Monitoring Brown-headed Cowbird and Avian Populations in Anza Borrego Desert State Park.

Prepared for:
STATE OF CALIFORNIA
ANZA BORREGO STATE DESERT PARK
Borrego Springs, CA

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EXECUTIVE SUMMARY

Brown-headed Cowbird (*Molothrus ater*) parasitism has long been recognized as a primary factor in the decline of several federally listed songbirds, including the Least Bell's Vireo (*Vireo bellii pusillus*). As a result, cowbird control has been implemented throughout the range of the vireo. Apparently, this has been a successful strategy since the Least Bell's Vireo population has increased over the past thirty years. At Anza Borrego Desert State Park (ABDSP), cowbirds were trapped in 1986, and from 1989 to 2016, the estimated vireo population increased from 11 (35 territories in 1986) territories in 1978 to 220 in 2016. However, over this time very few analyses have been done to examine the ABDSP cowbird population and to assess the cowbird trapping program.

To begin a cowbird assessment process, ABDSP ceased cowbird trapping in 2017 and contracted the Southern Sierra Research Station (SSRS) to conduct point count surveys in six riparian sites (Campbell Grade, Lower Willows, San Felipe North, San Felipe South, Sentenac Cienaga, and Vallecito Cienaga) in 2017. Cowbirds were detected at all five areas (San Felipe north and south are combined), however, we did not detect female cowbirds at the Sentenac and Vallecito sites. The other areas had very low numbers of female cowbirds, averaging between 0.03 and 0.11 females per point count station.

An examination of past cowbird trapping data (2010-2016) suggests that most of the cowbirds trapped in past years were likely non-breeding (i.e. wintering or migrating) birds. Thus the numbers of cowbirds trapped likely did not accurately reflect the breeding population numbers.

Due to the extremely low detected number of cowbirds, we could not calculate cowbird densities. Least Bell's Vireo, Verdin, House Finch and Bewick's Wren were the most abundant and had relatively high estimated densities among the six riparian sites we sampled. LBVIs were the second highest bird species counted during the 2017 surveys. They were detected at all six sites and were most abundant at Campbell Grade, Lower Willows, and Vallecito Cienaga. Sentenac Cienaga had the lowest detected bird counts and estimated bird densities, but had the highest species richness. This is likely due to its diversity of different habitats (cattail wetland, cottonwood riparian, mesquite bosque, open grassland, and rocky desert upland) and topography that appeared to funnel migrating songbirds moving through the site.

We recommend that ABDSP continue to suspend its cowbird trapping program, and continue to monitor cowbird and other bird populations. In addition, the park should be ready to initiate small scale targeted cowbird control measures (e.g. target mist netting or setting up a trap for a short time period) in case an increased number of female cowbirds (e.g average of 1 female per point count station) are detected in one of the study sites. Lastly, consider monitoring a subset of Least Bell's Vireo nests to measure parasitism rates for several years to help build a model to predict parasitism rates based on female cowbird numbers.

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INTRODUCTION

Brown-headed Cowbirds (*Molothrus ater*) are obligate brood parasites. They do not build their own nests, instead they lay their eggs in other bird species' nests, often removing or damaging a host's egg as well (Payne 1977, Sealy 1992, Sealy 1994, Peer and Sealy 1999). Cowbirds, while native to the United States, are not native to most of California, and expanded into the state in the late 1800s after suitable habitat was created through the clearing of land for agriculture (Laymon 1987, Rothstein 1994).

Cowbird parasitism has been attributed as one of the primary factors in the decline of several federally listed songbird species, such as Kirtland's Warbler (*Setophaga kirtlandii*), Black-capped Vireo (*Vireo atricapilla*), and Least Bell's Vireo (*Vireo bellii pusillus*) (Rothstein and Cook 2000). Thus, cowbird control has become a common tool to help increase populations of threatened or endangered birds that are susceptible to cowbird parasitism. These efforts have been largely successful at reducing parasitism and increasing productivity, though the results have been mixed on increasing population sizes (Kus and Whitfield 2005, Rothstein and Cook 2000, Hall and Rothstein 1999).

The Least Bell's Vireo (LBVI or vireo) appears to have benefitted from cowbird trapping (Kus 1999). Across its range, LBVIs increased from an estimate of 291 pairs when it was listed in 1985 to 2968 territories in 2005 (USFWS 2006). Cowbird trapping has been used as a management tool for LBVIs in Anza Borrego Desert State Park (ABDSP) since 1986 and has very likely helped increase the vireo population from 35 territories in 1986 to 220 territories in 2016 (McDonald et al. 2007, Clark and Hyland 2017).

However, there has been very little analysis to examine cowbird populations and assess the impact and continued need for cowbird control. It has been long recognized that cowbird trapping has costs, in terms of monetary expense, and its impact to non-target species that are inadvertently captured in the traps (Hall and Rothstein 1999, Rothstein and Cook 2000, Rothstein et al. 2003, Ortega et al. 2005). Clark and Hyland (2017) recommended that the cowbird program at ABDSP be re-evaluated and to monitor cowbirds in order to determine where cowbird traps should be placed. These recommendations as well as the low numbers of cowbirds trapped in recent years led to the cessation of cowbird trapping this year (2017) in order to make an assessment of the cowbird control program.

This purpose of this study was to estimate the number of cowbirds in several riparian areas that contain LBVI, as well as obtain estimates of other bird species at these sites. We will use these data to assess the need for cowbird control in these riparian patches and to make management recommendations for future cowbird control.

METHODS

Study Area. Study sites were located in Anza Borrego Desert State Park, located in San Diego County, in southern California. ABDSP is the largest State Park in California, encompassing approximately 240,000 hectares. We surveyed six sites (Lower Willows Canyon, San Felipe Creek North, San Felipe Creek South, Sentenac Cienega, Campbell Grade and Vallecito Cienega) located in Coyote Canyon, San Felipe Valley, and the Vallecito Valley and Campbell Grade areas of Vallecito Creek (Figure 1).*Point count surveys*. We set up six point count transects within the five survey sites, the largest survey site (San Felipe Valley) had three point-transects: San Felipe North, San Felipe South and Sentanac Cienaga. The number of point count stations within a transect varied due to differences in the size of the study site as well as due to logistical adjustments after the first visit. At some survey sites the number of point-count stations were reduced following the first round of surveys to primarily ensure that all point stations were within the site boundary or to meet logistical requirements. San Felipe North (10) and Sentanac Cienega (12) had the same number of point stations for all three visits. San Felipe South changed from 12 stations surveyed during the first visit down to 10 the following visits to remove stations too close to San Felipe North stations and those outside of the survey boundaries. Campbell Grade changed from 7 stations on the first visit to 6 on the subsequent surveys. At this site, 3 of our initial stations were located beyond the site boundary (digital map failed to upload during the first visit); we were able to relocate two of these points to within the boundary. Point count stations at

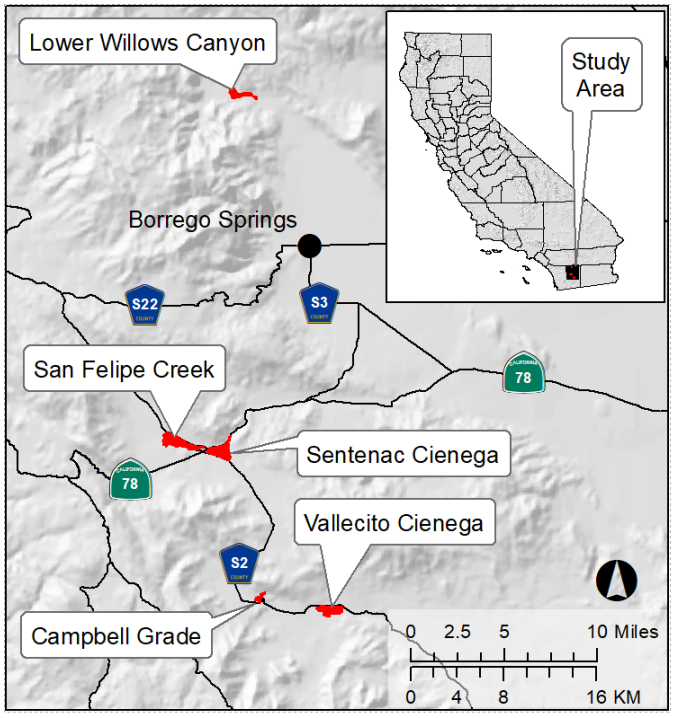

Figure 1. Location of study area and five point count sites in Anza Borrego Desert State Park, CA.

