Corvid Density and Population Trends Inside and Outside Campgrounds at Big Basin Redwoods State Park

Prepared for California State Parks, Santa Cruz District

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Abstract

I surveyed corvids at Big Basin Redwoods State Park during the summer months of 2017. Distance sampling methods provided estimates of corvid density in campgrounds and control plots. I established survey points along point transects located at ten previously studied research plots first surveyed in 2003. I surveyed each study plot once using the area search method and four times between June – August using standard point count protocols adjusted for distance sampling and targeting corvids. Jays and ravens occurred at greater densities and were detected more frequently in campgrounds compared to control plots. A total of 25 bird species were detected during point count surveys and control plots exhibited greater avian diversity compared to campgrounds. The relationship between 2017 point count data and 2017 area search data facilitated a conversion of area search data from previous years into density estimates. Raven density did not change significantly between 2003 – 2017 in campgrounds nor in control plots. Jay density did not change in control plots, but did decline significantly in campgrounds between 2003 – 2017. Jay density in campgrounds decreased a total of 87% at an estimated annual rate of 8%. The decrease in jay density in campgrounds contrasted with stable or slightly decreasing trends at larger spatial scales and suggested that local drivers including reduced human food subsidies contributed to fewer jays in campgrounds. I rarely observed anthropogenic food subsidies during point counts and anecdotally observed high levels of compliance among campers with guidelines for reducing food subsidies.

Introduction

I surveyed the corvid population in campgrounds and control plots at Big Basin Redwoods State Park in 2017 for the California State Parks Department, Santa Cruz District. This project extends previous corvid surveys (2003-2008,2012) designed to evaluate the effectiveness of corvid management in the park. In previous years, surveys include three additional state and county parks, however this year's effort focused exclusively on Big Basin Redwoods State Park.

The most abundant corvid species in the Coastal Redwood Forest of Big Basin includes Common Ravens (*Corvus corax*; hereafter ravens) and Steller's Jays (*Cyanocitta stelleri;* hereafter jays). As synanthropic species (or human commensals), raven and jay populations respond positively to anthropogenic resources intentionally or unintentionally provided to them (Webb et al. 2011, Goldberg et al. 2016). Human recreation serves as a prominent source of anthropogenic subsidies for corvids (Marzluff and Neatherlin 2006, Walker and Marzluff 2015). In parks and other designated wildlands, campgrounds provide supplemental resources such as refuse and human food which attract corvids and increases their survival and reproduction (Neatherlin and Marzluff 2004).

The positive response of ravens, jays and other corvids to anthropogenic subsidies and resultant widespread population growth present widespread conservation concerns. Some corvids depredate sensitive species, such as the federally-threatened and state-listed endangered Marbled Murrelet. At Big Basin, murrelets nests in remnant redwood forest habitat with old growth and mature components (Baker et al. 2006). Moreover, most remaining potential murrelet nesting habitat occurs within campgrounds or within 1km of campgrounds (Peery and Henry 2010). To address this conservation issue, State Parks initiated several management changes aimed to reduce anthropogenic subsidies in campgrounds including wildlife-proof trash receptacles and a visitor compliance and education program dubbed the "Crumb Clean Campaign". The goals of this management effort include reducing anthropogenic subsidies, lowering corvid number and by extension, decreasing predation pressure on nesting murrelets.

Methods

Establishing point transects

I established point transects at ten previously studied research plots (Halbert 2012) in Big Basin Redwoods State Park on June 22nd of this year. Four plots exist within campgrounds and six plots occur in similar habitat outside campgrounds along access roads or trails. Excluding anthropogenic modifications, all survey plots occur in redwood forest with old growth and mature characteristics (Halbert 2012). I placed equally-spaced survey stations within point transects at each study plot to ensure complete spatial coverage. Survey stations were located no closer than 125m to the nearest survey station to reduce double-counting. The number of survey stations ranged between 2 - 6 depending on plot size.

Point Count Surveys

Data collection during point counts followed standard procedures (Ralph et al. 1995) slightly modified for distance sampling (Buckland et al. 1993, Thomas et al. 2010) while also specifically targeting corvids (Luginbuhl et al. 2001). During point count surveys, I passively observed and recorded all bird species seen or heard for 10 minutes. For the target taxa (corvids), I also estimated radial distance to each bird observed within four distance bins: 0-25m, 25-75m, 75-125m and 125-250m. I verified distances using a hand-held laser rangefinder. I also estimated the maximum number of individuals of each corvid species observed at that point. Abiotic data collected at each point included temperature (recorded once at the beginning of each transect), cloud cover (0 - 33%, 34 - 66%; 67 – 100%)), Beaufort wind speed (Lewis 2015) and survey time. In addition, I recorded the presence or absence of anthropogenic food subsidies (*e.g*., spilled trash, unattended food, campers feeding wildlife) at each survey point.

Area Search Surveys

In addition to point transects, I also surveyed each study plot using the area search method (Ralph et al. 1993) following the protocol used in previous corvid surveys at Big Basin (Halbert 2012). In summary, this procedure involves walking slowly through each study plot and pausing often to listen to vocalizations and visually scan for corvids. The search area at campground included the entire campsite and a surrounding buffer of 50m. The search area at control plots extended 50m from the center of the road or trail. This method suffers from a relatively long list of potential sources of error including: bird movement, observer movement, reduced detectability due to distance, unequal survey times, unequal plot area and failure to count all individuals. The area search method employed for corvid surveys at Big Basin is described in more detail in Halbert (2012).

