Yellow-billed Cuckoo Occupancy, Breeding, and Habitat Use in the South Fork Kern River Valley, 2012 Annual Report

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Executive Summary

The Western Yellow-billed Cuckoo (*Coccyzus americanus occidentalis*) is a neotropical migrant that formally bred in riparian regions throughout the western United States (Hughes 1999). However, over the last 100 years wide-spread loss of their preferred cottonwood/willow habitat has resulted in the extirpation of the cuckoo from most of its historic range (Laymon and Halterman 1987, Hughes 1999). In California, cuckoos are now generally restricted to remnant habitat pockets along the Sacramento Valley, the Kern River, and the lower Colorado River with individuals occasionally reported in other areas (Laymon and Halterman 1987). Concern for the species has resulted in interest by state and federal agencies and private conservation organizations to monitor populations and have led to the Western Yellow-Billed Cuckoo being listed as: (1) endangered by the California Department of Fish and Game; (2) a Species of Special Concern by the Arizona Game and Fish Department; (3) a sensitive species by the U.S. Forest Service; and (4) a candidate for listing under the Federal Endangered Species Act (ESA) by the U.S. Fish and Wildlife Service.

The South Fork Kern River Valley (SFKRV) has been a consistent cuckoo breeding area for over 30 years (Gaines 1977, Schonholtz 1983, Laymon et al. 1997, Henneman 2009), holds one of the largest remaining contiguous cottonwood/willow forests in the state of California (Gaines 1977), and contains one of the largest populations of cuckoos in the state of CA. As such, the SFKRV provides critically important habitat for the Western Yellow-billed Cuckoo and this important breeding area should be studied, monitored, and managed to ensure that the local cuckoo population remains stable and to expand our understanding of the relationships between cuckoos and their habitat. This report details (1) surveys conducted in the SFKRV riparian areas between mid-June and mid-August 2012 to assess Yellow-billed Cuckoo occupancy using the latest cuckoo survey methods, (2) documentation of nesting success of breeding cuckoos, (3) and habitat characteristics vital to cuckoo habitat use. The goal of this research is to verify the status of the SFKRV Yellow-billed Cuckoo population and identify critical habitat information currently unknown to scientists and land managers to aid in the recovery of the species and reverse the trend toward the potential protected listing under the ESA.

Introduction

Yellow-billed Cuckoo History and Biology

Over the last 100 years, western cuckoo population declined dramatically due to extensive loss 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). Once considered a common breeder in California, by 1940 the Yellow-billed Cuckoo suffered severe population reduction (Grinnell and Miller 1944) and by 1987 was estimated to occupy only 30 percent of its historical range (Laymon and Halterman 1987). California statewide surveys conducted in 1977 (Gaines and Laymon 1984), 1986/1987 (Laymon and Halterman 1987), and 1999 (Halterman et. al 2001) found Yellow-billed Cuckoo populations were concentrated mostly along the Sacramento River from Red Bluff to Colusa, along the South Fork of the Kern River, and portions of the Lower Colorado River (LCR). Population estimates on the Sacramento and Kern Rivers from the 1999 surveys were similar to those of the 1986/1987 surveys, but lower when compared to the 1977 survey. The Lower Colorado River population appeared to suffer severe declines in the 12 years from the 1986/87 to the 1999 surveys.

In 2001, the United States Fish and Wildlife Service (USFWS) determined that western yellow-billed cuckoos represent a Distinct Population Segment (DPS), and as such became a candidate for protective listing under the Endangered Species Act (USFWS 2001). In 2002, the listing was determined to be warranted but precluded by higher priority listing actions (due to limited resources) (USFWS 2002). A final listing decision is expected to be published in 2013 (USFWS 2011). Yellow-billed cuckoos are recognized as state endangered in California (CDFG 1978), a species of special concern in Arizona (AGFD 1988), and a sensitive species on US Forest Service lands within Arizona and New Mexico (USDA 1988).

Yellow-billed cuckoos are among the latest-arriving Neotropical migrants. They arrive on their breeding grounds in Arizona and California by June (Bent 1940, Hughes 1999). Diet during the breeding season consists primarily of large insects such as grasshoppers, katydids, caterpillars, praying mantids, and cicadas; also tree frogs and small lizards (Bent 1940, Hamilton and Hamilton 1965, Nolan and Thompson 1975, Laymon 1980, Laymon et al. 1997). 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*) and Red willow (*S. laevigata*) (Laymon et al. 1997). Nests consist of a loose platform of twigs, which are built by both sexes and take one to two days to build (Hughes 1999), though occasionally the nest of another species is used (Jay 1911, Bent 1940, Payne 2005). Clutch size is 1-5 (Payne 2005), though up to 8 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 mostly large insects (Laymon and Halterman 1985, Laymon et al. 1997, Halterman 2009) similar to the adult diet. Young fledge after 5 to 7 days, but may be dependent on adults for at least three weeks (Laymon and Halterman 1985).

Fall migration is thought to begin in late August, with most birds gone by mid-September (Hughes 1999); however on the Lower Colorado River some individuals appear to begin migrating in early August (McNeil et al. 2011). Their non-breeding range is believed to be the western side of the Andes (Hughes 1999), though little information exists on 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).

Objectives

The objectives of this project are as follows:

1) Determine the overall level of occupancy for Yellow-billed cuckoos from comprehensive surveys conducted in all habitat types within the South Fork of the Kern River Valley.

2) Conduct nest searching and monitoring to understand reproductive success and habitat characteristics that may influence the breeding population.

3) Conduct radio-telemetry during the breeding season to investigate habitat use, home range size, and breeding status.

This report details (1) surveys conducted in the SFKRV riparian areas between mid-June and mid-August 2012 to assess Yellow-billed Cuckoo occupancy using the latest cuckoo survey methods, (2) documentation of nesting success of breeding cuckoos, (3) and habitat characteristics vital to cuckoo and habitat use. The goal of this research is to verify the state of the SFKRV Yellow-billed Cuckoo population and identify critical habitat information currently unknown to scientists and land managers to aid in the recovery of the species and reverse the trend toward the potential protected listing under the ESA.

Chapter 1. Presence-Absence Surveys, Detection Probability, and Habitat Occupancy

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, occupancy, 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 response to environmental changes such as habitat restoration or creation.

In 2012, we continued our long-term monitoring of yellow-billed cuckoos (cuckoo, ybcu) within the SFKRV to provide an annual status assessment of the species and to identify trends in cuckoo populations. Through repeated surveys, we estimated cuckoo detection probability and habitat occupancy in the study area. The analyses are stratified by survey area (South Fork Wildlife Area [SFWA] and the Audubon Kern River Preserve [KRP]) to maximize our power to detect cuckoo differences between these two areas. While surveys designed to monitor a species can uncover patterns of distribution and occupancy, the mechanisms behind these patterns are often better discerned through supplemental research (such as nest observations, radio telemetry, and habitat analyses) described in Chapters 2-5.

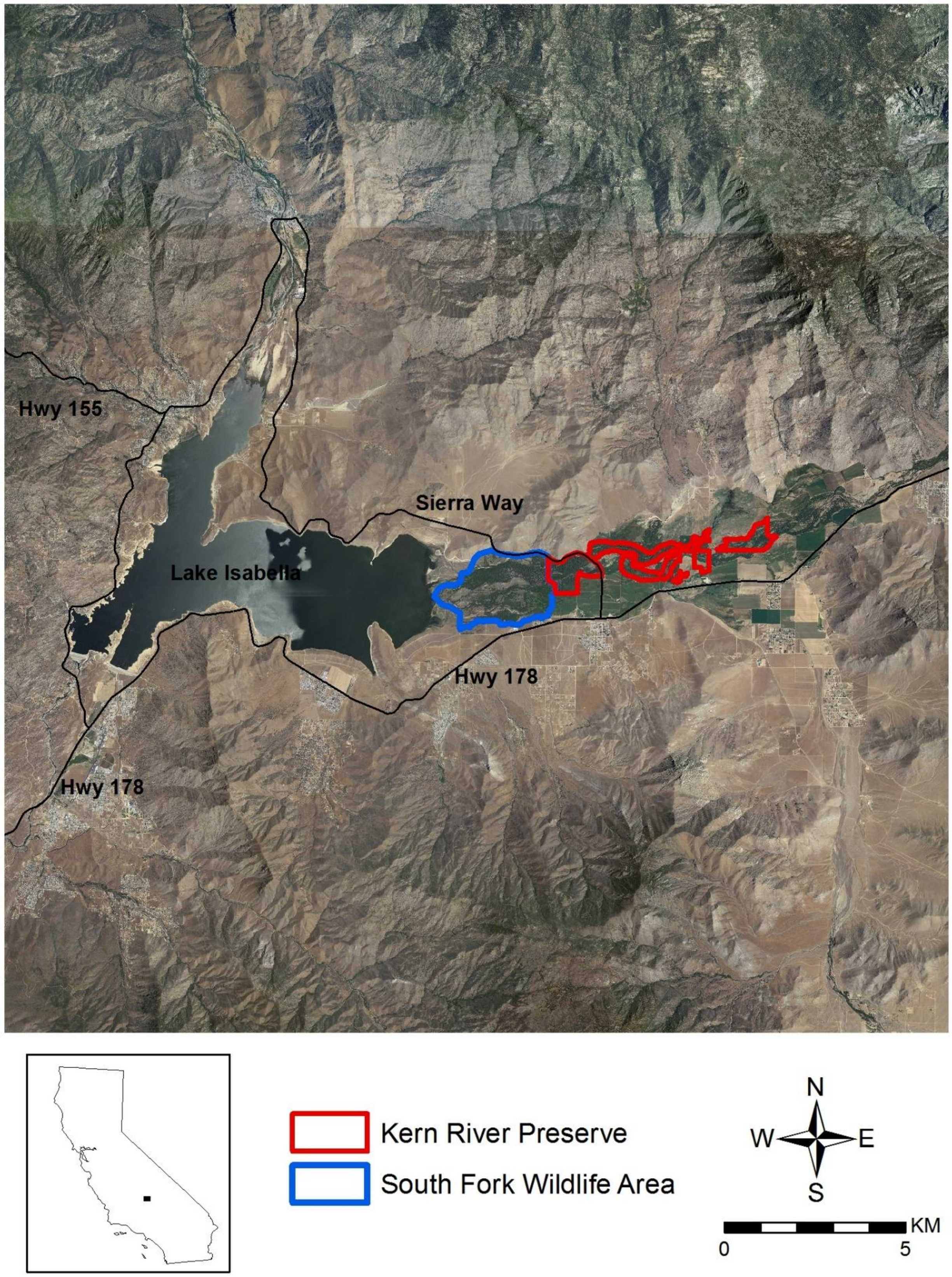
Methods

Study Area and Survey Route Selection

We conducted yellow-billed cuckoo surveys along a 6-river-mile stretch of the South Fork Kern River (Map a). Along this river stretch, all potentially suitable habitat was considered for inclusion. We also surveyed the extensive burn area (burned May 27-29, 2011) along the southern boundary of the SFWA to track the natural revegetation of this area and the cuckoos' eventual return to this portion of the riparian forest. Survey routes were located within part of a habitat patch, an entire habitat patch, or a collection of patches of potentially suitable habitat. We assessed survey routes by ground reconnaissance and selected these routes based on past cuckoo detections (Henneman 2009, 2010, Whitfield and Stanek 2011), patch size, plant species composition, and habitat structure (generally woody riparian land cover, at least 4-5 m in height).

