) from 2008 to 2012 (n = 1,052 SD error bars shown).

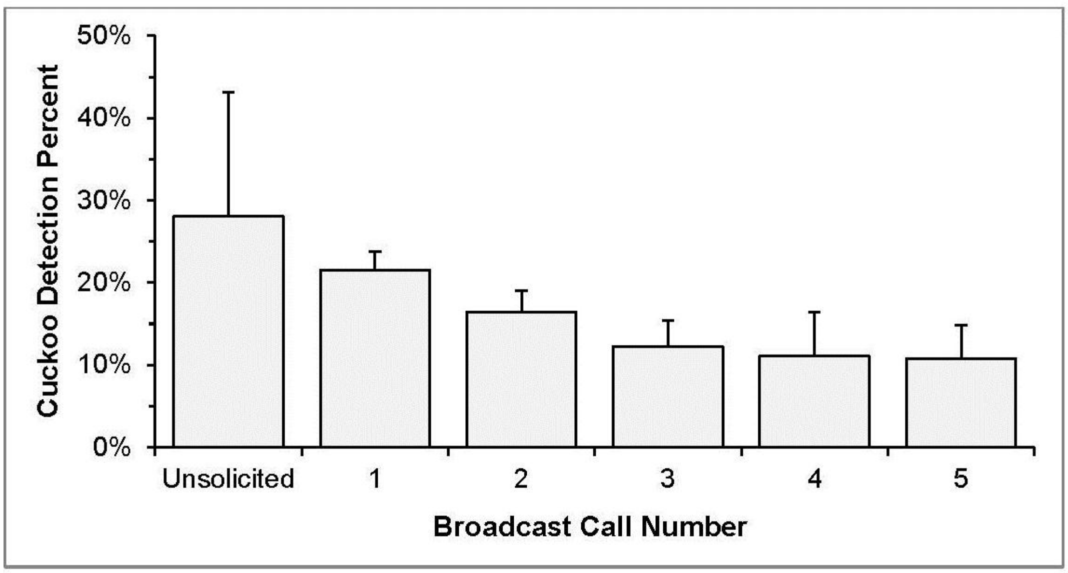


Figure 3-4.—From 2008 to 2012, survey detections steadily declined with each successive broadcast call.
Detections peaked with the first broadcast call (21.5% of all detections) and gradually declined by the fifth broadcast call (10.7%). Twenty-eight percent of all detections were unsolicited (detections not attributed to a previously played broadcast call; detections made immediately prior to or after the 5-minute broadcast call session; or detections made in between survey points) (n = 1,052, SD error bars shown).

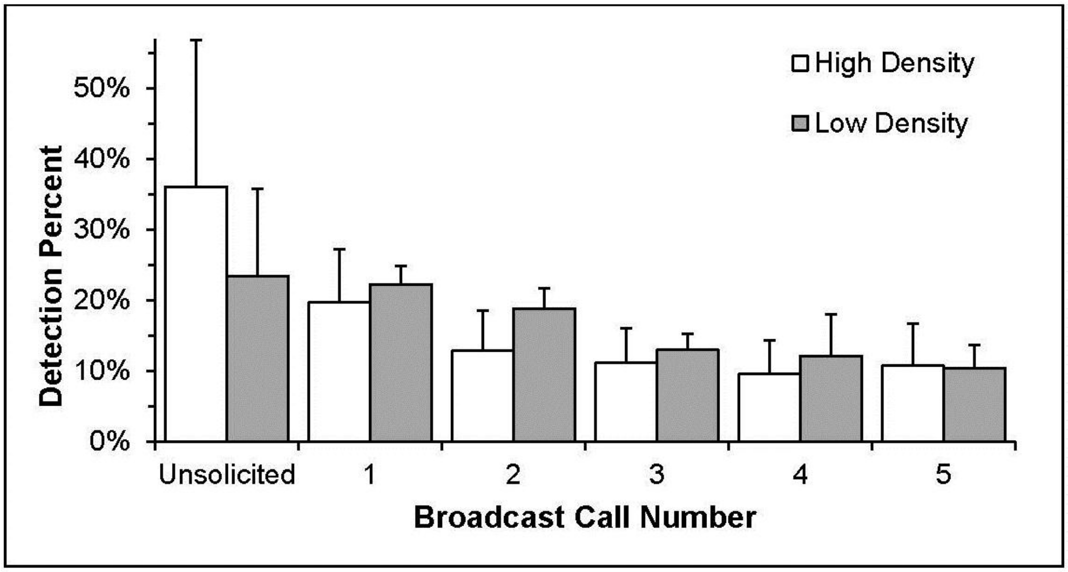


Figure 3-5.—When stratifying the data shown on figure 3-4, from 2008 to 2012, cuckoos at low-density sites (10 or fewer total detections) responded to initial broadcasts more readily than cuckoos at high-density sites (more than 10 total detections) (n = 1,052, SD error bars shown).

similar to the overall detectability trend of cuckoos across the LCR (table 2-22 in chapter 2 and figure 3-6). Lastly, coo call detections exhibited a clear trend through time, peaking in early July and declining thereafter (figure 3-7).

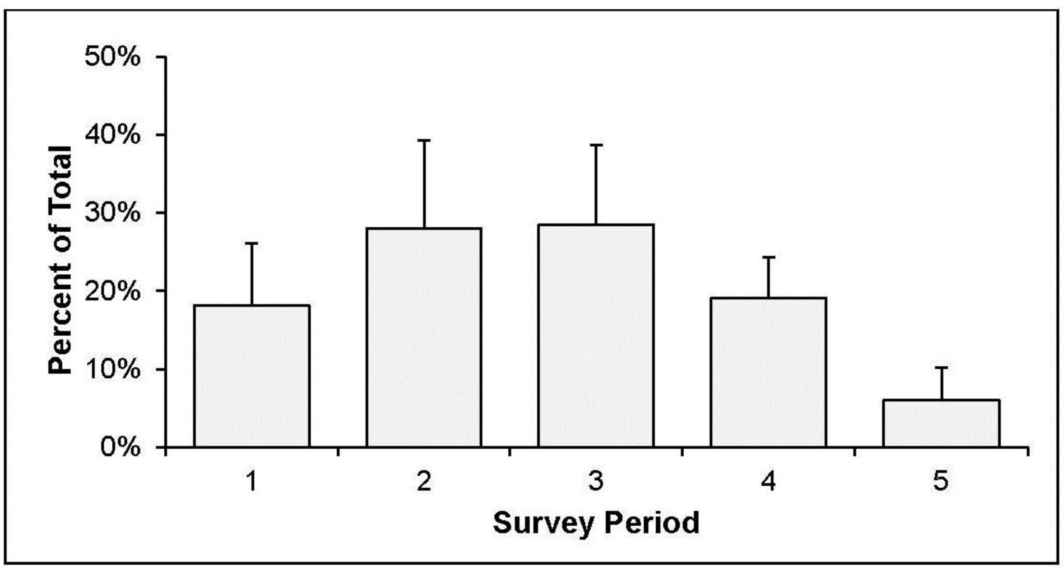


Figure 3-6.—2008–2012 LCR unsolicited cuckoo detections as a percent of the total number of unsolicited calls detected on a survey across all survey periods (from June 15 to August 30).

Unsolicited detections peaked during the second survey period (early July) and then gradually declined through August (n = 281 unsolicited detections, SD error bars shown).

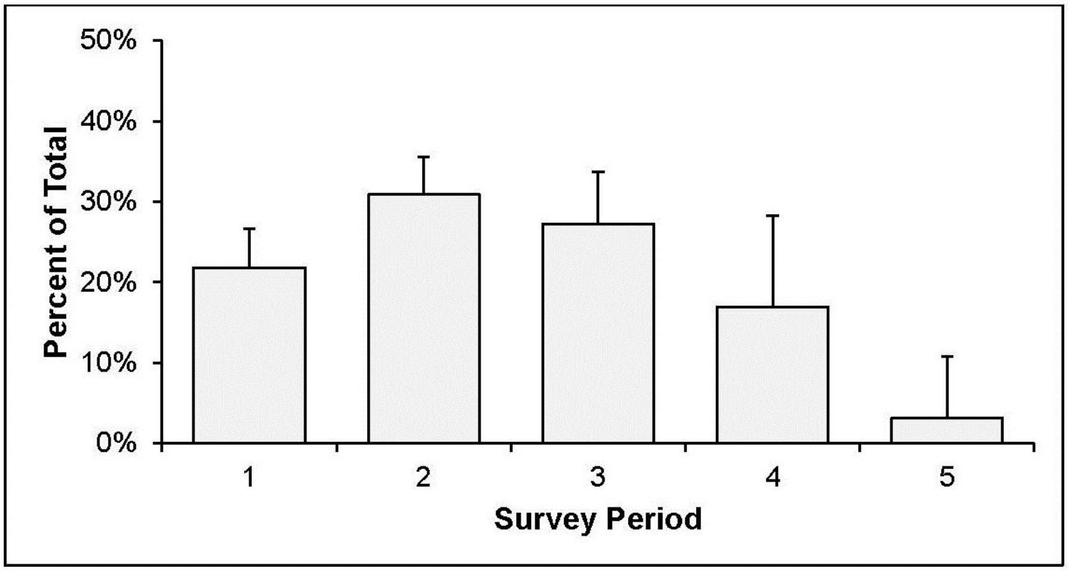


Figure 3-7.—2008–2012 LCR cuckoo coo call detections as a percent of the total number of coo calls detected (n = 126) on a survey across all survey periods (from June 15 to August 30).

DISCUSSION

The implementation of the modified survey protocol, conducting an extra July survey, was an effort to evaluate the survey protocol efficacy based on three objectives. Our foremost objective was to determine if we could increase the likelihood of detecting breeding cuckoos which, in turn, could increase the accuracy in estimating habitat use and increase our precision in identifying breeding territories. In this regard, the comparison of the Halterman et al. versus the modified protocol generated mixed results. The added July survey yielded additional survey detections; however, this resulted in an increase in the estimated proportion of habitat used in only a few habitat types in 2011 and no detected increase in the estimated proportion of habitat used in 2012. Overall, the two protocols yielded markedly similar habitat use and detection probability estimates. By conducting three July surveys, we hoped to increase the likelihood of detecting a cuckoo if it was missed on a previous survey. With the presumed increased detection frequency, we anticipated an increase in estimated territory precision because the occurrence and location of survey detections can be a significant source of information when conducting followup visits in some areas. The new survey frequency eliminated the possibility of conducting surveys 20 days apart, a period that could easily miss an entire cuckoo nesting cycle (a minimum of 16 days). However, it is unclear whether the increased July survey frequency provided enough additional information to significantly improve territory estimation (chapter 5). As expected, the modified protocol increased resolution in the detection trend and slightly increased precision (a smaller SE) in the habitat use and detectability estimates. The modified protocol improved the precision of estimated habitat use by 29%, and if this protocol were adopted in the future, the increased precision (lower SE and smaller CIs) may increase the ability to detect a statistically significant change in habitat use over time. Despite this precision increase, the modified survey protocol did not increase our ability to identify used habitat, or more accurately identify territories, failing to meet our first and primary objective.

By centering our surveys around the time cuckoos are most likely to breed, we met our second objective of decreasing the effort expended when cuckoo detectability is lower and the detected cuckoos may not necessarily be resident breeding birds. In June, we found few nesting cuckoos at LCR MSCP habitat and no nesting cuckoos at the BWR (attachment I). As such, June detections on the LCR are an unreliable indicator of breeding. The decreased detectability of cuckoos in June appears to be affected, in part, by their variable spring migration timing (chapter 2) and transient nature before and after breeding (Howe 1986; Groschupf 1987; McNeil et al. 2011). We also found cuckoos to be less responsive to broadcast surveys late in their breeding cycle when they have fledglings (on average from late-July through August) (chapter 4). The added July survey replaced the survey previously conducted in mid- to late August. Compared to the other survey rounds, the late August survey typically detected the fewest number of cuckoos (chapter 2). This survey offered little toward identifying breeding habitat occupancy due to low detectability and the possibility that detected birds were post-breeding transients rather than breeding residents. Replacing the late August survey with the additional July survey did not add additional monetary cost. However, an unintended consequence of increasing the frequency of our peak-season survey effort was a reduction in the frequency with which we could conduct other peak-season activities (e.g., followup visits, mist netting, telemetry, and nest searching). To alleviate this opportunity cost, an alternative would be to center the survey effort around the breeding peak (mid-July). For example, five surveys conducted 14 days apart, from June 10 to August 18, or five surveys conducted 12 days apart, from June 16 to August 14. By following a 12–14 day survey period, the majority of surveys could still be conducted during the peak of breeding activity while at the same time enabling opportunities to conduct other research activities.

Our third modified protocol objective was to identify a period of residency when the LCR population was largely closed to movement (MacKenzie et al. 2006). Analysis of a closed population provides more accurate and precise habitat use and detectability estimates. The increased survey frequency during peak breeding activity provided options on how we could analyze the presence-absence survey data depending on our residency findings. Occupancy analyses are best conducted on data with three or more repeat breeding season surveys, and the Halterman et al. protocol of only two surveys in July minimized our options for conducting a residency analysis given that June and August detections may be of transient rather than resident birds. Unfortunately, telemetry observations of cuckoos departing from our sites during all survey periods (McNeil et al. 2012;

2013, in review) (chapter 9) eliminated most hope for finding a closed population of breeding residents on the LCR. However, conducting three surveys during peak occupancy leaves the door open for future analysis of these data if a closed (or nearly closed) occupancy period is observed.

Lastly, we consider the scale of detecting individual cuckoos, at both the survey point and transect levels, and review pertinent observations. At an individual survey point, cuckoos were detected following all five broadcast playbacks. Surveyors are generally interested in increasing the speed and efficiency of conducting individual survey points; however, with 11% of detections occurring following the fifth playback, we do not recommend any changes to the survey playback methods or instructions. Similarly, we find that the protocol for the surveyor to move 300 m after a cuckoo is detected to be sufficient. We bring attention to this situation because, through our telemetry and survey observations, the practice of moving 300 m has a tendency to skip past cuckoos at high-density sites, which then remain undetected on the survey. This reinforces the premise that the survey protocol's purpose is to detect the presence of the species at a surveyed area and not the abundance of individuals or territories within the habitat.

Overall, we found that the Halterman et al. survey methodology needs little refinement, as it works well for its intended purpose to assess habitat use within the surveyed habitat (chapter 2) and adequately detects breeding cuckoos (chapter 4). Following the modified survey protocol for two seasons enabled a unique opportunity to assess if increasing peak-season survey frequency by adding a third survey in July was warranted. This did not yield definitive gains in estimating the proportion of habitat used or the precision of our territory estimates. Although centering surveys around the peak of breeding may improve survey efficiency, having only 10 days between surveys impacted our ability to conduct followup surveys after detections of cuckoos. From our analyses, comparisons, and observations, we recommend that surveys be centered around the peak of cuckoo detectability and occupancy (mid-July on the LCR) and that surveys be conducted approximately 12–14 days apart. Surveys 20 days apart allow for the possibility of missing an entire cuckoo nesting cycle (a minimum of 16 days), and, as stated above, a 10-day survey interval may require additional staff to implement in order to schedule followup surveys after cuckoos are detected.

Chapter 4 – Survey Protocol Assessment II: Breeding Habitat Detection Probability

INTRODUCTION

Cuckoos may disperse from sites during all survey periods (McNeil et al. 2011, 2012). This movement indicates that LCR cuckoo populations are open and adds uncertainty to the interpretation of detection probability estimates. Under open conditions, the estimate is a combination of two confounding components: (1) the probability that the species was present in the sampling unit and (2) the probability that the species was detected, given that it was present (MacKenzie et al. 2006). In chapter 2, we analyzed presence-absence detection data from all sites to determine the probability to detect cuckoos during a survey. With this dataset, changes in the detection probability between survey periods may not necessarily reflect a change in cuckoo behavior (e.g., from vocal one survey period to secretive the next) because there is the possibility that the cuckoo may have left the sampled habitat. The cofounding nature of this possibility increases the difficulty of evaluating cuckoo detection probabilities.

Observations of radio-tracked birds revealed that breeding cuckoos stayed at their breeding habitat at least 37.2 days on average (chapter 9). As such, these breeding birds represent a closed (or mostly closed) population, where the detection probability is simply the probability the species was detected given that it was present. This allows for more tangible inferences about cuckoo behavior when detection probability changes through time. From the analysis of a closed population, we can explore how the probability to detect cuckoos is affected by cuckoo abundance, breeding phenology, and responsiveness throughout their breeding cycle. Understanding these relationships enables us to draw sound inferences from our open population survey observations (chapter 2) and increases our ability to assess the efficacy of the survey protocol (chapter 3).

While conducting cuckoo research, we have made anecdotal observations regarding our ability to detect cuckoos and developed hypotheses on the three relationships listed above. Intuitively, we hypothesized that increases in cuckoo abundance yields an increased probability to detect one or more cuckoos during our presence-absence surveys. From observations of decreased responsiveness of breeding cuckoos to our survey broadcast calls as the breeding season progresses, we hypothesized that the probability to detect cuckoos is related to breeding behavior and that cuckoos become less responsive later in their nesting cycle, such as once their eggs hatch or nestlings fledge. From 2010 to 2011, we observed a close relationship between cuckoo fledging date and peak cicada abundance at the BWR, but not at LCR MSCP restoration habitat where cicada abundance was consistently low and cuckoo breeding was more dispersed through time. Thus, we investigated whether the tightly coupled synchronous nesting phenology observed at the BWR yielded a lower detection probability trend, which was closely coupled with cuckoo breeding activity, and the asynchronous breeding at LCR MSCP habitat resulted in a greater detection probability with a lower apparent relationship to cuckoo breeding activity. Lastly, and most important to our survey protocol assessment (objective 3), we estimated the probability of not detecting breeding cuckoos using the current survey methodology (Halterman et al. 2009a).

METHODS

Nest and Cuckoo Abundance

The detection probability analyses discussed below examine how the number of nests present affects the probability to detect cuckoos during a presence-absence survey. A more interesting comparison would be whether cuckoo abundance affects this detection probability. We are unable to make this explicit comparison, but if the relationship between nest abundance and breeding cuckoo abundance is positive and significant, then we can at least make inference to it. To assess this relationship, we conducted a correlation analysis to determine if increased nest abundance was related to increased cuckoo abundance. We examined whether the average number of survey detections within the sample units was related to sample unit nest abundance (see chapter 2 for a description of sample units). We suspect the majority of these survey detections were of breeding cuckoos, but expect that at least some were of non-breeding birds using breeding habitat sample units.

Probability to Detect Breeding Cuckoos

For these analyses, we used a subset of the presence-absence survey data, and the habitat use analysis methods described in chapter 2, to estimate the probability to detect breeding cuckoos (see tables 2-1, 2-2, and 2-3 in chapter 2). To do this, we analyzed only the survey data from sample units with confirmed nests. The survey data were formatted for the 2009–2010 survey periods (table 4-1). Sample units were prepared for the 2008–2012 habitat use analysis (chapter 2) and were randomly placed relative to the locations of discovered nests. The 87 confirmed nests (chapter 8) were located within 50 sample units, each containing between 1 and 5 known nests. The detection histories of these 50 sample units, spanning 2008–2012, were combined and analyzed using the program PRESENCE v5.5 as a single-season occupancy model to obtain detection probabilities by nest number and site management type (because 86 of the 87 nests were found at LCR MSCP restoration or BWR sites, detection probabilities were estimated for these sites only). Detectability can occur at the individual or species scale (McCarthy et al.

Table 4-1.—LCR YBCU survey period dates used for the analysis of the 2008–2012 breeding cuckoo survey data
Survey periods and survey intervals varied annually; survey data from all years were reassigned to conform to the (2009–2010) survey periods shown below. Cuckoo detection probabilities for each 15-day survey period are displayed by median date on figures 4-2 to 4-4.

Survey period	Dates	Median date
1	June 15 to June 30	June 22
2	July 1 to July 15	July 8
3	July 16 to July 31	July 23
4	August 1 to August 15	August 8
5	August 16 to August 31	August 23

2012); here we examine detectability at the species scale, where the estimated detection probabilities are derived from, and therefore describe, the probability of detecting one or more cuckoos within sample units during a survey (Williams et al. 2002; MacKenzie et al. 2006). Like the detection probabilities calculated in chapter 2, this does not estimate detectability at the individual scale (i.e., the probability to detect an individual cuckoo at an individual survey point).

Detection Probability and Breeding Stage

To search for a possible relationship between cuckoo breeding stages (incubation, brooding, and fledged) and detection probability, we plotted histograms of breeding stages against detection probability trends by sample unit nest abundance. To calculate breeding stage histograms, we determined the daily frequency of all 2008–2012 confirmed nests (n = 87) (attachment I) by breeding stage. For comparative analysis, nest stage data were grouped by sample unit nest abundance (n = 1, 2, 3, 4 + 5) and by site management type (LCR MSCP restoration and BWR natural). The observed length of each nest stage was used in the histogram analysis when known. Nest stage dates were also estimated based on observations of the first egg laid, first egg hatched, first chick fledged, and nestling age when banded. We estimated the incubation and brooding stages to have been 10 and 6 days, respectively. Nestlings fledge asynchronously, and for all nests, we observed or estimated the date the first fledgling left the nest. However, the length of time one or both adults tended to their fledglings was unknown. We estimated the fledged stage, the time one or both adults tend to fledged young, to be 3 weeks in length, though this stage may be longer (chapter 9). Due to nest failure during incubation or brooding stages, not all nests had complete incubation, brooding, and fledged data to contribute to the histograms.

Detection Probability and Breeding Phenology

Cuckoo breeding phenology appears to be highly synchronized with the summer emergence of Apache cicadas (*Diceroprocta apache*) at the BWR (Rosenberg et al. 1982; McNeil et al. 2011, 2012), but not at LCR MSCP restoration habitat where breeding is more dispersed through time (chapter 8). If the response to our surveys is related to their breeding cycle, then the timing and synchronicity of breeding may also affect our ability to detect cuckoos. To assess breeding stage and detection probability differences between the two site management types, we compared their respective survey period detection probabilities with breeding stage histograms. This comparative analysis followed the methods described above, with the exception that the detection history and breeding stage histogram data were grouped by sample unit management type (instead of by nest abundance).

Probability of Not Detecting Breeding Cuckoos

Lastly, we considered the probability not to detect breeding cuckoos present within sample units using the current survey methodology (Halterman et al. 2009a). This analysis was conducted to evaluate the efficacy of our survey methods, whereas the three previous analyses (detection probability relative to cuckoo abundance, nest stage, and breeding phenology) examined how behavioral and ecological factors affect detection trends. This analysis used the exact same data and methods as the probability to detect breeding cuckoos described above with one small exception: in a regular PRESENCE analysis, detections are coded as “1” and non-detections as “0” (see chapter 2 methods). For this analysis, we coded the detections as “0” and non-detections as “1”; in doing so, the software calculated the probability of non-detection at locations (sample units) known to have nesting cuckoos.

RESULTS

From 2008 to 2012, we located 87 nests dispersed across 50 sample units, each sample unit harboring between 1 and 5 confirmed nests. Nests were most frequently found in low densities (1 nest per sample unit, n = 26), but were also found in greater densities (16 sample units with 2 nests each, 5 sample units with 3 nests each, 1 sample unit with 4 nests, and 2 sample units with 5 nests each).

Nest and Cuckoo Abundance

The frequency of detecting at least one cuckoo on a survey increased with the number of nests within the sample unit (table 4-2). On average, cuckoos were detected on 2.8 surveys (or during 2.8 survey periods) in sample units with 1 nest ($n = 26$ sample units). The majority of these detections occurred during survey periods 2 and 3 (July). At sample units with 4 or more nests ($n = 3$ sample units, 14 nests), 1 or more cuckoos were detected on all surveys.

Table 4-2.—2008 to 2012 frequencies of survey detections in sample units harboring 1–5 nests
The average number of survey visits (survey periods) with at least one detection increased with the number of nests within the sample unit.

Number of nests in sample unit	Number of sample units with cuckoo detections in 1–5 survey visits					Average number of survey visits with detections
	1	2	3	4	5	
1 nest[1]	2	6	14	3	1	2.8
2 nests[2]	1	2	6	7	0	3.2
3 nests[3]	0	0	2	2	1	3.8
4 nests[4]	0	0	0	1	0	4.0
5 nests	0	0	0	0	2	5
Total	3	8	22	13	3	
Percent of total	6%	16%	44%	26%	8%	

[1] Fourteen of these sample units were surveyed only four times; one sample unit was surveyed only three times.
[2] Six of these sample units were surveyed only four times; one sample unit was surveyed only three times.
[3] One of these sample units was surveyed only four times.
[4] This sample unit was surveyed only four times.

We used a correlation analysis to determine if increased sample unit nest abundance was related to increased cuckoo abundance. We found that the number of nests within the sample unit was positively related to the average number of survey detections within the sample unit ($P = 0.0003$, $F_{1, 48} = 15.54$, intercept = 0.87, $\beta = 0.58$, $R^2 = 0.23$) (figure 4-1).

Probability to Detect Breeding Cuckoos

Cuckoo detection probabilities at nests were modeled using a set of four candidate models (table 4-3). The top model (model 1) had the lowest AIC value, highest ω_i (0.997), and incorporated survey period and number of nests per sample unit as

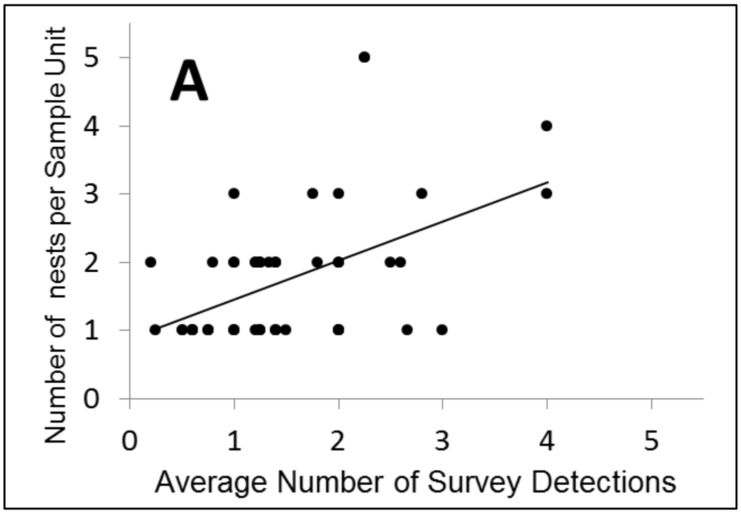


Figure 4-1.—Cuckoo nest abundance within breeding sample units (n = 50) was positively related to the average number of survey detections within the sample unit (P = 0.0009).

Table 4-3.—LCR cuckoo detection probability and habitat occupancy for sample units harboring 1–5 confirmed nests

Model, negative log likelihood value (-2*l*), number of predictor variables (K), AIC, AIC differences (ΔAIC_i), and Akaike weights (ωi) are shown.

Model number	Model	-2*l*	*K*	AIC	ΔAIC_i	ω_i
1	ψ(·) *p*(survey period, nest number)	224.48	10	244.48	0.00	0.9972
2	ψ(·) *p*(survey period)	244.24	6	256.24	11.76	0.0028
3	ψ(·) *p*(nest number)	277.68	5	287.68	43.20	< 0.0001
4	ψ(·) *p*(·)	288.97	2	292.97	48.49	< 0.0001

covariates to model detection probability. Model 2 incorporated survey period as a covariate, model 3 incorporated the number of nests per sample unit as a covariate, and model 4 detection probability was constant throughout the survey effort. Relative to model 1, we found no support for models 2–4 ($\Delta AIC_i > 11.75$).

The top model shows that the probability to detect cuckoos in a sample unit during presence-absence surveys varied by survey period and increased with additional nests within the sample unit (table 4-4 and figure 4-2). With one nest, the probability to detect a cuckoo was relatively low in June, peaked in late July (survey period 3), and then declined significantly in August (survey periods 4 and 5), similar to the detectability observed in June (table 4-4). With increasing confirmed nests within the sample unit, the detection trend gradually increased;

Table 4-4.—2008–2012 LCR YBCU detection probabilities with 95% CIs by number of nests within a sample unit
(Data are also displayed on figure 4-1.)

Survey period	Detection probability estimates at sample units with 1–5 nests			
	1 nest (CI)	2 nests (CI)	3 nests (CI)	4–5 nests (CI)
1	0.381 (0.244–0.540)	0.540 (0.364–0.706)	0.710 (0.419–0.893)	1.000 (1.000–1.000)
2	0.806 (0.643–0.906)	0.888 (0.753–0.954)	0.943 (0.804–0.985)	1.000 (1.000–1.000)
3	0.920 (0.779–0.974)	0.957 (0.860–0.988)	0.979 (0.899–0.996)	1.000 (1.000–1.000)
4	0.431 (0.283–0.591)	0.591 (0.412–0.748)	0.751 (0.468–0.912)	1.000 (1.000–1.000)
5	0.363 (0.194–0.573)	0.520 (0.309–0.725)	0.694 (0.376–0.895)	1.000 (1.000–1.000)

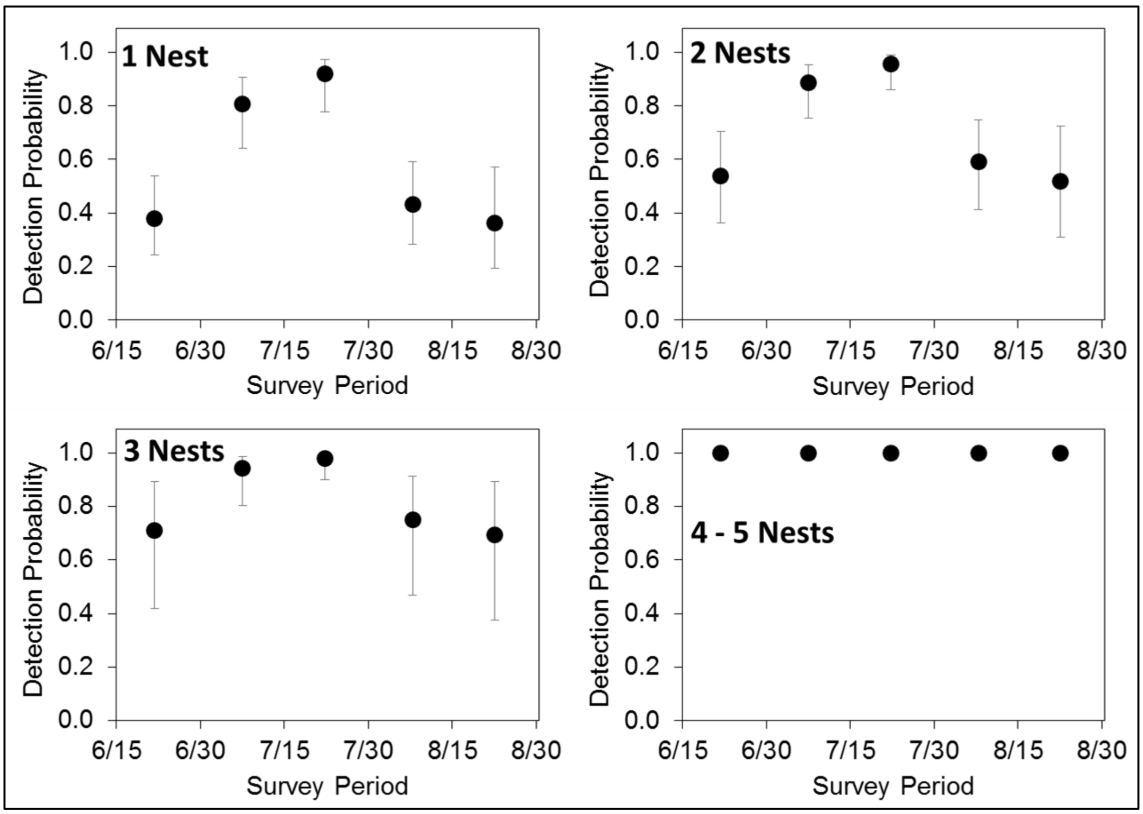


Figure 4-2.—2008–2012 LCR YBCU detection probabilities with 95% CIs per number of nests within a sample unit.
Detection probabilities are displayed by survey period median date. Data are also displayed in table 4-4.

the overall pattern of detection persisted at sample units with up to three nests, and thereafter, detectability was estimated to be 100% for the duration of the survey effort. The 100% detection probability was derived from a small sample (n = 3 sample units, 14 nests) in which cuckoos were detected on all survey visits.

Detection Probability and Breeding Stage

At sample units with 1 nest (n = 26 sample units), the probability to detect a cuckoo during a survey was high through the egg and nestling stages (blue and red histogram lines, figure 4-3), indicating that breeding cuckoos remained highly responsive to survey playbacks during these nest stages. The significant decrease in breeding cuckoo detectability in the transition from survey period 3 to 4 (median survey period dates July 23 to August 8) correlated with the steep increase in the number of fledged nests (green line, figure 4-3), when the number of nests with fledglings rose from near zero to its high plateau. These trends were clearest in sample units with one nest, but became less obvious as the number of nests per sample unit increased and the incubation and brooding stages (during which cuckoos remained highly responsive and easily detected) overlapped and persisted further into the breeding season. As the number of nests increased, the overall probability to detect a cuckoo during a survey, in any survey period, increased. At sample units with 4 or more nests (n = 3 sample units, 14 nests), the incubation and brooding stages (when cuckoo detectability was high) persisted throughout the survey effort, from mid-June through late August, and appeared to be bimodal.

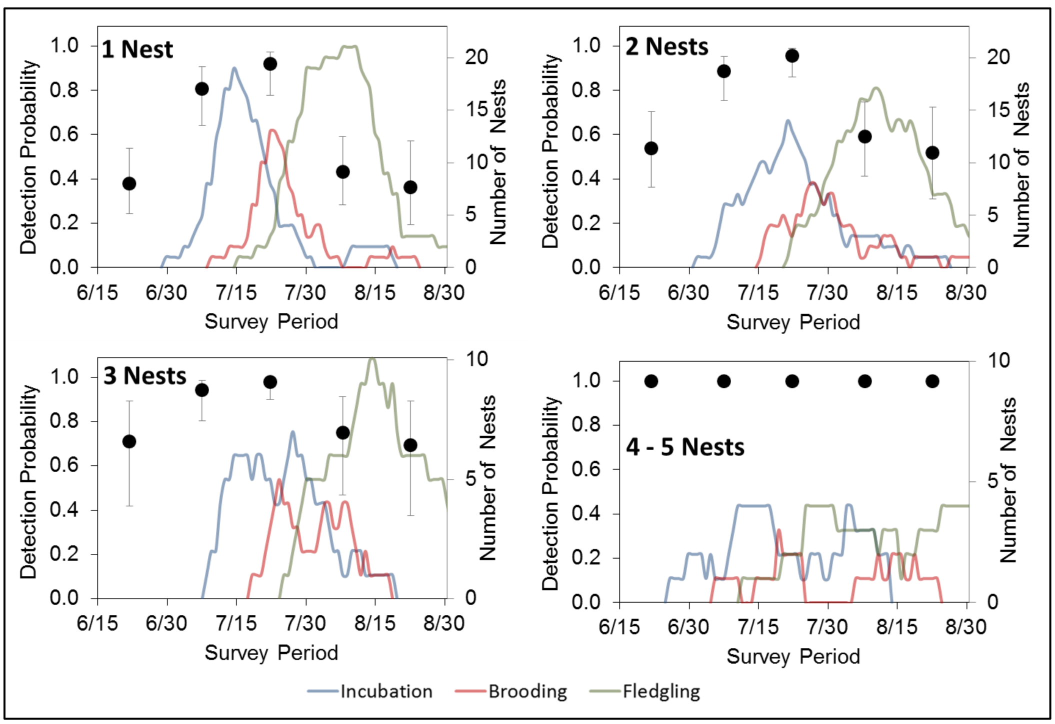


Figure 4-3.—2008–2012 LCR YBCU detection probabilities (black dots) with 95% CIs displayed with nesting stage histograms (incubation stage, blue line; brooding stage, red line; fledged stage, green line), by number of nests per sample unit. Detection probabilities (primary vertical axes on left) are displayed by survey period median date. Detection probability data are also displayed in table 4-4 and on figure 4-2. Nesting stage histograms (secondary vertical axes on right) are displayed by daily frequency of active nests in each breeding stage.

Detection Probability and Breeding Phenology

At BWR habitat (n = 16 sample units, 12 with 1 nest, 3 with 2 nests, 1 with 3 nests), detection trends at sample units with (any number of) nests (table 4-5 and figure 4-4) closely resembled that for sample units with only one nest (see figure 4-3). The nesting window at the BWR, measured from the first day of any incubation to the last day of any brooding, was more compressed than that observed for sample units with one nest. In contrast, the probability to detect breeding cuckoos at LCR MSCP habitat (n = 33 sample units, 13 with 1 nest, 13 with 2 nests, 4 with 3 nests, 1 with 4 nests, and 2 with 5 nests) was intermediate to those observed for habitat with 2 or 3 nests, and the nesting window spanned all survey periods (table 4-5 and figures 4-3 and 4-4).

Table 4-5.—LCR YBCU detection probabilities with 95% CIs by site management type (BWR natural, LCR MSCP restoration habitat)
(Data are also displayed on figure 4-3.)

Survey period	Breeding cuckoo detection probability estimates	
	BWR NWR (CI)	LCR MSCP (CI)
1	0.500 (0.284–0.716)	0.515 (0.349–0.678)
2	0.875 (0.614–0.969)	0.880 (0.711–0.952)
3	0.889 (0.648–0.972)	0.970 (0.814–0.996)
4	0.353 (0.168–0.596)	0.667 (0.492–0.805)
5	0.375 (0.125–0.715)	0.632 (0.403–0.813)

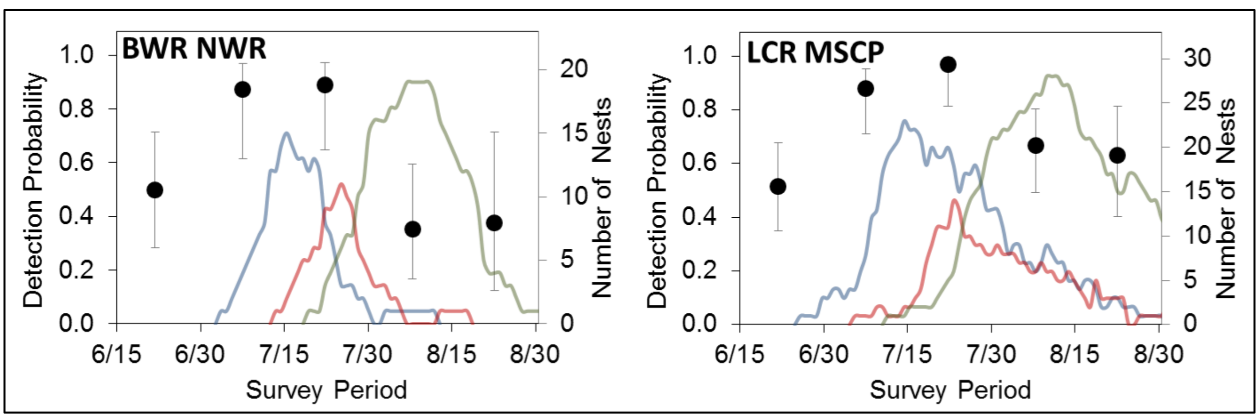


Figure 4-4.—2008–2012 LCR YBCU detection probabilities (black dots) with 95% CIs displayed with nesting stage histograms (incubation stage, blue line; brooding stage, red line; fledged stage, green line), by management type (BWR natural habitat, LCR MSCP restoration habitat).
Detection probabilities (primary vertical axes on left) are displayed by survey period median date. Detection probability data are also displayed in table 4-5. Nesting stage histograms (secondary vertical axes on right) are displayed by the daily frequency of active nests in each breeding stage.

Probability of Not Detecting Breeding Cuckoos

The probability of not detecting breeding cuckoos present in a sample unit was modeled using the same four candidate models as the probability to detect breeding cuckoos. The model selection results for these two analyses are the same and shown in table 4-3. The probability of not detecting breeding cuckoos (table 4-6) is the converse of the probability to detect breeding cuckoos (table 4-4).

Table 4-6.—2008–2012 probability of not detecting breeding cuckoos with 95% CIs by number of nests within a sample unit

Survey period	Probability not to detect cuckoos in sample units with 1–5 known nests							
	1 nest (CI)		2 nests (CI)		3 nests (CI)		4–5 nests (CI)	
1	0.619	(0.460–0.756)	0.461	(0.294–0.636)	0.290	(0.107–0.581)	0.000	(0.000–0.000)
2	0.194	(0.094–0.357)	0.112	(0.046–0.247)	0.057	(0.015–0.196)	0.000	(0.000–0.000)
3	0.080	(0.026–0.222)	0.044	(0.013–0.140)	0.021	(0.004–0.101)	0.000	(0.000–0.000)
4	0.569	(0.409–0.716)	0.409	(0.252–0.588)	0.249	(0.088–0.533)	0.000	(0.000–0.000)
5	0.637	(0.427–0.806)	0.480	(0.275–0.691)	0.306	(0.105–0.625)	0.000	(0.000–0.000)

In sample units with one nest, the probability of not detecting a cuckoo was relatively high in June, dropped in July, and then increased again in August (see table 4-6). The non-detection trend decreased with increasing sample unit nest abundance; the pattern persisted at sample units with up to three nests, and thereafter the probability not to detect cuckoos was 0% in all five survey periods (though the 0% was derived from just three sample units with four or five nests each). We multiplied the non-detection probabilities together to calculate the probability of not detecting a cuckoo on three, four, and five surveys for sample units containing one nest (table 4-7).

Table 4-7.–2008–2012 LCR probability of not detecting breeding cuckoos with 95% CIs on three, four, and five surveys for sample units containing one nest

Survey periods	Probability of non-detection (95% CI)	
Survey periods 1–5	0.0035	(0.0002–0.0345)
Survey periods 1–4	0.0055	(0.0005–0.0428)
Survey periods 2–4	0.0088	(0.0010–0.0566)

DISCUSSION

The probability to detect cuckoos on a presence-absence survey using the currently recommended survey protocols (Halterman et al. 2009a) is affected by cuckoo abundance, breeding stage, and breeding phenology. While these findings were not unexpected, to our knowledge, this is the first assessment of these relationships conducted at the species scale.

From 2008 to 2012, nests were most frequently found in low densities (one nest in a sample unit). Surveys in areas with confirmed breeding resulted in the species being detected on average during 2.8 surveys in habitat with one nest and on three (or more) surveys in habitat with more than one nest. Rarely were cuckoos within breeding habitat detected on just one of five surveys. This supports our recommendation that a single cuckoo detection is not a reliable indicator of breeding (chapter 5). Relative to the observed survey visit frequency of detecting cuckoos in breeding habitat (~three of five survey visits), when conducting presence-absence surveys, a low average frequency of detection suggests that breeding in that habitat occurs rarely if at all. However, an increased frequency of detection should not be taken as evidence that nesting has occurred due to the possibility of detecting transient or non-breeding cuckoos.

The probability to detect cuckoos during a survey increased with nest abundance. From the significant positive relationships between nest abundance and the number of survey detections, we can infer a positive relationship between detection probability and cuckoo abundance. From this, we conclude that the probability to detect cuckoos is density dependent. Intuitively, a species' detection rate should increase with abundance, and this trend has been recognized in rare flora and fauna (McCarthy et al. 2012). The relationship between detectability and abundance is important; it can be used to infer habitat use and relative abundance in different site management types (chapter 2) or to recommend the survey effort (number of surveys) required to estimate habitat use at low- or high-density habitat (chapter 3).

Researchers have noted declines in cuckoo response to survey broadcast calls during the breeding season (Johnson et al. 2007; McNeil et al. 2011), and our finding that breeding cuckoos are relatively responsive until young fledge was not unexpected. When viewed by nest abundance, these trends are clearest in sample units with one nest, but become less obvious as the number of nests increase. However, the lack of clarity observed with increased nest abundance appears to be related to breeding phenology. At the BWR, sample units contained up to three nests, but synchronous nesting resulted in a slightly shorter breeding window than that observed for one nest alone, and the breeding cycle/detection probability relationship remained clear. In contrast, this detectability relationship was no longer evident at LCR MSCP habitat where nest abundance was greater and cuckoos engaged in asynchronous breeding. As such, cuckoo detectability is apparently affected by their breeding ecology and life history traits. Breeding onset appears to be related to local food abundance (Nolan and Thompson 1975), which explains the disparate breeding phenology observed between the BWR, where nesting is tightly coupled to seasonal cicada abundance (Rosenberg et al. 1982; McNeil et al. 2010, 2011), and LCR MSCP restoration habitat where cicada abundance is low and cuckoos primarily forage on alternate prey (e.g., large arthropods such as katydids and mantids). Understanding the relationship between detectability and breeding behavior is important because it provides a baseline for comparative assessment. Higher abundance increases detection probability, but the overall pattern of the trend may be more valuable, as it indicates breeding activity.

With an understanding of breeding cuckoo detection probability patterns and variation, we consider two reasons why detection trends may deviate from those observed in this study: cuckoo movement and the detection of non-breeding birds. On the LCR, cuckoos reside in an open population where cuckoo movement, in or out of the habitat, is a confounding factor affecting the probability of detecting the species (chapter 2). These movements are characterized as non-random and are usually unilateral in their direction, in or out of the sample unit (MacKenzie et al. 2006). One example is early-season transitory or migratory habitat use (chapter 9) where birds rest and refuel before moving on. The continually declining detection trend observed at non-BWR natural habitat (see figure 2-1 in chapter 2) is indicative of non-random movement out of the habitat (MacKenzie et al. 2006) and appears to be the result of migratory stopover use of this habitat. Non-random movements can also include the relatively large pre-breeding movements resident birds may conduct (Sechrist et al. 2009; Stanek and Stanek 2013) (chapter 9), presumably to appraise habitat conditions for food abundance (Hughes 1999) or nesting quality.

We hypothesize that relative to nesting cuckoos, non-breeding birds respond differently to our survey broadcast calls and have the potential to shift the detection trend away from that observed within breeding habitat. Non-breeding birds may be searching for a mate and more readily respond to our survey calls in all survey periods. Their response rate in August may be greater than that of adults feeding fledglings, and their detection would obscure the detectability decline of resident breeding birds. The 5-year average BWR detection trend (figure 4-5) likely resulted from the detectability of breeding birds coupled with that of non-breeding birds possibly exhibiting behaviors described above.

The detection trend in habitat with only non-breeding birds is unknown, but could be envisioned given a set of certain behaviors. Consider the possible scenario in which unmated cuckoos give frequent breeding solicitation calls or readily respond to our broadcast calls, and are highly transitory, moving widely among habitat patches (sample units) to appraise the habitat and search for a mate. Under this scenario, each sample unit would have zero, one, or few detections, yielding an overall low detection probability trend and a high occupancy estimate

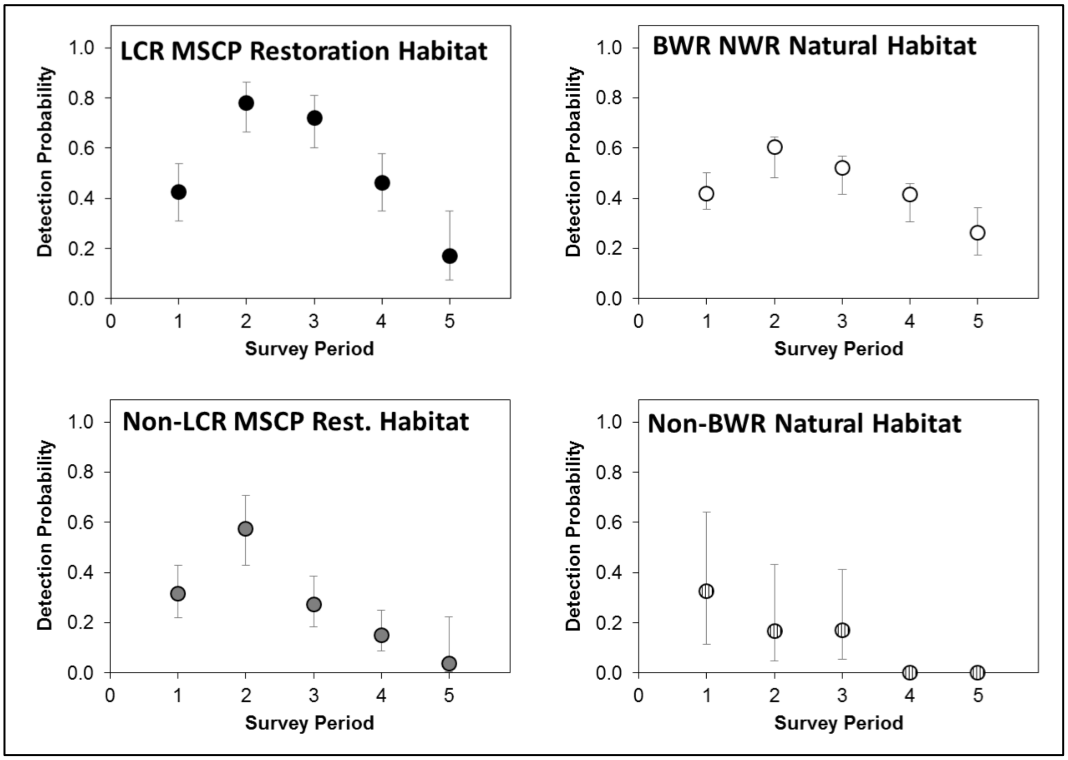


Figure 4-5.—Figure 2-1 from chapter 2. Five-year detection probabilities with 95% CIs by survey period and site management type (LCR MSCP restoration [black], non-LCR MSCP restoration [gray], BWR natural [white], and non-BWR natural habitat [striped]), 2008–2012.
Detection trends were similar at LCR MSCP restoration, non-LCR MSCP restoration, and BWR natural habitats. For most survey periods, detection probability was greatest at LCR MSCP restoration habitat.

(better considered as a measure of temporary use (chapter 2) than an upwardly biased estimate of season-long habitat occupancy) (Rota et al. 2009). If we add to this scenario the likely possibility that many cuckoos on arrival in June deem the habitat unsuitable and steadily depart, leaving the habitat with few or no cuckoos by August, the detection trend would resemble that estimated for non-BWR natural habitat (see figure 4-5). Alternatively, if a low number of cuckoos instead choose to breed at this habitat instead of departing, the detection trend may resemble that observed at non-LCR MSCP restoration habitat (see figure 4-5), which is similar to the trend estimated for the Sacramento River cuckoo population in 2010 (Dettling and Howell 2011a). Detection trends are derived from the average detection history of all sample units, which may include breeding birds, non-breeding birds, transient birds, or no birds at all, yielding varied detection histories and the diverse detection trends estimated for the different site management types.

Cuckoos are perceived to be difficult to detect, and they can be, but their detectability depends on the situation and the detection scale of measurement:

individual versus species. Many detection probabilities reported here and in chapter 2 are high, an apparent paradox to those reported elsewhere (Halterman 2009; Dettling and Howell 2011a). However, these differences are more easily understood when the scale of measurement, the closed population assumption, and the relationships between detectability and abundance, breeding stage, and breeding phenology are taken into account when making comparisons among studies. By knowing that these detection trends are influenced by cuckoo abundance, breeding stage, and breeding phenology, we are able to make sound inferences about behavior and abundance within these habitat types.

Lastly, we examined these results to measure the efficacy of our survey methodology. Our observations indicate that if cuckoos are breeding within the sample unit, they should be detected on at least one survey, and on average, detections will be made on three survey visits. We estimated that the probability of not detecting breeding cuckoos across four surveys (survey periods 1–4) was 0.6% (with a 95% CI of 0.05 to 4.3%) and across all five surveys was 0.4% (with a 95% CI of 0.02 to 3.5%). Stated another way, if zero cuckoos were detected in a sample unit across four or all five surveys, it can be stated with 95% confidence that cuckoos were not breeding in that sample unit. These results indicate that the current survey methodology is capable of detecting breeding cuckoos. Also, conducting the optional fifth survey in late August does not significantly increase the ability to detect breeding cuckoos (nor does it detect many cuckoos [chapter 2]). However, care should be taken when interpreting these results or extrapolating them beyond these breeding areas. These results measure cuckoo detectability in breeding habitat, and it is unknown how well they represent non-breeding birds. Also, while the lack of survey detections across all four or five surveys indicates that breeding cuckoos are most likely absent, the detection of cuckoos on multiple surveys does not necessarily indicate that the cuckoos detected were breeding.

Chapter 5 – Breeding Territory Estimation

INTRODUCTION

Yellow-billed cuckoos are challenging to observe and, as such, difficult to research. They can have large overlapping home ranges, are furtive by nature, call infrequently, and often evade detection (Hamilton and Hamilton 1965; Laymon et al. 1997; Bennett and Keinath 2003). Additionally, they are on their breeding grounds for only a short time; thus, the window to study these birds is relatively brief. Most cuckoos arrive by July and begin fall dispersal and migration in August (Bent 1940; Hughes 1999; McNeil et al. 2011). Lastly, researchers have observed that many non-breeding cuckoos are transitory and may only stay at a site briefly (Dettling and Howell 2011b; McNeil et al. 2011, 2012). To mitigate these challenges, surveyors use call broadcasts to increase detection probability, which improves habitat use and occupancy estimates (chapter 2). However, this survey method alone is inadequate to estimate cuckoo abundance, density, or population size, and an accurate determination of these estimates has thus far remained elusive.

In the past, cuckoo gender and breeding status were presumed based on vocal response type, and population estimates were largely derived from call broadcast survey results often coupled with nesting observations (Gaines 1974; Halterman 1991; Laymon et al. 1997). However, later research raises questions about the underlying vocalization assumptions (Wilson 2000; Halterman 2009; Southern Sierra Research Station [SSRS], unpublished data), and the omission of factors, such as varying detection probabilities, polyandry, within-patch movement, and within-season emigration or immigration, adds uncertainty to historical population estimates (Williams et al. 2002). The estimation of breeding pair or population abundance is complicated by difficulties locating nests, as well as detecting, capturing and uniquely identifying cuckoos, the polyandrous behavior of some females, and a cuckoo's ability to have multiple broods per season. Without overcoming these obstacles, cuckoo breeding pair or population estimates will remain clouded with uncertainty. In light of these difficulties, we have developed alternate methods to estimate breeding territory abundance (McNeil et al. 2010, 2011, 2012). In contrast to breeding pair or population abundance, breeding territory estimates do not require knowing the identity of each adult or the parentage of each nest.

METHODS

To estimate breeding territory abundance within the study area, we deemed areas as potentially harboring breeding cuckoos if detections occurred in at least two survey periods; single detections were considered unreliable indicators of breeding due to the transience of non-breeding birds (chapter 9) who may use an area during one survey period but not the next (Johnson et al. 2007; McNeil et al. 2011). All detections were assessed by location (using ArcGIS), observed behaviors, and date. These were then used to categorize breeding status for each detection area as a possible (POS), probable (PRB), or confirmed (COB) breeding territory (table 5-1). Two or more total detections in an area during at least two survey periods and at least 10 days apart warranted a possible breeding territory. POS cuckoos observed carrying food, traveling as a pair, exchanging vocalizations, or giving distraction behaviors were considered a probable breeding territory. Breeding was only confirmed when a copulation, stick carry, nest, or fledgling was observed. Estimates of breeding territories utilized all detections, including survey, incidental, followup, and telemetry observations. Incidental detections included repeat detections of a cuckoo during surveys and observations of non-target cuckoos during telemetry sessions. Followup visits included nest searching, mist netting, and other site visits. POS and PRB observations were followed up within a few days whenever possible to attempt to confirm breeding. We also used the territory estimates to define site occupancy (table 5-1); sites with at least one POB, PRB, or COB territory were deemed occupied, while all others were deemed unoccupied.

Table 5-1.—Summary of definitions for breeding territory and population estimation terms

Estimation type	Term	Definition
Breeding territory estimation	Possible breeding territory (POS)	Two or more total detections in an area during two survey periods and at least 10 days apart. For example, within a certain area, one detection made during survey period two coupled with another cuckoo detection made 10 days later during survey period three warrants a POS territory designation.
	Probable breeding territory (PRB)	POS territory, plus cuckoos observed traveling as a pair, exchanging vocalizations, carrying food, or displaying distraction behaviors.
	Confirmed breeding territory (COB)	Observation of copulation, stick carry, nest, or fledgling.
Population estimation	Minimum territory estimate	The observed number of confirmed breeding territories (COB).
	Maximum territory estimate	The sum of possible (POS), probable (PRB), and confirmed (COB) breeding territories.
Occupancy estimation	Site occupancy	Occupancy is based on two or more total survey detections during two or more survey periods and at least 10 days apart. Multiple detections in an area over an extended period of time suggest that the area may have been used for breeding. Site occupancy estimates are used in chapters 5–7.

While not required by our territory definition, all of our territories happened to have survey detections in two or more survey periods. Alternatively, a territory could have arisen from followup (non-survey) detections in two survey periods. However, this was unlikely because survey detections are usually the impetus for conducting followup visits (i.e., following a survey detection, we will often look for breeding evidence that same day and/or within a few days of the survey). Behaviors upgrading a POS to a PRB or COB territory may be observed during surveys, but are more likely observed during subsequent followup visits (particularly breeding confirmation). Overall, we find these guidelines useful to estimate breeding territory abundance within the study area (McNeil et al. 2011, 2012). However, sometimes extensive followup visits to POS and PRB territories yielded no breeding evidence, whereby exceptions to the guidelines were made and documented.

Using the POS, PRB, and COB counts, we calculated minimum and maximum territory estimates (see table 5-1). The minimum estimate is the number of confirmed breeding territories and is our most conservative estimate. The maximum estimate is the sum of all POS, PRB, and COB territories and may overestimate the true number of territories. It is important to note that the territory counts are used to estimate the number of breeding territories and not the number of breeding pairs. A territory represents the adults associated with a single nest, usually two adults. However, females have been observed leaving a nest before young have fledged (McNeil et al. 2011; 2013, in review). Females can be polyandrous, and after leaving one nest, they may re-nest with another male (Halterman 2009). Also, following a successful or failed nest, one or both parents may re-nest; calling a second nesting attempt an additional pair would be inappropriate. For clarification, from 2008 to 2012, our POS definition evolved with increasing knowledge of cuckoo behavior and changes to our survey periods. All observations from 2008 to 2012 were evaluated to conform to the present definition (see table 5-1), resulting in minor changes to previous breeding territory estimates.

RESULTS

Annual breeding territory estimates are listed by survey area (tables 5-2 to 5-4) and by site management type (table 5-5 to 5-7) for comparison. Hereafter, the use of the term territory or breeding territory refers to the maximum territory estimate except where described as a confirmed territory (COB).

Reach 1 sites (Pahranagat NWR, Overton WMA, and Littlefield Bridge; not surveyed in 2011) had no confirmed breeding from 2008 to 2012. During this time, these sites exhibited a flat annual territory abundance trend (figure 5-1) with

Table 5-2.—LCR YBCU POS,[1] PRB[2] and COB[3] breeding estimates by survey area, 2008–2012
The maximum territory estimates are also displayed on figure 5-1.

Year	Site	POS	PRB	COB	Minimum territories	Maximum territories
2008	Reach 1 – Pahranagat, Overton, Littlefield	0	0	0	0	0
	Reach 3 – Havasu NWR	2	0	0	0	2
	Reach 3 – BWR NWR	24	7	6	6	37
	Reach 4 – ‘Ahakhav Tribal Preserve	1	0	0	0	1
	Reach 4 – CVCA	0	0	2	2	2
	Reach 4 – PVER	1	0	0	0	1
	Reach 4 – Cibola NWR	2	0	0	0	2
	Reaches 5–6 – Imperial to Yuma	2	0	0	0	2
2009	Reach 1 – Pahranagat, Overton, Littlefield	1	0	0	0	1
	Reach 3 – Havasu NWR	1	0	0	0	1
	Reach 3 – BWR NWR	18	3	7	7	28
	Reach 4 – ‘Ahakhav Tribal Preserve	1	1	0	0	2
	Reach 4 – CVCA	2	0	2	2	4
	Reach 4 – PVER	0	0	2	2	2
	Reach 4 – Cibola NWR	1	0	1	1	2
	Reaches 5–6 – Imperial to Yuma	1	1	0	0	2
2010	Reach 1 – Pahranagat, Overton, Littlefield	1	0	0	0	1
	Reach 3 – Havasu NWR	2	1	1	1	4
	Reach 3 – BWR NWR	19	0	12	12	31
	Reach 4 - ‘Ahakhav Tribal Preserve	-	-	-	-	-
	Reach 4 – CVCA	1	0	6	6	7
	Reach 4 – PVER	2	1	2	2	5
	Reach 4 – Cibola NWR	3	0	1	1	4
	Reaches 5–6 – Imperial to Yuma	3	1	0	0	4
2011	Reach 1 – Pahranagat, Overton, Littlefield	-	-	-	-	-
	Reach 3 – Havasu NWR	2	0	1	1	3
	Reach 3 – BWR NWR	11	3	9	9	23
	Reach 4 – ‘Ahakhav Tribal Preserve	2	0	0	0	2
	Reach 4 – CVCA	4	2	7	7	13
	Reach 4 – PVER	5	2	10	10	17
	Reach 4 – Cibola NWR	2	0	1	1	3
	Reaches 5–6 – Imperial to Yuma	6	0	0	0	6
2012	Reach 1 – Pahranagat, Overton, Littlefield	2	0	0	0	2
	Reach 3 – Havasu NWR	2	0	0	0	2
	Reach 3 – BWR NWR	11	7	1	1	19
	Reach 4 – ‘Ahakhav Tribal Preserve	2	0	0	0	2
	Reach 4 – CVCA	0	2	3	3	5
	Reach 4 – PVER	9	6	24	24	39
	Reach 4 – Cibola NWR	4	1	2	2	7
	Reaches 5–6 – Imperial to Yuma	3	1	0	0	4

[1] POS – Two or more total detections in an area during two survey periods and at least 10 days apart.
[2] PRB – A POS territory, plus cuckoos observed traveling as a pair, or exchanging vocalizations.
[3] COB – Observation of copulation, stick carry, food carry, nest, or fledgling.

Table 5-3.—LCR YBCU annual, average, and total maximum breeding territories by survey area, 2008–2012
Data are a summary of the maximum breeding territory estimates found in table 5-2.

Site type	Maximum breeding territory estimates						
	2008	2009	2010	2011	2012	Average	Total
Reach 1 – Pahranagat NWR, Overton, Littlefield	0	1	1	0	2	1	4
Reach 3 – Havasu NWR	2	1	4	3	2	2	12
Reach 3 – BWR NWR	37	28	31	23	19	28	138
Reach 4 – ‘Ahakhav Tribal Preserve	1	2	0	2	2	1	7
Reach 4 – CVCA	2	4	7	13	5	6	31
Reach 4 – PVER	1	2	5	17	39	13	64
Reach 4 – Cibola NWR	2	2	4	3	7	4	18
Reach 5–6 – Imperial to Yuma	2	2	4	6	4	4	18
Total	47	42	56	67	80	58	292

Table 5-4.—LCR YBCU proportion of sites with POS, PRB, and/or COB breeding territories by survey area, 2008–2012.
‘Ahakhav Tribal Preserve was not surveyed in 2010; Reach 1 sites were not surveyed in 2011. Sites with territories were deemed occupied.

Site type	Proportion of sites with breeding territories/occupied										
	2008		2009		2010		2011		2012		Average
Reach 1 – Pahranagat, Overton, Littlefield	0%	(0/4)	0%	(1/8)	0%	(1/4)	–		0%	(2/4)	0%
Reach 3 – Havasu NWR	50%	(2/4)	14%	(1/7)	57%	(4/7)	40%	(2/5)	50%	(2/4)	42%
Reach 3 – BWR NWR	93%	(13/14)	81%	(13/16)	75%	(12/16)	75%	(12/16)	73%	(11/15)	79%
Reach 4 – ‘Ahakhav Tribal Preserve	100%	(1/1)	100%	(1/1)	–		100%	(1/1)	100%	(1/1)	100%
Reach 4 – CVCA	100%	(1/1)	67%	(2/3)	100%	(3/3)	100%	(3/3)	67%	(2/3)	87%
Reach 4 – PVER	100%	(1/1)	50%	(1/2)	75%	(3/4)	100%	(4/4)	100%	(5/5)	85%
Reach 4 – Cibola NWR	40%	(2/5)	50%	(2/4)	50%	(2/4)	29%	(2/7)	40%	(2/5)	42%
Reach 5–6 – Imperial to Yuma	20%	(2/10)	7%	(2/15)	50%	(4/8)	36%	(6/14)	25%	(4/12)	27%

Table 5-5.—LCR YBCU total POS[1], PRB[2], and COB breeding estimates by site management type, 2008–2012

Year	Site type	POS	PRB	COB	Minimum territories	Maximum territories
2008	BWR natural	24	7	6	6	37
	Non-BWR natural	0	0	0	0	0
	LCR MSCP restoration	3	0	2	2	5
	Non-LCR MSCP restoration	5	0	0	0	5
2009	BWR natural	18	3	7	7	28
	Non-BWR natural	2	0	0	0	2
	LCR MSCP restoration	4	1	4	4	9
	Non-LCR MSCP restoration	1	1	1	1	3
2010	BWR natural	19	0	12	12	31
	Non-BWR natural	1	0	0	0	1
	LCR MSCP restoration	5	1	10	10	16
	Non-LCR MSCP restoration	6	2	0	0	8
2011	BWR Natural	11	3	9	9	23
	Non-BWR natural	1	0	0	0	1
	LCR MSCP restoration	12	4	19	19	35
	Non-LCR MSCP restoration	8	0	0	0	8
2012	BWR natural	11	7	1	1	19
	Non-BWR natural	3	0	0	0	3
	LCR MSCP restoration	16	9	29	29	54
	Non-LCR MSCP restoration	3	1	0	0	4

[1] POS - Two or more total detections in an area during two survey periods and at least 10 days apart.
[2] PRB - A POS territory, plus cuckoos observed traveling as a pair, or exchanging vocalizations
[3] COB - Observation of copulation, stick carry, food carry, nest, or fledgling.

Table 5-6.—LCR YBCU annual, average, and total maximum breeding territories by site management type, 2008–2012

Data are a summary of the maximum breeding territory estimates in table 5-5.