Vallecito reduced from 11 to 10 to make it more feasible to finish the transect in a single morning. Lower Willows (Coyote Canyon) changed from 10 to 9 stations because two stations were too close to each other and only 9 stations could fit within the site boundary. Following the changes made after the first round of surveys, there were a total of 57 point count stations that were surveyed two more times.

We spent five minutes at each point count station, recording all birds detected within 100m. We recorded how each bird was detected (audio and/or visual), age (adult, local nestling, juvenile, adult or unknown), sex (if known), and the estimated distance (using a rangefinder). The point counts were generally conducted 15 minutes before sunrise to 0900. However, there were a few times (mostly during the first round) where we had to count until 1000 to finish the transect.

Data analysis. Cowbird and all bird observations were summed and averaged to calculate total and average observed species abundancies per point count station and by survey site (tables 1-3, Appendices, 1, 2, and 3). We summed the total number of observed species from 57 stations, surveyed three times each, to calculate species richness per point count station and survey area.

We used analysis software Distance 7.1 (Thomas et al. 2010) to calculate detection probabilities and species density estimates from the repeat visit data collected at 57 point-count stations. In addition to a bird's distance from the observer, the ability to detect a species can be affected by species specific characteristics (e.g. size, color, movement, call frequency, and call volume), the surrounding environment (e.g. vegetation height and density), and observer ability. When possible, for each species for which there were at least 60 independent detections, we calculated species specific detection probabilities to estimate respective species densities. We analyzed species data separately due to the variable detectability among species. The minimum number of detections required to model the detection function is relatively large, 60-80, and achieves increased precision with increased observations (Buckland et. al 2001). With fewer observations (< 60), detection probability/density estimates may be biased or inaccurate. In addition to species specific bird density estimates, bird densities for each site were estimated by calculating a global detection probability (a single detection probability calculated using all of the bird data), which was then used to estimate overall bird densities for each survey site. Birds flying over but not using the habitat were excluded. We truncated observations beyond 100 m to eliminate outliers. These few distant observations offer relatively little information to the detection modeling process (proximal distance locations, especially those closer to zero, are much more

important) and make modeling the detection function difficult as they can result in over-fitted models. A good detection function model should have a detection probability of one (100%), or close to one, from the survey point out to small distances, and then smoothly decline at larger distances (Buckland 2015). Distance software provides four models for the detection function (called 'key functions' - uniform, negative exponential, half-normal and hazard-rate), and allows for adjustment terms to provide an adequate model fit to the data.

For each species, the top detection function model was selected, using AICc, from a set of candidate models fitting the distance data using various combinations of key functions, adjustment terms, and a detection type covariate (aural or visual). The detection type covariate was included because, birds are often detected more frequently and from much greater distances by ear than by sight. A detection function covariate effectively changes the scale, but not the shape of the detection function for each detection type. As a result, for birds detected by ear the modeled detection probability declines more slowly with increasing distance compared to birds detected visually.

RESULTS

Cowbirds were detected at all sites, but in low numbers in during a survey (27 total detections, mean = 1.5 BHCO per survey, range = 0.67 – 3, Table 1). More importantly, we rarely observed female cowbirds (Table 1). We only detected six total, across three rounds of surveys, at just five point count stations (CG4, CG6, LW5, SF11, and SF4).

Table 1. Total number and averages of Brown-headed Cowbirds detected at five riparian sites in Anza Borrego Desert State Park late April to mid-June 2017.

Brown-headed Cowbirds	Campbell Grade	Lower Willows Canyon	San Felipe North	San Felipe South	Sentenac Cienega	Vallecito Cienaga	Average
Total detected on 3 surveys	9	3	2	8	2	3	4.50
Avg. detected per survey visit	3.00	1.00	0.67	2.67	0.67	1.00	1.50
Females detected on three surveys	2	1	1	2	0	0	1.00
Avg. females detected per survey visit	0.67	0.33	0.33	0.67	0.00	0.00	0.33
Avg female detected per point station	0.11	0.04	0.03	0.07	0.00	0.00	0.04

Across three survey visits to 57 point count stations spread across six survey sites, we observed 79 species, totaling 2145 bird detections. The most detected birds include White-Winged Dove (209), Least-Bell's Vireo (192), Bewick's Wren (184), Verdin (119), and House Finch (118) (Table 2, Figures 2 to 6, Appendix 1).

Table 2. The ten most abundant bird species detected at point count stations in six riparian sites in Anza Borrego Desert State Park in April to June 2017.

Species	Campbell	Lower Willow Canyon	San Felipe North	San Felipe South	Sentenac Cienega	Vallecito Cienaga	Grand Total
White-winged Dove	31	27	30	20	39	62	209
Least Bell's Vireo	32	44	31	17	12	56	192
Bewick's Wren	12	54	18	43	20	37	184
Verdin	19	11	12	19	5	53	119
House Finch	16	43	26	14	13	6	118
Mourning Dove	7	13	21	8	17	16	82
California Quail	1	6	12	51	9	2	81
California Towhee	8	17	8	29	9	5	76
Ash-throated Flycatcher	5	9	7	24	16	1	62
Lesser Goldfinch	3	20	14	8	14	3	62