Presence-Absence Surveys

The primary survey objective was to confirm the presence or absence of yellow-billed cuckoos at an area. Cuckoos are inherently secretive, avoid detection and call infrequently (Hamilton and Hamilton, 1965). Their furtive nature coupled with their somewhat transitory behavior lead to imperfect detection of the species (McNeil et al. 2010, 2011). Also, the use of call-broadcasts can attract cuckoos from neighboring habitat into the surveyed habitat. Furthermore, analyses of multi-year detection trends show that June migratory arrival differences adds considerable variation to annual detection totals and that cuckoo detectability is affected by cuckoo density, nesting stage and breeding phenology (McNeil et al. 2013). Given these observations, the surveys are not designed to determine the absolute number of cuckoos within an area, to solely identify breeding status, or be used to assess small-scale habitat preferences.



Map a. Yellow-billed cuckoo survey areas in the South Fork Kern River Valley, Kern Co., California in 2012.

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 occupancy (Johnson et al. 1981, Gaines and Laymon 1984, Halterman et al. 2009). We conducted five surveys between June 17th and August 15th (Table 1-4). We added an extra July survey relative to the current draft protocol suggestions (Halterman et al. 2009) so that the majority of surveys (three of five) were conducted in July during the peak of cuckoo detectability, site occupancy, and breeding activity (Laymon et al. 1997, McNeil et al. 2010, 2011). The probability of detecting a cuckoo during the times preceding and following this peak have been observed to be relatively lower, in the SFKRV (Henneman 2009, Whitfield and Stanek 2011), and in other areas throughout their western breeding range (Dettling and Howell 2011, Johnson et al. 2007, 2008; Halterman 2009; McNeil et al. 2010). This is likely due in part to their transient nature before and after breeding (Howe 1986, Groschupf 1987, McNeil et al. 2011) and that cuckoos have been observed to be responsive to broadcast surveys late in their breeding cycle when they have nestlings or fledglings (Halterman 2001, McNeil et al. 2011, McNeil et al. in prep). To accommodate the additional July survey, we increased the frequency of our peak breeding season survey effort from once every 12–20 days to once every 12 days. The added July survey replaced the survey previously conducted in the latter half of August, and increased the likelihood of detecting breeding cuckoo. Compared to the other survey rounds, the final survey (in the latter half of August) typically detected the fewest number of cuckoos (McNeil et al. 2010, 2011), which provided useful insight into the low response rate of post-breeding cuckoos and the timing of cuckoos' fall migration, but offered little information toward identifying habitat occupancy of breeding cuckoos.

Table 1-1. Kern YBCU Survey Period Dates, 2012.

Survey Period	Dates
1	June 17 to June 28
2	June 29 to July 10
3	July 11 to July 22
4	July 23 to Aug 3
5	Aug 4 to Aug 15

Cuckoo presence-absence surveys were conducted on survey routes along point transects on foot, between sunrise and 10:30 am. Because of the close proximity of some survey routes, adjacent survey routes were surveyed on the same day by different observers to minimize the possibility of double-counting the same cuckoo. On these occasions, surveyors used radios to communicate with each other to avoid double-counting cuckoos. Each site contained one or more survey transects with parallel transects spaced approximately 250 to 300m apart. Survey points were spaced every 100 m along transects. Most transects traversed through the habitat patches. However, some transects ran along riparian habitat edges to maintain a 250m buffer from adjacent transects and to take advantage of greater visual detectability from these. Survey points were located using Garmin GPS units and at each point we recorded the UTM location, date, and time.

Upon arriving at a survey point, surveyors listened and watched for cuckoos for one minute. If no cuckoos were detected, surveyors used an MP3 player and handheld speaker to broadcast a five-second yellow-billed cuckoo contact call (the 'kowlp' call) (Hughes 1999) at approximately 70 decibels once per minute for five minutes. A five-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 was recorded (see below). Following a detection, surveyors progressed along the point transect 300 m from the cuckoo's estimated location. This was done to avoid additional disturbance and duplicate detection of the same bird.

For each cuckoo detection, the surveyor recorded the true bearing and estimated distance from the surveyor to the cuckoo, time of detection, response type, behavior, vocalizations, 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 was recorded as a survey detection. If the same individual cuckoo was detected more than once during a single survey, we recorded these detections as only one survey detection. Cuckoos located >300 m apart during a single survey were counted as separate individuals and therefore separate survey detections. Cuckoos encountered any time other than during a survey were classified as non-survey or incidental detections. Information collected for an incidental detection was the same as that collected for a survey detection.

Detection Probability and Occupancy

During surveys it is possible that a cuckoo is present, but remains undetected. As a result an area may be incorrectly classified as unoccupied which can result in underestimating the true habitat occupancy (MacKenzie et al. 2006). To account for this situation, we conducted occupancy analyses which incorporated cuckoo detection probabilities. We analyzed cuckoo presence/absence data from our repeated surveys using the program PRESENCE v 5.5 (Hines 2006) to calculate detection probabilities, occupancy estimates (for surveyed areas) and the estimated proportions of habitat occupied by cuckoos.

To estimate detection probability and occupancy across a large study area, the area is subdivided into smaller defined areas, or sample units; detection probability and occupancy estimates are derived from (and therefore describe) the presence, absence, and detectability of cuckoos within these sample units (MacKenzie et al. 2006 ch 3, Williams et al. 2002 ch 5). 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 (Bart 2011). Additionally, estimates derived from sample units based on actual territory sizes will most accurately reflect true habitat occupancy; the proportion of sample units occupied can be more accurately interpreted as the proportion of habitat used within the study area. We created sample units based on estimated cuckoo territory sizes, instead of using area boundaries. Estimated home range size in the SFKRV in 1985 was 17.2 ha for two radio tracked cuckoos (using minimum convex polygon estimates) and estimated to be 20 ha for non-telemetered cuckoos (Laymon and Halterman 1985). Telemetry observations at lower Colorado River restoration sites, estimated the average territory size to be between 19.8 and 21.7 ha (range 8.0 – 48.9 using 95% KDE estimates) (McNeil et al. 2010, 2011). Halterman (2009) estimates that the average cuckoo territory on the San Pedro River in AZ was 38.6 ha (95% KDE). With the disparity between estimated territory sizes, we selected a sample unit size intermediate to the previously estimated territories, 25ha, and in future SFKRV research we will reevaluate this selection using additional SFKRV territory data. With an approximate territory-sized sample unit, results will be biologically relevant and can be directly inferred to reflect cuckoo territory selection and habitat use.

Table 1-2. Summary of definitions for occupancy estimation terms.

Term	Definition
Sample Unit	The territory-sized spatial unit used to estimate cuckoo detection probability and habitat occupancy (approximately 25 ha in size).
Occupied Sample Unit	A sample unit with cuckoo survey detections during one or more survey periods.
Unoccupied Sample Unit	A sample unit with no cuckoo survey detections during all survey periods.

Results

<u>Survey Detections</u>

From June 17 to August 15, across five survey periods and 17 survey routes, we conducted 85 surveys (Map b), yielding 123 yellow-billed cuckoo detections (Figure 1-1, Map c, Table 1-3 and Table 1-4). Fewer cuckoos were detected at the KRP (22) compared to the SFWA (101). Across all areas, cuckoo detections peaked in mid-July (survey period 3), declined sharply by late-July (survey period 4) and then rebounded in early-August (survey period 5), (Figure 1-1). However the detection trends varied between survey areas (Figure 1-1 and Table 1-3). Detections in the KRP peaked in early-July (10 detections, survey period 2) and declined to zero by early August. Whereas, detections at the SFWA peaked in late-June, mid-July and early August (18, 28 and 25 detections in survey periods 1, 3, and 5) and were less frequent in early-July and late-July (15 detections in survey periods 2 and 4), (Figure 1-1 and Table 1-3).

