Appendix H

Terrestrial Species Stressor Monitoring Reports

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Evaluating mammalian diversity in the Mojave Desert and Great Valley ecoregions of California using camera trap surveys

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Executive Summary

1. In response to the drought State of Emergency declared in 2014, California's Department of Fish and Wildlife (CDFW) prioritized monitoring of wildlife populations and their associations with drought stressors and habitat features. As part of this effort, CDFW initiated Terrestrial Species Stressor Monitoring (TSM) surveys in 2016 to collect baseline data on wildlife species in the Mojave Desert and Great Valley ecoregions. In this report, we present our analysis of camera trap data from the 2016-17 TSM surveys. For each ecoregion, our objectives were to estimate the occupancy and richness of terrestrial mammal species weighing >0.5kg and to evaluate community and species-specific responses to climate and habitat variables.
2. We deployed camera traps at 320 and 265 sites across the Mojave Desert and Great Valley ecoregions, respectively, in the springs of 2016 and 2017. We used this camera trap data, in combination with multi-species hierarchical occupancy models, to estimate and evaluate mammal distributions.
3. Sixteen and 22 species of terrestrial mammals (>0.5kg) were photographed in the Mojave Desert and Great Valley ecoregions, respectively, with camera-specific estimates of species richness ranging from 0 – 13. Black-tailed jackrabbits (ψ = 0.73) and kit foxes (ψ = 0.34) had the highest estimated occupancies in the Mojave, whereas coyotes (ψ = 0.49) and raccoons (ψ = 0.45) had the highest estimated occupancies in the Great Valley. The mammal community in the Mojave tended to be positively associated with elevation and negatively associated with mean temperature and distance to pinyon juniper forest. The mammal community in the Great Valley, alternatively, tended to be positively associated with crop diversity and negatively associated with natural vegetative cover.
4. Our results suggest projected increases in temperature will negatively influence the Mojave Desert's mammal community, and consequently, that the protection of climate refugia (e.g., high elevations, shaded areas, and permanent water sources) may be an increasingly important conservation strategy. This is particularly true for some species in the region, like deer, Audubon's cottontail, and bobcat, which appeared to be more vulnerable to projected climate changes than species like the kit fox.
5. In the Great Valley, our results suggest that the remnant mammal community is adept at accessing resources and surviving in this human-modified, agricultural landscape. Working with landowners to diversify agricultural practices and maintain habitat heterogeneity is important, however, as heterogeneity within and among croplands positively influences the mammal community.

6. Biodiversity loss, climate change, and anthropogenic pressures on ecosystems are accelerating. The infrastructure required to monitor changes in biodiversity and species' vulnerability to stressors, however, is often lacking. Our analysis demonstrates the utility of camera traps and multi-species occupancy models for monitoring terrestrial mammals, including elusive species. Expanding beyond our snapshot in time however, requires long-term data. With longer-term data (e.g., >5 years), we can develop an understanding of the processes occurring within these ecoregions including trends in species' occupancy and the influence of climate, environment, and humans on mammal communities. This information in turn, would allow managers to track, improve, and adapt management actions aimed at addressing the loss of wildlife populations.

Introduction

Following the drought State of Emergency declared in 2014, the California Department of Fish and Wildlife (CDFW) was tasked with implementing projects that respond to drought conditions. In order to effectively design and implement these projects, however, additional information on many wildlife populations is needed. Consequently, CDFW has prioritized monitoring wildlife populations including their distributions, abundances, vulnerability to drought stressors, and relationships to other habitat features.

The spatial distributions of wildlife are shaped by a diversity of biotic and abiotic factors. One such factor is water availability. In California, wildlife populations are generally positively associated with the presence of water (Schoenherr 1992). Bobcats (*Lynx rufus*), for example, are positively associated with stream density and riparian areas (Markovchick-Nicholls et al. 2008; Broman et al. 2014), the persistence of bighorn sheep (*Ovis canadensis*) is positively correlated with the presence of dependable springs (Epps et al. 2004), and striped skunks (*Mephitis mephitis*) often select for wetland habitat (Lariviére & Messier 2000). In southwestern USA, including the Mojave Desert, artificial water catchments (hereafter "guzzler") may also influence the distributions of wildlife because they provide permanent or semi-permanent surface water in areas where natural water is scarce (Bleich 1992; Cutler and Morrison 1998; Bleich et al. 2010; Larsen et al. 2012).

The influence of vegetative cover on the occurrence of wildlife, alternatively, is generally species-specific. Black-tailed jackrabbits (*Lepus californicus*) and kit foxes (*Vulpes macrotis*), for example, favor arid and semi-arid grasslands and shrublands (McGrew 1979; Wilson & Ruff 1999), whereas red foxes (*Vulpes vulpes*), California ground squirrels (*Otospermophilus beecheyi*), and opossums (*Didelphis virginiana*) are able to exploit a diversity of habitats (Whitaker 1980; Pérez-Hernandez et al. 2016). Landscape or habitat heterogeneity may also play a role in determining species' distributions. Species richness and landscape heterogeneity tend to be positively related, as heterogeneous landscapes provide more niches and resources (e.g., food, nest sites, den sites, and cover) than homogenous landscapes (MacArthur and MacArthur 1961; Rosenzweig 1995; Benton et al. 2003; Green et al. 2005).

Human disturbance fragments ecosystems, alters animal movements, and increases human activity and persecution, making it an additional driver of wildlife distributions (Forman & Alexander 1998; Crooks 2002; Ordeñana et al. 2010). In southern California, for example,

native carnivore richness was negatively associated with urban intensity (Ordeñana et al. 2010). In some instances, however, human disturbance can have a minimal or positive influence of species' distributions, as has been found with generalist carnivores like coyotes (*Canis latrans*), gray foxes (*Urocyon cinereoargenteus*), striped skunks, opossums, and raccoons (*Procyon lotor*; Crooks 2002; Ordeñana et al. 2010; Goad et al. 2014; Kowalski et al. 2015; Wang et al. 2015).

Lastly, climatic variables often influence species' distributions (Grinnell 1917). Warming temperatures over the past 30 years have influenced the function and composition of many ecological communities and, in turn, the distributions of many species (Walther et al. 2002). When climate change decreases habitat quality, the result may be local extinctions or a decrease in the number of available habitat patches, which in turn, may lead to the extirpation of a metapopulation (Hanski 1999). Bighorn sheep populations in hotter, drier environments, for example, are more likely to go extinct (Epps et al. 2004). Kit foxes, alternatively, have adaptations for reducing heat loads and conserving water (Cypher 2003), and consequently, may be more tolerant of increases in temperatures and decreases in precipitation. Climate may also influence a species' probability of detection. Increased movements of mule deer (*Odocoileus hemionus*), for example, were associated with decreased temperatures and increased weekly precipitation (Nicholson et al. 1997).

In 2016, CDFW began a coordinated monitoring process by initiating Terrestrial Species Stressor Monitoring (TSM) surveys. TSM surveys collected baseline data on a wide variety of common wildlife species throughout the drought-stricken Mojave Desert (MD) and Great Valley (GV) ecoregions of California. Survey methods included automated sound recordings, visual encounter surveys, rapid habitat assessments, and camera trap surveys. We began our analysis of the TSM surveys by focusing on data collected via camera traps, a non-invasive survey method that targets medium- to large-sized mammals. We had the specific objectives of: (1) estimating the occupancy and richness of terrestrial mammal species weighing >0.5kg in the MD and GV ecoregions; and (2) elucidating community and species-specific responses to ecological variables. Our overarching goal was to provide a better understanding of how ecological traits, including both climate and habitat features, are influencing mammal distributions and richness in the MD and GV ecoregions. This information will help guide the design and implementation of future drought-response projects.

Methods

Camera trap survey and photo identification

Personnel from CDFW deployed Reconyx PC900 cameras at 320 and 265 sites across the MD and GV ecoregions of California, respectively, between March – August 2016 and March – June 2017 (Fig. 1). To guide the placement of cameras, CDFW calculated the total cover of key lifeforms within each ecoregion (Table 1). For each ecoregion, they then selected a spatially-balanced random sample of hexagons, stratified by lifeform, from the USDA Forest Inventory and Analysis program's hexagon grid (hexagon radius is ~2.6 km) and deployed 1-3 cameras, spaced by 1-2 km, within each hexagon. Exact survey locations within the hexagon were also stratified by lifeform. To do this, CDFW created a finer scale grid of ~2400 points separated by 100m within each hexagon and calculated the lifeform at every point within the fine-scale grids.

Cameras were cable-locked onto T-posts that were securely placed in the ground. If T-post mounting was not possible, cameras were secured to a tree or shrub bole. To maximize detection probabilities, a 1-kg salt lick, 500 ml of oatmeal-peanut butter mixture, and 150 g of fishy cat food were placed on the ground near the center of the camera's field of view. When possible, CDFW personnel positioned cameras to face north in order to avoid direct sunlight and potential false triggers. They programmed cameras to take three photos at each trigger event with a delay of one second between trigger events. Each camera was deployed for 20 to 66 days ($\bar{x}$ = 34, *SD* = 7.6) at sites in the MD ecoregion and 9 – 37 days ($\bar{x}$ = 29, *SD* = 3.5) at sites in the GV ecoregion.

Two observers identified photographic detections to the species-level, unaware of how the other observer had classified photos. Observers only recorded a species once during each 24-hr period that a camera was deployed (e.g., a bobcat photographed 5 times over 24-hrs at camera *j* would result in a single data entry). We then determined when there were mismatches between observers in species identification, and had a third individual decide on the final classification (referred to as 'reconciled data'). We used the reconciled data for all analyses. To evaluate the influence that observer bias may have on estimates of occupancy (Table 4), we carried out a preliminary analysis where we compared occupancy estimates based on identifications by observer 1 vs. observer 2. Estimates did not differ between observers (i.e., estimates' 95% credible intervals overlapped), suggesting there were minimal discrepancies between observers in their classification of photos and in the future, the data entry process can be streamlined by using only a single observer.

Covariates

We hypothesized that climate, elevation, slope, water accessibility, vegetative cover, and human disturbance could influence the occupancy and detection patterns of terrestrial mammalian species. To represent climate, we downloaded 4-km resolution precipitation and temperature data from PRISM (Prism Climate Group 2018) for March – August 2016 and March – June 2017 (i.e., the study periods). We used ArcMAP 10.4.1 (ESRI, Redlands, CA, USA) to determine the mean precipitation, temperature, and maximum temperature at each camera location during the respective survey period. We then used the 30-m resolution National Elevation Dataset (USGS 2016) to calculate and extract slope and elevation values for each site location in ArcMAP.

To evaluate water accessibility in the GV, we used Point Blue's Automated Water Tracking System (http://data.pointblue.org/apps/autowater/), which provides up-to-date assessments of the distribution of open surface water in the Central Valley. Specifically, we downloaded data for the study periods and created a single layer for each year indicating whether water was present at some point during the sampling period or not. We then measured the distance from each camera location to the nearest water source. In the MD, we used Global Surface Water Explorer (Pekel et al. 2016) to identify permanent and seasonal water sources. Again, we measured the distances from each camera to the nearest water source. For the MD, we also included a categorical variable indicating whether the camera was located by a guzzler.

We then placed a buffer radius of 1km around the camera locations. A 1-km buffer size provides information on the general conditions surrounding the camera that is applicable to our suite of variably sized species. We used CDFW's Vegetation Classification and Mapping Program (vegCAMP; https://www.wildlife.ca.gov/Data/VegCAMP) data to calculate percent cover of natural vegetation at the GV sites, percent cover of desert scrub at the MD sites, and distance to the nearest forested area for all sites. In the Mojave where forest cover is limited, forested areas consisted solely of pinyon-juniper woodlands. We then used USDA's cropscape data (USDA CropScape 2016) to calculate the number of crop types within the buffered areas in the GV. Lastly, we estimated human disturbance by extracting values from the U.S. Geological Survey's human footprint model (https://sagemap.wr.usgs.gov/humanfootprint.aspx).

To account for variation in the probability of photographing mammals, we explored maximum temperature, precipitation, human disturbance, and bait status as covariates for detection. Bait status was a categorical variable indicating whether a camera station's bait was disturbed at the end of the sampling period (1) or not (0). In the MD, we also included a categorical variable indicating whether the camera was located by a guzzler (1) or not (0).

Multi-species occupancy modeling

We used multi-species hierarchical occupancy models (Dorazio and Royle 2005), analyzed under a Bayesian framework, to estimate and evaluate the distributions and richness of terrestrial mammal species weighing >0.5kg. Multi-species models link species-specific detection and occupancy using community-level hyper-parameters (Zipkin et al. 2010; Iknayan et al. 2014). These hyper-parameters specify the mean response and variation among species within the community to a respective covariate, thus permitting composite analyses of both communities and individual species (Kéry and Royle 2008). The models also facilitate estimates of species richness (i.e., number of species in the community and at each camera).

To discern non-detection from true absence, we treated each trap day as a repeat survey at a particular camera. We assumed occurrence and detection probabilities differed by species and year (2016 = 1, 2017 = 0), and were influenced by ecological covariates. In the MD ecoregion, we assessed two model structures for occupancy (ψ) and detection (p):

Model 1: ψ(guzzler, precipitation, temperature, slope, year), p(guzzler, maximum temperature, bait status, year)
Model 2: ψ(water, scrub, elevation, pinyon-juniper, year), p(human disturbance, precipitation, bait status, year)

In the GV ecoregion, we also assessed two model structures for occupancy and detection:

Model 1: ψ(water, precipitation, temperature, natural cover, year), p(crop diversity, maximum temperature, bait status, year)
Model 2: ψ(forest, crop diversity, latitude, year), p(human disturbance, precipitation, bait status, year)

We incorporated covariates into the model linearly on the logit-probability scale (Zipkin et al. 2010) and ensured models did not include covariates that were correlated. We estimated posterior distributions of parameters using Markov Chain Monte Carlo implemented in JAGS (Plummer 2011) through program R. We generated three chains of 50,000 iterations thinned by 50 and used uninformative priors.

Next, we projected our model results across each of the ecoregions to estimate species-specific probabilities of occupancy and species richness. We used these model-based inferences, which rely on covariate associations, to ensure our estimates were representative of the ecoregions and not just sampled locations (Gregoire 1998; Furnas and McGrann 2018). To project our results, we overlaid a 1km x 1km grid onto the two ecoregions and calculated covariate values for each grid cell. Using these covariate values and the multi-species occupancy modeling output (e.g., community- and species-level beta values for the model covariates), we projected occupancy probabilities across the MD and GV ecoregions for each detected species. We also summed species' occupancy probabilities within each of the grid cells to generate estimates of species richness at the 1km x 1km scale.

Results

In the MD ecoregion, we photographed 16 and 13 species of mammals over 7,402 and 3,467 trap nights in 2016 and 2017, respectively (Table 2). Black-tailed jackrabbits and kit foxes were the most frequently detected species in both years (Table 2). Among the species photographed the least often were the California ground squirrel, opossum, raccoon, striped skunk, and spotted skunk (*Spilogale gracilis*; Table 2).

In the Great Valley (GV) ecoregion, we photographed 17 and 20 species of mammals over 2,570 and 5,171 trap nights in 2016 and 2017, respectively (Table 2). The most photographed species was the black-tailed jackrabbit in both years (Table 2). Conversely, we photographed gray fox the least often in 2016 and American mink and mountains lions the least often in 2017 (Table 2).

Multi-species occupancy modeling

Black-tailed jackrabbits (ψ = 0.72), kit foxes (ψ = 0.36), and coyotes (ψ = 0.33) had the highest estimated occupancies in the MD ecoregion (Fig. 2). Many species in the MD, conversely, had low estimates of occupancy due to their limited numbers of photographic detections (Table 2; Fig. 2, Appendix S2). Species' occupancy probabilities varied among the key lifeforms, but the majority of species (i.e., 75%) were most likely to occupy upper Mojave desert scrub (Appendix S1). Among the covariates, mean temperature had the greatest influence on community-level occupancy in the MD, with occupancy decreasing as mean temperature increased (Table 3). This negative relationship was most evident for species like deer, bobcat, and Audubon's cottontail (*Sylvilagus audubonii*; Fig. 3; Appendix S2). The kit fox was the only species positively associated with temperature (Fig. 3; Appendix S2). Community-level occupancy in the MD was also related to elevation and distance to pinyon-juniper woodlands, with occupancy tending to increase at higher elevations close to pinyon-juniper habitat (Table 3). The positive influence of elevation also held true for individual species like the badger (*Taxidea taxus*), Audubon's

cottontail, bobcat, gray fox, and deer (Fig. 3; Appendix S2). The presence of guzzlers had a weak effect at the community-level, but at the species-level was strongly and positively associated with the occupancy of Audubon's cottontail, bighorn sheep, bobcat, coyote, and gray fox (Fig. 3; Appendix S2). Species' detection probabilities also tended to be positively associated with the presence of a guzzler (Appendix S2). Lastly, precipitation also had a weak effect at the community-level, but was strongly and negatively related to coyote occupancy, and strongly and positively related to Audubon's cottontail and mule deer occupancy (Appendix S2).

Coyotes (ψ = 0.49) and raccoons (ψ = 0.45) had the highest estimated occupancies in the GV ecoregion (Fig. 2). Thirteen of the 22 photographed species, conversely, had occupancy probabilities < 0.10 (Fig. 2). Similar to the MD, this result was a consequence of species having a limited number of photographic detections (Table 2). Among the key lifeforms, human-altered lifeforms like rice fields and orchards/vineyards had the highest mean estimated occupancies for over half of the species (Appendix S1). We note, however, that these lifeforms encompassed a limited number of sampling sites (Table 1). The 95% credible intervals overlapped zero for all community-level hyper-parameters in the GV except natural cover, where species' occupancy probabilities tended to decrease as natural cover increased (i.e., percent natural cover within a 1-km buffered area surrounding the camera trap; Table 3). This was particularly true for opportunistic mammals like California ground squirrel and red fox (Appendix S2). Among the remaining covariates, we found that community-level occupancy tended to increase with crop diversity in the GV and that community-level detection tended to decrease with human disturbance and again, increase with crop diversity (Table 3). Latitude had only a weak, positive influence on community-level occupancy, but at the species-level had a strong, negative influence on the occupancy of, for example, badger, kit fox, and Audubon's cottontail, and a strong, positive influence on the occupancy of, for example, deer, raccoon, and opossum (Fig. 4; Appendix S2). Similarly, precipitation only had a weak influence at the community-level, for both occupancy and detection, but often had a strong influence at the species-level (Fig. 4; Appendix S2).

The distributions of high and low occupancy value areas varied among species (examples shown in Fig. 5, 6). For example, areas with high occupancy values for badger were patchily distributed throughout the MD whereas areas with high occupancy values for kit fox were fairly contiguous in the central part of the ecoregion (Fig. 5). Projected estimates of mammal richness ranged from 0-9 in the MD with a mean of 2.4 (*SD* = 1.13), and 2-13 in the GV with a mean of 6.3 (*SD* = 2.39; Fig. 7). In the MD, estimated species richness appeared to be greatest in the mountainous regions where it was cooler, such as within the Mojave National Preserve. Over 70% of the area with the greatest estimated species richness fell within National Park Service boundaries (Fig. 7). In the GV, species richness appeared to be greatest at higher latitudes (Fig. 7).

Discussion

The California Department of Fish and Wildlife (CDFW) developed Terrestrial Species Stressor Monitoring (TSM) surveys with the goal of collecting baseline data on a wide variety of wildlife species throughout the Mojave Desert and Great Valley ecoregions of California. Having reliable estimates of wildlife populations and methods for detecting wildlife loss are vital in making

informed conservation and management decisions (Zipkin et al. 2010). Methods for directly or indirectly monitoring population abundance (e.g., mark-recapture), however, are often time and cost-intensive, particularly for large-scale or long-term monitoring (Bailey et al. 2004). Additionally, abundance estimation generally focuses on a single species. A viable alternative for managers involved in large-scale, multi-species monitoring programs is occupancy, or the probability that a landscape unit is occupied by a species of interest (Bailey et al. 2004; MacKenzie et al. 2005). By analyzing data from the camera trap surveys in an occupancy-modeling framework, we were able to help achieve TSM goals by generating baseline estimates of occupancy for 16 and 22 mammalian species in the Mojave Desert and Great Valley ecoregions, respectively, and empirically evaluate how these estimates were influenced by climate and habitat features. These efforts could form the foundation of a long-term monitoring program and be used to more effectively design said program (e.g., power analyses to determine number of sampling locations and sampling duration). Long-term monitoring is vital as it would allow managers to quantify and detect trends in occupancy, changes in habitat use, and drivers of local colonization and extinction (MacKenzie et al. 2005). This information, in turn, would have innumerable applications including the design of effective and efficient wildlife management strategies, the mitigation of large-scale ecological stressors, and the development of land use plans that minimize adverse impacts on biodiversity.

In addition to estimating occupancy and species richness, we also evaluated potential drivers of these parameters. In the Mojave Desert ecoregion, our results elucidated the influence of artificial water catchments (i.e., guzzlers) and climate on mammal distributions. Water is a critical resource to wildlife populations, particularly in arid ecosystems around the world (Larsen et al. 2012). We found that the occupancy probabilities of close to half the detected species in the Mojave Desert, as well as the probability of photographing these species, was greater at guzzler sites. Some of these species include, for example, bighorn sheep, Audubon's cottontail, and gray fox. Previous research has also found that ungulates (e.g., deer and bighorn sheep) and medium-sized mammals use these artificial water sources, as well as avian species, small mammals, and a variety of herptofauna (Smith and Henry 1985; Bleich 1992; Cutler and Morrison 1998; Bleich et al. 2010). Our results suggest that guzzlers are a viable and important conservation option in the Mojave, and may become increasingly important as habitats continue to be modified by human development (i.e., where wildlife and humans must compete for water) and climate change (Krausman et al. 2006).

Temperatures in southern California deserts are projected to increase 2° C by 2050 (Snyder and Sloan 2005). Our results suggest this will negatively affect the occupancy of medium to large-sized mammals in the Mojave. We found mean temperature was negatively associated with community- and species-level (n = 6) occupancy, and that elevation, which was highly correlated with temperature (r = -0.82), was positively associated with community- and species-level (n = 7) occupancy. There was only one species, the kit fox, which appeared to be well adapted for projected climate changes as their distributions were positively associated with temperature, negatively associated with elevation, and weakly and negatively associated to both precipitation and the presence of a guzzler. For other Mojave mammals, however, extreme heat and drought resulting from climate change may exceed survival thresholds (Bachelet et al. 2016). Deer, Audubon's cottontail, and bobcat, for example, tended to be negatively associated with temperature and positively associated with water (i.e., precipitation and guzzlers). These species

may be approaching their physiological thresholds in the Mojave, making them vulnerable to future climate change in the region (Serra-Diaz et al. 2014). Based on these results, we recommend protecting climate refugia including permanent water sources (e.g., guzzlers), shady valleys, high elevations, and north facing slopes in order to help mitigate hypothesized impacts of climate change (Bachelet et al. 2016). We also recommend protecting upper Mojave Desert scrub, which covers just 11.5% of the ecoregion, as 12 of the 16 detected mammals had their highest mean estimated occupancies within this lifeform.