Site type	Maximum breeding territory estimates						
	2008	2009	2010	2011	2012	Average	Total
BWR natural	37	28	31	23	19	28	138
Non-BWR natural	0	2	1	1	3	1	7
LCR MSCP restoration	5	9	16	35	54	24	119
Non-LCR MSCP restoration	5	3	8	8	4	6	28
All sites	47	42	56	67	80	58	292

Table 5-7.—LCR YBCU proportion of sites with breeding territories by site management type, 2008–2012

Site management type	Proportion of sites with breeding territories (occupied)									
	2008		2009		2010		2011		2012	
BWR natural	92.9%	(13/14)	81.3%	(13/16)	75.0%	(12/16)	75.0%	(12/16)	73.3%	(11/15)
Non-BWR natural	0.0%	(0/8)	9.1%	(2/22)	11.1%	(1/9)	14.3%	(1/7)	37.5%	(3/8)
LCR MSCP restoration	66.7%	(4/6)	62.5%	(5/8)	88.9%	(8/9)	83.3%	(10/12)	84.6%	(11/13)
Non-LCR MSCP restoration	41.7%	(5/12)	23.1%	(3/13)	66.7%	(8/12)	46.7%	(7/15)	30.8%	(4/13)

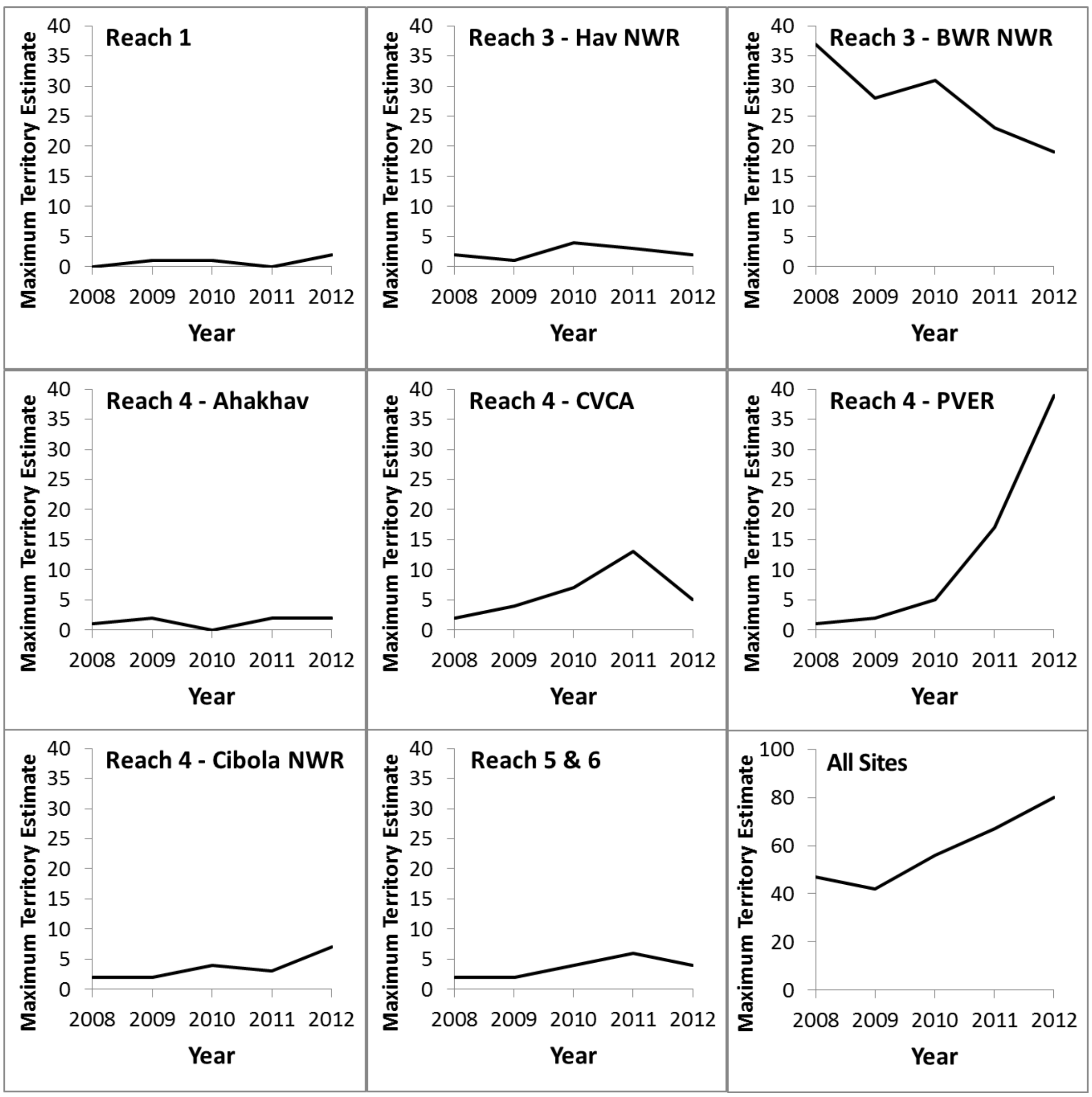


Figure 5-1.—Annual LCR YBCU maximum breeding territory estimates displayed by survey area, and all sites combined, 2008–2012.

an average of one possible territory per year (range 0 to 2 POS) (see table 5-2). Most were at Overton WMA; Pahranagat NWR had one POS territory in 2012, and no territories were estimated at Littlefield Bridge (attachment D).

From 2008 to 2012, Havasu NWR had two confirmed breeding territories (one each in 2010 and 2011), both at the Beal LCR MSCP restoration site (see figure 5-1 and table 5-2). The remaining Havasu NWR sites, both natural and non-LCR MSCP restoration, averaged two possible breeding territories per year (range 0–2 POS, 0–1 PRB) (attachment D), and no confirmed breeding. On average, 42% (range 0–57%) of Havasu NWR sites were occupied by estimated or confirmed breeding territories during each of the 5 years (see table 5-4).

As expected, the BWR supported a high number of territories in all years (28 per year on average, range 19–37) (see figure 5-1 and tables 5-2 and 5-3), with an average site occupancy rate of 80% (range 73–93%, approximately 12 sites per year) (see table 5-4). From 2008 to 2012, we estimated that the BWR had up to138 breeding territories, more than twice the total estimated for the second most prolific survey area, PVER (Phases 1–5, 64 breeding territories total) (figures 5-1 and 5-2, table 5-3). Over 2008 to 2012, breeding was confirmed at all eastern BWR sites (Cottonwood Patch [2009, 2010], Cave Wash [2009–2011], Honeycomb Bend [2008–2012], Mineral Wash [2009–2011], Esquerra Ranch [2011], Cougar Point [2008, 2010, and 2011] and Kohen Ranch [2009 and 2010]), (attachment D). Breeding appeared to be less prolific in the western portion of the refuge, with confirmation at only two of nine sites (Sandy Wash [2008–2010] and Mosquito Flats [2011]). Possible and probable territories were found throughout the refuge across the 5 years (attachment D). However, across this timespan, breeding activity appeared to decline; territory abundance declined by 49%, from 37 territories in 2008 to 19 in 2012 (figures 5-1 and 5-2, table 5-3), and the proportion of sites with breeding territories declined from 93% in 2008 to 73% in 2012 (see table 5-4).

Most LCR MSCP restoration sites are within River Reach 4, including ‘Ahakhav Tribal Preserve, PVER, CVCA, and Cibola NWR sites. All of these survey areas had confirmed breeding except ‘Ahakhav Tribal Preserve, which averaged two territories per year (range 1–2 POS, 0–1 PRB) (attachment D) and was deemed occupied all years surveyed (2008–2009 and 2011–2012) (see figure 5-1 and tables 5-2 to 5-4).

PVER exceeded all other LCR MSCP restoration areas in annual average breeding territory abundance (12.8 territories, range 1–39), 5-year total abundance (64 total breeding territories), and annual rate of territory abundance increase (average 155% increase over the previous year, range 100–240% increase per year) (see figure 5-1 and table 5-2). PVER territory abundance progressed from 1 (POS) territory in 2008 to 39 in 2012 (24 COB, 6 PRB, and 9 POS) (see figure 5-1), steadily increasing each year in proportion to the amount of available habitat (see figure 5-2), which increased from 8 ha to over 160 ha. This dynamic

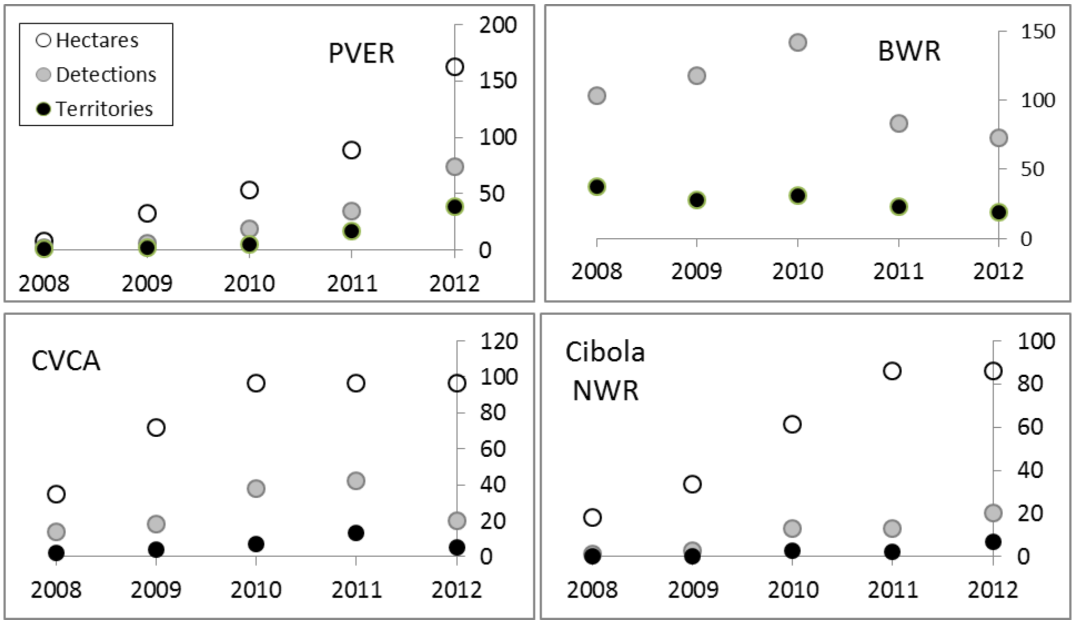


Figure 5-2.—Amount of available habitat (ha), survey detections (for comparison), and maximum territories estimates, PVER, CVCA, BWR, and Cibola NWR (Nature Trail area), 2008–2012.
The amount of surveyed BWR habitat did not significantly vary over the 5-year period (approximately 575–630 ha annually).

growth in available habitat and territories was not observed at any other area during this study. From 2008 to 2012, on average 85% (range 50 to 100%) of PVER area sites had breeding territories, with all sites occupied in 2011 and 2012 (see table 5-4).

CVCA had up to 31 breeding territories over the 5 years (6 territories per year on average, range 2–13), the second highest of all LCR MSCP restoration areas. The amount of available habitat at CVCA increased from 2008 to 2010 (as Phases 1–3 each entered their third year), after which no new habitat became available (several mesquite phases were planted which were not yet suitable). CVCA territory (and detection) totals increased each year until 2011, declining in 2012 (see figures 5-1 and 5-2, table 5-2). The proportion of CVCA sites with estimated or confirmed territories reached 100% (three of three sites occupied) in 3 years, then dropped to 66% in the remaining 2 years (see table 5-4).

Cibola NWR had five confirmed breeding territories from 2008 to 2012, one at Cibola Island Perri Marsh in 2009, one at the Nature Trail in 2010, and three at Crane Roost – one in 2011 and two in 2012 (see figure 5-1 and table 5-2). The Cibola NWR sites had an estimated four breeding territories per year (annual range 0–4 POS, 0–1 PRB, 0–2 COB) (attachment D). On average, 44% (range 29–50%) of the sites were occupied by estimated or confirmed territories during the 5 years (see table 5-4).

In Reaches 5–6 (Imperial to Yuma, 8 to 15 sites surveyed per year), we confirmed no breeding for the duration of this study. We estimated these sites averaged up to four territories per year (annual range 1–6 POS, 0–1 PRB) (see table 5-2 and attachment D) and had an average annual site occupancy rate of 32% (range 13–50%) (see table 5-4).

Across all sites, breeding territories increased by 70% from 2008 (47 estimated territories) to 2012 (80 estimated territories) (see table 5-6). During this time, the number of territories at non-LCR MSCP restoration sites remained low but stable (five in 2008 [11% of all 2008 territories] and four in 2012 [5% of all 2012 territories]). Non-BWR natural habitat had relatively few to no territories per year, with none in 2008 and three in 2012 (4% of all 2012 territories). BWR territories declined by an estimated 49%, from 37 estimated in 2008 (79% of all 2008 territories) to 19 in 2012 (24% of all 2012 territories). In contrast, at LCR MSCP restoration sites, we estimated that breeding territory abundance increased by over 1000%, from 5 in 2008 (11% of all 2008 territories) to 54 in 2012 (67.5% of all 2012 territories). In 2012, among all LCR MSCP restoration sites, PVER sites had the greatest density of breeding cuckoos (estimated at 4.8 territories per 20 ha of habitat), with the greatest estimated density at PVER4 (8.9 territories per 20 ha of habitat) (also see table 6-16 in chapter 6 that shows territories per ha along with vegetation summary statistics for LCR MSCP restoration sites).

In 2008, we confirmed eight breeding territories, two at LCR MSCP restoration sites and six at the BWR (see table 5-5). In contrast, in 2012, we confirmed 30 breeding territories, 29 at LCR MSCP restoration sites and 1 at the BWR (see table 5-5). Across all 5 years, we found 83% more confirmed breeding territories at LCR MSCP restoration sites (64 total confirmed territories) than at natural habitat sites (35 total confirmed BWR territories) (see table 5-5). From 2008 to 2012, we only confirmed one breeding territory at non-LCR MSCP restoration sites, and we confirmed no breeding at natural habitat outside of the BWR. Across all 5 years, on average, we estimated or confirmed breeding territories at 80% of LCR MSCP restoration sites, 77% of BWR natural sites, 42% of non-LCR MSCP restoration sites, and 14% of non-BWR natural sites (see table 5-7).

DISCUSSION

Cuckoo population data can be collected using a variety of methods (e.g., surveys, nest searching and monitoring, and radio telemetry), each with its own tradeoffs between the amount of effort and resources required and the type and value of information gained. Overall, we find our territory estimates to be useful for assessing breeding activity at our sites. They supplement other survey data analyses (e.g., comparison of survey detections, habitat use, and detection probability estimates) and provide information that surveys alone cannot. Initial designation of POS territories arise from data collected on standardized surveys conducted at each site. As such, all sites receive equal effort when making initial territory assessments. However, upgrading a POS territory, strengthening our confidence that a location holds breeding birds, often requires additional followup visits. Behaviors suggesting or demonstrating breeding are not usually observed during surveys (as they typically require more time to be spent within a breeding territory). As such, followup visits provide additional and often better opportunities to encounter breeding evidence and are thus an integral component of our territory estimation process.

From 2008 to 2012, we estimated a 70% increase in breeding activity at LCR MSCP restoration habitat (in particular at PVER sites). In contrast, we estimated breeding territory abundance declined by 49% at the BWR. By 2011 and into 2012, Reach 4 LCR MSCP restoration habitat (PVER, CVCA, and Cibola NWR) surpassed the BWR in survey detections, proportion of habitat used, (chapter 2), and confirmed and estimated breeding territories. Most increases were observed at PVER, where the amount of available contiguous habitat increased each year, growing to over 160 contiguous ha by 2012, far exceeding that of any area outside the BWR. In contrast, CVCA saw initial increases up to 2011, followed by a decline in 2012, and the BWR saw a steady decline. The majority of habitat planted at PVER is cottonwood-willow, whereas CVCA is currently dominated by immature honey mesquite, which is not yet suitable cuckoo habitat. Cuckoos readily use cottonwood-willow habitat after just two growing seasons, whereas slower-growing mesquite tends not to be suitable for several more years, until it has reached at least 5 m high. Suitable cottonwood-willow habitat at CVCA increased from around 35 ha in 2008 to just under 100 ha in 2010, then did not increase further. Cuckoo selection of large cottonwood-willow habitat patches is well known (Laymon and Halterman 1989; Hughes 1999; Girvetz and Greco 2009), but the use of young, dense cottonwood-willow stands for nesting (Laymon 1980; Anderson and Laymon 1989; Rosenberg et al. 1991) (chapter 6) has received less attention.

Another factor potentially contributing to PVER's increasing trend is management activity. Irrigation is generally known to increase arthropod productivity mostly from increased vegetation biomass (Kirchner 1977; Frampton et al. 2000), humidity (Chapman 1969), or leaf water or nitrogen content (Weisenborn and Pratt 2008). Herbivores also typically prefer younger over older leaves, as young leaves having higher water and nitrogen content (Raupp and Denno 1983). Additionally, young cottonwood trees have higher proportions of young leaves, which continue to be added through July, compared to older trees that stop leaf growth in late June (Meyer and Montgomery 1987). Thus, the combination of large patch size, young age structure, and ample irrigation at PVER may be supporting continued high annual insect abundances required by breeding cuckoos; Galli et al. (1976) found birds with large area requirements (including yellow-billed cuckoos) were most likely to be non-passerine insectivores, suggesting that small habitat patches may be food limited for these species. Irrigation schedules may also affect temperature, humidity, and other habitat features important to nest placement (chapters 6 and 7).

At this time, it is unclear if the observed increases at LCR MSCP restoration sites in the Blythe area originated from locally hatched birds successfully establishing new breeding territories within the area or if they are related to the decrease observed at the BWR or elsewhere within the species' breeding range; either scenario is possible. Researchers speculate that declines in their range (Hughes 1999) indicate that cuckoos may be choosing other breeding locations (Dettling and Howell 2011b) possibly due to an increase in prey abundance or available habitat at these alternative locations (Laymon et al. 1997). Because the mature habitat at the BWR did not appear to have significantly changed over the course of this study (the most recent managed large flood release in 2005–2006), it appears that some cuckoos, who otherwise would have occupied suitable habitat at the BWR, may have preferentially selected the overall younger LCR MSCP restoration habitat. With the imminent suitability of the recently planted PVER Phases 6 and 7, we expect these trends to continue over the next few years. Additional research exploring genetic linkages among breeding subpopulations, dispersal, and site fidelity may help to evaluate these trends. Regardless of the mechanisms behind the increases at LCR MSCP habitat, so far these restoration efforts appear successful in attracting high densities of breeding cuckoos. We have found that cuckoos prefer certain habitat features (chapter 6) found at LCR MSCP restoration habitat (i.e., high native small tree density and total canopy closure), but we recommend continued habitat assessment along with population monitoring in the years to come to help clarify the habitat features most strongly correlated to this influx of cuckoos and to assess changes in occupancy and breeding territory abundance as these restoration sites mature. See table 6-16 for summary statistics of important habitat variables at LCR MSCP restoration sites in relation to estimated maximum territories.

Maximum territory estimates varied widely by site management type. Annually, we estimated few breeding territories in non-BWR natural habitat, averaging one (possible) territory per year. The BWR averaged 28 territories per year, LCR MSCP restoration habitat averaged 24 territories per year, and non-LCR MSCP restoration habitat averaged 6 territories per year. Given these annual territory estimates, and despite the declines observed at the BWR, it is clear that habitat at the BWR and at LCR MSCP restoration sites (primarily at PVER, but also at CVCA and Cibola NWR) are important to LCR cuckoos. Proposed management for western cuckoos (Laymon and Halterman 1989) posits that the western DPS is in dire need of additional subpopulations of at least 25 breeding pairs each and that the LCR should strive for 7 new subpopulations. The LCR MSCP has made progress toward meeting this objective and the recovery of western cuckoos by demonstrating the level and acreage of restored habitat needed to achieve this goal and by establishing a new breeding subpopulation at PVER.

Chapter 6 – Habitat Analyses 2006–2012

INTRODUCTION

The riparian forests of the Southwest were historically part of a dynamic ecosystem dependent on periodic flooding to alter the community to earlier successional stages (Warner and Hendrix 1985). The ever-changing vegetation provided habitat for many species, including the endangered least bell's vireo, southwestern willow flycatcher, and western yellow-billed cuckoo (Bell 1998). However, modern river regulation and anthropogenic development across the Southwest has altered the natural hydrologic cycle and led to the loss of riparian vegetation turnover and variety in its successional stages. In addition to the loss of successional diversity, changes to hydrologic regimes have induced shifts in plant distributions (Scott et al. 1997) and changed riparian plant community composition (Nilsson et al. 1997). These changes have drastically reduced the amount of available breeding habitat, resulting in an extensive range reduction and population decline for western yellow-billed cuckoos (Hughes 1999).

To increase the amount of riparian habitat, revegetation has taken place on the lower Colorado River flood plain, most recently under the LCR MSCP. Studies have demonstrated that vegetative species composition and structure are important components of avian habitat selection within riparian habitats of the Southwest (Anderson and Ohmart 1977; Rice et al. 1983). A better understanding of the important components of suitable habitat will facilitate restoration efforts in creating optimal breeding habitat for yellow-billed cuckoos.

Research on yellow-billed cuckoo distribution and habitat use on the LCR was initiated in 2005 by the USGS Colorado Plateau Field Station under the LCR MSCP (Johnson et al. 2006). In 2006, the study expanded to include additional sites further north, extensive cuckoo surveys, and collection of vegetation data at most survey sites (Johnson et al. 2007, 2008). In 2008, the SSRS was contracted to continue cuckoo research under the LCR MSCP. In this chapter, we analyze vegetation data collected during the 2006–2012 field seasons at two spatial scales: site-level analysis (areas ranging from 0.7 to 126.8 ha; see chapter 2 for site definition and selection) and plot-level analysis (circular areas of 11.3 m radius, 0.04 ha). We aimed to expand our understanding of the factors influencing habitat selection through the examination of how (1) habitat characteristics at occupied sites differ from those at unoccupied sites, (2) habitat characteristics at nest plots differ from available habitat within occupied sites and (3) habitat characteristics at successful nests differ from habitat characteristics at failed nests.

Cuckoos are primarily foliage-gleaning insectivores and are known to prefer native vegetation over non-native vegetation (Gaines and Laymon 1984; Hunter et al. 1988; Laymon and Halterman 1989). We hypothesized that cuckoo habitat selection would be strongly influenced by the availability of foraging habitat at the site level. At both spatial scales, we expected a positive association with native vegetation, especially native trees. Although non-native tamarisk was the most common BWR nest tree, these nest trees occurred within a mosaic of native-dominated trees. We suspect that dense monotypic stands of tamarisk are unsuitable habitat, but at low densities where small patches are found within a mosaic of native flood plain vegetation, tamarisk is not a deterrent for cuckoo habitat selection (Sechrist et al. 2009) (chapter 8). Cicadas are an important yellow-billed cuckoo prey component in the LCR region (Rosenberg et al. 1982; McNeil et al. 2011) and are typically found in riparian areas with large native trees and dense vegetation (Glinski and Ohmart 1984; Smith et al. 2006). From previous research, we also predicted that increased canopy height and closure (Laymon et al. 1997) would be strong influences on cuckoo site occupancy. In the Kern River Valley, California, cuckoos have been observed foraging at an average height of 10.5 m (range 4 to 18 m) (Laymon and Halterman 1985) although they have also been observed foraging below this height in other California locations (Laymon 1980).

Laymon (1980) found that nests were typically placed in deciduous riparian forests amongst dense foliage. Cuckoo nests in the Kern River Valley were found in locations with increased canopy closure and willow densities when compared to random locations (Laymon et al. 1997). We hypothesized that nest locations would be associated with increased canopy closure, native tree stem density, and a multilayered canopy compared to available habitat, and successful nests would be characterized by increased canopy closure and native tree stem density. We assessed the influence of vegetation characteristics on cuckoo habitat selection at sites and nests to test our hypotheses. We used our results to develop suggestions for adaptive habitat management strategies (chapter 10).

METHODS

Vegetation Sampling Design

At the larger spatial scale, sites were considered to be occupied if there were two or more total detections during at least two survey periods (chapter 5); otherwise, sites were considered unoccupied during that year. For the nest-level analyses, we included only vegetation plots from occupied sites to examine differences in cuckoo nest site selection versus available habitat. To investigate nest success, we used habitat data from all nests with known fate (see chapter 8 for a description of methods for determining nest fate).

The original sampling design was selected to characterize riparian habitat at the site-level scale (Johnson et al. 2007, 2008), and data collection methods for all years followed the BBIRD Field Protocol (Martin et al. 1997) (see attachment E for data collection methods). This point-based sampling method was chosen to provide a general and scaled habitat characterization to guide riparian restoration efforts along the LCR. Habitat variables were selected based on the current understanding of cuckoo habitat use and physical features considered most important in characterizing breeding cuckoo habitat. Variables were selected to provide data on vegetation composition and structure, the numbers and identities of plant species present in a plot, and the relative abundance or importance of woody riparian species.

Vegetation Plot Selection

A total of 834 plots was sampled during the 7 years of the study (attachment F), including 729 random plots and 92 plots placed at the locations of cuckoo nests found between 2006 and 2012. Random plot placement and data collection methodology varied somewhat between years (table 6-1). We standardized the data so that the differing plot placement and collection methods did not bias the data in any way that would significantly affect the results of our analyses (table 6-2).

Plot data that could not be standardized to all years were removed prior to analyses. In 2006, each plot had four subplots; in 2007, the subplots were dropped (Johnson et al. 2008), and beginning in 2008, SSRS followed the 2007 vegetation sampling methods (Halterman et al. 2009b). The 2006 and 2007 dataset contained many vegetation plots in close proximity to each other. To control for effects of plot non-independence, we averaged vegetation data from plots within 50 m of each other for the 2006 and 2007 dataset.

For all years (2006–2012), plots consisted of two circles centered on the same point: a 5-m-radius circle nested within an 11.3-m-radius circle. The inner circle was used to determine ground cover estimates and stem counts of small trees (except 2006) (table 6-2), shrubs, and saplings. The larger circle was used to describe canopy layers and stem counts of large trees and snags.

Vegetation variables collected are summarized in table 6-3 (see attachment E for detailed vegetation data collection methods). Tree stem densities were derived from stem count data by dividing the total number of stems of a given species by the area of the plot. These categories were then grouped for analyses: native small tree stem density, native large tree stem density, small tree stem density, large tree stem density, tamarisk stem density, shrub/sapling stem density (native and non-native), *Populus fremontii* stem density, and *Salix gooddingii* stem density. A total of 46 habitat variables was collected (attachment G).

Table 6-1.—LCR vegetation plot placement methods, 2006–2012

Year	Plot placement method (also see attachment F)	Source
2006	"The survey region was stratified north to south from the Grand Canyon to the United States/Mexican International border, and 11 areas were selected from the total list based on the presence of cuckoos (in 2005) and/or the feasibility of placing the microclimate data loggers that were co-located with the vegetation sampling locations. Within study areas, vegetation sampling plots were located in both occupied and unoccupied survey sites. Within sites, vegetation plots were centered on microclimate sampling locations that were selected in two ways: (1) At occupied sites, vegetation sampling locations included the estimated coordinates of cuckoo detection locations and one or more GIS-generated random points. (2) At unoccupied sites, locations included one or more random UTM coordinates generated from orthorectified aerial photographs of sites. In cases where random UTM locations were inaccessible or located in inappropriate habitat such as marsh, an alternate was selected by choosing a random compass bearing and a random distance to a new location. If the random distance could not be reached, the plot was established at the first patch of riparian vegetation along that compass bearing."	Johnson et al. 2007
2007	"The entire survey region was stratified north to south from the Grand Canyon to the United States/Mexican International border. […] in 2007 […] we continued our vegetation sampling at the locations [sites] pre-established in our protocol [...] To identify sampling points we used orthorectified aerial photographs for each study site to identify habitat boundaries. We then created a numbered list of Geographic Information System (GIS)-generated random locations (UTM) coordinates for each site. Sampling locations [plots] were assigned to these random UTM coordinates. These points were then located in the field using a hand-held Global Positioning System (GPS) unit and, in cases where random UTM locations were inaccessible or located in inappropriate habitat, such as marsh, an alternate random location was selected by choosing the next point on the list for that site."	Johnson et al. 2008
2008	"Habitat characterization plots were established throughout the study region. Sampling plots were spaced approximately 300 m apart along established survey routes within potentially suitable habitat. Individual plot centers were located at a randomly selected distance (0–50 m) in one of two randomly chosen directions perpendicular to the survey route from a known survey point. If this direction placed the survey plot in unsuitable habitat (such as upland scrub vegetation) the plot was established in the opposite direction."	Halterman et al. 2009a, 2009b
2009	"Habitat characterization plots were established throughout the study region. One project objective was to determine microclimate differences between occupied and unoccupied cuckoo habitat. Because only minor microclimate differences have been found between occupied and unoccupied plots in previous years, a new method was used to place the [plots]. Using detection data from the previous 3 years (2006–2008), areas both occupied and unoccupied for each of the past 3 years were determined using ArcGIS 9.3, and [plots] were placed at the centers of these areas."	McNeil et al. 2010
2010	Habitat characterization plots were located at nests only.	
2011	In 2011, we collected habitat data at nest locations to compare with available habitat, following new 2011 Bureau of Reclamation Post-development Habitat Monitoring Field Methods (Bangle 2011). We also collected habitat data using previous (2008–2010) data collection methods at nest plots. Analyses for this chapter utilize only previous data collection methods at nest plots.	
2012	Habitat characterization plots were established throughout the study region. Sampling plots were randomly placed within 100 m of survey transects (within 50 m for BWR NWR plots). We used data collection methods from 2008–2010.	

Table 6-2.—Differences in vegetation data collection methods or definitions from 2006–2012 and how addressed

Issue	Year	Collection/sampling method	How addressed
Spatially dependent plots	2006	Each vegetation plot had four subplots close to one another	Vegetation data for plots that were located within 50 m of one another were averaged for each year's data (2006, 2007)
	2007	Subplots were dropped beginning in 2007, but some 2007 vegetation plots were located close to one another	
Small tree stems counted within different-sized areas	2006	Small tree stems counted in the larger (11.3-m radius) circle	Small tree stem counts for each species were divided by the area of the circle in which they were counted (i.e., 11.3-m radius or 401.15 square meters (m^2) for 2006, 5-m radius or 78.54 m^2 for all other years)
	2007–2012	Small tree stems counted in the smaller (5 m-radius) circle	
Nest data collection and analysis	2006	Vegetation data collected at all nest locations and also at vegetation plots in available habitat	Additional analysis was performed comparing nest plots to non-nest plots within occupied sites for 2006–2009 and 2012. Year was found not to be an influencing random factor and was excluded from the 2006–2012 analysis (as this would bias the results because only nest data and no available habitat data were collected in 2010 and 2011)
	2007 – 2009, 2012		
	2010, 2011	Vegetation data collected at all nest locations to increase sample size; no data collected at vegetation plots in available habitat	

Data Analysis

We performed multiple logistic regression mixed-effects models to test hypotheses of cuckoo site occupancy and nest site selection. We used site management type (LCR MSCP restoration, non-LCR MSCP restoration, BWR natural, and non-BWR natural) as a random factor in our models to help control for inherent differences in vegetation based on different management (for a statistical analysis and description of differences see attachment A). We also incorporated year as a blocking factor for the site level analysis, but not for the nest analysis (as this would bias the results because only nest data and no available habitat data were collected in 2010 and 2011). However, we did investigate whether year was a factor in our nest analyses by performing additional subset analyses to compare nest plots to non-nest plots within occupied sites for 2006–2009 and 2012. Year was not an influencing factor on

Table 6-3.—Vegetation parameters collected 2006–2012

Parameter	2006	2007	2008	2009	2010[1]	2011[1]	2012
Location information	X	X	X	X	X	X	X
Total canopy (all canopy layers, any height): Average height/dominant species/closure (densiometer reading)	X	X	X	X	X	X	X
High canopy (above 5 m): Average height/dominant species/closure (visual estimate)	X[2]	X[3]	X	X	X	X	X
Main canopy (layer that provides the most shade): Average height/dominant species/closure (visual estimate)	X	X	X	X	X	X	X
Litter depth: Average of 12 readings within 5-m plot	X		X	X	X	X	X
Percent ground cover (sum to 100%): Grass/leaf litter/downed logs/bare ground/standing water/all green/shrub/forb/sedge/marsh vegetation/brush	X	X	X	X	X	X	X
Shrub or sapling: Species/# < 2.5 centimeter (cm) diameter breast height (DBH)/# 2.5–8 cm DBH	X	X	X	X	X	X	X
Small tree stems: Species/# < 8 cm DBH/# 8–23 cm DBH	X[4]	X	X	X	X	X	X
Large tree stems: Species/# 23–38 cm DBH/# > 38 cm DBH	X	X	X	X	X	X	X
Snags: Species/# > 8 cm and < 12 cm DBH/# > 12 cm DBH	X	X	X	X	X	X	X

[1] Data recorded for nests to increase the sample size for nest analyses.
[2] In 2006, average canopy height was not recorded for the high canopy.
[3] In 2007, canopy closure was not recorded for the high canopy.
[4] In 2006, small trees were counted in the larger 11.3-m circle. In 2007–12, they were counted in the 5-m circle only.

the conclusions and as a result, year was excluded from the 2006–2012 analyses. To analyze nest success, we used logistic exposure models (Shaffer and Burger 2004). Similar to the Mayfield method (Mayfield 1975), logistic exposure models take into account the amount of time a nest is observed and gives each nest unique values of exposure covariates. Logistic exposure models are not able to incorporate site management type as a blocking agent. Because the BWR nests had 100% apparent nest success (chapter 8), we only analyzed data from LCR MSCP restoration sites to investigate nest fate in order to eliminate bias in the results.

For all analyses, we checked for multicollinearity between habitat variables and excluded variables from the same model if they had a variance inflation factor greater than 5 in any model (Belsey et al. 1980). We used an information theoretic approach (Burnham and Anderson 2002) to model the data. Model ranking and selection was done using AIC for small sample sizes. Burnham and Anderson (2002) advise the use of AIC_c (instead of AIC) when the sample size divided by the number of variables is less than 40, as was the case. For each model, we calculated the log likelihood (log ($\mathcal{L}$)), number of parameters (K), AIC values, the relative AIC difference (Δ_i, the AIC difference between each model compared to the top model with the lowest AIC), and the relative Akaike weights (ω_i). Models were selected using the Δ_i values used to quantify the uncertainty associated with model selection and to determine the likelihood of the model given the data (Burnham and Anderson 2002). Models with Δ_i less than 2 were considered to have substantial support, those with Δ_i between 2 and 7 considerably less support, and those with Δ_i greater than 10 to have no support (Burnham and Anderson 2002).

We used multi-model inference to obtain accurate estimates of model parameters from competing models by averaging models with a $\Delta_i < 2$ (Burnham and Anderson 2002). Model-averaged multiple logistic regression estimates and odds ratios were calculated using Akaike weights for the weighted model average (Burnham and Anderson 2002). The final averaged models contained the most important variables. We used the sample variances from each model in conjunction with the model's Akaike weight to calculate unconditional standard errors (the SE terms are not conditional upon any one model). We calculated the relative importance of each variable in the set of top competing models by summing the Akaike weights from all the models in the set from which the variable occurred (Burnham and Anderson 2002). We also calculated the independent contribution of each predictor variable to the total explained variance of the averaged model through hierarchical partitioning (MacNally 2002). Hierarchical partitioning isolates the amount of variance attributed to each predictor variable independent of any joint contribution, while the AIC relative importance is a measure of the variable's importance in explaining the data in the averaged model.

In our sampling design of nest site selection versus availability, model-averaged logistic regression results yield a logistic discriminate function that can be used to identify those habitat characteristics most strongly correlated with nest presence (habitat use) based on a comparison of observed use versus random available plots (Keating and Cherry 2004). The odds ratio is used to understand the influence of predictor variables on occupancy and use versus availability (Keating and Cherry 2004). An odds ratio greater than 1 indicates a positive relationship, and an odds ratio less than 1 signifies a negative relationship (Ott and Longnecker 2001). Strong relationships are indicated by odds ratios with 95% confidence intervals that do not contain 1 (Ott and Longnecker 2001). Prior to our analyses, we verified that the assumptions of all statistical tests had been met. We used R statistical package 2.11.1 for all data analyses (R-Development Core Team 2010).

RESULTS

Site Occupancy

One model with considerable support elucidated cuckoo occupancy at the site level (table 6-4), containing three explanatory variables (table 6-5). We did not perform model averaging because all other models had $\Delta_i > 2$.

Table 6-4.—Results of AIC-based model selection for yellow-billed cuckoo site occupancy (A * indicates the model had considerable support [$\Delta_i < 2$]).

Number	Model	K	-log likelihood	AIC	Δ_i	ω_i
1	TH + FP + AR	3	-351.50	715.11	0.00*	0.66268
2	TH + FP	2	-354.10	718.29	3.18	0.13498
3	TH + AR + SP	3	-353.81	719.73	4.62	0.06581
4	TH + FP + TC	3	-353.81	719.73	4.62	0.06580
5	TH + AR	2	-355.55	721.18	6.07	0.03182
6	TH +AR + TD	3	-354.81	721.74	6.63	0.02407
7	FP + AR	2	-357.63	725.33	10.22	0.00399
8	TH + SD	2	-351.50	725.64	10.53	0.00342
9	TH + PD	2	-357.78	725.65	10.54	0.00341
10	TH + MC	2	-357.86	725.72	10.61	0.00329
11	NLT + NST + FP	3	-358.68	729.47	14.36	0.00050
12	TC	1	-362.40	732.86	17.75	0.00009
13	NST + TC	2	-361.75	733.59	18.47	0.00006
14	NLT + NST	2	-361.92	733.93	18.82	0.00005

Abbreviations: AR = Area, FP = Percent forb ground cover, MC = Percent main canopy closure, NLT = Native large tree density, NST = Native small tree density, PD = *P. fremontii d*ensity, SD = *S. gooddingii* density, SP = Percent low shrub cover, TC = Percent total canopy closure, TH = Total canopy height, and TD = Tamarix density.

Table 6-5.—Model results for important vegetation characteristics of occupied (n = 414 plots) versus unoccupied yellow-billed cuckoo sites (n = 315 plots) from the top model ($\Delta_i < 2$)

The odds ratio is used to understand the influence of variables on occupied sites compared to unoccupied sites. An odds ratio > 1 indicates a positive relationship with site occupancy, while an odds ratio < 1 signifies a negative relationship with site occupancy. The vegetation variables with the strongest associations (indicated by *) have CIs that do not include 1.

Vegetation variable	Odds ratio	95% confidence interval for odds ratio	Association with site occupancy	Estimate (β)	Unconditional SE
Total canopy average height	1.065	(1.033, 1.131)*	+	0.077	0.021
Percent forb cover	1.028	(1.005, 1.056)*	+	0.030	0.012
Area	1.010	(0.998, 1.022)	+	0.010	0.006

* Indicates a strong association.

When controlling for site management type, the top model showed that sites with increased average total canopy height and forb cover were more likely to be occupied by cuckoos. Increased site size was also associated with cuckoo site occupancy, but to a lesser degree. Summary statistics for these variables are presented in tables 6-6 to 6-8. To investigate the differences in area between occupied and unoccupied sites, we performed nonparametric t-tests (i.e., Wilcoxon rank-sum tests) due to non-normal data distributions. Occupied sites were significantly larger in size than unoccupied sites ($W = 426$, $P < 0.001$), with occupied sites having a median size of 37.2 ± 21.9 ha, range = 1.6–88.0 ha (n = 414), compared to 12.8 ± 9.6 ha, range = 0.9–164 ha (n = 315) for unoccupied sites.

Table 6-6.—Summary statistics for total canopy average height

Average, standard error, range, and sample size for occupied and unoccupied sites by year and for all years.

	Total canopy average height (m)							
	Occupied sites				Unoccupied sites			
Year sampled	Average	SE	Range	N	Average	SE	Range	N
2006	7.98	0.68	3–20	35	6.55	0.46	0–16	81
2007	18.70	0.90	4–42	82	10.28	0.52	0–23	64
2008	6.54	0.37	0–18	88	7.94	0.79	0–23	48
2009	10.55	0.63	4–24	54	9.42	0.45	4–19	60
2012	7.50	0.26	2–17	155	6.47	0.31	3–12	62
2006–2012	9.95	0.33	0–42	414	8.05	0.24	0–23	315

Table 6-7.—Summary statistics for percent forb cover
Average, standard error, range, and sample size for occupied and unoccupied sites by year and for all years.

Year sampled	Percent forb cover							
	Occupied sites				Unoccupied sites			
	Average	SE	Range	N	Average	SE	Range	N
2006	3.30	1.15	0–30	35	0.53	0.22	0–13	81
2007	0.81	0.22	0–10	82	0.65	0.29	0–15	64
2008	7.24	2.25	0–100	88	0.75	0.30	0–11	48
2009	10.71	2.88	0–99	54	3.65	1.77	0–81	60
2012	4.06	1.13	0–96	155	2.02	0.76	0–38	62
2006–2012	4.89	0.76	0–100	414	1.48	0.38	0–81	315

Table 6-8.—Summary statistics for area (non-normal distribution)
Median, absolute median deviation, range, and sample size for occupied and unoccupied sites by year and for all years.

Year sampled	Area (ha)							
	Occupied sites				Unoccupied sites			
	Median	Deviation	Range	N	Median	Deviation	Range	N
2006	49.80	26.24	3.0–84.3	35	16.00	11.56	6.3–63.5	81
2007	49.80	44.85	3.0–84.3	82	10.00	5.49	6.3–24.0	64
2008	49.80	26.24	3.0–88.0	88	10.60	5.86	1.6–164.0	48
2009	37.20	19.87	3.0–63.5	54	10.10	6.15	0.9–67.5	60
2012	29.60	20.02	1.6–63.5	155	23.53	17.08	3.7–67.5	62
2006–2012	37.20	21.97	1.6–88.0	414	12.80	9.64	0.9–164.0	315

Nest Placement and Success

We analyzed the data using multiple logistic regression mixed-effects models for nest site selection. This analysis employed the full dataset from 2006–2012. Two models provided considerable support for predicting cuckoo nest placement (models 1 to 4) (table 6-9). The averaged model retained three explanatory variables (table 6-10). Of these, the most important were native small tree stem density and total canopy closure; these two variables also explained the most variance in the dataset (table 6-11).

Table 6-9.—Results of AIC-based model selection for predicting yellow-billed cuckoo nest placement (A * indicates the model had considerable support [$\Delta_i < 2$] and was used in the averaged model.)

Number	Model	K	-log likelihood	AIC	Δ_i	ω_i
1	NST + TC + NLT	3	-172.578	355.27	0.00*	0.35281
2	NST + TC	2	-172.311	357.28	2.00*	0.12952
3	NST + TC + NLT + TD	4	-172.565	357.30	2.02	0.12830
4	NST + TC + GP	3	-173.950	358.02	2.74	0.08944
5	NST + TC + BP	3	-174.079	358.28	3.00	0.07859
6	NST + TC + TH	3	-174.094	358.31	3.03	0.07744
7	NST + TC + TD	3	-174.578	359.27	4.00	0.04775
8	NST + TC + TD + GNP	4	-173.706	359.58	4.30	0.04101
9	NST + TC + TD + BP	4	-174.039	360.24	4.97	0.02941
10	NST + TC + TD + FP	4	-174.427	361.02	5.75	0.01994
11	NST + NLT	2	-178.091	364.26	8.99	0.00395
12	NST + NLT + SP	3	-178.060	366.24	10.97	0.00147
13	NST + WP	2	-180.468	369.01	13.74	0.00037
14	TC + SD	2	-184.991	378.06	22.79	0.00000
15	TC + SD + PD	3	-184.161	378.44	23.17	0.00000
16	TC + SD + TD	3	-184.965	380.05	24.77	0.00000
17	TC + PD	2	-186.740	381.56	26.28	0.00000

Abbreviations: BP = Percent bare ground, FP = Percent forb cover, GP = Percent grass cover, GNP = Percent green ground cover, MC = Percent main canopy closure, NLT = Native large tree density, NST = Native small tree density, PD = *P. fremontii* density, SD = *S. gooddingii* density, SP = Percent low shrub cover, TC = Percent total canopy closure, and TD = Tamarisk density.

Table 6-10.—Model-averaged results for important vegetation characteristics of nest (n = 92) versus non-nest plots (n = 414) within occupied yellow-billed cuckoo sites

The odds ratio is used to understand the influence of variables on nest plots compared to non-nest plots. An odds ratio > 1 indicates a positive relationship with nest plots, while an odds ratio < 1 signifies a negative relationship with nest plots. In the averaged model, the vegetation variables with the strongest associations [indicated by a *] have confidence intervals that do not include 1.

Vegetation variable	Odds ratio	95% CI	Association with nests	Estimate (β)	Unconditional SE
Native small tree stem density	1.288	(1.15, 1.44)*	+	0.253	0.056
Percent total canopy closure	1.028	(1.01, 1.05)*	+	0.027	0.009
Native large tree stem density	1.088	(0.94, 1.26)	+	0.084	0.075

* Indicates a strong association.

Table 6-11.—Relative importance of parameters in each averaged model (Δ_i < 2) for the nest-level logistic regression analysis
Hierarchical partitioning isolates the amount of variance attributed to each predictor variable independent of any joint contribution, while the AIC relative importance is a measure of the variable's importance in explaining the data in the averaged model. Parameters with higher numbers in the left column independently explain more variance in the model than those with lower numbers; parameters with higher numbers in the right column are of overall greater importance in the averaged model.

Variable	Variance explained	AIC relative importance
Native small tree stem density	72.12	1.00
Percent total canopy closure	27.38	1.00
Native large tree stem density	0.50	0.73

Native small tree (8–23 centimeter [cm] diameter breast height [DBH]) stem density and total canopy closure were positively associated with cuckoo nest placement (see table 6-11). Native large tree (> 23 cm DBH) stem density showed a weak positive association with nest placement. Summary statistics for these variables are presented in tables 6-12 to 6-15. Table 6-16 shows 2012 summary statistics of important vegetation characteristics for each LCR MSCP site, which also includes the maximum number of breeding territories estimated at each site (chapter 5) for comparison.

Table 6-12.—Summary statistics for native small tree stem density (non-normal distribution)
Median, absolute median deviation, range, and sample size for nests and available plots by year and for all years.

	Native small tree stem density (square meters)							
	Nest				Available			
Year sampled	Median	Deviation	Range	N	Median	Deviation	Range	N
2006	0.108	na	na	1	0.102	0.151	0–1.789	35
2007	0.388	0.217	0.038–0.598	4	0.076	0.094	0–0.497	82
2008	0.382	0.151	0.013–0.484	5	0.025	0.038	0–0.751	88
2009	0.204	0.245	0.013–2.203	8	0.038	0.057	0–0.726	54
2010	0.713	0.982	0–6.048	17	na	na	na	na
2011	0.344	0.359	0–2.266	29	na	na	na	na
2012	0.280	0.113	0.013–0.598	28	0.064	0.094	0–1.235	155
2006–2012	0.293	0.264	0–6.048	92	0.064	0.094	0–1.789	414

Table 6-13.—Summary statistics for percent total canopy closure (non-normal distribution) Median, absolute median deviation, range, and sample size for nests and available plots by year and for all years.

	Percent total canopy closure							
	Nest				Available			
Year sampled	Median	Deviation	Range	N	Median	Deviation	Range	N
2006	93	na	na	1	80	29.7	0–100	35
2007	95	7.4	90–100	4	73	40.8	8–100	82
2008	84	8.9	66–95	5	78	21.5	3–97	88
2009	87	17.3	44–99	8	77	20.4	41–99	54
2010	93	4.4	78–100	17	na	na	Na	na
2011	96	5.4	37–100	29	na	na	Na	na
2012	98	1.5	62–100	28	93	8.1	31 –100	155
2006–2012	95	6.9	37–100	92	85	17.9	0–100	414

Table 6-14.—Summary statistics for native large tree stem density (non-normal distribution) Median, absolute median deviation, range, and sample size for nests and available plots by year and for all years.

	Native large tree stem density (square meters)							
	Nest				Available			
Year sampled	Median	Deviation	Range	N	Median	Deviation	Range	N
2006	0.0062	na	na	1	0.0012	0.0018	0–0.249	35
2007	0.0025	0.0018	0–0.0050	4	0.0075	0.0074	0–0.0349	82
2008	0.0025	0.0037	0–0.0075	5	0.0000	0.0000	0–0.0374	88
2009	0.0075	0.0111	0–0.0224	8	0.0025	0.0037	0–0.0324	54
2010	0.0000	0.0000	0–0.0125	17	na	na	na	na
2011	0.0000	0.0000	0–0.3590	29	na	na	na	na
2012	0.0000	0.0000	0–0.0399	28	0.7479	0.0111	0–0.1396	155
2006–2012	0.0000	0.0000	0–0.3590	92	0.0025	0.0037	0–0.1396	414

Table 6-15.—Summary statistics for native large tree stem density
Average, standard error, range, and sample size for nests and available plots by year and for all years

Year sampled	Native large tree stem density (square meters)							
	Nest				Available			
	Median	Deviation	Range	N	Median	Deviation	Range	N
2006	0.0062	na	na	1	0.0053	0.0012	0–0.249	35
2007	0.0025	0.0010	0–0.0050	4	0.0081	0.0009	0–0.0349	82
2008	0.0029	0.0014	0–0.0075	5	0.0039	0.0007	0–0.0374	88
2009	0.0084	0.0022	0–0.0224	8	0.0070	0.0012	0–0.0324	54
2010	0.0013	0.0008	0–0.0125	17	na	na	na	na
2011	0.0251	0.0126	0–0.3590	29	na	na	na	na
2012	0.0035	0.0018	0–0.0399	28	0.0169	0.0020	0–0.1396	155
2006–2012	0.0102	0.0039	0–0.3590	92	0.0101	0.0009	0–0.1396	414

We included habitat data from 65 nests in the logistic exposure analysis to compare habitat variables at successful versus failed nests at LCR MSCP restoration sites. Of these, 43 fledged young, and 22 failed. We used the three variables found important for nest site selection in the logistic exposure models. Total canopy closure was close to statistically significant and was positively associated with nest success ($\beta = 0.019$, $P = 0.078$).

DISCUSSION

The revegetation efforts on the historical LCR flood plain has thus far created successful yellow-billed cuckoo breeding habitat. Compared to BWR natural sites, the LCR MSCP restoration sites are, overall, in an earlier successional stage; however, there is some overlap in vegetation characteristics (McNeil et al. 2011). Over future years, we expect to see this overlap increase, with LCR MSCP restoration sites having increased native large tree densities and tree heights. Although the data collection methods were inconsistent from 2006 to 2012, the results were in agreement with previous work on yellow-billed cuckoo habitat selection (Laymon 1980; Laymon and Halterman 1989; Laymon et al. 1997).

Table 6-16.—Summary statistics for LCR MSCP restoration sites, 2012: percent total canopy closure, average total canopy height, native small tree stem density, forb cover; and average (SD)

Maximum territories based on 2012 data (chapter 5). Maximum territories per 20 ha (average cuckoo territory size) are given to standardize variation in site size. Note that (vegetation plot) sample sizes are small.

Site name	Site code	Area (ha)	Maximum # estimated territories	Maximum territories/ 20 ha	Plot sample size (n)	Canopy closure	Average total canopy height (m)	Native small tree stem density (square meters)	Percent forb cover
ʻAhakhav Tribal Preserve	CRIT	59.6	2	0.7	6	76.0 (10.8)	5.8 (1.3)	0.2546 (0.2)	0.33 (21.3)
Beal	HAVBR	21.3	1	0.9	6	96.9 (5.2)	7.5 (1.0)	0.3777 (0.3)	0.50 (0.5)
Cibola Crane Roost	CIBCR	48.0	6	2.5	6	81.1 (25.1)	7.2 (3.9)	0.0997 (0.1)	9.00 (13.7)
Cibola Mass Planting	CIBMP	23.7	0	0.0	6	67.3 (20.8)	8.0 (2.4)	0.2228 (0.2)	0.33 (0.8)
Cibola Nature Trail	CIBCNT	14.4	1	1.4	4	93.5 (4.4)	5.8 (1.3)	0.1146 (0.1)	0.00 (0.0)
Cibola Valley Conservation Area	CVCA (all phases)	96.5	5	1.0	17	91.2 (7.2)	9.1 (3.0)	0.3280 (0.2)	9.65 (15.2)
Cibola Valley Phase 1	CVCA1	34.8	3	1.7	6	96.2 (2.4)	10.5 (3.7)	0.1846 (0.2)	13.5 (21.3)
Cibola Valley Phase 2	CVCA2	24.7	2	1.6	6	85.3 (9.1)	8.3 (2.5)	0.3586 (0.2)	5.83 (6.0)
Cibola Valley Phase 3	CVCA3	37.0	0	0.0	5	92.2 (2.5)	8.2 (2.5)	0.4635 (0.1)	9.60 (16.3)
Palo Verde Ecological Reserve	PVER (all phases)	161.8	39	4.8	26	81.5 (16.1)	9.3 (3.7)	0.3164 (0.3)	7.19 (22.7)
Palo Verde Phase 1	PVER 1	8.3	2	4.8	2	88.1 (3.7)	6.0 (1.4)	0.5793 (0.8)	0.00 (0.0)
Palo Verde Phase 2	PVER 2	24.2	5	4.1	5	71.1 (20.6)	7.6 (3.4)	0.1783 (0.2)	0.00 (0.0)
Palo Verde Phase 3	PVER 3	19.8	4	4.0	6	87.8 (6.4)	13.5 (3.6)	0.2334 (0.1)	1.83 (2.9)
Palo Verde Phase 4	PVER 4	35.8	16	8.9	7	88.0 (14.2)	9.9 (2.6)	0.4111 (0.4)	0.00 (0.0)
Palo Verde Phase 5	PVER 5	73.7	12	3.3	6	74.1 (19.3)	6.8 (1.0)	0.3162 (0.3)	29.33 (42.5)

Site Occupancy

In addition to area, total canopy average height was found to be an important predictor of cuckoo site occupancy. Increased canopy height positively influenced site occupancy. Cuckoo foraging behavior in dense canopy at heights greater than 4 m and in mature vegetation has previously been documented in California riparian habitat (Laymon 1980). In the South Fork Kern River, cuckoos have been observed foraging at an average height of 10.5 m (range 4–18 m) (Laymon and Halterman 1985) although they have also been observed foraging below this height (Laymon 1980). During this study, the mean total canopy average height for occupied sites was 10.0 m (range 0–42 m) (see table 6-6). These results indicate that at the site level, cuckoos prefer taller canopy on average.

At the ground level, increased forb cover was positively associated with cuckoo site occupancy. This result may be due to irrigated restoration sites causing increased forb cover (particularly alfalfa). This low vegetation may also provide an indirect source of food (i.e., an insect breeding and/or feeding ground). Although the result may be a factor of other site-level attributes, in the South Fork Kern River, cuckoos nested at sites with significantly greater forb cover than was found in the forest at random (Laymon et al. 1997). At LCR MSCP restoration sites, cuckoos forage on prey other than cicadas (McNeil et al. 2011), and the grasses and forbs at these sites could be a partial source of this alternative prey (directly or indirectly). Yellow-billed cuckoos feed on a variety of prey, including large macroinvertebrates such as caterpillars, katydids, grasshoppers, crickets, and mantids (Laymon 1980; Halterman 2009), which can be found in this type of habitat (Borror et al. 1989). Additional macroinvertebrate sampling would explore this hypothesis and assess whether this type of ground cover truly is important for cuckoo site occupancy.

To a lesser degree than total canopy height and forb cover, area (site size) was also a predictor of cuckoo site occupancy. We found the median size of occupied sites (37.2 ha) to be almost three times as large as unoccupied sites (12.8 ha). The positive relationship between habitat patch size and occupancy has been previously documented for yellow-billed cuckoos (Galli et al. 1976; Laymon and Halterman 1989; Parker et al. 2005; Girvetz and Greco 2009). Laymon and Halterman (1989) concluded in a California study that cottonwood-willow habitat less than 15 ha in extent and 100 m in width was unsuitable, sites 20–40 ha and 100–200 m wide were marginal, sites 41–80 ha and wider than 200 m were suitable, and sites > 80 ha and wider than 600 m were optimal.

Nest Placement and Success

In this study, yellow-billed cuckoo nests have primarily been found in locations with specific vegetation structures when compared to available habitat, mainly areas with increased native tree densities and total canopy closure. Increased closure at all canopy levels was a strong predictor of cuckoo nest placement; this result was expected and has been documented previously. In California, cuckoos chose nest locations characterized by greater canopy closure and higher foliage volume (Laymon et al. 1997). Increased closure from dense foliage is important for concealing and protecting the nest from predators (Laymon 1980). Additionally, increased canopy closure will shade the nest, keeping it cooler (chapter 7), and may increase nestling survival (Rangel-Salazar et al. 2008).

Increased native small tree stem density (8–23 cm DBH) had a strong positive relationship with cuckoo nest locations. Our results also showed a weak positive relationship between nest locations and increased stem density of native large trees (> 23 cm DBH). Native large trees are important because they provide canopy closure and are preferred by prey items, specifically cicadas and possibly other large invertebrates (Laymon 1980; Glinski and Ohmart 1984; Laymon and Halterman 1985), but cuckoos appear to find increased stem densities of native small trees suitable for nesting purposes.

The average total canopy height for nest plots in our study was 9.6 m; similar results have been observed along the South Fork Kern River in California where optimal nesting habitat tended to have a mean canopy height of 7–10 m, while sites 10–15 m high were chosen less frequently (Laymon et al. 1997). It seems cuckoos may prefer earlier successional stages for nesting, but will use older habitat as long as the canopy closure is sufficient. Overall, the results show that yellow-billed cuckoos are selecting nest locations based on increased stem densities of native small trees and increased closure at all canopy layers.

No measured habitat characteristics from the averaged model were statistically significant predictors of cuckoo nest fate. Similarly, successful and failed nests showed no temperature or humidity differences (chapter 7). While we found no statistically significant relationships between habitat variables and nest success ($\alpha = 0.05$), canopy closure may show positive biological relevance ($P = 0.078$). Other possible influences contributing to nest success may include parental age or experience, food abundance, and predation of eggs, young, or parents (Reese and Kadlec 1985; Martin 1987, 1993; Chalfoun and Schmidt 2012).

Our results support the current understanding that yellow-billed cuckoos prefer large patches of habitat and dense canopy closure for nesting (Laymon et al. 1997); this does not negate the importance of smaller-sized stopover habitat. We also found that increased stem densities of small native trees were important to cuckoo nest placement. Optimal management practices should aim to provide large riparian habitats that continue to produce a mosaic of both mature large trees and dense patches of small trees. Creation of this type of mosaic habitat is already a goal of the LCR MSCP (LCR MSCP 2004a).

Chapter 7 – Microclimate

INTRODUCTION

Birds respond directly and indirectly to microclimate variations depending on specific habitat preferences and life history traits (Champlin et al. 2009). A habitat's microclimate can affect a species' foraging and nesting decisions, and it can also be a determinant of habitat suitability. For example, in extreme environments, birds may shift their habitat use based on physiological comfort (Champlin et al. 2009) or prey availability (Wachob 1996; Wilson et al. 2005). In the Southwestern United States, Walsberg (1986) documented that during the summer months, phainopeplas (*Phainopepla nitens*) selected relatively cooler habitats to balance thermoregulatory demands. Additionally, the importance of microclimate to nesting birds has been documented for several species (D'Alba et al. 2009; Robertson 2009). These studies found that small-scale temperature and/or humidity differences affected reproductive outcomes. Few studies have specifically addressed avian habitat selection due to differences in microclimate in extreme desert riparian habitats where temperature and humidity likely have a strong influence. To understand microclimate influences on yellow-billed cuckoos on the LCR, we examined humidity and temperature data from 2008–2012 at (1) occupied sites compared to unoccupied sites (sites were considered occupied if there were two or more total survey detections in two or more survey periods and 10 days apart; otherwise, they were considered unoccupied in that year) (see chapter 5), (2) nest locations compared to available habitat (randomly chosen non-nest locations within occupied sites), and (3) successful nests compared to failed nests. We explored the importance of soil moisture in relation to cuckoo site occupancy and nest occurrence with a separate subset analysis of the data from 2008 and 2009. We also looked at how canopy closure, native small tree stem density, and soil moisture influenced temperature and humidity.

METHODS

We used one model of Thermocron iButton® (Embedded Data Systems LLC) to measure temperature (DS1921G) and another model (DS1923) to measure both temperature and relative humidity (RH). We programmed and uploaded data from iButtons® (hereafter called data loggers or loggers) using a dual iButton® receptor interface cable and high-speed USB interface adapter (SK-IB-R Connectivity Kit made by Embedded Data Systems LLC) and One Wire Viewer© software (Maxim Integrated Products). The data loggers were set to record temperature and RH once each hour on the hour. They were programmed to record temperature to the nearest 0.5 °C and to 0.6% RH.

We suspended the data loggers with wire approximately 2 m above the ground in a tree closest to the center of microclimate monitoring plots in a shaded location. We covered each data logger with a 3-inch-square of nylon mesh (2008) or suspended them from a 5.1 cm x 5.1 cm x 1 cm plastic container painted to reflect solar gain and provide shade (2009–2012). The mesh was dropped after 2008 and replaced with the plastic shading, as the mesh proved very desirable to rodents. We conducted a test with various housings (including the mesh and plastic container) and found no significant differences in temperature or humidity readings between the housings. We deployed the majority of data loggers in early June; additional loggers were placed below nests within a few days of discovery. We took care to conceal the loggers and to minimize disturbance to nesting birds. We retrieved the loggers between early and mid-September.

Each data logger recorded measurements through time during the breeding season (June – September), creating a repeated measures dataset. Data used for these analyses were from data logger locations that were randomly distributed at sites throughout the study area. Temperature and RH data loggers were placed at 616 random locations and 73 nests within 56 sites; 162 loggers recorded temperature only (attachment H).

Soil moisture data were collected in 2008 and 2009. Two soil moisture probes were used to collect volumetric water content (VWC) data: a Hydrosense™ (Campbell Scientific, Australia) and a Fieldscout® TDR 100/200 (Spectrum Technologies). The Fieldscout® TDR 100/200 measured VWC to a resolution of 0.1%, while the resolution of the Hydrosense™ unit was 1%. Field tests showed < 1.0% difference between these two types of probes when 13 readings were averaged (n = 5 replicates). Twelve-cm (4.7-inch) insertion rods were used for both types of soil moisture probe. Readings were taken at the center of the plot, and 1, 2, and 3 m from the center, in each of the four cardinal directions. This was done at each microclimate sampling plot once at the end of the survey season in 2008 and once during each of four or five survey periods in 2009. At nest plots where loggers were hung later in the season, soil moisture was measured fewer than five times. The average VWC at each plot was used for analyses.

Data Analysis

We averaged hourly data from each data logger to estimate diurnal (05:00:01–19:00:00) and nocturnal (19:00:01–05:00:00) mean and maximum temperature and RH for each day within each season. We used these averages to determine microclimate differences between occupied and unoccupied sites and between nest locations and available habitat (randomly chosen non-nest locations within occupied sites). We explored the importance of soil moisture in relation to cuckoo site occupancy and nest occurrence with a separate subset analysis of the data from 2008 and 2009. For the nest level analyses, we truncated the available habitat data to match the dates when nests were active each year.

For the microclimate analyses, we used logistic regression mixed-effects models to analyze temperature and humidity on our repeated measures dataset (measurements through time) and to account for latitudinal, seasonal, and yearly temperature variations. Effects of date (julian day), year, site, and latitude (UTM northing) were included as random effects in the models to analyze measurements through time and to account for yearly, latitudinal, and vegetative microclimate variation within the study area. For the soil moisture logistic regression mixed-effects models, we used the subset of data available (2008–2009). We used the same random factors (year and management type) and the main habitat variables from the top models of the habitat analyses for nest site selection and site occupancy (see chapter 6). We used AIC and deviance residual goodness-of-fit tests to assess model fit; final models were checked for overdispersion. The variance-covariance matrices were scalar with a compound symmetry structure.

Odds ratios from the output of the logistic models were used to evaluate the influence of microclimate and soil moisture on site occupancy and nest placement versus available habitat. An odds ratio greater than 1 indicates a positive relationship, whereas an odds ratio less than 1 signifies a negative relationship (Ott and Longnecker 2001). We performed separate analyses for nocturnal and diurnal RH and temperature due to high multicollinearity among these four variables.

Additionally, we employed Pearson's correlation coefficient to examine relationships between microclimate (temperature and RH), total canopy closure (spherical densiometer readings), and native small tree stem density (see chapter 6). We chose these habitat variables because they were found to have strong associations with nest site selection in the habitat analyses (see chapter 6). We also looked at the relationship between microclimate and soil moisture using Pearson's correlation coefficient. The dataset for these analyses used microclimate plot averages during the cuckoo breeding season (July – late August) from randomly located plots within the study area and were truncated to include only those plots from which variables of interest were available.

To analyze nest success, we used logistic exposure models (Shaffer and Burger 2004). Similar to the Mayfield method (Mayfield 1975), these models take into account the amount of time a nest is observed and gives each nest unique values of exposure covariates. Since the BWR nests had 100% apparent nest success, we only analyzed data from LCR MSCP restoration sites to investigate nest fate and microclimate in order to eliminate bias in the results. We used R statistical package 2.11.1 for all data analyses (R-Development Core Team 2010).

RESULTS

Microclimate averages are displayed on figures 7-1, 7-2, and in table 7-1. Both temperature and humidity showed temporal variation each year (figure 7-1). As expected, temperature and RH were negatively correlated, both diurnally (r_{446} = -0.852, r^2 = -0.726, n = 448, P < 0.001) and nocturnally (r_{446} = -0.842, r^2 = -0.709, n = 448, P < 0.001). Maximum diurnal temperature was negatively correlated to canopy closure, whereas maximum diurnal RH was not correlated (table 7-2). Canopy closure was not correlated to maximum nocturnal temperature or maximum nocturnal RH (table 7-2). Average diurnal and nocturnal temperatures showed the same patterns, while average diurnal RH was positively correlated with canopy closure (table 7-2). Soil moisture was negatively correlated to maximum diurnal temperature but not to maximum diurnal RH (table 7-2). Soil moisture was not correlated to maximum nocturnal temperature or maximum nocturnal RH (table 7-2). Soil moisture was negatively correlated to average diurnal and nocturnal temperatures and positively correlated to average RH (table 7-2). Soil moisture was not correlated to canopy closure (r_{173} = 0.102, n = 175, P = 0.178).

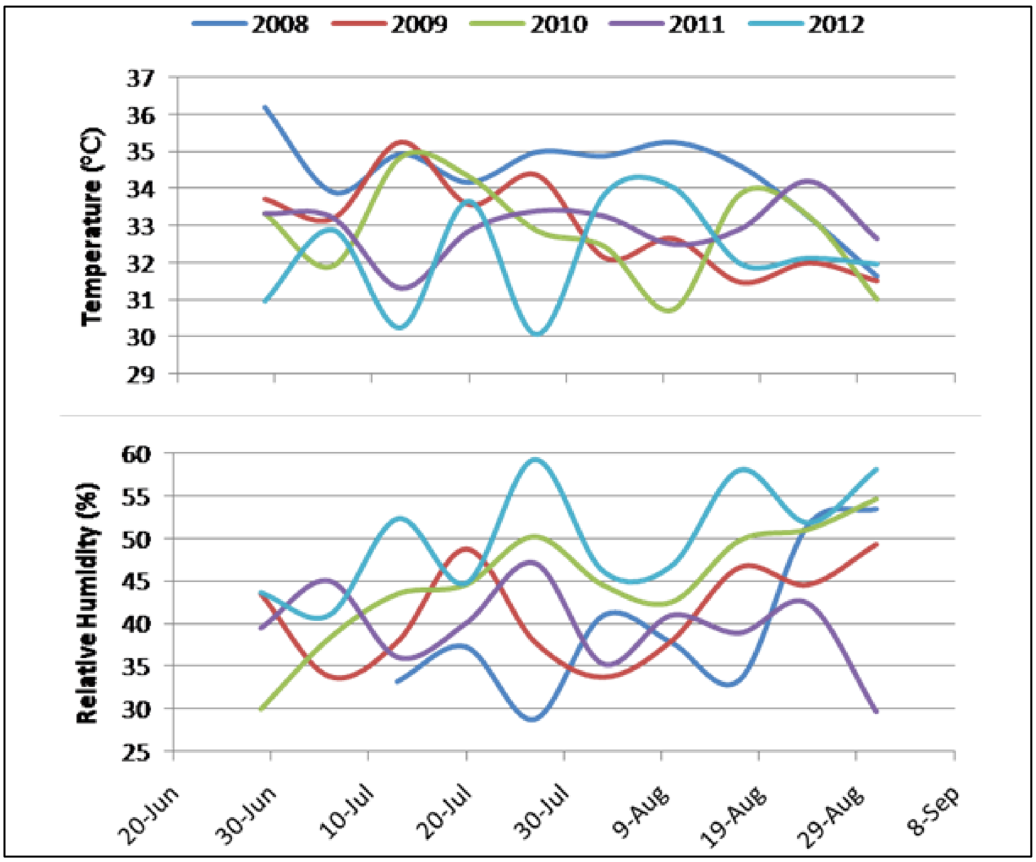


Figure 7-1.—Overall average diurnal and nocturnal temperature (°C) and RH (%) averaged by week for each year, LCR 2008–2012.