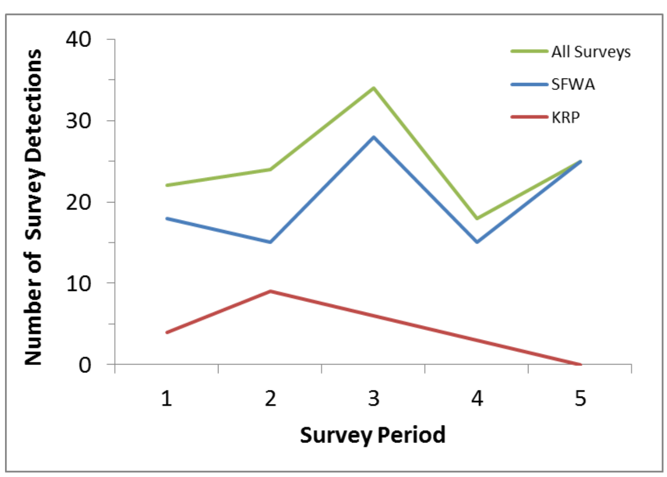
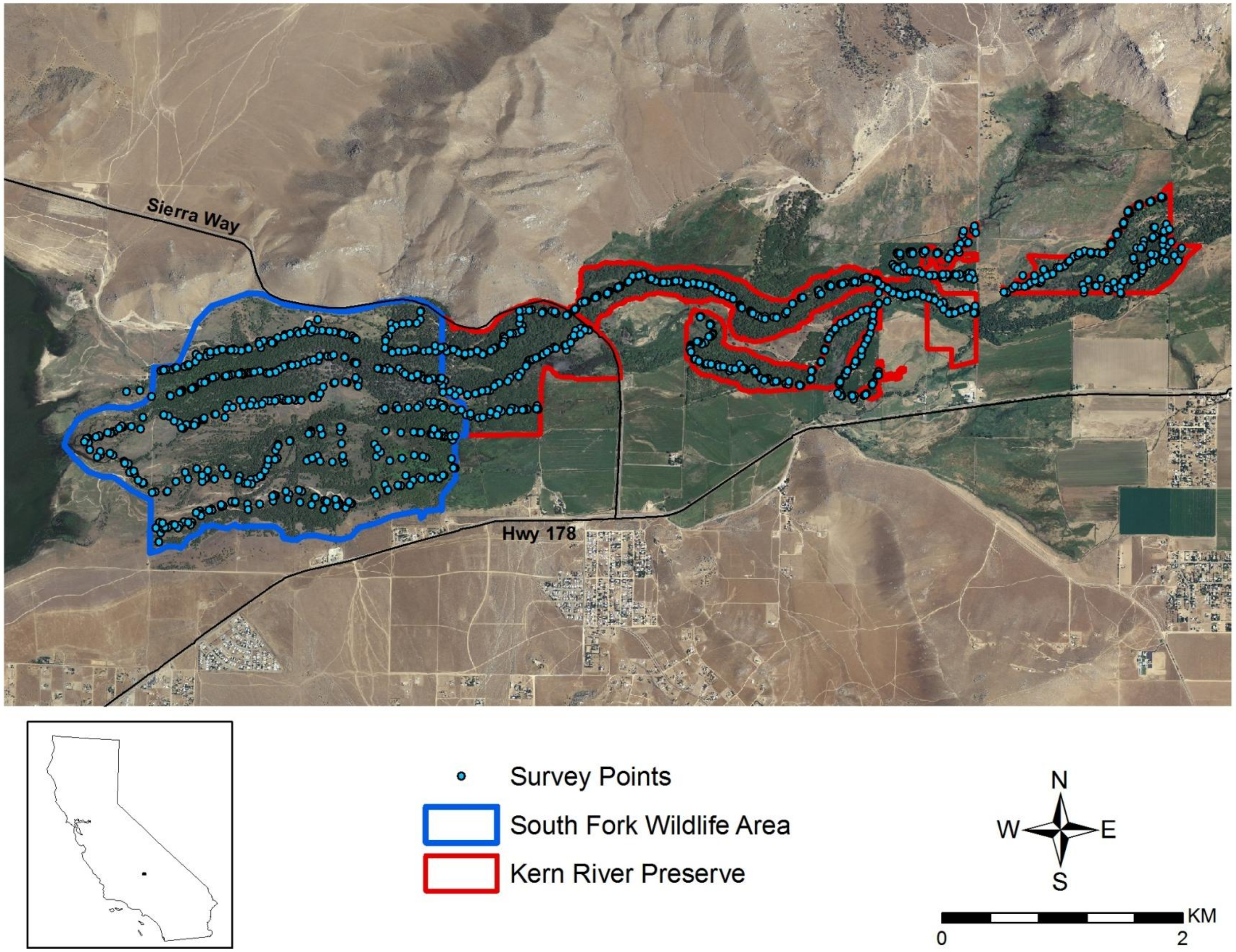
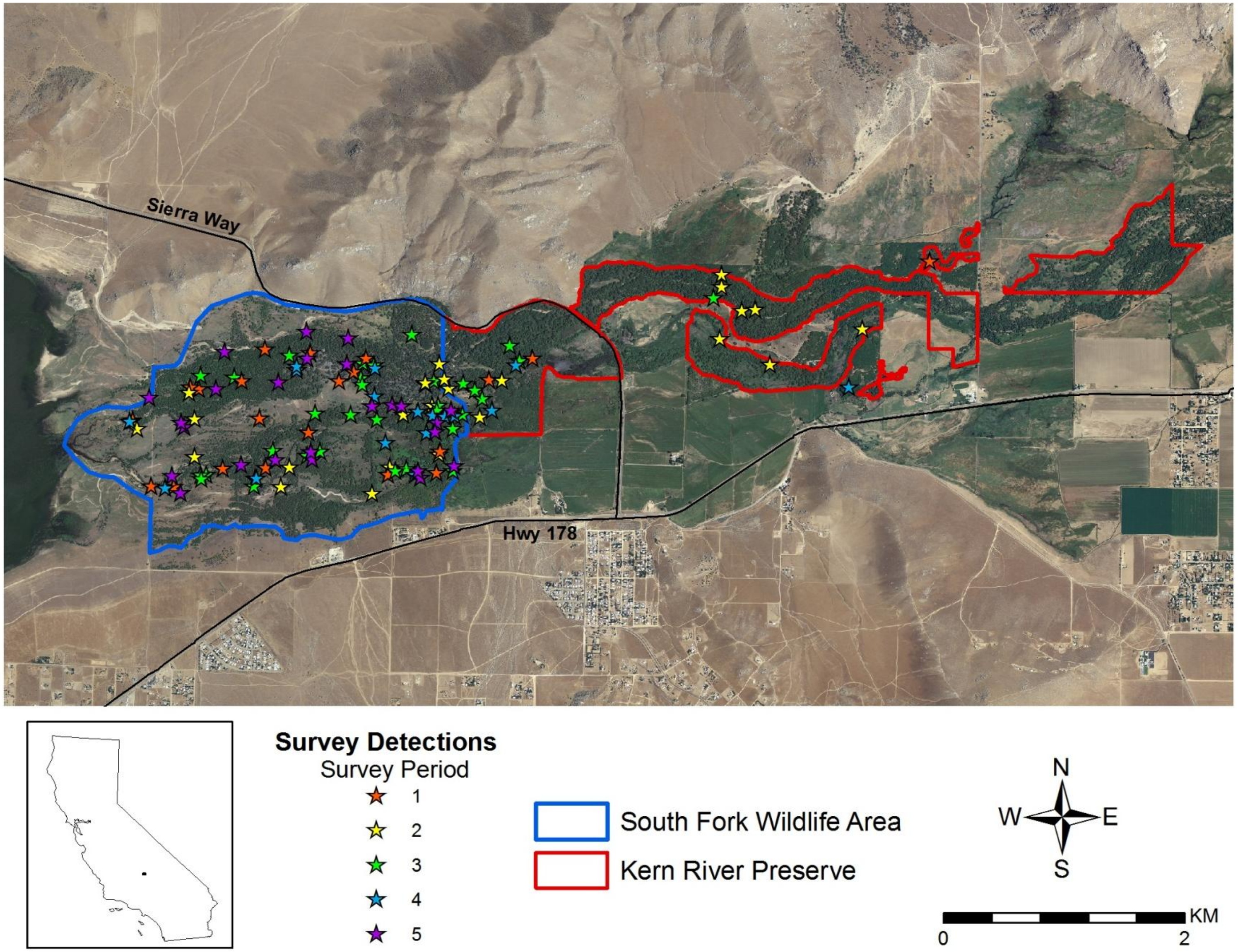


Figure 1-1. Detections are displayed by survey period for all sites (green), the South Fork Wildlife Area (SFWA, blue), and the Audubon Kern River Preserve (KRP, red).



Map b. Yellow-billed cuckoo survey points for all survey periods in the Kern River Valley, Kern Co. California, 2012.



Map c. Yellow-billed cuckoo survey detections in all survey periods in the Kern River Valley, Kern Co. California, 2012.

Table 1-3. YBCU survey detections, 2012.

Area	Area Code	Cuckoos Detected Per Survey Period					Total Survey Detections
		1	2	3	4	5	
South Fork Wildlife Area	SFWA	18	15	28	15	25	101
Kern River Preserve	KRP	4	9	6	3	0	22
Total		22	24	34	18	25	123

Table 1-4. Kern YBCU survey detection results by survey route, 2012.

Survey Route	Area	Cuckoos Detected Per Survey Period					Total Survey Detections
		1	2	3	4	5	
Coyote	KRP	0	0	0	0	0	0
Mariposa Marsh	KRP	1	0	0	0	0	1
Prince Field	KRP	1	4	6	3	3	17
River Bottom	KRP	0	0	0	0	0	0
Slough Channel East	KRP	0	1	0	1	0	2
Slough Channel West	KRP	0	2	0	0	0	2
Steerhead	KRP	0	0	0	0	0	0
Tantl	KRP	0	4	1	0	0	5
Prince Pond 1	KRP/SFWA	0	1	3	0	0	4
Prince Pond 2	KRP/SFWA	2	3	4	4	0	13
Far West	SFWA	2	1	0	1	1	5
KOA	SFWA	3	3	4	4	5	19
WA1	SFWA	1	0	2	1	3	7
WA2	SFWA	7	1	2	1	4	15
WA3	SFWA	1	1	4	1	4	11
WA4	SFWA	4	2	7	2	5	20
WA5	SFWA	0	1	1	0	0	2
All Sites		22	24	34	18	25	123

Detection Probability and Habitat Occupancy

In 2012, the frequency of detecting cuckoos (the average number of survey periods in which cuckoos were found within a sample unit) was greater at the SFWA (2.7 survey periods, S.D. = 1.5, n = 20 sample units) than the KRP (1.1 survey period, S.D. = 1.4, n = 15 sample units). Most detections occurred at the South Fork Wildlife Area where cuckoo detections peaked in mid-July (survey period 3), then declined in late July (survey period 4) and rebounded in early August (survey period 5), (Table 1-5). Across all areas, estimated probabilities of detecting a cuckoo (within a sample unit during a survey) were highest from late-June to mid-July (61.5 %) and declined thereafter into August (36.2 %), (Table 1-5, Figure 1-2). Cuckoo detectability at SFWA and KRP sample units exhibited some disparity, suggesting differences in cuckoo density, breeding territory abundance, and/or cuckoo transience (chapter 2, McNeil et al. in prep).

Table 1-5. Detection probabilities with 95% confidence intervals (CI) by survey period for the SFWA, KRP, and all areas combined. Data is also displayed in Figure 1-2.

Survey Period	Detection Probability Estimates					
	SFWA (95% CI)		KRP (95% CI)		All Areas (95% CI)	
1	0.675	(0.441 - 0.845)	0.474	(0.183 - 0.785)	0.615	(0.422 - 0.776)
2	0.571	(0.348 - 0.768)	0.712	(0.328 - 0.926)	0.615	(0.422 - 0.776)
3	0.675	(0.441 - 0.845)	0.474	(0.183 - 0.785)	0.615	(0.422 - 0.776)
4	0.363	(0.183 - 0.592)	0.356	(0.116 - 0.699)	0.362	(0.206 - 0.553)
5	0.519	(0.305 - 0.727)	0.000	(0.000 - 1.000)	0.362	(0.206 - 0.553)

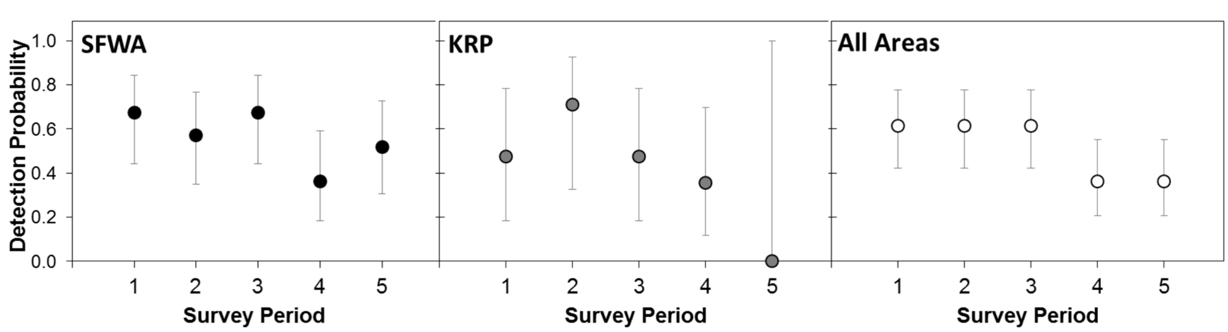


Figure 1-2 . Yellow-billed cuckoo 2012 detection probabilities with 95% confidence intervals for the SFWA (black), KRP (gray) and All Areas combined (white).

In examining the raw data, SFWA habitat had the greatest proportion of sample units with at least one cuckoo detection (19 out of 20) followed by KRP sample units (8 out of 15), yielding observed habitat use proportions of 0.95 (SFWA habitat), 0.533 (KRP habitat). Incorporating cuckoo detection probability with these raw observations increased the estimated habitat use at SFWA (0.963) and KRP (0.562) survey areas. Approximately twenty-three percent of our sample units (8 of 35) had no cuckoo detections during all survey visits. The probability that these sample units may have actually been used by an undetected cuckoo was estimated to be 0.268 (95%CI = 0 to 0.906, n= 1) at the SFWA sample unit, 0.062 (95% CI = 0 – 0.240, n= 7) at KRP sample units.

Table 1-6. 2012 SFKRV cuckoo occupancy rate by survey area using territory-based sample units.

