Yellow-billed Cuckoo Survey Effort Along the Sacramento and Feather Rivers

2012-2013

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Final report submitted to the California Department of Fish and Wildlife

Grant #1182002

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Suggested citation: Dettling, M.D., N.E. Seavy, and T. Gardali. 2014. Yellow-billed Cuckoo Survey Effort Along the Sacramento and Feather Rivers, 2012-2013. Final report to California Department of Fish and Wildlife (Grant #1182002). Point Blue Contribution #1988.

This report is split into three sections covering the Yellow-billed Cuckoo surveys, breeding evidence, and vegetation surveys. The first section will be submitted to The Condor: Ornithological Applications to be considered for publication and is formatted for submission. The other two sections outline information gathered during our surveys that were not included in the first section.

Section I

Current status of Western Yellow-billed Cuckoo along the Sacramento and Feather rivers, California

Current status of Western Yellow-billed Cuckoo along the Sacramento and Feather rivers, California

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ABSTRACT

To evaluate the current status of the western population of the Yellow-billed Cuckoo (*Coccyzus americanus*) along the Sacramento and Feather rivers in California's Sacramento Valley, we conducted extensive playback surveys in 2012 and 2013. We also quantified the amount and distribution of potential habitat. Our survey transects were randomly located and spatially balanced to sample representative areas of the potential habitat. We estimated that the total area of potential habitat was 8,134 ha along the Sacramento River and 2,052 ha along the Feather River, for a total of 10,186 ha. Large-scale restoration efforts have created potential habitat along both of these rivers. Despite this increase in the amount of habitat, the number of cuckoos we detected was extremely low. There were 8 detection occasions in 2012 and 10 occasions in 2013 on the Sacramento River, in both restored and remnant habitat. We had no detections on the Feather River in either year. We compared our results to 10 historic studies from as far back as 1972 and found that the Yellow-billed Cuckoo had unprecedentedly low numbers in 2010, 2012, and 2013. The current limiting factor for the Yellow-billed Cuckoo in the Sacramento Valley is likely not the amount of appropriate vegetation, as restoration has created more habitat over the last 30 years. Reasons for the cuckoo decline on the Sacramento and Feather rivers are unclear.
Keywords: Yellow-billed Cuckoo, restoration, riparian, state endangered, *Coccyzus americanus*, Sacramento River, Feather River

INTRODUCTION

The western population of the Yellow-billed Cuckoo (*Coccyzus americanus*, hereafter "cuckoo") was once common during the breeding season in riparian forests from northern Mexico to southern Canada west of the Rocky Mountains (Hughes 1999). This range has contracted over the last century and currently the cuckoo maintains small breeding populations in California, Arizona, New Mexico, Texas, and northern Mexico (Laymon and Halterman 1989, Hughes 1999). In California, breeding populations are now believed to be confined to just three areas in the state: the Sacramento River Valley, the South Fork Kern River Valley, and the Colorado River Valley (Laymon and Halterman 1987).

Evidence suggests that the population size of cuckoos along the Sacramento River has been declining over the last century (Halterman 1991, Halterman et al. 2001). A decline in the cuckoo population in the Sacramento Valley was first noted by Grinnell and Miller (1944), who concluded that the loss of large areas of riparian forest were the cause of the decline. By the 1980s, 95% of riparian forest in California's Central Valley had been lost (Katibah 1984). In 1972, surveys along the Sacramento River revealed that a small population still occupied some of the remaining riparian forests (Gaines 1974). Several survey efforts in the decades since have continued to find small numbers of cuckoos in the Sacramento Valley (Gaines and Laymon 1984, Halterman 1991, Halterman et al. 2001, Hammond 2011).

Evidence of a population decline has motivated special status designations for the cuckoo. In 1988, California listed the cuckoo as a state endangered species (California Department of Fish and Wildlife 2013). In 2001, the U.S. Fish and Wildlife Service concluded that the western population was warranted but precluded from federal listing (U.S. Fish and Wildlife Service 2001). On 3 October 2013, the U.S. Fish and Wildlife Service proposed to list

the western distinct population segment of the Yellow-billed Cuckoo as threatened under the Endangered Species Act. This proposal is currently under review.

The state listing and apparent decline in the Sacramento Valley population led government agencies and environmental organizations to include the Yellow-billed Cuckoo in their riparian forest restoration planning (RHJV 2004). Since 1988, over 2,500 ha of riparian forest have been restored along the Sacramento River (Golet et al. 2008). Most of these restorations have had many years to mature and have presumably increased the area of riparian forest for cuckoos in the breeding season.

Despite the investment in restoration in the Sacramento Valley, the current status of the cuckoo and its potential habitat has not been clearly documented. With recent vegetation mapping efforts (Geographical Information Center 2012) and spatial tools (Girvetz and Greco 2007), it is now possible to update the extent of potential cuckoo habitat that exists after 25 years of restoration activity.

Here, we present results from two years of surveys for Yellow-billed Cuckoos in potential habitat along the Sacramento and Feather rivers. The objectives of this study were to (1) describe the current extent and location of potential Yellow-billed Cuckoo habitat along the Sacramento and Feather rivers; (2) determine the current occupancy of habitat patches by Yellow-billed Cuckoos along the Sacramento and Feather rivers; and (3) assess these results in the context of the previous Yellow-billed Cuckoo surveys along the Sacramento and Feather rivers.

METHODS

Study Area

We studied Yellow-billed Cuckoos in the area along the main stems of the Sacramento and Feather rivers in California's Sacramento Valley (Figure 1). The riparian vegetation along these rivers is surrounded by large areas of intensive agriculture (primarily fruit and nut orchards and rice fields) and smaller urban areas (Gardali et al. 2006). The area experiences hot, dry summers and mild, wet winters (Holl and Crone 2004). The hydrology of the rivers has been altered by dams upstream from the study area (Singer 2007).

Defining Potential Cuckoo Habitat

Within this study area, we limited our sampling frame to 2 km on either side of the Sacramento (Red Bluff to Colusa; ca. 100 river miles) and Feather (Gridley to Nicolaus; ca. 32 river miles) rivers (Figure 1). Although riparian forest does exist outside the study area, the majority of cuckoo sightings during the breeding season have been <2 km from the Sacramento or Feather rivers (Halterman et al. 2001). Within this area, we needed to define and quantify potential cuckoo habitat to (1) refine the sampling frame for our survey effort and (2) describe the extent and distribution of potential habitat.

Not all land cover within our sampling frame is potential cuckoo habitat. We refined this area using information about the patch configuration of riparian vegetation. In California, cuckoos are riparian forest obligates that will use relatively young forests (e.g., 4 years old; Hammond 2011) as well as mature stands (Gaines 1974), and may prefer areas with both (Greco et al. 2002). To define potential habitat, we used the Central Valley Riparian Mapping Project vegetation layer (medium-scale layer, 2009 imagery; Geographical Information Center 2012) to identify and map all riparian vegetation (including restoration sites) within 2 km of the river. The

vegetation classifications used to define potential habitat were “RWF - Riparian Evergreen and Deciduous Woodland” and “RWS - Southwestern North America riparian wash/scrub”, which captured a wide array of riparian vegetation alliances (Table 1).

Potential Yellow-billed Cuckoo habitat is best defined as patches of riparian vegetation with sufficient area to support cuckoos (Laymon and Halterman 1989). Many patches of riparian vegetation are likely too small to provide habitat for cuckoos (Gaines 1974, Gaines and Laymon 1984, Girvetz and Greco 2009). Some areas with other land covers (e.g., grasslands) that are surrounded by or between patches of riparian forest and scrub can be incorporated into cuckoo territories and are not necessarily barriers (Halterman et al. 2001).

To quantitatively define potential cuckoo habitat, we used the program PatchMorph (Girvetz and Greco 2007) in ArcGIS (ESRI). This program delineates patches using an input GIS layer of riparian vegetation (described above) and user defined organism-specific parameters of minimum patch size, minimum patch width, and maximum width of gaps in suitable habitat (see Supplemental Appendix for the PatchMorph parameters used in this study; note that the minimum patch size was applied in ArcGIS after PatchMorph was run with no minimum). Previous efforts to define cuckoo habitat on the Sacramento River defined the minimum patch size as 5 ha, the minimum patch width as 100 m, and the maximum gap width as 100 m (Girvetz and Greco 2009). In this study, we used a minimum patch size of 15 ha, with the same values for minimum patch width and maximum gap width. We chose to increase the minimum patch size to better reflect the most recent estimate of minimum cuckoo home-range size derived from radio telemetry studies in Arizona (15 ha; Halterman 2009).