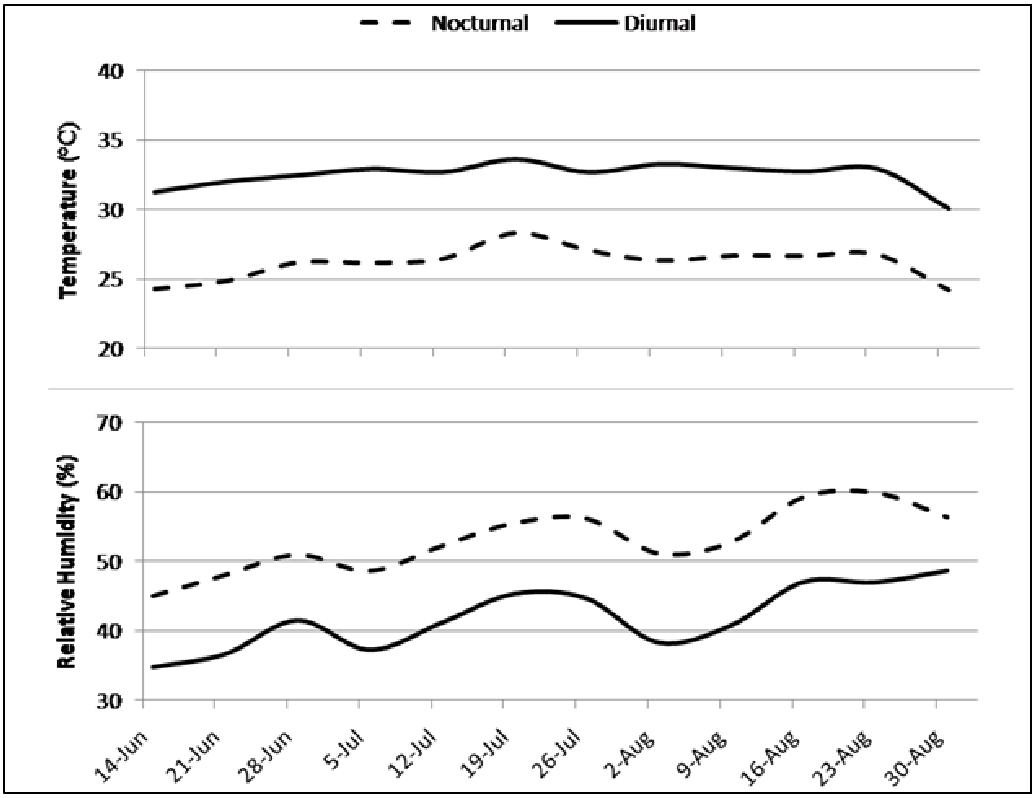


Figure 7-2.—Overall average diurnal and nocturnal temperature (°C) and RH (%) averaged by week for LCR 2008–2012.

Table 7-1.—Microclimate averages and SEs, at occupied and unoccupied sites, and nest locations compared to available habitat from 2008–2012
(Data presented as average ± SE, sample size [range].)

	Temperature (°C)		RH (%)	
Status[1]	**Diurnal**	**Nocturnal**	**Diurnal**	**Nocturnal**
Occupied site	32.51 ± 0.15, n = 457 (14.16, 44.96)	26.33 ± 0.16, n = 457 (14.81, 38.31)	49.22 ± 0.83, n = 339 (7.01, 100)	61.20 ± 0.93, n = 339 (7.91, 100)
Unoccupied site	33.49 ± 0.27, n = 159 (15.55, 45.11)	27.09 ± 0.29, n = 159 (13.38, 37.24)	41.88 ± 1.27, n = 115 (3.02, 99.49)	53.30 ± 1.53, n = 115 (5.64, 100)
Nest habitat	30.15 ± 0.29, n = 73 (15.63, 40.18)	25.29 ± 0.33, n = 73 (16.12, 35.59)	63.81 ± 1.71, n = 63 (18.98, 99.59)	73.51 ± 1.78, n = 63 (19.31, 100)
Available habitat	32.51 ± 0.15, n = 457 (14.16, 44.96)	26.33 ± 0.16, n = 457 (14.81, 38.31)	49.22 ± 0.83, n = 339 (7.01, 100)	61.20 ± 0.93, n = 339 (7.91, 100)

[1] Status: Occupied and unoccupied site averages were calculated by first averaging data from all data loggers within each site, then averaging the occupied and unoccupied sites for all years. Nest averages were calculated by averaging data recorded from each nest data logger during the breeding season. Available habitat averages were calculated from data loggers placed at random locations within occupied sites.

Table 7-2.—Pearson correlation coefficients (*r*) for microclimate variables and percent soil moisture, percent total canopy closure, and native small tree stem density
A positive number indicates a positive relationship between the variables, while a negative number indicates a negative relationship. P-values < 0.05 are shown in bold.

Microclimate variable	Percent soil moisture	Percent total canopy closure	Native small tree stem density
Average diurnal temperature	**-0.237*** (n = 176)	**-0.242**** (n = 353)	-0.065 (n = 353)
Average nocturnal temperature	**-0.162*** (n = 176)	0.068 (n = 353)	-0.068 (n = 353)
Average diurnal RH	**0.156*** (n = 168)	**0.144*** (n = 243)	-0.058 (n = 243)
Average nocturnal RH	0.103 (n = 168)	-0.006 (n = 243)	-0.047 (n = 243)
Maximum diurnal temperature	**-0.240*** (n = 176)	**-0.315**** (n = 353)	-0.048 (n = 353)
Maximum nocturnal temperature	-0.137 (n = 176)	-0.006 (n = 353)	-0.070 (n = 353)
Maximum diurnal RH	0.052 (n = 168)	-0.038 (n = 243)	-0.050 (n = 243)
Maximum nocturnal RH	0.092 (n = 168)	-0.025 (n = 243)	-0.027 (n = 243)

Note: * and ** significant (P < 0.05 and P < 0.01, respectively).

We found no differences in diurnal and nocturnal temperature or RH between occupied and unoccupied sites (tables 7-3 and 7-4). Nest microclimate was significantly different from that found at available habitat within occupied sites (figures 7-3 through 7-6 and tables 7-5 and 7-6). Nests were more likely to be located in areas with lower average and maximum diurnal temperatures and higher average and maximum diurnal and nocturnal RH (tables 7-5 and 7-6). The odds of nest placement decreased 23.8% for every degree (°C) increase in average diurnal temperature and increased 4.6% for every 1% increase in average diurnal RH. Maximum diurnal and nocturnal temperatures and RH showed similar patterns.

We had sufficient data to include 49 nests in the logistic exposure analysis to compare temperature and humidity between successful and failed nests. (Three of these data loggers only recorded temperature.) Of these nests, 31 fledged young, and 18 failed. None of the microclimate variables differed significantly between successful and failed nests.

Table 7-3.—Site occupancy (occupied sites compared to unoccupied sites) results of logistic regression mixed-effects models for average diurnal and nocturnal temperature and humidity, LCR 2008–2012
No significant results (α = 0.05). (LCL = lower confidence limit, and UCL = upper confidence limit.)

Microclimate variable	Estimate	Standard error	Wald statistic P-value	Odds ratio	95% LCL	95% UCL
Average diurnal temperature	0.021	0.022	0.337	1.021	0.978	1.067
Average nocturnal temperature	-0.007	0.017	0.668	0.993	0.960	1.027
Average diurnal relative humidity	-0.014	0.012	0.221	0.986	0.963	1.009
Average nocturnal relative humidity	0.002	0.009	0.849	1.002	0.984	1.020

Table 7-4.—Site occupancy (occupied sites compared to unoccupied sites) results of logistic regression mixed-effects models for maximum diurnal and nocturnal temperature and humidity, LCR 2008–2012
No significant results (α = 0.05). (LCL = lower confidence limit, and UCL = upper confidence limit.)

Microclimate variable	Estimate	Standard error	Wald statistic P-value	Odds ratio	95% LCL	95% UCL
Maximum diurnal temperature	-0.010	1.477	0.588	0.990	0.955	1.027
Maximum nocturnal temperature	-0.077	1.971	0.416	0.926	0.766	1.119
Maximum diurnal relative humidity	-0.003	0.470	0.673	0.997	0.982	1.012
Maximum nocturnal relative humidity	0.009	0.426	0.499	1.009	0.982	1.037

We found a weak (non-significant) negative association between cuckoo site occupancy and soil moisture ($\beta = -0.015$, $P = 0.059$). The median soil moisture at occupied sites was 12% ($n = 129$, range = 0–100) and at unoccupied sites was 25% ($n = 102$, range = 0–100). We found no difference in soil moisture between nests ($n = 18$) and available habitat ($n = 129$) ($\beta = -0.005$, $P = 0.813$).

DISCUSSION

We found no significant differences in RH or temperature (diurnal or nocturnal) between occupied and unoccupied sites. The lack of association between site occupancy and microclimate may be an indication that cuckoos are not selecting larger-scale areas (i.e., sites) based on temperature and humidity alone. Although we found a weak negative association with soil moisture and site occupancy, the

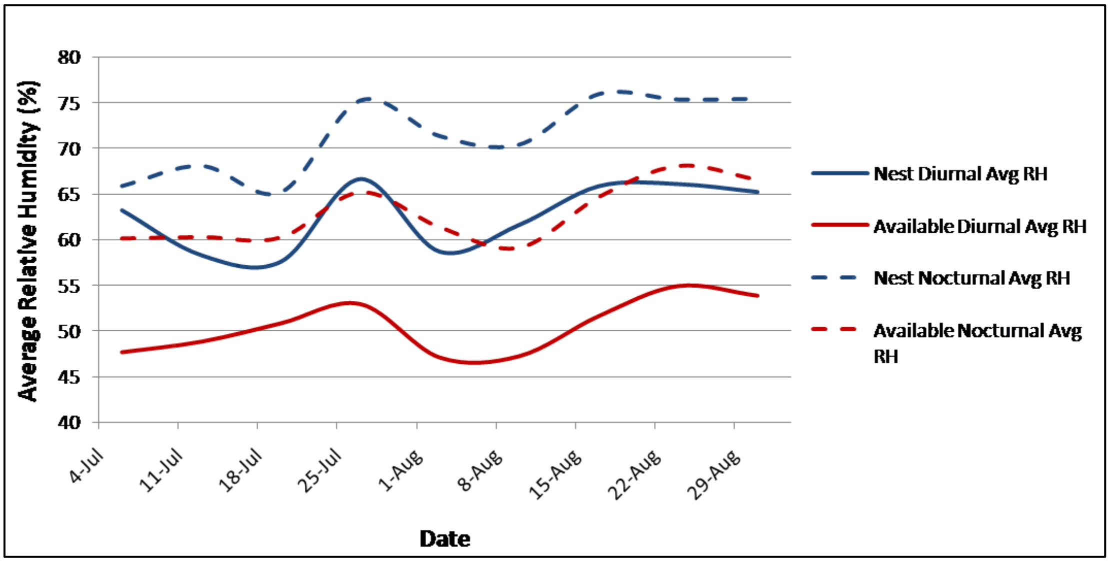


Figure 7-3.—Average diurnal and nocturnal RH (%) by week during the peak breeding season at nest habitat and available habitat (within occupied sites) 2008–2012.

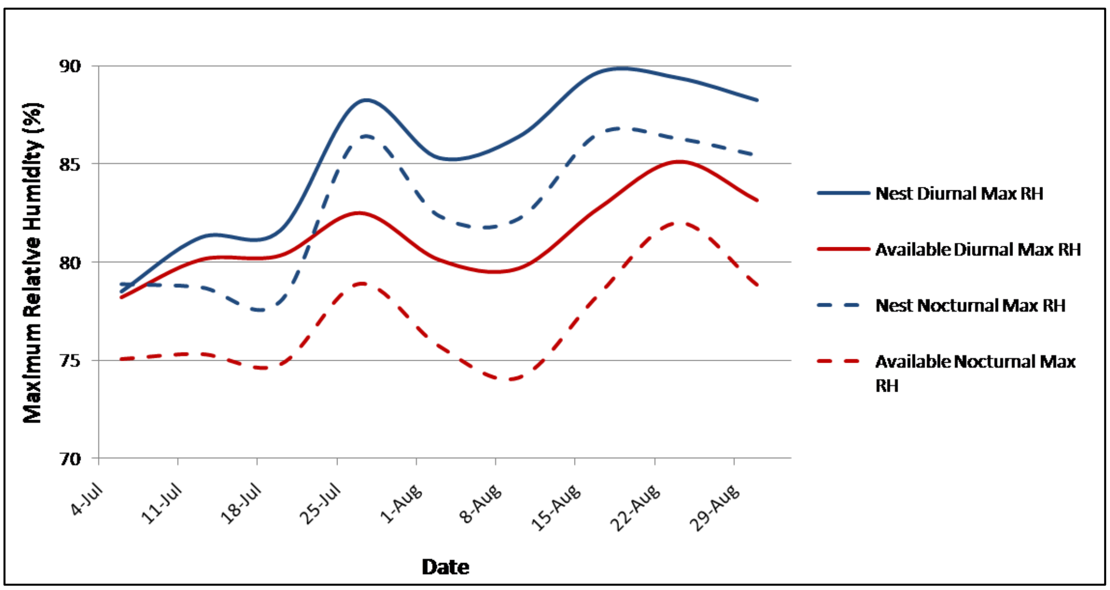


Figure 7-4.—Maximum diurnal and nocturnal RH (%) by week during the peak breeding season at nest habitat and available habitat (within occupied sites) during the 2008–2012 season.

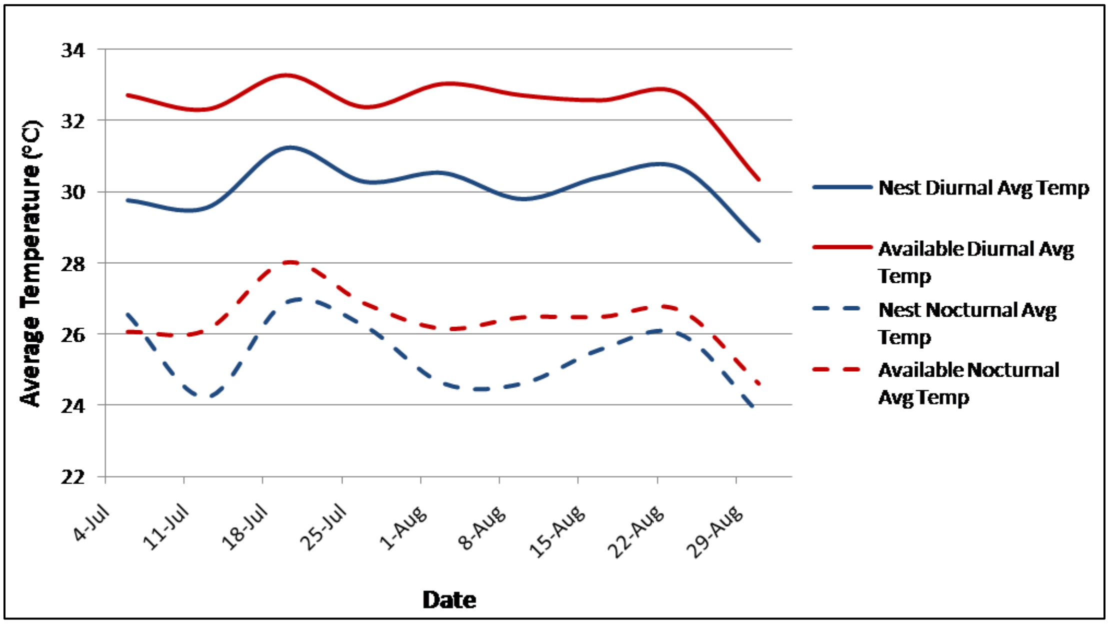


Figure 7-5.—Average diurnal and nocturnal temperature (°C) by week during the peak breeding season at nest habitat and available habitat (within occupied sites) 2008–2012.

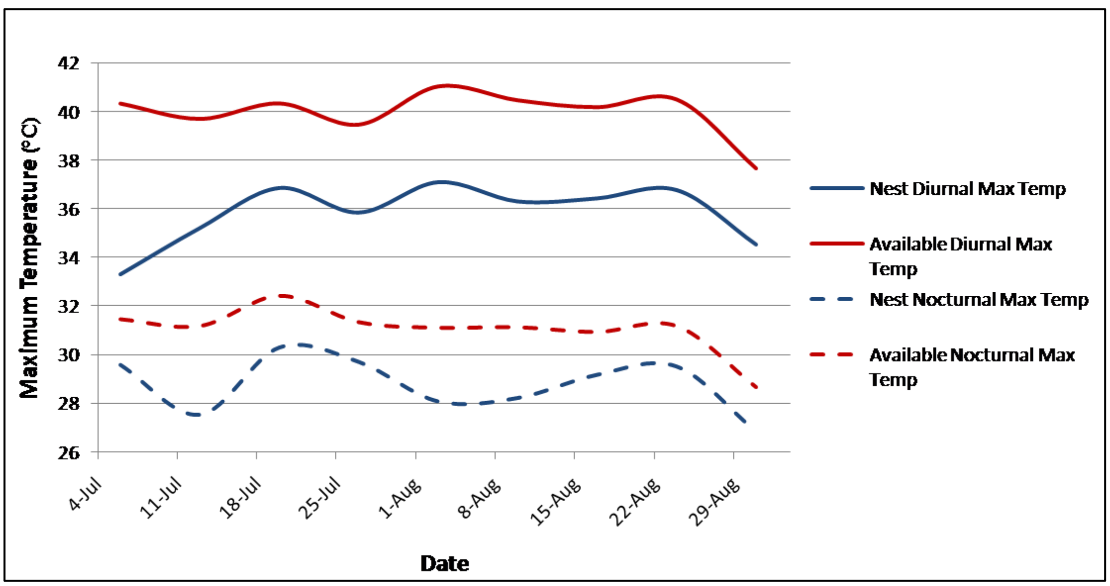


Figure 7-6.—Maximum diurnal and nocturnal temperature (°C) by week during the peak breeding season at nest habitat and available habitat (within occupied sites) during the 2008–2012 season.

Table 7-5.—Nest site selection results of logistic regression mixed-effects models for average diurnal and nocturnal temperature and humidity, LCR 2008–2012.
The odds ratio is used to interpret the difference in nest plots compared to available habitat for temperature and humidity. An odds ratio > 1 indicates a positive association with nest placement, whereas an odds ratio < 1 signifies a negative relationship.

Microclimate variable	Estimate	Standard error	Wald statistic P-value	Odds ratio	95% LCL	95% UCL
Nest diurnal average temperature	-0.272	0.011	< 0.001	0.762	0.745	0.780
Nest nocturnal average temperature	-0.017	0.009	0.059	0.983	0.965	1.001
Nest diurnal average RH	0.045	0.003	< 0.001	1.046	1.040	1.052
Nest nocturnal average RH	0.015	0.002	< 0.001	1.015	1.010	1.020

Table 7-6.—Nest site selection results of logistic regression mixed-effects models for maximum diurnal and nocturnal temperature and humidity, LCR 2008–2012.
The odds ratio is used to interpret the difference in nest plots compared to available habitat for temperature and humidity. An odds ratio > 1 indicates a positive association with nest placement, whereas an odds ratio < 1 signifies a negative relationship.

Microclimate variable	Estimate	Standard error	Wald statistic P-value	Odds ratio	95% LCL	95% UCL
Nest diurnal maximum temperature	-0.279	0.009	< 0.001	0.757	0.744	0.770
Nest nocturnal maximum temperature	-0.051	0.008	< 0.001	0.950	0.936	0.965
Nest diurnal maximum RH	0.024	0.003	< 0.001	1.024	1.018	1.030
Nest nocturnal maximum RH	0.016	0.003	< 0.001	1.016	1.011	1.021

results were non-significant ($P = 0.059$) and are counterintuitive. It should be noted that in 2010 and 2011, EcoPlan Associates, Inc., continued soil moisture monitoring with specialized equipment and found that occupied yellow-billed cuckoo sites exhibited generally low to moderate soil moisture, which may be related to the correlation between sandy soils and lower soil moisture (Balluff 2012).

The nest site selection results indicate that cuckoos are selecting cooler, more humid locations for nest placement particularly in relation to ambient diurnal microclimate. On the LCR in Arizona, southwestern willow flycatchers (*Empidonax traillii extimus*) also chose nest sites that were more humid and had cooler mean temperatures relative to their available habitat (McLeod et al. 2008). Likewise, there is evidence from numerous avian studies that microclimate plays a role in nest site selection (Beissinger et al. 2005; Rhodes et al. 2009; Robertson

2009). During the early stages of offspring development, microclimate must be regulated in the nest because embryos are unable to regulate their own temperature. Most species maintain eggs at temperatures of 32–35 °C regardless of habitat, incubation strategy, or body size (Webb 1987; Williams 1996). Typical lethal limits in select species have been found at extremes, with a lower limit of 24–26 °C (domestic chicken) and an upper limit of 40.5–44 °C (western gull, Heermann's gull, Adélie penguin, and domestic chicken) (Webb 1987; Conway and Martin 2000). Breeding birds along the LCR are exposed to these types of upper limit extreme environmental conditions (often exceeding 43 °C in July) during nesting. While we found no relationship between nest fate and microclimate in our study, cuckoos do appear to be selecting cooler, more humid locations as a nesting strategy. Other possible influences contributing to cuckoo nest success may include parental age or experience, food abundance, and predation of eggs, young, or parents (Reese and Kadlec 1985; Martin 1987, 1993; Chalfoun and Schmidt 2012).

Greater canopy closure and dense vegetation at the nest site (Laymon et al. 1997; McNeil et al. 2011) may provide a more suitable microclimate for nest incubation and rearing young as well as concealment from predators (Laymon 1980). In this study, we found that canopy closure was negatively associated with diurnal temperature and positively associated with diurnal RH. We also saw that soil moisture was negatively associated with diurnal and nocturnal temperature and positively associated with diurnal RH. Therefore, ensuring that restoration sites have high humidity and areas of dense canopy closure may increase the availability of suitable nesting locations for yellow-billed cuckoos.

Chapter 8 – Nest Searching and Monitoring

INTRODUCTION

The ability to detect changes in reproductive performance is a crucial part of assessing population health and creating solutions to species decline (DeSante et al. 2005; Hemmings et al. 2012). Long-term nest monitoring can reveal demographic trends across breeding populations and guide the creation of landscapes that support ongoing viable populations. An objective of this study included identifying key yellow-billed cuckoo breeding habitat characteristics to use as a basis for future habitat restoration, which was achieved by finding a sufficient number of nests within the study area and assessing fine-scale nest vegetation (chapter 6) and microclimate characteristics (chapter 7) compared to available habitat. We were also interested in assessing the success of ongoing LCR MCSP restoration phases as cuckoo breeding habitat by comparing breeding demographic measures such as productivity and nest success between restoration and natural habitat at the BWR. From 2008 to 2012, we performed intensive nest-searching and monitoring of yellow-billed cuckoo nests, concentrating our efforts at LCR MSCP restoration sites and the BWR NWR.

METHODS

We used a number of techniques to search for nests during the breeding season. As cuckoos may respond from the nest to broadcast survey calls, during or after surveys, we searched for nests in accessible woody vegetation surrounding cuckoo detections (following Martin and Geupel 1993). Another technique used the fact that nesting pairs share incubation duties (Potter 1980; Hughes 1999; Halterman 2009); soon after sunrise, the female replaces the male on the nest, both often vocalizing during the exchange. They may also call prior to arriving at the nest to feed young. One or more observers waited in the area of a suspected nest and triangulated the location of calling birds. A third technique followed localized activity or behavioral clues (e.g., food and stick carries, alarm calls) and directed efforts into these areas until a nest was located. We also performed systematic searches, concentrating on edge and structural transition habitats. Additionally, we used radio telemetry to locate nests (chapter 9). We distinguished used cuckoo nests from similar stick nests of other species (such as doves) by the presence of bluish egg fragments remaining in or directly below the nest.

After locating a nest, we recorded the GPS location a few meters from the nest; a more accurate reading was taken after nesting activity ceased. We recorded nest site characteristics such as nest substrate height, species and nest height, stage, and the banded status of adults if known. We used a telescoping mirror or small camera mounted on a pole to check nests every 2–5 days, recording nest contents and any observed behaviors. Nestlings were banded at 3–6 days when accessible (chapter 9). Nests were judged successful if at least one young fledged, which we determined by detecting an adult or fledgling in the vicinity of the nest within 2 days of the estimated fledge date. Young cuckoos leave the nest before they can fly; thus, they climb or hop onto nearby branches where they may remain in close proximity to the nest for several days. These fledglings can then be detected by observing parental feedings or hearing juvenile vocalizations. Nests were considered failed if they were found damaged/destroyed, with large eggshell fragments or remains, or empty before the earliest possible fledge date (~6 days after hatching) with no further activity detected nearby. Nests were considered deserted if intact eggs or live chicks were present with no further parental activity. We identified possible parasitic egg laying (more than one female laying eggs in a nest) by the appearance of two eggs in one 24-hour period during laying or the appearance of a new egg 3 or more days after laying had ceased (MacWhirter 1989). This is based on our observations and others (Jay 1911; Potter 1980) that cuckoos typically lay one egg per day until clutch completion.

We calculated apparent nest success as the number of successful nests divided by the number of successful plus unsuccessful nests. To account for nests that failed before they were found, we also calculated Mayfield nest success (Mayfield 1975) using the formula $\textit{nest survival} = [(\textit{total exposure days} - \textit{failed nests})/\textit{total exposure days}]^{\textit{nesting period}}$, assuming constant daily survival, and using 18 as the average length of the nesting period based on our data. We calculated exposure days using the midpoint method for nests of known fate and the last known active date for nests of unknown fate. We explored potential relationships between nest fate and habitat variables (including microclimate) in chapters 6 and 7.

To calculate nest productivity, as we did not always know how many young fledged from each nest, we averaged the minimum and maximum possible number of young fledged from each nest (minimum includes only known young fledged; maximum includes all young minus any known not to have fledged). We recorded clutch size as the total number of eggs laid in each nest. For averaging across sites and years, we included only nests in which clutch size was known. We compared nest success, productivity, and clutch size across years and survey areas using nonparametric analyses of variance (ANOVAs) (adjusting for multiple comparisons).

RESULTS

Between 2008 and 2012, we located 87 cuckoo nests in 5 LCR survey areas (65 in LCR MSCP restoration, 1 in non-LCR MSCP restoration, 21 in BWR natural habitat, and none in non-BWR natural habitat): Havasu NWR (n = 2),

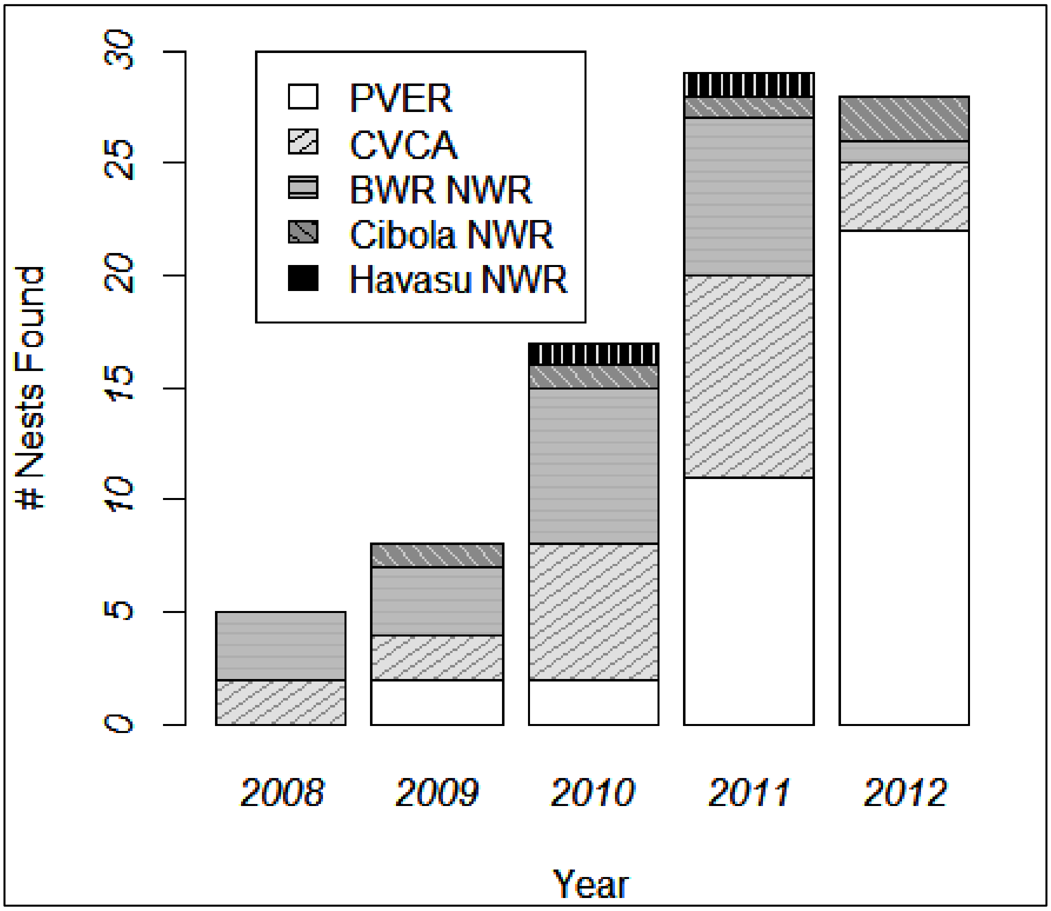


Figure 8-1.—Number of cuckoo nests found by year (2008–2012) and area, LCR.

BWR (n = 21), PVER (n = 37), CVCA (n = 22), and Cibola NWR (n = 5) (figure 8-1 and table 8-1). All nests found are summarized in attachment I. Additional information on individual nests can be found in Nest Accounts Appendices in our 2008 to 2012 annual reports (Halterman et al. 2009b; McNeil et al. 2010, 2011, 2012; 2013, in review). We found a significant increase in the number of nests found each year over the 5-year period at restoration sites (P = 0.001) and no significant change at the BWR (P = 0.52) (table 8-1 and figure 8-1).

Nesting activity peaked during the week of July 22–28 in most years (figure 8-2). Most nests were active between the last week of June and mid-August. At LCR MSCP restoration sites, the end of the season gradually shifted later over the course of the study, continuing into September at PVER in 2012.

Of 83 nests with known fate, 61 (73%) successfully fledged at least 1 young, and 22 (27%) failed (table 8-2). Fate was unknown for four nests (5% of all nests).

Table 8-1.—Summary of nests found by site and year (2008–2012), LCR

Area	Area/site	Year					
		2008	2009	2010	2011	2012	2008–2012
Havasu NWR	Beal	0	0	1	1	0	2
BWR NWR	All sites	3	3	7	7	1	21
	Cottonwood Patch	0	1	0	0	NS	1
	Cave Wash	0	0	0	1	0	1
	Honeycomb Bend	3	1	3	3	1	11
	Mineral Wash	0	0	1	1	0	2
	Cougar Point	0	0	2	2	0	4
	Sandy Wash	0	1	1	0	0	2
PVER	All sites	0	2	2	11	22	37
	PVER1	0	0	0	0	1	1
	PVER2	NS	2	1	3	3	9
	PVER3	NS[1]	NS	1	2	2	5
	PVER4	NS	NS	PS[2]	6	10	16
	PVER5	NS	NS	NS	NS	6	6
CVCA	All Sites	2	2	6	9	3	22
	CVCA1	2	2	3	6	2	15
	CVCA2	NS	NS	3	3	1	7
Cibola NWR	All sites	0	1	1	1	2	5
	Nature Trail	0	0	1	0	0	1
	Crane Roost	NS	0	0	1	2	2
	Cibola Island-Perri Marsh	NS	1	0	0	NS	1
All areas		5	8	17	29	28	87

[1] NS = Not surveyed.

[2] PS = Partially surveyed only.

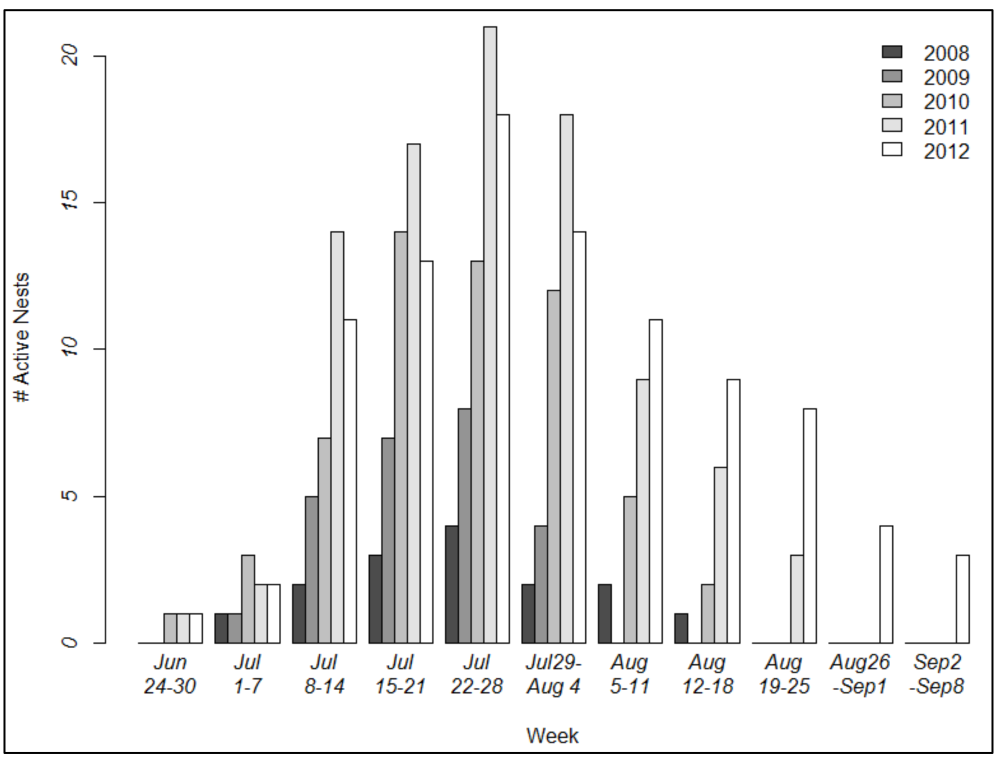


Figure 8-2.—Number of active cuckoo nests by week, 2008–2012, LCR.

Table 8-2.—YBCU nest success, clutch size, and productivity by area and year, 2008–2012 LCR

Area	Year	N	Apparent Success (# nests)	Mayfield Success[1]	Clutch size (#nests)	# fledged (min–max)	Mean Productivity (min–max)
Havasu NWR	2008–2012	2	100% (2)	100%[1]	3 (1)	2–3	1.25 (1.0-1.5)
	2010	1	100% (1)	100%	-(0)	1	1.0
	2011	1	100% (1)	100%	3 (1)	1–2	1.5 (1.0–2.0)
BWR NWR	2008–2012	21	100% (17)	100%[1]	2.3 (16)	26–52	1.85 (1.2–2.5)
	2008	3	100% (1)	100%	2.3 (3)	1–7	1.3 (0.3–2.3)
	2009	3	100% (2)	100%	2 (1)	2–8	1.7 (0.7–2.7)
	2010	7	100% (7)	100%	2 (5)	10–16	1.85 (1.4–2.3)
	2011	7	100% (7)	100%	2.6 (7)	13–17	2.15 (1.9–2.4)
	2012	1	-(0)		-(0)	(0–4)	
PVER	2008–2012	37	68% (37)	52%	2.9 (29)	45–64	1.45 (1.2–1.7)
	2009	2	50% (2)	0%[1]	(0)	1–3	1.0 (0.5–1.5)
	2010	2	100% (2)	100%[1]	2 (2)	4	2.0
	2011	11	45% (11)	26%[1]	2.7 (7)	8–12	0.9 (0.7–1.1)
	2012	22	77% (22)	65%	3.1 (20)	22–45	1.7 (1.4–2.0)
CVCA	2008–2012	22	64% (22)	53%	3 (22)	30–39	1.6 (1.4–1.8)
	2008	2	50% (2)	28%[1]	2.5 (2)	1–3	1.0 (0.5–1.5)
	2009	2	50% (2)	45%[1]	2.5 (2)	1–3	1.0 (0.5–1.5)
	2010	6	83% (6)	67%[1]	2.5 (6)	11–13	2.0 (1.8–2.2)
	2011	9	56% (9)	43%[1]	3.2 (9)	11–13	1.3 (1.2–1.4)
	2012	3	67% (3)	65%[1]	4 (3)	6–7	2.15 (2.0–2.3)
Cibola NWR	2008–2012	5	60% (5)	39%[1]	3 (4)	7–8	1.5 (1.4-–.6)
	2009	1	100% (1)	100%	(0)	2–3	1.5 (2.0–3.0)
	2010	1	0% (1)	11%	3 (1)	0	0
	2011	1	0% (1)	15%	3 (1)	0	0
	2012	2	100% (2)	100%	3 (2)	5	2.5
Restoration	2008–2012	66	67% (66)	51%	2.9 (56)	84–114	1.5 (1.3–1.7)
	2008	2	50% (2)	28%[1]	2.5 (2)	1–3	1.0 (0.5–1.5)
	2009	5	60% (5)	21%[1]	2.5 (2)	4–9	1.3 (0.8–1.8)
	2010	10	80% (10)	64%[1]	2.4 (9)	16–18	1.7 (1.6–1.8)
	2011	22	50% (22)	36%	3 (18)	20–27	1.05 (0.9–1.2)
	2012	27	78% (27)	67%	3.2 (25)	43–57	1.85 (1.6–2.1)
All sites	2008–2012	87	73% (83)	59%	2.8 (72)	110–165	1.6 (1.3–1.9)
	2008	5	67% (5)	53%[1]	2.4 (5)	2–10	1.2 (0.4–2)
	2009	8	71% (8)	41%[1]	2.3 (3)	6–17	1.4 (0.7–2.1)
	2010	17	88% (17)	78%[1]	2.3 (14)	26–34	1.75 (1.5–2)
	2011	29	62% (29)	46%	2.9 (25)	33–44	1.3 (1.1–1.5)
	2012	28	78% (27)	68%	3.2 (25)	43–60	1.85 (1.5–2.2)

[1] Mayfield estimates are not recommended for sample sizes < 20 nests (Hensler and Nichols 1981).

Overall, 75% of eggs hatched, and 84% of hatched chicks fledged (62% average individual egg success). Of nests that were active at least to hatching stage, 93.5% of eggs hatched.

To assess potential changes in nest fate over the season, we compared first egg dates between successful and unsuccessful nests using a two-sample Wilcoxon rank-sum test (due to non-normal distribution). Successful nests were initiated an average of 8 days earlier in the season (median first egg date = July 13, range = June 26 – August 22, n = 61) compared to failed nests (median = July 20, range = June 29 – August 19, n = 22, P = 0.012). Apparent annual nest success ranged from 60% at Cibola NWR to 100% at Havasu NWR and the BWR (see table 8-2). We found no significant variation in nest success between years (P = 0.395). The BWR had 100% apparent nest success each year from 2008–2011, though not all fates were determined (likewise, the single 2012 nest had unknown fate). No nests found at the BWR were known to have failed; therefore, we were not able to calculate Mayfield success for the BWR (as the method requires monitoring at least one failed nest). At restoration sites, apparent nest success averaged 67%, while Mayfield nest success averaged 51%. To explore the cause for apparent differences in nest failure rates, we compared the age of nests when they were found between restoration and BWR nests. We found that BWR nests were typically found significantly later in the nesting cycle (median = 10 days into incubation, n = 21) compared to restoration site nests (median = 3.5 days into incubation, n = 66, Wilcoxon test P = 0.006); as 45% of the 22 recorded nest failures during this study (all in restoration sites) occurred within the first 10 days, we most likely missed a number of early-failing BWR nests.

Just over one-half (55%) of all unsuccessful nests failed before any eggs hatched, 23% failed after all eggs had hatched, and 23% failed with a combination of eggs and chicks present. Depredation was the main cause of nest failure (64% of all failed nests), though the identity of the predator was usually unknown. A California king snake (*Lampropeltis getula californiae*) was confirmed by a nest video camera as the predator of one nest (three chicks) in 2011, avian egg predators (such as wrens, orioles, or chats) were implicated in four depredated nests in 2011 due to egg punctures, and Cooper's hawks (*Accipiter cooperii*) were implicated in two other failed nests. Weather (storms) was the suspected cause of two nest failures (one each in 2011 and 2012). Apparent desertion (unknown cause) occurred at two nests (both containing three eggs) in 2011. One of these deserted nests was on a habitat edge at PVER adjacent to a road observed to be used by heavy farm machinery. Human disturbance (site maintenance) was the assumed cause of failure of one nest at CVCA1 in 2011 after a large crew had chainsawed small patches of invading tamarisk throughout CVCA from August 13–15, including within 5 m of the active nest.

Over all sites and years, clutch size averaged 2.8 eggs and ranged from 2.4 in 2008 to 3.2 in 2012. Clutch size was relatively stable for the first 3years (average = 2.32 ± 0.48 eggs, n = 22), then increased in 2011 and 2012 (average = 3.02 ± 0.82 eggs, n = 50, P < 0.001). At restoration sites, average clutch size increased from 2.46 ± 0.52 eggs over 2008–2010 (range 2–3, n = 13) to 3.09 ± 0.81 eggs in 2011 and 2012 (range 2–5, n = 43, P = 0.002). At the BWR, the increase in average clutch size from 2008–2010 (2.11 ± 0.33 eggs, range 2–3, n = 9) to 2011–2012 (2.57 ± 0.79 eggs, range 2–4, n = 7) was not significant (P = 0.186) possibly due to small sample size.

Productivity over all sites and years averaged 1.6 young produced per nest and ranged from an average of 1.2 young in 2008 to 1.85 young in 2012. Despite the increase in average clutch size over the last 2 years of the study, we found no significant change in average productivity over the 5-year period (P = 0.938).

We found most nests in cottonwoods or willows (figure 8-3 and table 8-3); 47% were in Fremont cottonwood (*Populus fremontii*), 34% in Goodding's willow (*Salix gooddingii*), 13% in tamarisk (*Tamarix* spp.), 2% in honey mesquite (*Prosopis glandulosa*), 2% in seep willow (*Baccharis salicifolia*), and 1% in coyote willow (*Salix exigua*). At the BWR, tamarisk was the most common nest tree species (43% of all BWR nests), followed by Goodding's willow (33%) and cottonwood (19%). At restoration sites, most nests were in cottonwoods (56%), followed by Goodding's willow (35%), honey mesquite (3%), tamarisk (3%), coyote willow (1.5%), and seep willow (1.5%).

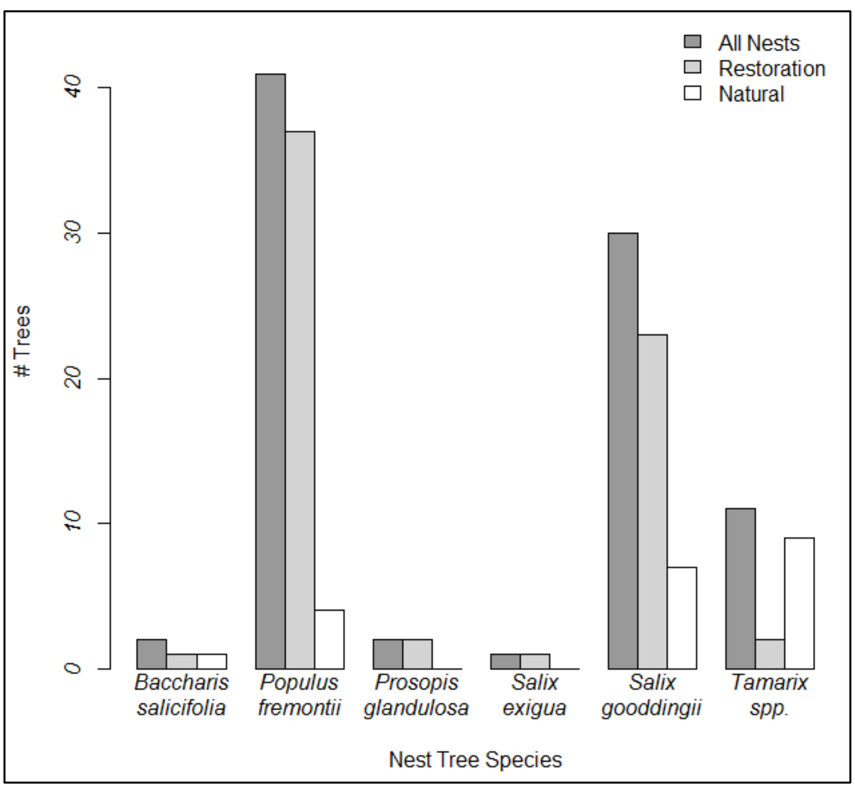


Figure 8-3.—Nest substrate species (all nests, restoration, natural site [BWR]), LCR, 2008–2012.

Table 8-3.—YBCU nest substrate height, nest height, and DBH by species, mean ± SD (minimum-maximum), LCR 2008–2012

Substrate species	n	Substrate height (m)	Nest height (m)	Substrate DBH (cm)
Cottonwood	41	11.28 ± 3.17 (4.5–22)	6.0 ± 2.97 (1.6–13)	15.26 ± 7.38 (6–45.5)
Goodding's willow	30	9.84 ± 2.57 (6–15)	4.65 ± 2.82 (1.1–13)	15.34 ± 8.36 (6–35)
Tamarisk	11	6.79 ± 1.49 (4–8.7)	3.95 ± 0.99 (2.5–5.7)	11.6 ± 3.92 (4–17.8)
Honey mesquite	2	6.55 ± 0.07 (6.5–6.6)	4.85 ± 0.21 (4.7–5)	8.85 ± 0.21 (8.7–9)
Seep willow	2	4.35 ± 0.21 (4.2–4.5)	2.79 ± 0.41 (2.5–3.1)	4.95 ± 0.07 (4.9–5)
Coyote willow	1	6.5	3	6
All substrates	87	9.89 ± 3.23 (4–22)	5.14 ± 2.77 (1.1–13)	14.33 ± 7.48 (4–45.5)

Overall nest substrate heights ranged from 4 to 22 m (mean 9.9 m) (see table 8-3), and averaged lowest in 2010 (8.0 m) and highest in 2012 (11.1 m), which was significantly higher than the previous 4 years combined (2008–2011 mean = 9.3 m, n = 59, P = 0.014; mean substrate heights in 2008–2011 were not significantly different from each other). Cottonwoods averaged higher (mean = 11.3 m) compared to all other nest substrate species combined (mean = 8.7 m, P = 0.006). Nest heights ranged from 1.1 to 13 m (mean = 5.1 m) and averaged significantly higher in 2012 (mean = 7.1 m) compared to the previous 4 years combined (mean = 4.1 m, P < 0.001; mean nest heights in 2008–2011 were not significantly different from each other). Nests in cottonwoods averaged significantly higher (mean = 6 m, n = 41) than nests in all other species (mean = 4.4 m, n = 46, P = 0.006); nests were also placed proportionally higher in trees in 2012 compared to previous years (figure 8-4). Mean nest substrate DBH was 14.3 cm (range 4–45.5 cm) and averaged significantly greater for trees (cottonwoods, Goodding's willow, and tamarisk; combined mean DBH = 14.8 cm) than for the more shrub-like substrate species (mesquite, seep willow, and coyote willow; combined mean DBH = 6.72 cm, P = 0.018).

Three anomalous nests containing both cuckoo and dove eggs were found during the study, all in 2011. They may have been parasitized by cuckoos, causing the doves to abandon, or more likely, they may already have been vacated by the doves before any cuckoo eggs were laid, as no doves were ever observed at these nests and no dove eggs ever hatched. Two of the nests were already inactive when found, and none of the nests were seen to fledge any young. We also observed large gaps in egg laying dates at five nests (three in 2011 and two in 2012, all at PVER or CVCA), suggesting the occurrence of intraspecific parasitism.

In 2012, we confirmed double-brooding, for the first time in the study, by four individuals with seven nests. All were confirmed by color band re-sighting or

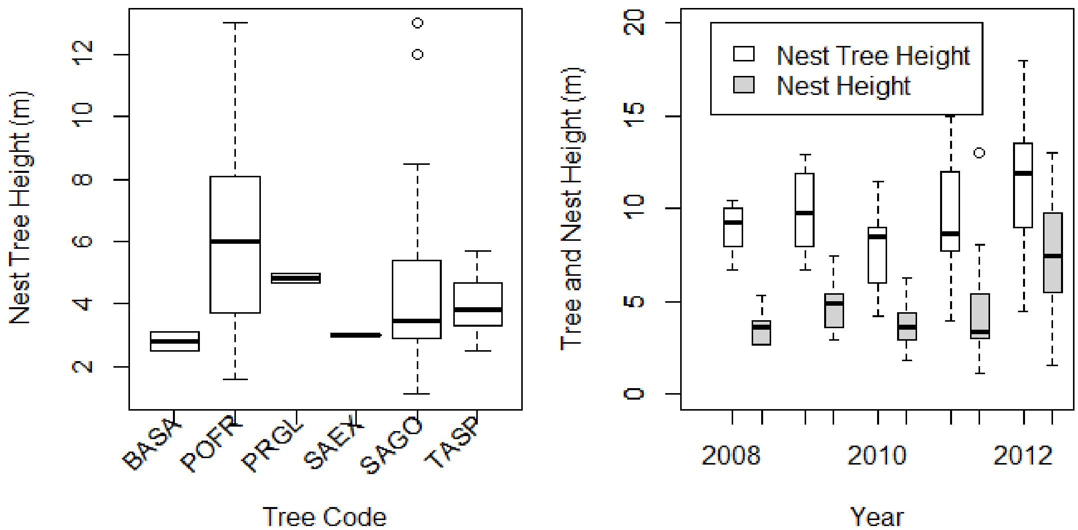


Figure 8-4.—Boxplots of nest substrate height and nest height.
Left: substrate height by species, all years (BASA = seep willow, POFR = Fremont cottonwood, PRGL = honey mesquite, SAEX = coyote willow, SAGO = Goodding's willow, TASP = tamarisk); right: substrate height and nest height by year, 2008–2012; all increased significantly in 2012.

telemetry at PVER (Phases 1, 2, and 4). Two males each had two successful nests (PUF and SLS) (attachment I); one female had three nests (PRI; two successful nests with the same male, with one failed nest in between [male never identified]); another female had a successful nest followed by a failed nest (GBO). We also confirmed four double-clutching events (re-nests following failed nests), one in 2011 (through re-sighting a banded male [BA] at CVCA1) and three in 2012 (through telemetry of two males [DEF, EZE] and one female [PRI], all at PVER4). Birds moved an average of 195 m to re-nest (range = 87–420 m, n = 7), with an average of 10 days between nests (range 3–25 days). Following nest failure, the average re-nesting distance was 147.3 m (range 87–210 m, n = 4); following successful fledging, the distance moved to re-nest averaged 258.3 m (range 99–420 m, n = 3).

DISCUSSION

From 2008–2012, we documented cuckoo nests in five LCR survey areas, including two areas with nests confirmed each of the 5 years (BWR and CVCA), two areas with nests during each of the last 4 years (PVER and Cibola NWR), and one with nesting during 2010 and 2011 (Havasu NWR, Beal). The total number of nests found significantly increased each year in habitat restoration sites, which we attribute to increased area of suitable nesting habitat each year of the project (due to yearly planting of new phases); in particular, at PVER where we recorded the majority of the nesting increases, suitable breeding habitat increased in area from 8 ha (Phase 1) to over 160 ha (Phases 1–5) between 2008 and 2012.

We located just one nest at the BWR NWR in 2012 along with fewer survey detections and estimated breeding territories (chapters 2 and 5). We most likely find a relatively small proportion of all nests in this survey area due to challenging field conditions, including dense vegetation and lack of access roads, and the single nest found in 2012 was not statistically lower that that found in previous years (averaging five nests per year from 2008–2011). However, in 2012, our field challenges increased even more due to loss of access to the eastern end of the refuge through Planet Ranch; as a result, we had to hike over an hour upstream from Mineral Wash to reach our easternmost sites (Cave Wash and Honeycomb Bend). We have typically found the highest number of nests and other breeding evidence at these eastern sites. Also, the increased effort we placed on capturing and radio tracking adults at the BWR in 2012 (chapter 9) may have reduced the overall time spent nest searching. We expected telemetry to lead us to several BWR nests, as telemetry has helped us to find a high proportion of our restoration site nests. We also found fewer nests at CVCA in 2012 compared to 2011 along with fewer survey detections and estimated territories (chapters 2 and 5) despite similar survey, nest searching, and telemetry efforts.

Cottonwoods and Gooding's willows were the most common restoration site nest trees, while tamarisk was the most common BWR nest tree. However, we found nests in six different species, including seep willow and coyote willow, which grow to above-average sizes at the well-irrigated restoration sites and are less common nest substrates. Cuckoos are likely choosing nesting substrates based on several factors other than species, such as structure, canopy closure, and microclimate (chapters 6 and 7) as well as availability; cottonwoods are among the most common restoration tree, while tamarisk is a common understory tree at the BWR. At Cibola NWR where patches of large mature mesquites occur, four nests were found in this habitat type (two in honey mesquites, one in a seep willow under a screwbean mesquite stand, and one in a tamarisk with co-dominant honey mesquite). Similarly, several cuckoo nests have been found in the extensive mature mesquite bosque lining the cottonwood-willow forest of the upper San Pedro River in southeast Arizona (e.g., Halterman 2002, 2004, 2006).

In 2011 and 2012, average clutch size increased significantly over what we previously recorded in this study, including the first observations of four and five egg clutches in the region. Before 2011, we had only observed clutches of up to three eggs on the LCR. Most large clutches occurred at LCR MSCP restoration sites; CVCA averaged 3.0, and PVER averaged 2.9 eggs per nest, compared to 2.5 at BWR NWR, which included just one four-egg clutch. Laymon (1998) noted that clutches greater than three eggs had never been found at the BWR NWR. Clutch size has been found to be correlated with food abundance and seasonal insect outbreaks in both yellow-billed cuckoos (MacWhirter 1989;

Laymon et al. 1997; Laymon 1998) and other avian species (Fleischer et al. 1985; Payne 2005). Cuckoos are indeterminate egg layers, able to increase their final clutch size to take advantage of abundant food (Lack 1947). Large clutch sizes can also result from intraspecific brood parasitism (discussed below).

Despite increased clutch sizes, we found no significant increase in average nest productivity over the 5-year period. This may be because eggs from large clutches (4 or 5 eggs) typically did not all hatch. Seven of eight successful large-clutched nests (87%) did not hatch all eggs, whereas all eggs from successful nests with fewer eggs hatched. Additionally, individual egg success from large clutches averaged 57% compared to 63% for eggs from smaller clutches. Daylight brooding may cease after bursting of the second chick's pin feathers (Potter 1980), so late-laid eggs may have experienced increased exposure to lethal temperature extremes (chapter 7). Alternatively, the unhatched eggs could have been infertile. Hatch rates have also been found to decrease with increasing nesting sociality (i.e., more than one male or female contributing to the nest) (Koenig 1982). Overall, just 6.5% of all eggs surviving to hatching stage failed to hatch, whereas for large-clutched nests, the failure rate increased to 25%, supporting circumstantial evidence (based on Koenig [1982]) that more than one female may have contributed to nests with large clutches.

Apparent nest success over the 5-year period was 73%. High nest success (exceeding 70%) has been reported in previous western cuckoo studies (Laymon et al. 1997; Halterman 2009); however, these rates did not take into account nests that failed before being found, positively biasing success rates. Typically, relatively few cuckoo nests are found during field studies due to a combination of factors, including low relative numbers, rapid nesting cycle, and cryptic nesting behavior, so it is reasonable to assume that many failed cuckoo nests go unnoticed. The Mayfield method is therefore expected to produce estimates much closer to the true average nest success for this species. However, results based on small sample sizes can be seriously impacted by stochastic events and are therefore unsuitable for generalizing over larger populations (Mayfield 1975); Hensler and Nichols (1981) recommend that Mayfield estimates never be calculated for sample sizes less than 20. Due to the significant increase in breeding activity and found nests during this study, we were able to use this method with confidence, though only for LCR MSCP restoration sites where nest failures were recorded. This resulted in a reduction in estimated average nest success by 16%, from 67 to 51%, which is probably closer to the true average nest success rate during this study and not significantly higher than rates reported for other open-cup nesters (e.g., 46%; Nice 1957; 42%; Knutson et al. 2004). We were not able to compare nest success rates between restoration sites and the BWR due to the lack of any failed monitored nests at BWR. However, there may still be variation in success rates between these areas due to differences in predator densities or assemblages.

Nest predation was the major cause of nest failure (64% of all failed nests), though the identity of the predator was usually unknown. We were able to identify one predator (a king snake via a nest video camera), and we have observed many king snakes at both PVER and CVCA, including one in the process of eating a dove chick. Eggs and nestlings may also be taken by birds, mammals, or other snake species (Nolan 1963; Potter 1980), and in some areas, nest depredation may account for failure to fledge young from 80% of cuckoo nests (Nolan 1963; Nolan and Thompson 1975). Punctured eggs were discovered in four nests in 2011 (14% of all nests that year). Nesting birds are known to puncture eggs of nearby nests, thereby reducing interspecific resource competition (Picman et al. 1996). Potential avian egg predators photographed at artificial LCR MSCP nests have included yellow-breasted chats (*Icteria virens*), Bullock's orioles (*Icterus bullockii*), and Bewick's wrens (*Thryomanes bewickii*) (Theimer et al. 2010). Other potential nest predators we have observed in LCR MSCP restoration sites include common ravens (*Corvus corax*), Cooper's and red-tailed hawks (*Accipiter cooperii, Buteo jamaicensis*), bobcats (*Lynx rufus*), western spotted skunks (*Spilogale gracilis*), common raccoons (*Procyon lotor*), and grey foxes (*Urocyon cinereoargenteus*). Raptors may also be an important cause of adult mortality; they have attacked incubating cuckoos (Hughes 1999), and in August 2011, we discovered partial remains of an adult cuckoo at the BWR NWR within a known Cooper's hawk territory. Restoration management decisions such as irrigation levels, tree species composition, tree spacing, edge amount, and water features may affect the suite of predators found at each site. The amount of edge and site fragmentation can affect depredation rates by snakes as well as other animals (Weatherhead and Blouin-Demers 2004). Proximity to agricultural areas may increase depredation by human-adapted species (Hartley and Hunter 1998; Bui et al. 2010), and as sites change in structure and composition, new predator suites may arise.

We observed possible interspecific and intraspecific brood parasitism events in 2011 and 2012, corresponding to years with larger clutches. Unlike many cuckoo species, yellow-billed cuckoos usually build their own nest and raise their own young. However, they are facultative brood parasites, occasionally practicing both intra- and interspecific brood parasitism (Bent 1940). Brood parasitism by yellow-billed cuckoos is most prevalent during years of high food abundance (Nolan and Thompson 1975; Hughes 1999) and is thought to be uncommon most years (Nolan and Thompson 1975). Yellow-billed cuckoo eggs have been found in the nests of at least 12 other species (including mourning doves [*Zenaidura macroura*]) (Jay 1911; Bent 1940; Dearborn et al. 2009). In a study examining over 10,000 nests for evidence of cuckoo parasitism, Dearborn et al. (2009) speculated that cuckoos may mistakenly lay eggs in similar-looking stick nests (such as dove nests) instead of the intended congeneric (i.e., black-billed or yellow-billed cuckoo) nests. In some cases, the nests have already been abandoned when appropriated (Jay 1911; Payne 2005), which may have been the case for the three anomalous nests found in 2011. These 2011 nest anomalies also corresponded to the late arrival of birds that year; thus, it is possible that some birds compensated for their late arrival by using old dove nests. Parasitism may also occur after accidental nest loss during the laying period, prompting the female to lay the remainder of her clutch in another nest (Bendire 1895; Laymon et al. 1997).

Intraspecific nest parasitism occurs more frequently than assumed (Rohwer and Freeman 1989; Johnsgard 1997), and genetic analyses have shown that clutches with mixed parentage are not infrequent (Sandell and Diemer 1999). Yellow-billed cuckoo clutches laid by more than one female have been confirmed molecularly at the Kern River, California (Fleischer 2001) and in Kansas (Fleischer et al. 1985). In many bird species, female (unmated) floaters that do not obtain nests or mates of their own may settle as secondary females (copulating with already-mated males) and may achieve reproductive success purely by engaging in intraspecific brood parasitism (Gibbons 1986). But, it is increasingly found that the parasitic layers can also be mated females that both tend a nest of their own and enhance their reproductive success through additional intraspecific parasitism (Kendra et al. 1988, Jackson 1993). We suspect that unpaired and paired female cuckoos may be doing the same. Our telemetry observations have revealed some females in close proximity to nests that were not their own, and we captured possible parasitic egg dumping on video in 2011. Genetic material taken from these nests could be analyzed under a separate study to confirm whether this has occurred.

We confirmed multiple double-brooding events for the first time in the study in 2012, all at PVER. Hughes (1999) stated there is probably no double-brooding in the West due to the short breeding season, though it has been documented in southeast Arizona (two females in 2002 and 2004) (Halterman 2009) and at the Kern River, California, in 1991, 1992 (Laymon et al. 1997), and 2012 (Stanek and Stanek 2013). Double-brooding may be more common than previously thought and may be under-reported in cuckoos due to the difficulties in nest finding, capturing, and re-sighting banded individuals. Quantifying double-brooding rates is important both for estimating seasonal/lifetime reproductive output and identifying its causes, which may be related to reduced post-fledgling care (previously documented in yellow-billed cuckoos) (Halterman 2009; McNeil et al. 2011), allowing more time for a second brood (Gruebler and Naef-Daenzer 2010), or increased food abundance, extending the breeding season (Geupel and DeSante 1990).

Over the past 5 years, the yellow-billed cuckoo nesting season on the LCR gradually expanded later into the year, from finishing early- to mid-August in the first 2 years, to September in 2012, in which three PVER nests were still active into early September, and many other post-breeding adults and juveniles most likely remained at least until late September. The gradual lengthening of the nesting season over the past 5 years may be an indication that double-brooding is becoming more frequent. A consequence of this shift is the potentially harmful overlap of the cuckoo breeding season with the dove hunting season, which begins September 1. To limit potential impacts on productivity caused by hunting disturbance, we recommend delaying the dove hunting season at late-breeding sites such as PVER until all breeding has ceased and cuckoos have departed (i.e., currently until early October).

Chapter 9 – Mist Netting, Color Banding, Re-sights, and Radio Telemetry

INTRODUCTION

Yellow-billed cuckoo breeding populations in the Western United States are restricted to small and isolated riparian habitat fragments comprising less than 1% of the western landscape (Rich 2002). Dispersal of individuals among breeding sites is vital for gene flow and population persistence, but can be significantly impacted by habitat fragmentation and isolation even in birds capable of long-distance flight (Martin et al. 2006; Martín et al. 2008; Ortego et al. 2008). It is therefore important to measure dispersal patterns within the western yellow-billed cuckoo population. Identifying limits to dispersal among breeding sites can guide the restoration of riparian landscapes toward supporting a more viable population and can be achieved through long-term color banding efforts. Long-term banding can provide information on natal and breeding dispersal patterns as well as other poorly understood key traits such as survivorship, mate and site fidelity, breeding behavior and morphology, population demography, and genetic structure.

Cuckoos can, however, be difficult to observe due to their furtive behavior, and their bands can be even more challenging to re-sight due to their habit of crouching on their legs in dense foliage. Radio tracking greatly increases the ability to make useful behavioral observations and can provide additional insights such as the effects of habitat characteristics on home range, territoriality, duration of stay, and within-season movements. Additionally, due to the cuckoo's secrecy and rapid nesting cycle, nests are often missed. Cuckoos can also occur as transients throughout the season; thus, it is often unclear if breeding has occurred in an area. Telemetry improves breeding pair estimates by increasing the likelihood of confirming both breeding and transiency. From 2008 to 2012, we attempted to color band, re-sight, and radio track as many cuckoos within the LCR region as possible, concentrating our efforts at known breeding locations and at LCR MSCP riparian habitat restoration sites.

METHODS

Mist Netting

We captured adult cuckoos each year during the breeding season between mid-June and mid-August. First we located a responsive cuckoo by broadcasting recorded conspecific vocalizations. If a cuckoo responded to the broadcast, we found a suitable net lane and used a target mist net technique modified from Sogge et al. (2001): we attached two to four stacked (7.8 to 12 m-high) mist nets ranging in length from 9 to 18 m (typically 12 m) between two canopy poles (Bat Conservation and Management, Inc.) placed in a vegetation gap of similar canopy height. We then broadcast various recorded vocalizations from speakers placed on either side of the net to lure in cuckoos. We used successful net lanes over multiple years, gradually extending the height of the poles to keep up with the increasing canopy height until the canopy became too high (> 12 m). The use of canopy poles reaching up to 12 m high greatly improved capture rates over previous studies, in which standard mist net poles (and two stacked nets) were used, reaching < 8 m high and therefore restricted to low-height habitat patches. During each attempt, we recorded information such as temperature, number of cuckoos in the area, and which vocalizations elicited a response or capture. If no cuckoos were captured after approximately 1 hour, we moved the setup to another location. We ceased our attempts when temperatures reached 40 °C (104 °F).

Color Banding

We banded all newly captured cuckoos with a color-anodized Federal numbered aluminum band, colored gold from 2008–2010, blue in 2011, and magenta in 2012. From 2008–2010, adults and older juveniles were additionally banded with three-color plastic (Darvic) bands, forming a unique color combination; chicks and small fledglings were given one additional Darvic band (usually not forming a unique color combination). Darvic bands require heat sealing, taking more time and effort to close than metal bands, which are easily closed with banding pliers. After 2010, we switched from Darvic to pinstriped (two- or three-striped) aluminum bands, giving each banded bird of any age just one additional band besides the Federal band to form a unique color combination (reducing the number of bands given to adults from four to two). Non-target captured birds were immediately released without banding. We banded and measured nestlings if reachable (i.e., from nests less than 7 m high and safely accessible by ladder) at 3–6 days old when their tarsi were long enough to hold a single leg band. We used a stopped wing rule to measure wing and tail length, calipers to measure tarsus and bill length, and a 100-gram (g) Pesola® scale or 400-g Acculab digital scale to weigh all birds. For adults, we recorded additional morphological data such as molt, feather wear, orbital ring color, cloacal protuberance score (0–3), and brood patch score (0–5) following the Monitoring Avian Productivity and Survivorship protocol).

We extracted a small amount of blood from each bird by brachial vein puncture, which was placed on PermaCode™ cards or in buffer containing Ethylenediamine tetraacetic acid. We extracted genomic DNA using a Qiagen blood and tissue kit and protocols (Qiagen Inc., Valencia, California), and sexed the adults following a universal avian DNA-sexing method (Han et al. 2009). We verified the accuracy of the method by correctly DNA-sexing tissue samples from 23 necropsy-sexed yellow-billed cuckoos (11 females and 12 males loaned from the University of Washington Burke Museum).