Timing of survey efforts

The schedule for conducting point transects followed the frequency and temporal methods established for previous corvid surveys at Big Basin (Halbert 2012). Following Halbert et al. (2012), I surveyed the study site four times: once in June and August and twice in July at equally-spaced intervals. In total, I surveyed each point transect four times using point counts and I surveyed each survey plot once using the area search method. Survey dates in 2017 included: June 29th and 30th; July 12th, 13th, July 14th, 26th, 27th; and August 15th. Surveys targeted at corvids often lack curfews based on the findings of Luginbuhl et al. (2001), who found time of day did not influence the results of corvid surveys. I followed the advice of Luginbuhl et al. (2001) and omitted a survey curfew for corvid surveys at Big Basin in 2017.

Distance Sampling

I used data from point transects to implement distance sampling using the program DISTANCE (Thomas et al. 2010). Distance sampling provides relatively unbiased density estimates and avoids several potential sources of error associated with the area search method. Double-counting due to bird movement represents the most significant potential source of error for distance sampling. The analytical approach involves first matching a detection function that adequately describes the relationship between the number of observations and radial distance to observed individuals. If the function adequately fits the data (based on visual inspection of the detection probability plot and/or a goodness-of-fit test), then the shape of the curve facilitates density estimates.

Model Selection and Parameter Estimation

Information-theoretic approaches (Burnham and Anderson 2002) balances model fit and parsimony and enables model comparison. Under the information-theoretic approach, the best model possesses the lowest AIC value and competing models differ from the best model by < Δ 10 AIC. For a suite of competitive models, I calculated model weights (Burnham and Anderson 2002) for each model and produced model-weighted estimates (Burnham and Anderson 2002) of corvid density and standard errors (SE's) separately for campgrounds and control plots. I used non-parametric Z-tests (Buckland et al. 2001) to evaluate the statistical significance of differences in densities between campgrounds and control plots.

Population Trend Analysis

I conducted a trend analysis to determine whether changes occurred in Big Basin corvid populations since surveys began in 2003. To accomplish this, I estimated the relationship between area search results and density estimates generated from point transects and distance sampling. I first compared the mean maximum number of jays and the mean maximum number of ravens at campgrounds and control plots observed during area search surveys from 2017 with corresponding density estimates. Plotting the 2017 area search results against 2017 density estimates for jays and ravens yielded linear equations from ordinary least-square regression (OLS; Python: NumPy.polyfit) (van der Walt et al. 2011). The equations allowed for the mean maximum number of jays or ravens observed during area searches from 2003 - 2012 to be converted into density estimates. I also used OLS (Python: NumPy.polyfit) (van der Walt et al. 2011) to produce a regression line from these data and evaluate trends in the density of jays and ravens at Big basin from 2003 – 2017. Specifically, I tested the hypothesis that the regression coefficient of the regression line estimated from corvid densities against year differed significantly from zero.

Covariates of Frequency of Occurrence

I investigated the relationship between biotic and abiotic factors and the total number of corvids detected at each survey point using Spearman's rank correlation (Python: SciPy. Stats (van der Walt et al. 2011). I also analyzed the frequency of occurrence at point counts for corvids and all other bird species observed. I used contingency tables to evaluate whether jays and ravens occurred more frequently in point counts located in campgrounds compared to control plots. I compared total avian diversity (Shannon Index (H'); (Shannon 1948) in campgrounds and control plots using the Hutcheson t-test (Hutcheson 1970).

Statistical Procedures

I used the programming language Python (Python Software Foundation) to conduct all statistical analyses and generate figures. Data were checked for normality (Python: SciPy. Stats (van der Walt et al. 2011) and visually for skew. If required, data were LOG- or inverse-transformed prior to analyses. All parametric tests of statistical significance employed the Type I error rate $\alpha = 0.05$, corrected for family-wise error rate using the Bonferroni correction (α/m), where m = number of related hypothesis tests.

Results

Summary and Observations of Food Subsidies
I conducted 133 point count surveys and 11 area search surveys within 10 study plots at Big Basin in 2017. Forty-eight point counts surveys occurred in four campgrounds and 85 took place in six control plots. During only two point count surveys (2%) did I observe anthropogenic food subsidies potentially accessible to corvids, and I never directly observed corvids successfully foraging on refuse or human food during surveys.

Diversity and Relative Abundance
The average start time for point count surveys was 1059. I detected jays at 46% and ravens at 16% of all point count surveys. I detected a total of 25 species during point count surveys. Jays and ravens ranked as the 5th and 10th most frequently-detected species respectively (Table 1, Fig. 9). I detected jays during 90% and 21% ($\chi^2_1 = 24.13$, $p < 0.001$) of campground and control plot surveys, respectively. I detected ravens at 38% and 4% of campground and control plot surveys, respectively ($\chi^2_1 = 55.09$, $p <0.001$) (Fig. 1). Overall avian diversity (H') was significantly greater in control plots (H' = 2.73) compared to campgrounds (H' = 2.43; $t_{458} = -4.21$; $p < 0.001$).

Covariates and Corvid Detection
I selected the Bonferroni correction for family-wise error rate ($p < 0.008$) to evaluate the statistical significance of correlations between biotic and abiotic covariates and the total number of corvids detected during each point count survey. Total corvids detected was negatively correlated with wind ($r_s = -0.36$, $p <0.001$) and start time ($r_s = -0.27$, $p = 0.001$) but not with cloud cover ($r_s = 0.20$, $p = 0.01$), temperature ($r_s = 0.12$, $p = 0.14$), date ($r_s = 0.03$, $p = 0.73$) or the number of non-corvid species ($r_s = -0.04$, $p = 0.68$).

Jay Density in Campgrounds and Control Plots
During the exploratory phase of model-fitting, several models of jay density were evaluated, and three models adequately fit the data (Buckland et al. 1993) based on both visual inspection of the detection probability plots and goodness-of-fit tests (all $p > 0.70$; Table 2). Each model utilized automatic selection of four intervals and the half-normal detection function, but they differed in the methods used for series expansion (see Buckland et al. 1993 for methodological details). I used model-weighted density estimates from the three best-fitting models to compare jay density in campground and control plots. The density (number of detections/ha) of jays in campgrounds (3.82 ± 0.48; $\bar{x} \pm$ SE) was significantly greater than jay density in control plots (1.79 +- 0.63) (Z = 2.63, $p = 0.008$) (Fig. 8).