Survey Area	Observed Habitat Use	Estimated Habitat Use	Estimated Habitat Use 95% CI
South Fork Wildlife Area	95.0%	96.3%	(95.0% - 99.8%)
Kern River Preserve	53.3%	56.2%	(53.3% - 79.5%)

Discussion

Outside of cuckoo research on the Lower Colorado River (McNeil et al. 2010, 2011, 2012) South Fork Kern River Valley (Henneman 2010, Whitfield and Stanek 2011) and Sacramento River (Dettling and Howell 2011) occupancy analyses utilizing detection probabilities are not widely reported, though we recommend its use. Relative to the total number of survey detections, occupancy estimates are more easily compared between areas within one season, and from year to year, because they account for imperfect detection and annual variation in the number of detections between survey periods (MacKenzie et al, 2006). The analysis detection probabilities are informative as they describe the probability of detecting a cuckoo within the habitat (sample unit), and can also be used glean information about the movement of cuckoos in or out of the habitat (sample unit).

As previously observed (Henneman 2010; Whitfield and Stanek, 2011), the ability to detect cuckoos was not constant throughout the breeding season and in general the overall detection probability trend was comparable to that observed in the past, with greater cuckoo detectability in July compared to August. However, detection probability trends, number of detections during a survey period, and the frequency of detecting cuckoos between survey periods differed greatly between survey areas. With exception to the survey period two detection probability, these detection trends were greatest at the South Fork Wildlife area compared to the Kern River Preserve.

We hypothesize that these detection differences were at least partly density dependent as opposed to inherent variation in cuckoo vocalization and secretive behavior at different habitat types. Due to the overall lack of repeated detections at the KRP, we suspect that the KPR survey period two detection probability spike (and corresponding SFWA detection probability dip) resulted from pre-breeding exploratory movement by cuckoos from the SFWA to the KRP. During this time we observed cuckoos flying east over Sierra Way towards the KRP habitat and recorded our largest pre-breeding movements by our radio telemetered cuckoos (on average 945 m movement between successive telemetry surveys, chapter 4), indicating that local cuckoo movements were greatest prior to establishing breeding territories (our earliest first egg date was July 9, chapter 3). Our density dependence hypothesis is also supported by our estimated breeding territory differences between the SFWA (up to 17 territories) which was five times greater than the maximum estimate at the KRP (3 territories), (chapter 2).

The proportion of SFWA habitat used by cuckoos (95.0%) exceeded that at KRP habitat patches (53.3%). The differences among these habitat use estimates and breeding territory occupancy proportions (Chapter 2, SWFA 60.0%, KRP 20.0%) suggest that the majority of habitat used at the SFWA is occupied by breeding cuckoos, whereas the majority of KRP habitat used temporarily by cuckoos and not used for breeding. The steeply declining detection probability trend observed at KRP habitat from mid-July to early-August corroborates this hypothesis and suggests that most cuckoos detected at KRP habitat, used them for only part of the breeding season and moved on (to the SFWA or elsewhere) by early august.

In conclusion, cuckoo occupancy at the SFWA exceeded that at the KRP, a trend that has been observed in the past (Henneman 2010, Whitfield and Stanek 2011). The 2012 occupancy estimates are similar to SFKRV cuckoo occupancy estimates made in 2009 (SFWA = 0.95, KRP = 0.20) and 2010 (SFWA = 0.82, KRP = 0.06), though the results were derived using slightly different methods. The 2009-2010 estimates calculated occupancy using a minimum of two cuckoo detections per sample unit (in an effort to estimate the occupancy of breeding cuckoos), where as we did so with just one detection per sample unit. Nonetheless, the comparison suggest that the Kern River Valley population is apparently stable and not experiencing declines like those observed on the Sacramento River in CA (Dettling and Howell 2010) or the mixed trends observed on the Lower Colorado River where cuckoos are in decline on the Bill Williams River NWR in AZ, but across the river are experiencing rapid growth at the Palo Verde Ecological Reserve restoration area in CA (McNeil et al. 2012, 2013). However, cuckoo distribution within the SFKRV is known to fluctuate from year to year and previous research suggests that as lake levels of Lake Isabella change, so do the locations of breeding Yellow-billed Cuckoos (Laymon and Halterman 1985, 1986, 1990; Laymon and Whitfield 1988; Laymon, et al. 1989, Laymon et al. 1997, Laymon and Williams 1999, 2002). When lake levels are kept low for multiple years, the number of yellow-billed cuckoos appears to increase. Since lake levels are expected to be kept at low for the next several years due to dam renovations, future collection of survey and habitat data could allow us to examine if the numbers of cuckoos will remain high or even increase and what characteristics (i.e. habitat characteristics, food resources, available nesting sites) promote these changes.

Chapter 2. 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 engage in behaviors to avoid detection (Bennett and Keinath 2003, Hamilton and Hamilton 1965, Laymon et al. 1997). Additionally, cuckoos are on their breeding grounds for only a short time and the window to study these birds is relatively brief. Most cuckoos arrive by July and begin their 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 do not stay long at their sites (Dettling and Howell 2011b, McNeil et al. 2011, 2012). To mitigate the research difficulties resulting from these behaviors, surveyors use call broadcasts to increase cuckoo detection which enables researchers to estimate habitat use and occupancy (Chapter 1). However, this survey method alone is inadequate to estimate cuckoo abundance, density, or be used to estimate population size, and an accurate determination of these estimates has thus far remained elusive.

In the past, cuckoo sex and breeding status were estimated using vocal response type, and population estimates were largely derived from call broadcast surveys coupled with nesting observations (Gaines 1974, Halterman 2001, Laymon et al. 1997). However, later research has found the underlying vocalization assumptions to be questionable (Halterman 2009, Wilson 2000), and the omission of factors such as varying detection probabilities, polyandry, local movement, and within-season emigration or immigration adds uncertainty to historic population estimates (Williams et al. 2002). The estimation of breeding pair or population abundance is complicated by the difficulties in locating cuckoo nests, detecting, capturing and uniquely identifying cuckoos. The polyandrous behavior of some females and a cuckoo's ability to have multiple broods adds additional complications in making pair and population estimates on unmarked birds. Without overcoming these obstacles, cuckoo breeding pair or population estimates will remain clouded with uncertainty. In light of these difficulties, we have developed alternative methods to estimate cuckoo breeding territory abundance (McNeil et al. 2010, 2011). In contrast to breeding pair or population abundance, these estimates do not require us to know the unique identity of each cuckoo or the parentage of each nest.

Methods

To estimate cuckoo breeding territory abundance, we deemed areas as potentially harboring breeding cuckoos if detections occurred in two or more survey periods. We deemed that a single cuckoo detection is not a reliable indicator of a breeding territory due to the transience of non-breeding cuckoos; these cuckoos may use an area during one survey period, but not the next (Johnson et al. 2007, McNeil et al. 2011, 2012). All detections were assessed by location (using ArcGIS), observed behaviors, and detection dates. These detections were then used to categorize breeding status for each detection area as a *possible* (POS), *probable* (PRB), or *confirmed* (COB) *breeding territory* (Table 2-1). 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, or exchanging vocalizations 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 cuckoo detections, including incidental, survey, telemetry and follow-up observations. Incidental observations include repeat detection of a cuckoo during a survey and observations of non-target cuckoos during telemetry surveys. Follow-up visits included nest searching, mist netting, and other site visits. During the field season POS and PRB observations were followed up whenever possible to confirm breeding status.

Overall, we find these breeding guidelines useful to estimate the number of breeding territories within the study area. However, on some occasions extensive follow-up visits on POS and PRB birds yielded no breeding evidence and so exceptions to these guidelines were sometimes made and documented. Using the POS, PRB, and COB classifications, we calculated minimum and maximum territory estimates (Table 2-1). The minimum number of territories is the number of confirmed breeding territories and is our most conservative estimate. The maximum territory estimate is the sum of POS, PRB, and COB breeding territories and may overestimate the true number of breeding territories. It is important to note that these POS, PRB and COB observations are used to estimate the number of breeding territories and not the number of breeding pairs. A territory estimate represents the adults associated with a single nest which is usually two adult cuckoos. However, nesting females have been observed to leave the nest before young are independent (McNeil et al, 2011); female cuckoos can be polyandrous and after leaving their original nest, they may re-nest with another male (Halterman 2009). Following a successful or failed nest one or both of the parents may choose to re-nest; calling this second nesting attempt an additional pair of cuckoos would be inappropriate.

Table 2-1. Summary of definitions for breeding territory, population, and occupancy estimation terms.

Estimation Type	Term	Definition
Breeding Territory Estimation	Possible Breeding Territory (POS)	Two or more total detections in an area from 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 during survey period three warrant a POS territory designation
	Probable Breeding Territory (PRB)	POS territory, plus cuckoos observed traveling as a pair, or exchanging vocalizations
	Confirmed Breeding Territory (COB)	Observation of copulation, stick carry, food 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

Results

Possible, probable and confirmed territory estimates and, minimum and maximum territory estimates were derived using 123 survey detections, 324 telemetry detections, 998 incidental/follow-up detections, and from locating 4 cuckoo nests and juvenile cuckoos in 3 additional cuckoo territories (fledglings with adults observed, nests were not located in these three territories) (Table 2-2).

Based on the timing, location and persistence of all detections, we estimate between 7 and 20 breeding territories within the SFWA and KRP surveyed areas in 2012 (Table 2-2), including 7possible, 6 probable, and 7 confirmed breeding territories (Table 2-2). Habitat occupancy by POS, PRB or COB territories at the SFWA (60.0%, 12 of 20 sample units held territories) exceeded that observed at the KRP (20.0%, 3 of 15 sample units held territories), (Table 2-3). Of the 20 maximum estimated breeding territories, 17 were located in the SFWA and 3 in the KRP. All but one of the KRP estimated breeding territories were located west of Sierra Way Blvd, adjacent to SFWA habitat. Breeding was confirmed at the KRP (1 territory with adults and juveniles found) in the vicinity of a historic yellow-billed cuckoo restoration habitat patch and in the eastern and western regions of the SFWA (4 nests found, 2 additional observations of territories with adults and juveniles), (Table 2-2).

Table 2-2. YBCU survey, follow-up, telemetry and nest searching results used to calculate breeding estimates for each survey area, 2012.

Survey Area	Area Code	Survey Detection Total (Visit Total)	Follow-up Detection Total[1] (Visit Total)	Telemetry Detection Total (Visit Total)	Nests & Territories Found	Possible Breeding (POS)	Probable Breeding (PRB)	Confirmed Breeding (COB)	Minimum Territory Estimate	Maximum Territory Estimate
South Fork Wildlife Area	SFWA	101 (40)	453 (38)	192 (20)	6	5	6	6	6	17
Kern River Preserve	KRP	22 (45)	545 (57)	132 (9)	1	2	0	1	1	3
Total		123 (85)	998 (95)	324 (29)	7	7	6	7	7	20

[1]Follow-up detections include follow-up visit detections, incidental survey detections, and incidental telemetry detections.

Table 2-3. 2012 SFKRV habitat (sample unit) occupancy rate by POS, PRB or COB territories by survey area.