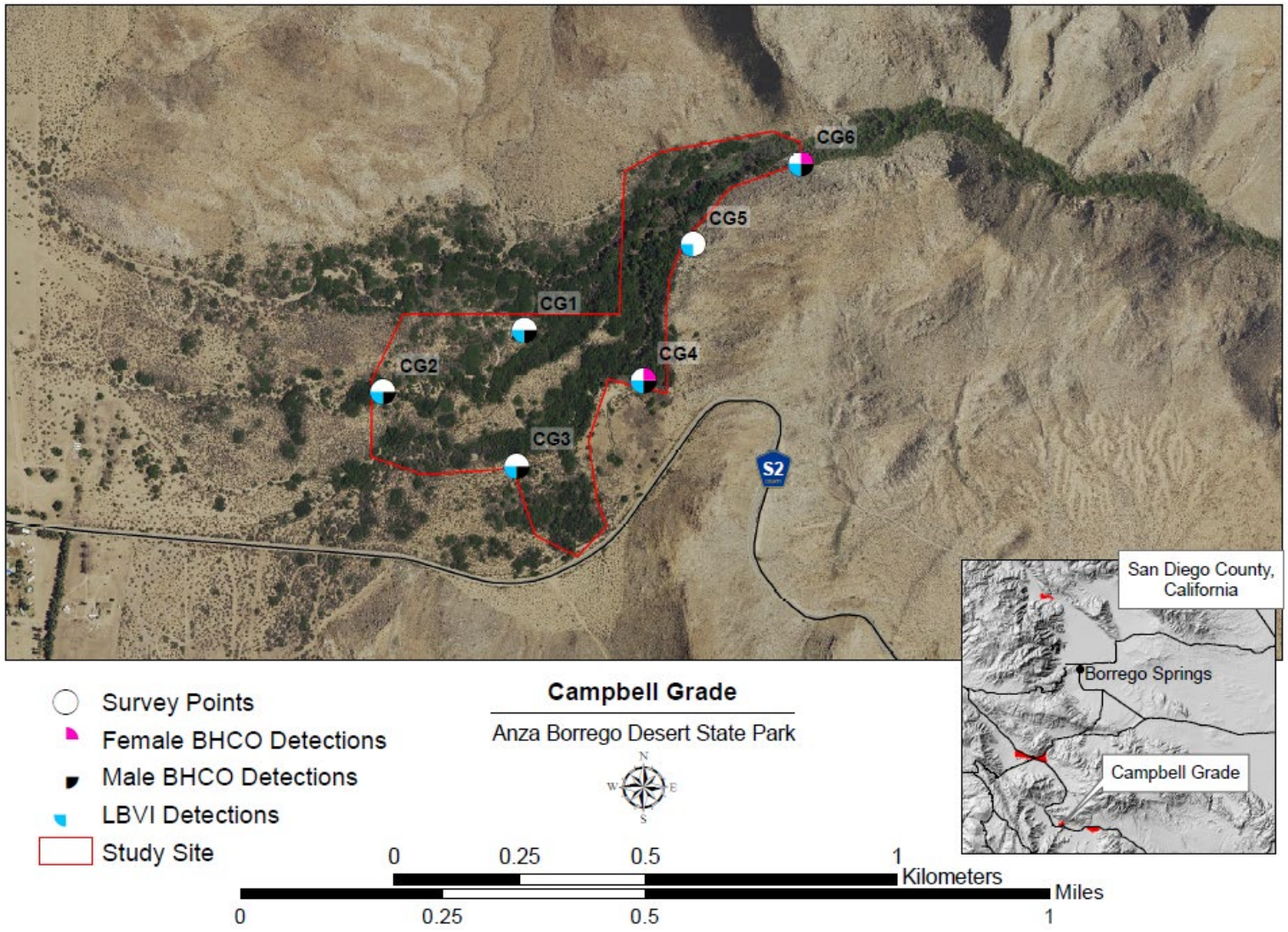

Figure 2. Campbell Grade point count station locations and points where we detected Least Bell's Vireos (LBVI) and Brown-headed Cowbirds (BHCO) in Anza Borrego Desert Park.

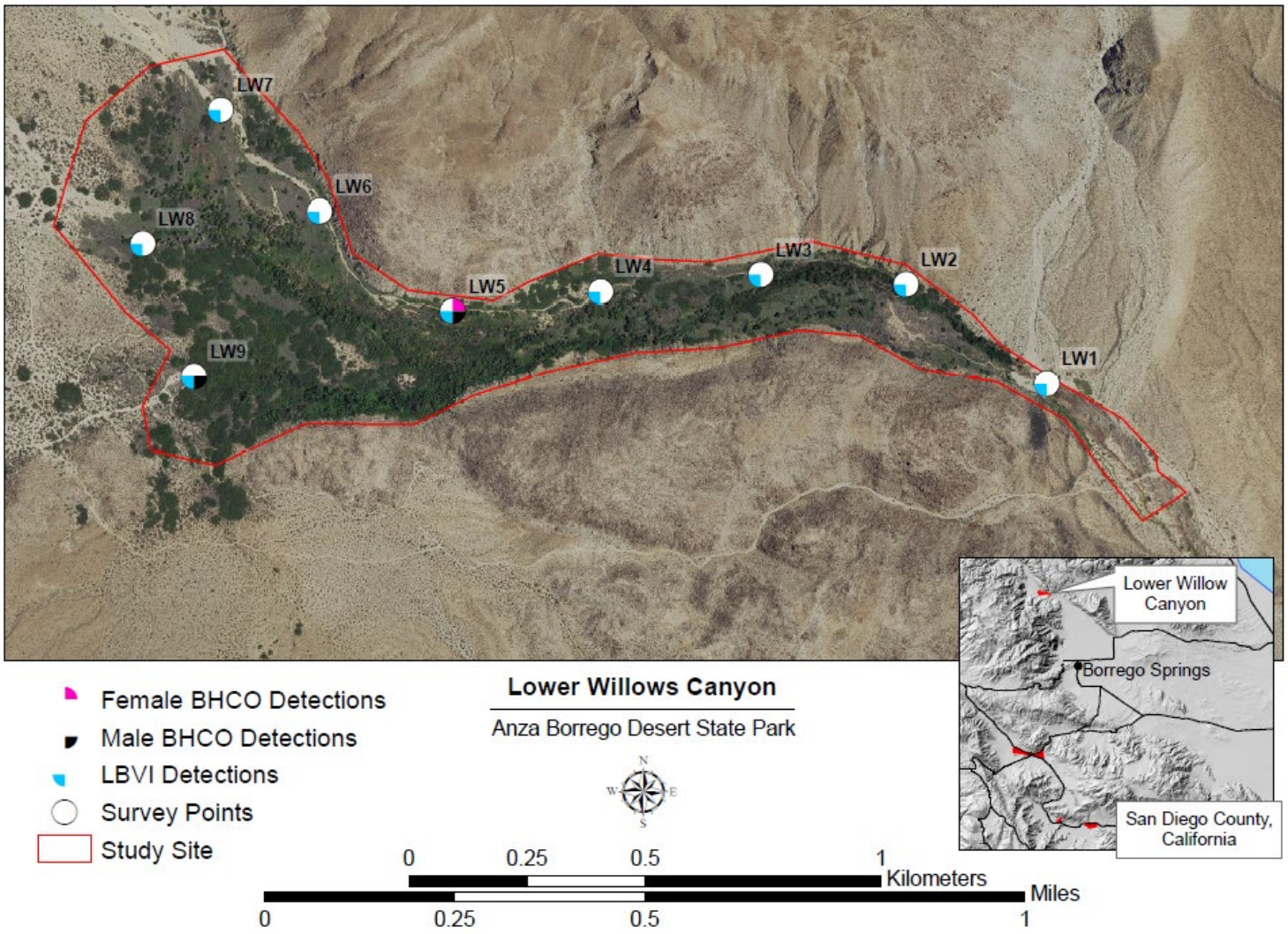

Figure 3. Lower Willows Canyon point count station locations and points where we detected Least Bell's Vireos (LBVI) and Brown-headed Cowbirds (BHCO) in Anza Borrego Desert Park.