Raven Density in Campgrounds and Control Plots
Numerous models (>20) employing various combinations of detection functions were explored for raven density. However, none of the models adequately passed the goodness-of-fit test (p >0.05) while simultaneously passing the visual inspection test for the probability density function. The single best-fitting model was chosen based on visual inspection of the detection probability plot, but it failed to pass the goodness-of-fit test (χ^2_1= 6.48; $p = 0.01$). This best-fitting model for raven density employed the half-normal detection function without series

[1]Based on the mean percentage of density/ha between 2003 (32.46) and 2017 (3.82); 1.54 jays/ha/18.14 jays/ha = 0.08

expansion and automatic selection of four intervals. I used raven density estimates from this model to compare raven density in campground and control plots. The density (number of detections/ha) of raven in campgrounds (1.68 ± 0.23) was significantly greater than raven density in control plots (0.98 ± 0.17) ($Z = 2.46$, $p = 0.01$) (Fig. 8).

Trends in Jay and Raven Populations, 2003 – 2017

The relationship between point counts density estimates and the mean maximum number of jays or ravens in 2017 yielded equations of the form ($y = 0.4440x + 1.6000$) for jays and ($y = 0.2434x + 0.9449$) for ravens (Figs. 2, 3). I used these equations to estimate corvid density from mean maximum jays or ravens observed during area search surveys conducted prior to 2017. The resulting density estimates were regressed against year using OLS. Raven density did not change significantly in campgrounds ($R^2 = 0.302$, $p = 0.176$; $y = 0.02x -32.51$; Fig. 4) or control plots ($R^2 = 0.029$, $p = 0.746$; $y = 0.003x -4.42$; Fig. 5) during 2003-17. Jay density declined significantly in campgrounds ($R^2 = 0.705$, $p =0.009$; $y = -1.54x + 3117.08$; Fig. 6), equating to an a total decline of 87%, and an annual decrease of 1.54 jays/ha or 8%[1] between 2003 – 2017. However, jay density did not decline significantly in control plots ($R^2 = 0.382$, $p = 0.096$; $y = -0.05x + 106.82$; Fig. 7).

[1]Based on the mean percentage of density/ha between 2003 (32.46) and 2017 (3.82); 1.54 jays/ha/18.14 jays/ha = 0.08

Discussion

Density, Relative Abundance and Diversity
The patterns of corvid relative abundance and density observed in 2017 reflected similar patterns observed in previous corvid surveys (Halbert 2012). The relative abundance and densities of both jays and ravens were greater in campgrounds compared to control plots. Jays occurred at 213% greater density in campgrounds compared to control plots and ravens occurred at 171% greater density in campgrounds compared to control plots. In contrast, total avian diversity (H') was significantly greater in control plots compared to campgrounds. Greater relative abundance of corvids in campgrounds combined with greater overall avian diversity in control plots underscores the synanthropic character of these species.

Density and Relative Abundance of Jays Compared to Ravens
Jays occurred at greater overall densities than ravens. In campgrounds, jays occurred at 227% greater density than ravens, and in control plots, jays occurred at 183% greater density than ravens. This result should be expected based on the two species' allometric relationship alone; mean raven mass (782g for California) (Boarman and Heinrich 1999) is 611% greater than mean jay body mass (128g). However, additional life history, ecological and behavioral differences (dominance hierarchies, for example) probably contribute to differences in their relative abundance.

Comparing Trends at Different Spatial Scales
Comparison with population trends occurring at broad spatial scales help determine if unique, local drivers influence smaller-scale trends. Trends in local corvid populations could be driven primarily by processes driving corvid populations over landscape scales such as the entire Santa Cruz Mountains. Data for corvid population trends over broad spatial scales comes from Breeding Bird Surveys (BBS) and Audubon-sponsored Christmas Bird Counts (CBC). These sources are potentially subject to substantial sources of error and require some subjectivity during interpretation, but they represent the best available data of their kind.

Population Trends for Ravens at Different Spatial Scales
CBC data for ravens in the Santa Cruz Mountains show sharp increases in the late 1980s, with numbers peaking between 2003-2009 and gradually declining since (Fig.10). The two BBS routes in the Santa Cruz Mountains, Waterman Gap and Pescadero show slight increases in raven populations, but large confidence intervals ("credible intervals"; (Sauer et al. 2017)) describe the estimates between 1966 – 2015 (Pescadero 1.78% ±1.89; Waterman Gap 0.15% ±2.62). The lack of a trend in the raven population at Big Basin (2003 – 2017) is consistent with the CBC and BBS data. Processes occurring at spatial scales larger than the extent of the study area at Big Basin represent the most likely drivers of raven population trends.

Population Trends for Jays at Different Spatial Scales
CBC data for jays from the Santa Cruz Mountains show some temporal variation, but suggest an overall gradual increase between 1961 – 2015 when plotted and visually examined (West 2017). When just considering CBC data between 2003 – 2015, jay abundance appears stable or declining (Fig. 11). The two BBS routes in the Santa Cruz Mountains, Waterman Gap and Pescadero, show conflicting trends for jays between 1966 – 2015. Waterman Gap indicates a

slight increase 1.76% ±1.01. While Pescadero indicates a decrease in jay populations, the estimate (-3.78%, ±0.97), is substantially less than the decrease observed at Big Basin. Thus, smaller-scale drivers, such as a reduction in access to human food, represent the most likely explanation for decreasing jay populations at Big Basin.