Survey Area	Breeding Habitat Occupancy
South Fork Wildlife Area	60.0 %
Kern River Preserve	20.0 %

Discussion

For the 2012 field season, in the Audubon Kern River Preserve and USFS South Fork Wildlife Area, we estimate between seven and twenty cuckoo territories, with a mean estimate of thirteen. Unfortunately, comparing current breeding estimates with historic estimates is problematic (Dettling and Howell 2010, Henneman 2010). Not only are our territory estimates a different type of breeding estimation from those made in the past, but the omission (e.g. varying detection probabilities, local movement, transient cuckoos, polyandry, multiple clutches) and commission (i.e. using vocalizations to characterize cuckoos as a paired or unmated) of certain factors in historic pair estimates adds additional uncertainty. By not accounting for these factors these pair estimates may be biased to an unknown degree (it may be non-existent or it may be large). However, Laymon et al. (1997) shows that the historic SFKRV pair estimates are closely related to the number of nests found in a given year, indicating that these pair estimates may be fairly accurate, but still the confounding factors of polyandry and multiple clutches did not appear to be addressed. Our territory estimates represent an unknown number of cuckoo pairs, though from our telemetry results we know that one female cuckoo (LST, chapter 4) was responsible for two territories and we suspect the same of our other tracked female (WRT, chapter 4). In light of the difficulties in estimating the Kern cuckoo population size, we find our territory estimation method to be a sound, non-subjective estimation tool. To provide a breeding pair estimate comparable to those using historical estimation methods, using all available data, and observations of double clutches we estimate that in 2012 the Kern River Valley supported 11 breeding pair.

In 2000, twelve cuckoo pair were estimated to inhabit the SFWA and KRP (Laymon and Williams 2002), down from the high estimate of twenty-four in 1992 (Laymon et al. 1997). Based on our territory estimation, we suspect that the number of breeding pair in the SFKRV in 2012 may be close to the 2000 breeding pair estimate, and as such it would appear that the cuckoo population in the SFKRV remains stable.

Chapter 3. Nest Searching and Monitoring

Introduction

Population assessments and habitat quality are best defined in terms of the survival and reproductive success, in addition to the density of the focal species (Van Horne 1983). For any species to maintain a healthy population, reproduction needs to be successful. Impaired reproduction may disrupt the population dynamics of bird species to the extent that population declines and local extinctions result (Finch 1991). We monitored cuckoo breeding effort through comprehensive nest searching to investigate the stability and health of cuckoo populations in the Kern River Valley and to more confidently estimate the number of cuckoo breeding pairs (Chapter 2 of this report) in the valley (Whitfield and Stanek 2011).

Methods

We used a number of techniques to search for nests during the breeding season. During surveys, we located all detected cuckoos visually if possible, and searched vegetation in the vicinity for nests (following Martin and Geupel 1993). Cuckoos may respond from the nest to broadcast survey calls, and if they are close enough to the surveyor, the nest can be located. We also relied on the fact that nesting pairs share incubation duties (Potter 1980, Hughes 1999, Halterman 2009) and soon after sunrise, the female replaces the male on the nest, with one or both often vocalizing during the exchange. To observe a nest exchange, before dawn, one or more researchers would wait in the area of a suspected nest; and if a call was given, attempts were made to triangulate the location of the calling bird. Cuckoos may also call prior to arriving at the nest to feed young and 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 4 of this report). 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 approximately 10 m from the nest; a more accurate reading was taken after nesting activity ceased. We recorded nest site characteristics such as nest tree species, tree height and nest height, stage, and the banded status of adults if known. If possible, we used a video camera attached to a telescoping pole to monitor nests every 2-5 days. Nestlings were banded at 3-6 days when accessible (Chapter 4 of this report). 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 two 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. Nests were considered failed if they were found damaged or destroyed, with large egg shell fragments or remains, or empty before the earliest possible fledge date with no further activity detected nearby. Nests were considered deserted if intact eggs or chicks were present and no further parental activity was observed.

Results and Discussion

Between July 15 and August 29, 2012, we found four Yellow-billed Cuckoo nests (Table 3-1). We confirmed a total of 7 breeding territories (nests and/or fledglings with feeding adults) and estimated up to 20 possible breeding territories within the surveyed areas based on the timing and duration of all activity during the season (Chapter 2 of this report, Table 2-2). All of the nests were found in the SFWA. Two of the three additional territories located were in the SFWA and one in the KRP, however, the territory in the KRP was located very close to the northeastern edge of the SFWA.

Table 3-1. Yellow-billed cuckoo nests found in the SFKRV, 2012.

Nest	Date Found	Ad.1[1]	Ad. 2	Tree Sp.[2]	# Eggs	1st Egg[3]	Fate[4]	Date[5]	Note
PF-N1-12	7-28	WRT	UNK	SAGO	2	7-15	F2	7-31	Too high for camera
PF-N2-12	8-29	WRT*	UNK	SAGO	1	8-18	F1+	8-28	Found late in nest cycle
WA4-N1-12	7-15	LST	UNK	SAGO	3	7-09	F1+	7-25	Banded three nestlings
WA4-N2-12	8-02	LST	GRD*	SAGO	3	8-01	X	8-10	Depredation suspected

[1]Adults: UNK=unknown, 2-3 letter ID =known banded bird (Chapter 45). [2]Tree species: POFR=*Populus fremontii*. [3]Estimated date first egg laid (based on 10 day incubation period and 6 day brooding period). [4]Fate: F=fledged (number of known fledglings), X=failed. *Highly suspected, but not confirmed visually. [5]Date first fledged or failed.

Three of the four nests were found using radio telemetry and all were located in Goodding's willow (*Salix gooddingii*). Nests were found in a range of tree heights from 4.5 m to 16.5 m above ground with an average height of 10 m. Overall canopy cover at nests averaged 68%. Clutch size (number of eggs per nest) ranged from 1 to 3. Apparent nest success (the proportion of nests fledging at least one young) was 75% overall.

Historically (1985-1996), optimal nesting sites along the South Fork Kern River occurred in habitat with a mean canopy height of 7-10 m, while forests with 4-7 m and 10-15 m high canopies were chosen less frequently; all nest sites were characterized by increased canopy closure (Laymon et al. 1997). Nest sites found during this field season (n= 4) occurred in habitat with a mean canopy height of 13.5 m (range 10-18 m). These results do not necessarily conflict with the historic observation of Laymon et al. (1997), but could be due to the overall maturation and vertical growth of the forest in the Kern River Valley (mean canopy height for randomly located plots was 10.7 m in 2012). Although we do not have enough data collected from nest locations to draw robust conclusions, perhaps cuckoos prefer where the most canopy cover occurs (rather than the actual height of the canopy) which may be located in higher canopies in this mature cottonwood willow forest. We will continue to conduct nest searching and monitoring to understand reproductive success and habitat characteristics that may influence the breeding population of cuckoos in the SFKRV.

Chapter 4. Mist Netting, Color Banding, and Telemetry

Introduction

The use of long-term color 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, and population demography. However, cuckoos are difficult to observe due to their furtive behavior, and their bands can be even more difficult to resight due to their habit of crouching on their legs in dense foliage. To help overcome these difficulties, the use of 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 difficult to locate and are often missed. Identifying nesting territories is made more difficult by the presence of non-breeding, or transient cuckoos at our study areas (McNeil et al. 2011). As such, the presence of cuckoos in an area is not a reliable indicator that breeding was attempted or has occurred. The use of radio telemetry improves breeding pair estimates by increasing the likelihood of confirming both breeding and transiency. In 2012, we banded, resighted, and radio-tracked cuckoos, to increase our ability to make behavioral observations, track cuckoo movements, identify home ranges, and locate nests.

Methods

Mist Netting

We attempted to capture adult cuckoos during the breeding season from mid-June to late-August. First we located a responsive cuckoo by broadcasting recorded conspecific vocalizations. Responsive cuckoos were often found while conducting presence absence surveys. We then found a suitable net lane and used a target mist net technique modified from Sogge et al. (2001): we attached three or four stacked mist nets (totaling 7.8 to 10.4 m high) ranging from 9 to 18 m in length between two canopy poles placed in a vegetation gap of similar canopy height. This type of mist-net set-up is typically used to band bats, but we have found it useful in catching cuckoos because they rarely fly close enough to the ground to use a conventional two meter high mist net set-up. With the nets in place, we then broadcast various recorded cuckoo vocalizations from speakers placed on either side of the net to lure in cuckoos. During each mist netting attempt we recorded number of cuckoos in the area and which vocalizations elicited a response. If no cuckoos displayed interest in our playbacks after approximately one hour, we took down the nets and moved the set-up to another location.

Color Banding

We banded all captured cuckoos with a federal aluminum band on one leg and a pin-striped color aluminum band on the other leg with a unique color combination. Non-target captured birds were immediately released without banding. We used a stopped wing rule to measure wing and tail, calipers to measure tarsus and bill length, and 100 g Pesola® scales or 400 g Acculab digital scales to weigh all birds. We also banded and measured nestlings at 3-6 days if reachable (i.e. nests safely accessible by ladder). For adults we recorded additional morphological data such as molt, feather wear, orbital ring color, cloacal protuberance (CP) score (0-3), and brood patch (BP) score (0-5) following MAPS protocols. We extracted a small amount of blood from each bird from the brachial artery, and placed the blood sample on PermaCode™ cards and/or in EDTA-treated buffer. To identify the cuckoo's sex, genomic DNA was extracted from the buffered blood or cards using standard Qiagen protocols. Birds were sexed using a PCR-based method following Han, Wang et al. (2009) to amplify sex-specific DNA fragments of the CHD gene located on the avian sex chromosomes (W and Z). Accuracy of the sexing results were verified by using another molecular sexing method (Fridolfsson and Ellegren, 1999) on 10% of the samples and on six known-sex birds as recommended (Casey et al., 2009; Robertson and Gemmell, 2006).

<u>Telemetry</u>

We equipped a subset of captured adults with a radio transmitter (Holohil BD-2 from Holohil Systems Ltd.) weighing 1.47 to 1.51 g and broadcasting at 151.5 to 152.0 MHz. All transmitters were operational for 6 to 8 weeks. We stitched the transmitter through the feather shafts of the central retricies with dental floss and secured the knots with a small drop of cyanoacrylate glue (following Bray and Corner 1972, Pitts 1995, Woolnough et al. 2004). We used telemetry receivers (Communications Specialists Model R1000) and a directional antennae (Communications Specialists RA-150 Folded Yagi) to monitor the marked birds. We attempted to record at least one accurate position per 15 to 60 minutes of observation. Vocalizations, intra-specific interactions, movements, and behaviors were recorded for each location. If an observer thought that their presence was disturbing the bird they noted this on the datasheet and then moved away from the bird. When possible we used triangulation of two or three bearings 90 ± 30° apart taken within fifteen minutes of each other to estimate the bird's location (Springer 1979). We also attempted to confirm the breeding status of all radioed birds by witnessing the birds at nests, or by observing other breeding behaviors.

We imported telemetry points into ArcGIS 9.3 (and adjusted locations as necessary based on distance-bearing and biangulation and triangulation estimates) and used Hawth's Analysis Tools (Beyer 2004) to estimate home ranges for each cuckoo. Three home range estimates were calculated: minimum convex polygons (MCP), and 95% and 50% kernel density estimators (KDE, Silverman 1986). MCP and 95% KDE estimates 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, MCP is extremely sensitive to data outliers, often over-estimating 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 towards outliers (Seaman and Powell 1996).

We also fitted three cuckoos that we knew (based on nest observations) or assumed to be breeding (based on proximity to a known nest, or duration of residency) with Mk20 ASLT geolocators (British Antarctic Survey) weighing 1.0 g total (0.8 g geolocator + 0.2 g cord attachment). Geolocators are archival tags capable of measuring and storing data for up to 12 months (British Antarctic Survey 2010). Daily sunrise and sunset times (based on light level) are stored and standard astronomical equations are used to determine the bird's approximate latitude and longitude. We attached the geolocators with lower-back leg-loop harnesses using 1 mm elastic cord, Kevlar thread, and cyanoacrylate glue to secure the knots (following Rappole and Tipton 1991, McNeil et al. 2012). The successful recapture of any of these birds in 2013 will provide valuable information on fall and spring migration routes and their non-breeding range.