We attempted to re-sight bands by observing with binoculars or photographing the legs of all detected cuckoos. For re-sighted second year (SY) birds (returning chicks banded the previous year), we calculated natal dispersal distance as the distance between the bird's natal nest and its (assumed first) nesting location (calculated in ArcGIS). For returning after-second-year (ASY) or older birds, breeding dispersal distance was calculated as the distance between each year's known nests associated with the bird. If no nest was found, we used the bird's capture site to estimate the distance moved. We also tried to re-sight banded juveniles to obtain information on post-fledging care and dispersal.

Telemetry

We equipped a subset of captured adults with one of two types of radio transmitters: Holohil BD-2 (Holohil Systems Ltd.) weighing 1.47 to 1.51 g, broadcasting at 151.5–152 megahertz (MHz), and Lotek Biotrack Radio PIP AG 393 (Lotek Wireless Inc.) weighing 1.09 to 1.24 g and broadcasting at 151.0 to 151.49 MHz. Transmitters were operational for 6 to 8 weeks. We stitched each transmitter near the base of the two central rectrices with dental floss or Kevlar thread and secured the knots with a small drop of cyanoacrylate glue (Bray and Corner 1972; Pitts 1995; Woolnough et al. 2004). We used Communications Specialists Model R1000 receivers and three-prong directional yagi antennae (AF Antronics model F151-3FB and Communications Specialists RA-150 Folded Yagi) to monitor the tagged birds. We tracked birds approximately every 1 to 3 days for up to 4 hours per session. Vocalizations, intraspecific interactions, movements, behaviors, and habitat characteristics were also recorded during telemetry sessions. If an observer thought that their presence was disturbing the bird, they moved away from the bird and continued tracking from a distance. For home range estimation, we attempted to record at least one accurate position per hour by recording triangulations of two or three bearings, approximately 90 degrees (°) (60–120°) apart, taken within 10 minutes of each other (Springer 1979). We attempted to confirm the breeding status of all tracked birds by witnessing birds at nests or exhibiting other breeding behaviors. Sampling error and bias associated with triangulation-based location estimates (Springer 1979) was considered to be acceptable (i.e., within 50 m of true locations) due to regular visual confirmation of bird locations, triangulation bearing angles averaging 90°, and relatively short distances (< 100 m) from observers to target birds (Saltz 1994). If a bird's signal was no longer detected at its capture site, we regularly searched for the signal by foot or vehicle for the remainder of the season at sites along the LCR. We assumed a lack of signal with no additional re-sights of a bird was due to the bird leaving the area, though transmitter failure was also possible.

We used LOAS™ 4.0 software (Ecological Software Solutions) to estimate true bird locations based on triangulated bearings, combined these with single point visual locations, then imported these into ArcGIS and used Hawth's Analysis Tools (Beyer 2004) to estimate home ranges for each tracked cuckoo. We initially selected a subset of points recorded at least 1 hour apart to reduce autocorrelation among points; however, in many cases, this reduced the sample size and significantly decreased the kernel density estimates (KDEs). Thus, we used all available points. Three home range estimates were calculated: minimum convex polygons (MCPs) and 95 and 50% KDEs (Silverman 1986). MCPs and 95% KDEs are commonly used to represent an animal's home range, with the 50% KDE describing an animal's core range (Laver and Kelly 2008). MCPs were obtained by connecting all outer data points to form a convex hull (following Mohr, 1947). While popular due to its simplicity, the MCP is extremely sensitive to data outliers, often overestimating the animal's true home range (Worton 1995; Burgman and Fox 2003). KDEs determine the probability of locating the bird in an area at any given time and are less biased toward outliers (Seaman and Powell 1996). We performed nonparametric ANOVAs to assess differences in average home range sizes based on gender, breeding status, site, habitat patch size, number of points, and number of days tracked.

RESULTS

Color Banding and Re-sights

Between June and August 2008 to 2012, we captured and color banded a total of 93 adult and 90 hatch-year cuckoos (attachment J) from Havasu NWR to Quigley WMA (summarized in table 9-1). Most birds were banded at CVCA and PVER (62 and 61 birds, respectively), followed by the BWR NWR (31), and Cibola NWR (17). Of the captured adults, 53 were sexed as male, and 40 were female (confirmed by the DNA-sexing method described in the methods). An additional five hatch-year-banded birds were recaptured as adults (three males and two females). Across all sites, the sex-ratio of captured adults was 1.33:1 (i.e., 57% male or 14% more males than females). Sex ratios of captured adults varied by site: we captured a much higher ratio of males at the BWR NWR (8:1), Cibola NWR and CVCA had slightly more males (1.6:1), PVER was the same as the overall average (1.33:1), and Havasu NWR had a lower male ratio (0.33:1); whereas we captured only females at Colorado River Indian Tribe (CRIT) land (n = 4), Picacho (n = 1), and Quigley WMA (n = 1).

Table 9-1.—Yellow-billed cuckoos captured or re-sighted by site and year, LCR, 2008–2012

				New captures		Recaptures		Re-sights					
								Confirmed		Unconfirmed			
Location		**Breeding adults**	**Sex ratio (M:F)**	**Adults**	**Hatch year**	**Adults**	**Returning nestling**	**Adult**	**Returning nestling**	**Bands known**	**Partial**	**Within-season movement**	**Total**
Havasu NWR	**Total**	**1**	**0.33:1**	**4**	**3**								**7**
	2010	1		3	1								4
	2011			1	2								3
BWR NWR	**Total**	**7**	**8:1**	**8**	**23**	**1**		**2**			**1**		**34**
	2008				2								2
	2009				1								1
	2010	4		3	7	1		1					12
	2011	1			13			1			1		14
	2012	2		5									5
CRIT	**Total**		**(all F)**	**4**									**4**
	2009			2									2
	2011			2									2
PVER	**Total**	**28**	**1.33:1**	**34**	**27**	**2**	**2**	**1**		**2**	**2**		**69**
	2009	2		1			1						2
	2010	4		6	4								10
	2011	6		8	7					1	1		16
	2012	16		19	16	2	1	1		1	1		41
CVCA	**Total**	**22**	**1.6:1**	**28**	**34**	**3**	**2**	**2**		**1**	**5**	**(2)**	**71**
	2008				3								3
	2009	2		3	3								6
	2010	6		8	12	1	1					+1	23
	2011	10		9	13	1	1	2		1	5		26
	2012	4		8	3	1						-1	12
Cibola NWR	**Total**	**4**	**1.6:1**	**13**	**4**							**(2)**	**17**
	2009	1		2									2
	2010	1		5								-1	5
	2011	1		5									5
	2012	1		1	4							+1	5
Picacho State Recreation Area	**2011**		**(all F)**	**1**									**1**
Quigley WMA	**2011**		**(all F)**	**1**									**1**
	Total		**1.33:1**	**93**	**90**	**5**	**4**	**5**		**3**	**8**		

During 2009–2012, we recaptured or positively re-sighted 13 cuckoos banded during a previous year of the project (tables 9-1 and 9-2), 9 males, and 4 females. The recaptures represented an average of 9.9% of all adults captured each year (range 6.9% in 2011 to 11.1% in 2009). Three other returning banded young were re-sighted; however, their color band combinations were not unique, and they could not be identified to individual. Altogether, the returns amounted to 15 dispersal records over the 4-year period: 10 breeding (8 individuals) and 5 natal (tables 9-3 and 9-4).

Table 9-2.—Summary of between-year and within-season movements between sites, LCR 2008–2012

	Area banded					
Area re-sighted	**BWR**	**CRIT**	**PVER**	**CVCA**	**Cibola**	**Total**
BWR	2	1				3
PVER			4	1		5
CVCA				7	(1)	7 (1)
Cibola				(2)		(2)
Total	2	1	4	8 (2)	(1)	15 (3)

Note: Numbers in parentheses indicate within-season movements.

Table 9-3.—Summary statistics of YBCU dispersal distances (in meters) by sex, LCR 2008–2012

Dispersal type	**Sex**	**N**	**Mean**	**SD**	**Median**	**Range**
Breeding	Male	8	483.5	506.5	252	48–1.389
	Female	2	18,744.0	2,6327.0	18,744	128–37.360
	Total	10	4,135.6	1,1682.9	252	48–37.360
Natal	Male	3	122.7	88.0	133	30–205
	Female	2	17,548.0	2,2297.9	17,548	1.781–33.315
	Total	5	7,092.8	1,4676.4	205	30–33.315
All	Male	11	385.1	457.8	149	30–1.389
	Female	4	18,146	19,931	17,548	128–37.360
	Total	15	5,121.33	12,303.2	205	30–37.360

Table 9-4.—YBCU recaptures, re-sights, and dispersal distances, LCR 2009–2012

Area	Year	Disp. type[1]	YBCU ID[2]	Band colors[3]	Site[4] banded	Sex[5]	Date banded	Age[6]	Re-sight date[7]	Return site[8]	Time since[9]	Distance (m)[10]
BWR	2010	B	CA	R Y/G Ag	CRIT	F	6/30/09	ASY	7/13/10	BWCP*	1 yr	37,360
CVCA	2010	B	LJ	W Ag/W O	CVCA1	M	7/11/09	ASY	6/23/10*	CVCA2*	1 yr	355
BWR	2011	B	AF	mB W/R Ag	BWCP	M	7/4/10	ASY	8/2/11	BWHB*	1 yr	1,389
CVCA	2011	B	BA	R W/Bk Ag	CVCA1	M	6/23/10	ASY	7/9/11	CVCA1*	1 yr	228
CVCA	2011	B	BA	R W/Bk Ag	CVCA1		6/23/10	ASY	8/1/11	CVCA1*	1 yr	26
CVCA	2011	B	TGB	Bk W/W Ag	CVCA1	M	6/24/10	ASY	7/14/11	CVCA2	1 yr	149
CVCA	2011	B	LJ	W Ag/W O	CVCA1	M	7/11/09	ATY	8/4/11	CVCA2*	1 yr	48
PVER	2012	B	PF	O W/Ag mB	PVER2	M	8/3/09	A4Y	8/5/12	PVER4*	3 yrs	1,100
PVER	2012	B	AA	mB Ag/R G	PVER3	M	7/7/10	ATY	7/2/12?	PVER3*	2 yrs	590
PVER	2012	B	PRI	mB/Lv-Y	PVER4	F	8/7/11	ASY	7/17/12*	PVER4*	1 yr	128
PVER	2012	B	BUT?	mB/(Bk+G)	PVER2?	M	7/26/11	ASY	7/21/12	PVER4*	1 yr	1,450
PVER	2012	B	CD?	mB/(Bk+G)	CVCA1?	M	7/12/11	ASY	7/21/12	PVER4*	1 yr	34,250
PVER	2012	B	NUR?	mB/(Bk+G)	CIBCR?	M	7/2/11	ASY	7/21/12	PVER4*	1 yr	39,600
PVER	2012	B?	ODY?	P-mB/Ag	CVCA1	F	7/24/08	5Y	7/26/12	PVER4	4 yrs	797
CVCA	2012	B	LJ	W Ag/W O	CVCA2	M	7/11/09	A4Y	7/22/12*	CVCA2*	3 yrs	110
PVER	2009	N	ODY	P-mB/Ag	CVCA1	F*	7/15/08	SY	8/3/09*	PVER2*	1 yr	33,315
BWR	2010	N	POM	Bk O/W Ag	BWHB	M*	8/30/09	SY	8/1/10	BWCW*	1 yr	30
CVCA	2010	N	SJR	R Ag/G W	CVCA1	M	7/29/09	SY	7/31/10*	CVCA1*	1 yr	133
PVER	2011	N?	SY1	lG/Ag	PVER3?	U	8/14/10	SY	8/2/11	PVER1*	1 yr	692
PVER	2011	N?	SY1	lG/Ag	CVCA1?	U	8/9/10	SY	8/2/11	PVER1*	1 yr	33,451
PVER	2011	N?	SY1	lG/Ag	CVCA2?	U	7/29/10	SY	8/2/11	PVER1*	1 yr	33,828
CVCA	2011	N	FJR	W R-mB/Ag	CVCA2	M	8/3/10	SY	7/12/11*	CVCA2*	1 yr	205
CVCA	2011	N	SY2	lG/Ag	CVCA1?	U	8/14/10	SY	8/8/11	CVCA1*	1 yr	220
CVCA	2011	N	SY2	lG/Ag	CVCA2?	U	8/9/10	SY	8/8/11	CVCA1*	1 yr	410
CVCA	2011	N	SY2	lG/Ag	PVER3?	U	7/29/10	SY	8/8/11	CVCA1*	1 yr	32,817
PVER	2012	N	WKA	Y-Bk-Y/Ag	PVER2	F	7/15/10	TY	7/30/12	PVER4	2 yrs	1,781
PVER	2012	N?	HY08	P-mB/Ag	CVCA1?	U	6/30/05	5Y	7/26/12	PVER4	4 yrs	33,786
PVER	2012	N?	HY08	P-mB/Ag	BWHB?	U	6/30/05	5Y	7/26/12	PVER4	4 yrs	80,577
PVER	2011	PF	HJR	mB-O-mB/mB	PVER4	U	8/4/11	HY	8/23/11	PVER4	19 d	175
PVER	2011	PF	HY2	Bk-Y-Bk/mB	PVER2	U	8/2/11	HY	8/21/11	PVER2	19 d	400
PVER	2012	PF	BGB	O-lB/Mg	PVER4	U	7/27/12	HY	8/27/12	PVER2	31 d	1,470
PVER	2012	PF	BGB	O-lB/Mg	PVER4	U	7/27/12	HY	8/15/12	PVER4	19 d	100
PVER	2012	PF	BBZ	Ag-Lv/Mg	PVER5	U	8/8/12	HY	9/3/12	PVER5	26 d	270
PVER	2012	PF	B52	Y-mB-Y/Mg	PVER5	U	8/1/12	HY	8/10/12	PVER5	9 d	230
PVER	2012	PF	B52	Y-mB-Y/Mg	PVER5	U	8/1/12	HY	8/14/12	PVER5	13 d	145
PVER	2012	PF	B55	G-Y/Mg	PVER5	U	8/6/12	HY	8/15/12	PVER5	14 d	420
PVER	2012	PF	B55	G-Y/Mg	PVER5	U	8/6/12	HY	9/3/12	PVER5	28 d	50
PVER	2012	PF	B55	G-Y/Mg	PVER5	U	8/6/12	HY	9/4/12	PVER5	29 d	30
PVER	2012	PF	BDEF	UNB	PVER4	U		HY	9/4/12	PVER4		465
CVCA	2010	WS	PM	O mB/mB Ag	CIBIPM	M	7/3/10	AHY	7/9/10	CVCA1	5 d	13,683
PVER	2012	WS	SLS	Mg/Y-Bk	PVER2	M	6/30/12	AHY	7/27/12	PVER1*	27 d	800
PVER	2012	WS	SLS	Mg/Y-Bk	PVER2	M	6/30/12	AHY	9/13/12	PVER4*	75 d	1,180
Cibola	2012	WS	LLL	Mg/lB-mB-lB	CVCA1	F	7/19/12	AHY	8/13/12	CIBCR*	25 d	5,665
Cibola	2012	WS	PEP	Mg/Bk-mB	CVCA3	F	6/24/12	HY	6/28/12	CIBEUC	4 d	4,700

[1] Dispersal type: B = breeding, N = natal, PF = post-fledging (same season), and WS = within-season movement.
[2] ? = possible ID of partial re-sight, SY = SY (non-unique comb.), HY08 = 2008 HY (non-unique), or 2–3 letter ID.
[3] Ag = gold, Bk = black, G = green, Lv = lavender, lB = light blue, lG = light green, Mg = magenta, mB = mid-blue, O = orange, P = pink, W = white, R = red, Y = yellow.
[4] * = possible site.
[5] DNA-sexed F = female, M = male, otherwise not sexed.
[6] AHY = after hatch year, ASY = after second year, ATY = after third year, A4Y = after fourth year, 5Y = fifth year, and HY = hatching year.
[7] * = recapture.
[8] * = breeding confirmed.
[9] Time between banding and re-sight in years or days.
[10] Distance between nests (and see dispersal type column between years or breeding dispersal [B], natal nest and first nest [N], natal nest and re-sight [PF], recapture and re-sight [WS]).

Returning birds dispersed a median distance of 205 m from their previous breeding or natal site (see table 9-3). Adults dispersed a median distance of 473 m from their previous breeding site. Seven of the eight returning adults returned to their previous breeding locations (three at CVCA, three at PVER, and one at BWR), dispersing to breed a median distance of 149 m between years (range 48–1,389 m). Six of the seven philopatric adults were male, which included one male returning to the same CVCA2 breeding territory 3 consecutive years. The single adult re-sighted away from its initial capture area was a female banded in 2009 at CRIT (no breeding evidence) who was re-sighted the following year, 37,360 m north at the BWR (Planet Ranch); there she was seen copulating with an unknown adult, though no nest was found.

Three of five returning young were males returning to their natal site in their second year to breed (see table 9-3). The remaining two were females relocated at sites other than their natal site: one female dispersed from CVCA1 to PVER2 the following year to breed (33,315 m from her natal nest); the other was banded at PVER2 in 2009 and recaptured at PVER4 as a third year bird in 2012 (1,781 m from her natal nest; no nest was found in 2012).

In 2011 and 2012, we re-sighted seven juveniles banded earlier in the season as nestlings or recent fledglings, all at PVER. All juveniles were re-sighted nearby; at least one adult and appeared to be receiving parental care, though no food carries were observed. Distances juveniles were re-sighted from their natal nest ranged from 30 m to 1,470 m. In 2011, we recaptured a 27-day-old juvenile 175 m from its nest, accompanied by an adult and another juvenile, and re-sighted a 26-day-old juvenile 400 m from its natal nest, observed with two adults. In 2012, we re-sighted five juveniles post-fledging (four banded and one unbanded accompanied by a banded parent) (see table 9-4). The greatest dispersal distance observed was by a 38-day-old from PVER4 nest 5 who was re-sighted 1,470 m away in PVER2. It appeared to be with a nearby adult, though again, no food carries were observed.

During the course of this study, we obtained limited data on between-year mate fidelity: one male (LJ) nested with a different female in 2011 (DUM) and 2012 (JLO), and another male (PF) nested with a different female in 2009 (ODY) and 2012 (GBO). In 2012, we confirmed seasonal monogamy, with a female (PRI) and male (SLS) having two successful nests together (chapter 8).

Telemetry

Between 2009 and 2012, we attached radio transmitters to 79 adult cuckoos and followed each between 0 and 38 days (averaging 9 days of tracking, 39 points per bird, table 9-5). Thirty-six tracked cuckoos were confirmed breeders, 2 were probable breeders, 35 were transient (showing no breeding evidence before

Table 9-5.—Summary of telemetry data for 79 adult yellow-billed cuckoos tracked at LCR sites, 2009–2012

Area	# birds tracked	Sex		Breeding status[1]			Avg. # points[2]	Avg. days tracked	Avg. min. days at site[3]
		M	F	B	T	U			
BWR NWR	8	7	1	4	2	2	29	5.2	20.5
2010	3	3	0	2		1		4	23.7
2012	5	4	1	2	2	1	29	6	18.6
Cibola	11	6	5	2	9		33	6.4	21.5
2009	2	1	1	1	1		45	10	12
2010	3	2	1		3		54	7.7	14.2
2011	4	2	2		4		18	4.7	26.5
2012	2	1	1	1	1		18	4.5	11.5
CRIT	4	0	4		4		32	4.7	11.5
2009	2		2		2		16	2.5	6
2011	2		2		2		39	7	17
CVCA	29	20	9	16	12	1	44	10.1	22.3
2009	3	2	1	2		1	52	7.7	14.7
2010	10	8	2	5	5		54	13.6	24.2
2011	8	4	4	5	3		42	9.1	24.1
2012	8	6	2	4	4		27	7.1	21
Havasu	4	1	3	1	3		22	8	15.5
2010	3	1	2	1	2		22	10.7	19.3
2011	1		1		1		-	-	4
PVER	22	10	12	15	4	3	44	11.6	30.3
2009	1	0	1	1			96	13	29
2010	4	3	1	2	2		26	9.2	18.2
2011	4	1	3	2	2		32	7.2	20.5
2012	13	6	7	10		3	49	13.5	37.1
Quigley 2011	1		1		1		16	5	13
All sites	79	44	35	38	35	6	39	9	22.6
2009	8	3	5	4	3	1	51	7.6	16
2010	23	17	6	10	12	1	44	10.4	20.9
2011	20	7	13	7	13		33	7	19.1
2012	28	17	11	17	7	4	37	9.7	28.4

[1] B = confirmed/probable breeding; T = transient (no breeding evidence); and U = unknown.
[2] Average number of points used to calculate home ranges.
[3] Average number of days birds stayed at site post-capture.

leaving), and 6 had unknown breeding status, either dropping their transmitter soon after release or were captured late in the season at known breeding sites. We found 35 nests by radio tracking breeding birds (40% of all nests found from 2008–2012) (chapter 8). To assess potential impacts of radio telemetry on nesting cuckoos, we compared nest fates between nests belonging to a radio tracked parent to nests with no radio-tracked parent (within restoration sites); of 66 nests found from 2009–2012, the nests of radio-tracked adults (n = 35) had slightly higher (non-significant) average nest success compared to nests without a radioed adult (n = 29, 69 versus 66%, respectively, t-test P = 0.8). We radio tracked slightly more males than females (54 versus 46%), similar to the sex ratio of all captured birds.

Telemetry observations indicated that most birds (83%) stayed at their capture site within a defined territory until leaving the area whether they nested or not. The number of days spent at the capture site was related to eventual breeding status. Confirmed breeders spent significantly more days at their capture area (average 37.2 days, n = 36) than birds that left before breeding was confirmed (average 10.4 days, n = 43, P < 0.0001) (table 9-6). Departure of birds from sites was steady throughout the season. Birds leaving sites in the first half of the season (< July 24) stayed at least 1 to 29 days post-capture (average 9.7 days, n = 33) with no breeding evidence, and most were assumed to be transient throughout the sites. Conversely, birds that left later in the season remained at their capture site longer (average 31.9 days, n = 46, P < 0.0001) and were more likely to nest. From 2009 to 2011, over one-half of all birds tracked appeared to be transient; however, in 2012, just over one-third of the tracked birds appeared transient. At PVER, all birds captured and tracked in 2012 before July 24 stayed at PVER and nested.

Table 9-6.—Minimum number of days at site post-capture by breeding status, LCR 2009–2012

Status	N	Minimum days at site	
		Range	**Mean ± SD**
Early departure (< July 24)	33	1–29	9.7 ± 6.85
No breeding confirmed	43	1–29	10.42 ± 6.41
Later departure (≥ July 24)	46	3–60	31.89 ± 14.39
Confirmed breeding	36	12–60	37.19 ± 11.22

Four birds that left their capture areas were relocated in different survey areas later in the season (one in 2010 and three in 2012): in 2010, a transient male moved from Cibola NWR (Island Unit) north 13 kilometers (km) to CVCA1 where he spent 11 days before leaving; in 2012, a transient female moved from CVCA3 south 4.7 km to Cibola Eucalyptus and was re-sighted during a survey; a transient male captured at Cibola Crane Roost was briefly located (by telemetry) ~700 m west across the river, also at Cibola Eucalyptus, returning to his capture site shortly before disappearing; and a female captured at CVCA1 on July 19 was found nesting 5.6 km to the south at Cibola Crane Roost. Five other birds moved at least 1 km away from their capture site to a contiguous site, three at BWR and two at PVER.

At the BWR NWR, one male captured in 2010 was found at a nest 2.5 km from his Mineral Wash capture location 20 days after his signal was lost. A 2012 male moved 1,600 m upstream from his Mineral Wash capture site to nest at Honeycomb Bend. Another male, also captured at Mineral Wash in 2012, moved 5 km downstream to Sandy Wash before temporarily settling 2.5 km back upstream at Cougar Point. This bird occupied a probable breeding area, although there were already two other birds in the same area (a probable pair). A female captured at Cougar Point in 2012 probably nested close to her capture location (in a probable breeding territory where food carries were seen); however, she left the area 6 days later before breeding could be confirmed. Three other BWR birds disappeared or experienced transmitter failure shortly after capture. At PVER, a female captured in 2012 moved 1,500 m west from PVER4 to PVER2 and then 3.6 km back east to PVER5 where she nested 2,100 m from her original capture location. A non-radioed male was also re-sighted 800–1,200 m east of his PVER2 capture location nesting at PVER1 and then PVER4.

All home range estimates showed high variation and non-normal distributions. The average home range size (95% KDE) of 70 birds tracked for at least 1 day was 18.4 ±9.23 ha (median = 16.93 ha) (table 9-7). MCPs were the most variable, averaging 31.33 ± 52.65 ha (median 16.3 ha). The average core area (50% KDE) was 3.98 ± 2.48 ha (median = 3.3 ha). There was a slight positive correlation between the number of points used and the 95% KDE (adj. $r^2 = 0.064$, $P = 0.0194$). This disappeared when birds with fewer than 10 points were excluded. Due to the high error in home range estimates among birds tracked for less than 7 days, 26 birds were excluded from further analysis, causing a slight increase in average home range estimates (table 9-7). We found no significant differences in average home range size (MCP, 95% KDE, or 50% KDE) based on gender, site, or days tracked ($P > 0.05$ for all tests). However, transient (unmated) birds had significantly larger home range sizes compared to breeding birds (MCP: Wilcoxon test $P = 0.013$; 95% KDE: $P = 0.028$) (table 9-7). In particular, transient females had significantly larger MCP sizes compared to both breeding males and breeding females (Kruskall Wallace test $P < 0.05$) and significantly larger 95% KDE sizes compared to transient females (Kruskall Wallace test $P < 0.05$) (table 9-7). Of 30 confirmed breeding birds tracked for at least 7 days, the average 95% KDE was 18.1 ha compared to 26 ha for 13 presumed non-breeding birds with at least 7 days of data. The core range (50% KDE) of nesting birds averaged 3.6 ± 1.5 ha (equivalent to a circle of radius 107 ± 69 m surrounding the nest).

Table 9-7.—Average YBCU home ranges ± SD by gender, breeding status, and site, LCR 2009–2012 (* indicates significantly different from another group [nonparametric Wilcoxon or Kruskal Wallace test P < 0.05]).

Factor	Group	Home range estimate (ha) mean ±SD (includes MCP median)		
		MCP	95% KDE	50% KDE
All birds	All (n = 70)	31.33 ± 52.65 (16.3)	19.55 ± 9.29	3.96 ± 2.47
	> 6 days (n = 44)	39.87 ± 63.86 (17.32)	21.38 ± 9.13	4.21 ± 2.28
Gender	Male (n = 38)	32.84 ± 63.21 (16.3)	19.79 ± 9.29	4.18 ± 2.88
	Female (n = 32)	29.53 ± 37.37 (15.96)	19.26 ± 9.44	3.7 ± 1.9
	Male > 6 days (n = 27)	39.21 ± 73.48 (16.8)	20.5 ± 8.19	4.2 ± 2.42
	Female > 6 days (n = 17)	40.93 ± 46.74 (18.9)	22.79 ± 10.55	4.24 ± 2.12
Breeding status	Non-breeding (n = 32)	46.98 ± 74.1 (19.65)	21.74 ± 11.34 (20.15)	4.7 ± 3. 16
	Breeding (n = 33)	18.5 ± 12.53 (15.32)	18.17 ± 6.88 (17.03)	3.43 ± 1.53
	Non-breeding (> 6 days, n = 14)	84.88 ± 99.9 (49.4)*	26.75 ± 11.3 (23.76)*	5.57 ± 3.03*
	Breeding (> 6 days, n = 29)	19.17 ± 11.88 (16.2)*	19.02 ± 6.85 (17.6)*	3.61 ± 1.54*
Gender x breeding status	All:			
	Non-breeding male (n = 16)	49.96 ± 95.09 (15.95)	20.41 ± 11.46 (18.7)	5.03 ± 3.85
	Non-breeding female (n = 16)	43.99 ± 47.8 (35.35)	23.06 ± 11.42 (21.45)	4.37 ± 2.35
	Breeding male (n = 21)	20.88 ± 14.08 (16.8)	19.56 ± 7.71 (17.7)	3.59 ± 1.77
	Breeding female (n = 12)	14.33 ± 8.15 (13.15)	15.74 ± 4.44 (16.22)	3.14 ± 0.96
	> 6 days:			
	Non-breeding male (n = 7)	93.71 ± 134.7 (31.85)	22.42 ± 9.64 (19.8)	5.68 ± 3.47
	Non-breeding female (n = 7)	76.06 ± 57.41 (50.6)*	31.08 ± 11.83 (32.4)*	5.47 ± 2.8
	Breeding male (n = 19)	20.66 ± 13.62 (16.8)*	20.09 ± 7.91 (18.96)	3.73 ± 1.81
	Breeding female (n = 10)	16.34 ± 7.37 (14.66)*	16.99 ± 3.7 (16.82)*	3.37 ± 0.88
Site	BWR NWR (500 ha, n = 5)	49.25 ± 81.62 (10.2)	11.5 ± 5.38	3.94 ± 4.54
	Cibola NWR (57 ha, n = 2)	29.32 ± 20.62 (30.4)	22.92 ± 12.74	4.42 ± 3.88
	CRIT (60 ha, n = 3)	51.88 ± 49.36 (30.4)	26.1 ± 16.44	6.27 ± 3.17
	CVCA (64 ha, n = 8)	30.51 ± 69.73 (16.2)	18.67 ± 8.41	3.98 ± 1.9
	Havasu NWR (21 ha, n = 3)	27.88 ± 39.49 (8.9)	17.33 ± 5.45	3.0 ± 0.9
	PVER (160 ha, n = 13)	27.88 ± 39.49 (14.9)	16.88 ± 7.16	3.61 ± 1.61
Year	2009 (n = 6)	27.63 ± 15.08 (30.1)	22.33 ± 8.49	3.8 ± 1.61
	2010 (n = 19)	42.57 ± 79.45 (16.8)	21.65 ± 10.41	4.27 ± 2.35
	2011 (n = 18)	22.5 ± 24.19 (16.3)	19.83 ± 9.73	4.11 ± 2.06
	2012 (n = 27)	30.12 ± 49.09 (10.7)	17.26 ± 8. 24	3.68 ± 3.0
	> 6 days:			
	2009 (n = 4)	32.75 ± 12.71 (30.1)	24 ± 6.19	3.52 ± 0.57
	2010 (n = 15)	50.97 ± 87.97 (28.5)	23.33 ± 10.59	4.54 ± 2.35
	2011 (n = 10)	27.71 ± 30.61 (16.4)	22. 12 ± 11.74	4.59 ± 2.52
	2012 (n = 15)	38.79 ± 62.42 (15.32)	18.25 ± 5.47	3.82 ± 2.41

DISCUSSION

From 2008–2010, we did not typically band nestlings with unique color band combinations, as nestling tarsi are only long enough to fit one band, and banded nestlings historically were rarely re-sighted; therefore, it was not considered a high priority. In 2011, we switched from Darvic bands to metal pinstripe bands and began giving every banded bird a unique two-band color combination regardless of age. This reduced the time and effort required to band birds (especially adults) and should also reduce the occurrence of re-sighted birds that cannot be identified to individual unless captured.

Our re-sight results suggest high site fidelity among male cuckoos and that both natal and breeding dispersal is female-biased, as is the case for most bird species (Greenwood 1980). All nine re-sighted males returned to their natal or previous breeding site. Two females returned to their previous breeding or natal area (one returning adult and one returning hatch-year-banded third-year), while another two females (one ASY and one SY) dispersed 33–38 km to other areas, the only long-distance dispersal events we recorded during the study. It remains unclear whether female cuckoos actually have lower site fidelity than males as our data suggests, or if other factors are masking true female site fidelity, such as reduced visibility of females due to behavioral differences; in response to call broadcasts, female cuckoos are less likely to fly closer to surveyors than males (Halterman 2009), providing fewer opportunities to re-sight banded females. Possibly for the same reason, fewer female cuckoos are typically captured than males. Additionally, there are on average 33% fewer adult females in wild bird populations (Donald 2007). Clearly more data are required.

Although dispersal is commonly believed to be easy or common among highly mobile species such as migratory birds, it is strongly influenced by ecological factors affecting dispersal costs (Weatherhead and Forbes 1994). Long-distance migrants often exhibit strong natal philopatry and only slightly higher mean dispersal distances compared to resident or less mobile taxa (Hansson et al. 2002; Ortego et al. 2008). In landscapes impacted by fragmentation, breeding birds must weigh the risk of mortality from dispersing through unfamiliar or hostile environments (Yoder et al. 2004) against the risk of inbreeding if they do not disperse (Hansson et al. 2004). Several studies have found reduced dispersal in isolated bird populations (Martin et al. 2006; Martín et al. 2008; Ortego et al. 2008), and western yellow-billed cuckoos are believed to have lower dispersal capabilities due to their habitat isolation and reduction (Bennett and Keinath 2003). Farrell (2006) found genetic evidence suggesting increased levels of inbreeding in western compared to eastern cuckoos.

Our re-sight rate among returning SY birds varied considerably over the 4-year period, from 20% in 2009 to 0 in 2012. Given the evidence suggesting high natal site fidelity, especially among males, it seems unlikely that none of the 35 banded 2011 hatch year birds returned to their natal site or nearby, and many likely went undetected. Four birds banded prior to 2011 were re-sighted for the first time in 2012, including a fifth-year and two after-fourth-year birds, our oldest known birds to date. This highlights both the challenges of re-sighting banded cuckoos (male or female) and the need for continued long-term monitoring of banded subpopulations.

We observed four within-season movements between non-contiguous sites, in 2010 and 2012, all in the Cibola area (CVCA and Cibola NWR/Eucalyptus). These areas are relatively close to each other (within 5–6 km), closer than most other survey areas are to each other. Many sites such as Cibola Eucalyptus were suitable nesting habitat in their first few years after planting (Rosenberg et al. 1991), but no longer appear to be suitable for breeding today; however, these re-sights show the importance of riparian forest patches connecting breeding sites (discussed in chapter 2).

Young cuckoos have previously been observed receiving parental care for at least 2 weeks post-fledging (Laymon 1998). In 2011, we re-sighted two juveniles, 3 and 3-1/2 weeks post-fledging, both still apparently receiving parental care (in close proximity to adults); in 2012, we witnessed apparent post-fledging parental care periods of 4 to 4-1/2 weeks post-fledging. Additional information on post-fledging care and dispersal may help guide future management decisions such as September dove hunting at LCR MSCP breeding sites.

Our telemetry results indicated that after cuckoos arrived at a site, they typically remained in one area during the length of their stay whether they nested or not (though some pre-breeding tracked birds made large movements before settling on a nesting territory). This suggests that cuckoos establish both breeding and foraging territories (as opposed to randomly moving through available habitat). Approximately one-half of the birds we tracked (mostly during the first half of the season) left their capture site within 2 weeks, before breeding was confirmed, and were thus in an open population (discussed in chapter 2). Some of these birds may have been migrating through the area and stopping long enough to replenish nutrients (Chernetsov 2006); others may have been searching for breeding territories and/or mates, either leaving due to lack of success or leaving with a mate to a new breeding site. In 2012, just over one-third of tracked birds appeared to be transient, and notably, all birds captured at PVER during the first half of the 2012 season remained at PVER to nest. More birds may have stayed to breed at PVER due to increased breeding habitat availability in 2012; apart from the previous 91 ha of available breeding habitat in 2011, another 74 ha (Phase 5) became available in 2012. The LCR, however, is still likely an important migration route for other western cuckoo subpopulations.

Our home range estimates averaged consistently close to 20 ha during each year of this study, though with high variation. Both an insufficient number of location points and number of days tracked significantly impacted the estimates, a common problem when tracking transient individuals (Hansteen et al. 1997). Despite these issues, we were able to track 44 birds for at least 7 days and found significantly larger home ranges among transient birds, especially transient females. This supports our evidence of lower site fidelity among females who may travel further average distances than males in search of available mates or breeding territories.

Our home range estimates for cuckoos are also considerably smaller than those reported from other areas such as the San Pedro River (38.6 ha 95% KDE) (Halterman 2009) and the Rio Grande (56.3 ha 95% KDE) (Sechrist et al. 2009) and may indicate differences in habitat area, quality, or prey densities. Also, as we found larger home ranges among transient birds, the other studies may have tracked relatively higher proportions of transient compared to breeding birds. There may also be differences in tracking and estimation methods among researchers.

In 2012, we increased our mist netting effort at the BWR NWR to be able to compare BWR home range estimates to those at LCR restoration sites. We expected BWR birds to have larger home ranges than at the smaller restoration sites, more comparable to those of other large, intact riparian forests; however, we did not find this to be the case. Mist netting and radio tracking at the BWR is problematic due to limited net lanes, signal bounce off cliff faces, dense vegetation, and access limitations. The combination of small sample size, transiency, and possible transmitter failures make our BWR results somewhat limited; however, they suggest that BWR birds also settled into relatively small foraging/nesting areas, which is similar to birds tracked at LCR MSCP restoration sites.

Five years of color banding, re-sighting, and telemetry at LCR breeding sites has enabled us to assess annual responses to habitat of varying patch sizes and connectivity and, if continued, may confirm or refute the existence of physical limits to dispersal among these subpopulations. Additionally, obtaining accurate annual survivorship estimates for most wild bird populations requires at least 10 years of continuous mark-re-sight data (Amstrup et al. 2005). We therefore recommend the continuation of long-term banding and monitoring of this as well as other western cuckoo breeding subpopulations.

Chapter 10 – Summary of Results and Management Recommendations

SURVEYS

- Through repeated standardized surveys throughout the study area, the annual status of the LCR cuckoo subpopulation can be assessed by examining spatial and temporal distribution and habitat use patterns (chapter 2). Overall, we found the Halterman et al. (2009a) survey protocol suitable for its intended purpose to assess cuckoo habitat use. From our analyses, comparisons, and observations, we recommend that surveys be conducted using 12–14 day survey periods rather than the currently recommended 12–20 days apart (chapter 3). We found that the probability of not detecting breeding cuckoos on a survey was less than 5% when conducting four or five surveys (chapter 4). Additional protocol assessment could include evaluating the use of other broadcast calls (such as the coo call) to increase response and detection (chapter 4).

HABITAT

- Our results support the current understanding that yellow-billed cuckoos prefer large patches of woody riparian habitat, taller canopy for foraging, and increased canopy closure for nesting (Laymon et al. 1997). Increased native small tree stem densities are important to cuckoo nest placement. Our strongest habitat assessment results and recommendations are presented in table 10-1. We recommend the continued collection of data (using consistent data collection methods) for these habitat variables, as well as other variables listed in attachment G, as they also may be important to cuckoo habitat selection.

Table 10-1.—Strongest factors associated with cuckoo site occupancy and nest placement (These variables should continue to be collected for future habitat analyses.)

Vegetation variable	Importance	Association	Recommended management action
Total canopy closure	Nest placement	+	Increase
Native small tree stem density	Nest placement	+	Increase – create varied habitat
Area	Site occupancy	+	Increase
Native large tree stem density	Nest placement	+	Increase – create varied habitat
Total canopy average height	Site occupancy	+	Create varied habitat
Forb cover	Site occupancy	+	Increase moisture at dry sites

- Area was a predictor of yellow-billed cuckoo site occupancy, and we found the median size of occupied sites (37.2 ha) to be almost three times as large as unoccupied sites (12.8 ha). We also found the average home range size of cuckoos radio tracked for at least 7 days was 20.3 ha. Creating larger habitat patches will increase cuckoo abundance and may also increase cicada and other large arthropod densities.

- We recommend joining clusters of small habitat patches together to form larger patches where possible by planting woody riparian vegetation in between. This would increase both age structure and size, increasing breeding habitat suitability. Several areas already have the necessary infrastructure (i.e., adjacent irrigation canals): at Havasu NWR, Pintail Slough and North Dike could be connected; at Cibola NWR, Cibola North and Nature Trail could be connected; and at Imperial NWR, the three surveyed patches (Imperial South, 20A and 50) could be connected together. By adding additional habitat to existing sites, the LCR MSCP could more easily meet the goal of establishing several new cuckoo subpopulations on the LCR as recommended by Laymon and Halterman (1989). Likewise, simulating natural large flood events at mature sites by felling bands of older trees may stimulate or enable room for successional growth.

- Maintenance of structural diversity (both early- and late-successional stages) of riparian forest are important for the successful management of yellow-billed cuckoos. A heterogeneous mix of mature and young stands of native trees would fulfill both foraging and nesting requirements. Cuckoos forage in late successional cottonwoods and use these areas for both day and night roosting and also use early successional trees and large shrubs for nesting. It is important to maintain a variety of plants for nesting substrate as well as the varied food sources they provide. Coyote willow may be an important addition to restoration sites (planted in high-density patches at PVER and CVCA). We observed frequent use of coyote willow at LCR MSCP restoration sites, with nests often occurring near the edges of these stands and fledglings observed using this low structure for protection, as well as foraging adults.

- We recommend the protection and restoration of adjacent mesquite habitat near restoration sites. On the upper San Pedro River in southeast Arizona, we observed large expanses of mature mesquite bosque adjacent to cottonwood-willow forest regularly used for cuckoo nesting, and we found four nests on the LCR where this habitat type occurs (all at Cibola NWR). Additionally, increased mesquite patches will add further diversity to the riparian habitat mosaic. The relationship of cuckoos with mesquite and other adjacent habitats and the importance of the surrounding landscape for nesting success, site connectivity, and dispersal warrant further study.

- Retention and expansion of stopover sites is recommended, as these habitat patches may provide vital migratory and dispersal stopover habitat that aid in the successful reproduction of cuckoos at LCR sites and elsewhere. Further study on the migratory behavior and dispersal capabilities of cuckoos would increase our understanding of migratory stopover habitat use and required connectivity.

MICROCLIMATE

- Yellow-billed cuckoos select nest sites at cooler and more humid locations. Ensuring that restoration sites have areas of dense canopy and relatively high humidity may increase the availability of suitable nesting locations. Although microclimate cannot be manipulated directly, providing a site with suitable nesting microclimates can be achieved indirectly through changes in vegetation characteristics (such as increased canopy closure) and increased soil moisture. Irrigation quantity as well as timing (both time of day and season) may also affect arthropod communities. We recommend that irrigation be monitored for its effects on plant growth, wildlife species, and the macroinvertebrate population. Knowledge of irrigation schedules would help to compare differences across sites.

SITE MANAGEMENT

- Over the past 5 years, the yellow-billed cuckoo nesting season on the LCR (mainly at LCR MSCP restoration sites) has gradually expanded later into the year, from finishing early- to mid-August in the first 2 years, to September in 2012 when three PVER nests were active into early September. This lengthening of the breeding season may be due in part to an increase in double-brooding, an important avian reproductive strategy that may contribute to western cuckoo population recovery. However, the lengthened breeding season now currently overlaps with the dove hunting season, beginning September 1. We recommend reducing all potential threats to breeding productivity, including delaying dove hunting at all known breeding sites, until after breeding is complete and juveniles have departed (currently at least until early October at PVER).

- Restoration sites are often subjected to extreme noise and other disturbances during the breeding season, including motor boats, jet skis, traffic, crop dusters, chainsaw clearing, irrigation pumps, heavy farm equipment, and lengthy construction projects. Clearing of tamarisk during the 2011 breeding season was the likely cause of one known nest failure at CVCA. Also, a previous nest tree was cut down at CVCA. We recommend limiting site construction or maintenance activities to the non-breeding season (October to February) whenever possible as well as retaining past nest trees (which may be reused in subsequent years).

RESEARCH AND MONITORING

- Research exploring the genetic relatedness among cuckoo subpopulations, dispersal, and site fidelity may help to evaluate population trends. Farrell (2006) stated evidence of possible increased inbreeding in western compared to eastern cuckoos. Though inbreeding has been studied in domestic populations, there is a paucity of population genetic studies from natural environments (Szulkin and Sheldon 2007). We recommend the funding of genetic analysis of samples that have already been collected, as well as the continuation of DNA sampling of both adults and juveniles, to establish a pedigree and measure gene flow among breeding sites.

- Through intensive nest-searching and monitoring over the past 5 years, we discovered large increases in the number of breeding territories at LCR MSCP sites and have begun to quantify population demographic parameters, such as nest success and productivity, important for assessing habitat quality. We recommend the continuation of long-term nest monitoring to determine population parameters among breeding subpopulations. Nest searchers should be experienced and trained to reduce disturbance and to avoid nest abandonment.

- Video nest monitoring can provide still-lacking information on cuckoo nesting ecology. Color nest video cameras (to identify bands) may help us identify a higher number of individuals and the nature of nesting interactions. Color video cameras can also assist with prey species identification as well as predator identification, which may provide information on nest depredation, the primary cause of nest failure at restoration sites. Although research has been conducted on avian predators at real and artificial nests at some LCR MSCP sites (Theimer et al. 2010), we recommend video nest monitoring over a number of years because predation varies greatly from one year to the next. In addition, restoration habitat changes rapidly, and over time, a different suite of predators may arise.

- Over the past 5 years of color banding and re-sighting banded LCR cuckoos, we have begun to gather valuable data on dispersal, including evidence of (particularly male) site fidelity. It is important to continue collecting these data over a long time period and wide geographic area to gain a better understanding of the causes and consequences of dispersal patterns as well as to assess juvenile and adult survival, demographic trends, and the extent of connectivity among the geographically separated breeding subpopulations. Additionally, obtaining accurate annual survivorship estimates for most wild bird populations requires at least 10 years of continuous mark-re-sight data (Amstrup et al. 2005). To build on our current knowledge, we recommend the continuation of long-term color banding of the LCR cuckoo subpopulation as well as of other western subpopulations. Banders should be highly skilled and trained in avian first aid.

- Cuckoo breeding and cicada abundance are correlated in natural systems, but less is known about prey base at the restoration sites. Various management actions (e.g., irrigation and spraying) may have significant positive or negative impacts on prey communities. We recommend additional research on factors influencing prey at LCR MSCP sites, emphasizing large arthropod species richness and abundance. Ideally, field work should be conducted pre- to post-cuckoo breeding to assess temporal changes over time, which may affect breeding phenology and density.

ACKNOWLEDGEMENTS

Southern Sierra Research Station wishes to thank the following organizations and individuals for their support and assistance with this project: Bob Achee (Arizona Game and Fish Department), Jack Allen (USFWS), Joseph Barnett (USFWS), Sue Barney (California State Parks), Pam Beare (California Department of Fish and Game), Dianne Bangle (Bureau of Reclamation [Reclamation]), Sharon Birks (University of Washington Burke Museum), Kathleen Blair (USFWS), Allen Calvert (Reclamation), Stacey Crow (Reclamation), Jim Dice (California State Parks), Christopher Dodge (Reclamation), Mitch Ellis (USFWS), Dick Gilbert (USFWS), Robin Greene (California State Parks), Gail Iglitz (Reclamation), Elaine Johnson (USFWS), Joe Kahl (Reclamation), Amy Leist (Great Basin Bird Observatory), Jerry Mulcahy (California Department of Fish and Game), Linda Miller (USFWS), David Martinez (‘Ahakhav Tribal Preserve), Mike Oldham (USFWS), Theresa Olson (Reclamation), Barbara Raulston (Reclamation), Steven Rimer (USFWS), Ashlee Rudolph (Reclamation), Todd Shoaff (Bureau of Land Management [BLM]), Bill Singleton (Reclamation), Joe Sims (‘Ahakhav Tribal Preserve), Jeff Young (BLM), and Brenda Zaun (USFWS). Funding was provided by Reclamation under the Lower Colorado River Multi-Species Conservation Program.

We also thank our 2008–2012 field crews and personnel of the Southern Sierra Research Station: Daniel Albrecht-Malinger, Timothy Alvey, Alicia Arcidiacono, Robert Baez, Leif Baieri, Sinéad Borchert, Alyson Brokaw, Pam Bullard, Caroline Cappello, Robert Chapman, Adam Clifford, Amanda Davila, Rebecca Dekay-Robson, Laura Doll, David Dwiggins, Erik Enbody, Anna Fasoli, Rachel Frieze, Andrew Furman, Ryan Gillespie, Sarah Green, Mary Murrelet Halterman, Christopher Hansen, Claire Hanson, Carlene Henneman, Joseph Hildreth, Angela Johnson, Michelle Johnson, Vona Kuczynska, Samantha Lantz, Ariana LaPorte, Melanie Mancuso, Alex McDonnell, Libby Megna, Brandon Miller, Jazelle Mondeau, Steve Mullin, Michael Nicosia, Michael Novak, David Patrusevich, Amanda Proudman, David Rankin, Evan Rehm, Ariana Yvette Renteria, William Rodriquez, Matthew Rogers, Eli Rose, Aliza Sager, Lindsey Smith, Andrew Van Lanen, Amanda Webb, Cara Whalen, Mary Whitfield, and Ben Zyla.

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ATTACHMENT A

Analysis of Vegetation by Site Management Type

DATA ANALYSIS

We analyzed the 2006–2012 vegetation data to determine vegetative differences in site management (BWR[1] natural, non-BWR natural, LCR MSCP[2] restoration, and non-LCR MSCP restoration) using Principal Coordinate Analysis (PCoA). We decided to use PCoA instead of non-metric multidimensional scaling (NMDS) because NMDS axes cannot be interpreted directly, as the axes only define multivariate space.

The object of PCoA is to reduce a dataset containing many (often correlated) variables to a smaller number of composite variables that explain the most variation in a multivariate dataset (Gotelli and Ellison 2004). PCoA is recommended for ordination applications in which the goal is to preserve the original multivariate distances between observations in reduced (ordination) space (Gotelli and Ellison 2004). PCoA creates a principal coordinate (PCO1) that passes through the center of a multi-dimensional dataset and minimizes the squared distance from each point to that coordinate (i.e., explains the most variation). The second coordinate (PCO2) must also pass through the center, but it must be completely uncorrelated (i.e., orthogonal) to PCO1. Additional coordinates are created until all of the variation in the dataset is explained. Typically, the higher order coordinates (greater than third order) account for negligible variation in the dataset. The data output generated by PCoA is in the form of numeric scores, which are referred to as points, one for each sample (vegetation sampling plot). We performed our PCoA on Bray Curtis dissimilarity matrices derived from vegetation data because it is most effective for continuous numerical data (Gotelli and Ellison 2004). We then graphed the output data to visually inspect the results. Vegetation plots similar in their data composition will be closer together when plotted on a graph. Output from the PCoA (which represents the original dataset) can be used for visual inspection as well as further analyses. Individual PCoA axes can be interpreted, and conclusions can be drawn from further analyses of the individual axes' output points.

We reduced habitat variables with PCoA and then examined the individual axes' output points to determine differences in vegetation characteristics for the four different site types. Significant principal coordinates were indicated by an eigenvalue > 1 (McCune and Grace 2002) and a percentage of variation explained > 10. We performed non-parametric Kruskal-Wallis rank-sum tests (due to non-normal data distributions) on the output data from each significant PCo ($\alpha = 0.05$). This test allowed us to determine if there were statistically significant differences for the four site types. We then performed multiple comparison tests to determine which site types were statistically different. We correlated PCo output data and original predictor variables (vegetation data) to infer the habitat variables responsible for the differences. Stronger correlations ($|r| > 0.30$) with predictor variables indicated a stronger association with that end of the respective axis.

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[1] BWR = Bill Williams River.
[2] LCR MSCP = Lower Colorado River Multi-Species Conservation Program.

RESULTS

The first two principal coordinates (PCO1 and PCO2) were significant in explaining the variation in the data (figures A-1 to A-4). PCO1 explained 21.6 percent (%) of variation, and PCO2 explained an additional 13% of variation, for a cumulative 34.6% variation explained. Plots at the four different site management types (BWR natural, non-BWR natural, LCR MSCP restoration, and non-LCR MSCP restoration) were all statistically different from each other for both PCO1 ($\chi^2(3, N = 729) = 728$, $P < 0.001$) and PCO2 ($\chi^2(3, N = 729) = 728$, $P < 0.001$).

The first coordinate (PCO1) represented the habitat variables that explained the most variation in the dataset. The positive end of the PCO1 axis is correlated to increased total canopy closure (all canopy layers); $r_{727} = 0.697$, $P < 0.001$), main canopy closure (layer that provides the most shade) ($r_{727} = 0.605$, $P < 0.001$), brush ($r_{727} = 0.318$, $P < 0.001$), and leaf litter ($r_{727} = 0.827$, $P < 0.001$). The negative end of the PCO1 axis is correlated to the percentage of bare ground ($r_{727} = -0.779348$, $P < 0.001$). The second coordinate (PCO2) explained less variation in the dataset (13%), and these variables are of lesser strength than those associated with PCO1. The positive end of the PCO2 axis is correlated to increased green ground cover ($r_{727} = 0.823$, $P < 0.001$), grass ($r_{727} = 0.814$, $P < 0.001$), and forbs ($r_{727} = 0.397$, $P < 0.001$). The negative end of the PCO1 axis is correlated to increased leaf litter ($r_{727} = -0.322$, $P < 0.001$).

BWR natural plots were characterized by high amounts of canopy closure and ground debris in the form of leaves and brush with lower amounts of bare ground compared to other site types (figure A-1). In comparison, non-BWR natural plots were more variable in their vegetative composition, but overall had similar amounts of brush, litter, and bare ground, and lower amounts of grasses and forbs (figure A-2). LCR MSCP restoration sites were characterized by increased canopy closure and green ground cover, mainly grasses and forbs (figure A-3). Non-LCR MSCP restoration plots showed the most variability in vegetative characteristics (i.e., the points on the biplot that represent vegetation sampling plots were more spread out when compared to the other habitat types) (figure A-4). Generally, the vegetative characteristics were most similar to non-BWR natural plots, but contained more green ground cover, mainly in the form of grasses.

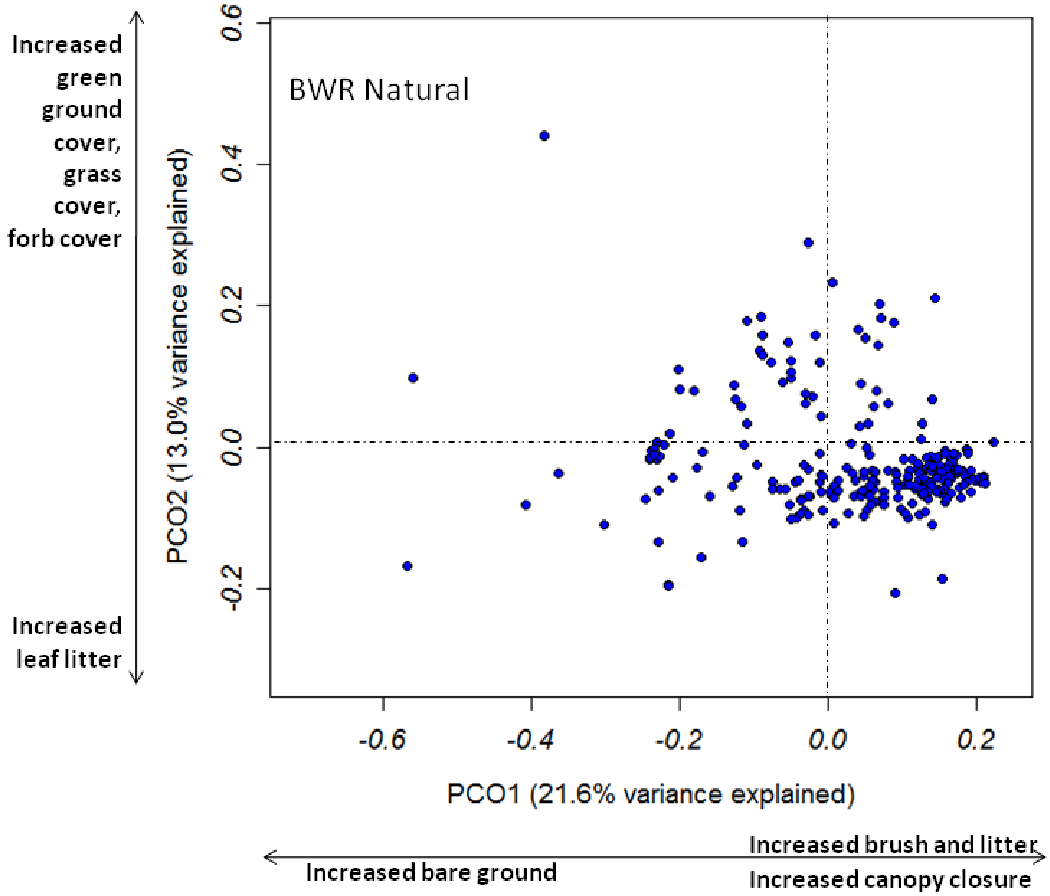


Figure A-1.—Principal coordinate analysis for vegetation data 2006–2012 depicting vegetation plots located at BWR natural sites.

Increased canopy closure, brush, and leaf litter were the main influences on the positive end of the PCO1 axis, while increased bare ground was associated with the negative end. For PCO2, increased grass cover, green cover, and forbs were associated with the positive end of the axis, while leaf litter was associated with the negative end.

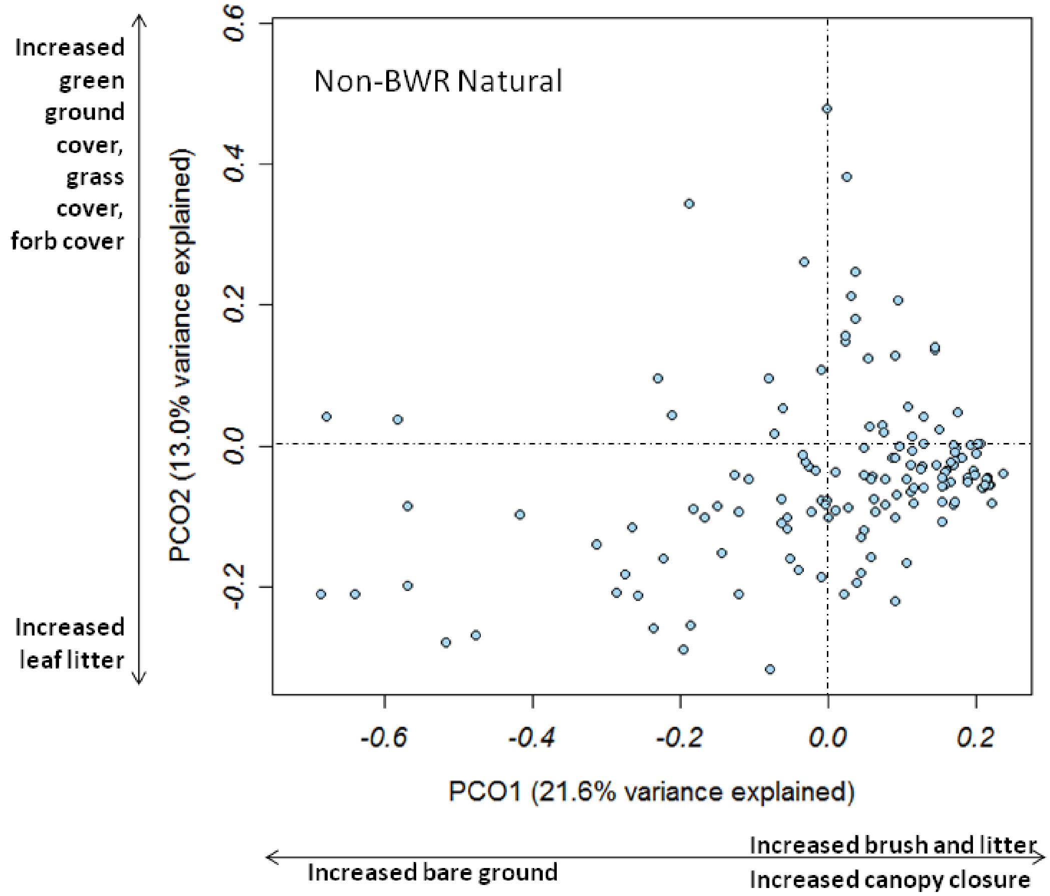


Figure A-2.—Principal coordinate analysis for vegetation data 2006–2012 depicting vegetation plots located at non-BWR natural sites.

Increased canopy closure, brush, and leaf litter were the main influences on the positive end of the PCO1 axis, while increased bare ground was associated with the negative end. For PCO2, increased grass cover, green cover, and forbs were associated with the positive end of the axis, while leaf litter was associated with the negative end.

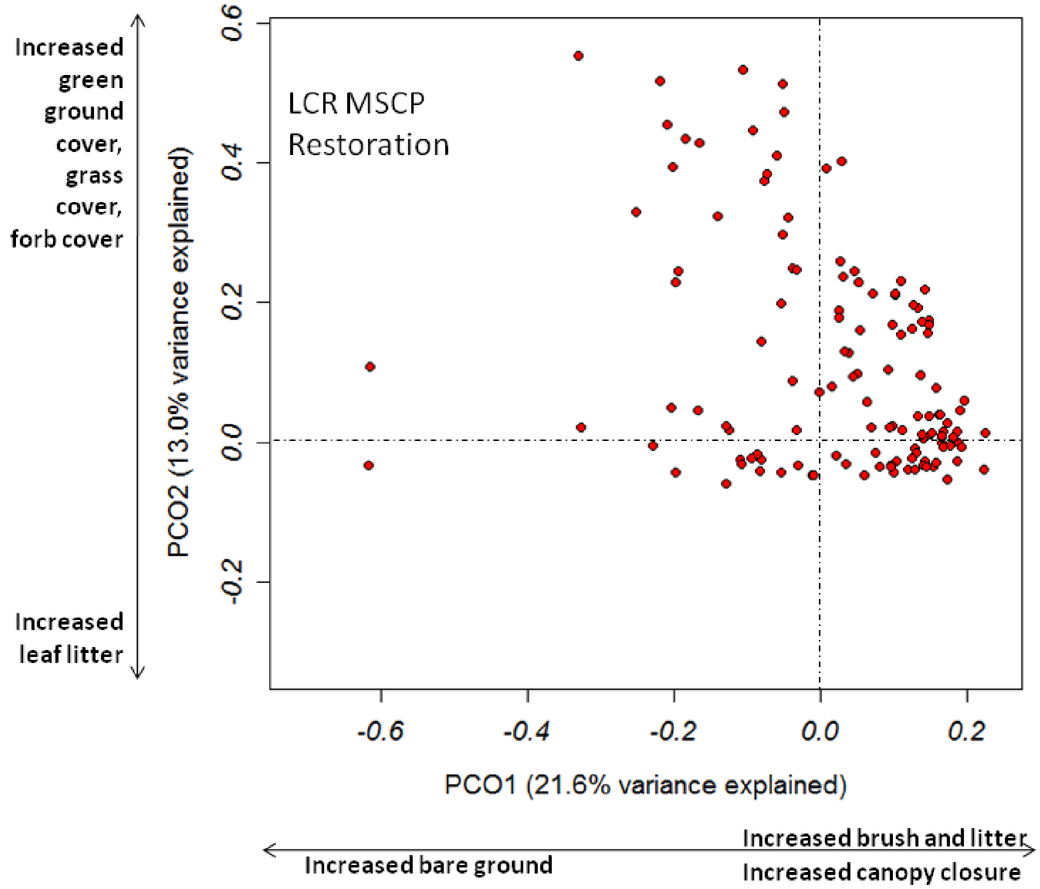


Figure A-3.—Principal coordinate analysis for vegetation data 2006–2012 depicting vegetation plots located at LCR MSCP restoration sites.

Increased canopy closure, brush, and leaf litter were the main influences on the positive end of the PCO1 axis, while increased bare ground was associated with the negative end. For PCO2, increased grass cover, green ground cover, and forb cover were associated with the positive end of the axis, while increased leaf litter was associated with the negative end.

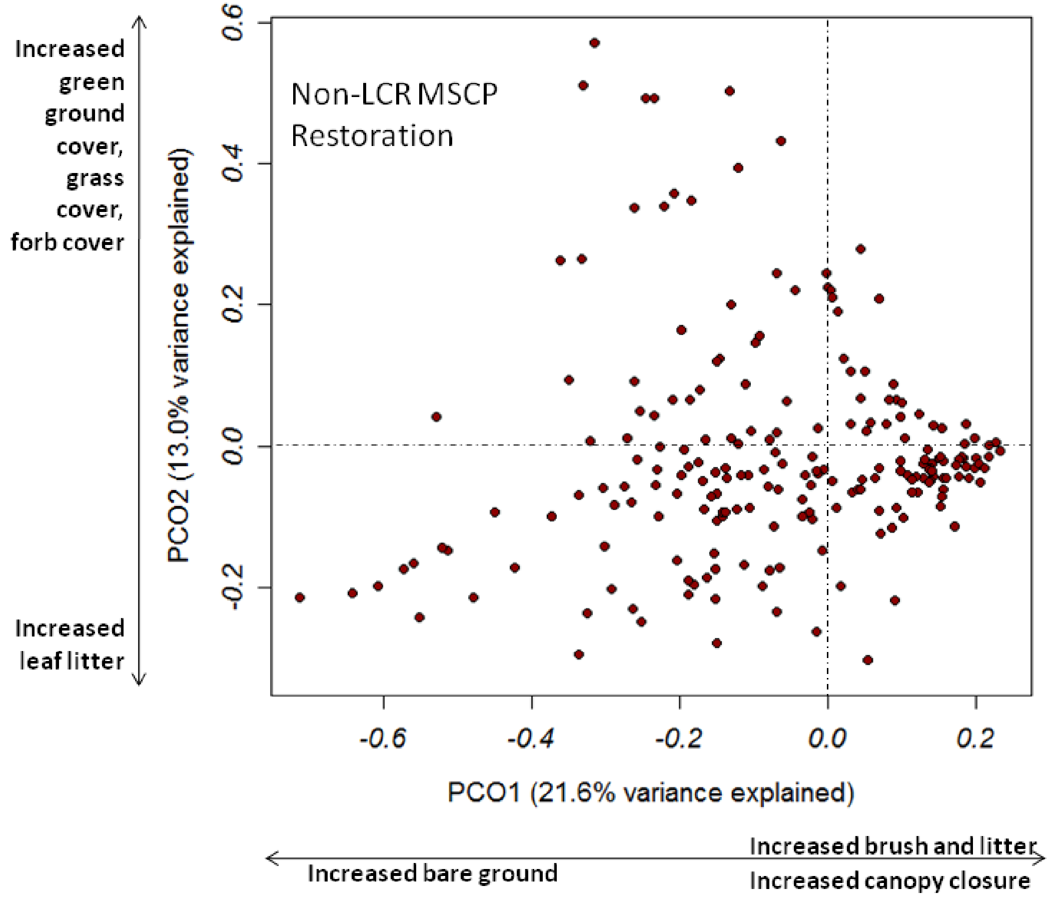


Figure A-4.—Principal coordinate analysis for vegetation data 2006–2012 depicting vegetation plots located at non-LCR MSCP restoration sites.

Increased canopy closure, brush, and leaf litter were the main influences on the positive end of the PCO1 axis, while increased bare ground was associated with the negative end. For PCO2, increased grass cover, green cover, and forbs were associated with the positive end of the axis, while leaf litter was associated with the negative end.

Boxplots showing differences in 20 vegetation variables among the four site management types are shown on figures A-5 to A-9. The boxplots reveal some differences that were not significant in the PCoA, such as overall increased tamarisk stem densities within non-BWR natural sites (figure A-8), and increased low shrub (< 50 centimeters high) densities in both non-BWR natural and non-LCR MSCP restoration sites.