Anthropogenic Subsidies and Corvid-human Interactions

Despite conducting numerous point count surveys, I rarely observed potential food subsidies and never observed corvids successfully accessing anthropogenic food. On one occasion, I did observe ravens accessing trash illegally dumped along the North Access Road, but this occurred between surveys and outside the boundaries of a study plot. This study did not include a systematic study of human-corvid interactions required to make conclusive inferences. However, since I camped several nights at Big Basin, I made many anecdotal observations of corvid behavior, most notably in campgrounds. Both adult and juvenile jays seem ubiquitous in campgrounds, appeared well-habituated to campers and I observed them frequently foraging in campsites. However, jay foraging success appeared extremely low at campsites, despite the significant amount of time they spent actively foraging. Ravens occurred less frequently in campsites and despite exercising greater wariness than jays, raven adults and fledglings also foraged in campsites. I did not observe ravens successfully foraging on human food subsidies. The absence of observations of successful foraging by corvids in campsites suggests a high level of compliance by campers with management efforts to reduce human food subsidies. On the other hand, continued foraging by corvids in campsites probably indicates the occurrence, either past or present, of successful foraging on anthropogenic food sources in campgrounds.

Covariates of Corvid Detections

Although most songbird survey protocols stipulate a time curfew (Ralph et al. 1993), specialized protocols developed for corvids do not, primarily based on the results of Luginbuhl et al. (2001). In the present study, the significant relationship observed between survey time and total detections of corvids differs from Luginbuhl et al. (2001). Significant difference between the present study and the work by Luginbuhl et al. (2001) could explain these results. Unlike the current study, the corvid survey methods based on Luginbuhl et al. (2001) use active methods involving broadcasting corvid calls at 25% of the survey points, which were particularly effective for detecting ravens. Other potential explanations for the different results achieved in this study compared to those of Luginbuhl et al. (2001) include different sample sizes and site-specific variation. The duration, spatial extent number of surveys included in the current study are dwarfed by the multi-year, large-scale effort by Luginbuhl et al. (2001) involving a much larger sample size (3308 surveys). In addition, Luginbuhl et al. (2001) studied corvids in western Washington State, a region characterized by a cooler, very mesic Maritime Climate and different forest types (Western Hemlock and Sitka Spruce Forests) which differs from the present study site.

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Tables

Table 1. Bird species observed during 133 point counts at six study plots located at Big Basin Redwoods State Park, June-August 2017

Species Code*	**Common Name**	**Scientific Name**	**Number of Point Counts**	**Number of Campground Point Counts**	**Number of Control Point Counts**	**Overall Detection Frequency**
BRCR	Brown Creeper	*Certhia americana*	79	29	50	0.59
CBCH	Chestnut-backed Chickadee	*Poecile rufescens*	78	28	50	0.58
ACWO	Acorn Woodpecker	*Melanerpes formicivorus*	69	35	34	0.51
PSFL	Pacific-slope Flycatcher	*Empidonax difficilis*	64	16	48	0.48
STJA	Steller's Jay	*Cyanocitta stelleri*	61	43	18	0.46
BTPI	Band-tailed Pigeon	*Patagioenas fasciata*	42	11	31	0.31
HETH	Hermit Thrush	*Catharus guttatus*	38	11	27	0.28
PAWR	Pacific Wren	*Troglodytes pacificus*	29	2	27	0.22
PYNU	Pygmy Nuthatch	*Sitta pygmaea*	25	8	17	0.19
CORA	Common Raven	*Corvus corax*	21	18	3	0.16
DEJU	Dark-eyed Junco	*Junco hyemalis*	19	2	17	0.14
SPTO	Spotted Towhee	*Pipilo maculatus*	19	5	14	0.14
AMRO	American Robin	*Turdus migratorius*	13	4	9	0.10
WIWA	Wilson's Warbler	*Cardellina pusilla*	13	4	9	0.10
PIWO	Piliated Woodpecker	*Dryocopus pileatus*	10	4	6	0.07
WAVI	Warbling Vireo	*Vireo gilvus*	8	0	8	0.06
GCKI	Golden-crowned Kinglet	*Regulus satrapa*	6	3	3	0.04
NOFL	Northern Flicker	*Colaptes auratus*	6	0	6	0.04
WBNU	White-breasted Nuthatch	*Sitta carolinensis*	4	0	4	0.03
HAWO	Hairy Woodpecker	*Picoides villosus*	3	2	1	0.02
RSHA	Red-shouldered Hawk	*Buteo lineatus*	3	1	2	0.02
NUWO	Nuttall's Woodpecker	*Picoides nuttallii*	2	0	2	0.01
HUVI	Hutton's Vireo	*Vireo huttoni*	1	0	1	0.01
MAMU	Marbled Murrelet	*Brachyramphus marmoratus*	1	0	1	0.01
TUVU	Turkey Vulture	*Cathartes aura*	1	0	1	0.01

Table 2. Best-fitting models of jay density derived from distance sampling analyses. Information-theoretic methods use AIC to choose the best model. AIC represents a tradeoff between precision (model fit) and the number of parameters (parsimony). The model with the lowest AIC values is considered the best and models < delta AIC are considered competitive with the best model. Final estimates of model parameters (density and SE) were obtained by computing an average across models weighted by their model weight.

Model ID	Model Name	K	AIC	Δ AIC	Model Weight
18	Jays_Seen+Heard_Auto_Interval_Strat_Half_Normal/Cosine	3	407.97	0	1
21	Jays_Seen+Heard_Auto_Interval_Strat_Half_Normal/Simple_Polynomial	2	409.37	1.4	0.93
20	Jays_Seen+Heard_Auto_Interval_Strat_Half_Normal/Hermite_Polynomial	2	409.37	1.4	0.93

Figures

Fig. 1.