Our final sampling frame represented potential habitat patches of suitable riparian vegetation within 2 km of the Sacramento or Feather rivers (Figure 1).

Field Survey

Sampling design

Due to logistical and funding constraints, we were unable to survey all the potential cuckoo habitat. Instead, we generated a sampling design to survey a subsample of the area which was used to make inferences over the entire area. Our sampling design was based on a 300 m grid (developed from the 100 m Military Grid Reference System) overlaid on the habitat patches. The size of the grid cells (9 ha) was smaller than the smallest patch, so each patch was covered by multiple cells, but large enough that cells near each other could be chosen and non-overlapping survey transects established.

Each year, we randomly selected grid cells from which to start survey transects (see below) using a generalized random-tessellation stratified (GRTS) sampling design (Stevens and Olsen 2003, 2004). The GRTS sampling method is increasingly being adopted for large-scale environmental monitoring programs, in part because it creates a spatially balanced random sample, while being flexible enough to allow additional samples to be added or removed without compromising the spatial balance of the overall sample (Stevens and Olsen 2003). We used the GRTS algorithm to select 40 starting grid cells and 100 "oversample" locations for the Sacramento River and 10 starting grid cells and 40 "oversample" locations for the Feather River. These oversamples were used to choose extra starting grid cells if time and staffing allowed and to replace random sites that needed to be dropped due to access restrictions or other logistical constraints. A different set of starting grid cells was chosen each year. In 2012, 54 starting grid cells were chosen (44 on the Sacramento River and 10 on the Feather River) and in 2013, 61 starting grid cells (51 on the Sacramento River and 10 on the Feather River).

From each starting grid cell, we established a transect of points at which surveys were conducted. Transects started with a survey point in the GRTS chosen grid cell and continued with survey points spaced at regular intervals through the potential habitat patch until the entire patch had been thoroughly surveyed or the surveyor ran out of time. Transect points were established based on logistical feasibility (ability to move through the site in a timely manner; able to complete in one morning before noon) and in such a way that as much of the patch as possible was covered. Transects ranged from 8 to 34 points. If the patch was entirely covered with time to spare, and another patch was within 500 m and on the same side of the river, the surveyor moved to that patch and surveyed until they ran out of time.

Survey protocol

Surveys were conducted using a call playback protocol developed by Halterman et al. (2011) and adopted by the Western Yellow-billed Cuckoo Working Group. Within a transect, survey points were spaced approximately every 100 m, and five sets of calls (with one minute of silence in between) were played at each point. A recording of a Yellow-billed Cuckoo (provided by M. Halterman) consisting of a contact call (series of "kuks" and "kowlps") was broadcast using an iPod Nano digital music player (Apple, Cupertino, California) and a Big Horn Remote speaker (Cass Creek, Grawn, Michigan). The volume was set to produce ~70 decibels at 1 m, allowing the call to be heard at least 100 m away through vegetation. When a cuckoo was detected, we stopped the call playback and recorded detection information. Points with a detection in one round were surveyed again in subsequent rounds. After a cuckoo detection, the surveyor moved 300 m (skipping points) and resumed the survey to avoid further disturbing or attracting the previously detected individual. If that individual responded again, the surveyor moved further (300 m or more depending on cuckoo behavior) before resuming the survey.

It is possible that after a cuckoo was initially detected, it could be detected again that same day even after the surveyor moved 300 m as specified by the protocol. The surveyor determined if any following detections were of the same bird or another individual using their judgment in the field. The surveyor estimated the location of the cuckoo, determined if and where it moved during observation, and observed habitat characteristics in an effort to keep track of the detected cuckoo. Surveyors were trained and were cautious when making decisions about the true number of cuckoos that were detected. For the purposes of our analysis these same day redetections were not included in any analyses. During the study there were 8 occasions (5 in 2012, 3 in 2013) where a cuckoo was redetected one or more times during a single visit.

All of the transects were surveyed four times, with each visit separated by at least 12 days but no more than 20 days. The survey period was from 15 June to 16 August, corresponding with the height of breeding activity (Hughes 1999). Our surveys were not designed specifically to find nesting activity, but we did attempt to follow individuals for ~30 minutes after their initial detection to record any evidence of breeding.

We added two specifications to the Halterman et al. (2011) protocol to aid in our planned statistical analysis. First, we surveyed the same points during each visit to a transect, whereas the protocol only requires the transects to be surveyed, not individual points. Second, initial starting points for transects were randomly chosen (see above).

Statistical Analysis

We used 500 m grid cells as the analysis unit to summarize our results. This size analysis unit (25 ha) is a good approximation of the average size of a cuckoo territory (Halterman 2009). The grid cells defining the analysis units were derived from the 100 m Military Grid Reference System and those units that contained any amount of potential habitat were included. We chose

to analyze the Sacramento and Feather rivers separately since they have been treated separately during previous survey efforts. We analyzed survey results from 2012 and 2013 separately.

Naïve occupancy

We calculated the naïve occupancy, which was the percent of surveyed analysis units with at least one detection during the four survey rounds. This method does not account for probability of detection, and hence underestimates true occupancy if detectability is less than perfect.

Estimating occupancy for the entire survey area

The naïve occupancy was then applied to the analysis units that were not surveyed to estimate occupancy for the entire survey area. This method relies on our random sample to capture the variability of potential habitat within each analysis unit. More sophisticated occupancy analyses could not be performed due to the paucity of second detections within an analysis unit in a single year.

Comparison to Previous Surveys

Since the early 1970s several comprehensive surveys of the Sacramento and Feather rivers have been conducted. We compiled the reported numbers of Yellow-billed Cuckoos found along the Sacramento and Feather rivers by these previous researchers (Table 2 in the Appendix).

We gathered information on survey effort and results published in journal articles, graduate theses, and reports to government agencies (Table 2 in the Appendix). In an effort to standardize the results of these studies which differ in survey protocol and effort, we calculated the number of cuckoos detected per surveyor day (one person surveying one day). Although the number of hours that were surveyed would be a more accurate account of effort, the majority of studies did not report total survey hours. In addition to differences in reporting effort, there were also differences in how the number of cuckoos detected was reported. In some cases, the total raw number of cuckoo detections was included while in others the total number reported was

modified after some interpretation by the researchers. For example, in some studies certain types of call responses were interpreted as representing a paired cuckoo or an unmated individual (and ultimately reported as two or one respectively), an interpretation which was recently found to be unreliable (Halterman 2009). Hence, to standardize detections for use in comparisons across surveys, we used the most conservative estimate of detections by counting reported pairs as one detection and unmated birds as one detection. When a range of pairs and/or unmated birds was given we chose the low end of each.

RESULTS

Potential Habitat

We estimated a total of 84 potential habitat patches along the Sacramento River and 31 along the Feather River (Figure 1). The potential habitat patches averaged 97 ha (range 15-555 ha) along the Sacramento River and 66 ha (range 17-476 ha) along the Feather River. The total area of potential habitat was 8,134 ha along the Sacramento River and 2,052 ha along the Feather River, for a total of 10,186 ha. Potential habitat was distributed relatively evenly across the entire Sacramento River study area, though the northern half seems to have sections with the largest areas (Figure 2a). Along the Feather River, most of the potential habitat was in the southern portion of our study area (Figure 2b).

Survey Effort

Survey effort was similar between 2012 and 2013 (Table 3). There was a slight increase in the area covered in 2013 due to a larger field crew. Transects were surveyed four times during the survey period. A small number of individual points were surveyed fewer than four times because they were skipped due to a nearby cuckoo detection, predator observation, or excessive noise (i.e., farm equipment).

The area of potential habitat we surveyed depends on the effective range of our broadcast call. The volume of the broadcast call was set high enough to be heard at least 100 m through thick vegetation, therefore it could be heard further in thinner vegetation. We estimated that on average our broadcast call covered a circle with a 150 m radius. Based on this radius, over the two years we surveyed 3,958 ha (48.7% of the total) of potential habitat on the Sacramento River and 862 ha (42.0% of the total) of potential habitat on the Feather River.

Number of Cuckoos

Along the Sacramento River, we detected Yellow-billed Cuckoos on 8 occasions in 2012 and 10 occasions in 2013. Each year there was one detection in restored riparian forest as well as one detection in narrow remnant riparian forest with adjacent restored forest. Detections spanned the length of the study area, though most of them were in the southern half (Figure 3). Only two of the detections were along a transect with a previous detection during the same year.