In the Great Valley, one of the most intensely developed agricultural regions in the world (Nelson et al. 2003), heterogeneity within and among croplands had a larger influence on mammal occupancy than did climate. The generally positive influence of crop diversity on mammal occupancy and detection supports the heterogeneity hypothesis, which states that diversity is maximized in heterogeneous landscapes, both farmed and natural, as they provide more niches and complementary resources than homogenous landscapes (MacArthur and MacArthur 1961; Rosenzweig 1995; Benton et al. 2003). Thus, in the Great Valley, working with landowners to diversify agricultural practices (e.g., crop diversity, cultivation practices, rotation planning) may greatly benefit the mammal community. In addition to the influence of crop diversity, we also found that the mammal community was negatively related to natural vegetative cover (i.e., grasslands, shrublands, forests, riparian areas, and wetlands). Supporting this trend, we found 15 of the 22 detected species had their highest mean estimated occupancies in a human-altered lifeform (i.e., crop/fallow fields, orchards/vineyards, or rice fields). While this result may seem surprising, it is not unexpected. Many of the species detected in the Great Valley are opportunistic feeders often associated with humans, such as striped skunks, Virginia opossums, raccoons, and California ground squirrels, or they are species known to be behaviorally plastic and adaptable, like coyotes, bobcats, and mule deer (Crooks 2002; Markovchick-Nichols et al. 2008; Ordeñana et al. 2010; Goad et al. 2014; Kowalski et al. 2015; Wang et al. 2015). In such an intensely developed region, it is likely that mammals sensitive to human disturbance have become locally extinct or rare, leaving behind species adept at accessing resources (e.g., food, cover, den sites) and surviving in agricultural, human-modified landscapes.

Biodiversity loss, climate change, and anthropogenic pressures on ecosystems are accelerating (Walther et al. 2002; Alkemade et al. 2009; Butchart et al. 2010). The infrastructure required to monitor changes in biodiversity and species' vulnerability to stressors, however, is often lacking (Ahumada et al., 2013). Our research demonstrates the utility of camera traps for monitoring terrestrial mammals; they provide records of detections for a wide diversity of species, living in a broad range of ecosystems, at any time of day. We also demonstrate the strength of multi-species hierarchical occupancy models (Dorazio and Royle 2005; Iknayan et al. 2014). Unlike traditional community analyses, our multi-species approach allowed us to: (1) account for observation error (i.e., detection probability) so results can be comparable across species, sites, and, in the future, years; (2) retain species identity; and (3) share data across species, permitting comprehensive assessments of the mammal communities and individual species (Zipkin et al. 2010). Furthermore, many species in our study had low detection probabilities. By integrating data across species, we were able to estimate occupancy probabilities for these rare and elusive species and properly account for them in our estimates of species richness.

We encourage continued, systematic camera trap surveys in both the Mojave Desert and Great Valley ecoregions such that results will expand beyond this snapshot in time. With multi-year data, we can estimate trends in occupancy and evaluate how water availability, climate, vegetation, and human disturbance are influencing mammal communities (MacKenzie et al. 2005; Ahumada et al. 2013). This information would allow policy makers and managers to then track, improve, and adapt policies and management actions aimed at addressing the loss of wildlife populations at both local and landscape scales (Butchart et al., 2010).

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Supplementary Materials

Appendix S1. Mammal species' mean occupancy, and 95% credible intervals, within each of the major habitat strata of the A) Mojave Desert and B) Great Valley ecoregions, 2016-17. The habitat with the largest estimated occupancy for each species is highlighted

Appendix S2. Species names and mean and 95% credible intervals (95% CI) for estimates of species-specific probabilities of occurrence, detection probability (for survey duration), and covariate effects on occupancy (PSI) and detection (P) in the Mojave Desert and Great Valley ecoregions of California, 2016-17. We present results from a) model 1 in the MD, b) model 2 in the MD, c) model 1 in the GV, and d) model 2 in the GV. We highlighted covariate effects that did not overlap 0.0.

Table 1. The number of cameras (*n*) deployed in each of the key lifeforms of the Mojave Desert (A) and Great Valley (B) ecoregions of California, 2016-2017, and the percent coverage (% cover) of each lifeform within the respective ecoregion.

A.

Lifeform	*n*	% cover	Lifeform	*n*	% cover
Desert outcrop & badlands	14	4.7	Riparian	38	2.7
Dunes	15	1.3	Great Basin saltbrush scrub	15	1.5
Grasslands	11	1.0	Upper Mojave desert scrub	50	11.5
Lower Mojave desert scrub	100	69.6	Wetlands/open water	13	0.05
Playa	14	4.3	Guzzler	50	

B.

Lifeform	*n*	% cover	Lifeform	*n*	% cover
Crop/fallow	32	30.1	Rice	7	4.2
Grassland/shrub	93	18.8	Riparian	68	0.3
Orchard/vineyard	11	24.9	Wetlands/open water	54	3.2
Alfalfa	0	7.1			

Table 2. Mammal species detected during TSM 2016-17 camera trap surveys in the Mojave Desert and Great Valley ecoregions, their numbers of detections (# det.), naïve occupancy estimates (naïve ψ), and estimates of occupancy across both years.

Common name	Scientific name	Mojave Desert					Great Valley				
		2016 (*n* = 217)		2017 (*n* = 103)		Both	2016 (*n* = 85)		2017 (*n* = 180)		Both
		# det.	Naïve ψ	# det.	Naïve ψ	ψ	# det.	Naïve ψ	# det.	Naïve ψ	ψ
Ringtail	*Bassariscus astutus*	---	---	---	---	---	---	---	7	0.02	0.01
Coyote	*Canis latrans*	211	0.34	95	0.28	0.33	82	0.41	178	0.42	0.49
Elk	*Cervus canadensis*	---	---	---	---	---	14	0.02	---	---	0.01
Opossum	*Didelphis virginiana*	2	0.005	---	---	0.003	40	0.12	199	0.23	0.20
Wild Burro	*Equus asinus*	18	0.02	74	0.05	0.03	---	---	---	---	---
Common porcupine	*Erethizon dorsatum*	---	---	---	---	---	---	---	7	0.02	0.02
Black-tailed jackrabbit	*Lepus californicus*	1106	0.68	730	0.77	0.72	242	0.32	615	0.36	0.34
Bobcat	*Lynx rufus*	107	0.17	88	0.22	0.25	31	0.13	57	0.09	0.11
Striped skunk	*Mephitis mephitis*	4	0.004	---	---	0.002	56	0.34	272	0.40	0.41
American mink	*Mustela vison*	---	---	---	---	---	---	---	1	0.01	0.02
Mule deer	*Odocoileus hemionus*	92	0.07	32	0.03	0.06	104	0.22	279	0.35	0.32
CA ground squirrel	*Otospermophilus beecheyi*	1	0.005	---	---	0.01	68	0.08	266	0.17	0.14
Rock squirrel	*Otospermophilus variegatus*	10	0.009	---	---	0.01	---	---	---	---	---
Bighorn sheep	*Ovis canadensis*	68	0.03	57	0.05	0.04	---	---	---	---	---
Raccoon	*Procyon lotor*	3	0.005	---	---	0.004	151	0.29	330	0.51	0.45
Mountain lion	*Puma concolor*	---	---	---	---	---	---	---	3	0.01	0.01
Western gray squirrel	*Sciurus griseus*	---	---	---	---	---	4	0.03	93	0.09	0.09
Fox squirrel	*Sciurus niger*	---	---	---	---	---	8	0.05	18	0.06	0.07
Spotted skunk	*Spilogale gracilis*	7	0.03	3	0.01	0.03	---	---	---	---	---
Wild Boar	*Sus scrofa*	---	---	---	---	---	---	---	14	0.02	0.01
Audubon's cottontail	*Sylvilagus audubonii*	485	0.22	196	0.24	0.25	170	0.18	447	0.24	0.22
Brush rabbit	*Sylvilagus bachmani*	---	---	---	---	---	8	0.03	---	---	0.02
American badger	*Taxidea taxus*	45	0.12	28	0.17	0.24	7	0.03	9	0.04	0.06
Gray fox	*Urocyon cinereoargenteus*	48	0.06	47	0.07	0.09	2	0.01	40	0.03	0.03
Kit fox	*Vulpes macrotis*	380	0.45	226	0.34	0.36	11	0.03	20	0.02	0.02
Red fox	*Vulpes vulpes*	---	---	---	---	---	35	0.05	12	0.03	0.04

Table 3. Mean ($\bar{x}$) and 95% credible interval estimates of the community-level hyper-parameters hypothesized to influence the probability of occupancy and detection of terrestrial mammal species in the (A) Mojave Desert and (B) Great Valley ecoregions of California, 2016-2017.

A.

	Occupancy				Detection			
	Covariate	$\bar{x}$	95% CI		Covariate	$\bar{x}$	95% CI	
Model 1	Guzzler site	0.38	-0.675	1.176	Guzzler site	0.63	0.182	1.066
	Precipitation	0.02	-0.411	0.412	Max temp	-0.90	-1.651	-0.307
	Temperature	-0.60	-1.132	-0.101	Bait status	-0.08	-0.566	0.413
	Slope	-0.20	-0.775	0.315	Year	0.42	-0.097	1.004
	Year	0.80	0.086	1.667				
Model 2	Water	-0.01	-0.179	0.129	Human disturb.	0.18	-0.006	0.361
	% scrub	-0.08	-0.450	0.245	Precipitation	0.01	-0.472	0.524
	Elevation	0.41	-0.089	0.934	Bait status	0.06	-0.442	0.563
	Forest	-0.22	-0.585	0.067	Year	-1.02	-1.548	-0.437
	Year	0.08	-0.239	0.397				

B.

	Occupancy				Detection			
	Covariate	$\bar{x}$	95% CI		Covariate	$\bar{x}$	95% CI	
Model 1	Water	-0.04	-0.277	0.138	Crop diversity	0.18	-0.084	0.419
	Precipitation	0.13	-0.233	0.488	Max temp	-0.07	-0.269	0.114
	Temperature	0.05	-0.259	0.324	Bait status	-0.02	-0.184	0.139
	Natural cover	-0.16	-0.301	-0.026	Year	-0.11	-0.619	0.418
	Year	-0.35	-0.844	0.136				
Model 2	Forest	0.07	-0.159	0.291	Human disturb.	-0.06	-0.148	0.047
	Crop diversity	0.19	-0.013	0.385	Precipitation	-0.05	-0.310	0.203
	Latitude	0.28	-0.194	0.753	Bait status	-0.00	-0.140	0.112
	Year	-0.15	-0.513	0.221	Year	-0.24	-0.846	0.357

Table 4. The total number of detections, based on observer 1 vs. observer 2, of each mammal species photographed during TSM 2016 camera trap surveys in the Mojave Desert (A) and Great Valley (B), California, 2016. The total number of detections is the sum of the number of days during which the species was photographed at each camera. The number of differences is the number of discrepancies between observer 1 and observer 2 in their camera-specific recordings of detections (e.g., if observer 1 recorded a coyote on 5 days at camera X and 2 days at camera Y whereas observer 2 recorded a coyote on 2 days at camera X and 5 days at camera Y, the total number of observations would be 7 for both observers but the number of differences would be 6).

A.

Species	Obs 1	Obs 2	# diff	Species	Obs 1	Obs 2	# diff
Coyote	213	225	20	Bighorn sheep	69	67	2
Opossum	2	2	0	Raccoon	3	3	0
Black-tailed jackrabbit	1101	1084	67	Western gray squirrel	3	0	3
Bobcat	107	110	7	Spotted skunk	7	7	0
Striped skunk	4	4	0	Audubon's cottontail	485	496	31
Mule deer	92	97	7	American badger	45	48	3
CA ground squirrel	3	10	7	Gray fox	48	68	24
Rock squirrel	6	1	5	Kit fox	379	353	48

B.

Species	Obs 1	Obs 2	# diff	Species	Obs 1	Obs 2	# diff.
Coyote	82	81	7	Raccoon	148	145	13
Elk	13	14	1	Western gray squirrel	3	13	10
Opossum	40	34	6	Fox squirrel	8	0	8
Black-tailed jackrabbit	237	218	27	Audubon's cottontail	173	143	50
Bobcat	32	29	3	Brush rabbit	10	18	24
Striped skunk	55	53	6	American badger	5	7	2
Mink	1	1	0	Gray fox	2	6	4
Mule deer	104	101	5	Kit fox	11	5	6
CA ground squirrel	71	65	6	Red fox	34	32	4

Figure 1. Camera traps deployed in the Mojave Desert and Great Valley ecoregions of California, 2016 – 2017, as part of the Terrestrial Species Stressor Monitoring surveys.

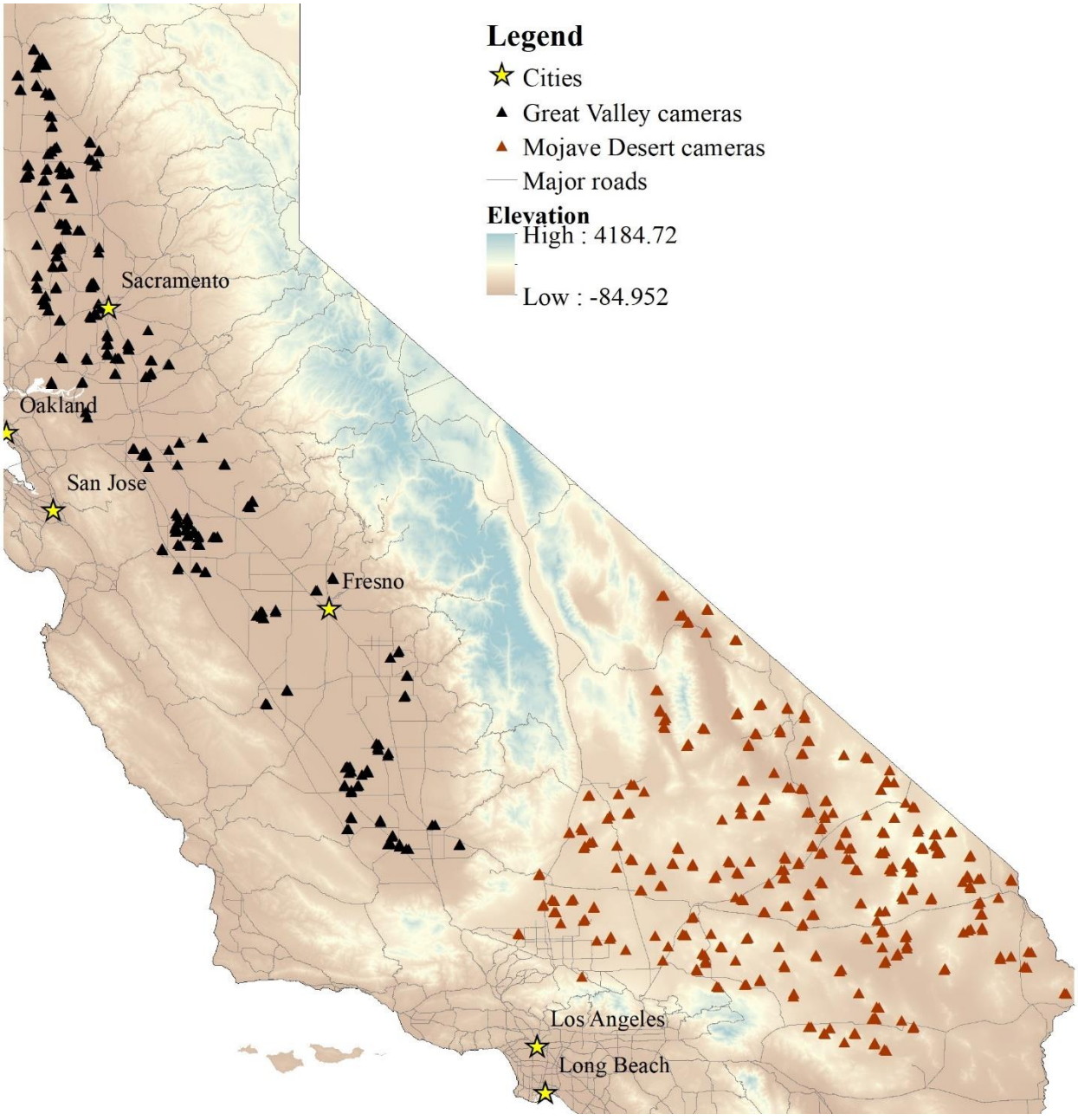
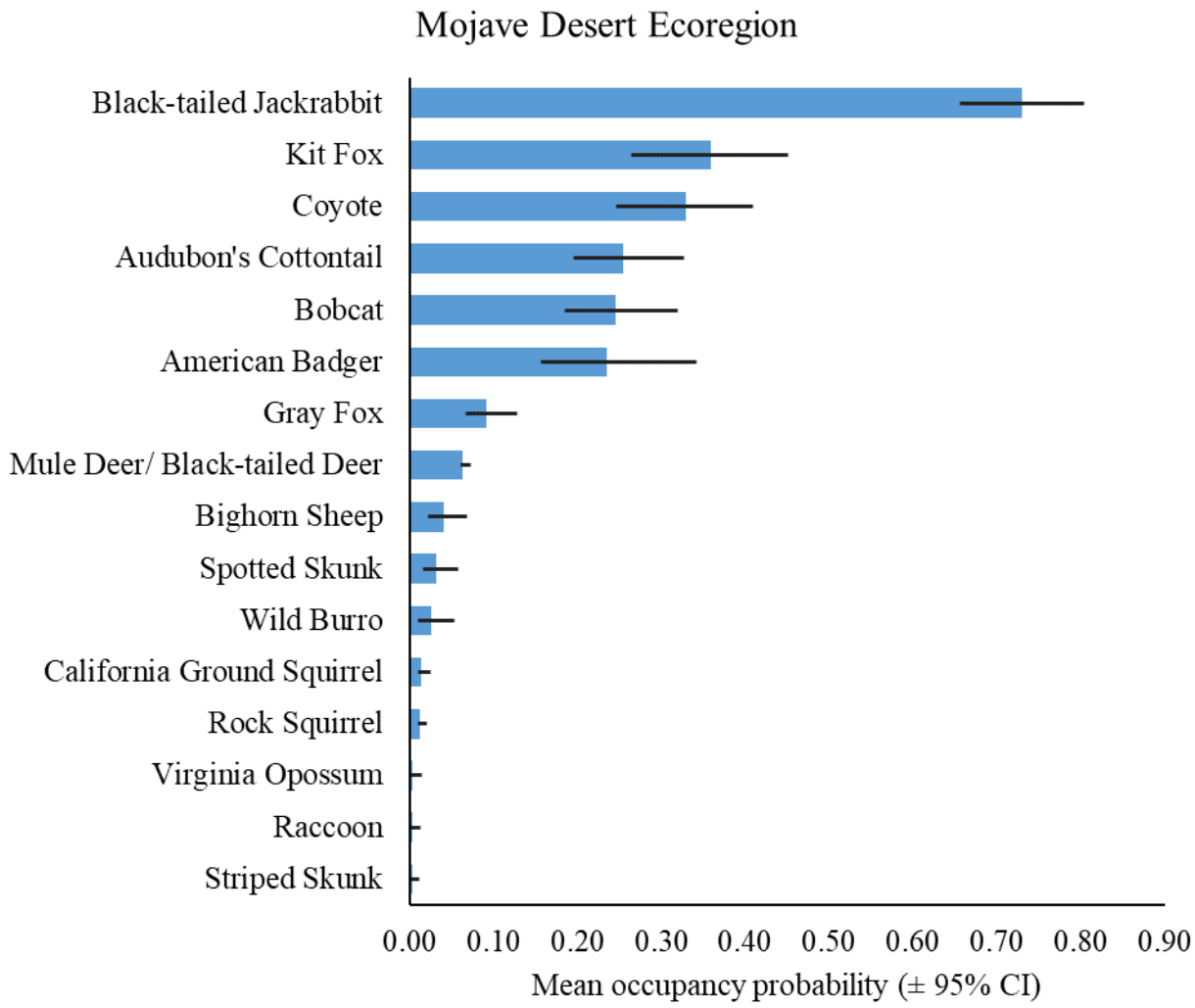


Figure 2. Mean occupancy probabilities for mammal species (> 0.5kg) in the A) Mojave Desert (*n* = 320 sites) and B) Great Valley (*n* = 265 sites) ecoregions of California, 2016-17.

A.



B.