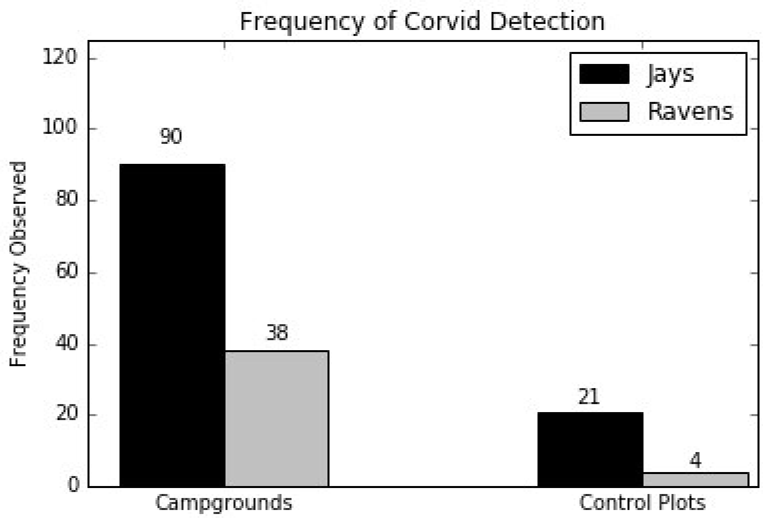

Fig 1. Frequency of corvid detection during 133 point count surveys conducted along point transects situated at campground and control plots during June – August 2017.

Fig. 2

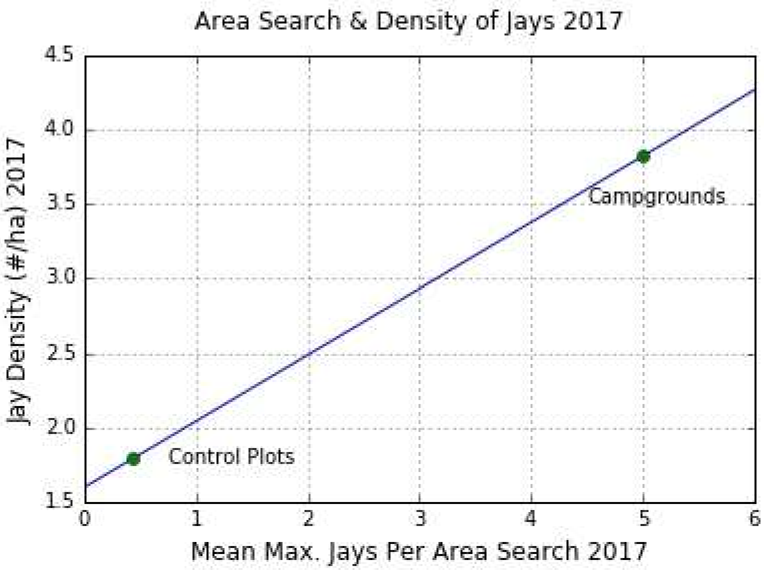

Fig. 2. Figure generated from plotting the relationship between jay density estimated from point count surveys conducted along point transects in campgrounds and controls against the mean maximum jay density observed during area search surveys also conducted during June – August 2017. The relationship is described by the equation $y = 0.4440x + 1.6000$.

Fig. 3.

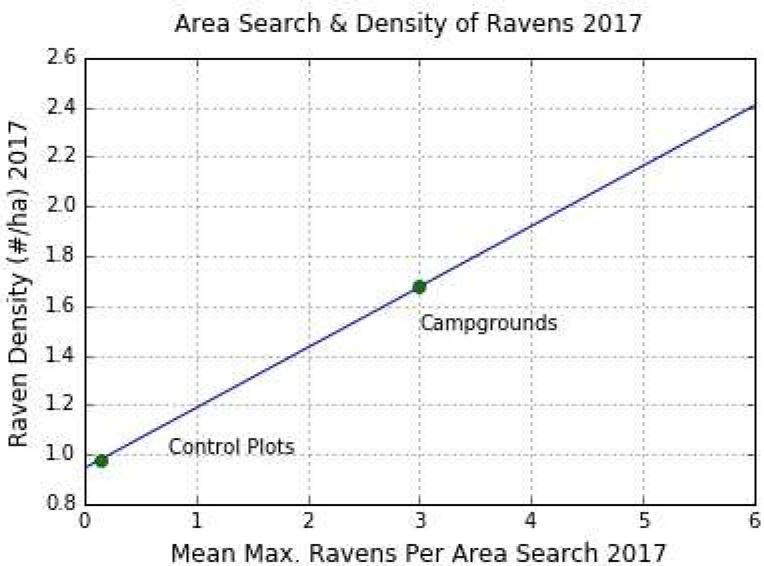

Fig. 3. Figure generated from plotting the relationship between raven density estimated from point count surveys conducted along point transects in campgrounds and controls against the mean maximum raven density observed during area search surveys also conducted during June – August 2017. The relationship is described by the equation y = 0.2434x + 0.9449.

Fig. 4.