No cuckoos were detected along the Feather River during either year.

Naïve occupancy rates of approximately 3% along the Sacramento River were similar between years (Table 4). Applying the naïve occupancy rate to all potential habitat in our sampling frame, we estimate that 27-28 analysis units were occupied. If we assume that each occupied analysis unit represents a mated pair of birds, this would suggest a population of under 30 pairs.

Because there were no detections along the Feather River, we cannot estimate occupancy. We have no evidence to indicate that cuckoos continue to occupy potential habitat along the Feather River.

Comparison to Previous Surveys

Our surveys showed substantially lower detections per surveyor day than any other previous study along the Sacramento River (Figure 4, Table 2 in the Appendix) despite a more robust sampling effort. Our rate of detection was 15-75 times lower than previous surveys. Two of the previous five surveys along the Feather River detected small numbers of cuckoos, with the other three surveys having zero detections (Table 2 in the Appendix).

DISCUSSION

Overall, our results suggest that despite significant efforts to increase the amount of available habitat for Yellow-billed Cuckoos along the Sacramento and Feather rivers, this increase has not resulted in an increase in the population. Given that habitat restoration has resulted in positive responses for riparian birds and other taxa in the Central Valley including the Sacramento River (Gardali et al. 2006, Golet et al. 2008, Dybala et al. In press), the lack of response by Yellow-billed Cuckoos suggests that something other than amount of breeding habitat is responsible.

Potential Habitat

Over the last three decades, there have been more than 2,500 ha of riparian forest restored along the Sacramento River (Golet et al. 2008) and more than 400 ha along the Feather River (H. Swagerty personal communication). One of the objectives of these restoration efforts was to create more Yellow-billed Cuckoo habitat (RHJV 2004). These efforts have increased the amount of potential cuckoo habitat, and today we estimate that there are 8,134 ha of potential habitat along the Sacramento River and 2,052 ha along the Feather River.

Understanding how much available habitat has changed over the last 50 years is complicated because previous efforts have used different definitions of potential habitat. There have been two previous efforts to estimate the amount of potential cuckoo habitat along the

Sacramento Valley. In the early 1970s, Gaines (1973) used topographical maps and aerial photographs to estimate there was 1,073 ha of potential cuckoo habitat along the Sacramento River and 121 ha along the Feather River. This analysis was based on the amount of "uncultivated woody vegetation" that was greater than 100 m wide and 10 ha in area. More recently, Girvetz and Greco (2009) used vegetation data from 1997 and 1999 with PatchMorph to estimate there was 6,018 ha of potential cuckoo habitat along the Sacramento River.

While our estimate is larger than both of these estimates, a direct comparison is difficult because ours included patches further from the river reflecting a more recent recognition that cuckoos will use areas > 100 m from the river (Halterman et al. 2001), and because we used a larger minimum patch size (15 ha instead of 5 or 10 ha) than either of these analyses, which reflects more recent information on the home range size of cuckoos (Halterman 2009).

In the Riparian Habitat Joint Venture Riparian Bird Conservation Plan (RHJV 2004), ecologists recommended that 6,070 ha of Yellow-billed Cuckoo habitat on the Sacramento River and 1,012 ha of habitat on the Feather River was necessary to support a self-sustaining population, assuming ~40 ha per pair (Laymon 1998). Their definition of suitable habitat was willow-cottonwood forest of any age that was greater than 100 m in width and 20 ha in area. It should be noted that our estimate included forest patches as small as 15 ha and forest types other than willow-cottonwood, and therefore comparisons should be made with care. In the future, we suggest that revisions to the amount of potential cuckoo habitat should use PatchMorph (Girvetz and Greco 2009) with the parameters we used in this analysis (Supplemental Appendix) and updated vegetation layers. Nonetheless, the amount of currently available potential habitat suggests that restoration efforts have been effective at creating the habitat conditions that were considered important for increasing the number of Yellow-billed Cuckoos.

The successful restoration of cuckoo habitat is underscored by recent findings that cuckoos are using restored riparian forest. In this study, 2 of our 18 cuckoo detections were in areas that had been restored (10-11 years old). In our 2010 surveys, 8 of the 23 detections were in areas restored 6-15 years prior (Dettling and Howell 2011). Surveys of restored areas 4-18 years old along the Sacramento River in 2007-2008 had 10-15 detections (Hammond 2011). Riparian restoration of several ages classes have been effective at creating areas where Yellow-billed Cuckoos are now detected and hence suggests that the amount of potential habitat has greatly increased, even above levels suggested for recovery (RHJV 2004).

Occupancy of Potential Habitat

In both years of the study, we detected Yellow-billed Cuckoos at ~3% of the analysis units we surveyed. Applying this estimate to the entire sampling frame (833 analysis units), we would expect a total of 27 analysis units with detections. If we assume that a detection within an analysis unit represents a pair, this would mean that the population is no more than 27 pairs, which is below the Riparian Habitat Join Venture management goal of 150 pairs (Laymon 1998, RHJV 2004).

This estimate should be interpreted in light of two critical uncertainties. First, by using naïve occupancy, we assume perfect detection. If detection is less than perfect, which it very likely is, then our approach would be an underestimate of the true number of pairs. In Arizona, cuckoos had a detection probability of 32% using the same survey protocol (Halterman 2009). One approach to accounting for imperfect detection is occupancy modeling (MacKenzie et al. 2002). Our survey approach, with four visits to each site, was designed to allow us to perform an occupancy analysis following MacKenzie et al (2002). However, this analysis method relies on

repeated detections over subsequent visits to develop a probability of detection and the very low number of detections on subsequent surveys prevented us from using this approach.

The second uncertainty is the assumption that all detections represent breeding pairs. We believe this assumption is highly unlikely along the Sacramento River given the very low number of analysis units where birds were detected more than once. Both mated and unmated cuckoos have been shown to respond to call-playback surveys with mated cuckoos detected at a higher rate (Halterman 2009). Furthermore, we could not confirm the pair status of any of the cuckoos we detected since we did not observe nesting activity (e.g., cuckoos carrying nest material or food) or more than one cuckoo at any single location.

Comparison to Previous Surveys

Estimating trends in Yellow-billed Cuckoo populations in the Sacramento Valley from historical survey efforts is complicated because these efforts have varied in their survey protocol, effort, habitat sampled, and interpretation of responses. Since 1972 there have been 12 surveys of the Sacramento River and 5 surveys of the Feather River (Table 2 in the Appendix). Some of the studies reported a population estimate based on available habitat and estimated territory size, while others assumed their surveys detected all of the cuckoos. An estimate of 120 pairs along the Sacramento River in 1972 was calculated by assuming all of the estimated 1,200 ha of potential cuckoo habitat was occupied at a density of one pair per 10 ha (Gaines 1974). That 1972 population estimate was revised to 60-96 pairs using a naïve occupancy of 60-80% for the 1,200 ha of habitat (Gaines and Laymon 1984). Surveys of the Sacramento River in 1977 found 29 pairs and estimated up to 60 pairs using a naïve occupancy of 50% (Gaines and Laymon 1984). Halterman (1991) did not estimate a Sacramento River population size but instead made the assumption that all available potential habitat was surveyed and that there was a population

of between 18 pairs (along with 23 unmated) and 35 pairs (31 unmated) from 1987-1990. Similarly from 1999-2000 between 28 and 40 cuckoo pairs were found along the Sacramento River (Halterman et al. 2001). Our naïve occupancy estimate of 28 pairs is lower than most previous estimates and suggests a decline since the earliest surveys, even under a generous assumption that all detections represented pairs of cuckoos.

However, because estimating the number of breeding pairs of cuckoos relies on a number of assumptions, an alternative approach is simply to evaluate the number of detections standardized by the amount of effort. In our analysis of historical surveys, detections per surveyor day decreased from ~3 in early surveys to ~0.05 in our current surveys (Figure 4). Although this method does not account for differences in protocol such as length of playback, the severe decline in detections, despite a substantial increase in effort and potential habitat surveyed, strongly suggests that the Yellow-billed Cuckoo is at-risk of extirpation in the Sacramento Valley. Further, by the time surveys began in the 1970s the cuckoo population was apparently already greatly reduced (Gaines 1974) making a historic decline of even greater magnitude.