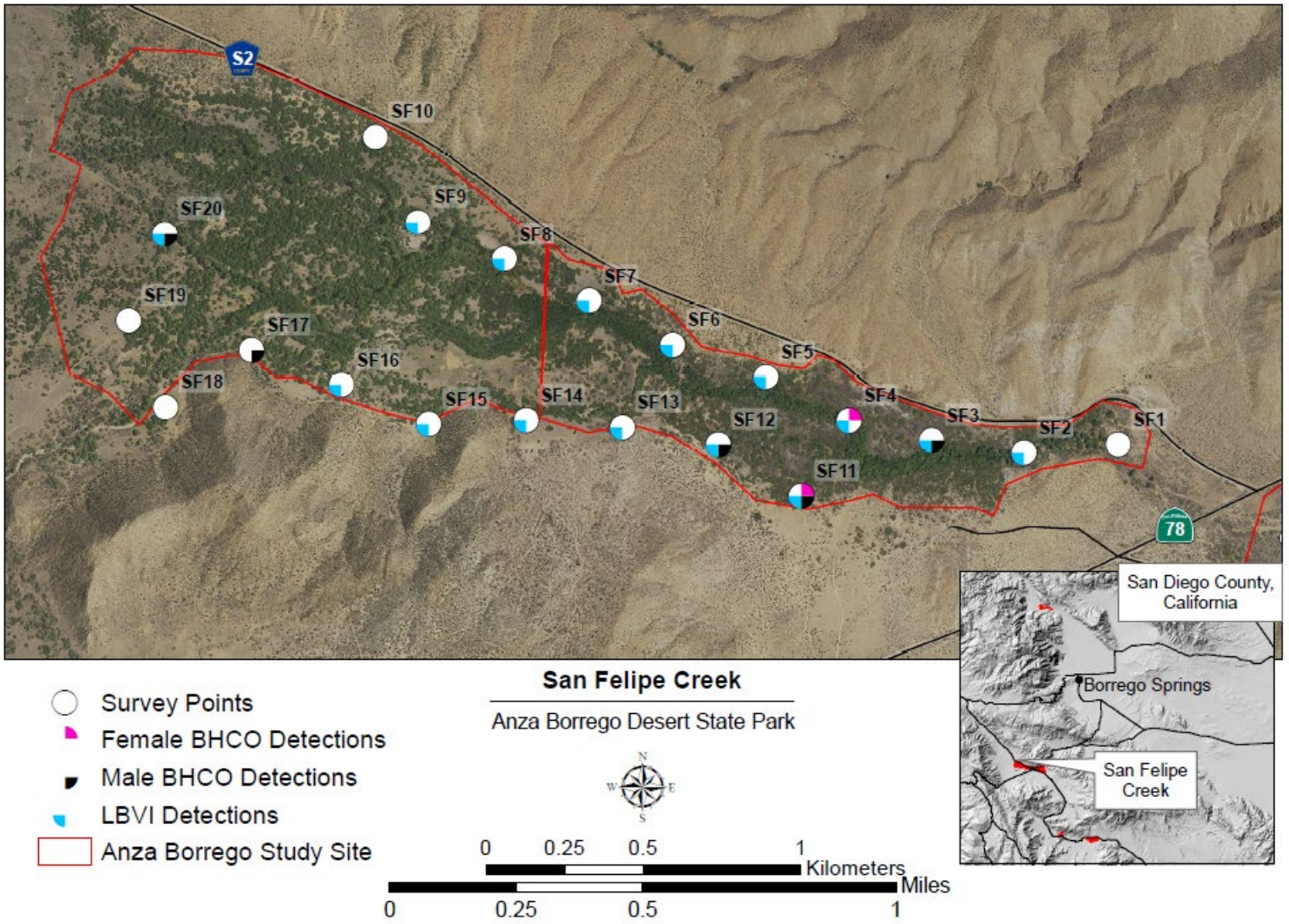

Figure 4. San Felipe Creek (North and South transects) point count station locations and points where we detected Least Bell's Vireos (LBVI) and Brown-headed Cowbirds (BHCO) in Anza Borrego Desert Park.

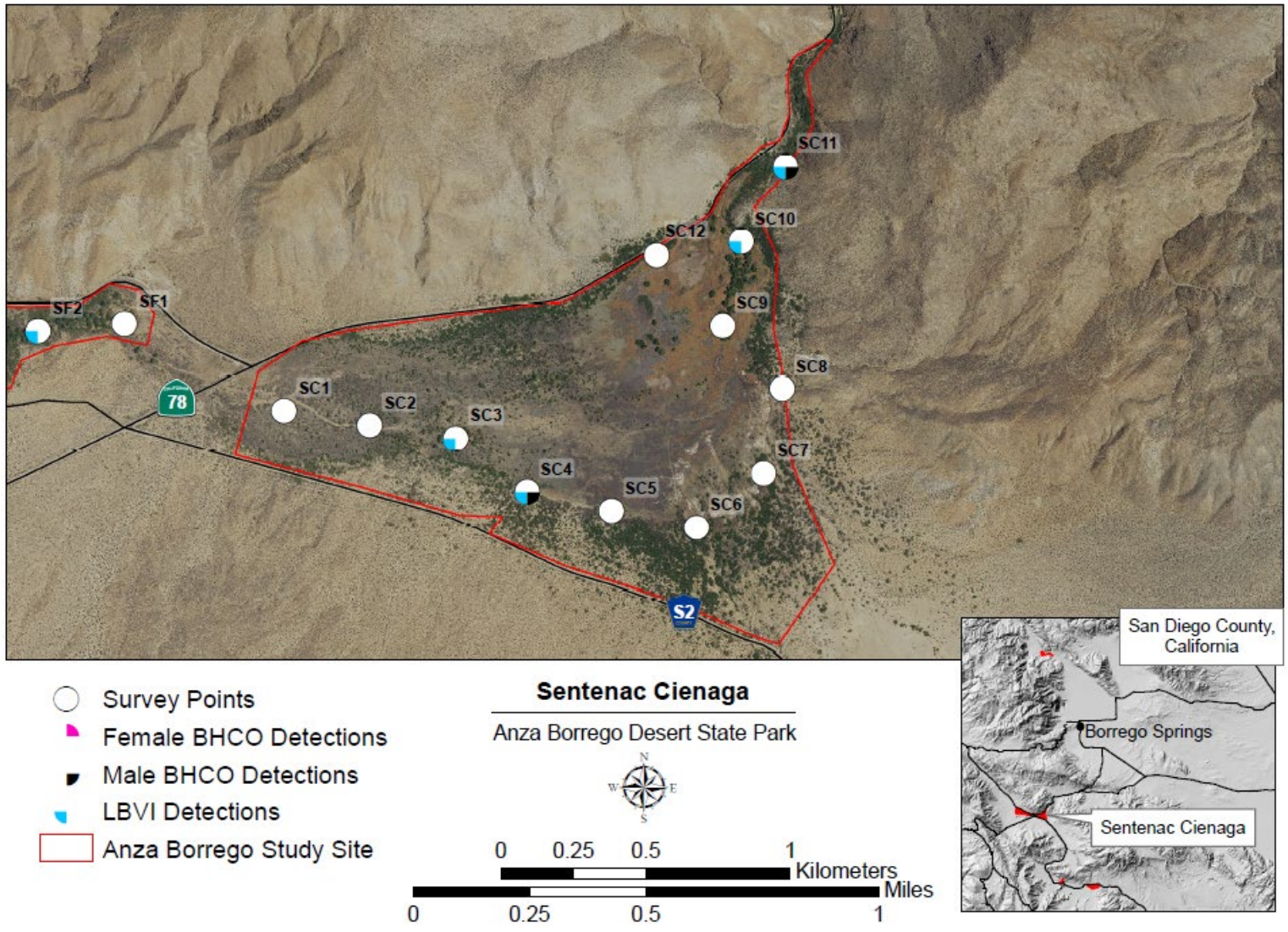

Figure 5. Sentenac Cienaga point count station locations and points where we detected Least Bell's Vireos (LBVI) and Brown-headed Cowbirds (BHCO) in Anza Borrego Desert Park.