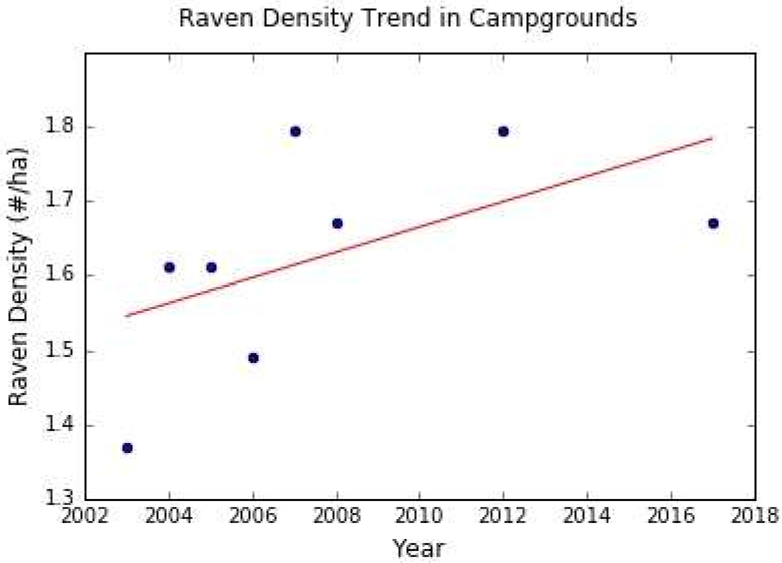

Fig. 4. Results of the linear trend analysis for raven populations in campgrounds during 2003 – 2017 at Big Basin. The density estimate for 2017 was generated by distance sampling and the density estimates for previous years were estimated using the relationship of density estimates and mean maximum ravens detected during area search surveys also conducted in 2017. Raven density did not change significantly in campgrounds during this period of time ($R^2 = 0.30$, $p = 0.176$).

Fig. 5.

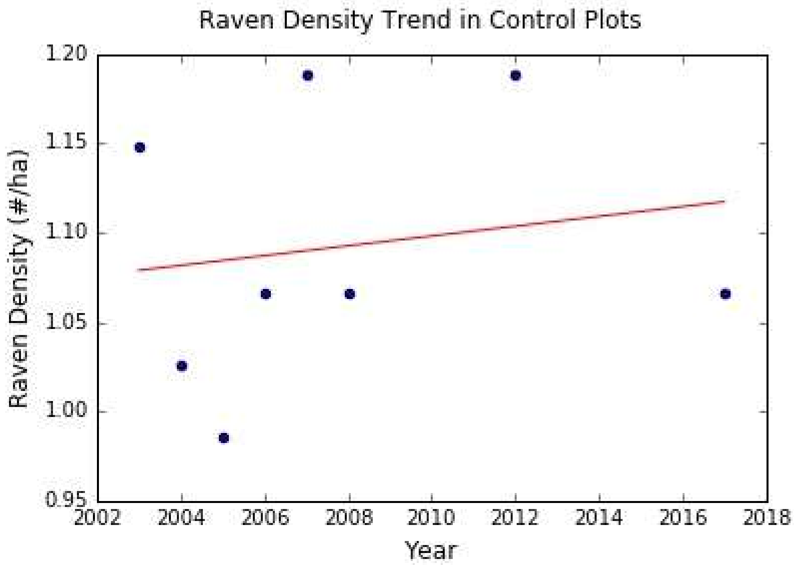

Fig. 5. Results of the linear trend analysis for raven populations in control plots during 2003 – 2017 at Big Basin. The density estimate for 2017 was generated by distance sampling and the density estimates for previous years were estimated using the relationship of density estimates and mean maximum ravens detected during area search surveys also conducted in 2017. Raven density did not change significantly in control plots during this period of time ($R^2 = 0.03$, $p = 0.746$).

Fig. 6.

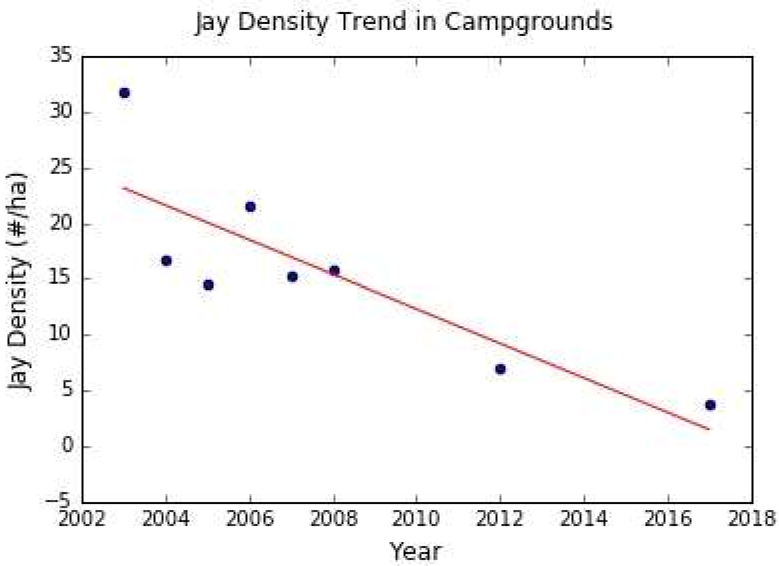

Fig. 6. Results of the linear trend analysis for jay populations in campgrounds during 2003 – 2017 at Big Basin. The density estimate for 2017 was generated by distance sampling and the density estimates for previous years were estimated using the relationship of density estimates and mean maximum jays detected during area search surveys also conducted in 2017. Jay density declined significantly in campgrounds during this period of time ($R^2 = 0.70$, $p = 0.009$).

Fig. 7.

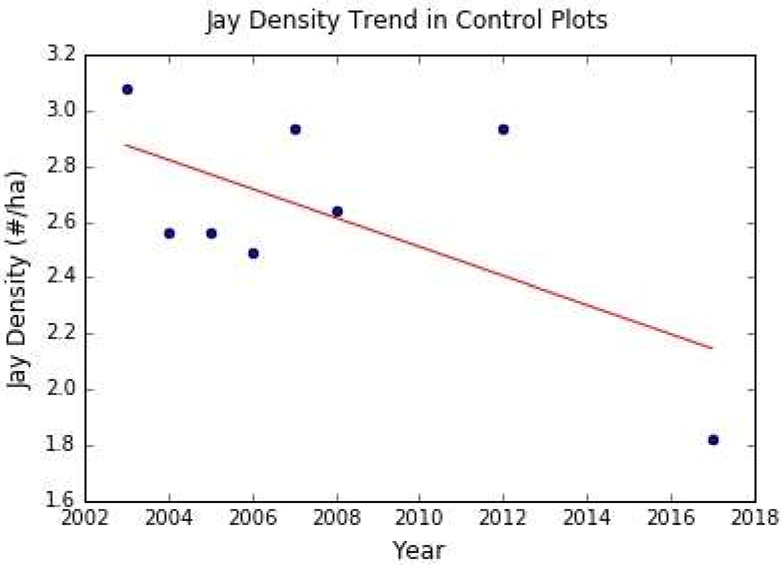

Fig. 7. Results of the linear trend analysis for jay populations in control plots during 2003 – 2017 at Big Basin. The density estimate for 2017 was generated by distance sampling and the density estimates for previous years were estimated using the relationship of density estimates and mean maximum jays detected during area search surveys also conducted in 2017. Jay density did not change significantly in control plots during this period of time ($R^2 = 0.38$, $p = 0.096$).