Another important difference between our surveys and historical ones is the method for choosing where to survey. Our use of potential habitat defined by remotely-sensed vegetation data and the PatchMorph program in combination with the GRTS sampling method explicitly defines how survey sites were chosen. In 1972, survey sites were chosen "to sample the range of available habitat" (Gaines 1974), and in 1977 they were chosen based on "where the cuckoo has been reported in the past or where habitat appeared to meet the requirements of the species" (Gaines and Laymon 1984). The more recent surveys in 1999 and 2000 focused on "public access riparian areas in California known or suspected to support breeding populations of

Yellow-billed Cuckoos in the last 25 years" (Halterman et al. 2001). Future surveys should clearly define how survey sites were chosen and avoid only surveying where cuckoos have been found or where habitat appears suitable.

The decline of cuckoo numbers along the Sacramento River is unfortunate in light of the decades of investment to create additional habitat. Indeed our naïve occupancy analysis suggests that up to 97% of the potential habitat is unoccupied. In contrast, the Southern California population along the Lower Colorado River has remained stable despite substantial increases in the amount of restored riparian forest (McNeil et al. 2013). For this area, the pattern has been for an increase in use of restored sites and a reduction in use of remnant sites (McNeil et al. 2013). The use of restored forests by cuckoos shown by our work and that of others (Hammond 2011, McNeil et al. 2013) is encouraging despite stable or decreasing populations.

Possible Reasons for Decline

The current limiting factor for the Yellow-billed Cuckoo in the Sacramento Valley is likely not the amount of appropriate vegetation, as there has been a net gain over the last 30 years. Thus, the cause of the continued decline of the population in the Sacramento Valley remains unknown. The decline may be an artifact of the habitat conversion that occurred over the past 150 years which left less than 5% of the historic riparian forest (Katibah 1984). In other words, with such a dramatic loss of habitat, the amount of forest restored may not be enough to slow the decline already in motion. For example, habitat loss may have reduced the cuckoo population to a level at which Allee effects impacted the ability of the population to recover (Stephens and Sutherland 1999, Penteriani et al. 2008).

Another possible contributor to the decline is the condition of food resources. Cuckoos are often observed feeding at outbreaks of caterpillars and large insects (Hughes 1999). If these

insects are less abundant now and/or affected by agricultural pesticides then the reduction in food resources could be a driving factor, especially for juvenile survival, despite an increase in riparian habitat. The impact that pesticides have on prey availability for other insectivorous birds that use habitat in a matrix of agriculture is of increasing concern (Benton et al. 2002, Bouvier et al. 2011, Paquette et al. 2013). However, given that many other species of insectivorous birds are known to be significantly increasing in restored and remnant forests in the Sacramento Valley (Gardali et al. 2006), this explanation would require that the impact of pesticides on food resources for Yellow-billed Cuckoos is substantially different then the effect on prey items of other insectivorous birds.

It is also possible that changes on the wintering grounds and/or during migratory stopovers are impacting the population of cuckoos breeding in the Sacramento Valley either directly by increased mortality in these life stages or indirectly by carry-over effects as has been noted for other migratory species (Holmes 2007, Ockendon et al. 2012). The Yellow-billed Cuckoo spends only 3-4 months in the Sacramento Valley with the rest of the year spent in transit to or on its wintering grounds in South America. Recent studies have begun to shed light onto this part of the cuckoo's life cycle, with some surprising results like late summer movements into Mexico (Rowher et al. 2009, Sechrist et al. 2012) and different spring and fall migration pathways (Sechrist et al. 2012).

Because none of these reasons for decline are mutually exclusive, we believe the most fruitful area of conservation research lies in developing a greater understanding of the full-life cycle of Yellow-billed Cuckoos. Currently, the most important step in that process would be to develop a better understanding of their migratory connectivity, including identifying migration stopover and wintering sites and studying the cuckoo's ecology in those locations.

Management Implications

Our Yellow-billed Cuckoo population estimates for the Sacramento and Feather rivers are well below the targets set by the Riparian Habitat Joint Venture, though our estimates of potential habitat are higher than the targets. Despite the apparent lack of response to restoration for this cuckoo, we still think additional restoration is warranted. If limiting factors are eased, and the population begins to recover, it will be essential to have adequate breeding habitat. Additionally, restoration is known to increase several species of resident and migratory birds in the Sacramento Valley so benefits extend beyond the cuckoo (Gardali et al. 2006) especially in areas with extensive riparian forest within the greater landscape (Gardali and Holmes 2011). Hence, with cuckoos shown to use restored forests (as soon as four years after planting), we recommend continuing to restore riparian forests throughout the Sacramento Valley focusing on areas adjacent to existing forest.

ACKNOWLEDGEMENTS

From the California Department of Fish and Wildlife, we would like to thank D. Wright, C. Nguyen, and H. Lomeli for their help with administrative, logistical and field work. For permission to survey on their property we thank the California Department of Parks and Recreation (D. Rist and J. Dempsey), the Sacramento River National Wildlife Refuge (K. Moroney and J. Silveira), and The Nature Conservancy (R. Luster and G. Golet). J. Roberts and M. Gilbert provided helpful recommendations while developing the sampling design. E. Girvetz assisted with use of PatchMorph. C. Nguyen, D. Wright, J. Silveira, and G. Geupel provided helpful comments on an earlier draft. We truly appreciate the hard work and dedication of our field technicians, B. Abbott, S. Avery, S. Barlow, B. Laurie, A. Levoy, M. Rogers, and L. Smith. Our work was funded by the California Department of Fish and Wildlife (grant #1182002). We would like to acknowledge the US Fish and Wildlife Service Traditional Section 6 – Threatened

and Endangered Wildlife Program for providing the funding to the California Department of Fish and Wildlife. This is Point Blue contribution #1987.

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TABLES

Table 1. Vegetation types (from Sawyer et al. 2009) that characterize the riparian classifications chosen to define potential Yellow-billed Cuckoo habitat. RWF=Riparian Evergreen and Deciduous Woodland, RWS=Southwestern North American riparian wash/scrub.

Classification	RWF	RWS
Vegetation types	*Acer negundo* alliance	*Baccharis salicifolia* alliance
	Juglans hindsii stands	*Cephalanthus occidentalis* alliance
	Platanus racemosa alliance	*Rosa californica* alliance
	Populus fremontii alliance	*Salix exigua* alliance
	Quercus lobata alliance	*Salix lasiolepis* alliance
	Salix gooddingii alliance	*Sambucus nigra* alliance
	Salix laevigata alliance	

Table 3. Yellow-billed Cuckoo survey effort along the Sacramento and Feather rivers, 2012-13. Area of potential habitat surveyed assuming the call playback elicits a response within an average of 150 m radius of the survey point.

	Sacramento River		Feather River	
Survey Effort	**2012**	**2013**	**2012**	**2013**
Transects	44	51	10	10
Points	1100	1283	288	270
Person hours	875	845	207	179
Surveyor days	182	204	40	40
Surveyed potential habitat (ha)	2571	2902	643	573

Table 4. Naïve occupancy estimates for Yellow-billed Cuckoos in surveyed analysis units for 2012 and 2013. Estimate of occupied analysis units based on all 500 m grid cells that contain at least some potential habitat.

	Sacramento River		Feather River	
	2012	**2013**	**2012**	**2013**
Naïve occupancy rate	0.032	0.033	0	0
Estimated # of occupied analysis units	26.9	27.5	0	0

FIGURE LEGENDS

Figure 1. Study area (shaded) for Western Yellow-billed Cuckoo surveys along the Sacramento and Feather rivers along with potential habitat (green). Inset 1 shows study area in context of the breeding range (black) of the Yellow-billed Cuckoo in the western USA (Birdlife International and NatureServe 2012). Inset 2 illustrates an example section of the study area with the potential habitat (green).

Figure 2a-b. Hectares of potential Western Yellow-billed Cuckoo habitat from north to south in 5 km increments along the (A) Sacramento and (B) Feather rivers, CA with city names as reference points.

Figure 3. Locations of Western Yellow-billed Cuckoo surveys during our study (gray outlined boxes) and detections during surveys in 2012 (filled gray boxes) and 2013 (black boxes), along the Sacramento River (panels A, B, and C from north to south) and Feather River (panel D), CA. Green areas represent potential Yellow-billed Cuckoo habitat.

Figure 4. Number of Western Yellow-billed Cuckoo detections per surveyor day for surveys along the Sacramento River, 1972-2013. Dashed lines connect non-consecutive survey years.