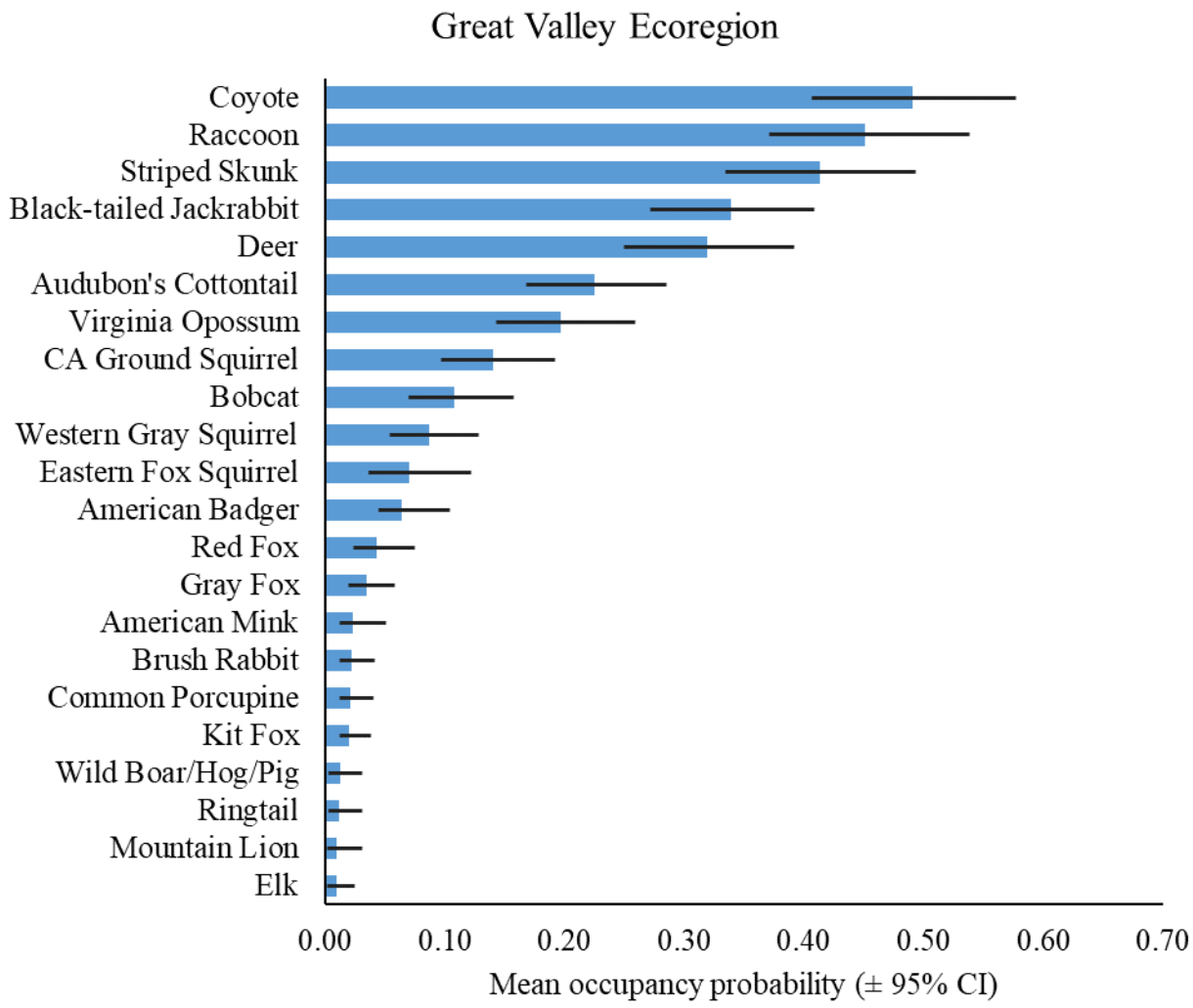
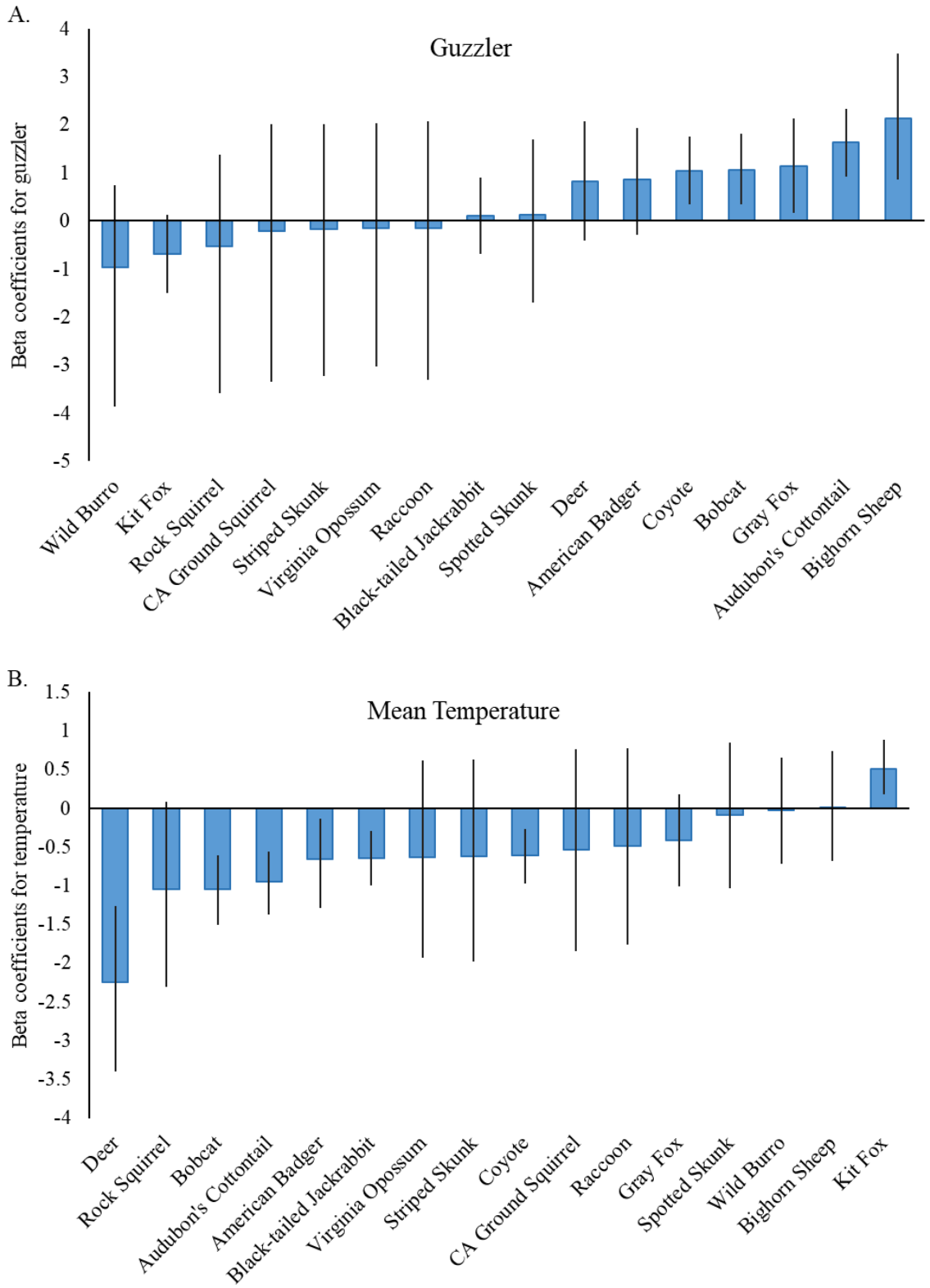
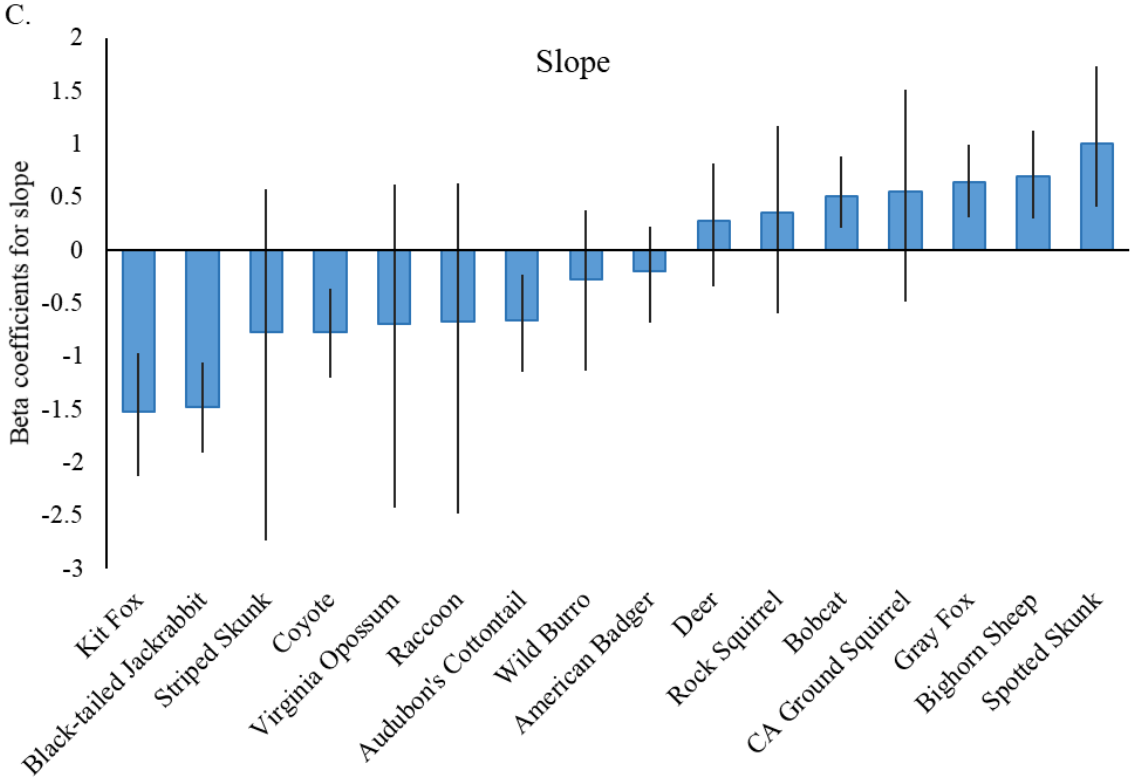

Great Valley Ecoregion
Coyote
Raccoon
Striped Skunk
Black-tailed Jackrabbit
Deer
Audubon's Cottontail
Virginia Opossum
CA Ground Squirrel
Bobcat
Western Gray Squirrel
Eastern Fox Squirrel
American Badger
Red Fox
Gray Fox
American Mink
Brush Rabbit
Common Porcupine
Kit Fox
Wild Boar/Hog/Pig
Ringtail
Mountain Lion
Elk
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
Mean occupancy probability (± 95% CI)

Figure 3. Standardized beta coefficients, and 95% credible intervals, for the influence of A) guzzler classification, B) mean temperature, C) slope, and D) elevation on species' probabilities of occupancy during camera trap surveys in the Mojave Desert ecoregion of California, 2016-17.



C.


Slope
Beta coefficients for slope
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
-2.5
-3
Kit Fox
Black-tailed Jackrabbit
Striped Skunk
Coyote
Virginia Opossum
Raccoon
Audubon's Cottontail
Wild Burro
American Badger
Deer
Rock Squirrel
Bobcat
CA Ground Squirrel
Gray Fox
Bighorn Sheep
Spotted Skunk

D.

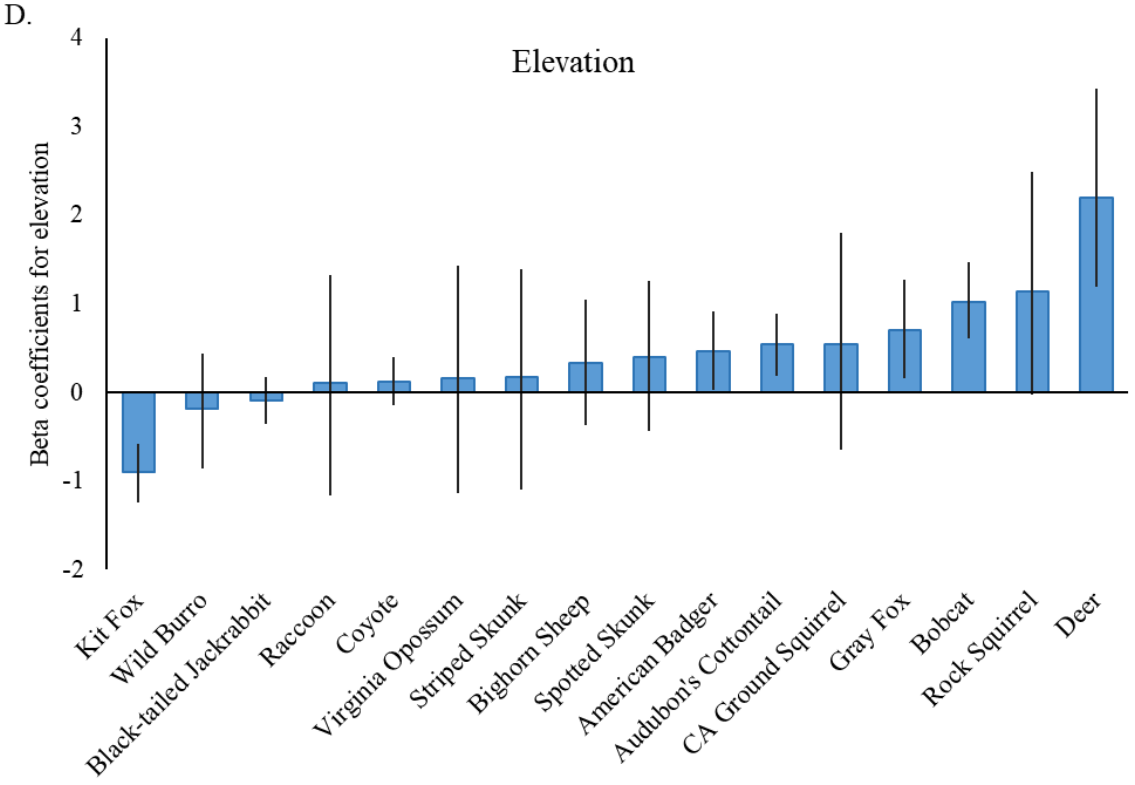
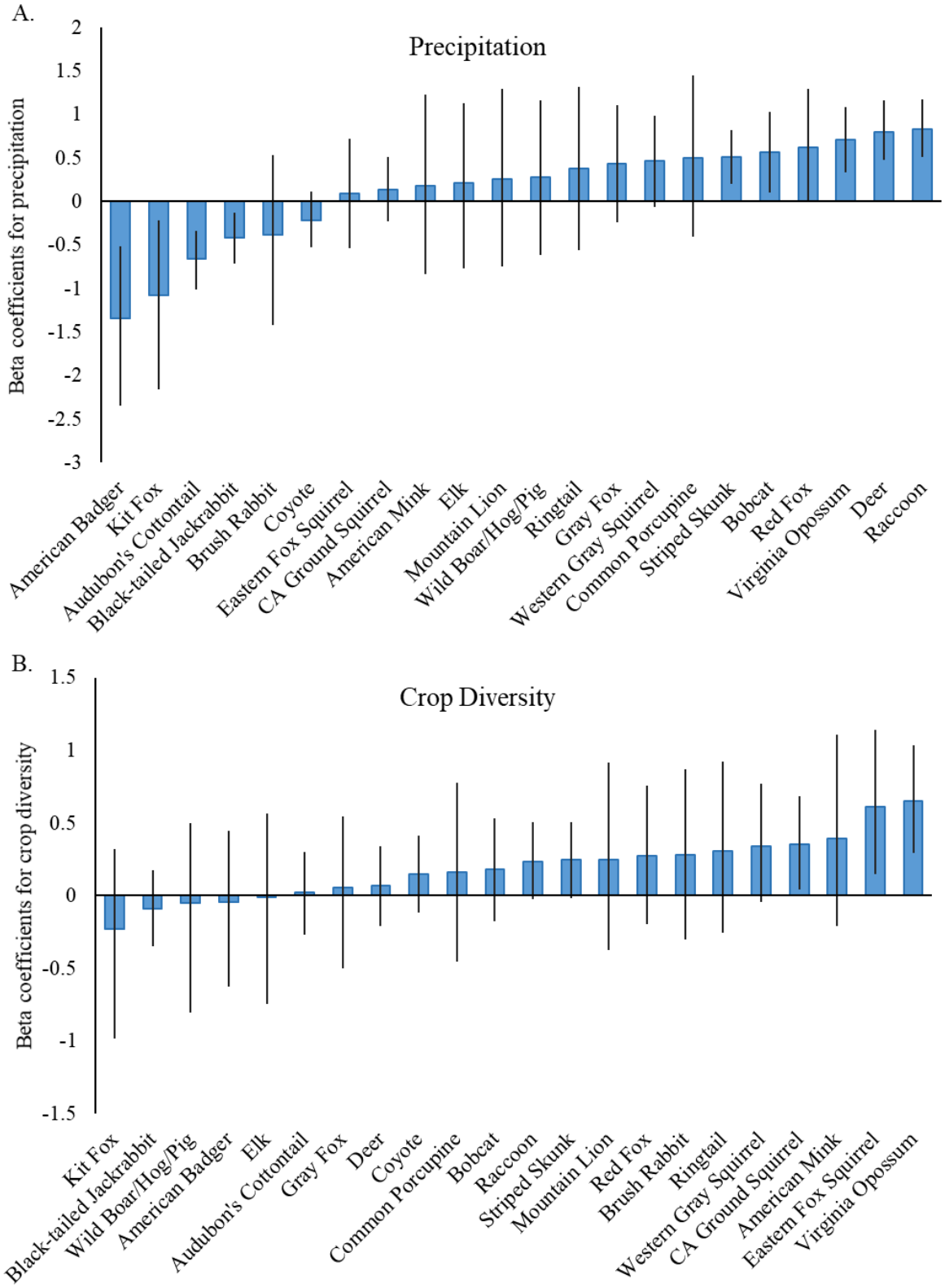

Elevation
Beta coefficients for elevation
4
3
2
1
0
-1
-2
Kit Fox
Wild Burro
Black-tailed Jackrabbit
Raccoon
Coyote
Virginia Opossum
Striped Skunk
Bighorn Sheep
Spotted Skunk
American Badger
Audubon's Cottontail
CA Ground Squirrel
Gray Fox
Bobcat
Rock Squirrel
Deer

Figure 4. Standardized beta coefficients, and 95% credible intervals, for the influence of A) precipitation, B) crop diversity, and C) latitude on species' probabilities of occupancy during the TSM 2016-2017 camera trap surveys in the Great Valley ecoregion of California.



C.

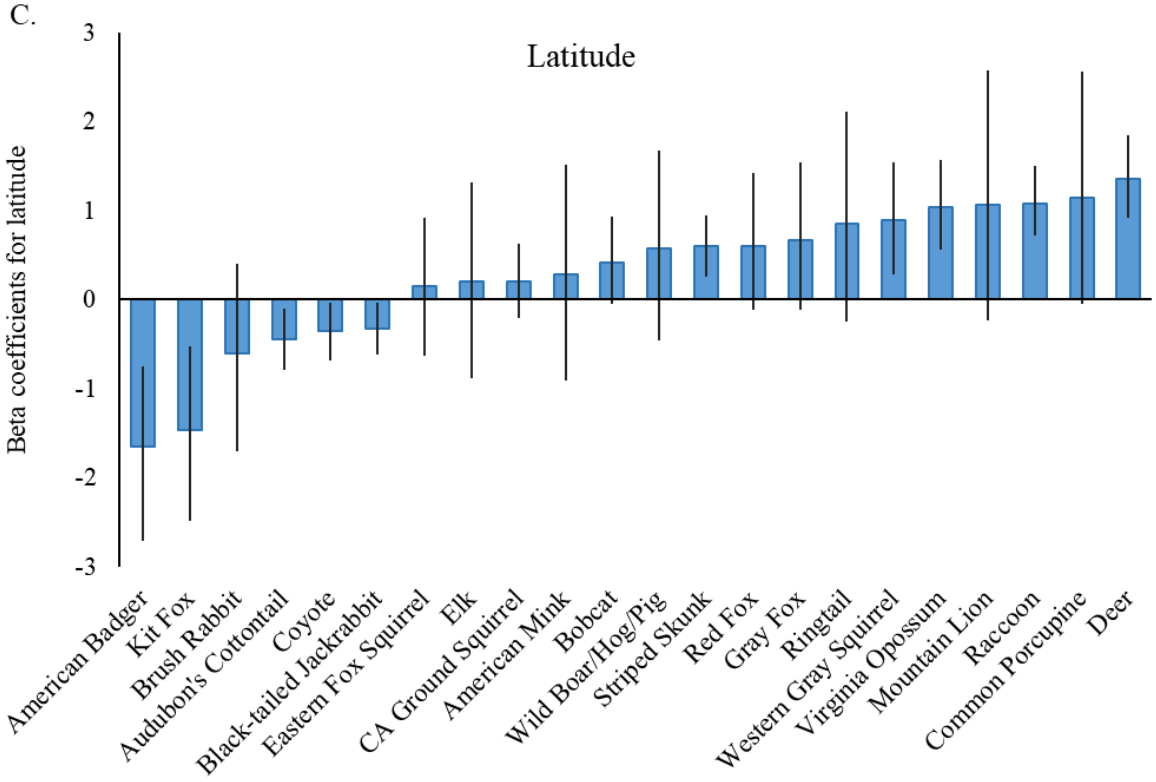
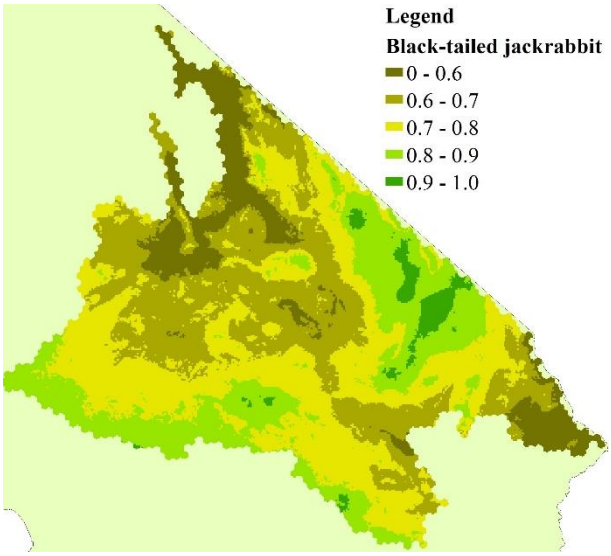
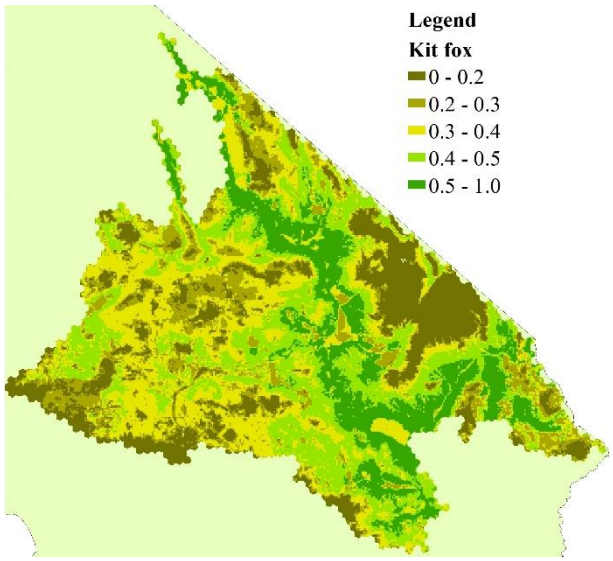

Latitude
Beta coefficients for latitude
3
2
1
0
-1
-2
-3
American Badger
Kit Fox
Brush Rabbit
Audubon's Cottontail
Coyote
Black-tailed Jackrabbit
Eastern Fox Squirrel
Elk
CA Ground Squirrel
American Mink
Bobcat
Wild Boar/Hog/Pig
Striped Skunk
Red Fox
Gray Fox
Ringtail
Western Gray Squirrel
Virginia Opossum
Mountain Lion
Raccoon
Common Porcupine
Deer

Figure 5. Projected occupancy probabilities across the Mojave Desert ecoregion of California, 2017, for A) black-tailed jackrabbits (*Lepus californicus*), B) kit fox (*Vulpes macrotis*), C) coyote (*Canis latrans*), and D) American badger (*Taxidea taxus*). Note that the occupancy scales differ among species.