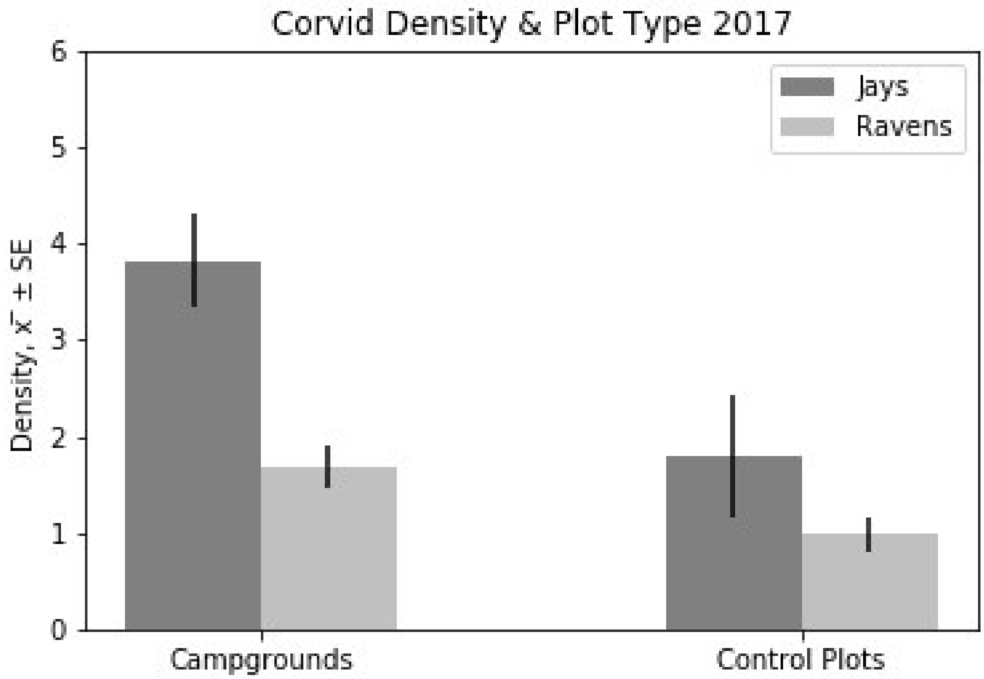

Fig. 8. Corvid density in campgrounds and control plots estimated from distance sampling conducted at Big Basin during June – August 2017.

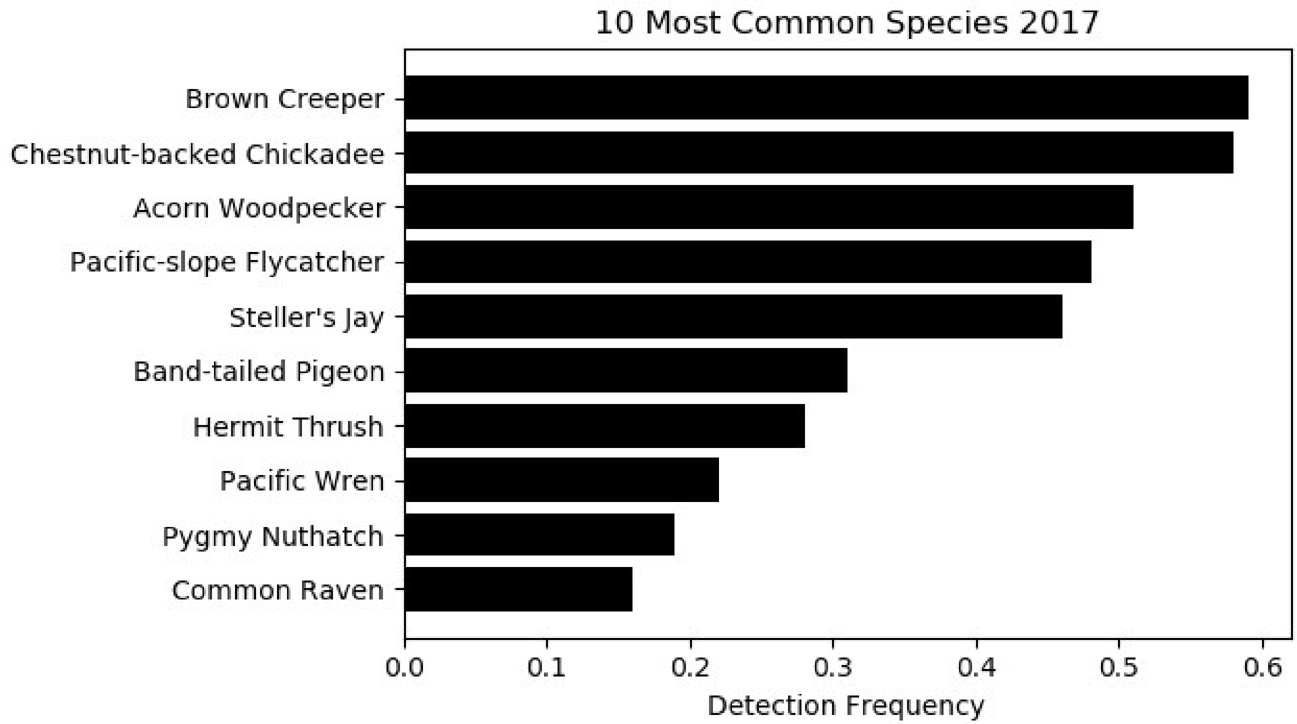

Fig. 9. The ten most commonly-detected species during corvid surveys conducted June – august 2017 at Big Basin Redwoods State Park.