FIGURES

Figure 1

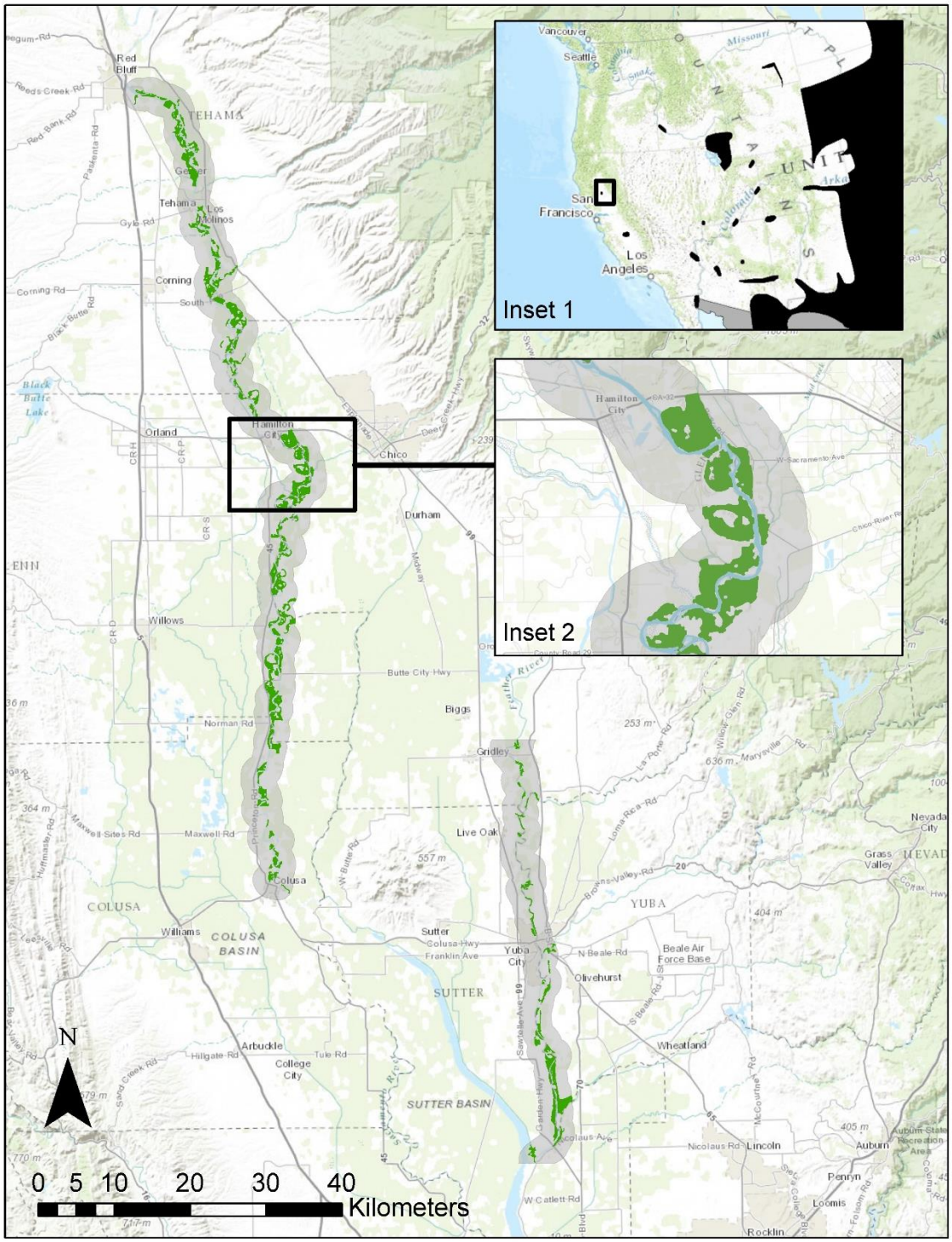


Figure 2

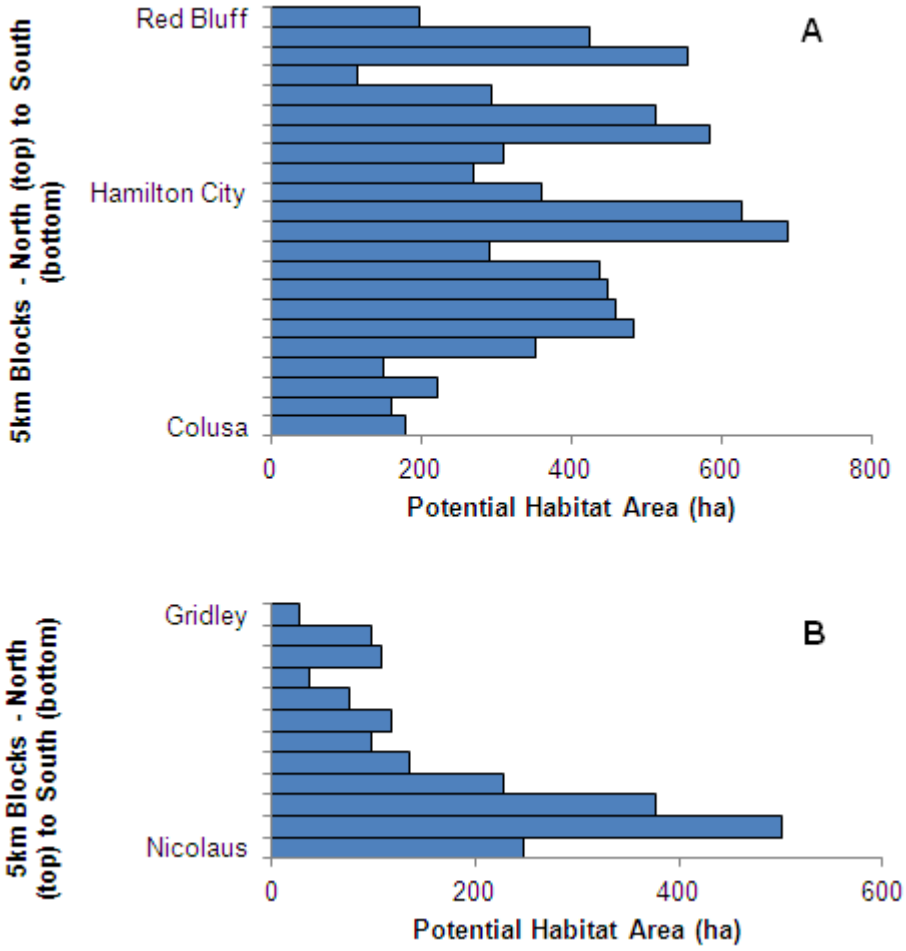

Red Bluff
Hamilton City
Colusa
5km Blocks - North (top) to South (bottom)
0
200
400
600
800
Potential Habitat Area (ha)
A
Gridley
Nicolaus
5km Blocks - North (top) to South (bottom)
0
200
400
600
Potential Habitat Area (ha)
B