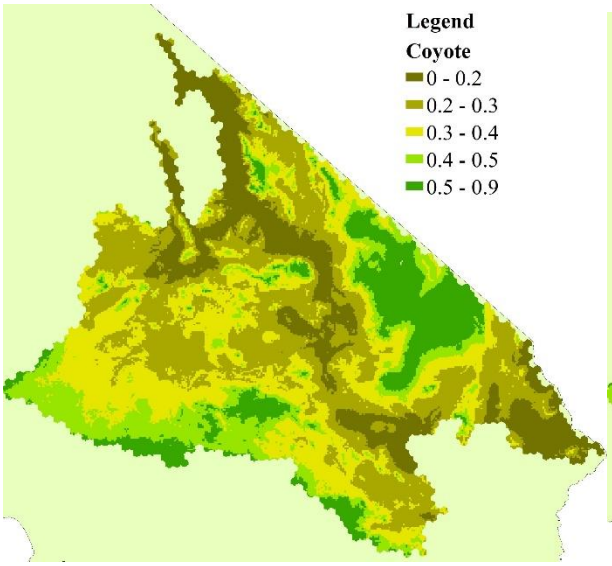
A.



B.



C.



D.

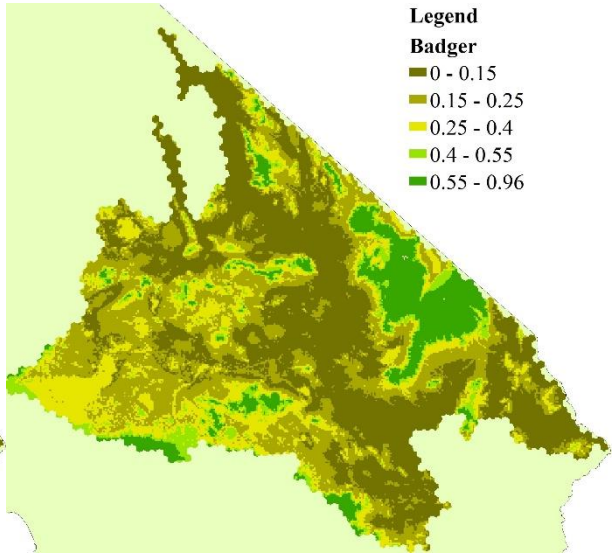
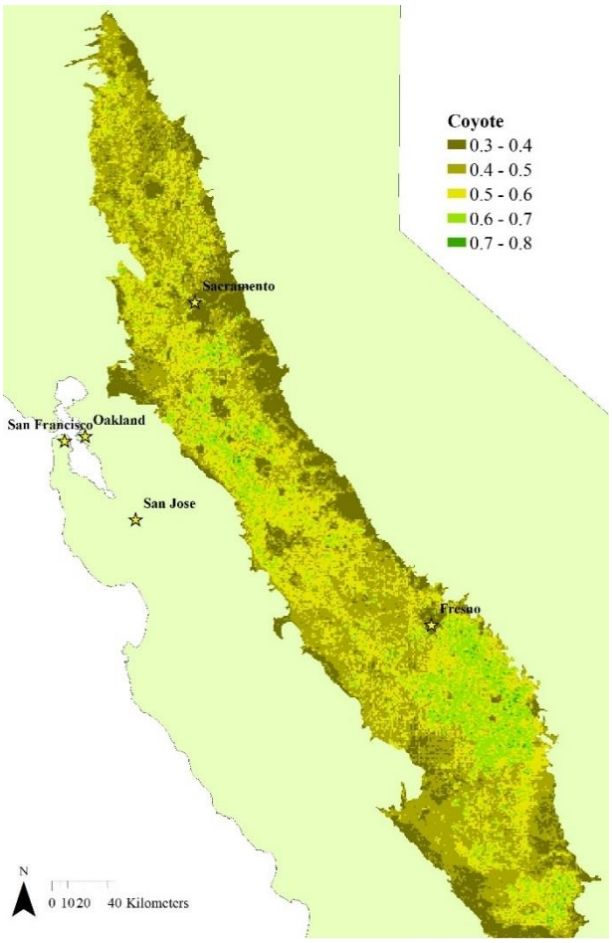
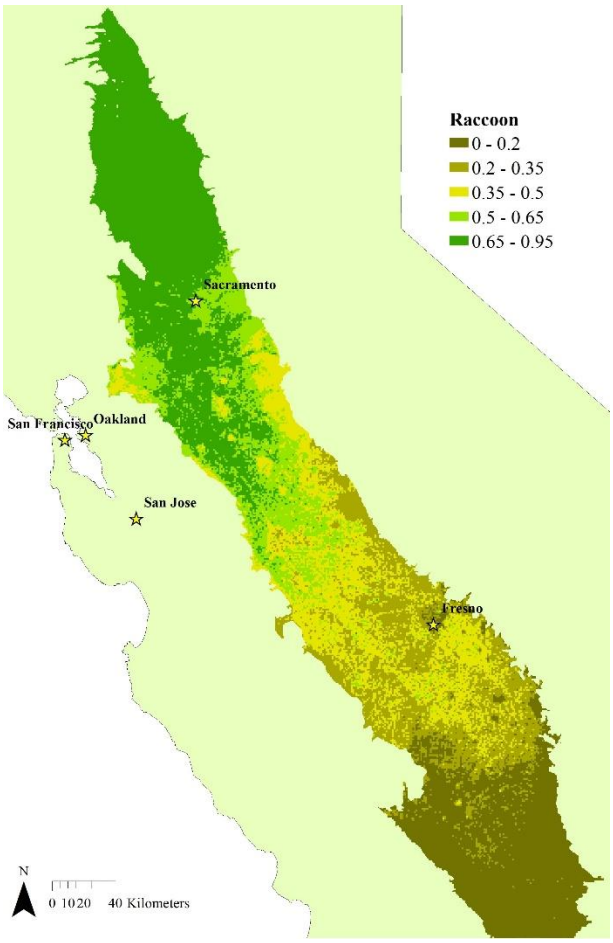


Figure 6. Projected occupancy probabilities across the Great Valley ecoregion of California, 2017, for A) coyotes (*Canis latrans*), B) raccoons (*Procyon lotor*), C) striped skunks (*Mephitis mephitis*), D) black-tailed jackrabbits (*Lepus californicus*), and E) mule deer (*Odocoileus hemionus*). Note that the occupancy scales differ among species.

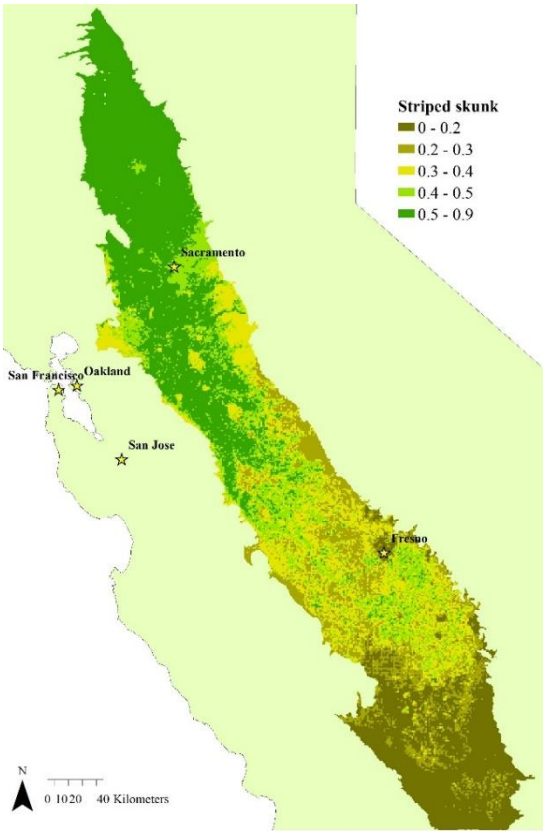
A.



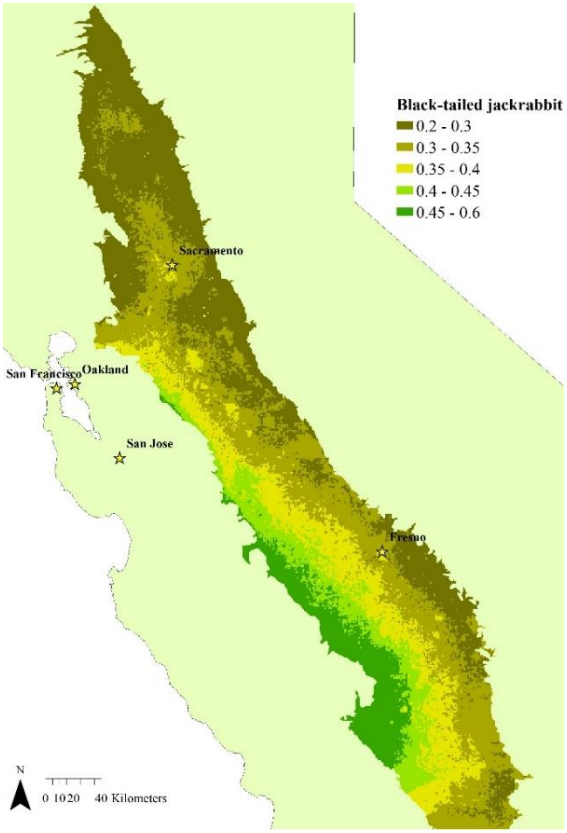
B.



C.


Striped skunk
0 - 0.2
0.2 - 0.3
0.3 - 0.4
0.4 - 0.5
0.5 - 0.9
Sacramento
San Francisco
Oakland
San Jose
Fresno
N
0 1020 40 Kilometers

D.


Black-tailed jackrabbit
0.2 - 0.3
0.3 - 0.35
0.35 - 0.4
0.4 - 0.45
0.45 - 0.6
Sacramento
San Francisco
Oakland
San Jose
Fresno
N
0 1020 40 Kilometers

E.

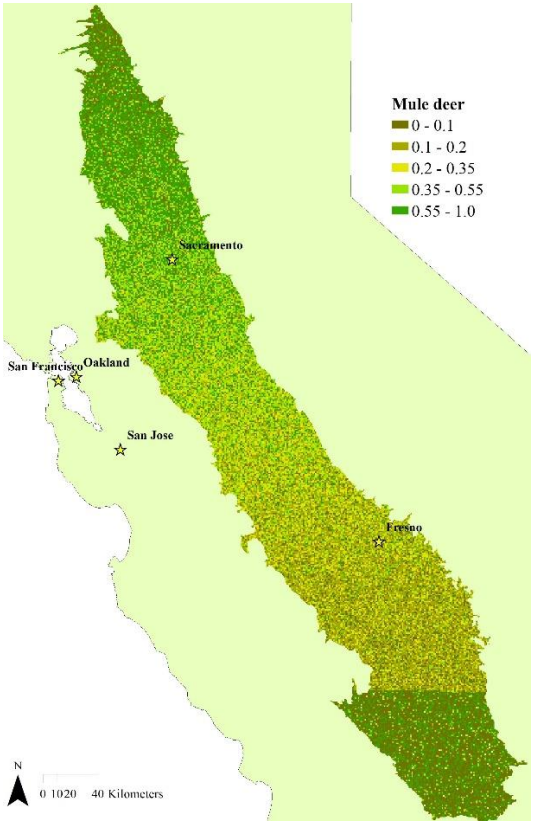
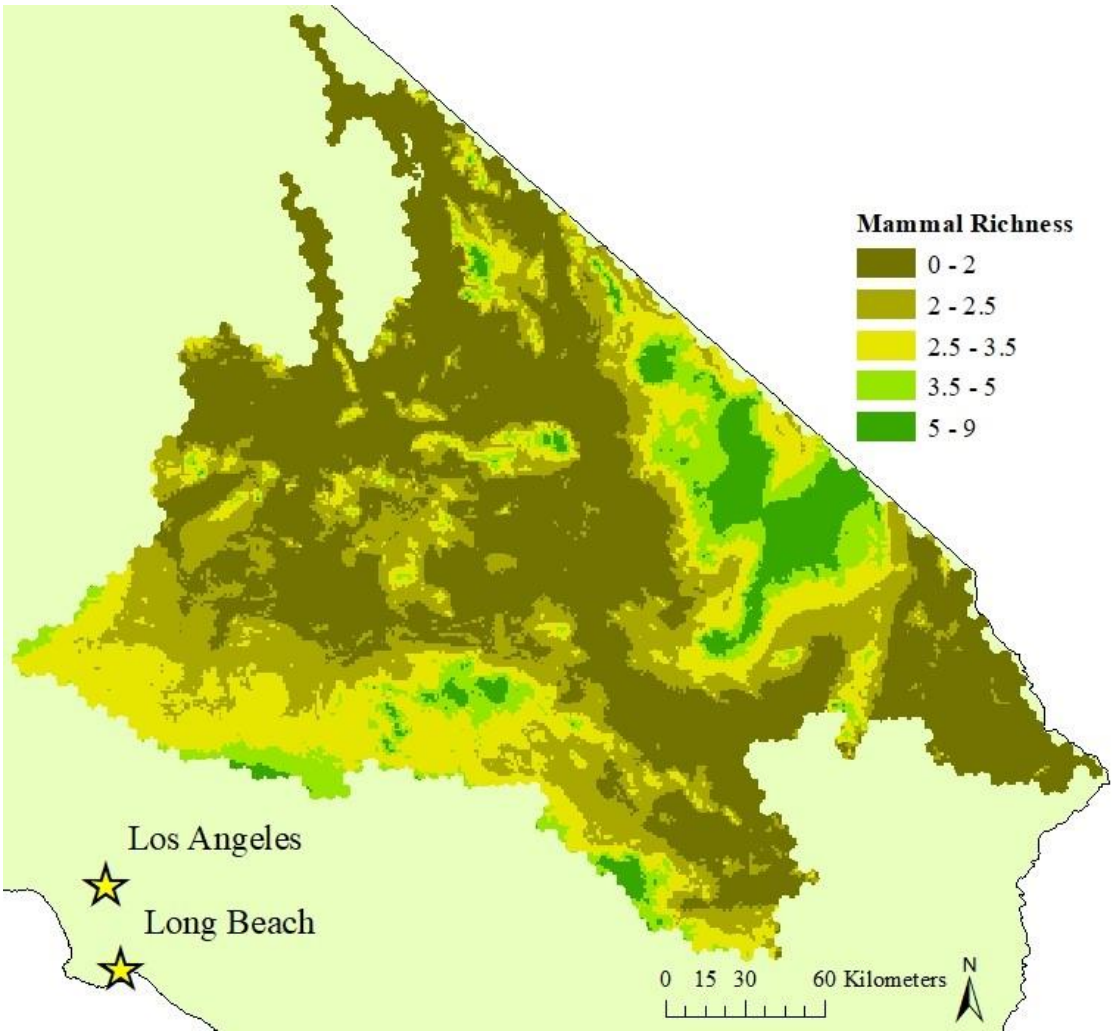
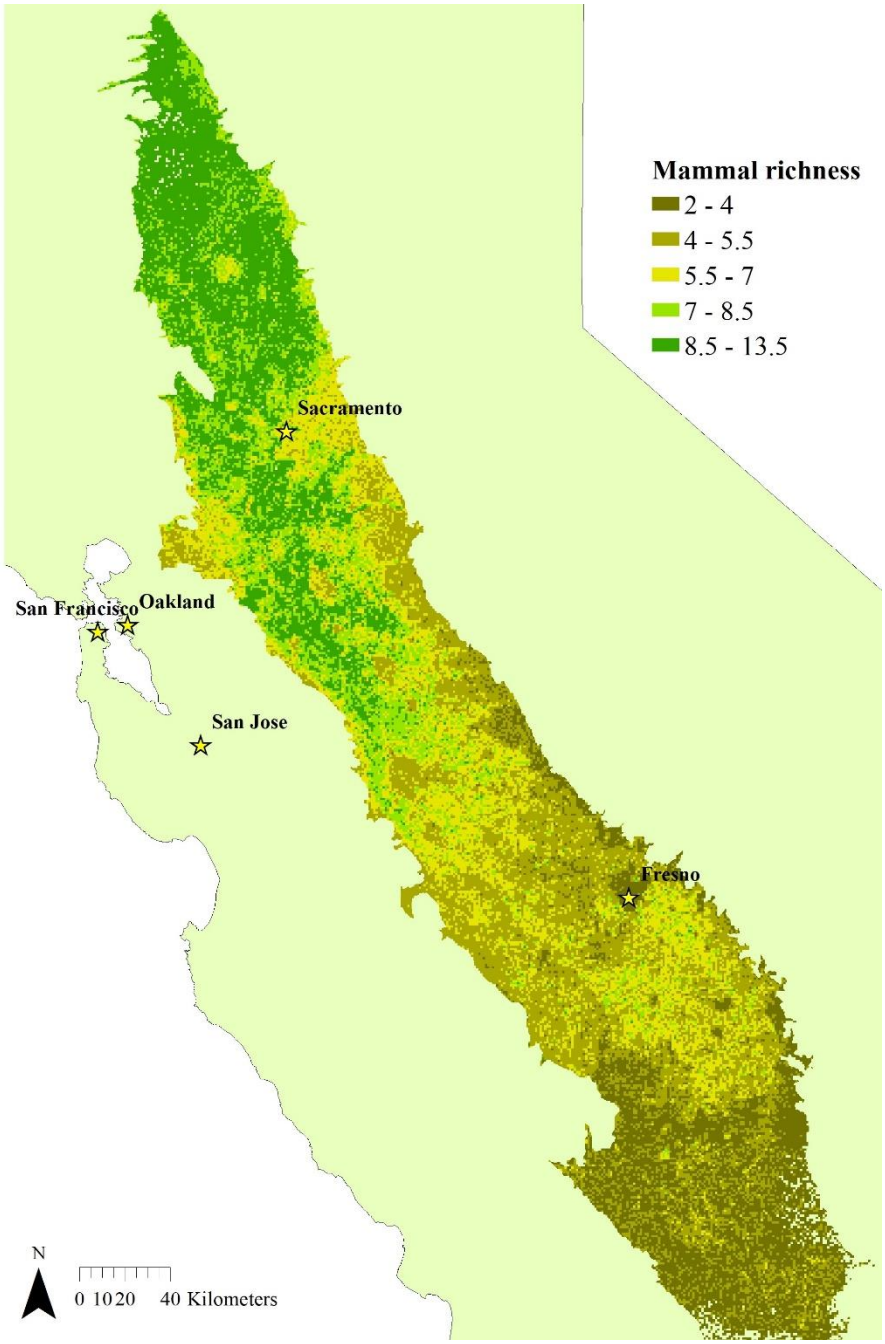

Mule deer
0 - 0.1
0.1 - 0.2
0.2 - 0.35
0.35 - 0.55
0.55 - 1.0
Sacramento
San Francisco
Oakland
San Jose
Fresno
N
0 1020 40 Kilometers

Figure 7. Estimated mammal richness across the A) Mojave Desert and B) Great Valley ecoregions of California.

A.



B.


Mammal richness
2 - 4
4 - 5.5
5.5 - 7
7 - 8.5
8.5 - 13.5
Sacramento
San Francisco
Oakland
San Jose
Fresno
N
0 10 20 40 Kilometers

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Appendix S1a. Mammal species' mean occupancy, and 95% credible intervals, within each of the major habitat strata of the Mojave Desert ecoregion, 2016-17. The habitat with the largest estimated occupancy for each species is highlighted

	Desert outcrop & badlands		**Lower Mojave Desert Scrub**		**Upper Mojave Desert Scrub**		**Dunes**		**Playa**	
	Mean	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*
American badger	0.20	0.073	0.18	0.061	0.38	0.096	0.20	0.070	0.20	0.083
Audubon's cottontail	0.13	0.038	0.12	0.033	0.44	0.063	0.17	0.043	0.16	0.049
Bighorn sheep	0.03	0.014	0.05	0.024	0.04	0.029	0.02	0.013	0.01	0.011
Black-tailed jackrabbit	0.71	0.060	0.71	0.053	0.70	0.062	0.72	0.053	0.72	0.063
Bobcat	0.11	0.037	0.16	0.045	0.45	0.077	0.11	0.034	0.07	0.030
CA ground squirrel	0.00	0.006	0.00	0.006	0.02	0.021	0.00	0.007	0.00	0.008
Coyote	0.32	0.063	0.34	0.058	0.39	0.069	0.34	0.058	0.33	0.067
Gray Fox	0.04	0.019	0.06	0.023	0.13	0.054	0.04	0.017	0.03	0.016
Kit Fox	0.52	0.070	0.55	0.062	0.18	0.041	0.48	0.062	0.51	0.075
Deer	0.00	0.003	0.01	0.004	0.22	0.054	0.00	0.003	0.00	0.003
Raccoon	0.00	0.006	0.00	0.006	0.01	0.012	0.01	0.007	0.01	0.009
Rock Squirrel	0.00	0.003	0.00	0.004	0.02	0.021	0.00	0.004	0.00	0.004
Spotted Skunk	0.02	0.015	0.03	0.023	0.05	0.040	0.02	0.016	0.02	0.016
Striped Skunk	0.00	0.006	0.00	0.005	0.01	0.013	0.00	0.007	0.01	0.008
Virginia Opossum	0.00	0.007	0.00	0.006	0.01	0.015	0.01	0.008	0.01	0.010
Wild Burro	0.05	0.033	0.03	0.019	0.03	0.021	0.04	0.026	0.05	0.033

	Saltbrush scrub		Grassland		Riparian		Wetland		Guzzler	
	Mean	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*
American badger	0.25	0.079	0.25	0.080	0.17	0.058	0.23	0.071	0.29	0.076
Audubon's cottontail	0.27	0.058	0.19	0.044	0.14	0.033	0.21	0.039	0.35	0.052
Bighorn sheep	0.02	0.013	0.03	0.017	0.04	0.020	0.03	0.016	0.05	0.028
Black-tailed jackrabbit	0.72	0.054	0.69	0.055	0.72	0.053	0.71	0.056	0.72	0.054
Bobcat	0.14	0.045	0.20	0.056	0.15	0.039	0.17	0.042	0.34	0.061
CA ground squirrel	0.01	0.008	0.01	0.007	0.00	0.006	0.01	0.008	0.01	0.015
Coyote	0.35	0.060	0.35	0.059	0.32	0.057	0.34	0.060	0.37	0.061
Gray Fox	0.04	0.021	0.06	0.025	0.05	0.022	0.05	0.022	0.11	0.041
Kit Fox	0.35	0.061	0.37	0.060	0.55	0.061	0.45	0.059	0.31	0.050
Deer	0.01	0.008	0.01	0.009	0.02	0.007	0.03	0.014	0.13	0.034
Raccoon	0.01	0.007	0.00	0.006	0.00	0.006	0.01	0.007	0.01	0.009
Rock Squirrel	0.00	0.005	0.00	0.005	0.00	0.004	0.00	0.005	0.02	0.013
Spotted Skunk	0.02	0.017	0.02	0.019	0.03	0.020	0.02	0.018	0.05	0.034
Striped Skunk	0.01	0.007	0.00	0.006	0.00	0.005	0.00	0.006	0.01	0.009
Virginia Opossum	0.01	0.008	0.00	0.006	0.00	0.006	0.01	0.008	0.01	0.011
Wild Burro	0.03	0.020	0.04	0.022	0.03	0.019	0.04	0.024	0.02	0.014

Appendix S1b. Mammal species' mean occupancy, and 95% credible intervals, within each of the major habitat strata of the Great Valley ecoregion, 2016-17. The habitat with the largest estimated occupancy for each species is highlighted.