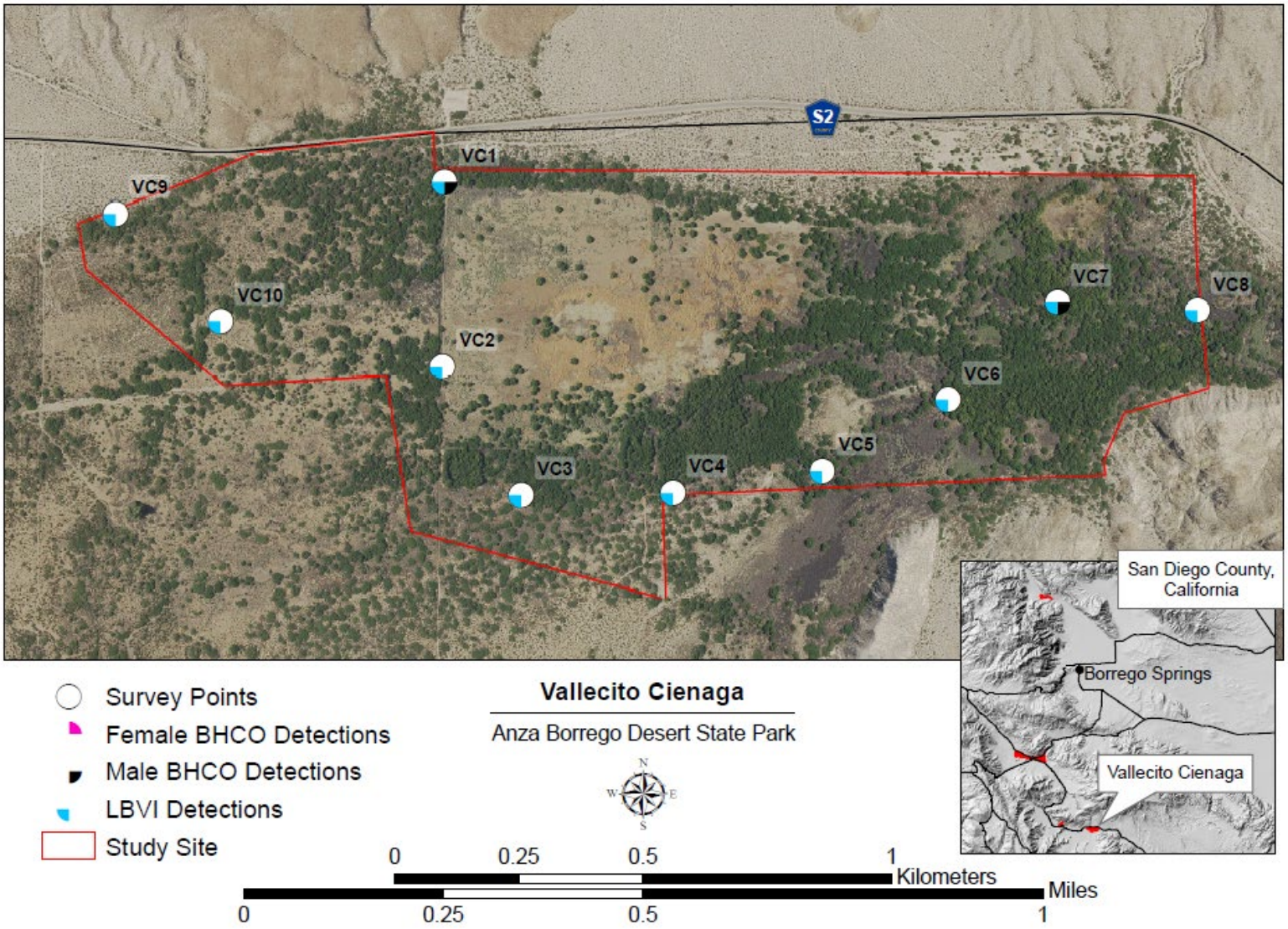

Figure 6. Vallecito Cienaga point count station locations and points where we detected Least Bell's Vireos (LBVI) and Brown-headed Cowbirds (BHCO) in Anza Borrego Desert Park.

The average point-count station bird abundance was similar across all survey sites (average 12.6 birds observed per point-count station survey visit, range 11.2 to 13.9) (Appendix 2). The observed study site species richness was lower at the xeric mesquite bosque sites, Vallecito Cienaga (32), and Campbell Grade (35), compared to the more mesic sites with riparian cottonwood corridors and mesquite uplands, Lower Willows Canyon (43), San Felipe South (49), and San Felipe North (52) (Table 3). The greatest observed species richness was observed at Sentenac Cienaga (57) due to its inclusive habitat diversity (dry cottonwood wash, mesic cottonwood stringer, mesquite bosque, arid grassland, rocky desert upland, moist cattail wetland, and narrow riparian canyon). At the Sentenac Cienaga, point-count station SC10 was located in close proximity to all of these habitats and had the greatest observed total species richness (29 species) and average species abundance (30) of all individual point-count stations.

Table 3. Total abundance and species richness at six riparian sites in Anza Borrego State Desert Park.

	Campbell	Lower Willows Canyon	San Felipe North	San Felipe South	Sentenac Cienega	Vallecito Cienaga	Grand Total	Average
Total Abundance	**210**	**372**	**396**	**396**	**394**	**347**	**2115**	352.5
Species Richness	35	43	52	49	57	32	77	44.7

For each of the six survey sites we used the software Distance 7.1 to estimate 'all bird' and species specific densities (Figure 7). Estimated bird densities for each survey site ranged from 22.05 (Sentenac Cienega) to 28.85 (San Felipe North) birds per hectare (Figure 7). Most of the sites had bird density estimates around 25 birds per hectare. Eight bird species had 60 or more independent observations, and for these birds we calculated species specific detection probabilities and density estimates. The species with the highest densities were Bewick's Wren, Verdin, Bell's Vireo and House Finch. Vallecito, Campbell Grade and Lower Willows had the highest Least Bell's Vireo densities at 3.20, 3.05, and 2.79 birds per hectare.