Figure 3

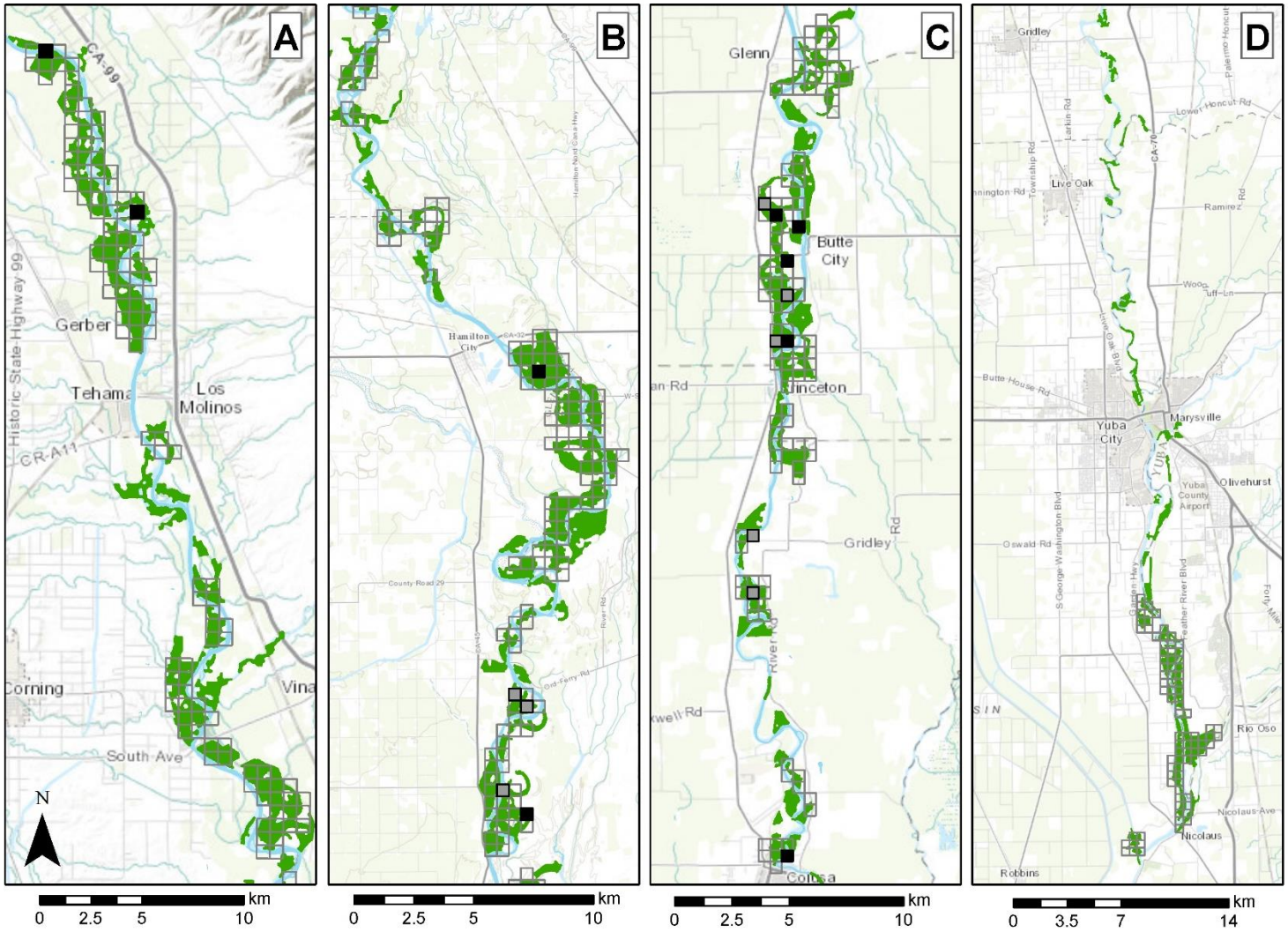
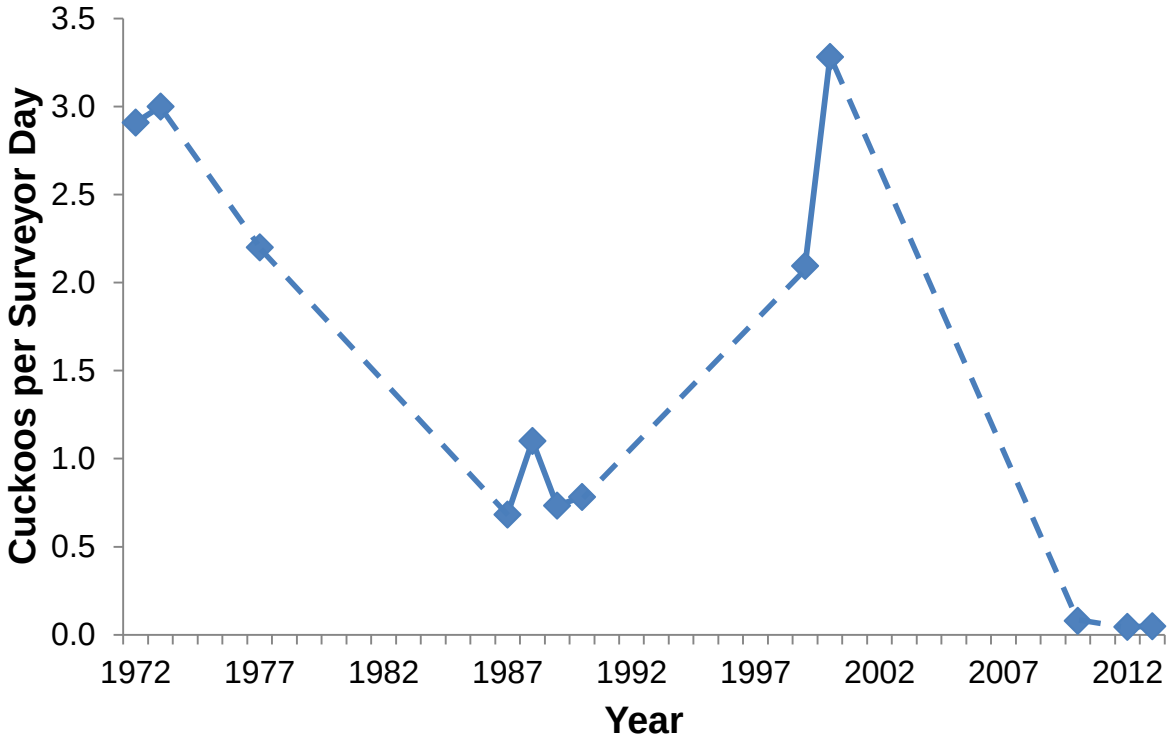

A
B
C
D
Gerber
Los Molinos
Corning
Vina
South Ave
CR-A11
Historic State Highway 99
Hamilton City
Glenn
Butte City
Princeton
Gridley
Colusa
River Rd
Live Oak
Yuba City
Marysville
Olivehurst
Rio Oso
Nicolaus
Robbins
N
km
0 2.5 5 10
0 2.5 5 10
0 2.5 5 10
0 3.5 7 14

Figure 4


Cuckoos per Surveyor Day
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1972
1977
1982
1987
1992
1997
2002
2007
2012
Year

APPENDIX

Table 2. Historic to current Yellow-billed Cuckoo survey studies along Sacramento and Feather rivers, 1972 to 2013. Information included is the number of cuckoos reported, number of rounds of survey per breeding season, citation, number of surveyor days (the total number of days a survey was conducted by each person conducting surveys), range of survey dates, our conservative estimate of the number of cuckoo detections (derived by assuming any reported pair was only single a detection of one individual and each unmated detection was one individual), and the number of cuckoos per surveyor day. The 2007 and 2008 study on the Sacramento River only surveyed restored habitat within the Sacramento River National Wildlife Refuge and hence was not used in the analysis of change.

Year	Reported Results	# Survey Rounds	Citation	Surveyor Days	Date Range	# Cuckoo Detections	Cuckoos/Surveyor Day
			Sacramento River				
1972	32 individuals	1	Gaines 1973	11	7/6-8/10	32	2.909
1973	33 individuals	1	Gaines 1973	11	6/23-8/23	33	3.000
1977	44 individuals	1	Gaines and Laymon 1984	20	6/5-7/31	44	2.200
1987	18 pairs, 23 unmated	3	Halterman 1991	60	6/15-8/15	41	0.683
1988	35 pairs, 31 unmated	3	Halterman 1991	60	6/15-8/15	66	1.100
1989	26 pairs, 18 unmated	3	Halterman 1991	60	6/15-8/15	44	0.733
1990	23 pairs, 24 unmated	3	Halterman 1991	60	6/15-8/15	47	0.783
1999	41 mated, 26 unmated	3	Halterman et al. 2001	32	6/17-8/11	67	2.094
2000	48 mated, 57 unmated	3	Halterman et al. 2001	32	6/17-8/9	105	3.281
2007	3 pairs, 12 individual	3-5	Hammond 2011		~6/15-8/31	15	
2008	1 pair, 9 individuals	3-5	Hammond 2011		~6/15-8/31	10	
2010	23 individuals	4	Dettling and Howell 2011	288	6/14-8/17	23	0.080
2012	8 individuals	4	This study	182	6/15-8/16	8	0.044
2013	10 individuals	4	This study	204	6/15-8/16	10	0.049
			Feather River				
1972	0 individuals	1	Gaines 1973	3	7/12-8/3	0	0.000
1973	0 individuals	1	Gaines 1973	2	7/11-7/12	0	0.000
1977	1 individual	1	Gaines and Laymon 1984	1	6/26	1	1.000
1987	1 pair, 5 unmated	3	Laymon and Halterman 1989	?	?	6	
1999	0 individuals	3	Halterman et al. 2001	6	6/28-7/26	0	0.000
2012	0 individuals	4	This study	40	6/21-8/3	0	0.000
2013	0 individuals	4	This study	40	6/20-8/9	0	0.000

SUPPLEMENTAL APPENDIX

PatchMorph inputs for the Sacramento River.