Results

<u>Mist Netting</u>

We made 17 mist netting attempts between June 21 and August 9 in 2012, resulting in 7 captures of 6 adults (Table 4-1).

Table 4-1. Yellow-billed cuckoo capture rate by area, 2012.

Area	Closest Survey Route	#Attempts	#Captures	Capture rate
SFWA	KOA	2	0	0%
SFWA	PF	3	3	100%
KRP	PP2	6	0	0%
SFWA	PP2	1	0	0%
SFWA	WA2	2	1	50%
SFWA	WA3	1	1	100%
SFWA	WA4	2	2[1]	100%
Total		17	7	41%

[1]One adult previously captured at WA3.

<u>Color Banding</u>

We captured and color-banded 6 adults, one of which was caught twice (on two different days and in two different locations) (Table 4-2). We attached radio transmitters to three adult cuckoos and geolocators to the other three adult cuckoos (Table 4-2). We also banded three hatch year birds (Table 4-3).

Table 4-2. Yellow-billed cuckoos banded in the SFKRV, 2012.

Date	Site Code	YBCU ID	Sex[1]	Attch.[2]	Federal Band #	Band combo.[3]
6-21	WA3	WRT	F	T	1202-68077	G-mB-G/AS
7-03	WA2	LST	F	T	1202-68076	Bk-lB-Bk/AS
7-06	KOA	PRD	M	T	1202-68078	O-mB-O/AS
7-29	PF	GLU	F	G	1202-68081	Y-W-Y/AS
8-02	PF	ENV	F	G	1202-68082	mB-W-mB/AS
8-09	WA4	GRD	M*	G	1202-68083	W-R-W/AS

[1]By DNA analysis. *Highly suspected M, but not confirmed by DNA analysis because of lack of blood.
[2]G=Geolocator, T=Transmitter. [3]Band color codes (top to bottom, left/right): AS = Aluminum Silver, Bk=black, G=green, lB=light blue, mB=medium blue, O=orange, R=red, W=white, Y=yellow. '-' between colors indicates a split band.

Table 4-3. Hatch-year Yellow-billed Cuckoos banded in the SFKRV, 2012.

Date	Nest #	Chick #	Parent	Federal Band #	Band combo.[2]
6-22	WA4-N1-12	1	LST	1713-67916[1]	G-R-G/AS
6-22	WA4-N1-12	2	LST	1202-68079	Lv-mB-Lv/AS
6-22	WA4-N1-12	3	LST	1202-68080	W-O-W/AS

[1]Banded with a size 3 band. [2]Band color codes (top to bottom, left/right): AS=Aluminum Silver, G=green, Lv=lavender, mB=medium blue, O=orange, R=red, W=white. '-' between colors indicates a split band.

Telemetry

We attached radio transmitters to three adult cuckoos, and followed each bird between 3 and 37 days. Two cuckoos molted their tail feathers and dropped their transmitters during the study: PRD only 3 days after attachment and WRT after 36 days. The third cuckoo (LST) was tracked for a total of 37 days. The average home range size (95% KDE) of the three birds was 20.3 ±3.6 ha (Table 4-4). The core range (50% KDE) averaged 2.9 ±0.4 ha overall (Table 4-4). For nesting birds (WRT and LST), the average home range was 18.4 ±2.3 ha and the core range averaged 3.1 ±0.1 ha (equivalent to a circle of radius 99 ±18 m) that usually surrounded the nest.

Table 4-4. Home range estimates of Yellow-billed Cuckoos radio-tracked in the SFKRV, 2012.

Area captured	YBCU ID	Breeding stage	# days tracked	# points	Average pts/day	MCP[2] (ha)	95% KDE[3] (ha)	50% KDE[3] (ha)
SFWA	WRT	Nesting[1]	36	101	5.1	23.3	20.0	3.2
	LST	Nesting[1]	37	127	4.7	13.7	16.8	3.0
KOA	PRD	Unknown	3	27	9	21.3	24.0	2.5
	Overall Mean (SD)					19.4 (5.1)	20.3 (3.6)	2.9 (0.4)

[1] Used telemetry points taken during estimated nesting dates. [2]MCP=minimum convex polygon. [3]KDE=kernel density estimate.

Prior to nest initiation, the two female cuckoos (WRT and LST) exhibited large movements across the study area. The longest movement recorded was by WRT, who was detected in the SFWA 1.5 km from her eventual nest territory; while LST was detected 1.1 km from her eventual nest territories. Additionally, both female cuckoos moved on average 945 m between successive telemetry surveys (approximately every 3 days) prior to nest initiation. During estimated nesting dates, LST's maximum observed distance from her nest was 330 m, the maximum distance observed from WRT was 590 m from her nest. While breeding, the average observed distances between successive telemetry surveys (~every 3 days) was 232 m for WRT and 160 m for LST.

Discussion

Although our sample size is very small, home range and core range estimates for the two confirmed breeding birds (95% KDE=18.4 ±2.3 ha, 50% KDE=3.1 ±0.1 ha, n=2) were similar to other CA cuckoos (Lower Colorado River [LCR] home range estimates: 95% KDE=17.4 ±4.0, 50% KDE=3.5 ±1.1 ha, n=7 (McNeil et al. 2012). Prior to nest initiation, the 2012 confirmed breeding cuckoos in the SFKRV exhibited large movements across the habitat. Similar movements were observed in radio tracked cuckoos in southern New Mexico at Elephant Butter Reservoir (Seacrest 2009). Conversely, while nesting, the 2012 SFKRV breeding cuckoos traveled shorter distances from the nest location and their average movements between successive telemetry surveys (~every 3 days) shrunk. Similar observations were made at restoration sites on the LCR, where the 95% KDE home ranges of breeding birds were 41% less variable than the overall LCR average (McNeil et al. 2011).

Our results based on only two birds and are inadequate to characterize SFKRV cuckoo home ranges. A larger sample size will be required to accurately compare these home range estimates and movement patterns. In 2013, we will continue our attempts to band and resight a significant proportion of SFKRV yellow-billed cuckoos, and will aim to recapture the three cuckoos with attached geolocators. Continued color-banding, resighting, and telemetry in the SFKRV will enable us to assess home range, breeding status, and within-season behavior and movement, as well as, elucidate cuckoo habitat use. We recommend continued long-term banding in the SFKRV and at other western cuckoo breeding sites.

Chapter 5. Habitat Use and Selection

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 Least Bell's Vireo (*Vireo bellii pusillus*), Southwestern Willow Flycatcher (*Empidonax traillii extimus*), and Western Yellow-billed Cuckoo (Bell 1997). However, modern river regulation and anthropogenic development across the Southwest has altered the natural hydrologic cycle which has led to the near cessation of riparian vegetation succession. In addition to the loss of successional diversity, changes to hydrologic regimes have induced shifts in plant distributions (Scott et al. 1997), facilitated the establishment of invasive non-native vegetation and altered riparian plant community composition (Nilsson et al. 1997). As a result, the amount of available riparian habitat has been greatly reduced, and has culminated in an extensive range reduction and population decline for western yellow-billed cuckoos (Hughes 1999).

The South Fork Kern River Valley (SFKRV) has been a consistent cuckoo breeding area for over 30 years (Gaines 1977, Schonholtz 1983, Laymon et al. 1997, Henneman 2009), holds one of the largest remaining contiguous cottonwood/willow forests in the state of California (Gaines 1977), and contains one of the largest populations of cuckoos in the state of CA. As such, the SFKRV provides critically important habitat for the western yellow-billed cuckoo and this important breeding area should be studied, monitored, and managed to ensure that the local cuckoo population remains stable and to expand our understanding of the relationships between cuckoos and their habitat which will enable land managers to facilitate cuckoo population growth elsewhere in the Southwest.

Research on the SFKRV in California began in 1985 and continued for 18 years (Laymon and Halterman 1985, 1986, 1990; Laymon and Whitfield 1988; Laymon, et al. 1989, Laymon et al. 1997, Laymon and Williams 1999, 2002). This research focused on monitoring populations, developing and understanding of breeding ecology, and exploring cuckoo habitat associations. Recent research has focused on cuckoo habitat occupancy and has found that the SFKRV continues to be an important area for breeding Yellow-billed Cuckoos (Henneman 2009, 2010, Whitfield and Stanek 2011). The SFKRV presents a unique opportunity to research cuckoo habitat use within a relatively large riparian forest. Through this research, we aimed to expand our understanding of the factors influencing cuckoo habitat selection by examining (1) how habitat characteristics at habitat use locations differed from available habitat and (2) how habitat characteristics at nests differed from available habitat.

Findings from a study in the SFKRV (Laymon and Halterman 1985) showed that cuckoos attracted by a playback behaved in a biased manner, and therefore did not reflect their true habitat use. Therefore, to address the question of how cuckoos are selecting habitat (aside from nest site selection) we employed habitat use observations through radio telemetry and unsolicited cuckoo detections paired with random available habitat sampling. Detections made from presence/absence surveys or those made using call playbacks of cuckoo calls were not used in this analysis.

We hypothesized that cuckoo habitat use would be strongly influenced by the availability of foraging habitat. In the SFKRV 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 CA locations (Laymon 1980). Additionally, based on previous research on the LCR and the SFKRV, we predicted that increased canopy cover and canopy height (Laymon et al. 1997, McNeil et al. 2010, 2013 in prep.) would be strong influences on cuckoo habitat use.

Laymon (1980) found that nests were typically placed in deciduous riparian forests amongst dense foliage and, in the SFKRV in particular, nests were placed in locations with increased canopy cover, foliage volume, and optimal canopy height (7 to 10 m high) (Laymon et al. 1997). Additionally, on the LCR nest locations were associated with increased canopy cover and native small tree densities (8-23 cm DBH) (McNeil et al. in prep.). We hypothesized that nest locations would be associated with increased canopy cover, tree density, and a multilayered canopy compared to available habitat.

Methods

Vegetation Sampling Design

Habitat variables were selected based on the current understanding of cuckoo habitat use and physical features considered most important in characterizing breeding cuckoo habitat. Sampling design and collection methods were derived from the BBIRD Field Protocol (Martin et al. 1997). 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 riparian woody species. Habitat selection analyses included a range of variables describing vegetation structure and plant species composition.

Vegetation sampling 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 counts of small trees, shrubs, and saplings. The larger circle was used to describe canopy layers and counts of large trees. Three general categories of vegetation data were collected: structural characteristics of the habitat (e.g. canopy height, cover, composition, foliage density); ground cover characteristics (e.g. litter cover, bare ground); and plant species composition and abundance. Tree densities were derived from stem count data by dividing the total number of stems of a given species by the area of the plot.

We quantified foliage density along a 20 m vertical axis by measuring whether vegetation “hit” or “missed” each 1-meter section, 10 cm radius around a 15-m telescoping pole (Whitfield and Henneman 2009). At hit (1 or 0) was recorded for each 1-meter height interval between 0 and 20 m at 17 locations in each plot (4 locations in each of the four cardinal directions and one in the plot center). For heights greater than 15 m we raised the pole up to 17 m, and visually estimated foliage density (hit or miss) up to 20 m. The total number of hits of each 1-meter height interval were summed to create a total number of hits for each sampling plot (total foliage density) (McLeod et al. 2008). The detailed methods for vegetation data collection are found in the Appendix.