	Crop/Fallow		**Grassland, shrub**		**Orchard, vineyard**	
	Mean	*SD*	*Mean*	*SD*	*Mean*	*SD*
American Badger	0.12	0.104	0.04	0.122	0.02	0.116
American Mink	0.01	0.094	0.02	0.090	0.01	0.085
Audubon's Cottontail	0.28	0.000	0.22	0.001	0.09	0.002
Black-tailed Jackrabbit	0.31	0.002	0.37	0.005	0.46	0.011
Bobcat	0.10	0.081	0.11	0.086	0.19	0.084
Brush Rabbit	0.00	0.059	0.01	0.062	0.00	0.051
CA Ground Squirrel	0.19	0.002	0.10	0.002	0.18	0.000
Common Porcupine	0.01	0.066	0.02	0.063	0.01	0.069
Coyote	0.38	0.205	0.51	0.166	0.60	0.144
Eastern Fox Squirrel	0.08	0.124	0.08	0.128	0.11	0.121
Elk	0.00	0.028	0.01	0.028	0.00	0.030
Gray Fox	0.06	0.023	0.02	0.028	0.09	0.013
Kit Fox	0.00	0.027	0.01	0.030	0.00	0.034
Mountain Lion	0.01	0.078	0.02	0.077	0.01	0.074
Deer	0.29	0.071	0.32	0.064	0.28	0.063
Raccoon	0.35	0.068	0.49	0.060	0.56	0.075
Red Fox	0.07	0.056	0.06	0.049	0.00	0.053
Ringtail	0.00	0.058	0.01	0.054	0.00	0.058
Striped Skunk	0.46	0.096	0.46	0.106	0.55	0.057
Virginia Opossum	0.19	0.034	0.17	0.032	0.28	0.040
Western Gray Squirrel	0.05	0.075	0.10	0.062	0.11	0.081
Wild Boar/Hog/Pig	0.03	0.039	0.00	0.039	0.00	0.042

	Rice		Riparian		Wetland, open water	
	Mean	*SD*	*Mean*	*SD*	*Mean*	*SD*
American Badger	0.03	0.116	0.08	0.112	0.07	0.103
American Mink	0.01	0.086	0.02	0.087	0.01	0.095
Audubon's Cottontail	0.29	0.000	0.24	0.001	0.20	0.001
Black-tailed Jackrabbit	0.43	0.000	0.29	0.002	0.33	0.006
Bobcat	0.15	0.073	0.13	0.083	0.10	0.077
Brush Rabbit	0.00	0.062	0.00	0.059	0.04	0.060
CA Ground Squirrel	0.14	0.000	0.19	0.002	0.11	0.002
Common Porcupine	0.00	0.057	0.02	0.059	0.02	0.056
Coyote	0.61	0.119	0.46	0.180	0.47	0.178
Eastern Fox Squirrel	0.02	0.133	0.09	0.130	0.02	0.133
Elk	0.00	0.030	0.00	0.028	0.02	0.026
Gray Fox	0.00	0.024	0.00	0.022	0.04	0.029
Kit Fox	0.00	0.019	0.05	0.023	0.04	0.022
Mountain Lion	0.01	0.085	0.02	0.074	0.01	0.078
Deer	0.58	0.068	0.35	0.064	0.26	0.049
Raccoon	0.30	0.104	0.47	0.067	0.44	0.054
Red Fox	0.00	0.039	0.01	0.059	0.06	0.055
Ringtail	0.15	0.048	0.02	0.054	0.00	0.057
Striped Skunk	0.72	0.050	0.37	0.147	0.30	0.157
Virginia Opossum	0.15	0.053	0.16	0.034	0.26	0.032
Western Gray Squirrel	0.15	0.058	0.09	0.073	0.08	0.054
Wild Boar/Hog/Pig	0.00	0.051	0.03	0.037	0.00	0.039

Appendix S2a. Species names and mean and 95% credible intervals (95% CI) for estimates of species-specific probabilities of occurrence, detection probability (for survey duration), and covariate effects on occupancy (PSI) and detection (P) in the Mojave Desert ecoregion of California, 2016-17. Results are presented for model 1; covariate effects that did not overlap 0.0 are highlighted.

Common name	**Occupancy**			**Detection**			**PSI (guzzler)**			**PSI (mean precip)**		
	Mean	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*	
American Badger	0.19	0.071	0.394	0.63	0.374	0.823	0.86	-0.295	1.932	0.22	-0.333	0.866
Audubon's Cottontail	0.14	0.064	0.245	1.00	0.995	0.999	1.64	0.931	2.340	0.51	0.118	0.923
Bighorn Sheep	0.01	0.002	0.027	1.00	0.963	1.000	2.13	0.871	3.473	-0.65	-1.510	0.061
Black-tailed Jackrabbit	0.73	0.589	0.845	1.00	1.000	1.000	0.12	-0.693	0.893	0.13	-0.238	0.518
Bobcat	0.09	0.040	0.174	0.95	0.871	0.982	1.07	0.342	1.808	0.20	-0.193	0.634
CA Ground Squirrel	0.00	0.000	0.017	0.98	0.191	1.000	-0.21	-3.355	2.009	0.11	-0.934	1.173
Coyote	0.11	0.052	0.208	0.92	0.852	0.961	1.03	0.336	1.747	-0.80	-1.211	-0.401
Gray Fox	0.02	0.007	0.061	1.00	0.991	1.000	1.14	0.166	2.135	-0.11	-0.667	0.387
Kit Fox	0.32	0.196	0.458	1.00	0.995	0.999	-0.69	-1.497	0.120	-0.28	-0.655	0.085
Deer	0.01	0.001	0.024	1.00	0.999	1.000	0.83	-0.401	2.078	1.04	0.407	1.742
Raccoon	0.00	0.000	0.008	1.00	0.556	1.000	-0.16	-3.298	2.066	-0.20	-1.338	0.786
Rock Squirrel	0.00	0.000	0.010	1.00	0.610	1.000	-0.52	-3.592	1.385	0.33	-0.538	1.171
Spotted Skunk	0.01	0.001	0.033	0.97	0.401	1.000	0.13	-1.708	1.705	0.24	-0.513	1.027
Striped Skunk	0.00	0.000	0.009	1.00	0.534	1.000	-0.17	-3.233	2.015	-0.15	-1.346	0.904
Virginia Opossum	0.00	0.000	0.010	1.00	0.400	1.000	-0.16	-3.030	2.033	-0.11	-1.233	0.898
Wild Burro	0.03	0.008	0.082	1.00	1.000	1.000	-0.97	-3.854	0.750	-0.26	-1.084	0.459

Common name	PSI (mean temp)			PSI (slope)			PSI (year)			P (guzzler)		
	Mean	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*	
American Badger	-0.66	-1.287	-0.133	-0.20	-0.688	0.221	0.64	-0.558	1.987	1.17	0.546	1.851
Audubon's Cottontail	-0.95	-1.369	-0.558	-0.66	-1.148	-0.237	0.00	-0.997	0.919	0.89	0.716	1.073
Bighorn Sheep	0.01	-0.676	0.735	0.69	0.300	1.119	1.00	-0.343	2.534	0.77	0.249	1.298
Black-tailed Jackrabbit	-0.64	-0.993	-0.296	-1.47	-1.912	-1.063	-0.04	-0.944	0.816	0.58	0.449	0.714
Bobcat	-1.04	-1.512	-0.610	0.51	0.208	0.883	0.64	-0.295	1.583	0.73	0.408	1.049
CA Ground Squirrel	-0.53	-1.845	0.759	0.56	-0.484	1.513	0.98	-0.816	3.086	0.56	-0.909	1.885
Coyote	-0.61	-0.969	-0.266	-0.77	-1.204	-0.370	1.89	0.880	2.924	0.70	0.436	0.957
Gray Fox	-0.41	-1.009	0.184	0.64	0.311	0.990	1.06	-0.178	2.448	0.03	-0.428	0.478
Kit Fox	0.51	0.174	0.882	-1.52	-2.127	-0.973	0.46	-0.325	1.233	-0.19	-0.591	0.175
Deer	-2.25	-3.405	-1.262	0.27	-0.345	0.819	0.91	-0.723	2.608	1.09	0.618	1.611
Raccoon	-0.49	-1.759	0.774	-0.67	-2.481	0.633	0.84	-0.950	2.890	0.62	-0.656	1.990
Rock Squirrel	-1.04	-2.306	0.081	0.35	-0.592	1.164	1.03	-0.735	3.096	0.62	-0.679	2.001
Spotted Skunk	-0.09	-1.034	0.846	1.01	0.412	1.732	1.60	-0.002	4.000	0.66	-0.472	1.756
Striped Skunk	-0.62	-1.983	0.631	-0.77	-2.734	0.574	0.86	-0.882	2.922	0.62	-0.750	1.915
Virginia Opossum	-0.64	-1.925	0.617	-0.70	-2.431	0.616	0.88	-0.908	2.969	0.60	-0.858	1.898
Wild Burro	-0.03	-0.721	0.648	-0.27	-1.141	0.372	0.09	-1.519	1.448	0.62	-0.725	1.975

Common name	P (max temp)			P (bait status)			P (year)		
	Mean	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*	
American Badger	0.08	-0.240	0.402	-0.47	-1.089	0.103	-0.52	-1.195	0.200
Audubon's Cottontail	-0.03	-0.131	0.072	0.16	-0.061	0.375	0.22	-0.014	0.449
Bighorn Sheep	1.29	0.924	1.676	-0.11	-1.336	1.149	-0.85	-2.150	0.414
Black-tailed Jackrabbit	-0.15	-0.203	-0.088	-0.16	-0.296	-0.032	-0.23	-0.366	-0.084
Bobcat	-0.08	-0.285	0.124	-0.25	-0.638	0.159	-0.32	-0.727	0.087
CA Ground Squirrel	0.39	-1.384	2.214	-0.33	-1.870	1.011	-1.49	-3.819	0.399
Coyote	0.20	0.067	0.332	-0.17	-0.494	0.152	-0.06	-0.408	0.298
Gray Fox	0.84	0.497	1.190	0.70	-0.141	1.588	-2.15	-3.190	-1.195
Kit Fox	-0.06	-0.152	0.025	0.63	0.374	0.902	-1.04	-1.305	-0.786
Deer	2.27	1.488	3.093	-1.13	-1.677	-0.571	-0.78	-1.485	-0.096
Raccoon	0.11	-1.553	1.725	0.00	-1.373	1.435	-0.70	-2.757	1.264
Rock Squirrel	0.79	-0.968	2.711	-0.03	-1.396	1.311	-0.81	-2.635	1.022
Spotted Skunk	0.26	-0.814	1.228	-0.31	-1.659	0.962	-1.68	-3.514	-0.056
Striped Skunk	-0.09	-1.567	1.301	-0.01	-1.405	1.487	-0.69	-2.827	1.409
Virginia Opossum	0.08	-1.398	1.475	-0.10	-1.463	1.313	-0.93	-3.153	1.075
Wild Burro	0.92	0.408	1.449	0.21	-0.303	0.741	-2.48	-3.219	-1.805

Appendix S2b. Species names and mean and 95% credible intervals (95% CI) for estimates of species-specific probabilities of occurrence, detection probability (for survey duration), and covariate effects on occupancy (PSI) and detection (P) in the Mojave Desert ecoregion of California, 2016-17. Results are presented for model 2; covariate effects that did not overlap 0.0 are highlighted.

Common name	Occupancy			Detection			PSI (water)			PSI (scrub)		
	Mean	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*	
American Badger	0.24	0.156	0.342	0.94	0.801	0.988	-0.01	-0.264	0.210	-0.33	-0.725	0.069
Audubon's Cottontail	0.25	0.195	0.328	1.00	1.000	1.000	0.02	-0.194	0.248	-0.61	-0.933	-0.294
Bighorn Sheep	0.04	0.022	0.068	1.00	0.966	1.000	-0.03	-0.363	0.237	0.58	-0.006	1.251
Black-tailed Jackrabbit	0.72	0.655	0.804	1.00	1.000	1.000	0.03	-0.148	0.221	-0.02	-0.273	0.238
Bobcat	0.25	0.185	0.319	1.00	0.993	1.000	-0.02	-0.267	0.186	-0.02	-0.377	0.337
CA Ground Squirrel	0.01	0.010	0.025	0.99	0.545	1.000	-0.03	-0.437	0.253	-0.27	-1.334	0.619
Coyote	0.33	0.247	0.409	0.98	0.955	0.994	-0.06	-0.286	0.127	-0.02	-0.273	0.230
Gray Fox	0.09	0.067	0.129	0.99	0.921	0.999	0.03	-0.221	0.305	0.08	-0.381	0.562
Kit Fox	0.36	0.264	0.452	1.00	0.987	0.998	0.10	-0.083	0.351	0.56	0.260	0.863
Deer	0.06	0.060	0.073	1.00	1.000	1.000	-0.04	-0.421	0.222	-0.69	-1.663	0.081
Raccoon	0.004	0.000	0.013	1.00	0.752	1.000	-0.04	-0.447	0.248	-0.11	-0.994	0.775
Rock Squirrel	0.01	0.010	0.021	1.00	0.829	1.000	-0.01	-0.360	0.291	-0.19	-1.128	0.652
Spotted Skunk	0.03	0.017	0.058	0.99	0.734	1.000	0.02	-0.262	0.314	0.19	-0.462	0.897
Striped Skunk	0.002	0.000	0.012	1.00	0.773	1.000	-0.03	-0.422	0.282	-0.21	-1.180	0.686
Virginia Opossum	0.004	0.000	0.014	1.00	0.624	1.000	-0.03	-0.413	0.278	-0.18	-1.157	0.722
Wild Burro	0.03	0.010	0.054	1.00	0.985	1.000	-0.06	-0.471	0.195	-0.01	-0.568	0.583

Common name	PSI (elevation)			PSI (forest)			PSI (year)			P (human disturbance)		
	Mean	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*	
American Badger	0.46	0.019	0.905	0.09	-0.282	0.494	0.10	-0.441	0.660	0.00	-0.277	0.244
Audubon's Cottontail	0.53	0.183	0.882	-0.43	-0.784	-0.089	-0.06	-0.580	0.346	0.14	0.039	0.244
Bighorn Sheep	0.33	-0.372	1.044	-0.54	-1.226	0.016	-0.01	-0.686	0.564	0.63	0.386	0.893
Black-tailed Jackrabbit	-0.10	-0.363	0.168	-0.13	-0.384	0.130	-0.12	-0.589	0.272	0.26	0.205	0.312
Bobcat	1.02	0.612	1.467	-0.19	-0.525	0.142	0.00	-0.513	0.456	0.42	0.247	0.602
CA Ground Squirrel	0.54	-0.649	1.802	-0.34	-1.339	0.398	0.09	-0.669	0.905	0.18	-0.432	0.770
Coyote	0.12	-0.150	0.398	-0.06	-0.323	0.197	0.19	-0.198	0.619	0.07	-0.061	0.194
Gray Fox	0.70	0.153	1.270	-0.22	-0.709	0.195	0.06	-0.519	0.637	0.05	-0.198	0.278
Kit Fox	-0.90	-1.247	-0.582	0.11	-0.165	0.382	0.33	-0.087	0.856	0.12	0.033	0.214
Deer	2.19	1.183	3.424	-0.58	-1.579	0.068	0.13	-0.465	0.825	0.02	-0.249	0.281
Raccoon	0.11	-1.173	1.320	-0.23	-1.164	0.536	0.08	-0.652	0.834	0.20	-0.375	0.750
Rock Squirrel	1.13	-0.033	2.489	-0.40	-1.415	0.321	0.11	-0.600	0.867	0.12	-0.511	0.659
Spotted Skunk	0.39	-0.432	1.249	-0.54	-1.440	0.089	0.23	-0.367	1.093	0.07	-0.533	0.595
Striped Skunk	0.17	-1.099	1.386	-0.29	-1.232	0.472	0.08	-0.673	0.843	0.21	-0.320	0.753
Virginia Opossum	0.16	-1.134	1.424	-0.30	-1.236	0.476	0.09	-0.689	0.882	0.18	-0.375	0.722
Wild Burro	-0.18	-0.862	0.440	0.50	-0.101	1.144	-0.06	-0.844	0.501	0.21	-0.107	0.517

Common name	P (precipitation)			P (bait status)			P (year)		
	Mean	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*	
American Badger	0.56	0.207	0.887	-0.61	-1.235	-0.007	-1.19	-2.043	-0.369
Audubon's Cottontail	0.87	0.752	1.002	0.52	0.296	0.741	-1.94	-2.335	-1.546
Bighorn Sheep	-0.91	-1.596	-0.300	0.58	-0.583	1.857	-0.51	-1.726	0.703
Black-tailed Jackrabbit	0.48	0.411	0.557	0.00	-0.132	0.143	-1.15	-1.338	-0.956
Bobcat	0.47	0.279	0.673	-0.15	-0.551	0.236	-1.65	-2.263	-1.052
CA Ground Squirrel	-0.16	-1.765	1.325	-0.24	-1.758	1.054	-1.41	-3.054	-0.002
Coyote	0.26	0.115	0.403	-0.36	-0.683	-0.023	-0.26	-0.655	0.148
Gray Fox	-0.45	-0.846	-0.080	0.73	-0.004	1.426	-0.96	-1.766	-0.159
Kit Fox	-0.20	-0.355	-0.042	0.64	0.389	0.908	-0.81	-1.119	-0.495
Deer	-0.20	-0.603	0.173	-0.81	-1.325	-0.335	-0.02	-1.119	1.263
Raccoon	-0.08	-1.649	1.452	0.07	-1.234	1.472	-1.04	-2.430	0.401
Rock Squirrel	-0.21	-0.804	0.294	0.23	-1.014	1.607	-0.86	-2.235	0.545
Spotted Skunk	0.14	-0.581	0.828	-0.28	-1.665	0.918	-1.54	-3.013	-0.227
Striped Skunk	-0.09	-1.705	1.523	0.09	-1.249	1.395	-0.95	-2.407	0.496
Virginia Opossum	-0.06	-1.578	1.565	-0.10	-1.543	1.216	-1.21	-2.761	0.157
Wild Burro	-0.74	-1.511	0.034	0.36	-0.168	0.897	-1.05	-2.197	0.091

Appendix S2c. Species names and mean and 95% credible intervals (95% CI) for estimates of species-specific probabilities of occurrence, detection probability (for survey duration), and covariate effects on occupancy (PSI) and detection (P) in the Great Valley ecoregion of California, 2016-17. Results are presented for model 1; covariate effects that did not overlap 0.0 are highlighted.

Common name	Occupancy			Detection			PSI (dist. to water)			PSI (precipitation)		
	Mean	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*	
American Badger	0.04	0.010	0.089	0.65	0.318	0.890	0.19	-0.286	0.847	-1.34	-2.340	-0.511
American Mink	0.02	0.003	0.061	0.66	0.126	0.978	-0.14	-0.868	0.390	0.18	-0.837	1.225
Audubon's Cottontail	0.22	0.160	0.292	1.00	1.000	1.000	0.13	-0.132	0.402	-0.66	-1.015	-0.334
Black-tailed Jackrabbit	0.37	0.294	0.457	1.00	1.000	1.000	0.26	-0.011	0.586	-0.42	-0.715	-0.132
Bobcat	0.11	0.068	0.171	0.92	0.804	0.975	-0.14	-0.605	0.228	0.56	0.101	1.031
Brush Rabbit	0.01	0.002	0.034	0.92	0.322	1.000	-0.13	-0.851	0.375	-0.38	-1.421	0.536
CA Ground Squirrel	0.14	0.094	0.197	1.00	1.000	1.000	0.25	-0.027	0.591	0.13	-0.229	0.510
Common Porcupine	0.02	0.003	0.039	0.87	0.491	0.988	-0.04	-0.632	0.448	0.50	-0.405	1.453
Coyote	0.51	0.422	0.600	0.89	0.819	0.934	-0.19	-0.542	0.122	-0.21	-0.527	0.110
Eastern Fox Squirrel	0.07	0.030	0.147	0.64	0.318	0.892	-0.24	-0.940	0.231	0.09	-0.539	0.717
Elk	0.01	0.002	0.025	0.99	0.511	1.000	-0.14	-0.861	0.355	0.22	-0.767	1.134
Gray Fox	0.03	0.009	0.052	1.00	0.978	1.000	0.31	-0.017	0.718	0.43	-0.235	1.107
Kit Fox	0.02	0.003	0.038	0.99	0.728	1.000	0.05	-0.479	0.489	-1.07	-2.162	-0.219
Mountain Lion	0.02	0.002	0.047	0.72	0.201	0.979	-0.12	-0.795	0.431	0.26	-0.745	1.289
Deer	0.32	0.242	0.405	0.99	0.980	0.996	-0.24	-0.648	0.062	0.80	0.481	1.161
Raccoon	0.46	0.364	0.555	0.97	0.955	0.986	-0.09	-0.376	0.161	0.83	0.507	1.173
Red Fox	0.03	0.013	0.065	0.88	0.610	0.978	0.31	-0.019	0.700	0.63	0.010	1.296
Ringtail	0.02	0.004	0.049	0.84	0.342	0.993	-0.19	-0.976	0.313	0.38	-0.564	1.312
Striped Skunk	0.43	0.345	0.517	0.98	0.960	0.990	-0.06	-0.335	0.200	0.51	0.207	0.823
Virginia Opossum	0.16	0.107	0.227	0.99	0.980	0.998	-0.41	-1.007	0.007	0.71	0.339	1.086
Western Gray Squirrel	0.08	0.044	0.132	0.99	0.939	0.998	-0.30	-0.995	0.131	0.46	-0.065	0.986
Wild Boar/Hog/Pig	0.01	0.004	0.035	0.99	0.769	1.000	-0.07	-0.686	0.371	0.28	-0.614	1.160