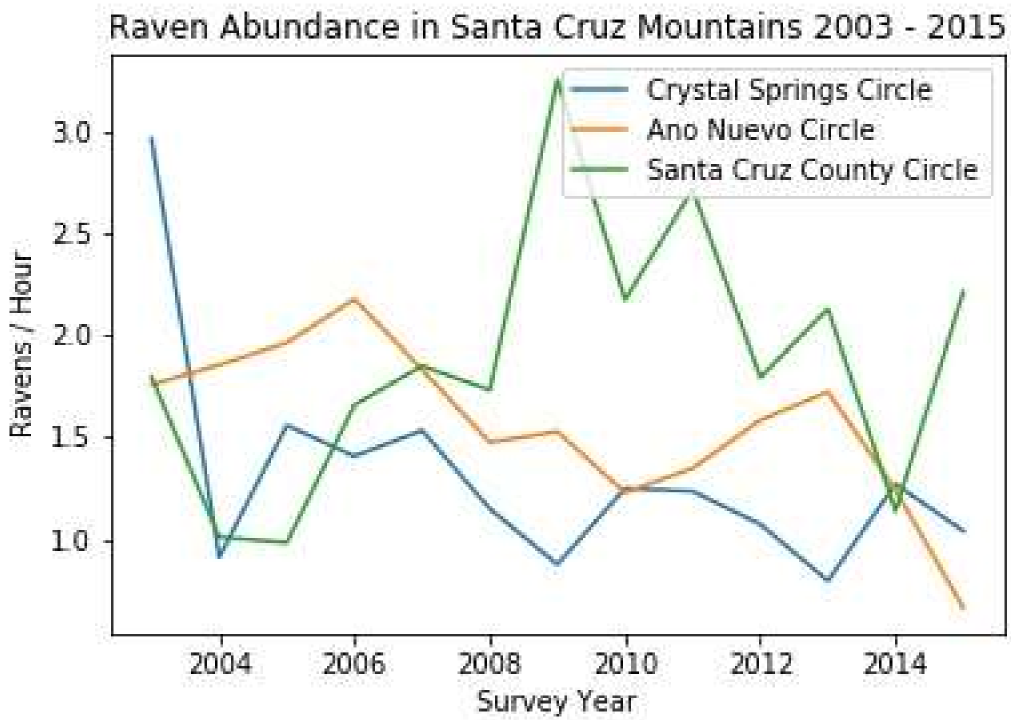

Fig. 10. Raven abundance in the Santa Cruz Mountains 2003-2015. Data are from the three closest Christmas Bird Count Circles: Ano Nuevo, Santa Cruz County and Crystal Springs.

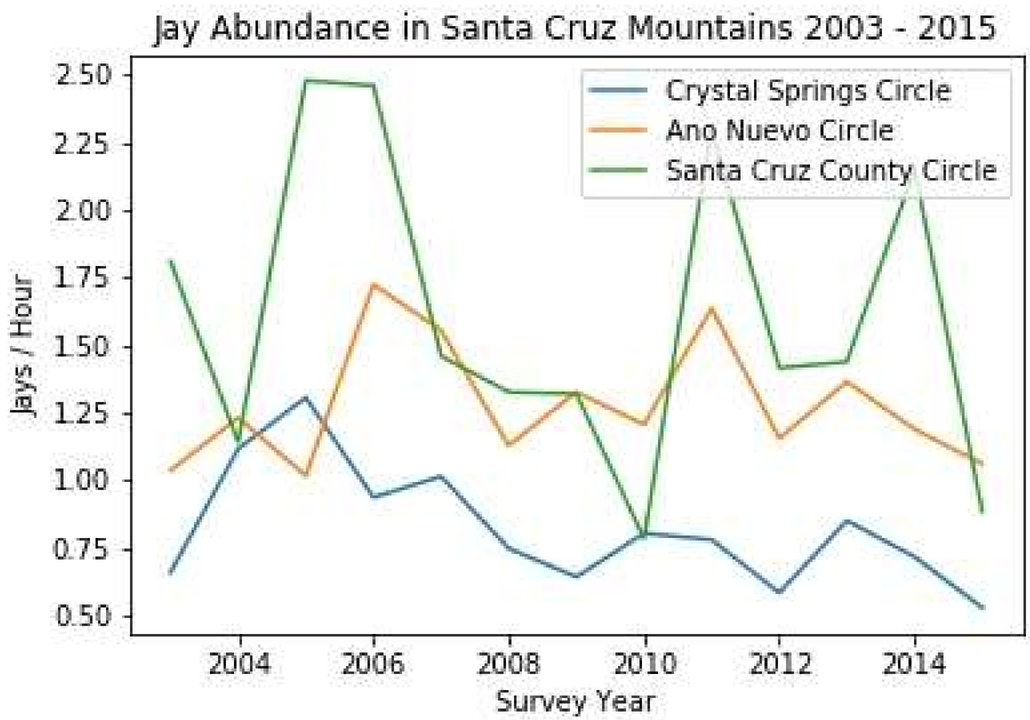

Fig. 11. Jay abundance in the Santa Cruz Mountains 2003-2015. Data are from the three closest Christmas Bird Count Circles: Ano Nuevo, Santa Cruz County and Crystal Springs.