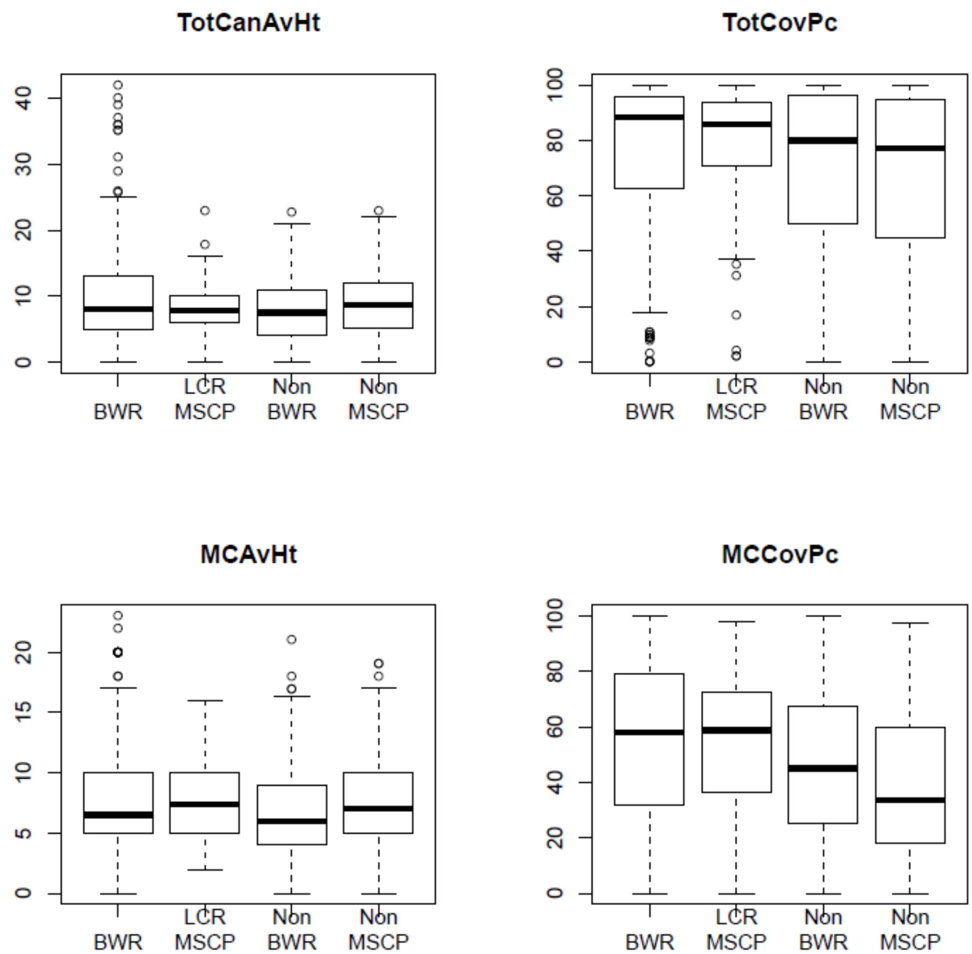


Figure A-5.—Boxplots showing differences among site management types for total canopy (all layers) average height (TotCanAvHt), percent total canopy closure (TotCovPc), main canopy (layer providing the most shade) average height (MCAvHt), and percent main canopy closure (MCCovPc).

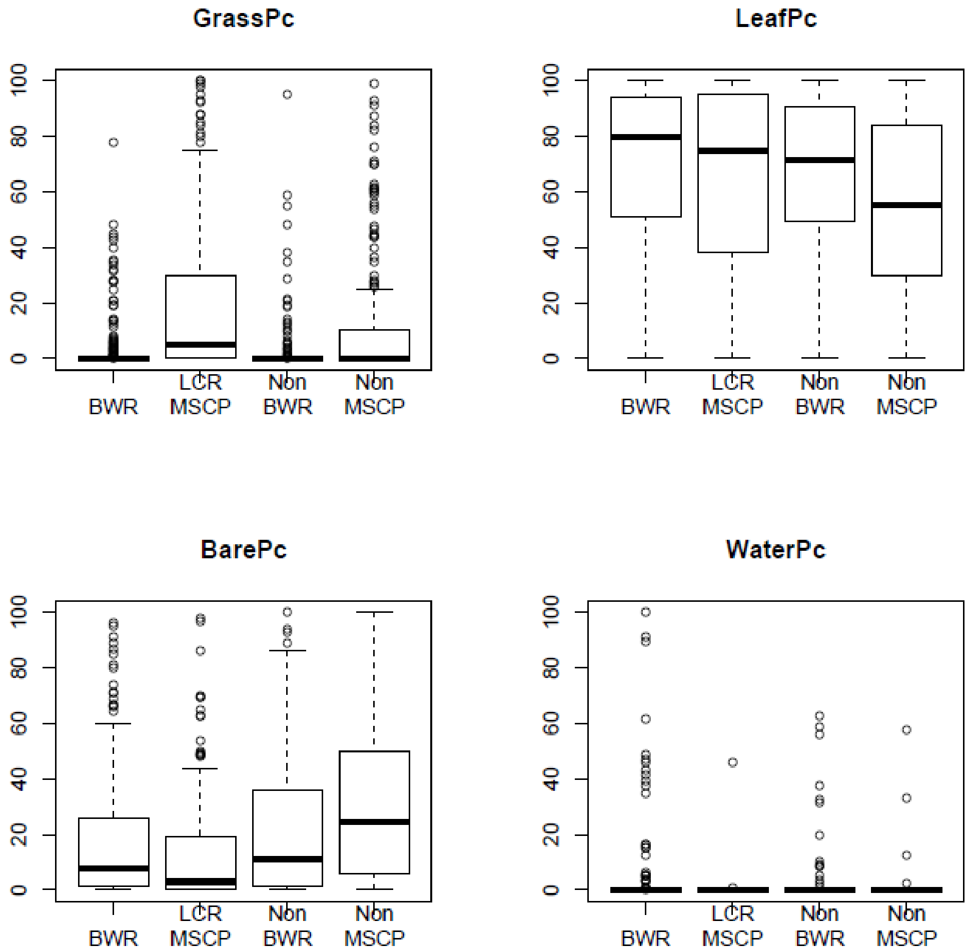


Figure A-6.—Boxplots showing differences among site management types for percent grass cover (GrassPc), percent leaf cover (LeafPc), percent bare ground (BarePc), and percent of ground covered with standing water (WaterPc).

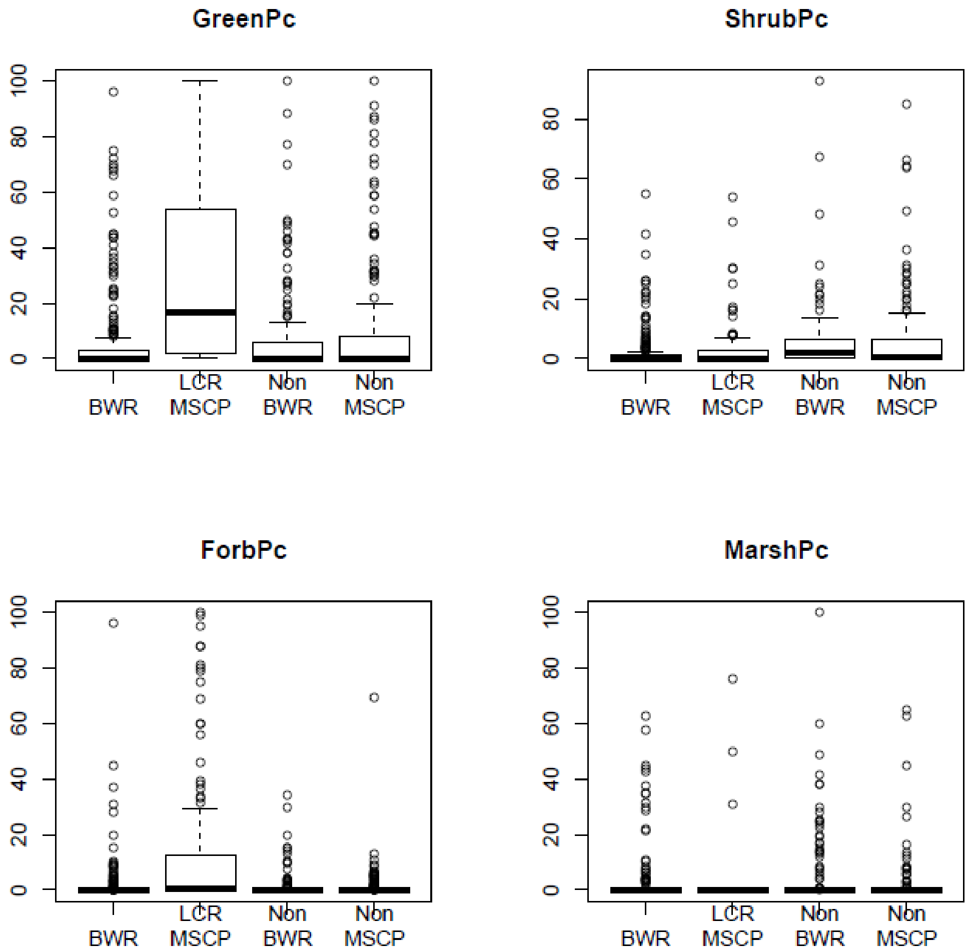


Figure A-7.—Boxplots showing differences among site management types for percent green ground cover (GreenPc), percent low shrub cover (ShrubPc), percent forb cover (ForbPc), and percent marsh vegetation (MarshPc).

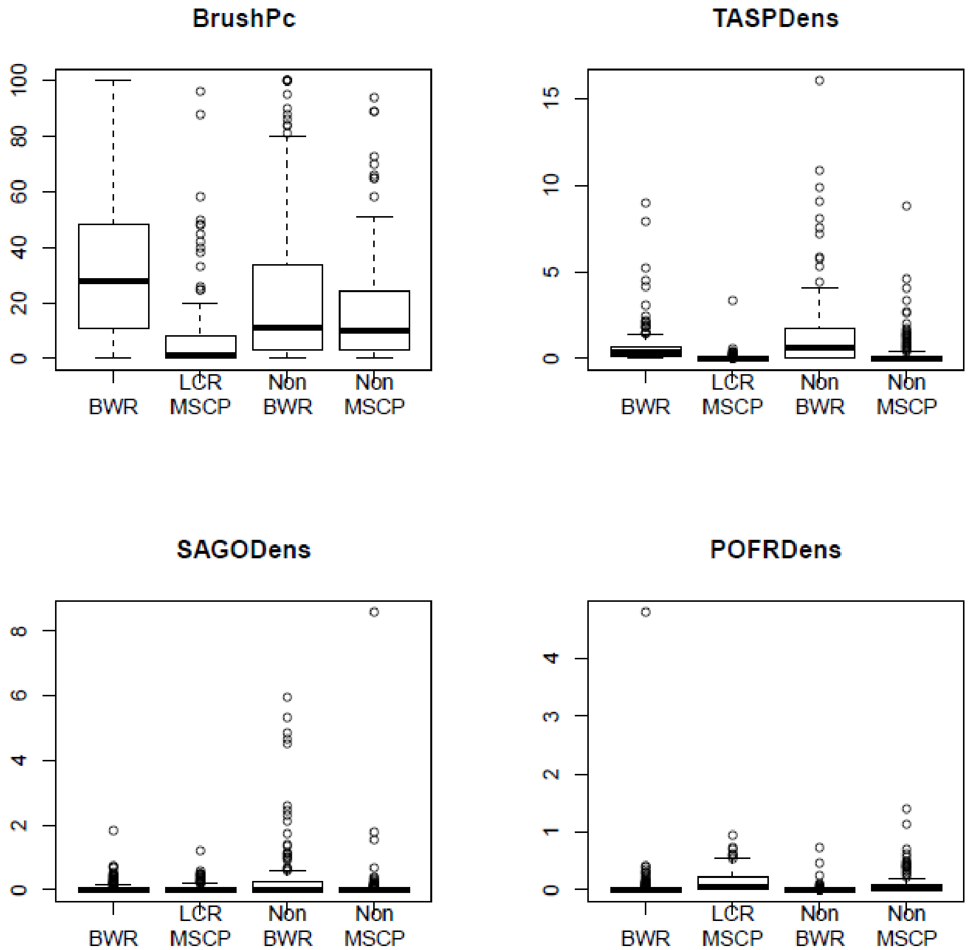


Figure A-8.—Boxplots showing differences among site management types for percent dead brush cover (BrushPc), tamarisk stem density (TASPDens), Goodding's willow stem density (SAGODens), and cottonwood stem density (POFRDens).

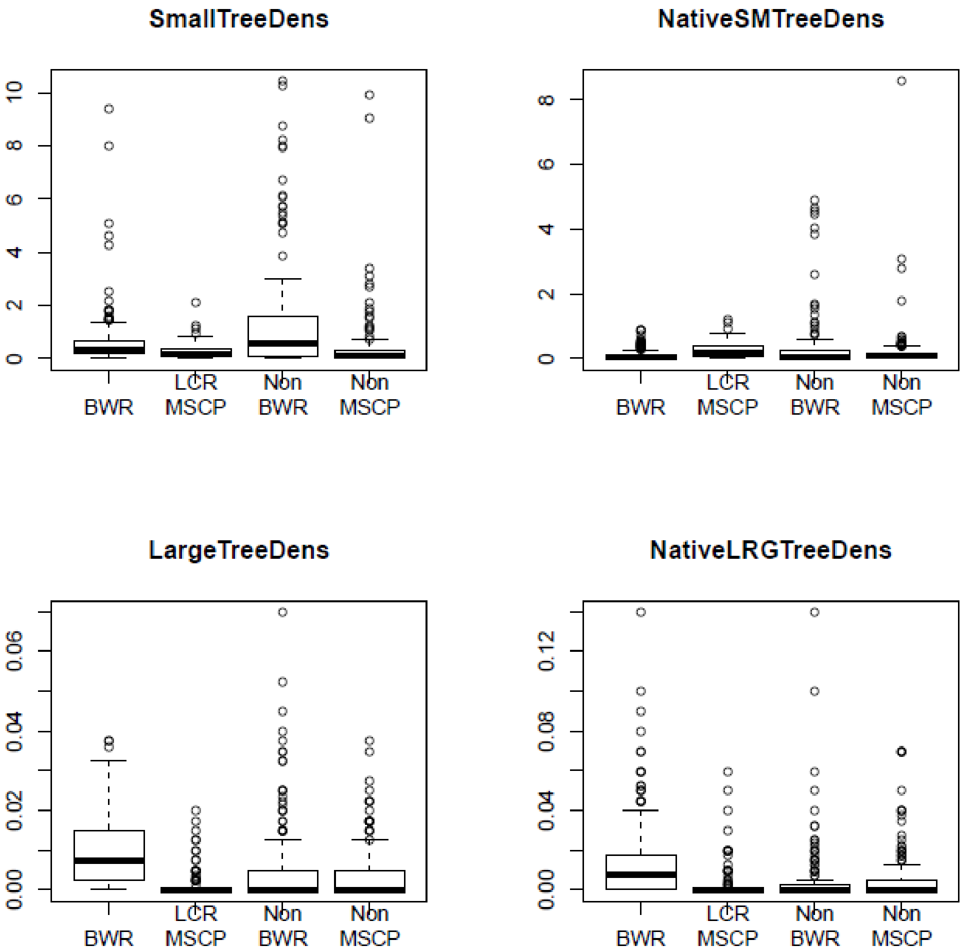


Figure A-9.—Boxplots showing differences among site management types for small tree stem density, native small tree stem density, large tree stem density, and native large tree stem density.

ATTACHMENT B

Site Descriptions, 2008–2012

Seventy-seven sites were surveyed throughout the study period between 2008 and 2012, comprising approximately 1,934 hectares (ha) of riparian habitat. Sites are described by geographic area, with the most northerly sites presented first. Within each geographical area, sites are presented alphabetically by site code. A map of all 2008–2012 survey locations is shown in chapter 1.

KEY PITTMAN WILDLIFE MANAGEMENT AREA

Lincoln County, Nevada (White River Drainage)

Key Pittman Wildlife Management Area (WMA) is in the Pahranagat Valley between the Pahranagat Range to the west and the Hiko Range to the east. It includes two lakes (Nesbit and Frenchy) approximately 180 kilometers (km) north of Las Vegas near the town of Hiko, Nevada. The WMA comprises about 146 ha (362 acres [ac]) of wetlands and aquatic habitats and 283 ha (700 ac) of adjacent uplands associated with the historic outflow of Hiko Spring. A few mature Fremont cottonwoods line portions of the shoreline of both Nesbit and Frenchy Lakes. This area is currently managed by the Nevada Department of Wildlife (NDOW) for farming, grazing, fishing and wildlife. Southwestern willow flycatchers nest in the few dense patches of coyote willow surrounding Nesbit Lake. One native-dominated site was surveyed for cuckoos within the WMA during the 2009 breeding season following an incidental cuckoo detection by SWCA in 2008.

Key Pittman WMA (KEYPIT) — Elevation: 1168 m, 1.9 ha

The habitat surveyed in 2009 consisted of a small patch of mature cottonwoods with an open understory at the southern end of Nesbit Lake as well as multiple dense patches of coyote willow along the lake's western shore. Adjacent to these isolated habitat patches there are extensive emergent wetlands that transition to alkali desert scrub. One cuckoo was detected during the 2009 surveys. Though the site contains 632 ac of wetland habitat, the available riparian habitat was considered too small to support a breeding territory and was not surveyed after 2009.

PAHRANAGAT NATIONAL WILDLIFE REFUGE

Lincoln County, Nevada (White River Drainage)

Pahranagat National Wildlife Refuge (NWR) is owned and managed by the U.S. Fish and Wildlife Service (USFWS). The refuge is approximately 145 km north of Las Vegas on U.S. Highway 93 near the town of Alamo. Within the refuge there are four water impoundments managed as habitat for migratory birds. Water levels are kept highest during the winter for waterfowl habitat. The inlet and outlet of upper Pahranagat Lake are lined with mature Fremont cottonwood (*Populus fremontii*) and Goodding's willow (*Salix gooddingii*). Two sites along the perimeter and immediately below upper Pahranagat Lake were surveyed for cuckoos in 2008, 2009, and 2012. During the 2008 breeding season, upper Pahranagat Lake was drained almost completely by early July.

Upper Pahranagat Lake North (PAHNTH) Elevation: 1020 m, 16.8 ha

Upper Pahranagat North consists of a contiguous patch of native habitat surrounding the inlet of Pahranagat Creek as well as a narrow string of native habitat following the perimeter of the northern end of the lake. Mature Fremont cottonwood and Goodding's willow dominate the high canopy while a dense layer of yerba mansa (*Anemopsis californica*) and milkweed (*Asclepias speciosa*) provide a thick groundcover. Along Pahranagat Creek upstream of the site, extensive fields used for grazing extend up the valley toward the creek's water source, Pahranagat Springs. Adjacent upland vegetation is characteristic of the Mojave Desert in the region, dominated by creosote bush (*Larrea tridentata*) and Joshua trees (*Yucca brevifolia*). Minor adjustments were made to the route in 2009 when two survey points were moved from the edge to the interior of the habitat in order to provide better coverage of the area.

Surveys were conducted here in 2008, 2009, and 2012. Surveys in 2008 returned no detections; however, there was a single detection by SWCA field personnel (Tom Koronkiewicz, personal communication). One cuckoo was detected during the surveys in 2009. Two detections were made in 2012 with one possible breeding territory.

Upper Pahranagat Lake South (PAHSTH) Elevation: 1020 m, 17.4 ha

The southern portion of Upper Pahranagat Lake has a narrow stringer of native riparian vegetation along the south and west shores of the lake as well as the first 900 meters (m) of the outlet channel downstream from the dam. Mature Fremont cottonwood makes up about 95 percent (%) of the overstory; the remainder is Goodding's willow. Young cottonwoods and willows make up the sparse understory. Cattails (*Typha* sp.) line the western edge of the riparian habitat near the southern outlet to Pahranagat Lake. Areas downstream from the survey stretch are drier and more typical of Mojave Desert vegetation. Surveys returned no detections in 2008 or 2009 and one detection in 2012.

LITTLEFIELD BRIDGE

Mohave County, Arizona (Beaver Wash)

Beaver Wash crosses county Highway 91 approximately 1.2 km north of Interstate 15 at Littlefield Bridge in the town of Littlefield. The flood plain of Beaver Wash consists of structurally diverse native-dominated riparian vegetation from its confluence with the Virgin River, upstream for over 2 km. One site was surveyed at Littlefield Bridge during the 2009 and 2010 breeding seasons.

Littlefield Bridge (LITBR) Elevation: 565 m, 39.9 ha

Surveys covered a continuous native-dominated riparian habitat upstream of Littlefield Bridge in 2010 and included both upstream and downstream in 2009. Extensive recruitment of young cottonwoods and willows was evident, while mature cottonwoods lined the edges of, and were interspersed within, the flood plain at this site. Water was present at this site throughout both breeding seasons. This area is used for camping, and there is off-road vehicle recreation at Beaver Wash. Land use in the adjacent uplands includes a golf course, residential and commercial areas, as well as grazing along the northeast border of the riparian vegetation. No cuckoos were detected in 2009 or 2010. Major flooding in 2011 destroyed the small riparian habitat, and surveys were discontinued.

MORMON MESA

Clark County, Nevada (Virgin River Drainage)

The Virgin River runs through a wide flood plain upstream of Lake Mead on the west side of the Mormon mesa. The flood plain consists of a variety of habitat types dominated by tamarisk (*Tamarix spp.*), with intermittent Goodding's willow and cattail marshes.

Smelly Jelly (SMJE) Elevation: 380 m, 18.7 ha

This site is dominated by mature tamarisk 4–5 m tall with scattered small Goodding's willow stands averaging between 4 and 7 m tall. Much of the tamarisk is dense with over 90% canopy cover. Standing water and deep mud persisted in much of the area for the duration of our surveys. After a cuckoo detection was reported by SWCA in 2009, the site was added to the surveys in 2010.

In 2010, we detected one cuckoo in a tall Goodding's willow stand during the first survey period, but no subsequent detections were observed at this site in 2010. The site was not surveyed after 2010 due to minimal habitat, considered too small to support breeding.

OVERTON WILDLIFE MANAGEMENT AREA

Clark County, Nevada (Muddy River Drainage)

Overton WMA lies in the Moapa Valley about 3.2 km south of Overton on SR 169. The WMA consists of 7,145 ha (17,657 ac) of Mojave Desert upland and riparian flood plain where the Muddy River flows into the Overton arm of Lake Mead. NDOW manages this area as wildlife habitat. Within the flood plain, 66 ha (165 ac) of agricultural crops, including barley and alfalfa, are grown to enhance habitat for migrating and wintering waterfowl.

Most riparian habitat not managed for waterfowl has been invaded by tamarisk. There are small patches of remnant Goodding's willow overstory with tamarisk understory along the main channel of the Muddy River. A narrow stringer of Fremont cottonwoods lines the perimeter of the agricultural fields. Two sites within the riparian areas of the WMA were surveyed during the 2008 breeding season (Honeybee Pond and Overton Wildlife), three during the 2009 season

(Honeybee Pond, Residential, and Overton Wildlife), two during the 2010 season (Overton Wildlife and Wilson Pond), no sites in 2011, and two sites in 2012 (Overton Wildlife and Wilson Pond).

Overton Honeybee Pond (OVRHP) — Elevation: 370 m, 3.6 ha

Potential cuckoo habitat includes a small patch of mixed native riparian forest below the levee south of Honeybee Pond. The overstory is dominated by Goodding's willow, tamarisk, and California fan palm (*Washingtonia filifera*). The dense and diverse understory includes common reed (*Phragmites australis*), cattail, arrowweed (*Pluchea sericea*), tamarisk, and Goodding's willow. A levee road borders the northern perimeter of the site, and Honeybee Pond extends to the north. Dense cattails grow around the reservoir perimeter. To the south of the site are open fields that were dry and fallow during the 2008 and 2009 survey seasons. This site was surveyed in 2008 and 2009 with no detections. The site was no longer surveyed after 2009 due to its minimal habitat.

Overton Residential (OVRR) — Elevation: 365 m, 2.8 ha

This route consists of two survey points near residences along the western edge of the WMA. The habitat consists of a narrow patch of mature cottonwoods with an understory of hackberry and saltbush (*Atriplex* sp.) between an alfalfa field, a residence, and a private plantation. This site was surveyed only in 2009 (no detections) and was considered too small to support breeding cuckoos.

Overton Wildlife (OVRW) — Elevation: 365 m, 10.1 ha

The survey route follows a line of young cottonwoods between an access road and fallow fields, continuing along the flood plain of the Muddy River. Dominant trees are Goodding's willow, which lines the main channel, and tamarisk forming a dense understory. Young cottonwoods are also scattered throughout the site. Potential cuckoo habitat at this site is composed of a scattered mosaic of young cottonwood, willow, and tamarisk. Several fields to the west are dry during the cuckoo breeding season and flooded in the winter to provide waterfowl habitat. Upstream to the north, east, and south, patches of young tamarisk line the main fork of the Muddy River. Adjacent to the riparian vegetation are creosote bush-dominated Mojave Desert uplands. No cuckoos were detected during surveys in 2008, and one cuckoo was detected in both 2009 and 2010. The site was not surveyed in 2011. Two detections were made during 2012 surveys.

Wilson Pond (OVRWP) — Elevation: 365 m, 0.7 ha

This site was newly added in 2010 after several incidental detections in 2009 by Bruce Lund. The riparian vegetation consists of cottonwood, Goodding's willow, tamarisk, and seep willow

(*Baccharis salicifolia*). The survey route along the road is bordered by a thin stand of intermittent cottonwood and willow with abundant seep willow and tamarisk. Surrounding habitat is dominated by tamarisk.

In 2010, two cuckoos were detected at the site. Surveys were not conducted in 2011. In 2012, two single detections on two surveys represented one possible breeding territory.

HAVASU NATIONAL WILDLIFE REFUGE

Mohave County, Arizona (Colorado River Drainage)

Havasu NWR was established in 1941 and encompasses over 30 river miles of the Colorado River and adjacent land from Needles, California, to Lake Havasu City, Arizona. Cuckoo habitat within the refuge is almost entirely within the Topock Marsh area, a historic river meander east of the main river channel currently managed as wildlife habitat. Water levels are increased in the early spring to benefit southwestern willow flycatchers and gradually lowered during the fall.

In 2008, six sites were surveyed here: Pintail Slough, North Dike, Levee Road, River Highway, Topock Platform, and Beal Restoration. In 2009, eight sites were surveyed: Pintail Slough, North Dike, Levee Road, River Highway, Topock Platform, and Beal Restoration with the addition of two new sites: Farm Ditch Road and Glory Hole. In 2010, seven sites were surveyed: Pintail Slough, North Dike, Levee Road, Topock Platform, Beal Restoration, Glory Hole, and one new site, Lost Lake, replacing Farm Ditch Road. In 2011, five sites were surveyed: Pintail Slough, North Dike, Topock Platform, Beal Restoration, and Glory Hole. Lost Lake and Levee Road were considered marginal habitat and dropped from the surveys, with Glory Hole being dropped after three surveys and no detections. Four sites were surveyed here in 2012. Two of these are on the north end of the marsh, separated by 350 m (Pintail Slough and North Dike). The rest are 5–7 km southwest, between the main channel of the Colorado River and Topock Marsh (Topock Platform and Beal Restoration).

Beal Restoration (HAVBR) Elevation: 137 m, 21.3 ha

Beal lies approximately 3 km south of Topock Platform between Beal Lake and Topock Marsh. The site consists of a mosaic of native trees planted in the historic Colorado River flood plain. Approximately 21.3 of the 43.4 ha planted from 2003 to 2005 as part of Phases 1 and 2 (LCR MSCP 2008a) were surveyed for cuckoos. Nearly 5 ha of cottonwood and 4 ha of mixed Gooding’s willow and mesquite were planted. The remaining area is relatively open with a sparse native overstory and an understory of arrowweed, screwbean mesquite (*Prosopis pubescens*), and coyote willow (*Salix exigua*). The overstory averages 5–10 m high, with 10–100% canopy closure. The understory ranges from 1–3 m and covers about 40% of the area. Multiple access roads cross the site and define the perimeter. There is year-round water in an irrigation ditch bordering the southeastern edge of the site, which connects Beal Lake on the southwest with Topock Marsh to the northeast.

This site was surveyed in 2008 with four cuckoo detections over a 10-day period (June 19–29) and then no further detections. One cuckoo was detected during surveys in 2009, and based on observations during followup visits, this was classified as a possible breeding territory. We detected three individual cuckoos during surveys in 2010, and from mist netting, telemetry, and followup efforts, we located the first known Beal nest. Beal had seven detections during surveys in 2011 and one nest. In 2012 over three survey periods, five detections were made, representing one possible breeding territory.

Farm Ditch Road (HAVFDR) Elevation: 139 m, 6.9 ha

This site consists of a narrow patch of mixed native vegetation following an irrigation ditch opposite Farm Ditch Road. A sparse overstory of Goodding's willow and honey mesquite (*Prosopis glandulosa*) grows above a dense understory of coyote willow, tamarisk, screwbean mesquite, and quailbush. The irrigation ditch contains water throughout the season and is lined with bulrush, cattails, and horsetail (*Equisetum* sp.). Adjacent vegetation is low, dense, and dominated by tamarisk and quailbush. This site was surveyed in 2009 (no detections), then dropped due to its marginal habitat.

Glory Hole (HAVGH) Elevation: 139 m, 13.2 ha

This mixed native site is on an island bounded by channels along the eastern shore of Topock Marsh. Suitable cuckoo habitat includes a mosaic of willow and tamarisk patches interspersed with marsh vegetation. The overstory covers less than 10% of the site while the understory is dominated by dense tamarisk. This site was added after an incidental detection by SWCA in 2008. No cuckoos were ever detected during surveys in 2009, 2010, or 2011, and the site was dropped in 2012.

Havasu Levee Road (HAVLR) Elevation: 143 m, 3.2 ha

This site is a narrow, small strip of remnant mixed native riparian habitat between the levee road and the Colorado River, 350 m northwest of Topock Platform. It has a sparse overstory of Goodding's willow, tamarisk, and mesquite. The main canopy ranges from 4–6 m high with average cover of about 20%. Arrowweed and seep willow provide a dense understory 1–3 m high. The Colorado River to the west experiences heavy motorized boat traffic. Surveyed from 2008–2010, this site was known as Havasu River Highway (HAVRH) in 2008 and consisted of a single patch. A small patch to the north was added for surveys in 2009–2010. The site had two detections in 2008 and no detections in 2009 or 2010. The site was not included in subsequent years due to small and low quality habitat.

Lost Lake (HAVLL) **Elevation: 137 m, 4 ha**

This site boarders the Lost Lake and consists of a narrow band of cottonwoods with an understory dominated by tamarisk. The overstory averages 5 m high. The site is surrounded by tamarisk and arrowweed on three sides. Marsh vegetation dominates the northwest side. This site was only surveyed in 2010 when one cuckoo was detected, but the site was considered too small to support breeding cuckoos and dropped in 2011.

North Dike (HAVND) **Elevation: 140 m, 5.1 ha**

North Dike is a mature restoration site along the north dike of Topock Marsh. The patch has an overstory of Fremont cottonwood and Goodding's willow and an understory of seep willow and honey mesquite. An agricultural field borders the site to the north. The site is surrounded by access roads, with a cement-lined irrigation canal along the western edge. To the south and west is a historic flood plain dominated by mesquite and tamarisk. Hunting activity occurs late in the field season. Surveys in 2008 accidentally included a patch of potential habitat to the north, which was already a part of Pintail Slough.

We detected cuckoos three times on North Dike during the 2008 season, representing at least two individuals. No cuckoos were detected during surveys in 2009. A single detection was made during two surveys at this site in 2010 – one was detected in 2011 and none in 2012.

Pintail Slough (HAVPS) **Elevation: 140 m, 11.7 ha**

This site consists of a narrow stand of large cottonwoods (50–60-centimeter diameter breast height) lining the slough, a restored field 250 m to the south, and another stand 300 m southeast. The slough is lined with cattails, and the surrounding understory is a mix of tamarisk, arrowweed, and quail bush. The southeast habitat is dominated by cottonwoods, which established naturally following flooding of nearby wintering waterfowl habitat (J. Allen, Refuge biologist, personal communication). The southern planted field has a sparse overstory of cottonwoods and a dense ground cover of non-native Johnson grass (*Sorghum halapense*). A system of access roads intersects the site. Water was present at the site intermittently throughout the season. This site was surveyed from 2008 to 2012.

No cuckoos were detected at the site in 2008 or 2009. Six detections were made in 2010, representing one probable breeding territory. Two cuckoos were captured and radio tracked, but no breeding behavior was observed. A total of five detections were made in 2011, representing two possible territories. An adult cuckoo was captured and banded in 2011, but no breeding behaviors were observed. There were no survey detections in 2012.

Topock Platform (HAVTPR) Elevation: 141 m, 9.3 ha

Topock Platform was planted as a nursery for other restoration efforts and includes 8.8 ha (21.7 ac) of restored native habitat located next to fields flooded in winter for waterfowl habitat. During the summer, this habitat patch is dry and supports a healthy cicada population. Three distinct areas make up the site. The section adjacent to the public access parking and Topock Platform consists of Fremont cottonwoods and Goodding's willows with tall (8–14 m), moderate canopy cover. The understory is open, with about 20% cover of 1–5 m-high screwbean mesquite, Goodding's willow, and Fremont cottonwood. To the east is a stand of shorter and more sparsely planted young cottonwoods and willows. Along the southern edge is a small stand of dense mesquites. Bermuda grass (*Cynodon* sp.) dominates the ground cover throughout the site. The landscape to the south and east is dominated by extensive stands of quailbush, arrowweed, and dense tamarisk, with a few remnant willows and mesquites.

Three detections were made during surveys in 2008. There was one detection in 2009 and six in 2010, representing one possible breeding territory. One cuckoo was detected in 2011. Three detections were made in 2012, representing one possible breeding territory.

LAKE HAVASU CITY

Mohave County, Arizona

Falls Spring Wash (LHCFSW) Elevation: 137 m, 6.8 ha

This site is within Lake Havasu City limits along the eastern shore of the lake, just north of the Mesquite Bay recreation access, Havasu NWR. Mixed native habitat lines the lakeshore within the flood plain of Falls Spring Wash. A sparse Goodding's willow, cottonwood, mesquite, and tamarisk overstory stands between the bulrush marsh along the edge of the lake and extensive arrowweed, Acacia, and creosote uplands to the east. The site was surveyed in 2009 only with no detections; the site was subsequently dropped due to its small size and marginal habitat.

Lake Havasu City Willow Patch (LHCWP) Elevation: 137 m, 1.0 ha

This site is within Lake Havasu City along the eastern shore of the lake, just south of Mesquite Bay recreation access, within Havasu NWR. It consists of a small, dense patch of coyote willow bordered to the west by bulrush and Mohave Desert upland to the north, south, and east. Dense arrowweed creates an understory that borders the thick coyote willow overstory. The site was added as it seemed to attract a large amount of migrating birds, and we were interested in possible use of the lakeshore by cuckoos. The site was surveyed in 2009 with no detections and dropped due to its small size.

DESILT WASH

San Bernardino County, California

Desilt Wash flows into the Colorado River 0.8 km below Parker Dam between the towns of Parker and Lake Havasu City. The Metropolitan Water District operates Gene Pumping Station immediately upstream of the potential cuckoo habitat. Desilt Wash and the surrounding uplands are owned by the County of San Bernardino, and public access is restricted. The wash between the Colorado River and Gene Pumping Station was surveyed for cuckoos in 2009.

Desilt Wash (DSWA) Elevation: 140 m, 3.4 ha

Potentially suitable cuckoo habitat at this site includes approximately 800 m of narrow riparian vegetation along Trails End Camp Road/MWD Road. California fan palms dominate the overstory of the upstream portion of the route with Fremont cottonwood stands above an understory of tamarisk, palo verde, and arrowweed downstream. Water was present at this site throughout the season. The site was only surveyed in 2009 with no detections and was dropped after 2009 due to its small size.

BILL WILLIAMS RIVER NATIONAL WILDLIFE REFUGE

Mohave and Yuma Counties, Arizona (Bill Williams River Drainage)

Bill Williams River (BWR) NWR was established in 1941 and is located 14.3 km south of Lake Havasu City, Arizona. It consists of 2,430 ha (6,000 ac) of BWR drainage managed by USFWS to protect the largest remaining natural riparian habitat in the lower Colorado River Valley. This refuge extends from Lake Havasu upstream on the BWR for 16 km and historically supports the most extensive and productive yellow-billed cuckoo habitat in the lower Colorado River watershed. Portions of the BWR contain perennial surface water. The managed hydrologic regime enables overbank flooding necessary for natural regeneration of native vegetation and persistence of cottonwood-willow forest. Regular winter releases from Alamo Dam since 2005 have resulted in recent natural riparian habitat regeneration. The habitat composition and structure in the eastern half of the refuge is significantly different from that found downstream from Gibraltar Rock in the western half. East of Gibraltar Rock, shallow underground bedrock and cliffs bordering the riparian area increase perennial flows and surface water; west of Gibraltar Rock, the river channel widens into a sandy, broad flood plain that persists to the western edge of the refuge at its interface with Lake Havasu.

There were 13 survey routes in 2008, covering over 518 ha (1,279 ac) of potential habitat. The Kohen Cliff survey route was added in 2008. Tepee Trail was surveyed in 2007, but was not surveyed in subsequent years after being considered unsuitable for cuckoos. In 2009, 16 routes were surveyed, covering over 680 ha (1,680 ac) of habitat. Three new routes were added in 2009 at the western end of the refuge, giving access to the wide interior western forest: Middle

Delta, Cross River, and Borrow Pit. Four routes were modified in 2009 for extended habitat coverage: Kohen Cliff, Big Bend (split into Esquerra Ranch and Cougar Point), Sandy Wash, and Mosquito Flats. These same routes were surveyed in 2010, 2011, and 2012.

Big Bend (BWBB) Elevation: 165 m, 84 ha

Surveyed under this name in 2008 only, this route lies between the Mineral Wash and Gibraltar Rock/Kohen Cliff routes. Dense cattails blocked access to part of the route previously surveyed in 2006 and 2007, and the route was modified in 2008. In 2009, the route was split into what was since surveyed as Esquerra Ranch (BWER) and Cougar Point (BWPT). Beginning at the intersection of Mineral Wash Road and the BWR, the eastern half of the survey route follows the old (pre-2005) river channel, bends around the Big Bend (also known as Cougar Point), and then follows the riparian edge and an old road. Several meanders contain perennial water, and the river channel is lined with cottonwoods, willows, and a dense understory of tamarisk and arrowweed. The western portion of the route winds between riparian areas, mesquite bosque, steep hills, and cliffs. Flooding in 2005 spurred natural regeneration of many young trees.

In 2008, there were 18 detections, and observed breeding activity included copulations, stick carries, and a single fledgling in late July, representing two probable territories and one confirmed breeding territory.

Bill Williams Marsh (BWMA) Elevation: 133 m, 19.7 ha

Surveyed by kayak, this route provides access to habitat within the broad western flood plain by following the main channel of the BWR upstream from Lake Havasu. The channel floods seasonally from upstream waters and is periodically inundated by fluctuating lake levels. Riparian vegetation consists of cottonwoods and willows with a dense understory of tamarisk. The shore is lined with cattails. There is regular boating and fishing activity at this site. Bill Williams Marsh was surveyed every breeding season from 2008 to 2012. The 2009 Saguaro Slot (BWSS) route paralleled this route from the xeric uplands and covered the same area, so the two sites were merged into one in 2010.

In 2008, there were seven detections, representing two possible breeding territories. There were four survey detections in 2009, representing two possible territories, and two in 2010, representing two possible territories. There were five detections in 2011 and three detections in 2012.

Borrow Pit (BWBP) Elevation: 140 m, 33.6 ha

This route follows a trail along an old river channel paralleling the west end access road. The survey is conducted from the dry river channel and bluffs overlooking the habitat. It connects Cross River to the west and Sandy Wash to the east. The habitat along the southern half of the route contains mature riparian cottonwood-willow forest with a dense tamarisk understory. The northern half includes occasional dense stands of tall cottonwoods and willows and extensive dense tamarisk. There were small ponds of standing water present on the site until mid-July in 2010, 2011 and 2012; however, no standing water was present on the site during 2009 surveys. Surveyed under this name from 2009–2012, this route was created in 2009 out of an area that had previously been split between Mosquito Flats (BWMF) to the south and Fox Wash (BWFW) to the north.

There were six survey detections in 2009, representing two possible territories. There were five detections in 2010, representing one possible breeding territory. There were two detections in 2011, representing one possible breeding territory, and three detections in 2012, representing one possible breeding territory.

Cave Wash (BWCW) Elevation: 175 m, 88.1 ha

Surveyed 2008–2012, this site is in the flood plain of the BWR at the eastern end of the refuge. From 2008–2011, the surveyed areas included refuge lands and portions of Planet Ranch. Between the 2011 and 2012 breeding seasons, ownership of private lands bordering the eastern end of the refuge changed, reducing the size of this site to completely exclude private lands outside the NWR as well as blocking access to nearby Cottonwood Patch (BWCP). This part of the refuge consists of a broad riparian area with both historic and recently formed river channels. There are extensive areas of dense tamarisk, although the vegetation is predominately native. Water is seasonally present in some side channels and perennial in the main channel. The main channel is lined with young cottonwood, willow, and tamarisk averaging 10 m high, surrounding dense marsh.

In 2008, there were multiple cuckoo detections (16) on all (throughout) 5 surveys and evidence of multiple pairs nesting on this route, although no nest was found. We observed several adults foraging, catching cicadas, and flying away with prey items. This represented six possible breeding territories. There were 15 survey detections in 2009, representing 2 possible, 1 probable, and 1 confirmed breeding territory. There were 20 survey detections in 2010, representing 3 possible and 1 confirmed breeding territory. There were seven survey detections in 2011 and one confirmed breeding territory. There were seven detections in 2012, representing one possible and one probable territory.

Cottonwood Patch (BWCP) Elevation: 180 m, 38.1 ha

This site is in the flood plain of the BWR at the eastern end of the refuge adjacent to Planet Ranch, which was owned and managed by the city of Scottsdale, Arizona, throughout the 2008–2011 breeding seasons. Following the sale of Planet Ranch to Freeport-McMoRan Copper & Gold Inc., permission to traverse this private land was denied; therefore, there were no cuckoo surveys in 2012.

The site is dominated by dense patches of cottonwoods, established following flooding in 2005, surrounded by large open areas. Ground cover is predominantly Bermuda grass. The survey route winds through the widest parts of the habitat. The soil is sandy gravel with intermittent water flow through river meanders. The upland side is composed of old agricultural fields, and the route is separated from the main streambed of the BWR by a 200–400-m open sandy wash with scattered tall cottonwoods.

In 2008, we had six cuckoo detections on this route, all during the first two survey periods. We had no detections after June 28, suggesting these birds were transient. There were six detections in 2009, representing one confirmed breeding pair (nest). There were 13 survey detections in 2010 and 1 confirmed breeding pair. There was one survey detection in 2011.

Cougar Point (BWPT) — Elevation: 165 m, 43.1 ha

This site is the western section of the pre-2009 Big Bend route and lies between the Esquerra Ranch and Gibraltar Rock routes. The route follows the river bend around Cougar Point. The northernmost part runs through an area of extensive forest, which regenerated following 2005 flooding. The southern part skirts older forest along the old main river channel, which is composed of cottonwoods, willows, and a dense understory of tamarisk and arrowweed. Several meanders contain perennial water. Part of this site was originally surveyed in 2008 as BWBB (Big Bend), with the north/west half becoming BWPT.

In 2008, there were 18 detections (between Cougar Point and Esquerra Ranch) with 2 probable and 2 confirmed breeding territories. Cougar Point had 10 detections in 2009, representing 1 possible and 1 probable territory, 21 detections in 2010, representing 3 confirmed breeding territories, 10 detections in 2011 with 2 confirmed breeding territories (2 nests), and 7 detections in 2012 with 2 possible breeding territories.

Cross River (BWCR) — Elevation: 140 m, 30.2 ha

This route was established in 2009 and bisects the BWR delta approximately 1 km upstream of Lake Havasu. It connects Borrow Pit to the south and North Burn to the north. This site is primarily composed of extensive tall cottonwoods and willows with a mixed native and dense tamarisk understory. There are also smaller patches of younger cottonwood-willow forest and occasional monotypic patches of dense tamarisk. There are multiple old meandering river channels within the site. This site is bordered both upstream and downstream by contiguous riparian habitat.

There were eight survey detections in both 2009 and 2010, representing two possible territories in each year. Five detections were made in 2011, representing two possible breeding territories. Four detections occurred in 2012, representing one possible breeding territory, with no confirmed breeding in any year.

Esquerra Ranch (BWER) Elevation: 165 m, 40.2 ha

This site is the eastern section of the 2008 Big Bend route, which was split in 2009 to increase coverage of the habitat, and lies between Mineral Wash and Cougar Point routes. The Esquerra Ranch route name was chosen after consulting with refuge personnel who do not use the name "Big Bend." The route begins at the intersection of Mineral Wash Road and the BWR. The route makes a loop downstream along the current river channel to a river bend (also known as Cougar Point) and then upstream along an old (pre-2005) river channel. Both channels contain perennial water and are lined with cottonwoods, willows, and a dense understory of tamarisk and arrowweed. Active beaver dams create regularly spaced ponds along both stream channels. The site is bounded by a steep cliff on the southwest and a broad dry upland area (the former Esquerra Ranch) to the northeast.

There were two survey detections in 2009 and four detections in 2010 with no evidence of breeding. Nine survey detections were made in 2011 with two possible territories and one confirmed breeding territory. In 2012, there were four detections with one possible breeding territory.

Fox Wash (BWFW) Elevation: 140 m, 62.5 ha

This route lies north of Sandy Wash, along the main channel of the BWR, and ends in a wide flood plain to the west. Scattered dense bands of tall cottonwoods and willows line the main channel. Narrower and more open native vegetation line several older channels. The interior is open with patches of scrubby tamarisk, while narrow patches of marsh vegetation surround remnant pools along the main channel. Mature cottonwood and mesquite are interspersed throughout the site. Ground cover is sparse and mostly bare sand. There is little recreational human disturbance but regular research activity.

In 2008, there were four detections on the site, representing two possible breeding territories. Four detections occurred in 2009 with one possible breeding territory. There were three detections in 2010, one in 2011, and three in 2012 with no estimated territories.

Gibraltar Rock (BWGR) Elevation: 145 m, 66.5 ha

This site is located between the Cougar Point and Sandy Wash sites and south of the Kohen Ranch site. Prior to 2011, the survey route was very long and followed an old road and the old river channel. In 2011, the route was truncated to include only the eastern, old river channel portion. This eastern portion of the route is generally xeric and open, with patches of large native trees and a dense understory of tamarisk. The western half of the route is drier, with small patches of large native trees and a dense understory of tamarisk, traversing along the old refuge road near Gibraltar Rock. From 2006–2012, no cuckoos were detected along this western stretch of the route. This site experiences winter flooding. Recreational use (hiking) is present but light.

Eight detections in 2008 all occurred along the eastern part of the route with two possible breeding territories. There were three detections in 2009, six in 2010, three in 2011, and five in 2012 with no breeding evidence in any year.

Honeycomb Bend (BWHB) Elevation: 170 m, 29.6 ha

This route follows the BWR, connecting with Cave Wash to the east and Mineral Wash to the west. It follows the river through some of the best riparian habitat on the refuge. Tall cottonwoods and willows with a dense understory of willow, arrowweed, and tamarisk dominate the multi-structured habitat. The river is perennial, and multiple beaver dams have created ponds lined with dense willows, cattails, and tamarisk. The riparian area is restricted by surrounding cliffs. Intermittent overbank flooding occurs at the site. The ground cover is sparse and dominated by leaf litter. This site was surveyed from 2008–2012. In the late part of the season of 2009, the river became impassible in places due to the water depth behind beaver dams. The survey route was modified accordingly during the last two survey rounds to bypass the river, but remained within 50 m of the original route. Otherwise, the route has remained unchanged throughout the study period. This site was difficult to access in 2012 due to the closing of the Planet Ranch eastern access road. We thus accessed the site by the Mineral Wash road and hiked upstream. The Mineral Wash road was also closed for periods during the breeding season due to flooding.

In 2008, there were 16 detections with 1 possible, 2 probable, and 3 confirmed breeding territories. There were 14 detections in 2009 with 2 possible and 1 confirmed territory. Thirteen detections were made in 2010 with 2 possible and 3 confirmed territories. In 2012, we had 16 detections, representing 1 confirmed and 2 probable breeding territories.

Kohen Cliff (BWKC) Elevation: 145 m, 33 ha

This site was added in 2008 during survey period two and, at that time, consisted of two separate habitat patches beginning at the intersection of the Big Bend and Gibraltar Rock routes. It then followed a cliff to the south, crossed the river, and then crossed the old Kohen Ranch. In 2009, the site was modified and expanded from the 2008 Kohen Cliff site as one contiguous site, shifting Gibraltar Rock (BWGR) to the south. The site was further modified in 2010 and from then on was surveyed under the name Kohen Ranch (BWKR). The site encompasses areas of natural regeneration that occurred following prolonged flooding during 2005–2006. There is a 2009 USFWS mesquite restoration site on the edge of this route. There were seven survey detections in 2008, and seven in 2009, with one confirmed breeding territory in 2009.

Kohen Ranch (BWKR) Elevation: 145 m, 37.1 ha

In 2010, Kohen Ranch was modified and expanded from the 2009 Kohen Cliff route and surveyed through 2012. The site covers areas of natural regeneration that occurred following prolonged flooding during 2005–2006. The route begins at the historic Kohen Ranch and heads northeast following the northern edge of the riparian habitat and paralleling the Gibraltar Rock route. The route passes through mature cottonwood-willow forest as well as a mix of park-like vegetation with a high cottonwood overstory and Bermuda grass ground cover. There is a 2009 USFWS mesquite restoration site on the edge of this route.

There were seven survey detections in 2010 with two possible and one confirmed breeding territory. In 2011, there were 11 survey detections with 2 probable breeding territories. There were six detections in 2012 with one possible and two probable breeding territories.

Middle Delta (BWMD) Elevation: 135 m, 25.2 ha

This site was added in 2009 and traverses an extensive patch of mature, mixed exotic vegetation extending upstream from the BWR delta between the Bill Williams Marsh and North Burn sites. It also connects to Cross River and North Burn. The eastern (upstream) end of the route has extensive patches of mature cottonwood overstory with an open understory. To the west, the overstory consists of patches of mature willow, which become sparse closer to Lake Havasu. The understory is dominated by dense tamarisk. Although no water was found within the site, the western end of the site is bordered by two forks of the BWR delta.

There were two survey detections in 2009 with no evidence of breeding and three survey detections in 2010 with two possible breeding territories. In 2011, there were five detections with one possible breeding territory and no detections in 2012.

Mineral Wash (BWMW) Elevation: 165 m, 49.8 ha

This linear route is located between Honeycomb Bend and Esquerra Ranch, following the river channel from a restricted canyon bordered by cliffs and then an open flood plain. The river is lined with bands of tall dense willows, large cottonwoods, and an understory of willows, tamarisk, arrowweed, mesquite, and marsh vegetation. The route is bordered by old agricultural fields. The surrounding Sonoran Desert vegetation includes saguaros and creosote bush. Perennial water flows through the site, and seasonal flooding occurs during winter and summer rains. A public access road follows Mineral Wash, and there is some recreational activity where the road terminates at the river. A riparian restoration site lies within the flood plain at the west end of the route, though few plants appear to be alive.

In 2008, there were cuckoo detections on this route with one possible and one probable breeding territory. In 2009, there were 13 detections with 2 possible and 1 confirmed territory. There were 16 survey detections in 2010 with 1 possible and 2 confirmed territories. Nineteen survey detections occurred in 2011 with 2 possible and 1 confirmed territory. In 2012, there were 11 detections with 1 possible and 1 probable breeding territory.

Mosquito Flats (BWMF) **Elevation: 140 m, 37.1 ha**

This route was significantly modified in 2010. The western section formerly surveyed from bluffs overlooking the riparian habitat; skirting along the edge of the riparian habitat was ceded to the Bill Williams Marsh route for logistical reasons. The riparian habitat at the western end of the refuge spreads out into a wide flood plain. The 2008 route followed the southern edge of the habitat, but in 2009, the route was moved to follow a new trail accessing more of the dense cottonwood-willow forest with occasional stands of tamarisk and scattered mesquite in the interior of the site. Both the 2008 exterior and 2009 interior routes were surveyed in 2012. There is light visitor use in the summer, and some vehicle traffic on the main road to the south. The water table is high here, and there were several standing ponds and water-filled side channels on or near the route. For the 2012 season, more habitat was added to the site, extending to the northwest.

In 2008 there were 10 detections, 4 in 2009 and 11 in 2010, all with no breeding evidence. In 2011, there were nine detections with one confirmed breeding territory. We had four survey detections in 2012.

North Burn (BWNB) **Elevation: 133 m, 30 ha**

Surveyed throughout the study period, this site has been slightly modified over the years. Originally, the route encompassed three distinct habitat types. The first was surveyed from a boat and included small clusters of mature willows surrounded by tamarisk and cattails. The second part to the south and west was a mixed native forest, with a mature cottonwood-willow overstory. The third, northeastern, portion of the site was dominated by tamarisk. Much of this site burned in 2005 and is regenerating with tamarisk and quail bush. In 2008, the route followed the north edge of the habitat, beginning at the northern branch of the BWR slough and continuing along the channel of the river for approximately 800 m before following the eastern edge of the river flood plain. This survey route was altered slightly in 2009 to conduct surveys from within the habitat rather than the edge, increasing the coverage area of potential habitat by almost 5 ha. Also in 2009, the easternmost section was ceded to Cross River (BWCR). In 2012, the extent of the site boundary underwent minor changes.

Four detections were made in 2008 with one possible breeding territory. Five were detected in 2009, representing one possible and one probable breeding territory. There were two detections in 2010 with no evidence of breeding. Five detections were made in 2011, representing one possible breeding territory and five again in 2012 with one possible breeding territory.

Saguaro Slot (BWSS) **Elevation: 143 m, 15 ha**

Saguaro Slot was surveyed in 2008 only. The western part of the survey was already being adequately covered by the Bill Williams Marsh (BWMA) survey, and the eastern part was given to Mosquito Flats (BWMF) in 2009. This route covered the westernmost riparian habitat accessible by land. It connects to Mosquito Flats on the east and ends at cliffs on the west. It is a discontinuous route, and for the most part, the habitat is surveyed from bluffs overlooking the riparian forest. The route borders upland Sonoran Desert habitat with several low rocky outcrops extending into dense mesquite and tamarisk with an overstory of large Goodding's willows and cottonwoods. The western end of the broad riparian flood plain is crossed by numerous old river channels. Many of these have seasonal water and support tall, nearly impenetrable cattails. There is light visitor use in the summer and some light traffic on the main road that parallels the route. Although there was no standing water on the vegetation plots, the water table is high here, and there are several standing ponds and water-filled side channels on or near the route. There were five detections in 2008, representing two possible breeding territories.

Sandy Wash (BWSW) Elevation: 145 m, 50.9 ha

This route connects Gibraltar Rock to the southeast, Fox Wash to the north, and Cross Rive to the northwest. This section of the refuge gradually widens into a flood plain laced with dry river channels. The route makes a loop around the eastern end of the broad flood plain, following an old road and river channel. The site is structurally diverse with an overstory of tall cottonwoods and willows with a tamarisk-dominated understory on the southern edge, mature tamarisk in the central part, and tall dense native-dominated cottonwood-willow to the east. There was standing water along the old river channel at the eastern part of the site during the field season, but the rest was dry. Hikers and researchers frequently use this easily accessible route. Surveyed throughout the study period, this site has undergone minor alterations to the boundary extent over the years. In 2009, approximately 1 km was added to access dense native-dominated habitat at the eastern part of the route.

In 2008, there were seven detections with two possible and one confirmed breeding territory (two fledglings observed in July). Thirteen survey detections occurred in 2009, representing one possible and two confirmed territories. There were eight survey detections in 2010, representing one possible and one confirmed territory, and two detections made in 2011, representing one possible breeding territory. Detection numbers rose in 2012 with 13 detections, though no breeding was confirmed.

'AHAKHAV TRIBAL PRESERVE

Colorado River Indian Tribe Lands, Arizona

'Ahakhav Tribal Preserve lies along the Colorado River approximately 3.5 km southwest of Parker, Arizona. The site is bordered by Mojave Road to the south and agricultural fields to the east and west. Established in 1995, the preserve comprises 507 ha (1,253 ac) of mixed native habitat, restored river channels, and a 1.4-ha park.

‘Ahakhav Tribal Preserve (CRIT) Elevation: 108 m, 59.6 ha

Over 54 ha of riparian habitat have been restored at this site since 2001. Periodic revegetation in some previously restored areas has resulted in multi-layer patches with canopy heights ranging from to 3–16 m. Species composition consists of 45 ha of mosaic plantings of cottonwood and Goodding’s willow and approximately 15 ha of honey and screwbean mesquite. Ground cover is sparse with little understory and sandy soil. There was little standing water during visits. The survey route follows roads around the perimeter and interior of the site. This site was surveyed during 2008–2009 and 2011–2012. The extent of the site slightly changed in 2011 when the northwest corner was added as habitat.

In 2008, there were five survey detections with one possible breeding territory, and in 2009, nine detections, representing one possible and one probable breeding territory. No surveys were permitted in 2010. There were 10 detections in 2011 with 2 possible breeding territories and 10 in 2012, again with 2 possible breeding territories. In 2007, Johnson et al. (2008) detected cuckoos only in the first survey period, and through telemetry, we have also found a highly transient population here, with birds leaving after a short period. No breeding has been confirmed at this site.

PALO VERDE ECOLOGICAL RESERVE

Riverside County, California

Palo Verde Ecological Reserve (PVER) is located 12 km north of Blythe, California. The 547-ha (1,351-ac) site was acquired by the State of California in 2004. Riparian restoration activities are being implemented by the Bureau of Reclamation (Reclamation), with public use and hunting managed by the California Department of Fish and Game. Details of planting and management are outlined in the Palo Verde Ecological Reserve Restoration Development Plan Overview (LCR MSCP 2006), including the specific development plans for each phase (see www.lcrmscp.gov). Phases 1–5 were fully surveyed in 2012, comprising over 160 contiguous ha of suitable breeding habitat spread over 4 linear km bordering the LCR. The phases were surveyed as they became suitable breeding habitat, with Phase 1 first surveyed in 2008, Phases 1 and 2 surveyed in 2009, Phases 1, 2, and 3 surveyed in 2010, and Phase 4 receiving late-season surveys due to observed cuckoo activity. Phases 1–4 were surveyed in 2011, and Phases 1–5 were surveyed in 2012. Over the years, cuckoos have been observed foraging in the adjacent newer habitats and then moving in to nest into these areas the following year. The restoration sites at PVER have changed considerably over the study period with rapid tree growth.

Palo Verde Ecological Reserve Phase 1 (PVER1) Elevation: 86 m, 8.3 ha

PVER Phase 1 was planted in 2006 as a nursery plot and surveyed during 2008–2012. The site is bordered by dirt access roads used to conduct the surveys. An agricultural field borders the site to the north and a newly recreated marsh habitat (2011) to the south. Two cuckoos were detected here in 2008 with one possible breeding territory. One was detected in 2009 and two in

2010 with no evidence of breeding. There were five survey detections at this site in 2011 with one possible breeding territory. In 2012, we had three survey detections with one probable territory plus the first confirmed breeding territory (a nest) at the site. Telemetry observations revealed that the nesting pair was also foraging in the adjacent PVER4 while nesting.

Palo Verde Ecological Reserve Phase 2 (PVER2) Elevation: 86 m, 24.2 ha

PVER2 was planted in 2007 and first surveyed in 2009. The site consists of alternating Goodding's willow, coyote willow, and Fremont cottonwood plantings. These trees now range in height from 3 to 14 m with high canopy cover. Coyote willow has grown rapidly and averaged 6–7 m high in 2012. The plantings were designed to maximize the amount of edge between Goodding's willow and coyote willow, considered preferred habitat for the southwestern willow flycatcher (LCR MSCP 2006b).

There were 6 survey detections in 2009 with 2 confirmed breeding territories, 8 survey detections in 2010 with 1 possible and 1 confirmed territory, and 10 survey detections in 2011 with 2 possible and 3ee confirmed breeding territories (3 nests). In 2012, there were nine survey detections with one possible and four confirmed breeding territories.

Palo Verde Ecological Reserve Phase 3 (PVER3) Elevation: 86 m, 19.8 ha

Phase 3 was planted with cottonwood and willow strips for southwestern willow flycatcher habitat in 2008. The species composition and density was planted to mimic a natural riparian landscape when fully mature. Tree heights range from 4 to 14 m, and canopy cover is high. An incidental detection occurred at PVER 3 in 2009 while surveying the adjacent PVER 2, and cuckoos were later observed flying across the road and foraging for short periods of time. Phase 3 was first fully surveyed for cuckoos in 2010.

There were seven detections in 2010 with one possible and one confirmed territory (nest); the nest tree was already 9 m high within a 2-year period. There were 10 detections in 2011 with 2 possible, 1 probable, and 2 confirmed breeding territories (2 nests). In 2012, there were 12 survey detections and 2 confirmed breeding territories.

Palo Verde Ecological Reserve Phase 4 (PVER4) Elevation: 86 m, 35.8 ha

Phase 4 was planted with cottonwood and willow strips in 2009. In 2010, the site was not surveyed until mid-season after cuckoo activity was first observed. Tree heights range from 3 to 12 m.

In 2010, there were four detections, representing one probable breeding territory. In 2011 and 2012, the site was fully surveyed. There were 18 detections in 2011 with 1 probable and 5 confirmed breeding territories. In 2012, cuckoo numbers surged at this site with 23 survey detections and 11 confirmed breeding territories.

Palo Verde Ecological Reserve Phase 5 (PVER5) Elevation: 86 m, 75 ha

Phase 5 was planted with cottonwood and willow strips in 2010 and first surveyed in 2012. Tree heights range from 3 to 8 m, and canopy closure is high in patches found in between large alfalfa-dominated openings.

We had 34 survey detections with 6 confirmed (6 nests), 2 probable, and 4 other possible breeding territories. Cuckoos nested in 2-year-old trees with an average nest tree height of 6.9 m. Several detections were also made in the adjacent Phase 6 (not yet surveyed in 2012 – 1-year old).

CIBOLA VALLEY CONSERVATION AREA

La Paz County, Arizona

Cibola Valley Conservation Area (CVCA) is located 24.2 km south of Blythe, California, south and east of the Colorado River and the California/Arizona border. Within Cibola Valley, 407.6 ha (1,019 ac) of land owned by the Mohave County Water Authority have been identified for riparian restoration as outlined in the Cibola Valley Conservation Area Restoration Development Plans (LCR MSCP 2007a–d, 2008, 2009, 2011). Riparian restoration has been implemented by Reclamation with hunting and public access managed by Arizona Game and Fish Department. Since 2006, 101 ha (250 ac) of native riparian trees have been planted in three phases. Phases 1 and 2 are located in adjacent fields, and Phase 3 is approximately 2.6 km to the west. Agricultural fields dominate the area surrounding the sites. CVCA1 was first surveyed in 2008, and CVCA2 and CVCA 3 were first surveyed in 2009.

Cibola Valley Conservation Area Phase 1 (CVCA1) Elevation: 72 m, 34.8 ha

This site consists of six fields planted in 2006. The Colorado River flows approximately 100 m from the northern edge of the site. The dominant tree species are Fremont cottonwood, Goodding’s willow, and coyote willow. The site is periodically flood irrigated throughout the breeding season. River Road and several dirt access roads define the perimeter of CVCA1 and additional dirt roads cross the site.

In 2008, there were 14 survey detections and confirmed 2 plus 1 probable breeding territory. In 2009, there were 12 survey detections and 2 confirmed breeding territories. In 2010, 19 survey detections occurred with 3 confirmed breeding territories. In 2011, there were 18 survey detections and 4 confirmed breeding territories. In 2012, we had 12 survey detections and 2 confirmed plus 1 probable breeding territory.

Cibola Valley Conservation Area Phase 2 (CVCA2) Elevation: 72 m, 24.7 ha

CVCA2 was planted in 2008 and is adjacent and south of CVCA1, separated by a dirt access road and a concrete-lined irrigation ditch. Fremont cottonwood and Goodding's willow are the co-dominant trees, with heights ranging from 3 to 11 m, with high canopy cover. Phase 2 was surveyed for the first time in 2009.

There were no survey detections at this site in 2009. In 2010, there were 13 survey detections and 3 confirmed breeding territories. In 2011, there were 27 survey detections with 1 probable and 3 confirmed breeding territories. In 2012, there were nine detections with one possible and one confirmed breeding territory.

Cibola Valley Conservation Area Phase 3 (CVCA3) Elevation: 72 m, 37 ha

CVCA Phase 3 is located 2.6 km west of CVCA1 and CVCA2 and 400 m east of the Colorado River. The site was planted in 2007 with Fremont cottonwood, Goodding's willow, and coyote willow (and mesquite which is not yet suitable habitat for cuckoos). Tree heights vary from 5–13 m, and canopy cover averages 80%. Dirt access roads line the perimeter and bisect the plantings.

Surveys were first conducted at this site in 2009. There were 6 survey detections in 2009, representing 2 possible breeding territories, 6 detections in 2010, representing 1 possible territory, and 14 detections in 2011, representing 1 possible breeding territory. There was one detection in 2012. No breeding has ever been confirmed at this site during the study period, and radio-tracked birds captured at this site stay for only a short period.

CIBOLA NATIONAL WILDLIFE REFUGE

La Paz County, Arizona (Colorado River Drainage)

Cibola NWR is 29.8 km south of Blythe, California, within the historic flood plain of the Colorado River. The refuge, exceeding 6,475 ha (16,000 ac), was established in 1964 and is managed by USFWS to preserve and protect wildlife habitat. The refuge includes both the historic Colorado River channel as well as a new channel constructed in the late 1960s. The old channel still receives irrigation water, and portions are maintained as wildlife habitat, while the new channel carries the Colorado River flow and is extensively levied. Most of the existing riparian forest patches on the refuge are restoration sites with varying degrees of irrigation. Within the refuge, fields of alfalfa and grain crops border tamarisk and mesquite-dominated uplands. Three sites were surveyed at Cibola NWR in 2008, four in 2009–2010, and seven in 2011. The five sites surveyed in 2012 are all located in the Area Unit 1 Conservation Area (Nature Trail area). Two sites at the Cibola Island Unit were not surveyed in 2012 due to a fire in the late summer and resulting access loss. During the period 2009–2012, we confirmed five nests at this refuge.

Cibola Eucalyptus (CIBEUC) **Elevation: 70 m, 29.4 ha**

Cibola Eucalyptus is adjacent to the refuge on the California side of the river. It is a mixed native restoration site planted in 1977, dominated by cottonwoods and eucalypts west of the levee road, and cottonwood, tamarisk, Goodding's willow, and mesquite to the east. Overstory in the two patches is approximately 10%, and height varies from 3–15 m. The understory is sparse with about 30% cover. A mixed understory of arrowweed, quailbush, palo verde, tamarisk, mesquite, and Goodding's willow averages 3–6 m high. The surrounding area consists of wheat and alfalfa fields to the north, west, and south, and the Colorado River main channel to the east.