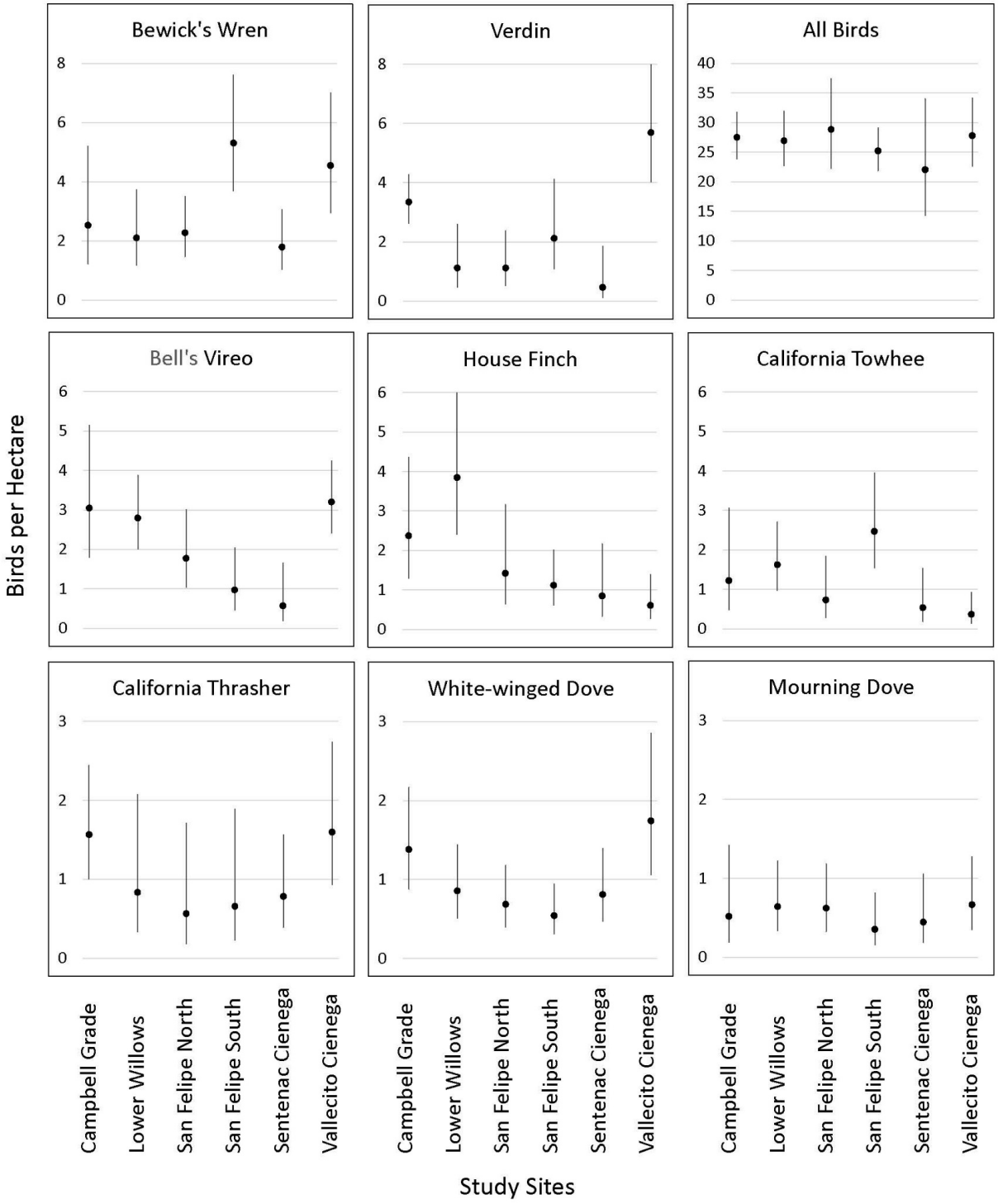

Figure 7. Bird densities for eight species and all birds detected on point counts at six riparian sites in Anza Borrego State Desert Park in California in 2017.

DISCUSSION

Overall, we detected few breeding cowbirds on our point counts at any of the five riparian areas (San Felipe North and South are combined). Male cowbirds were detected in all five areas. Female cowbirds were only detected in very low numbers at three areas (Lower Willows, San Felipe Creek, and Campbell Grade), averaging between 0.03 and 0.11 females per point count station (Table 1). This was a surprising result given that there were no cowbird control efforts this year. Past cowbird control efforts had taken out between 12 to 1079 cowbirds a year (McDonald and Thériault 2011, Thériault 2014, Clark and Hyland 2017).

An examination of historical trapping dates, number of traps, and number of female cowbirds captured from 2010 to 2016 in ABDSP indicates that trapping started in March for most years, which is outside of the cowbird breeding season (Jorgensen and Thériault 2010, McDonald and Thériault 2011, McDonald and Thériault 2012, Thériault 2013, Thériault 2014, Thériault and Clark 2015, Clark and Hyland 2017). Most cowbirds begin breeding in late April (Lowther 2000), though there are a few records in Anza Borrego that suggest that some cowbirds may lay in early or mid-April (Unitt 2004). Thus, most of the birds captured in March and early to mid-April were likely wintering birds and/or migrants (i.e. non-breeders). The number of traps and trap days also varied widely during this time period and the number of cowbirds captured also significantly decreased after 2013 (Figure 8). This is likely due to a combination of the reduction of March trapping, drought and perhaps annual variance in migration dates. Therefore, it is probable that the majority of cowbirds that have been caught in ABDSP were non-breeding birds and did not accurately reflect the breeding cowbird population. However, data collected from the more recent years may be influenced by numerous years of trapping as well as the drought, and it is possible the breeding cowbird population was larger in the past. A more thorough examination of cowbird trapping data may show different patterns.

Due to their extremely low numbers, we could not calculate cowbird densities. Least Bell's Vireo, Verdin, House Finch and Bewick's Wren had the highest estimated densities among the six riparian sites we sampled in ABDSP. Even though it had the lowest bird abundances and estimated bird densities, Sentenac Cienaga had the highest species richness, likely due to its diversity of different habitats. LBVIs were detected at all six sites and were most abundant and had the highest estimated densities at Campbell Grade, Lower Willows, and Vallecito. Cowbirds almost certainly had little

impact on the vireo population this year, given the high densities of vireos and other bird species and low number of female cowbirds.

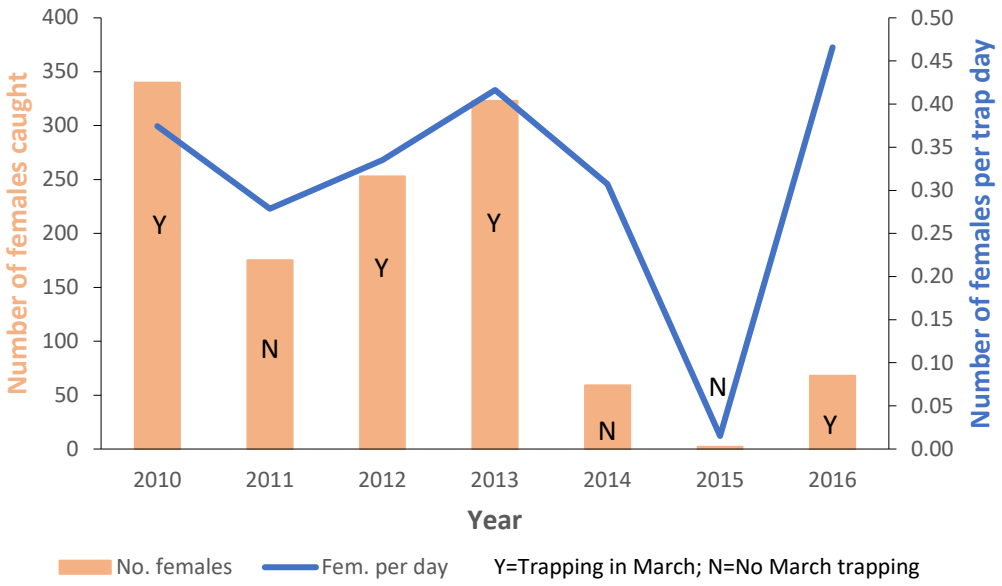

Figure 8. Number of female Brown-headed Cowbirds caught and average number of females caught per trap day in cowbird traps in Anza Borrego Desert State Park and nearby areas 2010-2016. Note that the number of trap days significantly decreased in 2014. A significant number of cowbirds trapped in March and early April were likely wintering birds or migrants.

MANAGEMENT RECOMMENDATIONS

1. Suspend cowbird trapping for another year; given the low number of female cowbirds detected this past year, it is unlikely that there will be a large increase in cowbirds in 2018.
2. Continue point counts in the six sites to keep track of cowbird numbers and other bird populations.
3. If point counts indicate that female cowbird numbers are high in a particular area (e.g. Campbell Grade) be ready to institute some sort of small scale cowbird control such as target mist-netting or placing a trap nearby for a short time period.
4. If funding permits, start a LBVI nest monitoring program for a few years to correlate female cowbird numbers to parasitism rates. It is possible to build a model using female cowbird numbers and host numbers to predict parasitism rates. This could be a valuable tool for deciding whether areas need to be trapped or not.

5. Consider conducting late season surveys for additional Federal Threatened and Endangered species that have been detected at ABDSP in recent years, in particular the Southwestern Willow Flycatchers and Yellow-billed Cuckoos (detected at San Felipe Creek in 2016, 2017).

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Appendix 1. Abundance and richness of birds detected during point counts at six sites in Anza Borrego Desert Park in 2017 (see Appendix 3 for bander's code names).