Run name = Sac2
Input landcover map = Sac_RWFRWS
Landcover map field = YBCU_HAB
Cell size = 10

Density Filter

Density filter = 0
Density neighborhood = 5
Density threshold = 0.25

Hard Barrier

Hard barrier = 1
Hard barrier map = Sac_RWFRWS
Hard barrier map field = WATER

Habitat Suitability

Minimum suitability = 0
Maximum suitability = 1
Number of suit. categories = 2

Hierarchical Patch Delineation

Gap then Spur = True
Spur then Gap = False

Threshold Perception Values

Landcover gaps removed = 1
Landcover gap--low = 100
Landcover gap--high = 100
# of hierarchical levels = 1
Iterate hierarchy = 0

Landcover spurs removed = 1
Landcover spur--low = 100
Landcover spur--high = 100
# of hierarchical levels = 1
Iterate hierarchy = 0

Minimum area of patch = 0

PatchMorph inputs for the Feather River.

Run name = Fthr2
Input landcover map = Feather_RWFRWS
Landcover map field = YBCU_HAB
Cell size = 10

Density Filter

Density filter = 0
Density neighborhood = 5
Density threshold = 0.25

Hard Barrier

Hard barrier = 1
Hard barrier map = Feather_RWFRWS
Hard barrier map field = WATER

Habitat Suitability

Minimum suitability = 0
Maximum suitability = 1
Number of suit. categories = 2

Hierarchical Patch Delineation

Gap then Spur = True
Spur then Gap = False

Threshold Perception Values

Landcover gaps removed = 1
Landcover gap--low = 100
Landcover gap--high = 100
# of hierarchical levels = 1
Iterate hierarchy = 0

Landcover spurs removed = 1
Landcover spur--low = 100
Landcover spur--high = 100
# of hierarchical levels = 1
Iterate hierarchy = 0

Minimum area of patch = 0

Section II

Breeding Evidence for Yellow-billed Cuckoos in the Sacramento Valley

INTRODUCTION

Our surveys in 2012 and 2013 (Section I) were focused on presence of Yellow-billed Cuckoos (hereafter "cuckoo") and were not designed specifically to determine breeding status. However, we did make an effort to gather information about breeding status when a cuckoo was detected. Here we present the results of those efforts.

METHODS

When a cuckoo was detected, the surveyor attempted to locate the bird and observe its behavior. The surveyor would spend up to 30 minutes looking for or watching the individual. We did not spend more time observing since the survey needed to be completed. The location of the individual was marked with a GPS unit and notes on behavior that may indicate nesting (pair interactions, nest, carrying nest material or food) were taken. Observations were made with as little disturbance as possible. If the bird was exhibiting nesting behavior, a follow-up visit occurred within 3 days to attempt to locate the nest. Nest searching guidelines from Martin and Geupel (1993) were followed to minimize disturbance. Had a cuckoo nest been located, it would have been monitored to determine the fate.

RESULTS

2012

We spent 15.62 hours observing cuckoos or searching for cuckoos after their initial detection on a survey. Some of the sighting locations were visited on following days and accounted for another 4.77 hours of observation. We did not find breeding evidence during the 20.39 hours of observation.

2013

We spent 8.52 hours observing cuckoos or searching for cuckoos after their initial detection on a survey. We did not find breeding evidence during these observations.

DISCUSSION

Although no evidence of breeding was observed, this should not be interpreted as the absence of a breeding population of cuckoos in the Sacramento Valley. Our surveys were designed as presence/absence surveys and are not ideal for confirming breeding. The use of call playback surveys alters the activity of the cuckoos making it more difficult to observe natural activity. The cuckoos would often respond by flying closer to the surveyor. After the surveyor stops the call playback, it is unclear how long it takes for cuckoos to resume natural activity. We were not able to observe birds for more time since our main objective was to survey as much potential cuckoo habitat as possible.

If future surveys include a breeding confirmation component, they will need to be modified. We recommend a crew large enough to complete a similar number of surveys as the 2012-13 effort as well as additional crew tasked with following up detections with more observation effort. Confirmation of breeding and determination of nest success are important pieces of information for future conservation decisions.

Section III

Yellow-billed Cuckoo Vegetation Surveys and Summary

INTRODUCTION

In 2012 and 2013 we conducted surveys (see Section I) for Yellow-billed Cuckoos (hereafter "cuckoo") along the Sacramento and Feather rivers. In an effort to quantify the vegetation structure, we measured vegetation at all of our cuckoo survey points and the locations of cuckoo detections. Here we summarize these vegetation surveys.

METHODS

Vegetation data were collected at all survey points, survey detection locations, and additional locations where cuckoos were detected outside of the survey effort. The vegetation data were taken in August during each year. The distance from water (standing or flowing) and distance to the river were estimated either on site or from satellite imagery. To quantify vegetation at a point, we established an 11.3 m radius plot, with the survey point or detection location as the center. The protocol was designed to captured forest structure and composition, without requiring an excessive amount of time.

Within the circular plot, we visually estimated canopy height in three categories, high canopy (95% of green canopy foliage is below this height), low canopy (95% of green canopy foliage is above this height), and average canopy height (50% of green canopy foliage is above this height). We also estimated percent canopy cover above 5 m and vegetative cover (%) in four height categories (1.4-5 m, 5-15 m, 15-30 m, and >30 m). Additionally, for individual tree species that covered greater than 5% of the plot, we estimated the maximum height and canopy cover in the same four height categories. Low cover (%) was assessed in broad categories: leaf litter/logs/bare, water, live woody, other, and nothing. The data form and a more detailed protocol can be found in the Appendix.

We summarized the vegetation structure for locations with and without cuckoo detections for each year, as well as for the two survey years combined (Tables 1-4).

RESULTS

We measured vegetation at 2,962 locations (1,409 in 2012 and 1,553 in 2013) with Yellow-billed Cuckoo detections constituting 35 of those locations. There were 18 cuckoo survey detection locations (8 in 2012 and 10 in 2013) and an additional 17 locations (14 in 2012 and 3 in 2013) where cuckoos were detected on a follow up visit or where an individual was redetected the same day following its original detection. We chose to include these additional locations since they significantly increased the number of sites with cuckoos present.

Between survey years the canopy height and cover was similar for both the locations with and without cuckoo detections along the Sacramento River (Tables 1-2). When we combine data from both years we see a suggestion that cuckoos prefer a taller canopy that provides more cover throughout the canopy strata (Table 3). Vegetation structure was similar between the Sacramento and Feather rivers (Table 2).

The vegetation at cuckoo detections in restored sites was similar to the vegetation at detections in remnant forest (Table 4). The remnant forest appears to have more canopy cover in the higher strata than the restored forest.

Table 1. Vegetation characteristics of Yellow-billed Cuckoo detection locations along the Sacramento and Feather rivers, 2012-13. (n=number of vegetation plots surveyed).

	Sacramento River		**Feather River**	
Characteristic	**2012** (n=22)	**2013** (n=13)	**2012** (n=0)	**2013** (n=0)
Distance to water (m)	205.6	270.8	NA	NA
Distance to river (m)	338.1	434.7	NA	NA
High Canopy Height (m)	16.8	19.2	NA	NA
Low Canopy Height (m)	2.5	2.8	NA	NA
Average Canopy Height (m)	10.5	12.2	NA	NA
Total Canopy Cover (%)	68.8	69.6	NA	NA
Cover between 1.4-5 m (%)	52.1	34.2	NA	NA
Cover between 5-15 m (%)	62.0	56.5	NA	NA
Cover between 15-30 m (%)	31.9	40.0	NA	NA

Table 2. Vegetation characteristics of Yellow-billed Cuckoo survey locations without detections along the Sacramento and Feather rivers, 2012-13. (n=number of vegetation plots surveyed).

	Sacramento River		**Feather River**	
Characteristic	**2012** (n=1103)	**2013** (n=1270)	**2012** (n=284)	**2013** (n=270)
Distance to water (m)	237.0	262.5	235.0	275.9
Distance to river (m)	477.6	434.0	387.1	526.9
High Canopy Height (m)	15.4	12.4	14.3	11.5
Low Canopy Height (m)	1.3	1.6	1.3	1.4
Average Canopy Height (m)	8.1	7.2	7.7	6.6
Total Canopy Cover (%)	40.9	36.3	33.1	27.4
Cover between 1.4-5 m (%)	37.3	33.5	28.0	24.4
Cover between 5-15 m (%)	34.3	31.3	28.6	24.0
Cover between 15-30 m (%)	14.0	8.4	9.4	5.1

Table 3. Vegetation characteristics of Yellow-billed Cuckoo detection and survey locations for both years combined along the Sacramento and Feather rivers, 2012-13. Detections were only along the Sacramento River. (n=number of vegetation plots surveyed).