There were two survey detections in 2009, three in 2010, and one survey detection both in 2011 and 2012. We have never noted any breeding activity at this site. The site is a migratory hotspot for other avian species due to its tall trees and location near the river. Followups of survey detections at this site have shown only short-term use.

Cibola Island Perri Marsh (CIBIPM) **Elevation: 65 m, 88.3 ha**

In 2009, the Cibola South site (on Cibola NWR Island Unit) was divided into two separate survey sites (Cibola Island: South and Perri Marsh), then in 2011, Perri Marsh was expanded to cover additional mesquite habitat after radio tracking in 2010 revealed use of these areas by foraging cuckoos. Both sites are on the Island Unit of the refuge and were connected by a meandering created channel surrounded by historical Colorado River flood plain dominated by tamarisk, mesquite, arrowweed, and quailbush. Perri Marsh was planted in 1999. The marsh features a meandering channel with a cottonwood and Goodding's willow overstory, an understory of mesquite, tamarisk and seep willow, and ground cover of cattails and Bermuda grass. Extensive mesquite plantings and agricultural fields used for wildlife enhancement surrounded the site. In 2011, we expanded the survey route to include these mesquite groves and additional cottonwoods to the west. A late season fire in August 2011 burned a large amount of habitat on the Island Unit, and no surveys were conducted in 2012.

In 2008, we had three detections with one possible breeding territory. In 2009, we detected four cuckoos and found our first confirmed breeding territory at Perri Marsh. We had six detections in 2010, representing one possible breeding territory. Radio tracking of captured cuckoos at this site showed frequent use of the surrounding mesquite groves, primarily transient use. There were 15 survey detections in 2011, representing 1 possible breeding territory. No surveys were conducted at this site in 2012 due to the late season fire thwarting access.

Cibola Island South (CIBSTH) **Elevation: 65 m, 13.8 ha**

The description below describes the area we surveyed between 2008 and 2011. Cibola Island South comprises an older cottonwood-dominated restoration patch. Mature cottonwoods 5–10 m tall provide 25% average canopy closure in this dry site. A sparse (about 25% closure) layer of mesquite, tamarisk, and seep willow create an understory 1–4 m tall. The site had changed little since the first survey in 2008 up to the fire in 2011. Old irrigation lines are found throughout the site with no recent irrigation.

This site was occupied during the 2008 season with three survey detections and one possible breeding territory. There were four survey detections in 2009 and one confirmed breeding territory (Perri Marsh). There were six survey detections at this site in 2010, representing one possible territory. There were two detections in 2011, both occurring July 7.

Cibola Mass Planting (CIBMP) — Elevation: 75 m, 23.7 ha

This area is adjacent to the Nature Trail site and was previously surveyed as part of the Nature Trail survey (2009–2010). A separate and expanded survey was conducted in this area beginning in 2011 as the available habitat had matured. The site consists of a thickly planted grove of cottonwoods, several fields of mixed open areas and cottonwoods, and an experimental seeded plot of mixed native trees. The site had two survey detections in 2011 and two in 2012 with no evidence or suspected breeding in either year.

Cibola Nature Trail (CIBCNT) — Elevation: 75 m, 14.4ha

This restoration site was first planted in 1999. The route follows a well-maintained walking trail that winds through the habitat. The species composition and height varies across the site, creating structural diversity. Cottonwoods dominate a 5–11-m-tall canopy, providing about 40% canopy cover. The understory includes Goodding's willow, honey and screwbean mesquite, seep willow, coyote willow, and young cottonwoods. Average understory measures 3 m with approximately 50% cover. This site was periodically flooded during the survey season. Much of the surrounding area is agricultural fields. Bordering the site to the north and east are seasonally flooded fields for wintering waterfowl. In 2008, this site was extended to include restored patches to the west (Mass Planting and Crane Roost). By 2010, these sites had grown in size and maturity and are now surveyed separately.

Two detections were made each in 2007 and 2008, and there were three survey detections in 2009. In 2010, there were 13 survey detections with 2 possible and 1 confirmed breeding territory (1 nest) at Unit 1. There was one survey detection here in 2011 and three detections in 2012 with one possible breeding territory.

Cibola North (CIBNTH) — Elevation: 71 m, 7.2 ha

Cibola North is a more open, structurally homogeneous site with a cottonwood overstory averaging 12 m high, providing around 60% canopy closure. The ground cover is dominated by Bermuda grass. The site is bordered on its northern edge by Baseline Road and agricultural fields. Fallow fields of sparse tamarisk, arrowweed, and quail bush extend east and west of the site. The Mass Planting site is 200 m southwest, separated by an agricultural field. Cibola

Nature Trail is 580 m to the south, separated by three agricultural fields. No cuckoos were detected in 2008. There was a single survey detection in 2009 and again in 2010. There were no survey detections 2011 or 2012.

Crane Roost (CIBCR) — Elevation: 75 m, 48 ha

This site was first surveyed in 2009–2010 as part of CIBCNT. In 2011, it was split into a separate site. Phase 1 consists of a block of dense 10–14-m-high cottonwoods, a grove of dense mesquites 5–7 m high, and a plot containing a mix of seep willow, mesquite, tamarisk, and tall emergent cottonwoods. Canopy cover at all plots is high. Phase 2: Several roads surround and dissect the more recently planted fields of mixed cottonwoods and willows just south of the older Phase 1 plot. In 2012, the site was still sparse, but contained a few patches of dense cottonwoods 3–8 m tall with high canopy cover. In 2011, there were 13 survey detections with 1 possible and 1 confirmed breeding territory. In 2012, there were 19 detections with 3 possible, 3 probable, and 2 confirmed territories.

PICACHO STATE RECREATION AREA

Imperial County, California (Colorado River Drainage)

Picacho State Recreation Area (SRA) is a historic mining town site, currently State owned and managed by the California State Parks Department. It is 38.6 km north of Winterhaven, California, on the Colorado River.

Picacho State Recreation Area (PICSRA) — Elevation: 59 m, 14.8 ha

Picacho SRA is a cottonwood-willow dominated restoration site situated where Picacho Wash flows into the Colorado River. The structurally diverse vegetation planted after tamarisk clearing in 1996 appears naturalized. Fremont cottonwood, Goodding’s willow, and honey and screwbean mesquite dominate the 6–17-m-tall canopy, averaging 30% cover. A diverse understory of arrowweed, quailbush, blue palo verde (*Cercidium floridum*), seep willow, mesquite, willow, and cottonwood provides about 50% cover. The site is bordered by the mature tamarisk-dominated Picacho SRA campground and adjacent Sonoran Desert uplands to the west and the river to the east. Surveyed from 2008–2012, there have been some modifications to the boundary, but overall, the site has remained unchanged.

A single cuckoo was detected each in 2008 and 2009. There were nine survey detections in 2010, representing one probable breeding territory. Two survey detections in 2011 represented one possible breeding territory. We had seven detections in 2012, representing one possible breeding territory.

Imperial National Wildlife Refuge

Yuma County, Arizona (Colorado River Drainage)

Imperial NWR was established in 1941 and encompasses 10,307 ha (25,768 ac) of riparian area and associated Sonoran Desert uplands. The headquarters is 40.3 km north of Yuma off Martinez Lake Road. The refuge follows 48.3 km of the Colorado River, including some of the last remaining unchannelized stretches. Refuge management activities include protecting backwater lakes, managing marshes, farming crops as food for wintering waterfowl, and restoring wetlands and associated riparian vegetation. Imperial 20A and Imperial South were surveyed from 2008 through 2012, with the Imperial 50A site added in 2011.

Imperial 20A Restoration (IMP20) — Elevation: 61 m, 2 ha

Imperial 20A is a native restoration site (planted in 1995) 560 m from the main body of Martinez Lake. Stunted Fremont cottonwoods form a sparse canopy (20% cover) and are planted 4 m apart in rows spaced every 3 m. The overstory varies from 4–14 m high and is interspersed with mesquite. A thick ground cover of saltgrass (*Distichlis spicata*), Bermuda grass, and Phragmites provide 90% ground cover. The site is bordered by seasonally flooded wildlife ponds to the north, mixed native marshland to the east, and fields to the south and west of the site. The habitat is spindly and sparse with no suitable habitat for nesting.

In 2008, we detected three cuckoos during the second survey – all observed foraging together – with no other detections that year. There were no detections in 2009. The site was not surveyed in 2010. There was one survey detection in 2011 and two detections in 2012.

Imperial 50 Restoration (IMP50) — Elevation: 61 m, 4.2 ha

This restoration site was planted in 2010 and first surveyed in 2011–2012 as the vegetation matured. It consists of a densely planted mix of cottonwood and mesquite with a dense quail bush perimeter. It is surrounded on three sides by agricultural fields and on one side by restored marshland. A gravel road and two dirt roads surround the perimeter with an irrigation canal to the north. It is surveyed along the perimeter road and is approximately 200 m southwest of Imperial 20A. In 2011, there were three survey detections with one possible breeding territory. There was one detection in 2012.

Martinez Lake (IMPAST) — Elevation: 61 m, 6.8 ha

This site consists of a narrow, linear band of riparian vegetation on Arizona State Trust land bordering Martinez Lake, 1.2 km east of Imperial NWR. The dominant species is Goodding’s willow, with lesser amounts of Fremont cottonwood and tamarisk. Tree heights range from

6–13 m, with a canopy cover of approximately 20%. The site is bordered to the east by dense arrowweed and dry desert uplands. This site was first surveyed in 2009 with no detections. There were two survey detections in 2011. The site was not surveyed in 2010 or 2012.

Imperial South Restoration (IMPSTH) Elevation: 60 m, 13 ha

Imperial South (INWR Forest) consists of a small native nursery planted in 1994 and a band of cottonwood and willow habitat lining a finger of Martinez Lake. The nursery site comprises mature 5–14-m-tall Fremont cottonwood, Goodding's willow, and mesquite, with approximately 60% canopy closure. There is a low, sparse (about 5% cover) understory of young cottonwood, mesquite, arrowweed, common reed, seep willow, and tamarisk. Surrounding habitat includes an open field, impoundment ponds, and a mix of tamarisk, willow, and marsh to the north. The survey route follows perimeter roads and was extended in 2011 to include tamarisk-willow to the north.

In 2008, there were three survey detections with one possible breeding territory, four detections in 2009 with one probable breeding territory, three detections in 2010 with one possible breeding territory, four detections in 2011 with one possible breeding territory, and six detections in 2012 with one possible breeding territory.

LAGUNA

Imperial County, California

Three Laguna sites (LAG1, LAG 2, and LAG 3) were surveyed during 2009–2012 on Bureau of Land Management (BLM)-managed lands near Imperial Dam. The sites consist of small riparian habitat patches, some with small pools, surrounded by a dry tamarisk/desert upland matrix. The Laguna 1 site was first surveyed in 2009, but dropped in 2010, as it was considered too small. Four other sites (LAGA, D, E, and W) were added just below Imperial Dam and were surveyed in 2011 to establish baseline cuckoo occupancy prior to planned riparian restoration in the area; they consisted of remnant cottonwoods in a mesquite-tamarisk matrix.

Laguna 1-3 (LAG1-3) Elevation: 50 m, 0.9, 3.9, and 3.8 ha

Goodding's willow is the dominant tree at the Laguna sites, providing an overstory 8–12 m high and canopy cover averaging 70%. A small amount of Fremont cottonwood and tamarisk are also present. The understory consists of tamarisk, cattails, and arrowweed. The three sites are relatively close to each other: LAG2 is 645 m south of LAG1 and 500 m north of LAG3. LAG1 is separated from the other sites by a canal. LAG3 is bisected by Imperial Road.

These three sites were first surveyed in 2009 with no detections, with LAG 1 dropped in 2010 due to its small size. There were no detections at LAG 2 in 2010 or 2012. No surveys were conducted in 2011. There was one detection at LAG3 in 2010, and no survey was conducted in 2011. There were three LAG3 detections in 2012, representing one possible breeding territory.

Laguna East (LAGE) — Elevation: 50 m, 13.9 ha

This transect follows a small established dirt road along a small line of riparian vegetation consisting of willows and cottonwoods and then follows the edge of a marsh. The site was surveyed in 2011 only. The only cuckoo detected on Laguna surveys in 2011 flew from this site, then across the road, and was detected on Transect A.

Laguna Transect "A" (LAGA) — Elevation: 50 m, 10.1 ha

This transect was established along a rough bulldozed road known by Fred Phillips Consulting as 'Transect A'. Surrounding habitat consisted of mixed natives and exotics including screwbean mesquite, arrowweed, and tamarisk. A few stunted remnant cottonwoods grow just to the west of the road. The site was surveyed in 2011 only with one survey detection.

Laguna Transect "D" (LAGD) — Elevation: 50 m, 14.3 ha

This transect follows a rough bulldozed road ending at a depression. It receives some water, indicated by the presence of slightly taller trees (5 m) and singing common yellowthroats. Surrounding vegetation consists of a mixed habitat of screwbean mesquite, tamarisk, quail bush, and arrowweed. The site was surveyed in 2011 only with no detections.

Laguna West (LAGW) — Elevation: 50 m, 1 ha

Laguna West consists of a small remnant cottonwood-willow and marsh patch just west of the planned restoration and east of the Colorado River. The site was surveyed in 2011 only with no detections.

MITTRY LAKE WILDLIFE MANAGEMENT AREA

Yuma County, Arizona (Colorado River Drainage)

Mittry Lake WMA is managed by the Arizona Game and Fish Department (AGFD) for wildlife habitat and outdoor recreation. The area is 24.2 km northeast of Yuma, between Laguna and Imperial Dams on the lower Colorado River, and is composed of open water, marsh, and desert riparian habitat. In 2008 through 2012, the only site in this vicinity deemed suitable for cuckoos was the Pratt Restoration Site. Mittry Lake East Road described below was only surveyed in 2011.

Mittry Lake East Road (MLEA) — Elevation: 40 m, 10.2 ha

This survey route follows along the gravel road leading to Laguna Dam and was added in 2011 to document pre-restoration occupancy below the dam. Habitat consists of open water, marshland, cattails, tamarisk, arrowweed, and a few pockets of native riparian trees. The site was surveyed in 2011 only with one cuckoo detected in a large solo cottonwood surrounded by dense arrowweed less than 20 m from the road.

Mittry Lake - Pratt Restoration (MLPR) — Elevation: 40 m, 14 ha

Pratt Restoration is a cooperative restoration planted in 1999 on a BLM agricultural lease. The overstory is 5–11 m with around 70% canopy cover and comprises approximately 80% cottonwood and 20% Goodding's and coyote willow. There is about 30% understory cover (< 5 m) of seep willow, Goodding's willow, mesquite, cottonwood, and tamarisk. Actively farmed fields border the north and east sides of the site, and a younger restoration patch abuts the southeastern edge (added to the surveyed area as it matured). The amount of available habitat approximately doubled in 2010 when the young restoration became suitable, but a large pre-season fire in 2011 destroyed most of the surrounding tamarisk-dominated vegetation at this site. The restoration sites were slightly damaged, but the majority was saved by surrounding roads, concrete canals, and firefighting efforts. Betty's Kitchen Nature Trail, which wound through the tall mature tamarisk and mesquite stand to the south and west of the site, was completely burned.

One cuckoo was detected here in 2008, and there were no detections in 2009. There were four detections at this site in 2010, representing one possible breeding territory, and five detections in 2011, representing one possible breeding territory. Seven detections were made in 2012, representing one probable territory.

QUIGLEY WILDLIFE MANAGEMENT AREA

Yuma County, Arizona (Gila River Drainage)

Quigley WMA is 4 km north of Tacna in the historic Gila River flood plain. This 244.8-ha (612-ac) WMA is owned and managed by AGFD for wildlife and recreation. Potentially suitable cuckoo habitat at this site includes mixed exotic/native historic flood plain and a small native-dominated restoration area surrounded on three sides by agricultural fields.

Quigley WMA (GRQP) Elevation: 75 m, 10.6 ha

The Quigley site (planted in 1999) consists of a small restoration plot to the east and adjacent mixed native habitat to the west. The restoration plot contains an overstory of mature cottonwood, tamarisk, willow, and mesquite 5–13 m high, providing about 60% canopy cover. The 1–5-m understory contains tamarisk, arrowweed, seep willow, mesquite, willow, and cottonwood. The mixed native area contains scattered dead and stressed cottonwoods, willows, and mesquites. The site is surrounded by agricultural fields on three sides and the dry Gila River flood plain to the west.

The site was surveyed 2008–2012. No cuckoos were detected during the 2008 season. There were three survey detections in 2009 with no evidence of breeding. There were three survey detections in 2010, representing one possible breeding territory, and four survey detections in 2011, representing one possible breeding territory. One of the possible pair was captured on July 14 and radio tracked, but no nest was found, and it had left the site between July 24 and July 29. There was one detection in 2012.

NORTH GILA VALLEY/COLORADO RIVER CONFLUENCE

Yuma County, Arizona (Colorado River Drainage)

Patches of riparian forest persist along the banks of both the Gila and Colorado Rivers near their confluence 6.5 km east of Yuma, Arizona. Ownership is divided among private parties and BLM. The Gila and Colorado confluence were both surveyed in 2008 and 2009, but both were dropped in 2010 due to poor habitat quality and lack of detections. Two new North Gila Valley sites were added in 2009.

Colorado Confluence (YUCC) Elevation: 37 m, 68 ha

Small patches of mixed exotic riparian vegetation line the main stem of the Colorado River immediately upstream of the Gila River confluence, creating a narrow 67.7-ha (167.2-ac) strip of potentially suitable cuckoo habitat. The sparse overstory (approximately 2% canopy cover) is about 98% tamarisk with isolated Goodding's willows and Fremont cottonwoods. The overstory ranges from 4–10 m tall. Tamarisk dominates the 1–3 m high understory, which covers approximately 30% of the site. Agricultural fields border the site opposite the river channel. This site was surveyed by kayak. YUCC was surveyed from 2008–2009. The marginal habitat found here appeared to be declining in quality over the years and was dropped from the project after 2009. No cuckoos were detected at this site during 2008 surveys. There was a single survey detection at this site in 2009 and no evidence of breeding.

Gila Confluence (GRGC) — Elevation: 41 m, 78 ha

Patches of mixed exotic riparian habitat line the Gila River for 6.3 km (3.9 miles) just upstream of its confluence with the Colorado River. This 78-ha (192.4-ac) site consists of sparse Fremont cottonwood, tamarisk, and willow overstory 4–10 m high with 25% cover. An understory (< 4 m) of tamarisk, arrowweed, willow, and seep willow covers 60% of the site. The site is surrounded by extensive agricultural fields.

In 2008 and 2009, one cuckoo was detected at this site, but it was not considered occupied during the breeding season. This area was once considered prime cuckoo habitat, but fires and clearing have now made the area marginal habitat; it was dropped from the project after 2009.

North Gila Valley (GRNVA, GRNVB) — Elevation: 44 m, 3.6, and 4.77 ha

Both sites are located in the North Gila Valley, Yuma, on the north side of the Gila River with a mature Goodding's willow and Fremont cottonwood overstory of 9–15 m high and canopy cover averaging 70%. The understory consists of dense tamarisk and arrowweed. The two sites are separated by about 680 m of this low shrubby habitat. Agricultural fields border the sites to the north. These sites were first surveyed in 2009. GRNVA was surveyed again in 2012, but access to GRNVB was blocked and was not surveyed after survey 1. No detections have occurred here.

YUMA WETLANDS

Yuma County, Arizona (Colorado River Drainage)

Yuma East and West Wetlands are restoration sites along the banks of the Colorado River in Yuma. Until recently, the area was a mix of exotic plants, trash dumps, and squatter camps. The West Wetlands is a 55-ha (135-ac) city park managed by the Yuma Department of Parks and Recreation. The East Wetlands is part of the Yuma Crossing Natural Heritage Area, which is under joint management by the city of Yuma, the Quechan Tribe, AGFD, and private ownership. Planting at Yuma West began in 1999 and at Yuma East in winter 2003–2004.

Yuma East Wetlands (YUEW) — Elevation: 36 m, 9 ha

The site is immediately east of the Ocean to Ocean Bridge and lies on both the north and south banks of the Colorado River approximately 1.2 km upstream of Yuma West Wetlands. Planted during 2003–2004, YUEW was surveyed and added to the project in 2009 following an incidental cuckoo detection by AGFD in 2008. It was first surveyed in 2009. The planted habitat consists of a mosaic of Fremont cottonwood, Goodding's willow, and mesquite spp. The overstory at the site ranges from 3–9 m with 50% canopy cover. Surveys were conducted on site from 2008 through 2012 and the northern shore by kayak in 2008 and 2009. In 2012, suitable habitat was added to the existing survey as the trees matured. There were no survey detections in 2009, one in 2010, none in 2011, and three in 2012 with no evidence of breeding.

Yuma West Wetlands (YUWW) Elevation: 36 m, 24.3 ha

Yuma West Wetlands consists of a mosaic of cottonwood, Goodding's willow, and mesquite. Overstory at the site ranges from 6–12 m with an estimated 30% canopy cover. Arrowweed, saltbush, seep willow, mesquite, tamarisk, and young naturally regenerating willow and cottonwood make up a diverse understory. Site management includes regular understory clearing for fuel reduction and safety. The Colorado River borders the northern edge of the site, and residential areas border the south, east, and west. YUWW was planted in 1999 and surveyed during 2008–2012. In 2009, habitat was added to the site on the east end. Three survey detections at this site in 2008 represented one possible breeding territory. All detections were at the east end of the site, an area comprising large remnant cottonwoods and a thickly planted patch of willows. There were no survey detections in 2009, one in 2010, two in 2011, and one in 2012. This site appears to be used as a migratory stopover.

LIMITROPHE DIVISION

Yuma County, Arizona (Colorado River Drainage)

The Limitrophe Division follows the lower Colorado River from Morelos Dam to the south, forming the international boundary between Mexico and the United States. This section contains little water, as the majority of the flow is diverted into Mexico's Alamo Canal above Morelos Dam. The vegetation below the dam is dense and dominated by tamarisk. Surveys were shifted from the 2007 survey site after a fire burned extensive sections of the route. Three small patches of mixed native habitat were combined into two survey sites during the 2008 season. There is heavy vehicular disturbance throughout the area due to U.S. Border Patrol activity. Limitrophe South was dropped in 2009, and Limitrophe North was dropped after 2009. Habitat was marginal due to management activity, including burning and clearing of understory to improve visibility. Additionally, access to the area to conduct surveys was complicated by the construction of the border wall.

Limitrophe North (LIMNTH) Elevation: 32 m, 164 ha

The Limitrophe North site lies along the east bank of the Colorado River below Morelos Dam. This 164-ha (405-ac) site of mixed exotic habitat is dominated by a 5–10 m tall overstory of Goodding's willow, Fremont cottonwood, and tamarisk, with approximately 15% canopy cover. The understory is dominated by tamarisk, arrowweed, willow and mesquite, providing about 45% cover. The site is bordered by an access road and a levee to the east and the Colorado River to the west. Limitrophe North was surveyed 2008–2009. In 2009, habitat surveyed in 2008 adjacent and north of Morelos Dam was cleared, and the new route was entirely below the dam. No cuckoos were detected during 2008 surveys. There were three survey detections at this site in 2009, representing one possible breeding territory.

Limitrophe South (LIMST A/B) Elevation: 27 m, 16 ha

Limitrophe South consists of two patches along the eastern edge of a large oxbow in the main channel of the Colorado River about 16.1 km (10 miles) downstream from Morelos Dam. Area A is an 8.3-ha (20.6-ac), native-dominated patch with sparse cottonwoods 4–17 m tall, providing 55% overstory cover. This patch has an understory of willow, tamarisk, arrowweed, Phragmites, cottonwood, and *Baccharis*, providing 55% cover below 2 m high. Area B is 800 m to the south of Area A and consists of 8 ha of a mixed native willow, cottonwood, mesquite, and tamarisk-dominated river channel with water present throughout the season. The overstory varies from 3–10 m and provides 15% cover. A diverse understory of arrowweed, Phragmites, cattails, willow, and tamarisk provides 45% cover below 3 m high. Both patches have actively farmed agricultural fields to the north and east, and the sparsely vegetated mixed exotic flood plain extends to the south and west. Limitrophe South (A and B) was only surveyed in 2008 and then dropped from the project. The habitat was poor, and access became restricted with the construction of the border wall. A single cuckoo was detected at this site (Area B) during 2008 surveys.

ATTACHMENT C

Birds Encountered on Yellow-billed Cuckoo Surveys by Site and Year, 2008–2012

Table C-1.—Birds at northern (Reach 1) sites, 2008–2012 (years 1–5)

Site code		KEYPIT					PAHNTH					PAHSTH					LITBR					OVRHP					OVRR					OVRW					OVRWP					SMJE				
Bird species	**Year**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Abert's towhee													1					1	1			1	1					1				1	1	1		1					1					
American avocet							1																																							
American coot			1					1			1					1			1			1	1															1	1		1					
American crow			1				1				1					1																				1					1					
American gadwall							1																																							
American goldfinch																																														
American kestrel												1										1										1														
American redstart																																														
American robin																												1																		
American white pelican			1									1																																		
Anna's hummingbird																			1																											
Ash-throated flycatcher			1				1	1				1	1					1	1																											
Bank swallow																			1																				1							
Barn owl			1																																											
Barn swallow																																														
Bell's vireo			1								1		1			1		1					1					1				1	1					1	1		1			1		
Belted kingfisher																																														
Bewick's wren			1				1				1	1	1			1			1														1			1								1		
Black phoebe			1				1	1			1	1				1						1	1									1	1	1												
Black rail																																														
Black-bellied plover																																														
Black-chinned hummingbird							1				1	1	1					1	1			1						1																		
Black-crowned night-heron								1			1					1		1	1				1									1									1					

Table C-1.—Birds at northern (Reach 1) sites, 2008–2012 (years 1–5)

Site code	KEYPIT					PAHNTH					PAHSTH					LITBR					OVRHP					OVRR					OVRW					OVRWP					SMJE				
Bird species / **Year**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Black-headed grosbeak						1																																							
Black-necked stilt						1	1																																						
Black-tailed gnatcatcher												1						1				1									1	1			1			1		1					
Black-throated gray warbler																																													
Black-throated sparrow											1																																		
Blue grosbeak						1				1	1	1					1				1	1					1				1	1			1					1					
Blue winged teal						1																																							
Blue-gray gnatcatcher															1												1																		
Bronzed cowbird																																													
Brown-crested flycatcher		1				1	1			1	1	1			1		1	1																	1					1					
Brown-headed cowbird		1				1	1			1	1	1			1		1	1			1	1					1				1	1	1		1			1		1			1		
Bullock's oriole		1				1	1			1					1		1															1								1					
Burrowing owl																																													
Bushtit																		1			1											1													
California gull						1					1																																		
Canada goose		1					1			1	1	1			1						1	1					1				1									1					
Canvasback																															1														
Canyon wren																	1															1													
Cassin's kingbird																																													
Cattle egret																															1														
Chipping sparrow															1																														
Cinnamon teal																					1																								
Clapper rail																																1													

Table C-1.—Birds at northern (Reach 1) sites, 2008–2012 (years 1–5)

Site code		KEYPIT					PAHNTH					PAHSTH					LITBR					OVRHP					OVRR					OVRW					OVRWP					SMJE				
Bird species	**Year**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Clarks grebe											1																																			
Cliff swallow																		1				1										1				1					1					
Common blackhawk																																														
Common ground dove																																														
Common moorhen																																														
Common nighthawk																																														
Common raven								1			1	1	1			1		1				1	1										1	1		1					1					
Common tern																							1																							
Common yellowthroat			1				1	1			1	1	1			1		1	1			1	1									1	1	1		1		1	1		1			1		
Coopers hawk								1										1																1												
Cordilleran flycatcher																																														
Costa's hummingbird																																														
Crissal thrasher																																1		1							1					
Double-crested cormorant											1											1																								
Eurasian collared dove			1									1				1		1	1				1									1														
European starling																																														
Ferruginous hawk																																														
Gadwall											1	1																																		
Gambel's quail												1	1			1		1	1			1	1					1				1	1			1			1		1					
Gila woodpecker																																														
Gilded flicker																																														
Gray catbird							1																																							
Great blue heron			1				1	1			1	1				1		1				1	1					1				1	1			1		1	1		1					

Table C-1.—Birds at northern (Reach 1) sites, 2008–2012 (years 1–5)

Site code	KEYPIT					PAHNTH					PAHSTH					LITBR					OVRHP					OVRR					OVRW					OVRWP					SMJE				
Bird species / **Year**	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Great egret							1				1										1	1										1	1				1								
Great horned owl							1				1				1																		1				1								
Greater pewee																																													
Greater roadrunner										1					1							1									1				1					1			1		
Greater yellowlegs																																													
Great-tailed grackle		1					1			1	1				1		1	1			1	1									1	1	1		1			1		1					
Green heron		1															1					1									1														
Green-winged teal											1																																		
Hairy woodpecker																																													
Hooded oriole							1					1					1										1																		
Horned lark																																													
House finch		1				1	1			1	1	1					1	1									1					1			1										
House sparrow																															1														
House wren		1					1				1																																		
Inca dove																																													
Indigo bunting															1		1					1																							
Killdeer		1				1	1			1	1							1													1									1					
Ladder-backed woodpecker						1				1	1	1			1			1																	1					1					
Lark sparrow																																													
Lazuli bunting											1																																		
Least bittern		1																																						1					
Lesser goldfinch						1	1			1	1				1		1										1				1				1										
Lesser nighthawk																																								1					

Table C-1.—Birds at northern (Reach 1) sites, 2008–2012 (years 1–5)

Site code		KEYPIT					PAHNTH					PAHSTH					LITBR					OVRHP					OVRR					OVRW					OVRWP					SMJE				
Bird species	**Year**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Lesser yellowlegs																																														
Loggerhead shrike			1																														1													
Long-billed curlew																																														
Long-billed dowitcher																																														
Lucy's warbler											1					1						1										1	1	1		1					1					
Macgilvray's warbler								1																																						
Mallard			1				1	1			1	1	1									1	1					1					1					1			1					
Marsh wren			1								1		1					1				1											1					1	1							
Mourning dove			1				1				1	1	1			1		1	1			1	1					1				1	1	1		1			1		1			1		
Northern flicker																																														
Northern harrier							1																									1		1												
Northern mockingbird							1				1	1	1			1												1				1				1										
Northern pintail												1																																		
Northern rough-winged swallow							1						1			1		1				1	1					1				1	1	1					1		1			1		
Orange-crowned warbler																																	1													
Osprey												1																																		
Pacific-slope flycatcher																																														
Peacock																												1																		
Peregrine falcon																1						1														1										
Phainopepla											1					1																1														
Pied-billed grebe											1					1						1																1	1		1			1		
Purple martin																																														

Table C-1.—Birds at northern (Reach 1) sites, 2008–2012 (years 1–5)

Site code	KEYPIT					PAHNTH					PAHSTH					LITBR					OVRHP					OVRR					OVRW					OVRWP					SMJE				
Bird species Year	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Red-shouldered hawk															1		1																												
Red-tailed hawk							1			1	1				1		1					1					1																		
Red-winged blackbird		1				1	1			1		1			1		1	1			1	1					1				1	1	1		1			1		1			1		
Ring-necked duck																					1																								
Ring-necked pheasant																																											1		
Rock wren																																													
Rooster																	1										1																		
Rose-breasted grosbeak																																													
Ruddy duck		1					1			1					1							1																							
Rufous-winged sparrow																	1															1													
Sage sparrow																																													
Say's phoebe															1						1										1														
Semipalmated plover																																													
Sharp-shinned hawk																																1													
Snowy egret							1			1					1						1						1				1	1					1								
Song sparrow		1				1	1			1	1	1			1		1	1			1	1									1	1	1		1			1					1		
Spotted sandpiper		1					1				1				1																														
Spotted towhee						1																																							
Sulphur-bellied flycatcher																																													
Summer tanager							1			1	1				1		1	1																											
Swainson's hawk																																													
Tree swallow																																						1							
Turkey vulture		1				1	1				1	1			1		1					1									1														

Table C-1.—Birds at northern (Reach 1) sites, 2008–2012 (years 1–5)

Site code		KEYPIT					PAHNTH					PAHSTH					LITBR					OVRHP					OVRR					OVRW					OVRWP					SMJE				
Bird species	**Year**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Unknown flycatcher																							1										1													
Unknown gull			1					1			1					1																						1								
Unknown heron																		1																												
Unknown hummingbird			1															1															1													
Unknown sparrow								1										1										1					1													
Unknown swallow																		1				1																								
Verdin																		1	1			1	1									1	1	1					1		1					
Vermillion flycatcher													1			1																														
Vesper sparrow																																														
Violet-green swallow			1													1																1														
Virginia rail			1								1							1				1											1								1					
Western flycatcher			1				1					1						1																												
Western grebe											1											1																								
Western kingbird			1				1	1			1	1	1			1		1	1									1					1					1								
Western meadowlark																																														
Western screech owl																																														
Western tanager							1	1				1				1																														
Western wood-pewee							1																																							
White-faced ibis								1			1					1						1											1								1					
White-tailed kite								1																																						
White-throated swift																						1										1				1			1							
White-winged dove			1										1					1	1			1	1					1				1	1			1					1					
Wild turkey																												1				1														

Table C-1.—Birds at northern (Reach 1) sites, 2008–2012 (years 1–5)

Site code		KEYPIT					PAHNTH					PAHSTH					LITBR					OVRHP					OVRR					OVRW					OVRWP					SMJE				
Bird species	**Year**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Willow flycatcher			1				1	1			1							1	1			1										1	1											1		
Wilson's warbler							1																																							
Wood duck																																														
Yellow warbler			1				1	1			1	1	1			1		1	1			1	1					1				1	1	1		1			1		1			1		
Yellow-billed cuckoo			1					1			1					1																		1		1		1	1		1					
Yellow-breasted chat			1				1	1			1	1	1			1		1	1			1	1					1				1	1	1		1		1	1		1			1		
Yellow-headed blackbird			1					1			1	1										1						1				1						1								

Table C-2.—Birds at Havasu NWR to Lake Havasu (Reach 3) sites, 2008–2012 (years 1–5)

Site code	HAVBR					HAVFDR					HAVGH					HAVLR					HAVND					HAVPS					HAVTPR					DSWA					LHCFSW					LHCWP				
Bird species / **Year**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Abert's towhee	1	1		1	1		1		1			1	1	1			1		1		1	1	1	1	1	1	1		1	1	1	1	1	1	1		1					1					1			
American avocet																																																		
American coot	1				1		1		1												1						1															1					1			
American crow																																																		
American gadwall																																																		
American goldfinch																											1																							
American kestrel					1									1															1	1				1																
American redstart																										1																								
American robin																																																		
American white pelican																					1																													
Anna's hummingbird																										1											1													
Ash-throated flycatcher	1	1		1	1		1		1								1	1	1			1	1	1			1	1	1	1	1	1		1	1		1													
Bank swallow																																																		
Barn owl														1										1																										
Barn swallow																																																		
Bell's vireo	1	1	1	1	1		1					1	1				1				1	1		1	1	1	1	1	1	1	1	1			1												1			
Belted kingfisher																																																		
Bewick's wren				1	1				1			1	1	1																		1			1															
Black phoebe		1		1			1					1		1			1					1		1			1		1		1	1		1								1					1			
Black rail												1																																						
Black-bellied plover																																																		
Black-chinned hummingbird		1			1		1						1								1		1	1	1	1			1	1		1					1													

Table C-2.—Birds at Havasu NWR to Lake Havasu (Reach 3) sites, 2008–2012 (years 1–5)

Site code	HAVBR					HAVFDR					HAVGH					HAVLR					HAVND				
Bird species / **Year**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Black-crowned night-heron																							1		
Black-headed grosbeak																									
Black-necked stilt				1																					
Black-tailed gnatcatcher		1		1	1		1		1				1	1			1	1	1				1	1	1
Black-throated gray warbler																									
Black-throated sparrow																									
Blue grosbeak	1	1		1	1		1		1			1					1		1		1	1	1	1	1
Blue winged teal																									
Blue-gray gnatcatcher																						1			
Bronzed cowbird		1																							
Brown-crested flycatcher	1			1	1		1		1			1	1	1				1				1		1	1
Brown-headed cowbird	1	1		1	1		1		1			1	1	1			1	1	1		1	1	1	1	1
Bullock's oriole	1	1	1	1	1									1								1			
Bunting species																									
Burrowing owl																									
Bushtit		1																							
California gull																									
Canada goose																						1			
Canvasback																									
Canyon wren																									
Cassin's kingbird																									
Cattle egret																									

Site code	HAVPS					HAVTPR					DSWA					LHCFSW					LHCWP				
Bird species / **Year**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Black-crowned night-heron				1																					
Black-headed grosbeak							1																		
Black-necked stilt																									
Black-tailed gnatcatcher		1		1	1	1	1		1	1		1													
Black-throated gray warbler																									
Black-throated sparrow																									
Blue grosbeak	1	1		1	1	1	1		1	1															
Blue winged teal																									
Blue-gray gnatcatcher			1																						
Bronzed cowbird																									
Brown-crested flycatcher		1			1		1	1	1	1		1													
Brown-headed cowbird	1	1	1	1	1	1	1		1	1		1					1					1			
Bullock's oriole	1	1		1	1	1	1		1			1					1								
Bunting species																									
Burrowing owl																									
Bushtit																									
California gull																									
Canada goose																									
Canvasback																									
Canyon wren												1					1								
Cassin's kingbird						1																			
Cattle egret																									

Table C-2.—Birds at Havasu NWR to Lake Havasu (Reach 3) sites, 2008–2012 (years 1–5)

Site code	HAVBR					HAVFDR					HAVGH					HAVLR					HAVND					HAVPS					HAVTPR					DSWA					LHCFSW					LHCWP				
Bird species Year	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Chipping sparrow																																																		
Cinnamon teal																																																		
Clapper rail												1																																						
Clarks grebe							1					1		1							1																					1								
Cliff swallow		1																			1			1	1	1			1	1																				
Common blackhawk																																																		
Common ground dove	1																					1																												
Common moorhen					1		1																				1															1					1			
Common nighthawk																																																		
Common raven					1																						1			1		1		1	1		1										1			
Common tern																						1																												
Common yellowthroat	1	1		1	1		1		1			1		1			1		1		1	1	1	1	1	1	1	1	1	1	1	1		1	1		1					1					1			
Coopers hawk																											1																							
Cordilleran flycatcher																																																		
Costa's hummingbird																																																		
Crissal thrasher		1		1													1		1			1		1			1		1	1		1	1	1													1			
Double-crested cormorant														1					1																															
Eurasian collared dove																							1									1			1															
European starling																																																		
Ferruginous hawk																																																		
Flicker species																																																		
Gadwall																																																		
Gambel's quail	1	1	1	1	1		1		1			1	1	1			1	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1										1			

Table C-2.—Birds at Havasu NWR to Lake Havasu (Reach 3) sites, 2008–2012 (years 1–5)

Site code		HAVBR					HAVFDR					HAVGH					HAVLR					HAVND					HAVPS					HAVTPR					DSWA					LHCFSW					LHCWP				
Bird species	**Year**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Gila woodpecker								1		1			1	1	1			1		1					1					1	1		1		1	1		1													
Gilded flicker																																																			
Gray catbird																																																			
Great blue heron			1					1					1					1									1	1	1	1	1												1								
Great egret			1																			1	1				1	1		1	1					1							1								
Great horned owl								1							1								1		1		1	1		1			1		1																
Greater pewee																																																			
Greater roadrunner		1	1		1	1												1		1		1	1		1		1	1		1	1		1		1	1							1								
Greater yellowlegs																																																			
Great-tailed grackle		1	1	1	1	1		1		1			1		1			1	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1			1					1					1			
Green heron		1	1					1					1									1				1	1	1	1		1												1								
Green-winged teal																																																			
Hairy woodpecker																																																			
Hooded oriole			1															1															1																		
Horned lark																												1																							
House finch		1				1		1						1					1			1			1	1	1	1			1	1	1		1	1		1					1					1			
House sparrow																																																			
House wren																																																			
Inca dove																																																			
Indigo bunting			1		1	1		1										1					1		1			1			1		1		1	1		1													
Killdeer		1				1																								1			1										1								
Ladder-backed woodpecker		1	1		1	1		1		1			1	1	1			1		1				1	1	1				1		1	1		1	1		1					1					1			

Table C-2.—Birds at Havasu NWR to Lake Havasu (Reach 3) sites, 2008–2012 (years 1–5)

Site code		HAVBR					HAVFDR					HAVGH					HAVLR					HAVND				
Bird species	**Year**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Lark sparrow																										
Lazuli bunting																										
Least bittern			1					1																		
Lesser goldfinch								1						1												
Lesser nighthawk		1	1		1	1		1					1		1			1		1		1	1		1	1
Lesser yellowlegs																										
Loggerhead shrike			1		1			1					1		1								1		1	
Long-billed curlew								1																		
Long-billed dowitcher																										
Lucy's warbler			1		1	1				1			1	1	1					1			1			
Macgilvray's warbler																										
Mallard		1	1																							
Marsh wren			1					1					1	1												
Mourning dove		1	1		1	1		1		1			1	1	1			1	1	1		1	1	1	1	1
Northern flicker								1											1							
Northern harrier																										
Northern mockingbird		1						1															1			
Northern pintail																										
Northern rough-winged swallow		1	1		1	1		1					1		1			1		1		1	1	1		1
Orange-crowned warbler																										
Osprey																										
Pacific-slope flycatcher																										

Site code		HAVPS					HAVTPR					DSWA					LHCFSW					LHCWP				
Bird species	**Year**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Lark sparrow																										
Lazuli bunting																										
Least bittern			1																				1			
Lesser goldfinch							1			1																
Lesser nighthawk		1	1		1	1		1		1	1							1								
Lesser yellowlegs																										
Loggerhead shrike			1		1			1		1			1													
Long-billed curlew																										
Long-billed dowitcher																										
Lucy's warbler		1	1	1				1		1	1															
Macgilvray's warbler																										
Mallard			1															1								
Marsh wren			1															1					1			
Mourning dove		1	1	1	1	1	1	1		1	1		1					1					1			
Northern flicker							1																			
Northern harrier								1																		
Northern mockingbird		1	1		1	1		1		1	1															
Northern pintail																										
Northern rough-winged swallow		1	1		1	1		1		1			1					1					1			
Orange-crowned warbler																										
Osprey																										
Pacific-slope flycatcher																										

Table C-2.—Birds at Havasu NWR to Lake Havasu (Reach 3) sites, 2008–2012 (years 1–5)

Site code	HAVBR					HAVFDR					HAVGH					HAVLR					HAVND					HAVPS					HAVTPR					DSWA					LHCFSW					LHCWP				
Bird species Year	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Peacock																																																		
Peregrine falcon																																																		
Phainopepla		1					1															1																												
Pied-billed grebe	1													1			1		1			1												1								1					1			
Purple martin																																																		
Red-shouldered hawk																																																		
Red-tailed hawk																									1		1	1		1																				
Red-winged blackbird	1	1		1	1		1					1									1	1			1	1	1	1	1	1		1										1					1			
Ring-necked duck																																																		
Ring-necked pheasant																																																		
Rock pigeon																																																		
Rock wren																																																		
Rooster																																																		
Rose-breasted grosbeak																																			1															
Ruddy duck																																																		
Rufous-winged sparrow																											1																							
Sage sparrow																																																		
Say's phoebe																					1				1					1		1			1															
Semipalmated plover																																																		
Sharp-shinned hawk																																																		
Snowy egret																										1	1															1								
Song sparrow	1			1	1		1		1			1	1	1			1	1	1		1	1		1		1	1			1		1			1		1					1								
Spotted sandpiper																																																		

Table C-2.—Birds at Havasu NWR to Lake Havasu (Reach 3) sites, 2008–2012 (years 1–5)

Site code	HAVBR					HAVFDR					HAVGH					HAVLR					HAVND					HAVPS					HAVTPR					DSWA					LHCFSW					LHCWP				
Bird species / **Year**	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Spotted towhee																																																		
Sulphur-bellied flycatcher																																																		
Summer tanager		1		1	1		1		1			1	1	1								1	1			1		1				1	1	1																
Swainson's hawk																					1																													
Tree swallow		1					1					1					1															1										1								
Turkey vulture																										1																1					1			
Unknown flycatcher																					1																													
Unknown gull		1					1																							1																				
Unknown hummingbird												1																														1								
Unknown sparrow												1										1					1																							
Unknown swallow												1														1																								
Verdin	1	1		1			1					1	1				1		1		1	1	1	1			1		1	1	1	1		1			1					1								
Vermillion flycatcher																																																		
Vesper sparrow																																																		
Violet-green swallow		1																								1																1					1			
Virginia rail									1																		1																							
Western flycatcher							1					1																				1																		
Western grebe	1											1									1																					1								
Western kingbird	1	1		1			1					1					1				1	1			1	1	1			1		1			1															
Western meadowlark																																																		
Western screech owl																																																		
Western tanager		1		1								1					1												1			1					1													
Western wood-pewee							1																								1																			

Table C-2.—Birds at Havasu NWR to Lake Havasu (Reach 3) sites, 2008–2012 (years 1–5)

Site code	HAVBR					HAVFDR					HAVGH					HAVLR					HAVND					HAVPS					HAVTPR					DSWA					LHCFSW					LHCWP				
Bird species / **Year**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
White-faced ibis	1	1		1	1		1							1													1															1								
White-tailed kite																																																		
White-throated swift																												1																						
White-winged dove	1	1		1	1		1		1			1	1	1			1	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1					1					1			
Wild turkey																																																		
Willow flycatcher							1					1																																						
Wilson's warbler																																																		
Wood duck																																																		
Yellow warbler	1	1		1	1		1		1			1	1	1			1		1		1	1	1				1	1			1	1	1	1			1					1								
Yellow-billed cuckoo	1	1	1	1	1																1		1	1				1	1		1	1	1	1	1															
Yellow-breasted chat	1	1	1	1	1		1		1			1	1	1				1	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1					1					1			
Yellow-headed blackbird	1				1		1		1								1										1	1														1					1			
Zone-tailed hawk																																																		

Table C-3.—Birds at Bill Williams River (Reach 3) sites, 2008–2012 (years 1–5) (part 1)

Site code		BWMA					BWBP					BWCW					BWCP					BWPT					BWCR					BWER					BWFW				
Species name	**Year**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Abert's towhee		1	1		1			1	1	1	1	1	1	1	1	1		1	1	1		1	1		1	1		1	1	1	1	1	1		1	1	1	1	1	1	1
American avocet																																									
American coot			1	1						1																															
American crow																																									
American gadwall																																									
American goldfinch																																									
American kestrel															1										1	1														1	1
American redstart																																									
American robin																																									
American white pelican																																									
Anna's hummingbird																				1											1										
Ash-throated flycatcher		1	1		1			1	1	1	1	1	1	1	1	1		1	1	1		1	1		1			1	1	1			1		1	1	1	1	1	1	1
Bank swallow				1																																					
Barn owl																																									
Barn swallow																																									
Bell's vireo		1	1			1		1	1	1	1	1	1	1	1	1		1	1	1		1	1		1	1		1	1	1	1	1	1		1	1	1	1	1	1	1
Belted kingfisher			1																																						
Bewick's wren		1	1		1	1		1	1	1	1	1	1		1	1			1	1		1	1		1	1		1		1	1		1		1	1	1	1	1	1	1
Black phoebe			1		1	1		1		1					1	1						1	1		1	1		1		1			1		1	1		1	1	1	1
Black rail												1			1	1				1		1	1									1	1								
Black-bellied plover																																									
Black-chinned hummingbird		1							1				1	1	1			1		1					1							1			1		1			1	
Black-crowned night-heron		1																												1							1		1		

Table C-3.—Birds at Bill Williams River (Reach 3) sites, 2008–2012 (years 1–5) (part 1)

Site code	BWMA					BWBP					BWCW					BWCP					BWPT					BWCR					BWER					BWFW				
Species name / **Year**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Black-headed grosbeak							1					1							1			1		1					1		1	1								
Black-necked stilt																																								
Black-tailed gnatcatcher	1			1			1	1	1	1	1	1	1	1	1				1		1	1		1	1		1	1	1					1			1		1	1
Black-throated gray warbler																																								
Black-throated sparrow																								1					1											
Blue grosbeak	1	1		1	1		1	1	1	1	1	1	1	1	1		1	1	1		1	1		1	1		1	1	1	1	1	1		1	1	1	1	1	1	1
Blue winged teal																																								
Blue-gray gnatcatcher	1	1																				1														1				
Bronzed cowbird							1										1																							
Brown-crested flycatcher	1		1	1	1		1	1	1	1	1	1	1	1	1		1	1	1		1	1		1	1		1	1	1	1	1	1		1	1	1	1	1	1	1
Brown-headed cowbird	1	1	1	1	1		1	1	1	1	1	1	1	1	1		1	1	1		1	1		1	1		1	1	1	1		1		1	1	1	1	1	1	1
Bullock's oriole								1	1		1	1	1	1	1		1	1	1		1	1		1	1				1			1		1					1	1
Bunting species																																								
Burrowing owl																																								
Bushtit	1											1																												
California gull																																								
Canada goose																						1										1								
Canvasback																																								
Canyon wren	1	1	1	1	1		1	1	1	1	1	1		1					1		1	1		1	1		1	1	1	1	1	1		1	1		1	1	1	1
Cassin's kingbird																																								
Cattle egret																																								
Chipping sparrow																																								
Cinnamon teal																																								

Table C-3.—Birds at Bill Williams River (Reach 3) sites, 2008–2012 (years 1–5) (part 1)

Site code	BWMA					BWBP					BWCW					BWCP					BWPT					BWCR					BWER					BWFW				
Species name Year	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Clapper rail		1																																						
Clarks grebe		1	1		1																																			
Cliff swallow														1	1				1		1			1	1						1			1	1	1	1			1
Common blackhawk																								1											1					
Common ground dove											1	1										1																		
Common moorhen		1	1		1									1	1							1			1										1					
Common nighthawk																						1			1										1					
Common raven				1					1		1				1				1		1	1		1	1				1			1		1			1		1	
Common tern																																								
Common yellowthroat	1	1	1	1	1		1	1	1	1	1	1	1	1	1		1	1	1		1	1		1	1		1	1	1	1		1		1	1	1	1	1	1	1
Coopers hawk												1		1	1										1		1					1							1	
Cordilleran flycatcher																																								
Costa's hummingbird																																								
Crissal thrasher	1			1	1				1	1	1			1					1		1	1		1	1		1			1		1		1	1	1	1		1	1
Double-crested cormorant		1			1																																			
Eurasian collared dove																																								
European starling																																								
Ferruginous hawk																																								
Flicker species	1														1										1										1					
Gadwall																																								
Gambel's quail	1				1		1	1	1	1	1	1	1	1	1		1	1	1		1	1		1	1		1	1	1		1	1		1	1	1	1	1	1	1
Gila woodpecker	1	1	1	1	1		1	1	1	1	1	1	1	1	1		1	1	1		1	1		1	1		1		1	1	1	1		1	1	1	1	1	1	1
Gilded flicker													1	1					1					1										1						

Table C-3.—Birds at Bill Williams River (Reach 3) sites, 2008–2012 (years 1–5) (part 1)

Site code		BWMA					BWBP					BWCW					BWCP					BWPT					BWCR					BWER					BWFW				
Species name	**Year**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Gray catbird																																									
Great blue heron		1	1	1	1	1			1													1	1		1	1			1			1	1		1		1	1		1	
Great egret			1			1							1																								1				
Great horned owl					1	1									1	1																			1	1					
Greater pewee																																									
Greater roadrunner			1		1	1		1		1	1		1		1	1		1	1	1			1		1	1		1		1	1		1		1	1		1	1	1	1
Greater yellowlegs																									1																
Great-tailed grackle		1	1	1		1				1				1	1	1															1		1				1	1			1
Green heron		1	1		1	1						1			1								1		1	1			1				1		1	1	1	1	1	1	1
Green-winged teal																																									
Hairy woodpecker																																									
Hooded oriole			1						1														1										1								
Horned lark																																									
House finch		1				1		1	1		1	1	1		1	1		1		1		1			1										1		1				
House sparrow																																									
House wren																																						1			
Inca dove																																									
Indigo bunting			1										1					1													1		1			1		1			
Killdeer		1											1	1											1																
Ladder-backed woodpecker		1	1	1	1	1		1	1	1	1	1	1	1	1	1			1	1		1	1		1	1		1	1	1	1		1		1	1	1	1	1	1	1
Lark sparrow																																									
Lazuli bunting																									1	1															
Least bittern			1	1	1	1										1										1							1								

Table C-3.—Birds at Bill Williams River (Reach 3) sites, 2008–2012 (years 1–5) (part 1)

Site code		BWMA					BWBP					BWCW					BWCP					BWPT					BWCR					BWER					BWFW				
Species name	**Year**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Lesser goldfinch					1			1		1	1		1		1					1		1	1		1	1		1		1							1	1	1	1	1
Lesser nighthawk			1		1			1	1	1	1	1	1	1	1	1		1	1	1		1	1		1	1		1	1	1	1				1	1	1	1	1	1	1
Lesser yellowlegs																																									
Loggerhead shrike					1			1		1			1		1			1		1			1	1	1	1		1					1		1			1	1	1	1
Long-billed curlew																																									
Long-billed dowitcher																																									
Lucy's warbler		1			1	1		1	1	1	1	1	1	1	1					1			1		1	1		1			1				1					1	1
Macgilvray's warbler																							1															1			
Mallard			1		1																															1					
Marsh wren					1																		1										1								
Mourning dove		1	1	1	1	1		1	1	1	1	1	1	1	1	1		1	1	1		1	1		1	1		1	1	1	1	1	1		1	1	1	1	1	1	1
Northern flicker				1									1					1					1																		
Northern harrier																																									
Northern mockingbird												1										1																	1	1	
Northern pintail																																									
Northern rough-winged swallow			1		1	1		1		1	1			1	1			1	1	1			1		1			1		1		1	1			1		1	1	1	1
Orange-crowned warbler																																						1			
Osprey						1																																			
Pacific-slope flycatcher		1										1										1														1	1				
Peacock																																									
Peregrine falcon																																				1					
Phainopepla									1													1										1									

Table C-3.—Birds at Bill Williams River (Reach 3) sites, 2008–2012 (years 1–5) (part 1)

Site code	BWMA					BWBP					BWCW					BWCP					BWPT					BWCR					BWER					BWFW				
Species name / **Year**	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Pied-billed grebe	1	1		1	1						1																													
Purple martin																																								
Red-shouldered hawk																																								
Red-tailed hawk		1									1	1										1		1	1		1					1			1		1			
Red-winged blackbird	1	1	1	1	1						1	1							1		1	1			1						1	1		1						1
Ring-necked duck																																								
Ring-necked pheasant																																								
Rock pigeon																																								
Rock wren	1																					1		1																
Rooster																																								
Rose-breasted grosbeak																																								
Ruddy duck																																								
Rufous-winged sparrow																																								
Sage sparrow								1																														1		
Say's phoebe	1						1										1		1					1								1								
Semipalmated plover																																								
Sharp-shinned hawk																																								
Snowy egret	1	1																																						
Song sparrow	1	1	1	1	1		1	1	1	1	1	1	1	1	1			1	1		1	1		1	1		1	1	1	1	1	1		1	1	1	1	1	1	1
Spotted sandpiper					1																			1																
Spotted towhee																																								
Sulphur-bellied flycatcher																																								
Summer tanager	1	1		1	1		1	1	1	1	1	1	1	1	1				1		1			1	1		1	1	1	1	1	1		1	1	1	1	1	1	1

Table C-3.—Birds at Bill Williams River (Reach 3) sites, 2008–2012 (years 1–5) (part 1)

Site code		BWMA					BWBP					BWCW					BWCP					BWPT					BWCR					BWER					BWFW				
Species name	**Year**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Swainson's hawk																																									
Tree swallow			1										1					1					1					1					1				1	1			
Turkey vulture		1			1				1			1	1			1		1		1		1	1		1	1						1	1		1	1		1	1		
Unknown flycatcher																																						1			
Unknown gull			1			1																																			
Unknown heron																																									
Unknown hummingbird			1								1																											1			
Unknown sparrow			1																				1										1								
Unknown swallow																1		1					1																		
Verdin		1	1	1	1			1		1	1	1	1	1	1	1				1		1	1		1	1		1		1	1		1		1	1		1		1	1
Vermillion flycatcher																																									
Vesper sparrow																																									
Violet-green swallow		1																				1			1	1									1						
Virginia rail			1										1												1							1	1								
Western flycatcher			1																				1										1					1			
Western grebe			1	1	1	1																																			
Western kingbird			1		1	1		1	1						1	1				1			1		1								1			1		1	1	1	1
Western meadowlark																																									
Western screech owl																							1																		
Western tanager					1					1	1		1			1		1					1		1			1		1			1	1						1	
Western wood-pewee											1																					1			1		1				
White-faced ibis		1	1		1			1	1		1		1									1										1									
White-tailed kite																																									

Table C-3.—Birds at Bill Williams River (Reach 3) sites, 2008–2012 (years 1–5) (part 1)

Site code	BWMA					BWBP					BWCW					BWCP					BWPT					BWCR					BWER					BWFW				
Species name / **Year**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
White-throated swift		1																			1	1		1	1					1	1			1						
White-winged dove	1	1	1	1	1		1	1	1	1	1	1	1	1	1		1	1	1		1	1		1	1		1	1	1	1	1	1		1	1	1	1	1	1	1
Wild turkey																																								
Willow flycatcher		1		1																		1		1																
Wilson's warbler			1																																					
Wood duck																																				1				
Yellow warbler	1	1	1	1	1		1	1	1	1	1	1	1	1	1			1	1		1	1		1	1		1	1	1	1	1	1		1	1	1	1		1	1
Yellow-billed cuckoo	1	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1		1	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1
Yellow-breasted chat	1	1	1	1	1		1	1	1	1	1	1	1	1	1		1	1	1		1	1		1	1		1	1	1	1	1	1		1	1	1	1	1	1	1
Yellow-headed blackbird		1			1																																			

Table C-4.—Birds at Bill Williams River (Reach 3) sites, 2008–2012 (years 1–5) (part 2)

Site code	BWGR					BWHB					BWKR					BWMD					BWMW					BWMF					BWNB					BWSW				
Species name **Year**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Abert's towhee	1	1	1	1	1	1	1	1	1			1	1	1	1		1		1	1	1	1	1	1	1	1	1	1	1	1		1		1	1	1	1	1	1	1
American avocet																																								
American coot							1												1																					
American crow																																								
American gadwall																																								
American goldfinch																																								
American kestrel						1			1						1																			1						
American redstart																																								
American robin																																								
American white pelican																																								
Anna's hummingbird				1	1									1											1							1			1					
Ash-throated flycatcher	1	1	1	1	1	1	1	1	1	1		1		1	1		1		1		1	1	1	1	1	1	1	1	1	1		1			1		1		1	1
Bank swallow																																								
Barn owl							1																	1																
Barn swallow																																								
Bell's vireo	1	1	1	1	1	1	1	1	1	1		1	1	1	1		1		1	1	1	1	1	1	1	1	1	1	1	1		1		1	1	1	1	1	1	1
Belted kingfisher																						1																		
Bewick's wren	1	1	1	1	1	1			1	1		1		1	1		1		1	1	1	1		1	1		1	1	1	1		1		1	1	1	1		1	1
Black phoebe	1	1		1		1	1	1	1	1		1	1	1	1						1	1	1	1	1															1
Black rail	1					1	1			1																1		1												
Black-bellied plover																																								
Black-chinned hummingbird	1					1	1		1								1									1			1			1		1	1	1				
Black-crowned night-heron																	1															1								

Table C-4.—Birds at Bill Williams River (Reach 3) sites, 2008–2012 (years 1–5) (part 2)

Site code		BWGR					BWHB					BWKR					BWMD					BWMW					BWMF					BWNB					BWSW				
Species name	**Year**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Black-headed grosbeak			1		1			1		1					1			1					1			1							1	1			1	1			1
Black-necked stilt																																									
Black-tailed gnatcatcher		1	1	1	1	1	1	1	1	1	1		1		1	1				1			1		1	1		1	1	1	1		1		1			1	1	1	
Black-throated gray warbler																																									
Black-throated sparrow			1		1			1	1	1													1		1			1													
Blue grosbeak		1	1	1	1	1	1	1	1	1	1		1	1	1	1		1		1		1	1	1	1	1	1	1	1	1	1		1		1		1	1	1	1	1
Blue winged teal																																									
Blue-gray gnatcatcher																						1					1														
Bronzed cowbird																																									
Brown-crested flycatcher		1	1	1	1	1	1	1	1	1	1		1	1	1					1	1	1	1	1	1	1	1	1	1	1	1		1		1	1	1	1	1	1	1
Brown-headed cowbird		1	1	1	1	1	1	1	1	1	1		1	1	1	1		1		1	1	1	1	1	1	1	1	1	1	1	1		1		1	1	1	1	1	1	1
Bullock's oriole		1	1	1	1		1	1	1	1	1				1	1						1	1	1	1		1						1				1				1
Bunting species																						1																			
Burrowing owl																																									
Bushtit									1																																
California gull																																									
Canada goose																																									
Canvasback																																									
Canyon wren		1	1	1	1	1	1	1	1	1	1		1		1	1		1		1	1	1	1		1	1	1	1	1	1	1		1		1	1	1	1	1	1	1
Cassin's kingbird																																									
Cattle egret																																									
Chipping sparrow														1																											
Cinnamon teal																																									

Table C-4.—Birds at Bill Williams River (Reach 3) sites, 2008–2012 (years 1–5) (part 2)

Site code	BWGR					BWHB					BWKR					BWMD					BWMW					BWMF					BWNB					BWSW				
Species name Year	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Clapper rail												1			1																									1
Clarks grebe																	1		1																					
Cliff swallow	1	1		1	1	1			1					1	1				1						1											1				1
Common blackhawk			1											1																										
Common ground dove		1													1																	1				1				
Common moorhen									1	1															1															
Common nighthawk																																								
Common raven	1	1	1	1	1	1						1					1				1	1		1	1		1	1				1		1		1	1	1	1	
Common tern																																1								
Common yellowthroat	1	1	1	1	1	1	1	1	1	1		1	1	1	1		1		1	1	1	1	1	1	1	1	1	1	1	1		1		1	1	1	1	1	1	1
Coopers hawk			1		1				1			1	1												1									1		1	1		1	1
Cordilleran flycatcher																																				1				
Costa's hummingbird																																								
Crissal thrasher		1	1	1	1				1	1				1	1						1	1					1		1	1		1		1	1	1	1			
Double-crested cormorant																																								
Eurasian collared dove																								1																1
European starling																																								
Ferruginous hawk									1																															
Flicker species																																								
Gadwall																																								
Gambel's quail	1	1	1	1	1	1	1	1	1	1		1	1	1	1						1	1		1	1	1	1	1	1	1		1		1		1	1	1	1	1
Gila woodpecker	1	1	1	1	1	1	1	1	1	1		1	1	1	1		1		1	1	1	1		1	1	1	1	1	1	1		1		1	1	1	1	1	1	1
Gilded flicker							1		1															1																

Table C-4.—Birds at Bill Williams River (Reach 3) sites, 2008–2012 (years 1–5) (part 2)

Site code		BWGR					BWHB					BWKR					BWMD					BWMW					BWMF					BWNB					BWSW				
Species name	**Year**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Gray catbird																																									
Great blue heron		1		1		1			1	1	1		1		1			1							1	1			1				1								
Great egret				1																																					
Great horned owl						1	1	1	1	1	1										1		1		1	1					1					1		1			1
Greater pewee																																									
Greater roadrunner			1	1	1	1		1		1			1		1	1				1	1	1	1	1	1		1	1	1	1	1		1		1	1	1	1	1	1	1
Greater yellowlegs																																									
Great-tailed grackle		1	1				1		1	1	1			1	1					1			1		1	1	1								1		1				
Green heron		1	1	1	1		1	1		1	1				1	1				1			1		1	1							1								1
Green-winged teal																																									
Hairy woodpecker									1														1																1		
Hooded oriole						1																	1			1															
Horned lark																																									
House finch		1	1		1	1	1	1		1	1		1		1							1	1	1		1	1	1									1	1			1
House sparrow				1																																					
House wren																																									
Inca dove																																									
Indigo bunting			1													1																	1								
Killdeer				1										1	1							1																			
Ladder-backed woodpecker		1	1		1	1	1	1	1	1	1		1	1	1			1		1	1	1	1	1	1	1	1	1	1	1	1		1		1	1	1	1	1	1	1
Lark sparrow																							1																		1
Lazuli bunting															1																		1								
Least bittern									1		1																						1								

Table C-4.—Birds at Bill Williams River (Reach 3) sites, 2008–2012 (years 1–5) (part 2)

Site code	BWGR					BWHB					BWKR					BWMD					BWMW					BWMF					BWNB					BWSW				
Species name Year	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Lesser goldfinch	1	1	1	1	1	1	1	1	1			1		1								1	1	1		1	1		1	1		1			1	1	1			
Lesser nighthawk	1	1	1	1	1	1	1	1		1		1	1	1	1				1		1	1			1	1	1		1	1		1		1	1	1	1	1	1	
Lesser yellowlegs																																								
Loggerhead shrike		1		1	1		1		1			1		1	1				1			1		1			1	1	1			1		1			1			
Long-billed curlew																																								
Long-billed dowitcher																																								
Lucy's warbler		1		1		1	1	1	1	1		1		1					1	1	1			1	1	1	1	1	1	1		1		1		1	1			1
Macgilvray's warbler																																								
Mallard					1										1																									
Marsh wren							1																									1								
Mourning dove	1	1	1	1	1	1	1	1	1	1		1	1	1	1		1		1	1	1	1	1	1	1	1	1	1	1	1		1		1	1	1	1	1	1	1
Northern flicker						1															1	1																		
Northern harrier																																								
Northern mockingbird	1											1									1		1	1								1								
Northern pintail																																								
Northern rough-winged swallow		1	1	1		1	1	1	1			1	1	1			1		1		1	1				1	1		1			1		1	1	1		1	1	
Orange-crowned warbler																																								
Osprey																																								
Pacific-slope flycatcher	1																				1				1															1
Peacock																																								
Peregrine falcon																													1			1								
Phainopepla									1												1			1		1						1								

Table C-4.—Birds at Bill Williams River (Reach 3) sites, 2008–2012 (years 1–5) (part 2)

Site code		**BWGR**					**BWHB**					**BWKR**					**BWMD**					**BWMW**					**BWMF**					**BWNB**					**BWSW**				
Species name	**Year**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Pied-billed grebe			1										1																						1						
Purple martin																																									
Red-shouldered hawk																																						1			
Red-tailed hawk		1	1	1	1	1	1	1	1	1	1				1							1	1	1	1	1				1								1	1	1	
Red-winged blackbird			1				1	1	1	1			1		1			1		1			1	1	1								1			1					1
Ring-necked duck																																									
Ring-necked pheasant																																									
Rock pigeon																																									
Rock wren																											1														
Rooster																																									
Rose-breasted grosbeak																																									
Ruddy duck																																	1								
Rufous-winged sparrow																																									
Sage sparrow																																									
Say's phoebe			1	1	1				1	1			1	1	1	1							1				1														1
Semipalmated plover																																									
Sharp-shinned hawk											1																						1								
Snowy egret																		1					1																		
Song sparrow		1	1	1	1	1	1	1	1	1	1		1	1	1	1		1		1	1	1	1	1	1	1	1	1	1	1	1		1		1	1	1	1	1	1	1
Spotted sandpiper																																									
Spotted towhee																																									
Sulphur-bellied flycatcher																																									
Summer tanager			1	1		1	1	1	1	1	1		1	1	1	1		1		1		1	1	1	1	1	1	1	1	1	1		1		1	1	1	1	1	1	1