Species (Bander's codes)	Campbell	Lower Willows Canyon	San Felipe North	San Felipe South	Sentenac Cienega	Vallecito Cienaga	Grand Total	Average
AMCR				1			1	
AMKE					1		1	
ANHU	4	3	1	1	1	1	11	
ATFL	5	9	7	24	16	1	62	
BCFL		1	9	2	7		19	
BCGN					1		1	
BCSP					2		2	
BEWR	12	54	18	43	20	37	184	
BGGN	5	3		1	1	1	11	
BHCO	9	3	2	8	2	3	27	
BHGR	1	2	2		1		6	
BLGR	3	3	1	1	7		15	
BRBL					28		28	
BTGN	6	1		3	2	12	24	
BTSP	3		1		2	1	7	
BUOR			13	2	29	6	50	
BUSH			2	22	2		26	
CACW		1	1	1	1		4	
CALT	8	17	8	29	9	5	76	
CAQU	1	6	12	51	9	2	81	
CASJ			4	8	8		20	
CATH	10	8	6	8	11	17	60	
CAVI			1	2	1		4	
CHSP					1		1	
COHU	7	11	2	3	1	6	30	
CORA		1	15	4	7	1	28	
COYE	1	1	2	1	1		6	
DOWO			1	1			2	
DUFL						1	1	
ECDO		2	1		13		16	
EUST			6	10	1		17	
GAQU				3			3	
GRRO					1	4	5	
HETH			3				3	
HOFI	16	43	26	14	13	6	118	
HOOR		5			1	7	13	

Appendix 1. continued

Species (Bander's codes)	Campbell	Lower Willows Canyon	San Felipe North	San Felipe South	Sentenac Cienega	Vallecito Cienaga	Grand Total	Average
HOWR	1		10	2			13	
LAGO	6	3	2	3			14	
LASP	1						1	
LAZB		1					1	
LBVI	32	44	31	17	12	56	192	
LBWO		2	3		18	3	26	
LEGO	3	20	14	8	14	3	62	
LENI		6	1			1	8	
LOSH	3	3			5	2	13	
LUWA				1			1	
MODO	7	13	21	8	17	16	82	
NOFL			1		2		3	
NOMO	1	4	1	2	4		12	
NUWO	1	1	12	9	9	3	35	
OATI				1			1	
OCWA			2		2		4	
PHAI	2	9	10	18	8	14	61	
PSFL	3			1			4	
QUAIL	2	1		8			11	
ROWR				1	1		2	
RTHA			4	3	5		12	
RWBL					2		2	
SAPH		1					1	
SCOR			2	1	7		10	
SOSP		1	14		2		17	
SPTO	1	5	18	13	10		47	
SUTA			2		1		3	
SWTH				1			1	
TUVU			1	1		2	4	
VERD	19	11	12	19	5	53	119	
WAVI			2		1		3	
WCSP	1		1		1		3	
WEKI		1	4		2		7	
WETA		2		1	3		6	
WEWP		2	1				3	
WIWA	1	5	8	4	7	6	31	
WREN	1	16		5		1	23	

Appendix 1. Continued

Species (Bander's codes)	Campbell	Lower Willows Canyon	San Felipe North	San Felipe South	Sentenac Cienega	Vallecito Cienaga	Grand Total	Average
WWDO	31	27	30	20	39	62	209	
YBCH	2	14	14	1	1	13	45	
YEWA		6	30	5	16	1	58	
YRWA	1		1				2	
Total Abundance	**210**	**372**	**396**	**396**	**394**	**347**	**2115**	352.5
Species Richness	35	43	52	49	59	32	79	45.0

Appendix 2. Average number of birds detected per point count station at six riparian areas in Anza Borrego Desert Park in 2017.

Species (Bander's Codes)	Campbell	Lower Willow Canyon	San Felipe North	San Felipe South	Sentenac Cienega	Vallecito Cienaga	Survey Visit Total per visit	average	Species Rank
AMCR				0.3			0.3		75
AMKE					0.3		0.3		75
ANHU	1.3	1.0	0.3	0.3	0.3	0.3	3.7		41
ATFL	1.7	3.0	2.3	8.0	5.3	0.3	20.7		10
BCFL		0.3	3.0	0.7	2.3		6.3		28
BCSP					0.7		0.7		66
BEWR	4.0	18.0	6.0	14.3	6.7	12.3	61.3		3
BGGN	1.7	1.0		0.3	0.3	0.3	3.7		40
BHCO	3.0	1.0	0.7	2.7	0.7	1.0	9.0		22
BHGR	0.3	0.7	0.7		0.3		2.0		49
BLGR	1.0	1.0	0.3	0.3	2.3		5.0		31
BRBL					9.3		9.3		20
BTGN	2.0	0.3		1.0	1.0	4.0	9.0		24
BTSP	1.0		0.3		0.7	0.3	2.3		45
BUOR			4.3	0.7	9.7	2.0	16.7		14
BUSH			0.7	7.3	0.7		8.7		23
CACW		0.3	0.3	0.3	0.3		1.3		52
CALT	2.7	5.7	2.7	9.7	3.0	1.7	25.3		8
CAQU	0.3	2.0	4.0	17.0	3.0	0.7	27.0		7
CASJ			1.3	2.7	2.7		6.7		26
CATH	3.3	2.7	2.0	2.7	3.7	5.7	20.0		12
CAVI			0.3	0.7	0.3		1.3		52
CHSP					0.3		0.3		75
COHU	2.3	3.7	0.7	1.0	0.3	2.0	10.0		19
CORA		0.3	5.0	1.3	2.3	0.3	9.3		20
COYE	0.3	0.3	0.7	0.3	0.3		2.0		49
DOWO			0.3	0.3			0.7		66
DUFL						0.3	0.3		75
ECDO		0.7	0.3		4.3		5.3		33
EUST			2.0	3.3	0.3		5.7		29
GAQU				1.0			1.0		58
GRRO					0.3	1.3	1.7		51
HETH			1.0				1.0		58
HOFI	5.3	14.3	8.7	4.7	4.3	2.0	39.3		5
HOOR		1.7			0.3	2.3	4.3		35
HOWR	0.3		3.3	0.7			4.3		35

Appendix 2. continued

Species (Bander's Codes)	Campbell	Lower Willow Canyon	San Felipe North	San Felipe South	Sentenac Cienega	Vallecito Cienaga	Survey Visit Total per visit	average	Species Rank
LAGO	2.0	1.0	0.7	1.0			4.7		33
LASP	0.3						0.3		75
LAWO					2.0		2.0		47
LAZB		0.3					0.3		75
LBVI	10.7	14.7	10.3	5.7	4.0	18.7	64.0		2
LBWO		0.7	1.0		4.0	1.0	6.7		26
LEGO	1.0	6.7	4.7	2.7	4.7	1.0	20.7		9
LENI		2.0	0.3			0.3	2.7		44
LOSH	1.0	1.0			1.7	0.7	4.3		35
LUWA				0.3			0.3		75
MODO	2.3	4.3	7.0	2.7	5.7	5.3	27.3		6
NOFL			0.3		0.7		1.0		58
NOMO	0.3	1.3	0.3	0.7	1.3		4.0		38
NUWO	0.3	0.3	4.0	3.0	3.0	1.0	11.7		17
OATI				0.3			0.3		75
OCWA			0.7		0.7		1.3		52
PHAI	0.7	3.0	3.3	6.0	2.7	4.7	20.3		11
PSFL	1.0			0.3			1.3		52
QUAIL	0.7	0.3		2.7			3.7		42
ROWR				0.3	0.3		0.7		66
RTHA			1.3	1.0	1.7		4.0		38
RWBL					0.7		0.7		66
SAPH		0.3					0.3		75
SCOR			0.7	0.3	2.3		3.3		43
SOSP		0.3	4.7		0.7		5.7		29
SPTO	0.3	1.7	6.0	4.3	3.3		15.7		15
SUTA			0.7		0.3		1.0		58
SWTH				0.3			0.3		75
TUVU			0.3	0.3		0.7	1.3		52
UNKN					1.3		1.3		52
UNBL					0.3		0.3		75
UNGN			0.3		0.3		0.7		66
UNHU	1.0	1.0	1.7	0.3	0.7	0.3	5.0		31
UNOR	0.3						0.3		75
UNTH				0.7			0.7		66
UNWO	0.3			0.3	0.3		1.0		58
UNWR						0.7	0.7		66