Common name	PSI (temperature)			PSI (natural cover)			PSI (year)			P (crop diversity)		
	Mean	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*	
American Badger	0.19	-0.341	0.787	-0.13	-0.446	0.234	-0.48	-1.466	0.253	0.13	-0.464	0.730
American Mink	-0.03	-0.837	0.673	-0.18	-0.599	0.197	-0.29	-1.106	0.746	0.12	-0.810	0.952
Audubon's Cottontail	-0.02	-0.427	0.372	-0.14	-0.352	0.096	-0.41	-1.158	0.249	0.22	0.109	0.335
Black-tailed Jackrabbit	0.24	-0.128	0.691	-0.09	-0.286	0.143	-0.54	-1.441	0.098	-0.14	-0.237	-0.038
Bobcat	0.45	-0.021	0.994	-0.14	-0.396	0.133	-0.33	-1.082	0.444	0.34	-0.005	0.698
Brush Rabbit	0.44	-0.212	1.283	-0.11	-0.457	0.296	-0.21	-0.964	0.829	-0.07	-1.047	0.757
CA Ground Squirrel	-0.14	-0.629	0.300	-0.28	-0.616	-0.050	-0.38	-1.119	0.368	0.52	0.321	0.718
Common Porcupine	0.01	-0.778	0.728	-0.15	-0.509	0.237	-0.44	-1.503	0.380	0.19	-0.903	1.209
Coyote	0.16	-0.218	0.550	-0.17	-0.396	0.037	-0.39	-1.084	0.276	0.13	-0.030	0.293
Eastern Fox Squirrel	-0.47	-1.381	0.162	-0.22	-0.616	0.048	-0.14	-0.867	1.202	0.37	-0.124	0.881
Elk	0.05	-0.723	0.737	-0.08	-0.407	0.419	-0.21	-0.957	0.992	0.12	-0.734	0.939
Gray Fox	-0.01	-0.703	0.607	-0.16	-0.490	0.187	-0.40	-1.283	0.414	0.66	0.251	1.153
Kit Fox	0.41	-0.167	1.140	-0.06	-0.375	0.418	-0.34	-1.187	0.544	-0.45	-1.181	0.226
Mountain Lion	-0.02	-0.846	0.713	-0.15	-0.519	0.251	-0.43	-1.471	0.428	0.24	-0.610	1.131
Deet	0.04	-0.357	0.462	-0.06	-0.257	0.212	-0.48	-1.278	0.144	0.19	0.052	0.327
Raccoon	-0.35	-0.831	0.055	-0.20	-0.426	0.008	-0.32	-1.001	0.461	0.20	0.079	0.313
Red Fox	0.15	-0.461	0.773	-0.33	-0.911	-0.037	-0.22	-0.936	0.842	-0.54	-1.124	-0.009
Ringtail	0.01	-0.741	0.709	-0.20	-0.615	0.125	-0.45	-1.511	0.352	0.29	-0.628	1.224
Striped Skunk	0.18	-0.230	0.566	-0.07	-0.274	0.198	-0.22	-0.831	0.597	0.19	0.064	0.325
Virginia Opossum	-0.23	-0.732	0.220	-0.23	-0.507	-0.012	-0.30	-0.994	0.526	-0.20	-0.390	-0.007
Western Gray Squirrel	0.00	-0.603	0.553	-0.25	-0.606	0.018	-0.41	-1.245	0.376	0.96	0.576	1.350
Wild Boar/Hog/Pig	-0.05	-0.851	0.613	-0.09	-0.407	0.400	-0.46	-1.549	0.332	0.44	-0.424	1.414

Common name	P (max temp)			P (bait status)			P (year)		
	Mean	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*	
American Badger	-0.04	-0.574	0.470	-0.08	-0.553	0.311	0.49	-0.682	1.660
American Mink	-0.04	-0.649	0.670	-0.06	-0.585	0.405	-0.30	-1.938	1.236
Audubon's Cottontail	-0.05	-0.176	0.080	0.01	-0.169	0.189	-0.06	-0.336	0.214
Black-tailed Jackrabbit	0.22	0.122	0.322	0.10	-0.057	0.270	-0.17	-0.358	0.022
Bobcat	-0.36	-0.631	-0.114	-0.13	-0.506	0.194	0.25	-0.406	0.919
Brush Rabbit	0.13	-0.494	0.792	-0.01	-0.529	0.514	0.18	-1.409	1.749
CA Ground Squirrel	0.40	0.235	0.577	-0.29	-0.586	0.003	-0.96	-1.419	-0.509
Common Porcupine	-0.10	-0.646	0.413	-0.01	-0.500	0.479	-0.34	-2.561	1.787
Coyote	-0.05	-0.196	0.089	-0.03	-0.269	0.204	-0.07	-0.425	0.258
Eastern Fox Squirrel	-0.19	-0.585	0.188	0.02	-0.454	0.514	0.06	-0.879	0.956
Elk	0.06	-0.621	0.803	-0.04	-0.550	0.407	0.81	-0.892	2.649
Gray Fox	-0.54	-1.124	-0.046	0.06	-0.360	0.589	-0.57	-1.981	0.671
Kit Fox	-0.03	-0.503	0.464	-0.07	-0.554	0.327	-0.46	-1.309	0.333
Mountain Lion	-0.06	-0.726	0.583	-0.04	-0.530	0.440	-0.33	-2.507	1.842
Deet	0.09	-0.024	0.195	0.00	-0.205	0.195	0.12	-0.156	0.396
Raccoon	-0.05	-0.151	0.056	-0.04	-0.233	0.139	0.60	0.366	0.826
Red Fox	0.00	-0.529	0.542	0.17	-0.192	0.694	1.82	0.656	3.066
Ringtail	-0.18	-0.882	0.437	-0.05	-0.562	0.398	-0.38	-2.553	1.767
Striped Skunk	-0.03	-0.162	0.092	-0.08	-0.304	0.119	-0.94	-1.330	-0.575
Virginia Opossum	-0.25	-0.401	-0.109	0.11	-0.120	0.406	-0.17	-0.563	0.196
Western Gray Squirrel	0.13	-0.098	0.369	0.19	-0.113	0.594	-1.81	-3.033	-0.810
Wild Boar/Hog/Pig	-0.56	-1.172	-0.056	-0.08	-0.673	0.362	-0.28	-2.608	2.016

Appendix S2d. Species names and mean and 95% credible intervals (95% CI) for estimates of species-specific probabilities of occurrence, detection probability for survey duration, and covariate effects on occupancy (PSI) and detection (P) in the Great Valley ecoregion of California, 2016-17. Results are presented for model 2; covariate effects that did not overlap 0.0 are highlighted.

Common name	**Occupancy**			**Detection**			**PSI (forest cover)**			**PSI (crop diversity)**		
	Mean	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*	
American Badger	0.06	0.044	0.104	0.93	0.596	0.996	0.23	-0.164	0.690	-0.04	-0.624	0.445
American Mink	0.02	0.012	0.051	0.89	0.831	0.933	0.04	-0.619	0.609	0.39	-0.211	1.109
Audubon's Cottontail	0.22	0.167	0.285	0.99	0.520	1.000	0.37	0.043	0.720	0.02	-0.269	0.303
Black-tailed Jackrabbit	0.34	0.271	0.409	1.00	0.987	0.999	0.19	-0.086	0.477	-0.09	-0.347	0.171
Bobcat	0.11	0.069	0.157	0.87	0.473	0.990	-0.19	-0.794	0.253	0.18	-0.175	0.531
Brush Rabbit	0.02	0.012	0.041	1.00	1.000	1.000	-0.10	-0.817	0.373	0.28	-0.305	0.868
CA Ground Squirrel	0.14	0.097	0.192	0.96	0.893	0.989	0.12	-0.248	0.483	0.35	0.044	0.685
Common Porcupine	0.02	0.012	0.040	0.98	0.958	0.989	0.15	-0.413	0.723	0.16	-0.453	0.775
Coyote	0.49	0.407	0.577	0.74	0.217	0.982	-0.08	-0.440	0.233	0.15	-0.114	0.411
Eastern Fox Squirrel	0.07	0.023	0.122	0.97	0.950	0.988	0.08	-0.404	0.530	0.61	0.147	1.140
Elk	0.01	0.006	0.024	1.00	1.000	1.000	-0.04	-0.750	0.458	-0.01	-0.747	0.563
Gray Fox	0.03	0.010	0.058	0.97	0.942	0.981	0.00	-0.596	0.484	0.06	-0.503	0.544
Kit Fox	0.02	0.007	0.039	0.78	0.295	0.976	-0.01	-0.575	0.403	-0.23	-0.983	0.322
Mountain Lion	0.01	0.008	0.031	1.00	0.999	1.000	0.07	-0.533	0.653	0.25	-0.372	0.916
Deer	0.32	0.250	0.392	0.80	0.532	0.940	0.26	-0.094	0.680	0.07	-0.207	0.341
Raccoon	0.45	0.371	0.539	0.97	0.778	0.999	0.18	-0.140	0.507	0.23	-0.026	0.506
Red Fox	0.04	0.023	0.075	1.00	1.000	1.000	-0.15	-0.909	0.332	0.28	-0.197	0.758
Ringtail	0.01	0.002	0.031	0.91	0.280	1.000	0.07	-0.564	0.630	0.31	-0.257	0.920
Striped Skunk	0.41	0.334	0.493	0.66	0.286	0.909	0.10	-0.230	0.425	0.25	-0.017	0.505
Virginia Opossum	0.20	0.142	0.259	1.00	0.992	1.000	0.16	-0.201	0.565	0.65	0.294	1.035
Western Gray Squirrel	0.09	0.054	0.129	0.99	0.687	1.000	0.10	-0.367	0.584	0.34	-0.043	0.769
Wild Boar/Hog/Pig	0.01	0.003	0.031	0.93	0.602	0.997	0.14	-0.378	0.754	-0.05	-0.804	0.501

Common name	PSI (latitude)			PSI (year)			P (human dist.)			P (precipitation)		
	Mean	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*	
American Badger	-1.65	-2.707	-0.745	-0.23	-1.031	0.461	-0.07	-0.380	0.202	0.04	-0.564	0.650
American Mink	0.29	-0.907	1.520	-0.11	-0.852	0.753	-0.06	-0.375	0.252	-0.10	-1.081	0.853
Audubon's Cottontail	-0.45	-0.788	-0.095	-0.12	-0.671	0.489	-0.06	-0.154	0.030	0.24	0.146	0.334
Black-tailed Jackrabbit	-0.32	-0.621	-0.030	-0.12	-0.633	0.419	0.02	-0.078	0.117	-0.18	-0.267	-0.102
Bobcat	0.41	-0.049	0.928	0.03	-0.539	0.820	-0.17	-0.379	0.011	0.03	-0.249	0.315
Brush Rabbit	-0.60	-1.696	0.401	0.02	-0.630	1.052	-0.07	-0.369	0.235	-0.30	-1.100	0.393
CA Ground Squirrel	0.21	-0.203	0.631	-0.32	-1.030	0.211	-0.08	-0.201	0.046	-0.23	-0.395	-0.070
Common Porcupine	1.15	-0.041	2.554	-0.22	-1.051	0.471	-0.06	-0.358	0.239	0.03	-0.768	0.846
Coyote	-0.35	-0.683	-0.034	-0.21	-0.821	0.327	0.02	-0.104	0.165	-0.08	-0.226	0.059
Eastern Fox Squirrel	0.15	-0.627	0.924	-0.14	-0.814	0.559	-0.02	-0.291	0.339	0.32	-0.545	1.365
Elk	0.20	-0.875	1.321	-0.03	-0.701	0.931	-0.09	-0.393	0.173	-0.01	-0.975	0.952
Gray Fox	0.67	-0.113	1.543	-0.21	-1.060	0.481	0.10	-0.126	0.432	-0.21	-0.620	0.204
Kit Fox	-1.46	-2.482	-0.527	-0.09	-0.831	0.733	-0.07	-0.317	0.168	-0.36	-1.209	0.388
Mountain Lion	1.06	-0.236	2.578	-0.20	-1.006	0.551	-0.07	-0.373	0.256	-0.22	-1.294	0.720
Deer	1.36	0.924	1.846	-0.10	-0.629	0.461	-0.20	-0.339	-0.065	0.38	0.205	0.573
Raccoon	1.08	0.720	1.497	-0.34	-0.984	0.151	-0.06	-0.149	0.035	0.21	0.079	0.354
Red Fox	0.61	-0.108	1.418	-0.09	-0.751	0.675	0.03	-0.232	0.410	-0.26	-1.125	0.500
Ringtail	0.86	-0.248	2.109	-0.23	-1.109	0.486	-0.06	-0.346	0.257	-0.05	-0.937	0.835
Striped Skunk	0.60	0.259	0.942	0.09	-0.436	0.812	-0.01	-0.118	0.117	0.14	0.001	0.287
Virginia Opossum	1.04	0.563	1.563	-0.25	-0.868	0.259	-0.17	-0.322	-0.036	-0.05	-0.248	0.145
Western Gray Squirrel	0.89	0.285	1.539	-0.14	-0.846	0.629	-0.08	-0.306	0.150	-0.91	-1.373	-0.481
Wild Boar/Hog/Pig	0.57	-0.462	1.668	-0.22	-1.123	0.455	-0.05	-0.317	0.261	0.43	-0.079	1.026

Common name	PSI (bait status)			PSI (year)		
	Mean	*95% CI*		*Mean*	*95% CI*	
American Badger	-0.02	-0.373	0.258	0.51	-0.630	1.591
American Mink	-0.02	-0.386	0.275	-0.43	-2.128	1.182
Audubon's Cottontail	0.04	-0.115	0.196	0.03	-0.199	0.250
Black-tailed Jackrabbit	0.12	-0.027	0.298	-0.02	-0.202	0.170
Bobcat	-0.07	-0.425	0.161	-0.25	-0.808	0.272
Brush Rabbit	0.00	-0.349	0.317	-0.12	-1.757	1.568
CA Ground Squirrel	-0.10	-0.355	0.090	-0.27	-0.653	0.105
Common Porcupine	0.00	-0.348	0.315	-0.46	-2.774	1.887
Coyote	-0.01	-0.238	0.175	-0.10	-0.431	0.233
Eastern Fox Squirrel	0.04	-0.253	0.393	-0.07	-1.031	0.855
Elk	-0.01	-0.364	0.281	0.72	-0.811	2.442
Gray Fox	0.01	-0.326	0.317	-1.37	-2.812	-0.176
Kit Fox	-0.01	-0.345	0.264	-0.56	-1.348	0.210
Mountain Lion	-0.01	-0.408	0.309	-0.44	-2.718	1.821
Deet	0.02	-0.150	0.195	0.21	-0.050	0.457
Raccoon	0.01	-0.156	0.161	0.67	0.441	0.879
Red Fox	0.08	-0.173	0.466	1.45	0.417	2.476
Ringtail	-0.01	-0.376	0.295	-0.51	-2.851	1.746
Striped Skunk	-0.05	-0.272	0.120	-0.86	-1.226	-0.522
Virginia Opossum	0.06	-0.127	0.284	-0.39	-0.787	-0.005
Western Gray Squirrel	0.05	-0.194	0.320	-2.51	-3.721	-1.396
Wild Boar/Hog/Pig	-0.11	-0.602	0.156	-0.44	-2.879	1.863

An evaluation of avifaunal diversity in California's Great Valley

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Executive Summary

1. Reconciliation ecology focuses on modifying human-dominated landscapes to maximize their ability to support wildlife, recognizing that wildlife habitat can be improved and expanded without losing human habitat. This approach may be applicable to songbird management in the Great Valley ecoregion of California, an intensely modified agricultural area. Developing management actions aimed at reconciling the Great Valley for a specific songbird of interest or native songbird diversity, however, requires reliable estimates and evaluations of species distributions and richness. In this study, we aimed to help provide this information using songbird data collected as part of California Department of Fish and Wildlife's Terrestrial Species Stressor Monitoring surveys.
2. We deployed automated recorders at 263 sites across the Great Valley ecoregion between March and July of 2016 and 2017. We identified recordings to the species-level, and used multi-species hierarchical occupancy models to estimate and evaluate the occupancy and richness of songbird species.
3. We recorded 84 species of songbirds, with estimated occupancies ranging from 0.01 for the black-throated gray warbler to 0.65 for the red-winged blackbird. Mean estimated richness ranged from 5 – 34 songbird species ($\bar{x}$ = 16.10) and was greatest in mixed habitats. Overall, our results suggest Great Valley's songbird community was positively associated with heterogeneous landscapes, both natural and agricultural, that were close to a forested area.
4. We used data collected by automated recorders to generate baseline estimates of occupancy for >80 songbird species in the Great Valley. Site-level detection probabilities were high for the majority of songbirds, providing support for the effectiveness of automated recorders as a monitoring tool. Further, our research highlights potential starting points for reconciling the Great Valley when the goal is to increase the distribution and richness of songbirds. These include increasing natural and agricultural heterogeneity, and conserving remnant forests and natural vegetation throughout the region. We encourage CDFW to use our estimates as baselines, thus setting the stage for long-term monitoring of songbird communities in the region. A long-term monitoring program would provide the agency with the empirical data needed to evaluate the processes driving the songbird populations, such as trends in occupancy and drivers of local colonization and extinction probabilities.

Introduction

Reservation ecology, restoration ecology, and reconciliation ecology describe three approaches for addressing ecosystem change and potential, corresponding losses and degradation of natural habitat and wildlife populations. Reservation ecology focuses on protecting areas from further development by designating them as preserves (Rosenzweig 2003). If the size of protected areas is small, however, then long-term maintenance of a diversity of species is unlikely (Rosenzweig 2003). Restoration ecology, alternatively, focuses on restoring an area to its historic state including the biota and ecosystem conditions (Rosenzweig 2001; Jackson and Hobbs 2009; Bullock et al. 2011). Restoring ecosystems to their historical conditions, however, is unlikely when considered in the light of rapid environmental and human-mediated change (Choi et al. 2008; Seastedt et al. 2008; Hobbs et al. 2009). Lastly, reconciliation ecology focuses on modifying and diversifying human-dominated landscapes so they can harbor a wide variety of wildlife, recognizing that we can improve and expand wildlife habitat without having to lose human habitat (Rosenzweig 2003). Reconciliation ecology acknowledges the relevance of new and novel ecosystems, which have often been irreversibly changed by modifications to abiotic conditions or biotic compositions (Fox 2007; Seastedt et al. 2008; Hobbs et al. 2009).

Some of the most important cases of reconciliation ecology are agricultural landscapes (Daily et al. 2001). Croplands and pastures occupy approximately 40% of the world's land surface, a number that will likely surge given projected two- to threefold increases in food demand by 2050 (Foley et al. 2005; Green et al. 2005). Agricultural landscapes' ability to serve as wildlife habitat ranges widely depending on a multitude of factors such as land tenure, crop species, the size of crop fields, cultivation practices, agrochemical usage, and rotation planning (Benton et al. 2003; Fahrig et al. 2011). For example, areas with low to intermediate-intensity land use can positively impact native wildlife (Daily et al. 2001) while areas experiencing rapid agricultural intensification tend to negatively impact native wildlife (McKinney 2002; Benton et al. 2003; Green et al. 2005). The negative effects of rapid agricultural intensification are likely due to large-scale transitions from heterogeneous (i.e., in structure, time, and space) to homogeneous agricultural landscapes that provide fewer niches and resources, such as food, nest sites, den sites, and cover (MacArthur and MacArthur 1961; Rosenzweig 1995; Benton et al. 2003; Green et al. 2005). The positive relationship between the richness of wildlife populations and landscape heterogeneity is widely supported (Benton et al. 2003; Lee and Martin 2017). Our understanding of the degree to which heterogeneity in croplands and pastures benefits wildlife and specific taxa, however, is limited (Benton et al. 2003; Fahrig et al. 2011). Improving this understanding would not only inform the conservation and management of wildlife in farmlands, but also provide a potentially feasible method in which to reconcile these human-dominated landscapes (Benton et al. 2003; Foley et al. 2005; Fahrig et al. 2011; Lee and Martin 2017). Reconciling agricultural areas in a way that maximizes their potential as wildlife habitat is imperative, given their increasing coverage globally and because the fate of many species depends on their ability to use human-modified landscapes (Green et al. 2005; Ewers and Didham 2006; Fahrig et al. 2011).

In this study, we explored the ecological drivers of songbird distributions in a human-modified, agricultural landscape. We focused on songbird species, specifically, as farming serves as one of the biggest threats to globally threatened and near-threatened birds (McKinney 2002; Green et al. 2005). We applied our question to the Great Valley of California, an area that has been transformed from seasonal wetlands and alkali scrub to one of the most intensely developed agricultural regions in the world (Frayer et al. 1989; Nelson et al. 2003). A better understanding of how to maximize the distributions of specific species of interest or overall songbird diversity in a landscape like the Great Valley, could have local to global relevance due to the loss of wildlife populations and increasing coverage of croplands and pastures worldwide (Alkemade et al. 2009; Fahrig et al. 2011). Additionally, our research was motivated by the lack of studies in areas of high-intensity agricultural land use (Haslem and Bennett 2008; Prevedello and Vieira 2010; Mendoza et al. 2014; Kennedy et al. 2017). Studies that sample outside of native habitats tend to take place in urban areas or areas of low-intensity land uses (Daily et al. 2001; Haslem and Bennett 2008; Prevedello and Vieira 2010; Mendoza et al. 2014).

Prioritizing management actions aimed at reconciling the Great Valley ecoregion for one or more bird species requires reliable estimates and evaluations of species richness and species distributions (Yoccoz et al. 2001; Lindenmayer and Hobbs 2007; Zipkin et al. 2009; Furnas and Callas 2015). Thus, our specific objectives for the Great Valley ecoregion and each of its major habitat strata were threefold. First, we determined baseline estimates of occupancy for songbird species. Species' estimates of occupancy are based on repeated detection-nondetection data, and are considered an informative index to population status (MacKenzie et al. 2002; Royle et al. 2005). Second, we identified habitats that support the greatest richness of songbirds. Third, to help determine which ecological variables should be targeted by reconciliation efforts, we evaluated community and species-specific responses to landscape heterogeneity, water, and land cover variables, all of which have been found to influence avian richness (Gill 1995; McKinney 2002; Benton et al. 2003; Billeter et al. 2008; Lee and Martin 2017). We considered anthropogenic-driven heterogeneity (e.g., different field crops, types of grazed lands, orchards) and natural heterogeneity (e.g., woodlands, wetlands, grasslands) separately, as the strength of their influences on avifaunal diversity may differ. We hypothesized that increasing water availability and landscape heterogeneity, both anthropogenic and natural, would have the greatest, positive influence on species-specific occupancy and overall songbird richness because of increased niche and resource availability (MacArthur and MacArthur 1961; Rosenzweig 1995).

Methods

Automated recorder survey and bird call classifications

In 2016, California Department of Fish and Wildlife (CDFW) initiated Terrestrial Species Stressor Monitoring (TSM) surveys in the Great Valley (GV) ecoregion of California. TSM surveys employ noninvasive survey techniques, including automated sound recordings, visual encounter surveys, and camera trap surveys, to collect baseline data on a wide variety of

common wildlife species. In this study, we focused on songbird data collected via automated recorders, an increasingly common tool for surveying bird communities (Furnas and Callas 2015; Shonfield and Bayne 2017).