Vegetation Plot Selection

Plots were delineated following the BBIRD Field Protocol (Martin et al. 1997) at random points, at locations where cuckoos were detected in an unsolicited manner (through telemetry or otherwise), and at nest locations. A total of 171 plots were sampled during the field season; vegetation plots were sample at the 4 nest locations (after the cuckoos had dispersed from the area), 73 habitat use locations, and 94 randomly selected locations. Each plot required 15 to 45 minutes to sample by 2 to 4 people.

Data Analysis

We used multiple logistic regression mixed-effects models to test hypotheses of cuckoo habitat use and nest site selection. We blocked our analyses by sample unit (used as a random effect in the models) to control for inherent vegetation differences within the study area (for a full description of sample units see Chapter 1 of this report). 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 five 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 Akaike's information criterion (AIC_c) 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_c values, the relative AIC_c difference (Δ_i, the AIC_c difference between each model compared to the top model with the lowest AIC_c), and the relative Akaike weights (ω_i). Models were selected using the Δ_i values, which are 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 of 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 Δ_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 contain 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 standard error terms are not conditional upon any one model).

In our sampling design of use 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 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).

To investigate the influence of structural diversity in the vegetation on YBCU habitat selection, we measured foliage density at available habitat (randomly located plots), at locations where YBCU were detected in an unsolicited manner (habitat use plots), and at nest locations. We performed t-tests to compare structural diversity (total foliage density) at each 1-meter height increment canopy levels between (1) habitat use plots and available habitat; (2) nest locations and available habitat located within occupied sample units; and (3) the South Fork Wildlife Area (SFWA) and the Kern River Preserve (KRP) to investigate suspected differences between these two areas. Prior to our analyses we verified that the assumptions of all statistical tests had been met. We used the R statistical package 2.11.1 for all data analyses (R Development Core Team 2010).

RESULTS

Habitat Use

All models are presented in Table 5-1. Only two models had considerable support (Δ_i <2) elucidating cuckoo habitat use. These models were averaged (Burnham and Anderson 2002), resulting in an averaged model containing three explanatory variables (Table 5-2).

Table 5-1. Results of AIC-based model selection for yellow-billed cuckoo habitat use. A * indicates the model had considerable support (Δ_i <2) and was used in the averaged model.

Number	Model	K	-log likelihood	AIC_c	Δ_i	w_i
1	TC + TCH	2	-67.61	143.46	0.00*	0.35535
2	TC + STD + TCH	3	-67.20	144.40	0.94*	0.22235
3	FP + TCH	2	-68.75	145.50	2.04	0.12829
4	TC + LTD + TCH	3	-67.57	145.51	2.04	0.12793
5	TC + BCH	2	-69.01	146.26	2.80	0.08752
6	FP + STD + TCH	3	-68.50	147.35	3.89	0.05077
7	FP + TC + STD + BP + TCH + VP	6	-65.84	148.56	5.10	0.02780
8	FP + LP + STD + BP + TC + TCH + VP	7	-101.97	210.08	66.62	0.00000
9	TC	1	-101.00	210.23	66.77	0.00000
10	TC + STD	2	-101.10	210.44	66.98	0.00000
11	TC + LTD	2	-101.44	211.13	67.66	0.00000
12	LTD	1	-101.96	212.15	68.68	0.00000
13	TC + PD	2	-105.34	216.83	73.36	0.00000

Abbreviations: ACH = Average Canopy Height, BP = Percent Bare Ground, FP = Percent Forb Groundcover, LP = Percent Leaf Litter, MC = Percent Main Canopy Cover, LTD = Large Tree Density, PD = *P. fremontii* Density, SD = *Salix gooddingii* Density, STD = Sapling/Small Tree Density, TC = Percent Total Canopy Cover, TCH = Total Canopy Height, VP = Percent Woody vegetation Groundcover. All abbreviations are in the Appendix .

Table 5-2. Model averaged results for important vegetation of habitat use plots (n=73) versus available habitat (n=94) from top models (Δ_i <2.00). The odds ratio is used to understand the influence of variables on occupied sites compared to unoccupied sites. An odds ratio greater than 1 indicates a positive relationship with site occupancy, while an odds ratio less than 1 signifies a negative relationship with site occupancy. None of the variables in the averaged model showed strong associations (confidence intervals contain 1).

Vegetation Variable	Odds Ratio	Habitat Use association	Estimate	Unconditional Standard Error	Lower 95% CI of Odds Ratio	Upper 95% CI of Odds Ratio
Percent Total Canopy Cover	1.029	+	0.028	0.015	0.999	1.059
Total Canopy Height	1.185	+	0.178	0.096	0.982	1.432
Sapling/Small Tree Density	0.921	-	-0.082	0.153	0.683	1.242

The averaged model showed that plots with increased total canopy cover and total canopy height were more likely to be used by cuckoos. Increased sapling/small tree (0-20 cm DBH) density was negatively associated with cuckoo habitat use. However, all of these variables did not have strong associations with cuckoo habitat use (confidence intervals contained 1) which may be due to our relatively low sample size and limited one year dataset. We will continue to collect data at habitat use plots and random locations in order to increase our sample size and obtain robust results.

Vertical foliage density between habitat use plots and available habitat was significantly different at certain one meter increment canopy levels (Table 5-3). Vertical canopy levels 1-4 meters at habitat use plots had decreased foliage density compared to available habitat, while vertical canopy levels 10-20 meters at habitat use plots showed increased foliage density compared to available habitat (Table 5-3). When we compared vertical foliage density at random locations (N=94) between the SFWA (n=52) and the KRP (n=42) we saw that the foliage density at the 1-7 and 9 meter levels were greater at the SFWA than the KRP, but the 10-20 meter levels were not significantly different (Table 5-4).

Table 5-3. Results of t-tests on vertical foliage density for each 1-meter height increments at habitat use plots (n=48) and available habitat (n=94).

Vertical Foliage meter level	Habitat Use[1]	Available Habitat[1]	*T*	*df*	P-Value[2]
0-1	15.2 (0.7)	14.9 (0.3)	*0.4789*	140	*0.633*
1-2	4.4 (0.4)	7.0 (0.4)	*-3.8345*	140	***<0.001***
2-3	4.0 (0.4)	5.7 (0.3)	*-3.1522*	140	***0.002***
3-4	4.4 (0.4)	5.9 (0.3)	*-2.7863*	140	***0.006***
4-5	4.9 (0.4)	6.4 (0.3)	*-2.6680*	140	***0.009***
5-6	5.8 (0.5)	6.6 (0.3)	*-1.4613*	140	*0.146*
6-7	6.0 (0.5)	6.4 (0.3)	*-0.8359*	140	*0.405*
7-8	6.4 (0.5)	6.2 (0.4)	*0.3161*	140	*0.752*
8-9	6.9 (0.4)	5.9 (0.4)	*1.4641*	140	*0.145*
9-10	6.7 (0.5)	5.6 (0.4)	*1.5881*	140	*0.115*
10-11	6.6 (0.6)	4.9 (0.4)	*2.4406*	140	***0.016***
11-12	6.1 (0.6)	4.4 (0.4)	*2.3579*	140	***0.020***
12-13	5.3 (0.6)	3.8 (0.4)	*1.9759*	140	***0.050***
13-14	4.9 (0.7)	3.0 (0.4)	*2.4362*	140	***0.016***
14-15	4.0 (0.6)	2.0 (0.3)	*3.0045*	140	***0.003***
15-16	3.1 (0.5)	1.4 (0.3)	*3.0602*	139	***0.003***
16-17	2.3 (0.5)	0.9 (0.2)	*2.8633*	138	***0.005***
17-18	1.6 (0.4)	0.5 (0.1)	*3.2693*	138	***0.001***
18-19	1.1 (0.3)	0.2 (0.1)	*3.1214*	138	***0.002***
19-20	0.6 (0.2)	0.1 (0.1)	*2.5974*	138	***0.010***

[1]Vertical foliage counts are total hits summed at each sampling plot for each 1-meter height increment. Data are presented as mean (SE). [2]Statistical significance (α=*0.05*) indicated in bold.

Table 5-4. Results of t-tests on vertical foliage density for each 1-meter height increments at the KRP (n=42) and the SFWA (n=52). Meter levels 1-9 are reported; all other meter levels were not significantly different.

Vertical Foliage meter level	KRP[1]	SFWA[1]	*T*	*df*	P-Value[2]
1-2	8.5 (0.4)	5.8 (0.5)	*3.2568*	92	**0.002**
2-3	7.0 (0.3)	5.6 (0.4)	*4.0990*	92	***<0.001***
3-4	6.8 (0.5)	5.1 (0.4)	*2.7735*	92	**0.006**
4-5	7.3 (0.5)	5.7 (0.4)	*2.4283*	92	**0.017**
5-6	7.8 (0.5)	5.8 (0.4)	*3.0115*	92	**0.003**
6-7	7.5 (0.5)	5.6 (0.4)	*3.2422*	92	**0.001**
7-8	7.3 (0.6)	5.4 (0.4)	*2.6316*	92	**0.009**
8-9	6.8 (0.7)	5.3 (0.4)	*1.8677*	92	0.064
9-10	6.7 (0.7)	4.8 (0.5)	*2.1171*	92	**0.037**

[1]Vertical foliage counts are total hits summed at each sampling plot for each 1-meter height increment. Data are presented as mean (SE). [2]Statistical significance (α=*0.05*) indicated in bold.

Nest site selection

Only four YBCU nests were located for the 2012 field season resulting in a small nest sample size to include in the logistic regression mixed effects model to compare habitat variables at nest sites (n=4) and available habitat (n=94). None of the habitat variables differed between nest sites and available habitat, likely because of the extremely small nest sample size. Several authors have recommended for this type of analysis a minimum ratio of 10 to 1, with a minimum total (N) sample size of 100, plus a variable number that is a function of the number of predictor variables (minimum 10 to 1 ratio) (Lawley and Maxwell 1971, Tabachnick and Fidell 1996, 2001, Burnham and Anderson 2002,). We will continue to collect habitat data at nest locations and will need data from at least 10 nests to meet these criteria.

Vertical foliage density between nest plots and available habitat within occupied sample units was significantly different at certain one meter increment canopy levels (Table 5-5), but should be interpreted with caution as the sample size is so small (n=4). Vertical canopy level 3-4 meters at nests had decreased foliage density compared to available habitat, while vertical canopy levels 14-16 meters at nests showed increased foliage density compared to available habitat within occupied sample units (Table 5-5).

Table 5-5. Results of t-tests on vertical foliage density for each 1-meter height increments at nest plots (n=4) and available habitat plots located within occupied sample units (n=54). Only meter levels 3 and 14-16 are reported; all other meter levels were not significantly different.

Vertical Foliage meter level	Nests[1]	Available Habitat[1]	*T*	*df*	P-Value[2]
3-4	2.0 (0.9)	5.2 (0.4)	*-2.2768*	56	**0.027**
14-15	5.3 (3.4)	1.9 (0.4)	*2.0210*	56	**0.048**
15-16	4.3 (3.3)	1.3 (0.3)	*2.1313*	56	**0.037**
16-17	3.5 (2.1)	1.0 (0.3)	*2.1234*	56	**0.038**

[1]Vertical foliage counts are total hits summed at each sampling plot for each 1-meter height increment. Data are presented as mean (SE). [2]Statistical significance (α=*0.05*) indicated in bold.