Table C-4.—Birds at Bill Williams River (Reach 3) sites, 2008–2012 (years 1–5) (part 2)

Site code	BWGR					BWHB					BWKR					BWMD					BWMW					BWMF					BWNB					BWSW				
Species name / **Year**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Swainson's hawk														1																										
Tree swallow		1															1															1								
Turkey vulture	1	1		1	1	1		1	1	1		1		1	1		1				1	1		1	1	1		1	1			1				1	1	1	1	
Unknown empdid																																								1
Unknown flycatcher										1															1															
Unknown hummingbird		1					1					1					1								1		1					1					1			1
Unknown sparrow																	1																							
Unknown swallow					1		1			1		1			1										1							1								1
Unknown warbler															1																									
Verdin		1			1	1	1	1	1			1		1			1				1	1				1	1	1	1	1		1			1	1	1		1	
Vermillion flycatcher														1																										
Vesper sparrow																																								
Violet-green swallow	1			1		1			1					1	1						1					1						1								
Virginia rail									1			1										1																		
Western flycatcher							1										1															1								
Western grebe																																								
Western kingbird		1		1		1	1		1	1		1		1	1							1			1							1			1					1
Western meadowlark																																								
Western screech owl		1							1	1							1							1			1									1				
Western tanager		1							1	1		1		1			1		1			1																	1	
Western wood-pewee		1					1							1	1											1						1								1
White-faced ibis	1	1			1		1			1												1			1											1				
White-tailed kite																																								

Table C-4.—Birds at Bill Williams River (Reach 3) sites, 2008–2012 (years 1–5) (part 2)

Site code		BWGR					BWHB					BWKR					BWMD					BWMW					BWMF					BWNB					BWSW				
Species name	**Year**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
White-throated swift		1	1		1	1	1	1							1								1													1					1
White-winged dove		1	1	1	1	1	1	1	1	1	1		1	1	1	1		1		1	1	1	1	1	1	1	1	1	1	1	1		1		1	1	1	1	1	1	1
Wild turkey																																									
Willow flycatcher																						1								1			1						1		
Wilson's warbler								1																		1		1					1								
Wood duck																																									
Yellow warbler		1	1		1	1	1	1	1	1	1		1	1	1	1		1		1	1	1	1	1	1	1	1	1	1	1	1		1		1	1	1	1	1	1	1
Yellow-billed cuckoo		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1	1	1		1	1	1	1	1	1	1	1	1	1		1		1	1	1	1	1	1	1
Yellow-breasted chat		1	1	1	1	1	1	1	1	1	1		1	1	1	1		1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Yellow-headed blackbird				1					1											1													1								
Zone-tailed hawk																																									

Table C-5.—Birds at Parker to Cibola (Reach 4) sites, 2008–2012 (years 1–5)

Site code	CRIT					CIBCR					CIBEUC					CIBIPM					CIBSTH					CIBMP					CIBCNT					CIBNTH				
Species name / **Year**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Abert's towhee	1	1		1	1				1	1	1	1	1	1	1				1		1	1	1	1					1	1	1	1	1	1	1	1	1	1	1	1
American avocet																																								
American coot				1																			1						1											
American crow																																								
American gadwall																																								
American goldfinch																																								
American kestrel				1	1				1			1	1	1	1				1			1							1		1	1	1	1			1	1	1	
American redstart																																		1						
American robin																																		1						
American white pelican																																								
Anna's hummingbird	1	1		1	1							1	1																1			1	1			1	1			
Ash-throated flycatcher	1	1		1	1				1		1	1	1	1	1				1		1	1	1	1					1	1	1	1	1	1	1		1	1	1	1
Bank swallow																																								
Barn owl	1	1		1					1					1																		1						1		
Barn swallow									1																															
Bell's vireo		1																				1	1											1	1					
Belted kingfisher																																								
Bewick's wren																																								
Black phoebe		1			1				1	1			1						1			1	1	1					1	1		1	1	1						
Black rail																																								
Black-bellied plover																																								
Black-chinned hummingbird	1	1		1	1										1				1										1		1	1	1	1			1		1	
Black-crowned night-heron		1																															1							

Table C-5.—Birds at Parker to Cibola (Reach 4) sites, 2008–2012 (years 1–5)

Site code	CRIT					CIBCR					CIBEUC					CIBIPM					CIBSTH					CIBMP					CIBCNT					CIBNTH				
Species name / **Year**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Black-headed grosbeak	1	1		1																									1	1			1							
Black-necked stilt																			1																					
Black-tailed gnatcatcher		1		1	1				1		1	1	1	1					1		1	1	1	1					1					1			1			
Black-throated gray warbler																																								
Black-throated sparrow																																					1			
Blue grosbeak	1	1		1	1				1	1			1	1	1				1		1	1	1	1					1	1	1	1	1	1	1	1	1	1	1	1
Blue winged teal																																								
Blue-gray gnatcatcher													1																				1							
Bronzed cowbird	1																																							
Brown-crested flycatcher	1	1		1					1	1											1												1						1	
Brown-headed cowbird	1	1		1	1				1	1	1	1	1	1	1				1		1	1	1	1					1	1	1	1	1	1	1	1	1	1		1
Bullock's oriole	1	1		1	1				1		1	1	1	1	1				1		1	1	1	1					1		1		1	1		1	1	1	1	1
Bunting species																																								
Burrowing owl																																		1						
Bushtit																																								
California gull																																								
Canada goose																																	1			1			1	
Canvasback																																								
Canyon wren																																								
Cassin's kingbird																																				1				
Cattle egret					1				1														1											1						
Chipping sparrow																																								
Cinnamon teal																																								

Table C-5.—Birds at Parker to Cibola (Reach 4) sites, 2008–2012 (years 1–5)

Site code	CRIT					CIBCR					CIBEUC					CIBIPM					CIBSTH					CIBMP					CIBCNT					CIBNTH				
Species name / **Year**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Clapper rail																																								
Clarks grebe																																								
Cliff swallow				1	1				1	1			1						1			1	1	1					1	1		1	1							
Common blackhawk																																			1					1
Common ground dove									1			1	1	1									1						1		1	1	1	1						1
Common moorhen																																								
Common nighthawk																																								1
Common raven	1	1							1			1	1	1					1		1			1								1	1	1						
Common tern																																								
Common yellowthroat	1	1		1	1				1	1			1		1				1		1	1	1	1					1	1	1	1	1	1	1	1	1	1		1
Coopers hawk													1									1															1			
Cordilleran flycatcher																																								
Costa's hummingbird																																								
Crissal thrasher				1	1				1					1					1			1	1	1								1							1	1
Double-crested cormorant				1																		1																		
Eurasian collared dove		1			1				1	1	1	1	1	1	1							1	1									1		1	1	1	1		1	1
European starling									1				1						1					1					1					1					1	
Ferruginous hawk													1																											
Flicker species																																								
Gadwall																																								
Gambel's quail	1	1		1	1				1	1	1	1	1	1	1				1		1	1	1	1					1	1	1	1	1	1	1	1	1	1	1	1
Gila woodpecker		1																	1		1	1	1	1					1					1						1
Gilded flicker																																								

Table C-5.—Birds at Parker to Cibola (Reach 4) sites, 2008–2012 (years 1–5)

Site code		CRIT					CIBCR					CIBEUC					CIBIPM					CIBSTH					CIBMP					CIBCNT					CIBNTH				
Species name	**Year**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Gray catbird																																									
Great blue heron			1							1	1		1			1				1			1		1								1	1	1						
Great egret		1								1	1		1							1		1								1	1			1							
Great horned owl		1	1		1	1				1		1	1	1	1	1				1		1									1		1		1	1		1	1	1	1
Greater pewee																																									
Greater roadrunner			1		1	1				1			1	1	1					1			1	1	1					1			1		1					1	1
Greater yellowlegs										1					1					1										1											
Great-tailed grackle		1	1		1	1				1	1	1	1	1	1	1				1		1	1	1	1					1		1	1	1	1		1	1	1	1	
Green heron										1										1														1							
Green-winged teal																																									
Hairy woodpecker																																									
Hooded oriole			1																	1																					
Horned lark		1			1																																				
House finch		1	1		1	1				1		1	1	1	1					1		1	1	1						1	1	1	1	1	1	1	1	1		1	
House sparrow		1																																							
House wren																																	1								
Inca dove																																									
Indigo bunting			1																	1			1	1	1						1										
Killdeer			1			1				1	1				1	1				1			1	1	1					1	1	1	1	1	1	1	1	1	1	1	
Ladder-backed woodpecker		1	1		1	1					1	1	1	1	1	1				1		1	1	1	1					1	1		1	1	1	1					
Lark sparrow																																									
Lazuli bunting																						1		1																	
Least bittern										1																															

Table C-5.—Birds at Parker to Cibola (Reach 4) sites, 2008–2012 (years 1–5)

Site code		CRIT					CIBCR					CIBEUC					CIBIPM					CIBSTH					CIBMP					CIBCNT					CIBNTH				
Species name	**Year**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Lesser goldfinch		1	1		1	1				1														1									1	1					1		
Lesser nighthawk			1		1	1				1		1	1	1	1	1				1		1	1	1	1					1	1	1	1	1	1		1	1		1	
Lesser yellowlegs																																									
Loggerhead shrike			1		1	1				1	1	1	1	1	1	1				1		1	1	1	1					1	1		1	1	1			1	1	1	1
Long-billed curlew										1				1						1				1						1					1						
Long-billed dowitcher										1										1																					
Lucy's warbler		1	1		1	1				1		1		1	1	1				1		1		1	1									1	1		1			1	
Macgilvray's warbler			1																														1								
Mallard										1										1		1	1	1																	
Marsh wren																																									
Mourning dove		1	1		1	1				1	1	1	1	1	1	1				1		1	1	1	1					1	1	1	1	1	1	1	1	1	1	1	1
Northern flicker																				1				1											1						
Northern harrier										1										1																					
Northern mockingbird		1	1							1		1	1	1	1					1		1	1	1	1					1	1	1	1	1	1			1		1	1
Northern pintail																																									
Northern rough-winged swallow		1	1			1				1	1	1	1	1	1					1		1	1	1	1					1		1			1		1				
Orange-crowned warbler																																									
Osprey										1	1																														
Pacific-slope flycatcher																									1					1					1						
Peacock																																									
Peregrine falcon																				1										1					1						
Phainopepla						1																1			1																

Table C-5.—Birds at Parker to Cibola (Reach 4) sites, 2008–2012 (years 1–5)

Site code		CRIT					CIBCR					CIBEUC					CIBIPM					CIBSTH					CIBMP					CIBCNT					CIBNTH				
Species name	**Year**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Pied-billed grebe					1																									1											
Purple martin																																									
Red-shouldered hawk																																									
Red-tailed hawk					1	1						1		1		1						1								1	1			1	1	1					
Red-winged blackbird		1	1		1	1				1	1	1	1	1	1	1				1		1	1	1	1					1	1	1	1	1	1	1	1	1	1	1	
Ring necked duck																																									
Ring-necked pheasant																																									
Rock pigeon																																									
Rock wren																																									
Rooster																																									
Rose-breasted grosbeak													1																												
Ruddy duck																																									
Rufous-winged sparrow																																									
Sage sparrow																																									
Say's phoebe			1		1	1														1			1							1	1			1	1				1		
Semipalmated plover																																									
Sharp-shinned hawk																																									
Snowy egret										1												1																			
Song sparrow			1		1					1	1									1		1	1	1	1					1	1	1	1	1	1	1					
Spotted sandpiper																																									
Spotted towhee																																									
Sulphur-bellied flycatcher																																							1		
Summer tanager		1	1		1	1																									1										

Table C-5.—Birds at Parker to Cibola (Reach 4) sites, 2008–2012 (years 1–5)

Site code	CRIT					CIBCR					CIBEUC					CIBIPM					CIBSTH					CIBMP					CIBCNT					CIBNTH				
Species name / **Year**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Swainson's hawk				1																																				
Tree swallow									1				1																1											
Turkey vulture		1		1	1				1		1	1	1	1	1							1	1	1								1	1		1			1		
Unknown empdid																								1																
Unknown flycatcher																			1												1									
Unknown gull														1																										
Unknown hummingbird		1							1					1					1					1					1					1						
Verdin	1	1		1	1				1		1	1	1	1					1		1	1	1	1								1	1	1	1			1	1	1
Vermillion flycatcher	1	1		1	1						1								1				1																	
Vesper sparrow																																								
Violet-green swallow				1																																				
Virginia rail																																								
Western flycatcher		1		1																	1																			
Western grebe																																								
Western kingbird	1	1		1	1				1	1	1	1	1	1	1				1		1	1	1	1					1	1	1	1	1	1	1	1	1	1	1	1
Western meadowlark	1			1	1				1	1			1																1		1			1						
Western screech owl																																								
Western tanager		1			1				1	1			1										1	1								1					1		1	
Western wood-pewee		1																														1					1			1
White-faced ibis	1	1			1				1		1		1	1	1				1		1	1	1	1					1		1	1	1	1				1		
White-tailed kite																													1											
White-throated swift				1																																				
White-winged dove	1	1		1	1				1	1	1	1	1	1	1				1		1	1	1	1					1	1	1	1	1	1	1	1	1	1	1	1

Table C-5.—Birds at Parker to Cibola (Reach 4) sites, 2008–2012 (years 1–5)

Site code	CRIT					CIBCR					CIBEUC					CIBIPM					CIBSTH					CIBMP					CIBCNT					CIBNTH				
Species name / **Year**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Wild turkey																																				1	1			
Willow flycatcher																					1																		1	
Wilson's warbler		1																														1								
Wood duck																																								
Yellow warbler		1		1	1					1				1							1	1	1									1	1	1						
Yellow-billed cuckoo	1	1		1	1		1	1	1	1		1	1	1	1		1	1	1		1	1	1	1				1	1	1	1	1	1	1	1	1	1	1		
Yellow-breasted chat	1	1		1	1				1	1		1	1	1	1				1		1	1	1	1					1	1	1	1	1	1	1					1
Yellow-headed blackbird		1		1	1				1	1		1	1	1					1		1		1	1					1	1	1	1	1	1			1	1	1	
Zone-tailed hawk					1																		1																	

Table C-6.—Birds at Imperial to Laguna (Reach 5) sites, 2008–2012 (years 1–5)

		IMP20A					IMP50					IMPSTH					IMPAST					PICSRA					LAG1					LAG2					LAG3					LAGA-W				
Species name	**Year**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Abert's towhee			1		1						1	1	1	1	1	1		1				1	1	1	1	1		1					1	1		1		1	1		1				1	
American avocet															1																															
American coot													1	1	1	1		1				1																							1	
American crow																																														
American gadwall																																														
American goldfinch																																														
American kestrel		1														1																														
American redstart																1																														
American robin																																														
American white pelican																																														
Anna's hummingbird															1			1						1	1											1			1							
Ash-throated flycatcher		1	1			1					1	1	1	1	1	1		1		1		1	1	1	1	1		1					1	1		1		1	1		1				1	
Bank swallow																																														
Barn swallow														1																																
Black-bellied plover														1																																
Brown-crested flycatcher													1			1							1			1															1					
Black-chinned hummingbird											1		1		1								1	1												1					1					
Black-crowned night-heron														1																																
Belted kingfisher																						1																								
Bell's vireo											1			1	1							1	1	1		1										1										
Bewick's wren																																														
Blue-gray gnatcatcher														1										1																						
Brown-headed cowbird		1	1	1	1						1	1	1	1	1	1		1				1	1	1	1			1					1	1		1		1	1		1				1	

Table C-6.—Birds at Imperial to Laguna (Reach 5) sites, 2008–2012 (years 1–5)

		IMP20A					IMP50					IMPSTH					IMPAST					PICSRA					LAG1					LAG2					LAG3					LAGA-W				
Species name	**Year**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Black-headed grosbeak															1											1																				
Blue grosbeak		1										1	1	1	1			1				1	1	1	1			1								1		1	1		1				1	
Black phoebe						1							1	1	1	1						1																			1					
Black rail																1							1																						1	
Barn owl													1					1																												
Black-necked stilt		1										1		1	1										1	1																				
Bronzed cowbird																																														
Black-tailed gnatcatcher			1		1	1					1		1	1	1	1		1				1		1		1		1					1	1		1			1		1				1	
Black-throated sparrow																																														
Black-throated gray warbler																																														
Bunting species																																														
Bullock's oriole		1	1			1					1	1	1	1	1	1		1				1	1	1	1	1		1					1					1							1	
Burrowing owl																																														
Bushtit																						1																								
Blue winged teal													1																																	
Cattle egret														1																																
California gull																1																														
Cassin's kingbird																																														
Canada goose																																														
Canvasback																																														
Canyon wren																																														
Common ground dove					1								1	1		1																				1										
Chipping sparrow																																														

Table C-6.—Birds at Imperial to Laguna (Reach 5) sites, 2008–2012 (years 1–5)

		IMP20A					IMP50					IMPSTH					IMPAST					PICSRA					LAG1					LAG2					LAG3					LAGA-W				
Species name	**Year**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Cinnamon teal																									1																					
Clarks grebe											1																																			
Clapper rail												1		1	1																															
Cliff swallow													1	1		1		1				1		1												1					1					
Common blackhawk																																														
Cordilleran flycatcher																																														
Coopers hawk																																														
Costa's hummingbird																																														
Common moorhen														1																											1					
Common nighthawk																																														
Common raven																																														
Common tern																																														
Common yellowthroat		1	1	1	1	1					1	1	1	1	1	1		1		1		1	1	1	1	1		1					1	1		1		1	1		1				1	
Crissal thrasher					1																																				1					
Double-crested cormorant													1	1														1						1												
Eurasian collared dove												1	1	1									1	1															1							
European starling			1																																											
Ferruginous hawk																																														
Flicker species																																														
Gadwall																																														
Gambel's quail		1	1		1	1					1	1	1	1		1		1		1		1	1	1	1	1		1						1				1	1		1				1	
Great blue heron												1	1	1	1	1																		1					1		1				1	
Great horned owl													1					1						1															1							

Table C-6.—Birds at Imperial to Laguna (Reach 5) sites, 2008–2012 (years 1–5)

		IMP20A					IMP50					IMPSTH					IMPAST					PICSRA					LAG1					LAG2					LAG3					LAGA-W				
Species name	**Year**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Gilded flicker																																														
Gila woodpecker				1	1							1	1	1		1		1		1		1	1	1	1	1		1						1		1		1	1		1				1	
Gray catbird																																														
Great egret			1	1								1		1	1	1							1		1	1		1											1		1					
Green heron					1						1	1	1	1	1	1						1						1													1					
Greater pewee																																														
Greater roadrunner																								1															1							
Greater yellowlegs																																														
Great-tailed grackle		1	1	1	1	1					1	1	1	1	1	1		1		1		1	1	1	1	1		1						1					1		1				1	
Green-winged teal																																														
Hairy woodpecker																																														
House finch												1	1	1	1	1		1		1		1	1	1	1																				1	
Horned lark																																														
Hooded oriole																																														
House sparrow																																														
House wren																																														
Indigo bunting																		1					1															1								
Inca dove																																														
Killdeer		1				1						1		1	1										1																					
Lark sparrow														1										1																						
Lazuli bunting																																														
Long-billed curlew														1																																
Long-billed dowitcher																																														

Table C-6.—Birds at Imperial to Laguna (Reach 5) sites, 2008–2012 (years 1–5)

		IMP20A					IMP50					IMPSTH					IMPAST					PICSRA					LAG1					LAG2					LAG3					LAGA-W				
Species name	**Year**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Ladder-backed woodpecker											1	1	1	1	1	1		1				1	1	1	1	1		1					1	1		1		1	1		1				1	
Least bittern														1		1								1																	1					
Lesser goldfinch						1						1										1		1																						
Lesser nighthawk		1	1		1	1					1	1	1	1	1	1		1		1		1	1	1	1			1					1	1				1			1				1	
Lesser yellowlegs														1																																
Loggerhead shrike			1		1	1					1	1	1	1	1	1		1		1		1	1	1	1	1		1						1				1	1		1				1	
Lucy's warbler												1		1	1			1					1	1	1								1			1										
Mallard											1		1	1																									1							
Marsh wren					1							1		1	1	1																									1				1	
Macgilvray's warbler																																														
Mourning dove		1	1	1	1	1					1	1	1	1	1	1		1		1		1	1	1	1	1		1					1	1		1		1	1		1				1	
Northern flicker																							1																							
Northern harrier																																														
Northern mockingbird				1	1	1					1				1			1		1																			1						1	
Northern pintail																																														
Northern rough-winged swallow		1		1		1					1			1	1			1				1			1	1							1	1				1							1	
Orange-crowned warbler																																														
Osprey																																														
Pied-billed grebe		1			1								1	1	1	1		1		1					1									1											1	
Peacock																																														
Peregrine falcon																																														
Phainopepla			1			1					1				1							1																								

Table C-6.—Birds at Imperial to Laguna (Reach 5) sites, 2008–2012 (years 1–5)

Species name	Year	IMP20A					IMP50					IMPSTH					IMPAST					PICSRA					LAG1					LAG2					LAG3					LAGA-W				
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Pacific-slope flycatcher																																														
Purple martin																																														
Rose-breasted grosbeak																																														
Ring necked duck																																														
Ring-necked pheasant																																														
Rooster																										1																				
Rock pigeon																																							1							
Rock wren																																														
Red-shouldered hawk																																														
Red-tailed hawk						1										1						1		1															1							
Ruddy duck													1	1	1																															
Red-winged blackbird		1	1	1	1	1					1	1	1	1	1	1				1		1		1	1	1															1				1	
Rufous-winged sparrow																																														
Sage sparrow																																														
Say's phoebe														1	1																							1								
Sulphur-bellied flycatcher																																														
Semipalmated plover																																														
Snowy egret												1				1																							1		1					
Song sparrow											1	1	1	1	1	1						1	1	1	1			1					1					1	1		1				1	
Spotted sandpiper														1																																
Spotted towhee																																														
Sharp-shinned hawk																																														
Summer tanager				1								1	1	1	1							1																								

Table C-6.—Birds at Imperial to Laguna (Reach 5) sites, 2008–2012 (years 1–5)

		IMP20A					IMP50					IMPSTH					IMPAST					PICSRA					LAG1					LAG2					LAG3					LAGA-W				
Species name	**Year**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Swainson's hawk																																														
Tree swallow														1		1																														
Turkey vulture													1		1	1				1		1	1	1	1	1		1											1							
Unknown empdid																																				1									1	
Unknown flycatcher																								1																						
Unknown hummingbird															1													1													1				1	
Vermillion flycatcher												1																																		
Verdin			1		1	1					1		1		1	1		1				1	1	1	1	1		1					1	1		1		1	1		1				1	
Vesper sparrow																																														
Violet-green swallow																																														
Virginia rail																1																														
Western flycatcher																																														
Western grebe																1																														
Western kingbird		1	1	1	1	1					1	1	1	1	1	1		1				1	1	1	1	1		1						1		1									1	
Western meadowlark																																									1					
Western screech owl																																														
Western tanager											1	1	1		1									1		1																				
Western wood-pewee																							1															1								
White-faced ibis											1	1	1	1								1																								
Willow flycatcher		1														1						1														1										
Wild turkey																																														
Wilson's warbler																																														
Wood duck																																														

Table C-6.—Birds at Imperial to Laguna (Reach 5) sites, 2008–2012 (years 1–5)

		IMP20A					IMP50					IMPSTH					IMPAST					PICSRA					LAG1					LAG2					LAG3					LAGA-W				
Species name	**Year**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
White-tailed kite																																														
White-throated swift																						1		1		1																				
White-winged dove		1	1	1	1	1					1	1	1	1	1	1		1		1		1	1	1	1	1		1					1	1		1		1	1		1				1	
Yellow-breasted chat											1		1	1	1	1		1		1		1	1	1	1	1		1					1	1		1		1	1		1				1	
Yellow-billed cuckoo		1			1	1				1	1	1	1	1	1	1				1		1	1	1	1	1													1		1				1	
Yellow-headed blackbird			1		1						1			1	1	1							1																							
Yellow warbler												1		1									1	1										1												
Zone-tailed hawk																																														

Table C-7.—Birds at Yuma (Reaches 5–6) sites, 2008–2012 (years 1–5)

		MLPR					MLEA					YUCC					GRGC					GRNVA-B					GRQP					YUEW					YUWW					LIMNTH					LIMSTH				
Species name	**Year**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Abert's towhee		1	1	1	1	1				1		1	1				1			1			1			1	1	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1				1	1			
American avocet																																																			
American coot		1	1	1								1	1				1			1			1											1								1	1								
American crow																																																			
American gadwall																																																			
American goldfinch													1										1															1													
American kestrel				1																											1			1			1		1		1	1									
American redstart																																																			
American robin																																																			
American white pelican																																																			
Anna's hummingbird			1	1		1											1			1			1					1	1	1	1		1	1	1	1	1	1	1	1	1		1				1				
Ash-throated flycatcher		1	1	1	1	1				1			1				1			1			1			1		1	1	1	1			1		1	1	1	1		1	1	1				1				
Bank swallow																																																			
Barn swallow																																		1																	
Black-bellied plover																																																			
Brown-crested flycatcher																												1																							
Black-chinned hummingbird				1	1							1					1										1	1	1	1	1		1	1	1	1	1	1	1	1	1	1					1	1			
Black-crowned night-heron												1																					1	1																	
Belted kingfisher																												1																							
Bell's vireo				1																							1									1			1	1			1								
Bewick's wren																																																			
Blue-gray gnatcatcher																																																			

Table C-7.—Birds at Yuma (Reaches 5–6) sites, 2008–2012 (years 1–5)

		MLPR					MLEA					YUCC					GRGC					GRNVA-B					GRQP					YUEW					YUWW					LIMNTH					LIMSTH				
Species name	**Year**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Brown-headed cowbird		1	1	1	1	1						1	1				1			1			1			1	1	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1				1	1			
Black-headed grosbeak				1																						1		1	1		1								1		1										
Blue grosbeak		1	1	1	1	1				1		1	1				1						1			1	1	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1				1				
Black phoebe			1	1		1						1	1													1	1	1	1	1	1		1	1		1					1	1	1				1				
Black rail																																																			
Barn owl			1										1																	1								1													
Black-necked stilt												1	1																				1	1																	
Bronzed cowbird																																					1														
Black-tailed gnatcatcher		1		1	1	1				1		1					1									1	1				1		1	1		1	1	1	1		1	1	1				1				
Black-throated sparrow																																																			
Black-throated gray warbler																																				1		1													
Bullock's oriole		1	1	1		1				1		1					1						1			1	1	1	1	1	1					1		1	1		1	1	1					1			
Burrowing owl																																					1					1	1								
Bushtit																																																			
Blue winged teal																																																			
Cattle egret				1									1																1																		1	1			
California gull																																																			
Cassin's kingbird																																																			
Canada goose																																																			
Canvasback																																																			
Canyon wren																																																			
Common ground dove			1	1		1						1					1						1			1	1	1	1	1	1			1			1	1	1	1	1						1				

Table C-7.—Birds at Yuma (Reaches 5–6) sites, 2008–2012 (years 1–5)

		MLPR					MLEA					YUCC					GRGC					GRNVA-B					GRQP					YUEW					YUWW					LIMNTH					LIMSTH				
Species name	**Year**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Chipping sparrow																																																			
Cinnamon teal																																																			
Clarks grebe																																																			
Clapper rail																																			1	1															
Cliff swallow		1	1	1		1						1					1			1						1			1		1			1	1	1	1		1		1	1					1				
Common blackhawk																																																			
Cordilleran flycatcher																																																			
Coopers hawk																																						1			1										
Costa's hummingbird																												1																							
Common moorhen		1				1						1	1													1								1		1						1	1								
Common nighthawk																																											1								
Common raven																												1																							
Common tern																																																			
Common yellowthroat		1	1	1	1	1				1		1	1				1			1			1			1	1	1	1				1	1	1	1	1	1	1	1	1	1	1				1	1			
Crissal thrasher				1		1																				1							1	1	1		1		1	1	1	1	1								
Double-crested cormorant																																																			
Eurasian collared dove		1		1								1	1				1			1							1	1	1	1	1		1	1		1		1	1	1	1	1	1				1				
European starling						1																							1		1			1			1	1	1	1	1										
Ferruginous hawk																																																			
Gadwall																																																			
Gambel's quail		1	1	1	1	1				1		1	1				1			1			1			1	1	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1				1	1			
Great blue heron					1							1	1							1									1							1	1		1		1	1	1				1				
Great horned owl				1		1						1	1				1										1	1	1	1							1		1	1		1									

Table C-7.—Birds at Yuma (Reaches 5–6) sites, 2008–2012 (years 1–5)

		MLPR					MLEA					YUCC					GRGC					GRNVA-B					GRQP					YUEW					YUWW					LIMNTH					LIMSTH				
Species name	**Year**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Gilded flicker																																																			
Gila woodpecker		1	1	1	1	1				1		1	1										1				1		1		1		1	1		1	1	1	1	1	1	1	1								
Gray catbird																																																			
Great egret			1	1	1	1											1						1						1					1	1	1	1		1	1			1				1				
Green heron		1		1								1	1										1										1	1		1	1	1	1		1	1	1				1				
Greater pewee																																					1														
Greater roadrunner				1		1						1	1							1			1						1				1	1	1	1	1	1	1	1	1	1	1				1	1			
Greater yellowlegs												1								1																															
Great-tailed grackle		1	1	1	1	1				1		1	1				1			1			1			1	1	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1				1	1			
Green-winged teal																																																			
Hairy woodpecker																																																			
House finch		1	1	1	1	1				1		1	1										1			1	1	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1				1				
Horned lark																																																			
Hooded oriole																																																			
House sparrow																				1														1					1		1						1	1			
House wren																																																			
Indigo bunting			1			1							1										1				1											1					1								
Inca dove																															1					1					1	1									
Killdeer		1	1	1								1	1				1											1	1	1			1	1	1	1	1		1			1	1				1	1			
Lark sparrow																																																			
Lazuli bunting				1																						1			1		1								1												
Long-billed curlew																																																			
Long-billed dowitcher																																		1																	

Table C-7.—Birds at Yuma (Reaches 5–6) sites, 2008–2012 (years 1–5)

		MLPR					MLEA					YUCC					GRGC					GRNVA-B					GRQP					YUEW					YUWW					LIMNTH					LIMSTH				
Species name	**Year**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Ladder-backed woodpecker		1	1	1	1	1						1	1				1						1			1	1	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1				1	1			
Least bittern												1																								1															
Lesser goldfinch					1																					1	1		1	1	1		1	1		1	1	1	1	1							1				
Lesser nighthawk			1	1	1	1				1													1				1	1	1	1	1		1			1							1								
Lesser yellowlegs																																		1																	
Loggerhead shrike			1	1	1	1				1							1			1			1					1	1	1	1		1		1	1			1	1	1		1								
Lucy's warbler				1	1					1		1					1						1						1				1	1			1		1			1	1				1				
Mallard				1								1	1				1										1		1																						
Marsh wren		1	1		1							1	1				1						1											1		1											1				
Macgilvray's warbler																																																			
Mourning dove		1	1	1	1	1				1		1	1				1			1			1			1	1	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1				1	1			
Northern flicker																																																			
Northern harrier																																																			
Northern mockingbird																	1										1						1	1	1	1	1	1	1	1	1	1					1				
Northern pintail																																																			
Northern rough-winged swallow		1	1		1							1	1				1						1			1	1	1	1				1		1		1	1	1	1	1	1	1				1	1			
Orange-crowned warbler				1																																1					1										
Osprey												1	1																													1									
Pied-billed grebe		1		1	1	1				1		1					1																1		1	1				1		1	1								
Peacock																																																			
Peregrine falcon																										1			1		1																				

Table C-7.—Birds at Yuma (Reaches 5–6) sites, 2008–2012 (years 1–5)

	MLPR					MLEA					YUCC					GRGC					GRNVA-B					GRQP					YUEW					YUWW					LIMNTH					LIMSTH				
Species name **Year**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Phainopepla												1																								1		1		1										
Pacific-slope flycatcher																										1																								
Purple martin																																																		
Rose-breasted grosbeak																																																		
Ring-necked duck																																																		
Ring-necked pheasant											1					1																														1				
Rooster																						1					1		1	1							1			1		1					1			
Rock pigeon												1																				1	1	1	1	1		1		1	1	1								
Rock wren																																																		
Red-shouldered hawk																																																		
Red-tailed hawk					1																	1			1	1	1	1	1	1																				
Ruddy duck																																		1																
Red-winged blackbird	1	1	1	1	1						1	1				1			1			1				1	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1				1	1			
Rufous-winged sparrow																																																		
Sage sparrow																																																		
Say's phoebe																																			1															
Sulphur-bellied flycatcher																																																		
Semipalmated plover											1																																							
Snowy egret	1	1	1		1						1	1																1		1		1	1		1	1	1	1		1	1	1				1	1			
Song sparrow	1	1	1	1	1						1	1				1			1			1			1	1	1	1						1				1	1		1	1				1				
Spotted sandpiper											1	1																					1					1												
Spotted towhee																																																		
Sharp-shinned hawk																																					1													

Table C-7.—Birds at Yuma (Reaches 5–6) sites, 2008–2012 (years 1–5)

	MLPR					MLEA					YUCC					GRGC					GRNVA-B					GRQP					YUEW					YUWW					LIMNTH					LIMSTH				
Species name **Year**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Summer tanager																																																		
Swainson's hawk																														1																				
Tree swallow																																																		
Turkey vulture			1	1	1				1		1	1													1		1	1		1			1		1			1		1		1								
Unknown blackbird																																														1				
Unknown egret																																		1																
Unknown empdid																																				1														
Unknown flycatcher																												1									1									1	1			
Unknown hummingbird	1											1				1						1				1				1				1		1					1	1					1			
Vermillion flycatcher																											1	1	1																					
Verdin	1	1	1	1	1				1		1	1										1			1	1	1	1		1		1	1	1	1	1	1	1	1	1	1	1				1	1			
Vesper sparrow			1																																															
Violet-green swallow																																																		
Virginia rail																																			1															
Western flycatcher																																																		
Western grebe																																																		
Western kingbird	1	1	1	1	1				1		1	1				1			1			1			1	1	1	1	1	1		1	1	1	1	1	1	1		1	1	1				1	1			
Western meadowlark																1																																		
Western screech owl																																																		
Western tanager			1	1	1																						1	1		1		1																		
Western wood-pewee			1																			1					1															1								
White-faced ibis	1	1	1													1																									1									
Willow flycatcher		1	1																							1										1		1								1				

Table C-7.—Birds at Yuma (Reaches 5–6) sites, 2008–2012 (years 1–5)

		MLPR					MLEA					YUCC					GRGC					GRNVA-B					GRQP					YUEW					YUWW					LIMNTH					LIMSTH				
Species name	**Year**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Wild turkey																																																			
Wilson's warbler																															1		1																		
Wood duck																																																			
White-tailed kite																																																			
White-throated swift						1																									1																				
White-winged dove		1	1	1	1	1				1		1	1				1			1			1			1	1	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1				1	1			
Yellow-breasted chat		1	1	1	1	1						1					1						1			1	1			1							1	1				1									
Yellow-billed cuckoo		1		1	1	1				1			1				1											1	1	1	1			1		1	1		1	1	1	1									
Yellow-headed blackbird				1		1						1	1				1						1					1	1					1				1				1	1								
Yellow warbler																	1						1				1	1			1			1					1												
Zone-tailed hawk																																																			

ATTACHMENT D

Yellow-billed Cuckoo Breeding Territory (Possible [POS], Probable [PRB], and Confirmed [COB]) Estimates, Lower Colorado River, 2008–2012

Note: In all tables of this appendix, sites not surveyed = blank.

Table 1.—2008 breeding territory estimates for northern (Reach 1) sites

Site name	Site code	Possible (POS)	Probable (PRB)	Confirmed (COB)	Minimum territories	Maximum territories
Key Pittman	KEYPIT					
Honeybee Pond	OVRHP	0	0	0	0	0
Littlefield Bridge	LITBR					
Overton Residential	OVRR					
Overton Wildlife	OVRW	0	0	0	0	0
Overton Wilson Pond	OVRWP					
Pahranagat NWR North	PAHNTH	0	0	0	0	0
Pahranagat NWR South	PAHSTH	0	0	0	0	0
Smelly Jelly	SMJE					
Total		0	0	0	0	0

Table 2.—2008 breeding territory estimates for Reach 3 (Havasu) sites

Site name	Site code	Possible (POS)	Probable (PRB)	Confirmed (COB)	Minimum territories	Maximum territories
Pintail Slough	HAVPS	0	0	0	0	0
North Dike	HAVND	1	0	0	0	1
Farm Ditch Road	HAVFDR					
Glory Hole	HAVGH					
Havasu Levee Road	HAVLR					
Lost Lake	HAVLL					
Topock Platform	HAVTPR	0	0	0	0	0
Beal Restoration	HAVBR	1	0	0	0	1
Falls Spring Wash	LHCFSW					
LHC Willow Patch	LHCWP					
Desilt Wash	DSWA					
Total		2	0	0	0	2

Table 3.—2008 breeding territory estimates for Reach 3 (Bill Williams River) sites

Site name	Site code	Possible (POS)	Probable (PRB)	Confirmed (COB)	Minimum territories	Maximum territories
Borrow Pit	BWBP	0	0	0	0	0
Cottonwood Patch	BWCP	1	0	0	0	1
Cross River	BWCR					
Cave Wash	BWCW	6	0	0	0	6
Esquerra Ranch	BWER	0	1	0	0	1
Fox Wash	BWFW	2	0	0	0	2
Gibraltar Rock	BWGR	2	0	0	0	2
Honeycomb Bend	BWHB	1	2	3	3	6
Kohen Ranch	BWKR	1	0	0	0	1
Bill Williams Marsh	BWMA	4	0	0	0	4
Middle Delta	BWMD					
Mosquito Flats	BWMF	3	1	0	0	4
Mineral Wash	BWMW	1	2	0	0	3
North Burn	BWNB	1	0	0	0	1
Cougar Point	BWPT	0	1	2	2	3
Sandy Wash	BWSW	2	0	1	1	3
Total		24	7	6	6	37

Table 4.—2008 breeding territory estimates for Reach 4 (Parker to Cibola) sites

Site name	Site code	Possible (POS)	Probable (PRB)	Confirmed (COB)	Minimum territories	Maximum territories
‘Ahakhav Tribal Preserve	CRIT	1	0	0	0	1
Cibola Crane Roost	CIBCR					
Cibola Eucalyptus	CIBEUC	1	0	0	0	1
Cibola Island Perri Marsh	CIBIPM					
Cibola Island South	CIBSTH	1	0	0	0	1
Cibola Mass Planting	CIBMP					
Cibola Nature Trail	CIBCNT	0	0	0	0	0
Cibola North	CIBNTH	0	0	0	0	0
Cibola Valley Phase 1	CVCA1	0	0	2	2	2
Cibola Valley Phase 2	CVCA2					
Cibola Valley Phase 3	CVCA3					
Palo Verde Phase 1	PVER1	1	0	0	0	1
Palo Verde Phase 2	PVER2					
Palo Verde Phase 3	PVER3					
Palo Verde Phase 4	PVER4					
Palo Verde Phase 5	PVER5					
Total		4	0	2	2	6

Table 5.—2008 breeding territory estimates for Reaches 5–6 (Imperial to Yuma) sites

Site name	Site code	Possible (POS)	Probable (PRB)	Confirmed (COB)	Minimum territories	Maximum territories
Colo/Gila Confluence	YUCC	0	0	0	0	0
Imperial NWR 20A	IMP20A	0	0	0	0	0
Imperial NWR 50	IMP50					
Imperial NWR South	IMPSTH	1	0	0	0	1
Laguna 1	LAG1					
Laguna 2	LAG2					
Laguna 3	LAG3					
Martinez Lake	IMPAST					
Laguna Transect “A”	LAGTA					
Laguna Transect “D”	LAGTD					
Laguna East	LAGE					
Laguna West	LAGW					
Limitrophe North	LIMSTA	0	0	0	0	0
Limitrophe South	LIMSTB	0	0	0	0	0
Mittry Lake East Road	MLEA					
Mittry Lake/Pratt	MLPR	0	0	0	0	0
North Gila Valley “A”	GRNVA					
North Gila Valley “B”	GRNVB					
Picacho SRA	PICSRA	0	0	0	0	0
Quigley WMA	GRQP	0	0	0	0	0
Gila Confluence	GRGC	0	0	0	0	0
Yuma East Wetlands	YUEW					
Yuma West Wetlands	YUWW	1	0	0	0	1
Total		2	0	0	0	2

Table 6.—2008 breeding territory estimates for all sites grouped by river reach (Summary of tables D-1 to D-5)

River reach	Possible (POS)	Probable (PRB)	Confirmed (COB)	Minimum territories	Maximum territories
Reach 1 – Pahranagat NWR, Overton Littlefield	0	0	0	0	0
Reach 3 – Havasu	2	0	0	0	2
Reach 3 – Bill Williams River NWR	24	7	6	6	37
Reach 4 – Ahakhav Tribal Preserve	1	0	0	0	1
Reach 4 – Cibola Valley Conservation Area	0	0	2	2	2
Reach 4 – Palo Verde Ecological Reserve	1	0	0	0	1
Reach 4 – Cibola NWR	2	0	0	0	2
Reaches 5–6	2	0	0	0	2
Total	32	7	8	8	47

Table 7.—2008 breeding territory estimates for all sites grouped by site management type (Summary of tables D-1 to D-5)

Site type	Possible (POS)	Probable (PRB)	Confirmed (COB)	Minimum territories	Maximum territories
BWR natural sites	24	7	6	6	37
Non-BWR natural sites	0	0	0	0	0
LCR MSCP restoration sites	3	0	2	2	5
Non-LCR MSCP restoration sites	5	0	0	0	5
Total	32	7	8	8	47

Table 8.—2009 breeding territory estimates for northern (Reach 1) sites

Site name	Site code	Possible (POS)	Probable (PRB)	Confirmed (COB)	Minimum territories	Maximum territories
Key Pittman	KEYPIT	0	0	0	0	0
Honeybee Pond	OVRHP	0	0	0	0	0
Littlefield Bridge	LITBR	0	0	0	0	0
Overton Residential	OVRR	0	0	0	0	0
Overton Wildlife	OVRW	0	0	0	0	0
Overton Wilson Pond	OVRWP	1	0	0	0	1
Pahranagat NWR North	PAHNTH	0	0	0	0	0
Pahranagat NWR South	PAHSTH	0	0	0	0	0
Smelly Jelly	SMJE					
Total		1	0	0	0	1

Table 9.—2009 breeding territory estimates for Reach 3 (Havasu) sites

Site name	Site code	Possible (POS)	Probable (PRB)	Confirmed (COB)	Minimum territories	Maximum territories
Pintail Slough	HAVPS	0	0	0	0	0
North Dike	HAVND	0	0	0	0	0
Farm Ditch Road	HAVFDR	0	0	0	0	0
Glory Hole	HAVGH	0	0	0	0	0
Havasu Levee Road	HAVLR	0	0	0	0	0
Lost Lake	HAVLL					
Topock Platform	HAVTPR	0	0	0	0	0
Beal Restoration	HAVBR	1	0	0	0	1
Falls Spring Wash	LHCFSW	0	0	0	0	0
LHC Willow Patch	LHCWP	0	0	0	0	0
Desilt Wash	DSWA	0	0	0	0	0
Total		1	0	0	0	1

Table 10.—2009 breeding territory estimates for Reach 3 (Bill Williams River) sites

Site name	Site code	Possible (POB)	Probable (PRB)	Confirmed (COB)	Minimum territories	Maximum territories
Borrow Pit	BWBP	2	0	0	0	2
Cottonwood Patch	BWCP	0	0	1	1	1
Cross River	BWCR	2	0	0	0	2
Cave Wash	BWCW	2	1	1	1	4
Esquerra Ranch	BWER	0	0	0	0	0
Fox Wash	BWFW	1	0	0	0	1
Gibraltar Rock	BWGR	0	0	0	0	0
Honeycomb Bend	BWHB	2	0	1	1	3
Kohen Ranch	BWKR	1	0	1	1	2
Bill Williams Marsh	BWMA	2	0	0	0	2
Middle Delta	BWMD	0	0	0	0	0
Mosquito Flats	BWMF	1	0	0	0	1
Mineral Wash	BWMW	2	0	1	1	3
North Burn	BWNB	1	1	0	0	2
Cougar Point	BWPT	1	1	0	0	2
Sandy Wash	BWSW	1	0	2	2	3
Total		18	3	7	7	28

Table 11.—2009 estimates for Reach 4 (Parker to Cibola) sites

Site name	Site code	Possible (POS)	Probable (PRB)	Confirmed (COB)	Minimum territories	Maximum territories
‘Ahakhav Tribal Preserve	CRIT	1	1	0	0	2
Cibola Crane Roost	CIBCR					
Cibola Eucalyptus	CIBEUC	1	0	0	0	1
Cibola Island Perri Marsh	CIBIPM					
Cibola Island South	CIBSTH	0	0	1	1	1
Cibola Mass Planting	CIBMP					
Cibola Nature Trail	CIBCNT	0	0	0	0	0
Cibola North	CIBNTH	0	0	0	0	0
Cibola Valley Phase 1	CVCA1	0	0	2	2	2
Cibola Valley Phase 2	CVCA2	0	0	0	0	0
Cibola Valley Phase 3	CVCA3	2	0	0	0	2
Palo Verde Phase 1	PVER1	0	0	0	0	0
Palo Verde Phase 2	PVER2	0	0	2	2	2
Palo Verde Phase 3	PVER3					
Palo Verde Phase 4	PVER4					
Palo Verde Phase 5	PVER5					
Total		4	1	5	5	10

Table 12.—2009 breeding territory estimates for Reaches 5–6 (Imperial to Yuma) sites

Site name	Site code	Possible (POS)	Probable (PRB)	Confirmed (COB)	Minimum territories	Maximum territories
Colo/Gila Confluence	YUCC	0	0	0	0	0
Imperial NWR 20A	IMP20A	0	0	0	0	0
Imperial NWR 50	IMP50					
Imperial NWR South	IMPSTH	0	1	0	0	1
Laguna 1	LAG1	0	0	0	0	0
Laguna 2	LAG2	0	0	0	0	0
Laguna 3	LAG3	0	0	0	0	0
Martinez Lake	IMPAST	0	0	0	0	0
Laguna Transect “A”	LAGTA					
Laguna Transect “D”	LAGTD					
Laguna East	LAGE					
Laguna West	LAGW					
Limitrophe North	LIMSTA	1	0	0	0	1
Limitrophe South	LIMSTB					
Mittry Lake East Road	MLEA					
Mittry Lake/Pratt	MLPR	0	0	0	0	0
North Gila Valley “A”	GRNVA	0	0	0	0	0
North Gila Valley “B”	GRNVB	0	0	0	0	0
Picacho SRA	PICSRA	0	0	0	0	0
Quigley WMA	GRQP	0	0	0	0	0
Gila Confluence	GRGC					
Yuma East Wetlands	YUEW	0	0	0	0	0
Yuma West Wetlands	YUWW	0	0	0	0	0
Total		1	1	0	0	2

Table 13.—2009 breeding territory estimates for all sites grouped by river reach
(Summary of Tables D-8 to D-12)

River reach	Possible (POS)	Probable (PRB)	Confirmed (COB)	Minimum territories	Maximum territories
Reach 1 – Pahranagat NWR, Overton Littlefield	1	0	0	0	1
Reach 3 – Havasu NWR	1	0	0	0	1
Reach 3 – Bill Williams River NWR	18	3	7	7	28
Reach 4 – ‘Ahakhav Tribal Preserve	1	1	0	0	2
Reach 4 – Cibola Valley Conservation Area	2	0	2	2	4
Reach 4 – Palo Verde Ecological Reserve	0	0	2	2	2
Reach 4 – Cibola NWR	1	0	1	1	2
Reaches 5–6	1	1	0	0	2
Total	25	5	12	12	42

Table 14.—2009 breeding territory estimates for all sites grouped by site management type (Summary of tables D-8 to D-12)

Site management type	Possible (POS)	Probable (PRB)	Confirmed (COB)	Minimum territories	Maximum territories
BWR natural sites	18	3	7	7	28
Non-BWR natural sites	2	0	0	0	2
LCR MSCP restoration sites	4	1	4	4	9
Non-LCR MSCP restoration sites	1	1	1	1	3
Total	25	5	12	12	42

Table 15.—2010 breeding territory estimates for northern (Reach 1) sites

Site name	Site code	Possible (POS)	Probable (PRB)	Confirmed (COB)	Minimum territories	Maximum territories
Key Pittman	KEYPIT				0	0
Honeybee Pond	OVRHP					0
Littlefield Bridge	LITBR	0	0	0	0	0
Overton Residential	OVRR					0
Overton Wildlife	OVRW	0	0	0	0	0
Overton Wilson Pond	OVRWP	1	0	0	0	1
Pahranagat NWR North	PAHNTH				0	0
Pahranagat NWR South	PAHSTH				0	0
Smelly Jelly	SMJE	0	0	0	0	0
Total		1	0	0	0	1

Table 16.—2010 breeding territory estimates for Reach 3 (Havasu) sites

Site name	Site code	Possible (POS)	Probable (PRB)	Confirmed (COB)	Minimum territories	Maximum territories
Pintail Slough	HAVPS	0	1	0	0	1
North Dike	HAVND	1	0	0	0	1
Farm Ditch Road	HAVFDR					
Glory Hole	HAVGH	0	0	0	0	0
Havasu Levee Road	HAVLR	0	0	0	0	0
Lost Lake	HAVLL	0	0	0	0	0
Topock Platform	HAVTPR	1	0	0	0	1
Beal Restoration	HAVBR	0	0	1	1	1
Falls Spring Wash	LHCFSW					
LHC Willow Patch	LHCWP					
Desilt Wash	DSWA					
Total		2	1	1	1	4

Table 17.—2010 breeding territory estimates for Reach 3 (Bill Williams River) sites

Site name	Site code	Possible (POS)	Probable (PRB)	Confirmed (COB)	Minimum territories	Maximum territories
Borrow Pit	BWBP	1	0	0	0	1
Cottonwood Patch	BWCP	1	0	1	1	2
Cross River	BWCR	2	0	0	0	2
Cave Wash	BWCW	3	0	1	1	4
Esquerra Ranch	BWER	0	0	0	0	0
Fox Wash	BWFW	0	0	0	0	0
Gibraltar Rock	BWGR	1	0	0	0	1
Honeycomb Bend	BWHB	2	0	3	3	5
Kohen Ranch	BWKR	2	0	1	1	3
Bill Williams Marsh	BWMA	0	0	0	0	0
Middle Delta	BWMD	2	0	0	0	2
Mosquito Flats	BWMF	2	0	0	0	2
Mineral Wash	BWMW	1	0	2	2	3
North Burn	BWNB	0	0	0	0	0
Cougar Point	BWPT	0	0	3	3	3
Sandy Wash	BWSW	2	0	1	1	3
Total		19	0	12	12	31

Table 18.—2010 breeding territory estimates for Reach 4 (Parker to Cibola) sites

Site name	Site code	Possible (POS)	Probable (PRB)	Confirmed (COB)	Minimum territories	Maximum territories
‘Ahakhav Tribal Preserve	CRIT					
Cibola Crane Roost	CIBCR					
Cibola Eucalyptus	CIBEUC	0	0	0	0	0
Cibola Island Perri Marsh	CIBIPM					
Cibola Island South	CIBSTH	1	0	0	0	1
Cibola Mass Planting	CIBMP					
Cibola Nature Trail	CIBCNT	2	0	1	1	3
Cibola North	CIBNTH	0	0	0	0	0
Cibola Valley Phase 1	CVCA1	0	0	3	3	3
Cibola Valley Phase 2	CVCA2	0	0	3	3	3
Cibola Valley Phase 3	CVCA3	1	0	0	0	1
Palo Verde Phase 1	PVER1	0	0	0	0	0
Palo Verde Phase 2	PVER2	1	0	1	1	2
Palo Verde Phase 3	PVER3	1	0	1	1	2
Palo Verde Phase 4	PVER4	0	1	0	0	1
Palo Verde Phase 5	PVER5					
Total		6	1	9	9	16

Table 19.—2010 breeding territory estimates for Reaches 5–6 (Imperial to Yuma) sites

Site name	Site code	Possible (POS)	Probable (PRB)	Confirmed (COB)	Minimum territories	Maximum territories
Colo/Gila Confluence	YUCC					
Imperial NWR 20A	IMP20A					
Imperial NWR 50	IMP50					
Imperial NWR South	IMPSTH	1	0	0	0	1
Laguna 1	LAG1					
Laguna 2	LAG2	0	0	0	0	0
Laguna 3	LAG3	0	0	0	0	0
Martinez Lake	IMPAST					
Laguna Transect “A”	LAGTA					
Laguna Transect “D”	LAGTD					
Laguna East	LAGE					
Laguna West	LAGW					
Limitrophe North	LIMSTA					
Limitrophe South	LIMSTB					
Mittry Lake East Road	MLEA					
Mittry Lake/Pratt	MLPR	1	0	0	0	1
North Gila Valley “A”	GRNVA					
North Gila Valley “B”	GRNVB					
Picacho SRA	PICSRA	0	1	0	0	1
Quigley WMA	GRQP	1	0	0	0	1
Gila Confluence	GRGC					
Yuma East Wetlands	YUEW	0	0	0	0	0
Yuma West Wetlands	YUWW	0	0	0	0	0
Total		3	1	0	0	4

Table 20.—2010 breeding territory estimates for all sites grouped by river reach (Summary of tables D-15 to D-19)

River reach	Possible (POS)	Probable (PRB)	Confirmed (COB)	Minimum territories	Maximum territories
Reach 1 – Pahranagat, Overton, Littlefield	1	0	0	0	1
Reach 3 – Havasu NWR	2	1	1	1	4
Reach 3 – Bill Williams River NWR	19	0	12	12	31
Reach 4 – ‘Ahakhav Tribal Preserve					
Reach 4 – Cibola Valley Conservation Area	1	0	6	6	7
Reach 4 – Palo Verde Ecological Reserve	2	1	2	2	5
Reach 4 – Cibola NWR	3	0	1	1	4
Reaches 5–6	3	1	0	0	4
Total	31	3	22	22	56

Table 21.—2010 breeding territory estimates for all sites grouped by site management type (Summary of tables D-15 to D-19)

Site management type	Possible (POS)	Probable (PRB)	Confirmed (COB)	Minimum territories	Maximum territories
BWR natural sites	19	0	12	12	31
Non-BWR natural sites	1	0	0	0	1
LCR MSCP restoration sites	5	1	10	10	16
Non-LCR MSCP restoration sites	6	2	0	0	8
Total	31	3	22	22	56

Table 22.—2011 breeding territory estimates for northern (Reach 1) sites (no northern sites surveyed in 2011)

Site name	Site code	Possible (POS)	Probable (PRB)	Confirmed (COB)	Minimum territories	Maximum territories
Key Pittman	KEYPIT					
Honeybee Pond	OVRHP					
Littlefield Bridge	LITBR					
Overton Residential	OVRR					
Overton Wildlife	OVRW					
Overton Wilson Pond	OVRWP					
Pahranagat NWR North	PAHNTH					
Pahranagat NWR South	PAHSTH					
Smelly Jelly	SMJE					
Total						

Table 23.—2011 breeding territory estimates for Reach 3 (Havasu) sites

Site name	Site code	Possible (POS)	Probable (PRB)	Confirmed (COB)	Minimum territories	Maximum territories
Pintail Slough	HAVPS	2	0	0	0	2
North Dike	HAVND	0	0	0	0	0
Farm Ditch Road	HAVFDR					
Glory Hole	HAVGH	0	0	0	0	0
Havasu Levee Road	HAVLR					
Lost Lake	HAVLL					
Topock Platform	HAVTPR	0	0	0	0	0
Beal Restoration	HAVBR	0	0	1	1	1
Falls Spring Wash	LHCFSW					
LHC Willow Patch	LHCWP					
Desilt Wash	DSWA					
Total		2	0	1	1	3

Table 24.—2011 breeding territory estimates for Reach 3 (Bill Williams River) sites

Site name	Site code	Possible (POS)	Probable (PRB)	Confirmed (COB)	Minimum territories	Maximum territories
Borrow Pit	BWBP	1	0	0	0	1
Cottonwood Patch	BWCP	0	0	0	0	0
Cross River	BWCR	2	0	0	0	2
Cave Wash	BWCW	0	0	1	1	1
Esquerra Ranch	BWER	2	0	1	1	3
Fox Wash	BWFW	0	0	0	0	0
Gibraltar Rock	BWGR	0	0	0	0	0
Honeycomb Bend	BWHB	0	1	3	3	4
Kohen Ranch	BWKR	0	2	0	0	2
Bill Williams Marsh	BWMA	0	0	0	0	0
Middle Delta	BWMD	1	0	0	0	1
Mosquito Flats	BWMF	1	0	1	1	2
Mineral Wash	BWMW	2	0	1	1	3
North Burn	BWNB	1	0	0	0	1
Cougar Point	BWPT	0	0	2	2	2
Sandy Wash	BWSW	1	0	0	0	1
Total		11	3	9	9	23

Table 25.—2011 breeding territory estimates for Reach 4 (Parker to Cibola) sites

Site name	Site code	Possible (POS)	Probable (PRB)	Confirmed (COB)	Minimum territories	Maximum territories
‘Ahakhav Tribal Preserve	CRIT	2	0	0	0	2
Cibola Crane Roost	CIBCR	1	0	1	1	2
Cibola Eucalyptus	CIBEUC	0	0	0	0	0
Cibola Island Perri Marsh	CIBIPM	1	0	0	0	1
Cibola Island South	CIBSTH	0	0	0	0	0
Cibola Mass Planting	CIBMP	0	0	0	0	0
Cibola Nature Trail	CIBCNT	0	0	0	0	0
Cibola North	CIBNTH	0	0	0	0	0
Cibola Valley Phase 1	CVCA1	2	1	4	4	7
Cibola Valley Phase 2	CVCA2	0	1	3	3	4
Cibola Valley Phase 3	CVCA3	2	0	0	0	2
Palo Verde Phase 1	PVER1	1	0	0	0	1
Palo Verde Phase 2	PVER2	2	0	3	3	5
Palo Verde Phase 3	PVER3	2	1	2	2	5
Palo Verde Phase 4	PVER4	0	1	5	5	6
Palo Verde Phase 5	PVER5					
Total		13	4	18	18	35

Table 26.—2011 breeding territory estimates for Reaches 5–6 (Imperial to Yuma) sites

Site name	Site code	Possible (POS)	Probable (PRB)	Confirmed (COB)	Minimum territories	Maximum territories
Colorado/Gila Confluence	YUCC					
Imperial NWR 20A	IMP20A	0	0	0	0	0
Imperial NWR 50	IMP50	1	0	0	0	1
Imperial NWR South	IMPSTH	1	0	0	0	1
Laguna 1	LAG1					
Laguna 2	LAG2					
Laguna 3	LAG3					
Martinez Lake	IMPAST	1	0	0	0	1
Laguna Transect “A”	LAGTA	0	0	0	0	0
Laguna Transect “D”	LAGTD	0	0	0	0	0
Laguna East	LAGE	0	0	0	0	0
Laguna West	LAGW	0	0	0	0	0
Limitrophe North	LIMSTA					
Limitrophe South	LIMSTB					
Mittry Lake East Road	MLEA	0	0	0	0	0
Mittry Lake/Pratt	MLPR	1	0	0	0	1
North Gila Valley “A”	GRNVA					
North Gila Valley “B”	GRNVB					
Picacho SRA	PICSRA	1	0	0	0	1
Quigley WMA	GRQP	1	0	0	0	1
Gila Confluence	GRGC					
Yuma East Wetlands	YUEW	0	0	0	0	0
Yuma West Wetlands	YUWW	0	0	0	0	0
Total		6	0	0	0	6

Table 27.—2011 breeding territory estimates for all sites grouped by river reach (Summary of tables D-22 to D-26)

River reach	Possible (POS)	Probable (PRB)	Confirmed (COB)	Minimum territories	Maximum territories
Reach 1 – Pahranagat NWR, Overton Littlefield					
Reach 3 – Havasu NWR	2	0	1	1	3
Reach 3 – Bill Williams River NWR	11	3	9	9	23
Reach 4 – ‘Ahakhav Tribal Preserve	2	0	0	0	2
Reach 4 – Cibola Valley Conservation Area	4	2	7	7	13
Reach 4 – Palo Verde Ecological Reserve	5	2	10	10	17
Reach 4 – Cibola NWR	2	0	1	1	3
Reaches 5–6	6	0	0	0	6
Total	32	7	28	28	67

Table 28.—2011 breeding territory estimates for all sites grouped by site management type (Summary of tables D-22 to D-26)

Site management type	Possible (POS)	Probable (PRB)	Confirmed (COB)	Minimum territories	Maximum territories
BWR natural sites	11	3	9	9	23
Non-BWR natural sites	1	0	0	0	1
LCR MSCP restoration sites	12	4	19	19	35
Non-LCR MSCP restoration sites	8	0	0	0	8
Total	32	7	28	28	67

Table 29.—2012 breeding territory estimates for northern (Reach 1) sites

Site name	Site code	Possible (POS)	Probable (PRB)	Confirmed (COB)	Minimum territories	Maximum territories
Key Pittman	KEYPIT					
Honeybee Pond	OVRHP					
Littlefield Bridge	LITBR					
Overton Residential	OVRR					
Overton Wildlife	OVRW	0	0	0	0	0
Overton Wilson Pond	OVRWP	1	0	0	0	1
Pahranagat NWR North	PAHNTH	1	0	0	0	1
Pahranagat NWR South	PAHSTH	0	0	0	0	0
Smelly Jelly	SMJE					
Total		2	0	0	0	2

Table 30.—2012 breeding territory estimates for Reach 3 (Havasu) sites

Site name	Site code	Possible (POS)	Probable (PRB)	Confirmed (COB)	Minimum territories	Maximum territories
Pintail Slough	HAVPS	0	0	0	0	0
North Dike	HAVND	0	0	0	0	0
Farm Ditch Road	HAVFDR					
Glory Hole	HAVGH					
Havasu Levee Road	HAVLR					
Lost Lake	HAVLL					
Topock Platform	HAVTPR	1	0	0	0	1
Beal Restoration	HAVBR	1	0	0	0	1
Falls Spring Wash	LHCFSW					
LHC Willow Patch	LHCWP					
Desilt Wash	DSWA					
Total		2	0	0	0	2

Table 31.—2012 breeding territory estimates for Reach 3 (Bill Williams River) sites

Site name	Site code	Possible (POS)	Probable (PRB)	Confirmed (COB)	Minimum territories	Maximum territories
Borrow Pit	BWBP	1	0	0	0	1
Cottonwood Patch	BWCP					
Cross River	BWCR	1	0	0	0	1
Cave Wash	BWCW	1	1	0	0	2
Esquerra Ranch	BWER	1	0	0	0	1
Fox Wash	BWFW	0	0	0	0	0
Gibraltar Rock	BWGR	0	0	0	0	0
Honeycomb Bend	BWHB	0	2	1	1	3
Kohen Ranch	BWKR	1	1	0	0	2
Bill Williams Marsh	BWMA	0	0	0	0	0
Middle Delta	BWMD	0	0	0	0	0
Mosquito Flats	BWMF	1	0	0	0	1
Mineral Wash	BWMW	1	1	0	0	2
North Burn	BWNB	1	0	0	0	1
Cougar Point	BWPT	0	2	0	0	2
Sandy Wash	BWSW	3	0	0	0	3
Total		11	7	1	1	19

Table 32.—2012 breeding territory estimates for Reach 4 (Parker to Cibola) sites

Site name	Site code	Possible (POS)	Probable (PRB)	Confirmed (COB)	Minimum territories	Maximum territories
‘Ahakhav Tribal Preserve	CRIT	2	0	0	0	2
Cibola Crane Roost	CIBCR	3	1	2	2	6
Cibola Eucalyptus	CIBEUC	0	0	0	0	0
Cibola Island Perri Marsh	CIBIPM					
Cibola Island South	CIBSTH					
Cibola Mass Planting	CIBMP	0	0	0	0	0
Cibola Nature Trail	CIBCNT	1	0	0	0	1
Cibola North	CIBNTH	0	0	0	0	0
Cibola Valley Phase 1	CVCA1	0	1	2	2	3
Cibola Valley Phase 2	CVCA2	0	1	1	1	2
Cibola Valley Phase 3	CVCA3	0	0	0	0	0
Palo Verde Phase 1	PVER1	0	1	1	1	2
Palo Verde Phase 2	PVER2	1	0	4	4	5
Palo Verde Phase 3	PVER3	2	0	2	2	4
Palo Verde Phase 4	PVER4	2	3	11	11	16
Palo Verde Phase 5	PVER5	4	2	6	6	12
Total		15	9	29	29	53

Table 33.—2012 breeding territory estimates for Reaches 5–6 (Imperial to Yuma) sites

Site name	Site code	Possible (POS)	Probable (PRB)	Confirmed (COB)	Minimum territories	Maximum territories
Colo/Gila Confluence	YUCC					
Imperial NWR 20A	IMP20A	0	0	0	0	0
Imperial NWR 50	IMP50	0	0	0	0	0
Imperial NWR South	IMPSTH	1	0	0	0	1
Laguna 1	LAG1				0	0
Laguna 2	LAG2	0	0	0	0	0
Laguna 3	LAG3	1	0	0	0	1
Martinez Lake	IMPAST					
Laguna Transect “A”	LAGTA					
Laguna Transect “D”	LAGTD					
Laguna East	LAGE					
Laguna West	LAGW					
Limitrophe North	LIMSTA					
Limitrophe South	LIMSTB					
Mittry Lake East Road	MLEA					
Mittry Lake/Pratt	MLPR	0	1	0	0	1
North Gila Valley “A”	GRNVA	0	0	0	0	0
North Gila Valley “B”	GRNVB	0	0	0	0	0
Picacho SRA	PICSRA	1	0	0	0	1
Quigley WMA	GRQP	0	0	0	0	0
Gila Confluence	GRGC					
Yuma East Wetlands	YUEW	0	0	0	0	0
Yuma West Wetlands	YUWW	0	0	0	0	0
Total		3	1	0	0	4

Table 34.—2012 breeding territory estimates for all sites grouped by river reach (Summary of tables D-29 to D-33)

River reach	Possible (POS)	Probable (PRB)	Confirmed (COB)	Minimum territories	Maximum territories
Reach 1 – Pahranagat NWR, Overton Littlefield	2	0	0	0	2
Reach 3 – Havasu NWR	2	0	0	0	2
Reach 3 – Bill Williams River NWR	11	7	1	1	19
Reach 4 – ‘Ahakhav Tribal Preserve	2	0	0	0	2
Reach 4 – Cibola Valley Conservation Area	0	2	3	3	5
Reach 4 – Palo Verde Ecological Reserve	9	6	24	24	39
Reach 4 – Cibola NWR	4	1	2	2	7
Reaches 5–6	3	1	0	0	4
Total	33	17	30	30	80

Table 35— 2012 breeding territory estimates for all sites grouped by site management type (Summary of tables D-29 to D-33)

Site management type	Possible (POS)	Probable (PRB)	Confirmed (COB)	Minimum territories	Maximum territories
BWR natural sites	11	7	1	1	19
Non-BWR natural sites	3	0	0	0	3
LCR MSCP restoration sites	16	9	29	29	54
Non-LCR MSCP restoration sites	3	1	0	0	4
Total	33	17	30	30	80

ATTACHMENT E

Vegetation Data Collection Methods, 2008–2012

2009 VEGETATION SAMPLING INSTRUCTIONS

I. Setting up a Vegetation Plot

At a vegetation point, two sizes of circular plots are established:

1) A 5 meter radius plot is used to measure ground cover, count small trees, and count shrub and sapling stems.
2) An **11.3** m radius plot used to count the stems of trees.