We surveyed 263 sites across the GV ecoregion between March and July of 2016 and 2017 (Fig. 1). We identified survey locations by first selecting a spatially balanced random sample of hexagons, stratified by vegetative community, from the USDA Forest Inventory and Analysis program's hexagon grid (hexagon radius is ~2.6 km). We then randomly selected 1-3 survey locations within each hexagon, which were spaced by 1-2 km and stratified by vegetative community. At each survey location, we deployed an SM3-BAT bioacoustic recorder with microphone (Wildlife Acoustics, Inc., Maynard, MA, USA, hereafter termed ARU). We cable-locked ARUs to securely placed T-posts 2-m above the ground and if T-post mounting was not possible, we secured devices to a tree or other vegetation. We programmed ARUs to record three, 5-min sessions on three consecutive days during the survey period. The first session was at 30 minutes before sunrise, the second at sunrise, and the third at 30 minutes after sunrise (Furnas & Callas, 2015).

After the field season, we reviewed the recordings and identified bird species by song or call. To aid in bird identification, we examined spectrograms in Raven Pro software (v. 1.5; Cornell Lab of Ornithology Bioacoustics Research Program, Ithaca, NY, USA). We omitted recordings that could not be identified to the species-level and in an effort to ensure species were similar ecologically, we restricted our analysis to songbirds (i.e., species in the order Passeriformes; Barker, Cibois, Schikler, Feinstein, & Cracraft, 2004). We also classified the level of background noise (e.g., wind, rain, vehicle and air traffic) during each recording using an ordinal variable ranging from zero, indicating no noise, to four, indicating loud noise.

Covariates

We expected that land cover, water accessibility, and landscape heterogeneity would influence songbird distributions in the GV. To represent land cover, we buffered each sampling location by 500m in ArcMAP 10.4.1 (ESRI, Redlands, CA, USA). We used this buffer size because in our preliminary analyses, we found that the direction of covariate relationships was consistent across buffer sizes (i.e., 1km, 500m, and 100m) but the strength of the relationships tended to be greatest when using the 500m buffer. We used data from CDFW's Vegetation Classification and Mapping Program (CDFW 2017)) to calculate percent cover of natural vegetation (i.e., within each 500m buffered area), percent cover of agricultural vegetation, and distances from each sampling location to the nearest forested area and urban area. We used data from Point Blue's Automated Water Tracking System (Point Blue 2017) to identify areas that had open surface water during the survey period, and then measured the distance from each ARU to the nearest available water source.

To represent landscape heterogeneity, we calculated the number of crop types and number of natural vegetation types within each 500m buffered area. To quantify crop types, we

used USDA cropscape data (USDA 2017) and to quantify natural vegetation types, we used the regional dominance types identified in the vegCAMP data. We also represented landscape heterogeneity by calculating Simpson's measure of evenness, which accounts for the relative abundance of different species making up the richness of an area (Simpson 1949):

$$\frac{-\sum_{i=0}^{n} P(i) \times lnP(i)}{\ln(\#\ vegetation\ types)}, \text{ where } P(i) = \frac{area\ covered\ by\ vegetation\ type\ i}{total\ area}$$

When estimating natural and agricultural evenness, vegetation types included each natural dominance type and each crop species, respectively, and total area included natural and agricultural cover within the buffered areas, respectively.

To account for the influence that temperature may have on the vocal activity of songbirds, we included maximum daily temperature as a covariate for species' detection probabilities (McGrann and Furnas 2016). To estimate maximum temperatures, we downloaded 4-km resolution temperature data from PRISM (Prism Climate Group 2017) for the survey period. We then determined the mean maximum temperature at each sampling location over the 3-day survey period. We also included background noise and Julian day and its quadratic term as covariates for detection. Background noise can impede the audibility and identification of bird species while the phenology of birds' vocal behaviors can change over the course of the breeding season (Slagsvold 1977; Strebel et al. 2014).

Multi-species occupancy modeling

We used multispecies hierarchical occupancy models to estimate the probability songbird *i* occurred within the area sampled by an ARU during our survey period (i.e., occurrence; Dorazio & Royle 2005; Iknayan et al. 2014). Multi-species models link species-specific detection and occupancy using community-level hyper-parameters, which specify the mean response and variation among species within the community to a respective covariate (Kéry and Royle 2008; Zipkin et al. 2010). Linking occurrence models for individual species together within a hierarchical model results in a more efficient use of data, increased precision in estimates of occupancy, and assessments of ecological variables at both the species- and community-level (Kéry and Royle 2008; Zipkin et al. 2009; Iknayan et al. 2014). The models also produces estimates of species richness (i.e., number of species in the community and at each sampling location). To produce estimates of songbird richness that accounted for songbird species that were not recorded during sampling but may have occupied areas of the GV, we augmented the dataset by adding ten all-zero observations.

Occupancy models distinguish the true absence of a species from the non-detection of a species (i.e., species present but not recorded) using spatially or temporally replicated survey data. For each sampling location, we treated each 5-minute acoustic recording (n = 9) as a repeat survey at that particular site. We assumed occurrence and detection probabilities differed between years and among species, and were influenced by ecological covariates. To avoid over-

parameterizing our models and ensure all parameters were estimable, we restricted the number of covariates included in each model. We assessed two model structures for occupancy (ψ) and detection (p):

Model 1	Occupancy	# natural types, # agricultural types, forest, water, year
	Detection	Max temperature, Julian day, Julian day^2, noise, year
Model 2	Occupancy	Crop cover, natural evenness, crop evenness, urban, year
	Detection	Max temperature, Julian day, temp * Julian day, noise, year

We incorporated covariates into the model linearly on the logit-probability scale (Zipkin et al. 2010) and ensured models did not include covariates that were correlated. We then linked species-specific models using a mixed modelling approach where we assumed species-specific parameters were random effects derived from a normally distributed, community-level hyper-parameter (Iknayan et al. 2014).

We estimated posterior distributions of parameters using Markov Chain Monte Carlo implemented in JAGS (Plummer 2011) through program R. We generated three chains of 50,000 iterations thinned by 50 and used uninformative priors. We assessed model convergence using the Gelman-Rubin statistic, where values < 1.1 indicated convergence (Gelman et al. 2004). During each model iteration, we summed the number of estimated species at recorder j to generate probability distributions representing site-specific estimates of species richness (Zipkin et al. 2010). We also used our model output to estimate mean, habitat-specific estimates of occupancy and songbird richness. To classify habitat, we used vegCAMP data to quantify the percent cover of (1) urban and agriculture, (2) grassland and oak savannah, (3) riparian and wetland, (4) forest, and (5) shrub within each 500m buffered sampling locations. We then categorized each sampling location based on the dominant habitat type. When a single habitat type did not cover >60% of the area, we categorized the habitat type as ‘mixed’.

Results

We recorded 84 songbird species during our 2,367 sampling occasions (i.e., 5-minute recordings) in the Great Valley ecoregion (Table 1). Eight species were recorded on over 500 occasions, including western meadowlarks and red-winged blackbirds, whereas 20 species were recorded on less than 10 occasions (Table 1). Among the covariates, natural and agricultural cover were correlated ($|r| > 0.6$) as were measures of habitat heterogeneity, both natural (i.e., number of natural vegetation types and natural evenness) and agricultural (i.e., number of agricultural vegetation types and agricultural evenness).

Mean estimated richness ranged from 5 – 34 songbird species ($\bar{x}$ = 16.10) with red-winged blackbirds (ψ = 0.65), brown-headed cowbirds (ψ = 0.65), and western meadowlarks (ψ = 0.65) having the highest estimated occupancies (Table 1; Appendix S1). Many species, conversely, had low estimates of occupancy due to their limited numbers of detections (Table 1;

Appendix S1). Site-level detection probabilities were > 0.3 for every species but the Lincoln's sparrow, and > 0.6 for the majority of species (Table 1; Appendix S2). At the community-level, and for close to half of the songbird species, detection probability had a quadratic relationship with Julian day (Table 2; Appendix S3). We were also more likely to detect songbirds on cooler days and at sites with reduced levels of noise (Table 2; Appendix S3).

Overall, our results suggest Great Valley's songbird community was more likely to use heterogeneous landscapes, both natural and agricultural, that were close to a forested area (Table 2). Among the covariates, natural heterogeneity, as measured by Simpson's measure of evenness, had the largest positive influence on community-level occupancy while distance to forest had the largest negative influence (Table 2). At the species-level, natural evenness was positively related to the distributions of 25 songbirds, including Bewick's wren, song sparrow, and wrentit, and distance to forest was negatively related to the distributions (i.e., species more likely to occupy areas close to forest) of 29 songbirds, including the black-headed grosbeak, bushtit, and oak titmouse (Table 2; Appendix S3). Six and seven songbird species had the converse relationship with natural evenness and distance to forest, respectively (Table 2; Appendix S3). Our alternative measure of habitat heterogeneity, which was the number of natural and agricultural vegetation types, also tended to have a positive influence on songbird occupancy at both the community and species level (Table 2). Specifically, 13 and 11 songbird species were positively related to the number of natural and agricultural vegetation types, respectively, whereas only 3 and 2 species had a negative relationship with these variables (Table 2; Appendix S3). Lastly, in general, songbirds were more likely to occupy areas close to water but this relationship tended to be weak (Table 2; Appendix S3). Water availability appeared to be most important to common yellowthroat, marsh wren, song sparrow, and tree swallow (Appendix S3).

The greatest number of sampling locations fell within urban and agricultural habitat (n = 105), followed by mixed habitat (n = 60), grassland and oak savannah (n = 52), riparian areas and wetlands (n = 38), and shrublands (n = 7). At the community and species-levels, occupancy probabilities varied among the major habitat strata but tended to be greatest in mixed habitat (n = 27 species; Fig. 3; Appendix S1). We note, however, that among the various habitat strata, error estimates for mean and species-specific occupancy probabilities tended to overlap. This limits our ability to determine if the community or a particular species was more or less likely to occupy riparian and wetland habitat than mixed habitat, for example. Songbird richness also appeared to be greatest in mixed habitat ($\bar{x}$ = 17.48), followed by urban and agricultural habitat ($\bar{x}$ = 17.13; Fig. 4). Error bars associated with our estimates of songbird richness also tended to overlap, however (Fig. 4).

Discussion

Effectively prioritizing actions aimed at conserving wildlife requires reliable estimates of species richness, species distributions, and an understanding of how these parameters are driven by ecological factors (Yoccoz et al. 2001; Lindenmayer and Hobbs 2007; Zipkin et al. 2009; Furnas and Callas 2015). The distribution and habitat requirements of species within an ecosystem are

rarely known, however, making it difficult to discern optimal management strategies (White et al. 2013). In this study, we applied a field technique that was developed in forested regions as part of the Ecoregion Biodiversity (EBM) surveys, and applied it in the Great Valley, an intensely modified agricultural region. Despite the dramatically different landscapes, similar to Furnas and Callas (2015), we found that detection probabilities using ARUs were high for most species. Further, because the ARUs collected data on a numerous species simultaneously, we were able to estimate the distributions and richness of over 80 songbird species in the Great Valley (Fig. 2; Appendix S1). Our research provides additional support for the effectiveness of automated recorders as a tool for collecting detection-nondetection data on multiple species (Furnas and Callas 2015).

It is challenging and often infeasible to create new protected areas or to implement major restoration efforts in intensely developed regions like the Great Valley (Rosenzweig 2003; Seastedt et al. 2008; Choi et al. 2008; Jackson and Hobbs 2009). Thus, efforts must focus on reconciling these ecosystems in a way that maximizes their ability to function as suitable habitat for both endemic wildlife species and humans (Rosenzweig 2003; Seastedt et al. 2008; Hobbs et al. 2009). In addition to providing baseline estimates of occupancy for songbirds, our research also produced a number of key findings relevant to prioritizing actions aimed at reconciling the Great Valley. Specifically, our evaluation of community and species-specific responses to ecological variables suggests that increasing natural and agricultural heterogeneity, and conserving remnant forests and natural vegetation throughout the region, offer potential starting points for reconciling the Great Valley when the goal is to increase the distribution and richness of songbirds.

We found that songbird richness was greatest in mixed habitat (i.e., areas encompassing multiple habitat types), that over 30% of the songbird species were most likely to occupy mixed habitat, and that songbirds, both the community and individual species, tended to be positively associated with natural and agricultural heterogeneity. Similar to prior studies, these results support that diversity is maximized in heterogeneous landscapes, likely because they provide more niches and complementary resources than homogeneous landscapes (MacArthur and MacArthur 1961; Benton et al. 2003; Haslem and Bennett 2008; Lee et al. 2017). Increasing landscape heterogeneity by actively managing natural areas and encouraging landowners to tailor their agricultural practices (e.g., crop diversity, cultivation practices, rotation planning) may therefore be a viable approach for reconciling the Great Valley. While the songbird community tended to be positively associated with both natural and agricultural heterogeneity, the strength of these relationships varied. Natural evenness, for example, had the largest positive influence on the songbird community (Table 4; Appendix S2). Thus, even in this intensely modified landscape, native vegetation played a vital role in maintaining songbird populations (Haslem and Bennett 2008). These results suggest actions aimed at increasing landscape heterogeneity should not be done in isolation, but rather in parallel with the protection of remnant natural habitats.

Our multi-species model also illustrated the importance of forested habitats, specifically, to songbirds in the Great Valley. Forest had the largest influence on the occupancy of avian

species, at both the community- and species-levels, where species were more likely to occupy areas close to forest cover (Table 2). Forested areas generally have high species diversity, including bird diversity, as they provide critical resources like foraging and roosting sites and help facilitate the movement of individuals (Gill 1995; Haslem and Bennett 2008; Mendoza et al. 2014). Despite their role in supporting terrestrial wildlife, however, forested landscapes continue to be converted into agricultural, mining, and urban areas (White et al. 2013). Our results highlight the importance of conserving forests within the Great Valley and that maximizing landscape heterogeneity should not be considered a replacement for reducing the loss and degradation of native forests (Kennedy et al. 2017).

Climate and land use change will continue to transform many of the world's ecosystems (Rosenzweig 2003; Millenium Ecosystem Assessment 2005; Seastedt et al. 2008; Hobbs et al. 2009; Walther et al. 2009; Bullock et al. 2011; Steffen et al. 2015). Methods for reconciling these novel landscapes in a way that maximizes their potential as wildlife habitat is imperative, as the fate of many species depends on their ability to utilize human-modified landscapes (Green et al. 2005; Ewers and Didham 2006; Fahrig et al. 2011). This is particularly true for agricultural landscapes given their increasing coverage globally (Daily et al. 2001; Foley et al. 2005; Green et al. 2005). Our research employed automated recorders and multispecies occupancy models to estimate and evaluate the distributions of 84 songbird species and to identify plausible ways in which the Great Valley, an intensely developed agricultural region, could be reconciled for the benefit of the songbird community. Our findings underscore the importance of conserving natural vegetation, forested areas in particular, and of promoting landscape heterogeneity in both natural and agricultural areas. If done in isolation, however, these results will represent only a snapshot in time. We encourage CDFW to use our estimates as baselines, thus setting the stage for long-term monitoring of songbird communities in the region. A long-term monitoring program would allow CDFW to develop an understanding of the processes driving the songbird populations, such as trends in occupancy, changes in habitat use, and drivers of local colonization and extinction probabilities (MacKenzie et al. 2005; Tingley and Beissinger 2013). Furthermore, this information would allow managers to test, track, improve, and adapt management actions aimed reconciling the Great Valley for the benefit of endemic songbird species.

Supplementary Material

Appendix S1. Songbird species in the Great Valley ecoregion of California and their occupancy probabilities overall, and within each of the major habitat strata. The habitat strata in which each species had the highest occupancy probability is highlighted.

Appendix S2. Songbird species in the Great Valley ecoregion of California and their site-level detection probabilities (± 95 credible intervals).

Appendix S3. Mean and 95% credible interval estimates for covariate effects on occupancy (PSI) and detection (P) for 84 songbird species in the Great Valley ecoregion of California, 2016-17. Results are based on model 1 (3a) and model 2 (3b); covariate effects that do not overlap 0.0 are highlighted in yellow.

Table 1. Songbird species detected during TSM 2016-17 automated recorder surveys in the Great Valley ecoregion of California, numbers of detections (# det.), proportion of sites at which the species was detected (naïve ψ), occupancy probabilities (ψ), and site-level detection probabilities (*p**).

Common name	Scientific name	# det.	Naïve ψ	ψ	*p**
American Crow	*Corvus brachyrhynchos*	156	0.25	0.24	0.90
American Goldfinch	*Spinus tristis*	186	0.32	0.29	0.89
American Pipit	*Anthus rubescens*	76	0.12	0.15	0.44
American Robin	*Turdus migratorius*	423	0.40	0.33	0.99
Ash-throated Flycatcher	*Myiarchus cinerascens*	343	0.34	0.29	0.98
Bank Swallow	*Riparia riparia*	1	0.00	0.01	0.50
Barn Swallow	*Hirundo rustica*	37	0.10	0.19	0.52
Bell's Sparrow	*Artemisiospiza belli*	40	0.03	0.01	0.99
Bewick's Wren	*Thryomanes bewickii*	350	0.29	0.27	1.00
Blue-gray Gnatcatcher	*Polioptila caerulea*	1	0.00	0.01	0.53
Brown-headed Cowbird	*Molothrus ater*	505	0.61	0.65	0.97
Black-headed Grosbeak	*Pheucticus melanocephalus*	205	0.20	0.12	0.97
Blue Grosbeak	*Passerina caerulea*	86	0.13	0.19	0.71
Black Phoebe	*Sayornis nigricans*	273	0.38	0.37	0.95
Brewer's Blackbird	*Euphagus cyanocephalus*	258	0.44	0.51	0.88
Black-throated Gray Warbler	*Setophaga nigrescens*	4	0.00	0.00	0.94
Bullock's Oriole	*Icterus bullockii*	318	0.39	0.39	0.98
Bushtit	*Psaltriparus minimus*	130	0.20	0.12	0.91
Cassin's Kingbird	*Tyrannus vociferans*	10	0.01	0.01	0.98
California Towhee	*Melozone crissalis*	303	0.30	0.24	0.99
California Thrasher	*Toxostoma redivivum*	4	0.02	0.05	0.34
Cassin's Vireo	*Vireo cassinii*	1	0.00	0.01	0.50
Cedar Waxwing	*Bombycilla cedrorum*	16	0.04	0.05	0.57
Chipping Sparrow	*Spizella passerina*	2	0.01	0.02	0.46
Cliff Swallow	*Petrochelidon pyrrhonota*	107	0.21	0.29	0.70
Common Raven	*Corvus corax*	222	0.34	0.38	0.93
Common Yellowthroat	*Geothlypis trichas*	343	0.27	0.24	1.00
Dark-eyed Junco	*Junco hyemalis*	6	0.02	0.03	0.37
European Starling	*Sturnus vulgaris*	321	0.39	0.34	0.97
Fox Sparrow	*Passerella iliaca*	1	0.00	0.01	0.51
Golden-crowned Sparrow	*Zonotrichia atricapilla*	65	0.11	0.15	0.38
Grasshopper Sparrow	*Ammodramus savannarum*	10	0.02	0.01	0.91
Great-tailed Grackle	*Quiscalus mexicanus*	40	0.07	0.08	0.87
Hermit Thrush	*Catharus guttatus*	12	0.02	0.03	0.41
House Finch	*Haemorhous mexicanus*	632	0.63	0.64	0.99
Horned Lark	*Eremophila alpestris*	283	0.21	0.15	1.00
House Sparrow	*Passer domesticus*	96	0.13	0.13	0.90
House Wren	*Troglodytes aedon*	436	0.31	0.18	1.00
Hutton's Vireo	*Vireo huttoni*	6	0.01	0.01	0.73
Lark Sparrow	*Chondestes grammacus*	27	0.06	0.05	0.75
Lazuli Bunting	*Passerina amoena*	19	0.05	0.10	0.47

Le Conte's Thrasher	*Toxostoma lecontei*	7	0.01	0.01	0.93
Lesser Goldfinch	*Spinus psaltria*	90	0.16	0.10	0.86
Lincoln's Sparrow	*Melospiza lincolnii*	12	0.03	0.07	0.24
Loggerhead Shrike	*Lanius ludovicianus*	119	0.15	0.12	0.96
Marsh Wren	*Cistothorus palustris*	404	0.23	0.21	1.00
MacGillivray's Warbler	*Geothlypis tolmiei*	3	0.01	0.02	0.42
Nashville Warbler	*Oreothlypis ruficapilla*	1	0.00	0.01	0.54
Northern Mockingbird	*Mimus polyglottos*	643	0.53	0.53	1.00
Northern Rough-winged Swallow	*Stelgidopteryx serripennis*	39	0.07	0.07	0.52
Oak Titmouse	*Baeolophus inornatus*	107	0.14	0.08	0.78
Orange-crowned Warbler	*Oreothlypis celata*	45	0.10	0.15	0.96
Phainopepla	*Phainopepla nitens*	7	0.02	0.02	0.51
Pacific-slope Flycatcher	*Empidonax difficilis*	20	0.02	0.01	0.65
Purple Finch	*Haemorhous purpureus*	4	0.01	0.02	0.95
Ruby-crowned Kinglet	*Regulus calendula*	12	0.02	0.02	0.50
Rufous-crowned Sparrow	*Aimophila ruficeps*	6	0.00	0.01	0.44
Rock Wren	*Salpinctes obsoletus*	4	0.01	0.01	0.98
Red-winged Blackbird	*Agelaius phoeniceus*	970	0.65	0.65	0.67
Sage Sparrow	*Artemisiospiza nevadensis/belli*	1	0.00	0.01	1.00
Savannah Sparrow	*Passerculus sandwichensis*	192	0.21	0.19	0.58
Song Sparrow	*Melospiza melodia*	527	0.36	0.34	0.74
Spotted Towhee	*Pipilo maculatus*	419	0.32	0.14	1.00
Swainson's Thrush	*Catharus ustulatus*	1	0.00	0.01	1.00
Tricolored Blackbird	*Agelaius tricolor*	16	0.02	0.03	0.51
Tree Swallow	*Tachycineta bicolor*	534	0.50	0.47	0.83
Warbling Vireo	*Vireo gilvus*	19	0.05	0.04	1.00
White-breasted Nuthatch	*Sitta carolinensis*	77	0.11	0.08	0.55
White-crowned Sparrow	*Zonotrichia leucophrys*	248	0.22	0.33	0.92
Western Bluebird	*Sialia mexicana*	31	0.07	0.05	0.41
Western Kingbird	*Tyrannus verticalis*	660	0.57	0.58	0.72
Western Meadowlark	*Sturnella neglecta*	921	0.61	0.65	1.00
Western Scrub-Jay	*Aphelocoma californica*	278	0.35	0.29	1.00
Western Tanager	*Piranga ludoviciana*	11	0.03	0.06	0.96
Western Wood-Pewee	*Contopus sordidulus*	87	0.09	0.06	0.46
Wilson's Warbler	*Cardellina pusilla*	39	0.09	0.09	0.84
Wrentit	*Chamaea fasciata*	42	0.06	0.03	0.61
White-throated Swift	*Aeronautes saxatalis*	1	0.00	0.01	0.89
Yellow-breasted Chat	*Icteria virens*	9	0.01	0.01	0.53
Yellow-billed Magpie	*Pica nuttalli*	31	0.05	0.04	0.96
Yellow Warbler	*Setophaga petechia*	24	0.05	0.04	0.94
Yellow-headed Blackbird	*Xanthocephalus xanthocephalus*	55	0.10	0.09	0.74
Yellow-rumped Warbler	*Setophaga coronata*	50	0.09	0.15	0.88

Table 2. Mean ($\bar{x}$) and 95% credible interval estimates for the community-level parameters hypothesized to influence songbird species' occupancy (ψ) and detection (p) probabilities in the Great Valley ecoregion, California, 2016-17. Bolded beta values have credible intervals that did not include zero.