Discussion

Our results indicate that increased total canopy cover and total canopy heights are important to cuckoo habitat use. 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, Laymon et al. 1985). Similar results have also been found for cuckoo site occupancy along the lower Colorado River (LCR) where sites with increased total canopy cover and average canopy height were more likely to be occupied by cuckoos (McNeil et al. 2013 in prep.). Increases in sapling/small tree (0-20 cm DBH) densities were negatively associated with cuckoo habitat use, which may show a preference for taller and more mature vegetation, but may possibly be an artifact of the mature forest structure in the SFKRV rather than a preference in cuckoo habitat use.

When compared to available habitat, habitat use plots contained less foliage density between 1-5 m heights and increased foliage density between 10-20 m. Vertical foliage density was different between the SFWA and the KRP at the 1-5 m canopy levels, but was similar at the 10-20 m canopy levels. This suggest that cuckoos may not be selecting for less foliage density between 1-5 m heights, but may be selecting for habitat with higher foliage densities at the 10-20 m canopy levels.

Although we did not have enough data collected from nest locations to draw robust conclusions, foliage density was greater at the 14-16 m canopy level when compared to available habitat at occupied sample units, possibly suggesting that cuckoos selected nest locations with greater foliage density above the nest height (μ=14.25 m, range 4.5-16.5 m, n=4). This concurs with Laymon et al. (1997) whose research from 1985-1996 in the SFKRV showed that canopy cover above the nest was on average 96.8%. We will continue to collect data at nest locations, habitat use locations, and random locations to build on our knowledge and gain a better understanding of the habitat features most important to cuckoos.

Chapter 6. Summary of Results and Recommendations

- Through repeated standardized surveys throughout the study area, the annual status of the SFKRV cuckoo population can be assessed by examining spatial and temporal distribution and occupancy patterns. We recommend five surveys conducted from mid-June to mid-August. Surveys conducted during the peak of cuckoo activity, in July on the LCR, are the most cost-effective for identifying habitat occupancy. June and August surveys are important in their ability to identify the annual variability in arrival and departure of cuckoos to and from their breeding grounds, in addition to their contribution to habitat occupancy analysis.

- Our results indicate that increased canopy height and total canopy cover are important to cuckoo habitat use. From the results of this study and research (Laymon et al. 1997, McNeil et al. 2011, 2013), cuckoos may favor a structurally diverse habitat of both native large and small trees, preferring more native large trees for foraging purposes, but using smaller trees for nest placement. Mixed-height habitat stands would be similar to the historical riparian habitat where frequent spring flooding created patches of small native trees including Fremont cottonwood and Goodding's willow (Stromberg 2001).

- Cuckoo location data obtained from call-broadcast surveys are highly influenced by the cuckoo call playback (they can pull cuckoos in from hundreds of meters away) and the resulting recorded cuckoo location does not accurately reflect their habitat use (McNeil et al. 2011). We recommend the continuation of habitat use analyses from data collected at unsolicited cuckoo detection locations from multiple years in order to draw robust conclusions about cuckoo habitat use.

- We recommend the continuation of long-term nest monitoring to determine possible trends in breeding subpopulations and to understand reproductive success and habitat characteristics that may influence the breeding population.

- Color-banding and resighting banded cuckoos, can aid in the collection of valuable data on dispersal, including evidence of strong male natal and breeding site fidelity. It is important to continue collecting this data over a long time period, to gain a better understanding of the causes and consequences of dispersal patterns, as well as to assess juvenile and adult survival, and demographic trends. To build on our current knowledge we recommend the continuation of long-term color-banding of the SFKRV cuckoo population, as well as other western populations.

- Radio telemetry of cuckoos has revealed important behavioral information that would not be possible through other means of study. For example, on the LCR mean home ranges are estimated to be approximately 20 ha, for both breeding and transient cuckoos (McNeil et al. 2011, 2012). This type of data can be used to define an appropriate spatial scale for sample units used in habitat occupancy analyses. Through telemetry we located three of four nests in 2012 that may have otherwise been undetected. We also used radio-telemetry to investigate habitat use, within season movements, and breeding status. We recommend the continuation of telemetry on a subset of SFKRV cuckoos to build on our understanding of cuckoo ecology and habitat selection.

- We fitted three cuckoos with geolocators in 2012. The return and recapture of any of these cuckoos in 2013 will provide previously unknown information on migration routes and the location of the winter range for the western yellow-billed cuckoo. Though the destruction or reduction in quality of migration and non-breeding habitat is thought to be a factor in cuckoo decline and population viability (Terborgh 1980, Wiggins 2005), little information is currently known on cuckoo migration routes, stopovers, wintering distribution or ecology, and further research is needed (Bennett and Keinath 2003, Wiggins 2005).

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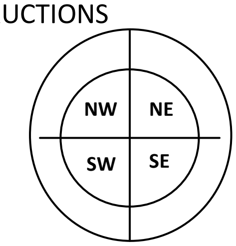
APPENDIX. DETAILED VEGETATION SAMPLING METHODS, SFKRV 2012.

2012 KERN YBCU VEGETATION SAMPLING INSTRUCTIONS



Setting up a Vegetation Plot
At a vegetation point, two sizes of circular plots are established:

1) A <u>5</u> meter radius plot
2) An <u>11.3</u> m radius plot

The 5 m plot is nested within and centered on the same point as the 11.3 m plot. Establish 4 quadrants (NW, SE, SW, and NE) to facilitate ground cover and foliar estimates and stem counting

Filling out the Data Sheet

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 closest transect code followed by a number and -12 (for the year) (i.e. PF-1-12).

UTM E and N
Enter the easting and northing readings for the center of the circular plot.

<u>DENSIOMETER COVER</u>
Canopy Cover- To measure canopy cover use the densitometer at each of the 5 meter marks (on the rope) in each cardinal direction. Hold the densitometer in front of you at elbow height and make sure it is level. Look at the densiometer and count each corner of a square that is covered by the canopy. This procedure should be performed at each 5 meter mark four times, once facing in each cardinal direction. Turn yourself in each direction, but keep the densiometer over the 5 meter mark. We will get the average at the office. If there is no canopy cover record it as 96.

<u>GROUND AND FOLIAR COVER ESTIMATES</u>
Ground cover consists of low, terrestrial cover layers where the cover categories are discrete and cannot overlap one another. Percent ground cover must sum to 100%!

PERCENT GROUND COVER
For each of the 4 quadrants in the 5m plot, make an ocular estimate of the percent of the ground covered in each category of cover types (*Vegetation, Litter*, *Bare, Downed debris, and Water*). These percents must sum to 100%. All values should be independent of foliar cover (measurements from 50 cm above the ground to ground level).

<u>% VEGETATION</u>
The % *Vegetation Cover* is the percentage of the ground covered by *live* vegetation ground. Please note that in late August and September some of the vegetation that was once alive in July is now dead.

<u>% LITTER COVER</u>

Percent *Litter* is the percent of ground covered by litter i.e. dead vegetation.

% BARE GROUND
The % *Bare Ground* is the percent of open ground not covered by leaf litter or any other low, dense cover. This includes bare dirt, rock, gravel, or sand.

% DOWNED DEBRIS COVER
The % *Downed debris* is the percent of ground covered by dead branches, sticks, and logs.

% WATER COVER
The % *Water Cover* is the percent of ground covered by standing water.

PERCENT FOLIAR COVER
Foliar cover consists of "knee-high" (ground to 50cm) cover where the 5 cover types can overlap with each cover types. The foliar cover categories can sum to more than 100% because of vertical stratification of foliar cover layers. For each of the 4 quadrants in the 5m plot, make an ocular estimate of the percent of the ground covered in each category of cover types (*Grass, Shrub, Forb, Marsh, and Brush*). These percents can sum to less than or over 100% because of vertical stratification of plant layers.

% GRASS COVER
The % *Grass Cover* is the percentage of the ground covered by grasses below 50 cm in height.

% SHRUB COVER
The % *Shrub Cover* is the percentage of ground covered by woody perennial plants that are below 50 cm tall.

% FORB COVER
The % *Forb Cover* is the percentage of ground covered by broad-leafed non-woody plants below 50 cm height.

% 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).

% 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.

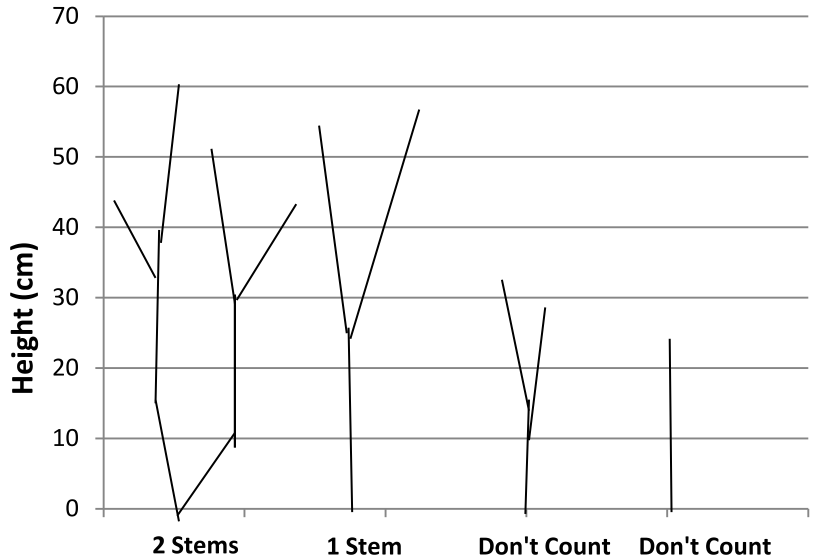
STEM COUNTS

Shrub stem counts done within 5m Radius Circle
Stems of all shrubs should be counted by species within each 5m plot at 10cm above the ground.

Tree stem counts done within 11.3m Radius Circle
Stems of all trees should be counted by species within each 11.3m plot at 10cm above the ground.

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).



<u>NUMBER OF STEMS - SHRUB SPECIES</u>
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 quadrant. Enter the total on the right of the tally marks.
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".

<u>NUMBER OF STEMS - SMALL/ LARGE TREE</u>
Count the total number of live stems for each size class, of each species within the large vegetation plot (11.3m radius circle). There is no specific order in which tree species must be presented. Enter the total on the right of the tally marks.

<u>CANOPY HEIGHT</u>
The canopy height can be taken at the same time as the hit/miss (foliage density) reading using an extension pole while standing at the center of the plot and at the 3, 6, 9, and 11 meter increments in each of the four cardinal directions (N, E, S, W). For the lowest canopy height measurement, raise the extension pole up until it touches the first live leaves of the canopy. For the top canopy height, measure the highest point of the canopy within a meter of the poles (estimate this height if need be). Record the heights to the nearest 0.1m.
*Note: There will be times when there is no canopy directly above the pole's position. If there is no canopy of which to measure the height record it as a dash (-) on the datasheet DON'T record the canopy height as zero.

<u>HIT/MISS DATA - FOLIAGE DENSITY</u>
At the center of the plot and in each cardinal direction at 3m, 6m, 9m, and 11m measure the vertical foliage density using the 17 m yellow extension pole. Working your way up the pole, record the

presence of vegetation (live) within a 10-cm radius of the rod in 1-m intervals. Record presence (hit) data with a 1 and miss data as a 0 up to 20 meters in height.

Please give an ocular estimate of the top canopy height and lower canopy height within the 11.3 meter circle.

*Please indicate if cuckoos were present during the veg data collection by circling yes or no.