The 5 m plot is nested within and centered on the same point as the 11.3 m plot.

Establish 4 quadrants to facilitate estimates and stem counting; then count stems in each quadrant separately.

II. Filling out the Data Sheet

SITE CODE
Enter the survey site code.

VEG PLOT NAME
This is a unique combination of letters and numbers. No other points in any of the survey areas or sites will have the same identification. This is generally the site code followed by a number, and should be the same number that is on the Veg. Plot Establishment Form.

UTM NAD
Enter the NAD used when marking points with GPS. This should be NAD 83.

UTM ZONE
Enter the appropriate zone.

ACCURACY
Enter the GPS reading accuracy, in number of meters.

UTM E and N
Enter the easting and northing readings for the center of the circular plot.

Measurements Made from the Center of Vegetation Plots

The following measures are taken while standing at the center of the plot (nest, or systematic vegetation sampling point).

DOMINANT PLANT SPECIES IN CANOPY
Species name of plant species that dominates the high canopy. Species' dominance is determined by eye. Record the species name for any that accounts for at least 40% of the high canopy present. Leave blank if no single plant species represents > 40% of the high canopy present.

PERCENT OF DOMINANT CANOPY SPECIES
This is the percent of high canopy present that is occupied by the DOMINANT CANOPY SPECIES.

CO-DOMINANT PLANT SPECIES IN CANOPY
Species name of plant species that co-dominates the high canopy. Use this variable when there are 2 plant species that each represent > 40% of the high canopy present. Leave blank if there is not a second plant species that represents > 40% of the high canopy that is present.

PERCENT OF CO-DOMINANT CANOPY SPECIES
This is the percent of high canopy occupied by CO-DOMINANT CANOPY SPECIES.

HABITAT TYPE and %
Write the two or three letter code (Anderson and Ohmart) for the dominant habitat type present at the vegetation plot (See Habitat Card). If the Habitat type is Cottonwood-Willow (CW), include a percentage of cover (10-19%=**1**, 20-49%=**2**, 50-89%=**3**, 90-100%=**4**). This is the percentage of the plot that is shaded by this species when the sun is directly overhead.

STRUCTURAL TYPE
Record the Structural Type of the habitat at the vegetation plot (1-6, see Habitat Card).

OPENNESS
This number represents the amount of cover above the shrub layer (0-24%=Open, 25-74%=Medium, 75-100%=Closed). Record the Openness within the 11.3m plot. If >100m to the nearest change record >100.

DISTANCE TO HABITAT CHANGE
Measure the distance to the nearest 11.3 m radius (.1 acre) patch of habitat, which is a different Habitat Type or Structure Type (Anderson and Ohmart) than that at the center of the veg. plot (CW IV to SSM IV, or CW I to CW III). If we

DIST. TO WATER
Record the distance from the center of the plot to the nearest water. If you know there was water (present persistently throughout the season) nearby during June, July, or August record the distance to where this water was.

ASPECT
The direction the plot faces in degrees. Take a compass bearing, in degrees, from the highest point to the lowest point (of the 11.3m plot. (What direction would water run?)

SLOPE
Measure the slope across the 11.3m plot from the bottom to the top of the plot in degrees. Standing upright, look across the plot to something at eye-height, and read the left hand scale of the clinometer. Alternatively a compass with a slope measuring tool can be used. To do this, align the top edge of the compass with your eye and an object at the same height across the plot, then read the slope arrow.

TABLE I: DENSIOMETER COVER (0-96)

AVG Height-Using a range finder (or a clinometer and the tree height estimation sheet) determine the average height of the overall canopy cover. This is all canopy cover above 1.4m (all

Dominant Species-Record the species that makes up the greatest percentage of the canopy cover.

Total Canopy Cover- Using a spherical densiometer estimate the total canopy cover by standing at the center of the plot and recording cover in each of the four cardinal directions (N, E, S, W).

How to use a spherical densiometer: Hold the densiometer in front of you at breast height. Imagine four equally spaced dots in each of the squares outlined on the mirror. Count the number of these imaginary dots covered by vegetation. Write the total number of dots covered by vegetation on the data sheet. This number should be between 0 and 96. This number divided by 96 then multiplied by one hundred will give us the percent canopy cover (We will do this once the data is entered).

<u>TABLE II:</u> **VISUAL COVER ESTIMATES (%)**
Visually estimate the percent cover for each vegetation layer within each quadrant. The observer must move around the plot to get a good feel for this.

*****For all visually estimated percent cover data record no cover as <u>0</u>, <3% as <u>1</u>, and for all other estimates round to the nearest 5 percent*****

High Canopy Layer- This layer is any canopy above 5 meters in height.
Main Canopy Layer- Can overlap with high canopy, but this layer provides the most cover/shade. This layer does not overlap with the Shrub/Sapling Layer.
Sub Canopy Layer- Record this layer when there is a distinct canopy layer between the main and the shrub/sapling layer. *This layer is often absent.*
Shrub/Sapling Layer- this layer is composed of all shrubs and sapling species, as well as any tree species that is less than 1.4 meters in height.

<u>Table III-V</u> NEAREST LIVE SHRUB, LIVE TREE, and TREE **≥6.0cm** DBH
The next measurements are taken at all plots. These measures are all based on the point-centered quarter method of estimating densities of plants (e.g., Mueller-Dombois and Ellenberg 1974). For these measurements, stand at the center of the plot, and locate the nearest live tree, live shrub, or snag (dead tree) within each of the quarters of the circle surrounding you. This measure should be taken regardless of its distance (do not leave blank if there is not a *live shrub/live tree/tree ≥6.0cm* within the plot). Divide the circle into quadrates along the cardinal compass directions. Within each quadrate, record the following information:

<u>SPECIES, NEAREST *LIVE SHRUB/LIVE TREE/TREE* **≥6.0cm** *DBH*</u>
Species name of closest *live shrub/live tree/tree ≥6.0cm DBH*, for each quadrate (1-4). For Table V count the closest tree that is larger than 6.0cm in diameter at breast height (1.4m) and ≥3m tall.

<u>DISTANCE TO NEAREST *LIVE SHRUB/LIVE TREE/TREE* **≥6.0cm** *DBH*</u>
The distance (in meters) from the center of the plot, to the selected *live shrub/live tree/tree ≥6.0cm DBH*.

<u>HEIGHT OF NEAREST *LIVE SHRUB/LIVE TREE/TREE* **≥6.0cm** *DBH*</u>
Height (in meters) of the selected *live shrub/live tree*.

<u>MAX WIDTH OF NEAREST *LIVE SHRUB*</u>
The Max Width is the maximum crown width (in meters) of the selected *live shrub*.

<u>PERP WIDTH OF NEAREST *LIVE SHRUB*</u>
The perpendicular width is the width of the *live shrub* measured at a right angle to the maximum width.

<u>DIAMETER AT BREAST HEIGHT (DBH) OF NEAREST *LIVE TREE/TREE* **≥6.0cm** *DBH*</u>
Record the diameter at breast height (measured in centimeters) of the closest *live tree/tree ≥6.0cm DBH* to the center of the plot in each of the four quadrates. If more than one stem/trunk, take the DBH of the largest.

<u>CROWN WIDTH, NEAREST *LIVE TREE/TREE* **≥6.0cm** *DBH*</u>

The Crown Width is the average width (in meters) of the crown (drip line to drip line), of the closest *live tree/tree ≥6.0cm DBH* to the center of the plot in each of the four quadrates. Measure the largest, and the smallest width of the crown, then estimate the average.

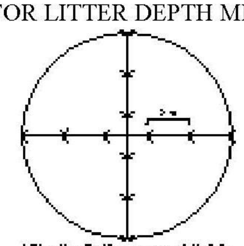
<u>CANOPY COVER, NEAREST *LIVE TREE*</u>
Standing under the selected tree, use the densiometer to measure the canopy cover of the closest tree.

Measurements Taken Within the Small (5 Meter) Plot

In each of the 5m plots we measure the depth of organic litter, ground cover of categories of ground cover, and counts of shrubs and saplings.

<u>Table VI:</u> Measuring Litter Depth
Measure the depth of organic litter, using a stake or other tool (meter stick, ruler) to dig a small hole down to where individual leaf parts are no longer visible (leaf veins usually decompose last), to where the soil layer starts. We are interested in the depth of leaf litter and partially decomposed organic matter that accumulates on top of the mineral soil. Litter depth is measured at 2m intervals along the ropes and within the 5m plots. If any of these 12 points land on a log or a rock, move the meter stick slightly to a location where you are actually measuring litter depth. Note if you are in an area covered in water, leave Litter Depth blank, and do not record litter depth as zero: there is litter...just not at the surface.

LOCATIONS FOR LITTER DEPTH MEASUREMENTS



Organic litter depth (in mm) should be measured across the center of the plot parallel and perpendicular to the slope of the plot. Measures should be made at 12 points as shown in the figure, above.

<u>Table VII:</u> Percent Ground Cover
These vegetation measurements, made within the 5m plots, are estimates of different types of ground cover. For each of the 4 quadrants in the 5m plot, make an ocular estimate of the percent of the ground covered from 50cm above ground, to ground level.

There are two types of ground cover that affect cover estimation rules; tall sparse cover that can overlap with low cover types, and low dense cover that cannot overlap with other low cover types. Percent cover in low cover types (*Grass, Leaf Litter*, *Downed Logs*, *Bare Ground*, and *Water*) alone must sum to 100%, the remaining cover categories can sum to more than 100% because of vertical stratification of plant layers. However no single layer of *Shrub*, *Forb*, *Sedge*, *Marsh Vegetation*, or *Brush* can be greater than the value for *All Green Cover*.

% LEAF LITTER COVER
Percent *Leaf Litter* is the percent of ground covered by leaf litter (including tamarisk needles). This value should be independent of taller, sparser vegetation (litter + tall sparse vegetation can sum to more than 100%), but is dependent on low dense vegetation (litter + low dense vegetation sum to 100% or less). Example: a plot with a layer of small shrubs/saplings covering 80% of the ground at 50 cm can have little plant cover at ground level so more than 20% of the ground could be leaf litter. However, a plot with 80% coverage of short, dense grass could have no more than 20% leaf litter cover.

% GRASS COVER
The % *Grass Cover* is the percentage of the ground covered by grasses below 50 cm in height. This value should be independent of taller, sparser vegetation (can sum to more than 100%), but dependent on low dense vegetation (sum to 100% or less). SEE GRASS COVER EXAMPLE.

% DOWNED LOGS COVER
The % *Downed Logs* is the percent of ground covered by downed logs (logs >12cm diameter). This value should be independent of taller, sparser vegetation (can sum to more than 100%), but dependent on low dense vegetation (sum to 100% or less). SEE GRASS COVER EXAMPLE.

% BARE GROUND
The % *Bare Ground* is the percent of open ground not covered by leaf litter or any other low, dense cover. This value should be independent of taller, sparser vegetation, but dependent on low dense vegetation. SEE GRASS COVER EXAMPLE.

% WATER COVER
The % *Water Cover* is the percent of ground covered by standing water. This value should be independent of taller, sparser vegetation, but dependent on low dense vegetation. SEE GRASS COVER EXAMPLE.

% ALL GREEN COVER
The percent *All Green Cover* is the percentage of the ground covered by green vegetation that is below 50 cm in height. This includes grass, shrubs, forbs, and marsh vegetation.

% SHRUB COVER
The % *Shrub Cover* is the percentage of ground covered by woody perennial plants that are below 50 cm tall. This layer cannot be greater than the % *All Green Cover*.

% FORB COVER
The % *Forb Cover* is the percentage of ground covered by broad-leafed non-woody plants below 50 cm height. This layer cannot be greater than the % *All Green Cover*.

% MARSH VEGETATION

The % *Marsh Vegetation* is the percentage of ground covered by marsh vegetation (vegetation undifferentiated by species or type that is growing in water). This layer cannot be greater than the % *All Green Cover*.

% BRUSH COVER

The % *Brush Cover* is the percentage of ground covered by small dead woody vegetation (i.e. dead shrubs and bramble) less than 50 cm above the ground. This layer cannot be greater than the % *All Green Cover*.

Table VIII. Measuring Shrubs and Saplings within 5m Radius Circle

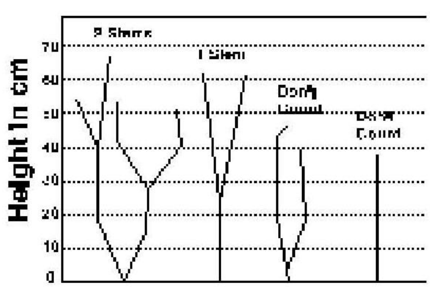
The following are the measurements to be taken within the 5m radius plot. One measurement taken is a count of the numbers of stems of shrubs that exist within the plot circle. Stems of all saplings and shrubs should be counted by species within each 5m plot at 10cm above the ground. The number of stems of each species should be counted for each of two size classes (<2.5 cm diameter or >2.5 cm diameter). We make no distinction in the data between shrubs and saplings, but different criteria must be used to place shrubs (often having no main stem) and saplings (often having a single, main stem) in one of the two size classes into which we place shrubs (see below). Separate counts are made of the number of stems of each species of shrub/sapling within the plot. Please note: growth form and size class **do not** constitute 4 different categories. We are **only** categorizing stems as small or large, not as single stem small, multiple stem large, etc. Count the numbers of stems that fit any of these criteria:

No single central stem at which DBH can be measured:
Small Size Class: < 2.5cm stem diameter at 10cm above ground
Large Size Class: > 2.5cm stem diameter at 10cm above ground

With a single central stem
Small Size Class: < 2.5cm DBH, or less than 1.4m tall
Large Size Class: 2.5 - 8.0cm DBH

Many plant species break into multiple stems fairly close to the ground. In these situations, it is reasonable to assume that birds respond to stem densities rather than individual plant numbers. Therefore, we count vertical stems, not individual plants.

Rules for counting stems:
Plants/stems less than 50cm (i.e. approximately knee height) high are not counted
Count the number of vertical stems at 10cm above the ground (ankle level), i.e if a stem branches above 10cm then it is counted as 1 (see figure, below).



SHRUB or SAPLING SPECIES
Enter the species name for each species encountered in the 5m plot, and then tally the number of stems for each species, placing the tallies in the appropriate size class. Species do not have to be placed in any specific order. Use as many entries as necessary for the species of shrubs encountered. Rare species can be pooled into the group "OTHER".

Tables IX, X, and XI. Measuring Small /Large Tree/Snag Species
Small Trees are counted within the 5m circle only, and *Large Trees* and *Snags* are counted in the 11.3m circle. Live trees are separated into the size classes given in the table, below. Separate counts should be made for each species of tree in the plot. If you can accurately identify the species of snag, enter this, otherwise put unknown.

TREE SIZE CLASSES

Live Trees (measure the DBH for each species separately)	Small trees (within 5m circle): 8 -- 23cm Medium trees (within 11.3m circle): 23 -- 38cm Large trees (within 11.3m circle): >38cm
Snags (count within 11.3m circle)	Small snags: < 12cm DBH and > 1.4m tall Medium snags: > 12cm DBH and > 1.4m tall

Use as many lines in the table as needed to record each species encountered in the large plot. Rare species can be pooled into the category "OTHER".

SMALL/ LARGE TREE/SNAG SPECIES
Record the species name for each species encountered on the large vegetation plot (11.3m radius circle). There is no specific order in which tree species must be presented. If you can accurately identify the species of snag, enter this, otherwise put unknown.

NUMBER OF STEMS (SMALL/ LARGE TREE/SNAG)
Count the total number of live stems for each size class, of each species within the large vegetation plot. Enter the total on the right of the tally marks.

RIPARIAN PLANTS OF THE LOWER COLORADO RIVER AND FOUR LETTER CODES

Common Name	Genus	Species	Code	Growth Form
Whitethorn Acacia	*Acacia*	*constricta*	ACCO	Shrub
Catclaw Acacia	*Acacia*	*gregii*	ACGR	Shrub
Giant Reed	*Arundo*	*donax*	ARDO	Grass
Arundo	*Arundo*	*sp.*	ARSP	Cane
Four Winged Saltbush	*Atriplex*	*canescens*	ATCA	Shrub
Desert Holly	*Atriplex*	*hymenelytra*	ATHY	Shrub
Alkalai Saltbush	*Atriplex*	*polycarpa*	ATPO	Shrub
Atriplex sp.	*Atriplex*	*sp.*	ATSP	Shrub
Quailbush or Big Saltbush	*Atriplex*	*lentiformis*	ATSP	Shrub
Emory Baccharis	*Baccharis*	*emoryi*	BAEM	Shrub
Seep Willow/Mulefat	*Baccharis*	*salicifolia*	BASAL	Shrub
Desert Broom	*Baccharis*	*sarathroides*	BASAR	Shrub
Unspecified Baccharis	*Baccharis*	*sp.*	BASP	Shrub
Blue Palo Verde	*Cercidium*	*floridum*	CEFL	Tree
Yellow Palo Verde	*Cercidium*	*microphyllum*	CEMI	Tree
Unspecified Palo Verde	*Cercidium*	*sp.*	CESP	Tree
Salt Grass	*Distichlis*	*spicata*	DISP	Grass
Russian Olive	*Elaeagnus*	*angustifolia*	ELAN	Tree
Unspecified Eucalyptus	*Eucalyptus*	*sp.*	EUSP	Tree
Alfalfa	*Medicago*	*sp.*	MESP	Forb
Common Reed	*Phragmites*	*australis*	PHAU	Grass
Arroweed	*Pluchea*	*sericea*	PLSE	Shrub
Fremont Cottonwood	*Populus*	*fremontii*	POFR	Tree
Honey Mesquite	*Prosopis*	*glandulosa*	PRGL	Tree
Screwbean Mesquite	*Prosopis*	*pubescens*	PRPU	Tree
Unspecified Mesquite	*Prosopis*	*sp.*	PRSP	Tree
Velvet Mesquite	*Prosopis*	*velutina*	PRVE	Tree
Coyote Willow	*Salix*	*exigua*	SAEX	Shrub
Gooding's Black Willow	*Salix*	*goodingii*	SAGO	Tree
Johnson Grass	*Sorghum*	*halapense*	SOHA	Grass
Tamarisk	*Tamarix*	*sp.*	TASP	Tree
Unknown Aster			UNAS	
Unknown			UNK	
California Fan Palm	*Washingtonia*	*filifera*	WAFI	Tree

ATTACHMENT F

Vegetation Plots by Site and Year, 2006–2012

Total number of plots: 2006–2012 (n = 826), 2006 (n = 117), 2007 (n = 150), 2008 (n = 141), 2009 (n = 127), 2010 (n = 17), 2011 (n = 29), and 2012 (n = 245)
(Due to changes in vegetation monitoring protocols, only nest data were collected 2010–2011.)

Site code	Year	Number of plots	Plot type		
			Nest	Available/ occupied	Unoccupied
BWBP	2008	3	0	3	0
	2009	1	0	1	0
	2012	6	0	0	6
BWCP	2007	1	1	0	0
	2008	2	0	2	0
	2009	2	2	0	0
BWCR	2009	2	0	2	0
	2012	6	0	6	0
BWCW	2007	1	1	0	0
	2008	5	0	5	0
	2009	2	1	1	0
	2011	1	1	0	0
	2008	4	0	4	0
	2009	3	0	0	3
	2012	6	0	6	0
BWFW	2006	6	0	0	6
	2008	7	0	7	0
	2009	3	0	3	0
	2012	6	0	6	0
BWGR	2006	5	0	5	0
	2008	6	0	6	0
	2009	4	0	0	4
	2012	6	0	0	6
BWHB	2007	1	1	0	0
	2008	8	3	5	0
	2009	3	2	1	0
	2010	3	3	0	0
	2011	3	3	0	0
	2012	7	1	6	0
BWKR	2007	7	0	7	0
	2008	1	0	1	0
	2009	1	0	1	0
	2012	6	0	6	0

Site code	Year	Number of plots	Plot type		
			Nest	Available/ occupied	Unoccupied
BWMA	2006	3	1	2	0
	2008	1	0	1	0
	2012	6	0	6	0
BWMD	2009	2	0	0	2
	2012	6	0	0	6
BWMF	2006	3	0	3	0
	2008	4	0	4	0
	2009	4	0	4	0
	2012	6	0	6	0
BWMW	2006	3	0	3	0
	2007	17	0	17	0
	2008	6	0	6	0
BWMW	2009	3	0	3	0
	2010	1	1	0	0
	2011	1	1	0	0
	2012	6	0	6	0
BWNB	2008	5	0	5	0
	2009	1	0	1	0
	2012	6	0	6	0
BWPT	2006	3	0	3	0
	2007	12	1	11	0
	2008	5	0	5	0
	2009	4	1	3	0
	2010	2	2	0	0
	2011	2	2	0	0
	2012	6	0	6	0
BWSW	2006	5	0	5	0
	2007	16	0	16	0
	2008	4	0	4	0
	2009	7	1	6	0
	2010	1	1	0	0
	2012	6	0	6	0
CIBCNT	2006	2	0	2	0
	2007	5	0	0	5
	2008	2	0	0	2
	2009	4	0	4	0
	2010	1	1	0	0
	2012	4	0	4	0

Site code	Year	Number of plots	Plot type		
			Nest	Available/ occupied	Unoccupied
CIBCR	2011	1	1	0	0
	2012	8	2	6	0
CIBEUC	2006	3	0	0	3
	2008	2	0	0	2
	2009	2	0	2	0
CIBMP	2012	6	0	0	6
CIBNTH	2007	5	0	0	5
	2008	2	0	0	2
	2009	2	0	0	2
	2012	2	0	0	2
CIBSTH	2006	6	0	0	6
	2007	8	0	8	0
	2008	2	0	2	0
	2009	4	1	3	0
CRIT	2008	10	0	10	0
	2009	6	0	6	0
	2012	6	0	6	0
CVCA1	2008	5	2	3	0
	2009	5	3	2	0
	2010	3	3	0	0
	2011	6	6	0	0
	2012	8	2	6	0
CVCA2	2008	3	0	3	0
	2009	1	0	0	1
	2010	3	3	0	0
	2011	3	3	0	0
	2012	7	1	6	0
	2009	3	0	3	0
CVCA3	2012	5	0	0	5
GCRM	2006	5	0	0	5
GRCB	2007	10	0	0	10
GRCH	2007	17	0	0	17
GRGC	2006	14	0	0	14
	2008	4	0	0	4
GRNVA	2009	2	0	0	2
	2012	3	0	0	3
GRNVB	2009	1	0	0	1

Site code	Year	Number of plots	Plot type		
			Nest	Available/ occupied	Unoccupied
GRQP	2006	6	0	0	6
	2007	9	0	9	0
	2008	4	0	0	4
	2009	3	0	0	3
GRRM	2007	6	0	0	6
HAVBR	2008	4	0	0	4
	2009	3	0	3	0
	2010	1	1	0	0
	2011	1	1	0	0
	2012	6	0	6	0
HAVGH	2009	3	0	0	3
HAVLR	2008	2	0	0	2
HAVND	2006	3	0	0	3
	2008	3	0	3	0
	2009	3	0	0	3
	2012	4	0	0	4
HAVPS	2007	2	0	0	2
	2008	6	0	0	6
	2009	2	0	0	2
	2012	6	0	0	6
HAVTAM	2006	3	0	0	3
HAVTPR	2006	4	0	0	4
	2007	6	0	6	0
	2008	4	0	0	4
	2009	2	0	0	2
	2012	5	0	5	0
HAVTT	2006	2	0	0	2
	2007	4	0	0	4
IMP20A	2008	1	0	0	1
	2009	1	0	0	1
	2012	1	0	1	0
IMP50	2012	2	0	0	2
IMPAST	2009	2	0	0	2
IMPSTH	2006	2	0	2	0
	2007	8	0	8	0
	2008	3	0	3	0
	2009	3	0	3	0
IMPSTH	2012	3	0	3	0
LAG1	2009	1	0	0	1

Site code	Year	Number of plots	Plot type		
			Nest	Available/ occupied	Unoccupied
LAG2	2009	2	0	0	2
	2012	3	0	0	3
LAG3	2009	3	0	0	3
	2012	3	0	3	0
LIMNTH	2008	4	0	0	4
LIMSTA	2008	1	0	0	1
LIMSTB	2008	3	0	0	3
LITBR	2009	2	0	0	2
MLPR	2006	13	0	0	13
	2007	10	0	0	10
	2008	3	0	0	3
	2009	3	0	0	3
	2012	5	0	5	0
OVRHP	2006	2	0	2	0
	2009	2	0	0	2
OVRW	2006	3	0	3	0
	2009	2	0	0	2
	2012	1	0	1	0
OVRWP	2012	3	0	3	0
PAHE	2006	3	0	0	3
PAHNTH	2006	3	0	0	3
	2009	2	0	0	2
	2012	5	0	5	0
PAHSTH	2012	2	0	0	2
PAHW	2006	3	0	0	3
PICSRA	2008	3	0	0	3
	2009	2	0	0	2
	2012	3	0	3	0
PVER1	2008	2	0	2	0
	2009	2	0	0	2
	2012	3	1	2	0
PVER2	2008	1	0	1	0
	2009	4	2	2	0
	2010	1	1	0	0
	2011	3	3	0	0
	2012	8	3	5	0
PVER3	2010	1	1	0	0
	2011	2	2	0	0
	2012	8	2	6	0

Site code	Year	Number of plots	Plot type		
			Nest	Available/ occupied	Unoccupied
PVER4	2011	6	6	0	0
	2012	17	10	7	0
PVER5	2012	12	6	6	0
YUCC	2006	5	0	5	0
	2008	3	0	0	3
YUEW	2009	2	0	0	2
	2012	5	0	0	5
YUWW	2006	7	0	0	7
	2007	5	0	0	5
YUWW	2008	3	0	3	0
	2009	6	0	0	6
	2012	6	0	0	6
Total		826	97	414	315

ATTACHMENT G

Important Vegetation/Habitat Use Variables

Based on vegetation results from this report and our 2010 annual report, we recommend continuing to collect these variables for future habitat analyses, as they may be important to cuckoo habitat use.

Variable	Continue to collect?
Atriplex spp. stem density	Yes
Percent bare ground	Yes
Baccharis spp. stem density	Yes
Percent brush cover	Yes
Distance to structural transition (ecotone)	Yes
Distance to river	No
Distance to water (standing or otherwise)	Yes
Percent forb cover	Yes
Percent grass cover	Yes
Percent green ground cover	Yes
High canopy (> 5 meters) average height	No
Percent high canopy closure	No
High canopy dominant species	No
Large tree stem density (can be derived from individual species' stem densities)	Yes
Percent leaf litter ground cover	Yes
Litter depth average	No
Percent log cover	No
Main canopy (layer providing most shade) average height	No
Percent main canopy closure	No
Main canopy dominant species	No
Percent marsh vegetation	Yes
Native shrub stem density (can be derived from individual species densities)	Yes
Native small tree stem density (can be derived from individual species densities)	Yes
Native large tree stem density (can be derived from individual species densities)	Yes
Pluchea sericea stem density	Yes
Populus fremontii stem density (size categories: sapling, small tree, large tree)	Yes
Prosopis stem density (size categories: sapling, small tree, large tree)	Yes
Salix exigua stem density (size categories: sapling, small tree, large tree)	Yes
Salix gooddingii stem density (size categories: sapling, small tree, large tree)	Yes
Percent sedge vegetation	Yes
Shrub stem density (can be derived from individual species' stem densities)	Yes
Percent low shrub (< 50-centimeter high) cover	Yes
Small tree stem density (can be derived from individual species' densities)	Yes
Soil moisture	No
Shrub/sapling layer dominant species	No
Subcanopy average height	No
Percent subcanopy closure	No
Tamarisk stem density (size categories: shrub, small tree, large tree)	Yes
Total canopy (all layers) average height	Yes
Total canopy dominant species	No
Percent total canopy closure	Yes
Percent standing water	Yes
Shrub/sapling layer average height	Yes
Shrub/sapling layer percent cover	No

ATTACHMENT H

Microclimate Data Loggers by Site and Year, 2008–2012

Site code	Year	Occupied/ unoccupied[1]	Temperature and relative humidity nest[2]	Temperature and relative humidity randomly located	Temperature randomly located
BWBP	2009	O	0	2	0
	2011	O	0	4	0
	2012	U	0	3	3
BWCP	2008	O	0	2	0
	2009	O	1	1	0
	2010	O	0	0	1
	2011	U	0	2	1
BWCR	2009	O	0	2	0
	2010	O	0	2	0
	2011	O	0	2	2
	2012	O	0	3	3
BWCW	2008	O	0	5	0
	2009	O	0	3	0
	2010	O	0	0	2
	2011	O	1	6	4
BWER	2008	O	0	3	0
	2009	U	0	2	0
	2010	U	0	2	2
	2012	O	0	2	4
BWFW	2008	O	0	7	0
	2009	O	0	3	0
	2010	O	0	3	0
	2011	U	0	4	3
	2012	O	0	2	4
BWGR	2008	O	0	5	0
	2009	U	0	4	0
	2010	O	0	5	1
	2011	O	0	2	1
	2012	U	0	2	4
BWHB	2008	O	2	4	0
	2009	O	1	2	0
	2010	O	3[3]	1	6
	2011	O	3	1	0
	2012	O	1	4	2
BWKR	2009	O	0	1	0
	2010	O	0	1	0
	2011	O	0	3	1
	2012	O	0	2	4
BWMA	2012	O	0	3	3

Site code	Year	Occupied/ unoccupied[1]	Temperature and relative humidity nest[2]	Temperature and relative humidity randomly located	Temperature randomly located
BWMD	2009	U	0	2	0
	2010	O	0	2	0
	2011	O	0	3	1
	2012	U	0	2	4
BWMF	2008	O	0	6	0
	2009	O	0	3	0
	2010	O	0	1	2
	2011	O	0	8	0
	2012	O	0	2	3
BWMW	2008	O	0	6	0
	2009	O	0	3	0
	2010	O	1[3]	1	2
	2011	O	1	6	2
	2012	O	0	1	3
BWNB	2008	O	0	4	0
	2009	O	0	1	0
	2010	U	0	1	0
	2011	O	0	2	1
	2012	O	0	1	4
BWPT	2008	O	0	3	0
	2009	O	0	4	0
	2010	O	2	3	0
	2011	O	2	8	3
	2012	O	0	3	3
BWSW	2008	O	0	4	0
	2009	O	1	6	0
	2010	O	1[3]	7	0
	2011	O	0	4	0
	2012	O	0	2	1
CIBCNT	2008	U	0	1	0
	2009	O	0	3	0
	2010	O	1	3	1
	2011	U	0	4	0
	2012	O	0	1	2
CIBCR	2011	O	0	4	2
	2012	O	2	1	3
CIBEUC	2008	U	0	1	0
	2009	O	0	2	0
CIBMP	2011	U	0	2	0
	2012	U	0	1	2

Site code	Year	Occupied/ unoccupied[1]	Temperature and relative humidity nest[2]	Temperature and relative humidity randomly located	Temperature randomly located
CIBNTH	2009	U	0	2	0
	2010	U	0	0	1
	2012	U	0	1	1
CIBSTH	2009	O	0	3	0
	2010	O	0	5	0
CRIT	2008	O	0	4	0
	2009	O	0	6	0
	2011	O	0	4	2
	2012	O	0	3	1
CVCA1	2008	O	2	0	0
	2009	O	2	1	0
	2010	O	3	3	0
	2011	O	3[4]	13	0
	2012	O	1	2	3
CVCA2	2008	O	0	1	0
	2009	U	0	1	0
	2010	O	3	2	0
	2011	O	2	3	2
	2012	O	1	2	2
CVCA3	2009	O	0	1	2
	2010	O	0	3	0
	2011	O	0	4	2
	2012	U	0	2	3
GRNVA	2009	U	0	2	0
GRNVB	2009	U	0	1	0
GRQP	2008	U	0	1	0
	2009	U	0	3	0
	2010	O	0	2	0
HAVBR	2008	U	0	2	0
	2009	O	0	3	0
	2010	O	1[3]	4	0
	2011	O	1	6	0
	2012	O	0	3	3
HAVGH	2009	U	0	3	0
	2010	U	0	2	0
HAVND	2009	U	0	3	0
	2010	O	0	3	0
	2011	U	0	3	0
	2012	U	0	1	3

Site code	Year	Occupied/ unoccupied[1]	Temperature and relative humidity nest[2]	Temperature and relative humidity randomly located	Temperature randomly located
HAVPS	2009	U	0	2	0
	2010	O	0	2	0
	2011	O	0	3	0
	2012	U	0	1	4
HAVTPR	2008	U	0	1	0
	2009	U	0	3	0
	2010	O	0	3	0
	2011	U	0	3	0
	2012	O	0	2	2
IMP20A	2009	U	0	1	0
	2010	U	0	1	0
	2012	O	0	1	0
IMP50	2012	U	0	1	1
IMPAST	2009	U	0	1	1
IMPSTH	2008	O	0	1	0
	2009	O	0	3	0
	2010	O	0	2	0
	2012	O	0	1	1
LAG1	2009	U	0	1	0
LAG2	2009	U	0	1	1
	2010	U	0	1	0
	2012	U	0	0	1
LAG3	2009	U	0	2	0
	2010	U	0	2	0
	2012	O	0	2	1
LITBR	2009	U	0	0	2
	2010	U	0	2	0
MLPR	2008	U	0	1	0
	2009	U	0	3	0
	2010	O	0	3	0
	2011	O	0	3	0
	2012	O	0	1	3
OVRHP	2009	U	0	2	0
OVRW	2009	U	0	1	0
	2010	U	0	1	0
OVRWP	2010	O	0	1	0
	2012	O	0	0	2
PAHNTH	2009	U	0	1	0
	2012	O	0	2	3
PAHSTH	2012	U	0	1	0

Site code	Year	Occupied/ unoccupied[1]	Temperature and relative humidity nest[2]	Temperature and relative humidity randomly located	Temperature randomly located
PICSRA	2009	U	0	2	0
	2010	O	0	3	0
	2012	O	0	1	2
PVER1	2008	O	0	1	0
	2009	U	0	0	1
	2010	U	0	1	0
	2012	O	1	1	1
PVER2	2009	O	2	1	1
	2010	O	1	2	0
	2011	O	3	5	2
	2012	O	3	2	3
PVER3	2010	O	1	0	0
	2011	O	2	4	1
	2012	O	2	4	2
PVER4	2010	O	1[3]	0	0
	2011	O	4[5]	5	2
	2012	O	8	3	4
SMJE	2010	U	0	2	0
YUEW	2009	U	0	2	0
	2010	U	0	1	0
	2012	U	0	2	2
YUWW	2008	O	0	2	0
	2009	U	0	5	1
	2010	U	0	2	0
	2011	U	0	2	0
	2012	U	0	3	3
Total		457 O/159 U	73	454	162
				339 O/115 U	118 O/44 U

1 Sites were deemed occupied if there were one or more detections in two or more of the five survey periods. Only occupied sites were used as available habitat for the nest site selection analysis.

2 Data loggers that measured temperature and humidity were place at nest locations; exceptions are designated with superscript numbers.

3 All data loggers were temperature only.

4 Two data loggers were temperature only.

5 One data logger was temperature only.

ATTACHMENT I

Yellow-Billed Cuckoo Nests Founds on the Lower Colorado River, 2008–2012

Tree Sp: BASL = seep willow (*Baccharis salicifolia*), PRGL = honey mesquite (*Prosopis glandulosa*), POFR = Fremont cottonwood (*Populus fremontii*), SAEX = coyote willow (*Salix exigua*), SAGO = Goodding's willow (*Salix gooddingii*), TASP = tamarisk (*Tamarisk spp.*). Mal = identity of adult male, Fem = identity of adult female; UNB = unbanded, UNK = unknown banded status, otherwise 2–3-letter banded YBCU ID. 1st fate = date first fledged or failed. Fate: 1 = success (fledged at least 1), U = unknown fate, D = depredated, S = by snake, W = weather, A = deserted/abandoned, HY = hatch year

Area	Year	Site code	N#	Tree sp.	Mal	Fem	Date found	1st egg	1st fate	# eggs	Fate	# fledged	# hatch year banded
Havasu	2010	HAVBR	1	POFR	UNB	LB	7/20	7/11	7/27	1+	1	1	1
	2011	HAVBR	1	POFR	UNK	UNB	7/10	7/10	7/28	3	1	2	2
BWR	2008	BWHB	1	SAGO	UNK	UNK	7/22	7/15	7/31	2	U	U	0
	2008	BWHB	2	TASP	UNK	UNK	7/28	7/22	8/7	3	U	2	2
	2008	BWHB	3	SAGO	UNK	UNK	7/24	7/7	7/24	2	1	2	0
	2009	BWCP	1	POFR	UNK	UNK	7/21	7/9	7/29	2	U	U	0
	2009	BWHB	1	TASP	UNK	UNK	7/22	7/4	7/22	1+	1	1+	1
	2009	BWSW	1	POFR	UNK	UNK	7/17	7/13	7/29	1+	1	1+	0
	2010	BWHB	1	TASP	POM	UNK	7/17	7/15	8/1	2	1	2	1
	2010	BWHB	2	TASP	RAL	UNK	7/19	7/16	8/3	2	1	2	2
	2010	BWHB	3	TASP	UNK	UNK	7/17	7/16	8/3	2+	1	2+	0
	2010	BWMW	1	BASL	UNK	UNK	8/4	7/14	8/1	1+	1	1+	0
	2010	BWPT	1	SAGO	UNK	UNK	7/27	7/13	7/29	2	1	2	2
	2010	BWPT	2	POFR	UNK	UNK	8/2	7/21	8/7	2	1	2	2
	2010	BWSW	1	TASP	UNK	UNK	7/30	7/19	8/5	2	1	2	2
	2011	BWCW	1	SAGO	UNK	UNK	7/14	7/12	7/27	4	1	3	3
	2011	BWHB	1	TASP	UNK	UNK	7/24	7/10	7/26	3	1	3	2
	2011	BWHB	2	SAGO	UNK	UNK	7/24	7/13	7/29	2	1	2	2
	2011	BWHB	3	TASP	AF	UNB	8/9	8/3	8/20	2	1	1	1
	2011	BWMW	1	TASP	UNK	UNK	7/12	7/6	7/21	3	1	2	3
	2011	BWPT	1	POFR	UNK	UNK	7/13	7/8	7/24	2	1	2	0
	2011	BWPT	2	SAGO	UNK	UNK	7/21	7/11	7/27	2	1	2	2
	2012	BWHB	1	SAGO	FMF	UNK	7/23	7/13	7/29	1+	U	U	0

Area	Year	Site code	N#	Tree sp.	Mal	Fem	Date found	1st egg	1st fate	# eggs	Fate	# fledged	# hatch year banded
PVER	2009	PVER2	1	SAGO	PF	ODY	8/1	7/26	8/3	1+	D	0	0
	2009	PVER2	2	SAGO	UNK	UNK	8/3	7/17	8/3	2+	1	2+	0
	2010	PVER2	1	SAGO	AA	UNB	7/13	6/30	7/16	2	1	2	2
	2010	PVER3	1	POFR	LG	UNK	7/15	7/15	7/31	2	1	2	2
	2011	PVER2	1	SAGO	BUT	UNK	7/14	7/13	7/29	2	1	2	2
	2011	PVER2	2	SAEX	UNK	UNK	7/26	7/21	7/29	3	D	0	0
	2011	PVER2	3	POFR	UNK	UNK	8/2	7/31	8/2	1+	D	0	0
	2011	PVER3	1	POFR	UNK	UNB	7/18	7/14	7/30	3	1	3	3
	2011	PVER3	2	POFR	UNK	UNK	7/25	7/24	8/10	1+	1	1+	0
	2011	PVER4	1	SAGO	UNK	UNK	7/14	7/12	7/14	1+	D	0	0
	2011	PVER4	2	POFR	HAY	UNK	7/22	7/17	8/2	2	1	2	2
	2011	PVER4	3	POFR	UNK	MRD	7/22	7/20	8/2	3	D	0	0
	2011	PVER4	4	SAGO	EOW	UNK	7/24	7/23	8/5	3	DS	0	0
	2011	PVER4	5	POFR	UNK	UNB	7/29	7/12	7/28	2+	1	2+	0
	2011	PVER4	6	POFR	UNK	UNK	8/15	8/10	8/20	3	A	0	0
	2012	PVER1	1	SAGO	SLS	PRI	7/20	7/11	7/27	4	1	3	0
	2012	PVER2	1	SAGO	PUF	UNK	7/24	7/22	8/7	3	1	3	0
	2012	PVER2	2	SAGO	ODB	UNB	8/4	7/31	8/15	3	D	0	0
	2012	PVER2	3	SAGO	PUF	UNB	8/19	8/17	9/2	2	1	1	0
	2012	PVER3	1	POFR	AA	UNB	7/11	7/8	7/24	3	1	3	0
	2012	PVER3	2	POFR	UNK	UNK	7/16	7/7	7/23	3	1	3	0
	2012	PVER4	1	POFR	DOG	UNK	7/4	6/26	7/11	2	1	2	2
	2012	PVER4	2	POFR	B1	GMF	7/7	7/5	7/21	4	1	2	0
	2012	PVER4	3	POFR	EZE	UNB	7/12	7/11	7/25	3	D	0	0
	2012	PVER4	4	POFR	DEF	UNB	7/24	7/21	7/29	3	D	0	0
	2012	PVER4	5	SAGO	PF	GBO	7/27	7/10	7/25	2+	1	2+	1
	2012	PVER4	6	POFR	DEF	UNB	8/2	8/1	8/19	2	1	2	0
	2012	PVER4	7	POFR	EZE	UNB	8/5	8/4	8/21	3	1	3	0
	2012	PVER4	8	SAGO	UNK	PRI	8/12	8/4	8/18	2	D	0	0
	2012	PVER4	9	POFR	UNK	GBO	8/21	8/19	8/24	1+	W	0	0
	2012	PVER4	10	POFR	SLS	PRI	8/29	8/22	9/6	3	1	3	0
	2012	PVER5	1	SAGO	UNK	QLA	7/28	7/27	8/13	5	1	2	2
	2012	PVER5	2	SAGO	LIO?	UNK	7/30	7/15	8/1	3	1	3	1
	2012	PVER5	3	POFR	UNK	CHL	8/2	7/23	8/8	3	1	1	3
	2012	PVER5	4	POFR	BZB	UNK	8/1	7/25	8/9	3	1	3	3
	2012	PVER5	5	POFR	UNK	UNB	8/6	7/19	8/6	3	1	3	1
	2012	PVER5	6	POFR	GFK	UNK	8/19	8/9	9/4	4	1	1	2

Area	Year	Site code	N#	Tree sp.	Mal	Fem	Date found	1st egg	1st fate	# eggs	Fate	# fledged	# hatch year banded
CVCA	2008	CVCA1	1	POFR	UNK	UNK	7/15	7/6	7/24	3	1	3	3
	2008	CVCA1	2	POFR	UNK	UNK	8/6	8/5	8/11	2	D	0	0
	2009	CVCA1	1	POFR	SLR	UNB	7/16	7/14	8/1	3	1	1+	3
	2009	CVCA1	2	SAGO	UNB	LBD	7/17	7/15	7/28	2	D?	0	0
	2010	CVCA1	1	TASP	UNB	UNK	7/18	7/2	7/18	3	1	3	3
	2010	CVCA1	2	POFR	BA	TA	7/22	7/7	7/23	2	1	2	1
	2010	CVCA1	3	POFR	SJR	UNK	8/2	7/30	8/17	3	1	3	3
	2010	CVCA2	1	POFR	LJ	UNK	7/12	7/9	7/19	2	D	0	0
	2010	CVCA2	2	POFR	TGB	UNB	7/28	7/26	8/13	2	1	2	2
	2010	CVCA2	3	SAGO	FZ	UNK	8/2	7/22	8/6	3	1	3	3
	2011	CVCA1	1	SAGO	UNK	UNK	7/2	6/30	7/3	3	W	0	0
	2011	CVCA1	2	POFR	BA	UNK	7/8	7/8	7/13	3	D	0	0
	2011	CVCA1	3	SAGO	ROB	MM	7/12	7/9	7/26	4	1	3	3
	2011	CVCA1	4	SAGO	UNK	UNK	7/23	7/15	8/2	4	1	2	2
	2011	CVCA1	5	POFR	BA	UNK	8/4	7/27	8/12	2	1	2	0
	2011	CVCA1	6	SAGO	SY	CBR	8/10	8/10	8/15	2	H	0	0
	2011	CVCA2	1	SAGO	DG	GRE	7/15	7/12	7/30	5	1	4	4
	2011	CVCA2	2	SAGO	FJR	UNK	7/21	7/20	8/5	4	A?	0	2
	2011	CVCA2	3	POFR	LJ	DUM	8/1	7/28	8/14	2	1	2	2
	2012	CVCA1	1	SAGO	DRE	UNK	7/10	7/9	7/25	5	1	3	3
	2012	CVCA1	2	POFR	LWB	UNB	7/12	7/11	7/28	4	1	4	3
	2012	CVCA2	1	POFR	LJ	JLO	7/25	7/20	7/31	3	W?	0	0
Cibola	2009	CIBIPM	1	TASP	TF	UNK	7/28	7/11	7/28	2+	1	2+	0
	2010	CIBCNT	1	BASL	KS	UNK	7/27	7/21	8/4	3	D	0	0
	2011	CIBCR	1	PRGL	UNK	MON	8/12	8/10	8/20	3	A	0	0
	2012	CIBCR	1	POFR	UNK	UNK	7/21	7/9	7/25	3	1	3	3
	2012	CIBCR	2	PRGL	UNK	LLL	8/11	8/9	8/24	3	1	2	1

ATTACHMENT J

Yellow-billed Cuckoos Captured or Re-sighted by Site and Year, Lower Colorado River, 2008–2012

Band code: N = new capture, R = recapture, S = re-sight, * = within-year (re-sight or recapture only).
Colors: (top to bottom, left/right): Ag = gold, As = silver, Bk = black, Bl = blue, G = green, Lg = light green, Lv = lavender, Mg = magenta, O = orange, P = pink, R = red, W = white, Y = yellow.
A dash (-) between colors indicates split-color band.
Age: AHY = after hatching year, ASY = after second year, A3Y = after third year, A4Y = after fourth year, L = local (nestling or young fledgling born at band site), HY = hatching year (juvenile), SY = second year, TY = third year.
Sex: F = female sexed by DNA, M = male sexed by DNA (unless with * = tentatively sexed by morphology or behavior), U = not sexed.

Area	Year	Date	Site code	YBCU ID (parent)	Band code	Band #	Color bands	Age	Sex
Havasu	2010	7/25	HAVBR	N1-1 (LB)	N	1212-13768	Ag/	L	U
		6/23	HAVBR	LB	N	1212-13750	G Ag/W G	AHY	F
		7/10	HAVPS	PC	N	1212-13765	Ag W/Y Bl	AHY	F
		7/14	HAVPS	TB	N	1212-13767	Ag G/Bk O	AHY	M
	2011	7/25	HAVBR	N1-1	N	1222-90559	Lv-R/mB	L	U
		7/28	HAVBR	N1-2	N	1222-90560	Lv-mB/mB	L	U
		6/30	HAVPS	AP	N	1222-90521	Bl-W-Bl/Bl	AHY	F
BWR NWR	2008	8/6	BWHB	N1-1	N	1212-13727	P-Bl/Ag	L	U
		8/6	BWHB	N1-2	N	1212-13728	P-Bl/Ag	L	U
	2009	8/20	BWCW	POM	N	1212-13745	Bk O/W Ag	HY	M*
	2010	7/13	BWCP	CA	S	1212-13729	R Y/G Ag	ASY	F
		6/19	BWCP	GZ	N	1212-13762	W Ag/R W	AHY	M*
		7/4	BWCP	AF	N	1212-13764	Bl W/R Ag	AHY	M
		6/20	BWCW	POM	R	1212-13745	Bk O/W Ag	SY	M*
		8/1	BWHB	N1-1 (POM)	N	1212-13766	Ag/G-O	L	U
		8/1	BWHB	N2-1 (RAL)	N	1212-13769	Ag Bl/O-G	L	U
		8/1	BWHB	N2-2 (RAL)	N	1212-13770	Ag/O-G	L	U
		6/28	BWMW	RAL	N	1212-13763	R Ag/R G	AHY	M
		8/6	BWPT	N3-2	N	1212-13773	Ag/G-O	L	U
		8/6	BWPT	N3-1	N	1212-13774	Ag/G-O	L	U
		8/2	BWSW	N1-1	N	1212-13771	Ag/G-O	L	U
		8/2	BWSW	N1-2	N	1212-13772	G-O/Ag	L	U
	2011	7/27	BWCW	N1-1	N	1222-90514	Bk-R-Bk/Bl	L	U
		7/27	BWCW	N1-2	N	1222-90515	Bk-Y/Bl	L	U
		7/27	BWCW	N1-3	N	1222-90516	Bk-G/Bl	L	U
		7/27	BWHB	N2-1	N	1222-90508	Bk-O-Bk/Bl	L	U
		7/27	BWHB	N2-2	N	1222-90509	G-O/Bl	L	U
		7/27	BWHB	N1-1	N	1222-90510	R-Bk-R/Bl	L	U
		7/27	BWHB	N1-2	N	1222-90511	W-Bk-W/Bl	L	U
		8/18	BWHB	N3-1 (AF)	N	1222-90512	Bk-R/Bl	L	U
		8/2	BWHB	AF	S	1212-13764	Bl W/R Ag	ASY	M
		7/20	BWMW	N1-1	N	1222-90503	G-W/Bl	L	U

Area	Year	Date	Site code	YBCU ID (parent)	Band code	Band #	Color bands	Age	Sex
BWR NWR (continued)	2011	7/20	BWMW	N1-2	N	1222-90504	Y-Bk/Bl	L	U
		7/24	BWMW	N1-3	N	1222-90505	R-Bl-R/Bl	L	U
		7/26	BWPT	N2-1	N	1222-90506	O-Bl/Bl	L	U
		7/26	BWPT	N2-2	N	1222-90507	O-Bk-O/Bl	L	U
	2012	6/25	BWMW	TRD	N	1202-68001	Mg/Bk-G	AHY	M
		6/25	BWMW	BLL	N	1202-68002	Mg/Bk-lB	AHY	M
		6/26	BWMW	FMF	N	1202-68003	Mg/Bk-Lv-Bk	AHY	M
		7/10	BWMW	HED	N	1202-68004	Mg/G-lB	AHY	M
		7/16	BWPT	LIM	N	1202-68005	Mg/G-Lv	AHY	F
CRIT	2009	6/30	CRIT	CA	N	1212-13729	R Y/G Ag	AHY	F
		7/18	CRIT	DJ	N	1212-13744	O Bl/W Ag	AHY	F
	2011	6/28	CRIT	VTI	N	1222-90501	Bl/R-Y	AHY	F
		7/2	CRIT	SCM	N	1222-90502	Bl/G-W-G	AHY	F
PVER	2009	8/3	PVER2	ODY	R	1212-13724	R-Bl/Ag	SY	F*
		8/3	PVER2	PF	N	1212-13730	O W/Ag Bl	AHY	M*
	2010	7/15	PVER2	N1-1 (AA)	N	1212-13756	/Ag	L	U
		7/15	PVER2	N1-2 WKA (AA)	N	1212-13757	/Ag	L	U
		7/1	PVER2	PD	N	1212-13741	Y Ag/R Bl	AHY	M
		7/1	PVER2	LL	N	1212-13748	G Ag/W R	AHY	F
		7/29	PVER3	N1-1 (LG)	N	1212-13779	Lg/Ag	L	U
		7/29	PVER3	N1-2 (LG)	N	1212-13781	Lg/Ag	L	U
		7/7	PVER3	AA	N	1212-13752	Bl Ag/R G	AHY	M
		7/30	PVER3	LG	N	1212-13782	Bk R/O Ag	AHY	M
		7/28	PVER4	MBS	N	1212-13778	W Bl/R Ag	AHY	M
		8/12	PVER4	LIB	N	1212-13790	R Y/Y Ag	AHY	F
	2011	7/26	PVER2	N1-1	N	1222-90555	R-Ag/Bl	L	U
		7/26	PVER2	N1-2	N	1222-90556	Bk-Y-Bk/Bl	L	U
		7/26	PVER2	BUT	N	1222-90539	Bl/G-Bk	AHY	M
		7/29	PVER3	N1-1	N	1222-90562	W-R-W/Bl	L	U
		7/29	PVER3	N1-2	N	1222-90563	W-Y-W/Bl	L	U
		7/29	PVER3	N1-3	N	1222-90564	W-G-W/Bl	L	U
		8/23	PVER4	HJR	R*	1222-90567	Bl-O-Bl/Bl	HY	U
		8/2	PVER4	N2-1 (HAY)	N	1222-90567	Bl-O-Bl/Bl	L	U
		8/2	PVER4	N2-2 (HAY)	N	1222-90568	Bl-G-Bl/Bl	L	U
		7/2	PVER4	MRD	N	1222-90522	Bl/Y-Bk-Y	AHY	F
		6/24	PVER4	BOO	N	1222-90523	Bl/W-Bl-W	AHY	F
		7/14	PVER4	EOW	N	1222-90529	Bl/G-Y-G	AHY	M
		7/24	PVER4	GUL	N	1222-90535	Bl/Lv-W	AHY	M
		7/14	PVER4	ARA	N	1222-90540	Bl/R-Bk	AHY	F
		8/3	PVER4	HAY	N	1222-90569	Bl/Bl-Lv	AHY	M
		8/7	PVER4	PRI	N	1222-90578	Bl/Lv-Y	AHY	F

Area	Year	Date	Site code	YBCU ID (parent)	Band code	Band #	Color bands	Age	Sex
PVER (continued)	2012	8/5	PVER2	ODB	N	1202-68009	Mg/W-Bk-W	AHY	M
		6/30	PVER2	SLS	N	1202-68031	Mg/Y-Bk	AHY	M
		7/29	PVER2	TEE	N	1202-68034	Mg/G-mB	AHY	F
		7/31	PVER2	PUF	N	1202-68035	Mg/Ag-G	AHY	M
		7/2	PVER3	AA	R	1212-13752	Bl Ag/R G	A3Y	M
		8/13	PVER3	AFM	N	1713-67924	Mg/lB-Y-lB	AHY	F
		7/11	PVER4	N1-1 (DOG)	N	1202-68038	R-lB-R/Mg	L	U
		7/11	PVER4	N1-2 (DOG)	N	1202-68039	R-Bk/Mg	L	U
		7/26	PVER4	N5-1 (GBO PF)	N	1202-68048	O-lB/Mg	L	U
		6/22	PVER4	GMF	N	1202-68021	Mg/W-Bk	AHY	F
		7/18	PVER4	GBO	N	1202-68022	Mg/R-Y-R	AHY	F
		7/3	PVER4	QLA	N	1202-68032	Mg/Lv-mB	AHY	F
		7/7	PVER4	EZE	N	1202-68033	Mg/Lv-R	AHY	M
		8/3	PVER4	PF	S	1212-13730	O W/Ag Bl	A4Y	M
		7/30	PVER4	WKA	R	1212-13757	Y-Bk-Y/Ag	TY	F
		7/17	PVER4	PRI	R	1222-90578	mB/Lv-Y	ASY	F
		7/17	PVER4	JAZ	N	1713-67915	Mg/Y-W	AHY	M
		7/20	PVER4	DEF	N	1713-67921	Mg/Y-O	AHY	M
		7/5	PVER4	DOG	N	1713-67923	Mg/lB-W-lB	AHY	M
		8/1	PVER5	N2-1 (LIO?)	N	1202-68049	Y-mB-Y/Mg	L	U
		8/1	PVER5	N2-2 (LIO?)	N	1202-68050	Bk-lB/Mg	L	U
		8/7	PVER5	N3-1 (CHL)	N	1202-68051	G-Lv/Mg	L	U
		8/7	PVER5	N3-3 (CHL)	N	1202-68052	O-W-O/Mg	L	U
		8/6	PVER5	N5-1	N	1202-68053	G-Y/Mg	L	U
		8/7	PVER5	N3-2 (CHL)	N	1202-68054	Lv-W-Lv/Mg	L	U
		8/8	PVER5	N4-1 (BZB)	N	1202-68055	Ag-Lv/Mg	L	U
		8/8	PVER5	N4-2 (BZB)	N	1202-68056	lB-Y/Mg	L	U
		8/8	PVER5	N4-3 (BZB)	N	1202-68057	Lv-R-Lv/Mg	L	U
		8/11	PVER5	N1-1 (QLA)	N	1202-68058	Lv-Bk-Lv/Mg	L	U
		8/11	PVER5	N1-2 (QLA)	N	1202-68059	Lv-G/Mg	L	U
		9/2	PVER5	N6-1 (GFK)	N	1202-68062	W-G/Mg	L	U
		9/2	PVER5	N6-2 (GFK)	N	1202-68063	Lv-O/Mg	L	U
		7/29	PVER5	BZB	N	1202-68006	Mg/O-Lv	AHY	M
		8/2	PVER5	LIO	N	1202-68007	Mg/R-Lv	AHY	M
		8/4	PVER5	JLY	N	1202-68008	Mg/Y-lB-Y	AHY	F
		8/7	PVER5	CHL	N	1202-68010	Mg/W-mB	AHY	F
		8/8	PVER5	GFK	N	1713-67906	As/Lv-O	AHY	M
		8/8	PVER5	MET	N	1713-67907	As/R-Lv-R	AHY	M
		8/12	PVER5	TOZ	N	1713-67908	As/lB-O-lB	AHY	F

Area	Year	Date	Site code	YBCU ID (parent)	Band code	Band #	Color bands	Age	Sex
CVCA	2008	7/21	CVCA1	N1-1 ODY	N	1212-13724	P-Bl/Ag	L	U
		7/21	CVCA1	N1-2	N	1212-13725	P-Bl/Ag	L	U
		7/21	CVCA1	N1-3	N	1212-13726	Bl-Bk/Ag	L	U
	2009	7/29	CVCA1	N1-1 SJR (SLR)	N	1212-13737	Ag/Y	L	U
		7/29	CVCA1	N1-2 (SLR)	N	1212-13738	Ag/Y	L	U
		7/29	CVCA1	N1-3 (SLR)	N	1212-13739	Ag/Y	L	U
		7/11	CVCA1	LJ	N	1212-13733	W Ag/W O	AHY	M
		7/19	CVCA1	LBD	N	1212-13734	G O/Bl Ag	AHY	F*
		7/7	CVCA1	SLR	N	1212-13735	Bk Y/R Ag	AHY	M*
	2010	7/18	CVCA1	N1- 1	N	1212-13758	W/Ag	L	U
		7/18	CVCA1	N1-2	N	1212-13759	W/Ag	L	U
		7/18	CVCA1	N1-3	N	1212-13760	W/Ag	L	U
		7/24	CVCA1	N2-1 (BA)	N	1212-13761	W/Ag	L	U
		8/14	CVCA1	N3-1 (SJR)	N	1212-13792	Lg/Ag	L	U
		8/14	CVCA1	N3-2 (SJR)	N	1212-13793	Lg/Ag	L	U
		8/14	CVCA1	N3-3 (SJR)	N	1212-13794	Lg/Ag	L	U
		6/23	CVCA1	LJ	R	1212-13733	W Ag/W O	ASY	M
		6/24	CVCA1	TGB	N	1212-13742	Bk W/W Ag	AHY	M
		6/23	CVCA1	BA	N	1212-13743	R W/Bk Ag	AHY	M
		6/24	CVCA1	YB	N	1212-13746	Bl O/W Ag	AHY	M
		7/15	CVCA1	PM	S*	1212-13749	O Bl/Bl Ag	AHY	M
		8/3	CVCA2	N3-1 (FZ)	N	1212-13784	W/Ag	L	U
		8/3	CVCA2	N3-2 FJR (FZ)	N	1212-13785	W/Ag	L	U
		8/3	CVCA2	N3-3 (FZ)	N	1212-13786	/Ag	L	U
		8/9	CVCA2	N2-1 (TGB)	N	1212-13788	Lg/Ag	L	U
		8/9	CVCA2	N2-2 (TGB)	N	1212-13789	Lg/Ag	L	U
		7/31	CVCA2	SJR	R	1212-13737	R Ag/G W*	SY	M
		7/25	CVCA2	PQ	N	1212-13776	R G/Bl Ag	AHY	M
		7/31	CVCA2	TA	N	1212-13783	Bl Ag/O Bk	AHY	F
		8/5	CVCA2	FZ	N	1212-13787	O Ag/O Y	AHY	M
		7/8	CVCA3	GO	N	1212-13753	G Ag/R Bl	AHY	F
		7/8	CVCA3	GG	N	1212-13754	W O/Y Ag	AHY	M
	2011	7/24	CVCA1	N3-1 (ROB MM)	N	1222-90536	O-Y/Bl	L	U
		7/26	CVCA1	N3-2 (ROB MM)	N	1222-90543	O-Y/Bl	L	U
		7/26	CVCA1	N3-3 (ROB MM)	N	1222-90544	Y-Bl/Bl	L	U
		7/31	CVCA1	N4-1	N	1222-90565	Bk-W-Bk/Bl	L	U
		7/31	CVCA1	N4-2	N	1222-90566	lB-O/Bl	L	U
		6/12	CVCA1	BA	R	1212-13743	W R/Bk Go	ASY	M
		7/12	CVCA1	FJR	R	1212-13785	W R-Bl/Ag*	SY	M

Area	Year	Date	Site code	YBCU ID (parent)	Band code	Band #	Color bands	Age	Sex
CVCA (continued)	2011	7/9	CVCA1	SME	N	1222-90527	Bl/R-G	AHY	M
		7/12	CVCA1	CD	N	1222-90528	Bl/Bk-G-Bk	AHY	M
		7/28	CVCA1	ROB	N	1222-90557	Bl/G-Lv-G	AHY	M
		7/28	CVCA1	MM	N	1222-90558	Bl/O-G-O	AHY	F
		7/29	CVCA2	N1-1 (DG GRE)	N	1222-90545	O-Bl-O/Bl	L	U
		7/29	CVCA2	N1-2 (DG GRE)	N	1222-90546	Bl-W-Bl/Bl	L	U
		7/29	CVCA2	N1-3 (DG GRE)	N	1222-90547	Bl-Y/Bl	L	U
		7/29	CVCA2	N1-4 (DG GRE)	N	1222-90548	Bl-W/Bl	L	U
		8/4	CVCA2	N2-1 (FJR)	N	1222-90570	lB-Bl/Bl	L	U
		8/4	CVCA2	N2-2 (FJR)	N	1222-90571	W-Bk/Bl	L	U
		8/12	CVCA2	N3-1 (LJ DUM)	N	1222-90572	Y-W/Bl	L	U
		8/12	CVCA2	N3-2 (LJ DUM)	N	1222-90573	Y-G/Bl	L	U
		8/4	CVCA2	LJ	S	1212-13733	W Ag/W O	A3Y	M
		7/14	CVCA2	TGB	S	1212-13742	Bk W/W Ag	ASY	M
		7/4	CVCA2	DG	N	1222-90524	Bl/Y-Bl-Y	AHY	M
		7/29	CVCA2	DG	R*	1222-90524	Bl/Y-Bl-Y	AHY	M
		7/4	CVCA2	JE	N	1222-90525	Bl/G-O-G	AHY	F
		7/15	CVCA2	CBR	N	1222-90541	Bl/Go-Bl-Go	AHY	F
		7/23	CVCA2	CBR	R*	1222-90541	Bl/Go-Bl-Go	AHY	F
		7/15	CVCA2	DUM	N	1222-90542	Bl/O-W-O	AHY	F
		7/15	CVCA2	GRE	N	1713-67913	No Band	AHY	F
		7/29	CVCA2	GRE	R*	1713-67913	As/No Band	AHY	F
	2012	7/24	CVCA1	N1-1 (DRE)	N	1202-68040	Y-lB-Y/Mg	L	U
		7/24	CVCA1	N1-2 (DRE)	N	1202-68041	R-lB/Mg	L	U
		7/24	CVCA1	N1-3 (DRE)	N	1202-68042	W-lB/Mg	L	U
		6/24	CVCA1	LWB	N	1202-68027	Mg/Bk-R	AHY	M
		6/27	CVCA1	DRE	N	1202-68030	Mg/Bk-W	AHY	M
		6/28	CVCA1	DRE	R*	1202-68030	Mg/Bk-W	AHY	M
		6/27	CVCA1	KIM	N	1713-67912	Mg/Ag-R	AHY	M
		7/19	CVCA1	LLL	N	1713-67914	Mg/lB-mB-lB	AHY	F
		7/2	CVCA2	ICE	N	1202-68037	Mg/W-Y-W	AHY	M
		7/22	CVCA2	LJ	R	1212-13733	W Ag/W O	A4Y	M
		7/22	CVCA2	JLO	N	1713-67922	Mg/Y-Bk	AHY	F
		6/24	CVCA3	SAL	N	1202-68028	Mg/Bk-Lv	AHY	M
		6/24	CVCA3	PEP	N	1202-68029	Mg/Bk-mB	AHY	F

Area	Year	Date	Site code	YBCU ID (parent)	Band code	Band #	Color bands	Age	Sex
Cibola	2009	7/21	CIBCR	MG	N	1212-13732	R G/W Ag	AHY	F
		7/27	CIBIPM	TF	N	1212-13731	Bl Ag/O W	AHY	M*
	2010	6/19	CIBCNT	RP	N	1212-13740	W Ag/Bl O	AHY	M
		7/5	CIBCNT	KW	N	1212-13751	W R/Bl Ag	AHY	M
		7/11	CIBCNT	KS	N	1212-13755	Y Ag/O W	AHY	M
		6/17	CIBIPM	WFF	N	1212-13736	G W/G Ag	AHY	F
		7/3	CIBIPM	PM	N	1212-13749	O Bl/Bl Ag	AHY	M
	2011	7/2	CIBCR	NUR	N	1222-90530	Bl/G-Bk-G	AHY	M
		7/21	CIBCR	MON	N	1222-90534	Bl/G-Y	AHY	F
		7/25	CIBCR	RIS	N	1222-90537	Bl/No Band	AHY	F
		8/5	CIBCR	RIS	R*	1222-90537	Bl/No Band	AHY	F
		7/25	CIBCR	TIN	N	1222-90538	Bl/O-Bk	AHY	M
		7/8	CIBIPM	ND	N	1222-90526	Bl/Y-G-Y	AHY	F
	2012	7/25	CIBCR	N1-1	N	1202-68023	mB-Lv/Mg	L	U
		7/25	CIBCR	N1-2	N	1202-68024	Ag-R/Mg	L	U
		7/25	CIBCR	N1-3	N	1202-68025	O-Bk/Mg	L	U
		8/24	CIBCR	N2-1 (LLL)	N	1202-68061	Y-Lv/Mg	L	U
		6/19	CIBCR	SMA	N	1713-67911	Mg/Lv-G	AHY	M
		7/19	CIBCR	LLL	S*	1713-67914	Mg/lB-mB-lB	AHY	F
		6/28	CIBEUC	PEP	S*	1202-68029	Mg/Bk-mB	AHY	F
Picacho	2011	7/10	PICSRA	YS	N	1222-90531	Bl/Bl-Y-Bl	AHY	F
Quigley	2011	7/14	GRQP	ANG	N	1222-90532	Bl/Y-Bl	AHY	F