		No detections	
Characteristic	**Detection locations** (n=35)	**Sacramento River** (n=2373)	**Feather River** (n=554)
Distance to water (m)	229.8	250.6	254.9
Distance to river (m)	374.0	454.2	455.2
High Canopy Height (m)	17.7	13.8	13.0
Low Canopy Height (m)	2.6	1.5	1.3
Average Canopy Height (m)	11.2	7.6	7.2
Total Canopy Cover (%)	69.1	38.5	30.3
Cover between 1.4-5 m (%)	45.3	35.3	26.2
Cover between 5-15 m (%)	59.9	32.7	26.4
Cover between 15-30 m (%)	35.0	11.0	7.3

Table 4. Vegetation characteristics of Yellow-billed Cuckoo detections in remnant and restored forest along the Sacramento River. (n=number of vegetation plots surveyed).

Characteristic	**Remnant forest** (n=33)	**Restored forest** (n=2)
Distance to water (m)	234.8	148.5
Distance to river (m)	331.4	1076.5
High Canopy Height (m)	17.8	16.5
Low Canopy Height (m)	2.7	1.5
Average Canopy Height (m)	11.2	9.5
Total Canopy Cover (%)	70.2	52.5
Cover between 1.4-5 m (%)	45.2	47.5
Cover between 5-15 m (%)	61.8	30.0
Cover between 15-30 m (%)	35.6	25.0

DISCUSSION

The basic summaries we provide here are a helpful guide to what habitat was surveyed and currently exists out on the rivers.

With our previous work in 2010 we were unable to find statistically significant differences between locations with and without Yellow-billed Cuckoo detections (Dettling and

Howell 2011). This prior information and the small number of detections we had on the current survey led us to only summarize vegetation characteristics. Our experiences in the field suggest that any differences would be heavily influenced by the small sample size and that minor differences might be amplified.

These data should be interpreted cautiously. First, our vegetation survey plots were 11.3 m radius and our survey calls covered an at least 100 m radius. The smaller vegetation plot was chosen to allow for the large number of surveys we had conducted. In many cases the survey point was within the riparian forest and represents the forest structure well, but in other cases the survey point was on the edge of the forest and may include some vegetation that was not used by cuckoos. Our surveys were able to capture finer detailed information about canopy structure that could not be acquired with remotely sensed vegetation data.

Second, the locations of cuckoo detections might not represent breeding territories (see Section I). We did not find evidence of breeding during our surveys (see Section II) raising the possibility that the cuckoos were not on territory. If this were the case then our results might not accurately portray the preferred breeding vegetation structure in the Sacramento Valley. Focused breeding studies are needed to narrow down the definition of breeding habitat for Yellow-billed Cuckoos in the Sacramento Valley.

Only two of our detections were in restored riparian forest with vegetation characteristics similar to that of remnant riparian forest (Table 4). Previous work by Hammond (2011) found a few significant differences in restored forest with cuckoo detections compared to restored forest without detections. She found that restorations with cuckoo detections had great canopy cover, more willow shrub area, and higher average shrub height. These findings also come with the caveat that these characteristics can only be associated with cuckoo use and not necessarily

breeding since no breeding evidence was found. Comparisons with remnant riparian forest were not included.

LITERATURE CITED

Dettling, M. D., and C.A. Howell. 2011. Status of the Yellow-billed Cuckoo along the Sacramento River in 2010. Report to California Department of Fish and Game. PRBO Contribution #1794.

Hammond, J. E. 2011. It was built…did they come? Habitat characteristics of Yellow-billed Cuckoo in restored riparian forests along the Sacramento River, California. M.S. thesis, California State University, Chico, CA, USA.

Appendix

POINT BLUE YBCU VEGETATION FORM

Site Code: _____ Site Name:_____ Transect #:_____ Point #:_____

Observer: _____ Date(mm/dd/yyyy)**:___/___/____ Time:_____**

From Map - Distance to Water: _____ Distance to Sac. River: _____ Edge? Y / N

High Canopy ht: 95% of green canopy foliage is below this height	
Low Canopy ht: 95% of green canopy foliage is above this height	
Average ht of canopy:	
% Total Canopy Cover (above 5m):	

Tree Cover Visual Estimates

Record the percent cover of ALL live tree species within each strata, as well as EACH tree species within each strata	**Max ht of each tree species**	**% Cover within 11.3m radius circle by height strata (in 5% increments if >10%)**			
		>1.4 - 5m	**>5-15m**	**>15-30m**	**>30m**
ALL trees (% cover)					
Record individual woody species below					

Low Cover Visual Estimates

Visual Cover Estimates (%)	**0 to 50 cm**	**>50cm to 1.4 m**
Leaf litter/Logs/Bare		
Water		
Other		
Woody (live)		
Nothing		
TOTAL	**100%**	**100%**

Up to three most common shrub species:	

	Date	**Init**
Review:		
Data Entry:		
Proof :		

Notes: _____

Yellow-billed Cuckoo Vegetation Survey Protocol

Follow the transect and stop at every point to complete a vegetation survey. At the point, visually establish an 11.3 meter radius survey plot. You should walk around the plot if you cannot see it all from the center. If you are on the boat, do your best to estimate. These surveys will characterize the survey location. We have remote sensing data that characterizes the area on a broader scale. These surveys are intended to be quick, so please don't spend time deciding between a couple percentage points.

Site Code, **Site Name**, **Transect #**, **Point #, Observer**, **Date**, and **Time** are self explanatory.

Distance to water – From a map (probably Google Earth), estimate the distance in meters to closest water. May be a slough, stream or the main river. If closest water is the river, then will be the same as **Distance to Sac. River**. If water is not visible on map, please estimate while in the field.

Edge – Yes or No. An edge is where the forest meets a substantially different habitat (gravel bar, grassy field, river) not associated with cuckoos. This is not necessarily the edge of the survey plot. If the open area is small (less than 50m wide), this is not an edge. If the change in habitat is from forest with thick blackberry understory to forest with grass understory, this is not an edge. In general, you are at an edge when the non-cuckoo habitat makes up more than 25% of your vegetation plot.

High canopy ht – Height in meters of the top of the canopy. 95% of the green foliage will be below this height.

Low canopy ht – Height in meters of the bottom of the canopy. 95% of the green foliage will be above this height. This will often be below 5m as there are short trees with low branches.

Average ht of canopy – Height in meters of canopy for which 50% of the green foliage is above/below.

% Total Canopy Cover – Visual estimate of cover provided by canopy above 5m in the 11.3m radius plot.

Tree cover visual estimates – A list of tree species will be provided. This section only concerns species on that list. If you come across a tree not on the list, please record it and check with your supervisor to see if it should be included in the tree list. Cover estimates will be made within an 11.3 meter radius.

In the ALL Trees category, record the % cover of all trees combined for each of the 4 height categories. To estimate the cover imagine all the other layers are gone and you are floating above the plot, then estimate how much of the plot is covered by that layer.

For the individual tree species, record the 4-6 letter code for each species present in the plot and estimate the maximum height of that species. Within each height category, record the percentage of the plot covered by each individual species. The percentage of cover of the individual species should add up to approximately the percentage of cover for all species in each height category. It may not be exact since species may overlap, but will not be less than the percentage for all trees. Estimates should be in 5% increments once above 10% cover. Species that make up only a few percent can be ignored.

Low cover visual estimates – Cover in two height categories near the ground will be assessed using general categories in the 11.3m radius plot. The cover estimates for each height category will add up to 100%. The definitions of the categories are:

Leaf litter/Logs/Bare – Dead leaves, flattened forbs, flattened grass, logs, bare dirt or rocks.

Water – Still or moving water.

Other – Usually vegetation not covered by other categories (forbs, grasses, non-woody).

Woody (live) – Live woody vegetation, shrubs, vines, blackberry.

Nothing – This category is for the 1.4 to 5m height range and will be the percentage of cover not taken up by the other categories.

Most Common shrub species – List up to three of the most common shrub species (as listed on the plant list). These should be common on the plot, so do not record species with only a few small individual plants.

Notes – Please make notes that you think are relevant to the vegetation survey.