Appendix 2. continued

Species (Bander's Codes)	Campbell	Lower Willow Canyon	San Felipe North	San Felipe South	Sentenac Cienega	Vallecito Cienaga	Survey Visit Total per visit	average	Species Rank
VERD	6.3	3.7	4.0	6.3	1.7	17.7	39.7		4
WAVI			0.7		0.3		1.0		58
WCSP	0.3		0.3		0.3		1.0		58
WEKI		0.3	1.3		0.7		2.3		46
WETA		0.7		0.3	1.0		2.0		47
WEWP		0.7	0.3				1.0		58
WIWA	0.3	1.7	2.7	1.3	2.3	2.0	10.3		18
WREN	0.3	5.3		1.7		0.3	7.7		25
WWDO	10.3	9.0	10.0	6.7	13.0	20.7	69.7		1
YBCH	0.7	4.7	4.7	0.3	0.3	4.3	15.0		16
YEWA		2.0	10.0	1.7	5.3	0.3	19.3		13
YRWA	0.3		0.3				0.7		66
Average Survey Abundance	**71.7**	**125.0**	**134.0**	**133.3**	**134.3**	**116.7**	**715.0**	**119.2**	
Average point count station abundance	**11.9**	**13.9**	**13.4**	**13.3**	**11.2**	**11.7**	**12.6**	**12.6**	

Appendix 3. Bander's Codes, Common names and Scientific names of birds detected at six riparian areas in Anza Borrego Desert Park in 2017.

Bander's Code	Common name	Scientific name
AMCR	American Crow	*Corvus brachyrhynchos*
AMKE	American Kestrel	*Falco sparverius*
ANHU	Anna's Hummingbird	*Calypte anna*
ATFL	Ash-throated Flycatcher	*Myiarchus cinerascens*
BCFL	Brown-crested Flycatcher	*Miyarchus tyrannulus*
BCSP	Black-chinned Sparrow	*Spizella atrogularis*
BEWR	Bewick's Wren	*Thryomanes bewickii*
BGGN	Blue-grey Gnatcatcher	*Polioptila caerulea*
BHCO	Brown-headed Cowbird	*Molothrus ater*
BHGR	Black-headed Grosbeak	*Pheucticus melanocephalus*
BLGR	Blue Grosbeak	*Guiraca caerulea*
BRBL	Brewer's Blackbird	*Euphagus cyanocephalus*
BTGN	Black-tailed Gnatcatcher	*Polioptila melanura*
BTSP	Black-throated Sparrow	*Amphispiza bilineata*
BUOR	Bullock's Oriole	*Icterus galbula*
BUSH	Bushtit	*Psaltiparus minimus*
CACW	Cactus Wren	*Campylorhynchus brunneicapillus*
CALT	California Towhee	*Melozone crissalis*
CAQU	California Quail	*Callipepla californica*
CASJ	California Scrub-Jay	*Aphelcoma californica*
CATH	California Thrasher	*Toxostoma redivivum*
CAVI	Cassin's Vireo	*Vireo cassinii*
CHSP	Chipping Sparrow	*Spizella passerina*
COHU	Costa's Hummingbird	*Calypte costae*
CORA	Common Raven	*Corvus corax*
COYE	Common Yellow-throat	*Geothlypis trichas*
DOWO	Downy Woodpecker	*Picoides pubescens*
DUFL	Dusky Flycatcher	*Empidonax oberholeri*
ECDO	Eurasian Collared Dove	*Streptopelia decaocto*
EUST	European Starling	*Sturnus vulgaris*
GAQU	Gambel's Quail	*Callipepla gambelii*
GRRO	Greater Roadrunner	*Geococcyx californianus*
HETH	Hermit Thrush	*Catharus guttatus*
HOFI	House Finch	*Carpodacus mexicanus*
HOOR	Hooded Oriole	*Icterus cucullatus*
HOWR	House Wren	*Troglodytes aedon*

Appendix 3. continued

Bander's Code	Common name	Scientific name
LAGO	Lawrence's Goldfinch	*Spinus lawrencei*
LASP	Lark Sparrow	*Chondestes grammacus*
LAZB	Lazuli Bunting	*Passerina amoena*
LBVI	Least Bell's Vireo	*Vireo belli pusillus*
LBWO	Ladder-backed Woodpecker	*Picoides scalaris*
LEGO	Lesser Goldfinch	*Spinus psaltria*
LENI	Lesser Nighthawk	*Chordeiles acutipennis*
LOSH	Loggerhead Shrike	*Lanius ludovicianus*
LUWA	Lucy's Warbler	*Oreothlypis luciae*
MODO	Mourning Dove	*Zenaida macroura*
NOFL	Northern Flicker	*Colaptes auratus*
NOMO	Northern Mockingbird	*Mimus polyglottos*
NUWO	Nuttall's Woodpecker	*Picoides nuttallii*
OATI	Oak Titmouse	*Baeolophus inornatus*
OCWA	Orange-crowned Warbler	*Vermivora celata*
PHAI	Phainopepla	*Phainopepla nitens*
PSFL	Pacific-slope Flycatcher	*Empidonax difficilis*
QUAIL	California or Gambel's Quail	*Callipepla spp.*
ROWR	Rock Wren	*Salpinctes obsoletus*
RTHA	Red-tailed Hawk	*Buteo jamaicensis*
RWBL	Red-winged Blackbird	*Agelaius phoenicus*
SAPH	Say's Phoebe	*Sayornis saya*
SCOR	Scott's Oriole	*Icterus parisorum*
SOSP	Song Sparrow	*Melospiza melodia*
SPTO	Spotted Towhee	*Pipilo maculatus*
SUTA	Summer Tanager	*Piranga rubra*
SWTH	Swainson's Thrush	*Catharus ustulatus*
TUVU	Turkey Vulture	*Cathartes aura*
UNKN	Unknown bird	*n/a*
UNBL	Unknown Blackbird	*n/a*
UNGN	Unknown Gnatcatcher	*n/a*
UNHU	Unknown Hummingbird	*n/a*
UNOR	Unknown Oriole	*n/a*
UNTH	Unknown Thrush	*n/a*
UNWO	Unknown Woodpecker	*n/a*
UNWR	Unknown Wren	*n/a*
VERD	Verdin	Auriparus flaviceps

Appendix 3. continued

Bander's Code	Common name	Scientific name
WAVI	Warbling Vireo	Vireo gilvus
WCSP	White-crowned Sparrow	Zonotrichia leucophrys
WEKI	Western Kingbird	Tyrannus verticalis
WETA	Western Tanager	Piranga ludoviciana
WEWP	Western Wood-Pewee	Conotopus sordidulus
WIWA	Wilson's Warbler	Wilsonia pusilla
WREN	Wrentit	Chamaea fasciata
WWDO	White-winged Dove	Zenaida asiatica
YBCH	Yellow-breasted Chat	Icteria virens
YEWA	Yellow Warbler	Setophaga petechial
YRWA	Yellow-rumped Warbler	Setophaga coronata