	Covariate		Community-level		Species-level	
			$\bar{x}$	95% CI	+	–
Model 1	ψ_1	# natural vegetation types	0.09	-0.007 – 0.195	13	3
	ψ_2	# agricultural vegetation types	**0.11**	0.018 – 0.191	11	2
	ψ_3	Distance to forest	**-0.57**	-0.799 - -0.345	7	29
	ψ_4	Distance to water	-0.04	-0.139 – 0.053	2	4
	ψ_5	Year	**0.24**	0.097 – 0.405	12	2
	p_1	Maximum temperature	**-0.10**	-0.192 - -0.018	3	11
	p_2	Julian day	**0.88**	0.526 – 1.212	34	0
	p_3	Julian day^2	**-0.93**	-1.279 - -0.574	0	32
	p_4	Noise level	**-0.13**	-0.214 - -0.050	3	15
	P_5	Year	0.03	-0.029 – 0.104	7	3
Model 2	ψ_1	Crop cover (%)	0.10	-0.010 – 0.206	14	3
	ψ_2	Natural evenness	**0.20**	0.080 – 0.322	25	6
	ψ_3	Agricultural evenness	**0.14**	0.064 – 0.217	11	1
	ψ_4	Distance to urban	-0.07	-0.153 – 0.003	0	4
	ψ_5	Year	**0.24**	0.102 – 0.404	12	2
	p_1	Maximum temperature	**0.17**	0.013 – 0.339	2	0
	p_2	Julian day	**0.32**	0.111 – 0.521	21	0
	p_3	Temperature * Julian day	**-0.58**	-0.888 - -0.287	0	22
	p_4	Noise level	**-0.13**	-0.215 - -0.049	2	15
	p_5	Year	0.05	-0.009 – 0.116	9	2

Figure 1. Automated recorder locations during Terrestrial Species Stressor Monitoring surveys in the Great Valley ecoregion of California, 2016-2017.

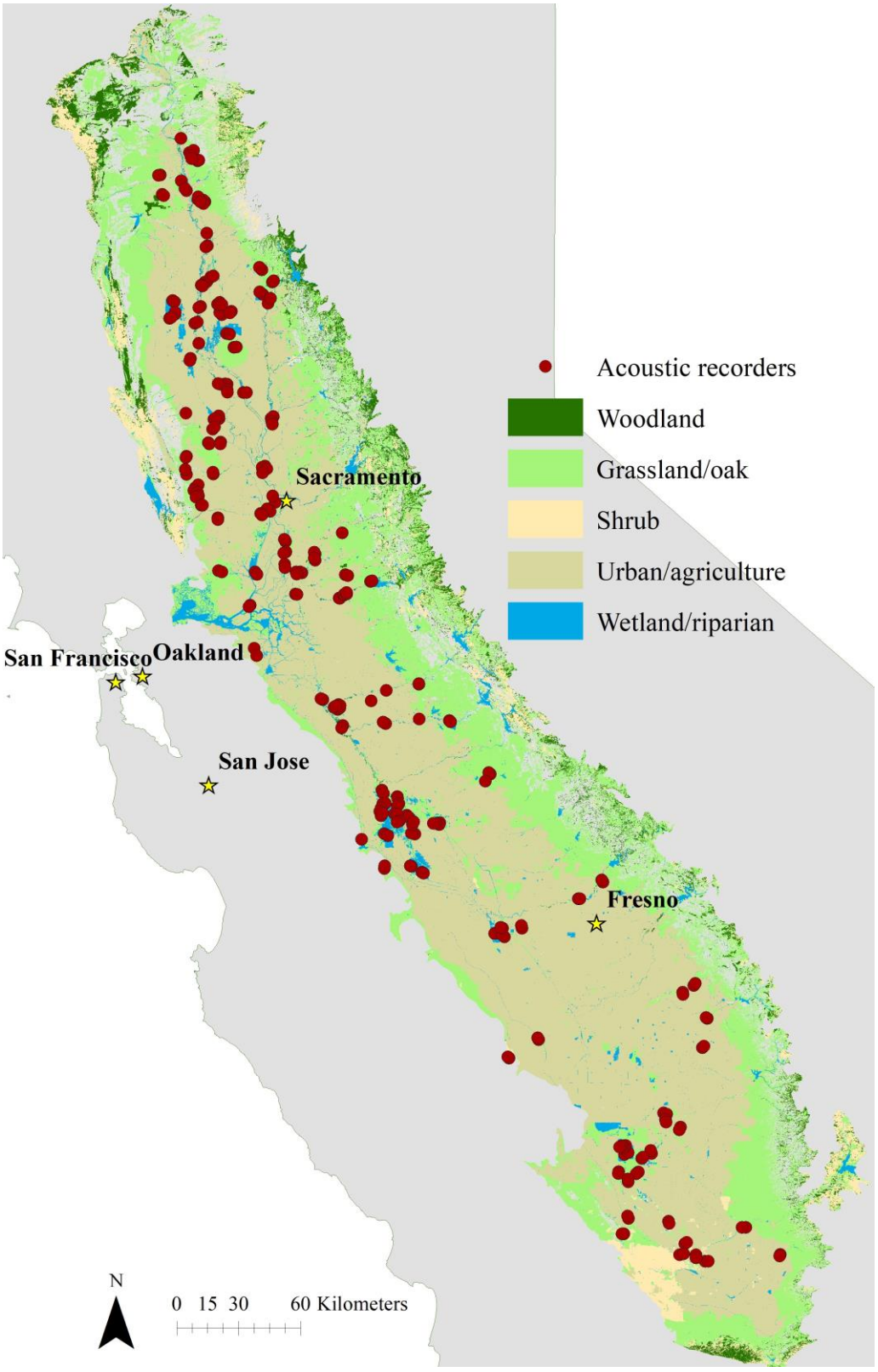


Figure 2. Mean occupancy probabilities (± 95% credible intervals) for songbird species across the Great Valley ecoregion, California, 2016-17. We present species with occupancy estimates > 0.05.

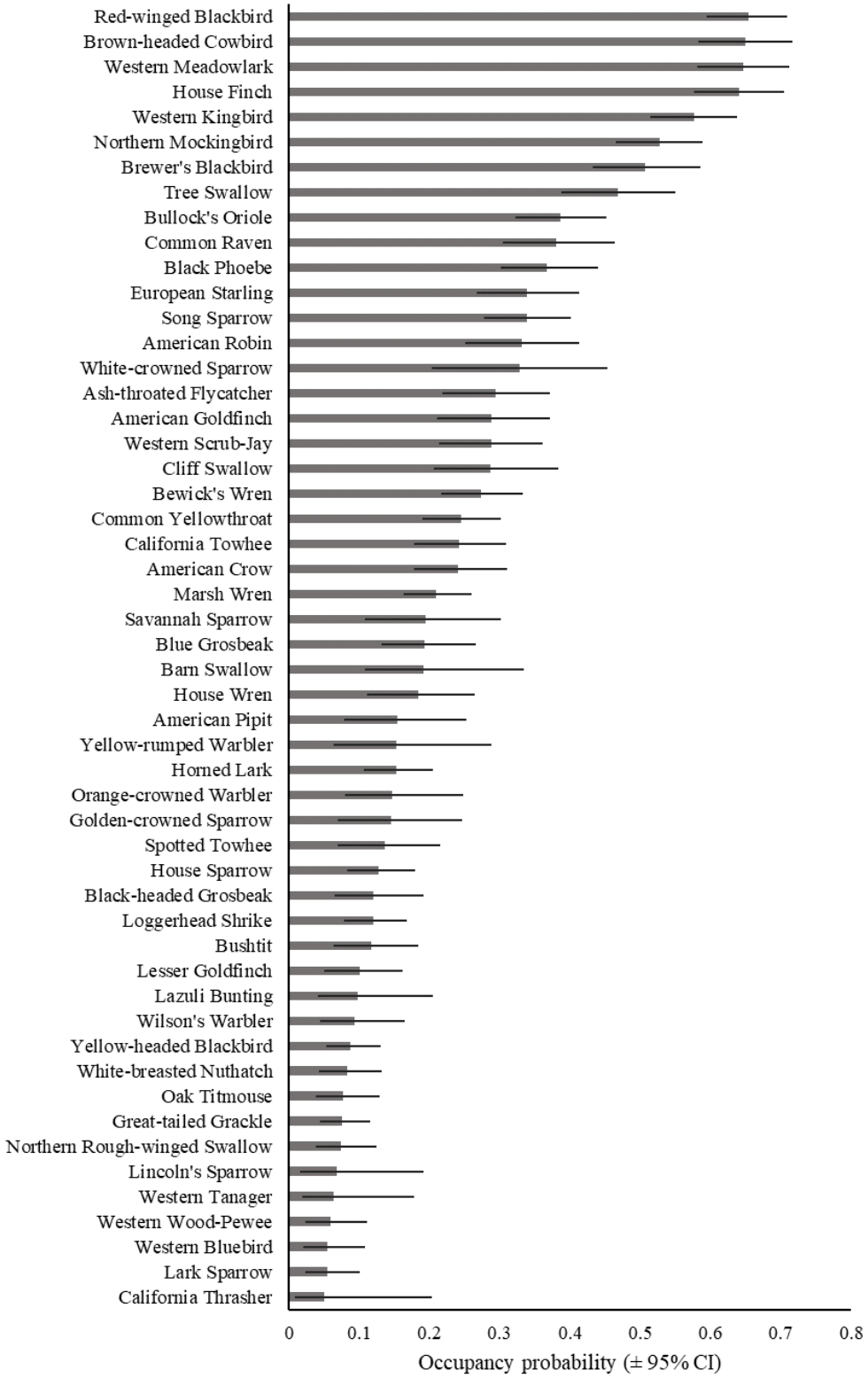


Figure 3. Region-wide and habitat-specific mean estimated occupancy probabilities (± 1 standard deviation) for songbird species in the Great Valley ecoregion of California, 2016-17.

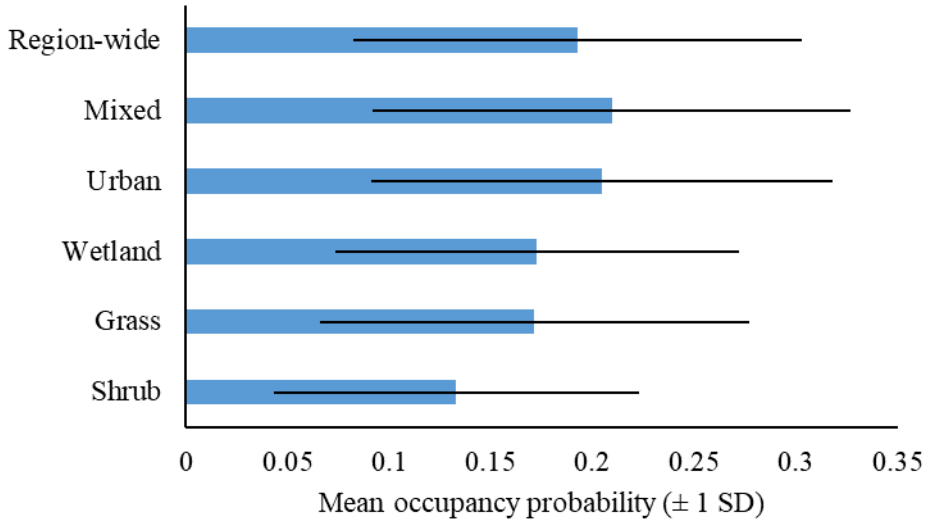
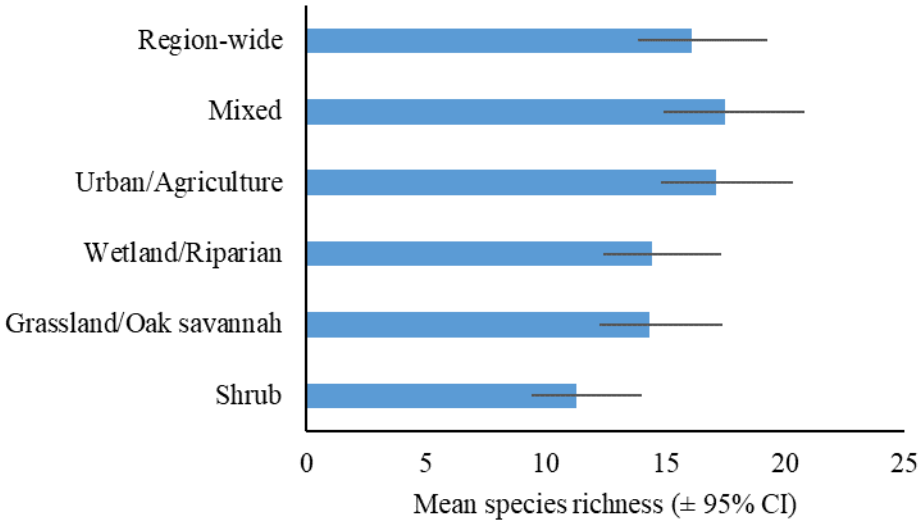


Figure 4. Overall and habitat-specific estimates (± 95% credible interval) of songbird richness in the Great Valley ecoregion, California, 2016-17.



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Appendix S1. Songbird species in the Great Valley ecoregion of California and their occupancy probabilities overall, and within each of the major habitat strata . The habitat strata in which each species had the highest occupancy probability is highlighted.

Species Code	Common Name	OCCUPANCY											
		Overall		Grass/Oak Savannah		Mixed		Riparian & Wetland		Urban & Agriculture		Shrub	
		Mean	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*
AMCR	American Crow	0.24	0.034	0.16	0.138	0.41	0.118	0.17	0.150	0.31	0.144	0.17	0.126
AMGO	American Goldfinch	0.29	0.042	0.16	0.174	0.42	0.152	0.34	0.111	0.47	0.133	0.03	0.131
AMPI	American Pipit	0.15	0.045	0.24	0.241	0.24	0.238	0.24	0.240	0.21	0.238	0.09	0.238
AMRO	American Robin	0.33	0.041	0.20	0.058	0.50	0.062	0.24	0.042	0.55	0.044	0.14	0.017
ATFL	Ash-throated Flycatcher	0.29	0.039	0.37	0.058	0.37	0.106	0.19	0.057	0.40	0.089	0.43	0.031
BANS	Bank Swallow	0.01	0.012	0.01	0.090	0.03	0.107	0.01	0.088	0.01	0.103	0.01	0.071
BARS	Barn Swallow	0.19	0.058	0.26	0.252	0.16	0.288	0.26	0.295	0.21	0.277	0.21	0.369
BESP	Bell’s Sparrow	0.01	0.006	0.02	0.021	0.07	0.016	0.05	0.027	0.00	0.024	0.29	0.028
BEWR	Bewick's Wren	0.27	0.030	0.14	0.035	0.44	0.040	0.21	0.013	0.32	0.038	0.43	0.017
BGGN	Blue-gray Gnatcatcher	0.01	0.014	0.01	0.092	0.03	0.100	0.01	0.103	0.01	0.094	0.01	0.103
BHCO	Brown-headed Cowbird	0.65	0.035	0.54	0.090	0.60	0.117	0.84	0.019	0.67	0.088	0.17	0.116
BHGR	Black-headed Grosbeak	0.12	0.033	0.17	0.070	0.30	0.126	0.11	0.033	0.27	0.112	0.30	0.043
BLGR	Blue Grosbeak	0.19	0.033	0.15	0.189	0.24	0.219	0.20	0.200	0.22	0.218	0.22	0.224
BLPH	Black Phoebe	0.37	0.036	0.31	0.107	0.39	0.112	0.35	0.068	0.49	0.114	0.16	0.095
BRBL	Brewer's Blackbird	0.51	0.039	0.56	0.158	0.42	0.194	0.50	0.189	0.55	0.172	0.48	0.156
BTYW	Black-throated Gray Warbler	0.00	0.004	0.00	0.036	0.00	0.039	0.00	0.028	0.01	0.039	0.00	0.019
BUOR	Bullock's Oriole	0.39	0.033	0.27	0.095	0.50	0.084	0.38	0.086	0.43	0.083	0.29	0.060
BUSH	Bushtit	0.12	0.032	0.18	0.113	0.28	0.138	0.11	0.068	0.28	0.126	0.02	0.086
CAKI	Cassin's Kingbird	0.01	0.006	0.02	0.030	0.02	0.033	0.00	0.037	0.00	0.039	0.00	0.036
CALT	California Towhee	0.24	0.034	0.20	0.057	0.31	0.058	0.06	0.044	0.44	0.064	0.29	0.021
CATH	California Thrasher	0.05	0.052	0.04	0.200	0.07	0.213	0.08	0.213	0.06	0.210	0.19	0.201
CAVI	Cassin's Vireo	0.01	0.014	0.03	0.094	0.01	0.111	0.01	0.090	0.01	0.104	0.01	0.075
CEDW	Cedar Waxwing	0.05	0.024	0.08	0.171	0.08	0.184	0.03	0.154	0.10	0.183	0.15	0.089

Species Code	Common Name	OCCUPANCY											
		Overall		Grass/Oak Savannah		Mixed		Riparian & Wetland		Urban & Agriculture		Shrub	
		Mean	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*
CHSP	Chipping Sparrow	0.02	0.024	0.04	0.123	0.02	0.141	0.04	0.130	0.02	0.131	0.02	0.125
CLSW	Cliff Swallow	0.29	0.045	0.39	0.219	0.26	0.246	0.29	0.225	0.29	0.265	0.26	0.281
CORA	Common Raven	0.38	0.041	0.45	0.079	0.25	0.105	0.33	0.125	0.41	0.127	0.73	0.072
COYE	Common Yellowthroat	0.24	0.029	0.19	0.028	0.19	0.041	0.71	0.009	0.21	0.049	0.00	0.029
DEJU	Dark-eyed Junco	0.03	0.026	0.06	0.169	0.08	0.198	0.03	0.153	0.06	0.185	0.01	0.107
EUST	European Starling	0.34	0.038	0.30	0.085	0.50	0.078	0.25	0.087	0.46	0.066	0.01	0.088
FOSP	Fox Sparrow	0.01	0.013	0.01	0.092	0.01	0.110	0.01	0.087	0.02	0.106	0.01	0.081
GCSP	Golden-crowned Sparrow	0.15	0.046	0.16	0.252	0.19	0.273	0.17	0.232	0.31	0.222	0.06	0.207
GRSP	Grasshopper Sparrow	0.01	0.008	0.06	0.059	0.02	0.066	0.00	0.049	0.01	0.069	0.00	0.043
GTGR	Great-tailed Grackle	0.08	0.018	0.09	0.101	0.10	0.102	0.06	0.089	0.10	0.127	0.01	0.084
HETH	Hermit Thrush	0.03	0.020	0.03	0.146	0.06	0.178	0.02	0.137	0.08	0.159	0.01	0.097
HOFI	House Finch	0.64	0.032	0.49	0.058	0.71	0.033	0.45	0.058	0.75	0.029	0.29	0.026
HOLA	Horned Lark	0.15	0.025	0.44	0.003	0.18	0.006	0.08	0.012	0.14	0.013	0.43	0.005
HOSP	House Sparrow	0.13	0.025	0.09	0.098	0.12	0.104	0.18	0.118	0.20	0.129	0.03	0.150
HOWR	House Wren	0.18	0.039	0.19	0.012	0.45	0.005	0.11	0.011	0.37	0.007	0.14	0.006
HUVI	Hutton's Vireo	0.01	0.008	0.02	0.065	0.04	0.093	0.01	0.064	0.01	0.082	0.00	0.054
LASP	Lark Sparrow	0.05	0.020	0.06	0.135	0.11	0.135	0.02	0.122	0.10	0.148	0.01	0.100
LAZB	Lazuli Bunting	0.10	0.044	0.14	0.233	0.12	0.248	0.08	0.209	0.13	0.242	0.05	0.209
LCTH	Le Conte's Thrasher	0.01	0.006	0.00	0.042	0.02	0.045	0.00	0.046	0.00	0.047	0.14	0.032
LEGO	Lesser Goldfinch	0.10	0.029	0.08	0.135	0.32	0.136	0.07	0.090	0.21	0.144	0.01	0.080
LISP	Lincoln's Sparrow	0.07	0.050	0.14	0.241	0.12	0.271	0.07	0.230	0.13	0.255	0.03	0.151
LOSH	Loggerhead Shrike	0.12	0.023	0.23	0.080	0.17	0.064	0.25	0.091	0.09	0.075	0.21	0.178
MAWR	Marsh Wren	0.21	0.025	0.13	0.000	0.15	0.000	0.76	0.000	0.13	0.000	0.00	0.000
MGWA	MacGillivray's Warbler	0.02	0.025	0.04	0.146	0.05	0.168	0.02	0.134	0.04	0.159	0.01	0.099
NAWA	Nashville Warbler	0.01	0.011	0.01	0.088	0.01	0.109	0.01	0.087	0.02	0.093	0.01	0.074
NOMO	Northern Mockingbird	0.53	0.032	0.58	0.022	0.50	0.021	0.37	0.024	0.56	0.026	0.57	0.028

	Common Name	OCCUPANCY											
		Overall		Grass/Oak Savannah		Mixed		Riparian & Wetland		Urban & Agriculture		Shrub	
		Mean	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*
NRWS	Northern Rough-winged Swallow	0.07	0.022	0.10	0.122	0.15	0.145	0.02	0.117	0.09	0.169	0.29	0.055
OATI	Oak Titmouse	0.08	0.023	0.05	0.076	0.24	0.072	0.06	0.047	0.19	0.078	0.00	0.038
OCWA	Orange-crowned Warbler	0.15	0.041	0.18	0.246	0.17	0.247	0.10	0.219	0.21	0.258	0.33	0.150
PHAI	Phainopepla	0.02	0.013	0.05	0.104	0.03	0.115	0.01	0.096	0.01	0.106	0.15	0.062
PSFL	Pacific-slope Flycatcher	0.01	0.007	0.00	0.049	0.02	0.052	0.00	0.038	0.03	0.048	0.00	0.028
PUFI	Purple Finch	0.02	0.016	0.02	0.114	0.06	0.139	0.01	0.105	0.03	0.131	0.01	0.073
RCKI	Ruby-crowned Kinglet	0.02	0.016	0.03	0.137	0.08	0.175	0.02	0.129	0.06	0.135	0.01	0.084
RCSP	Rufous-crowned Sparrow	0.01	0.004	0.02	0.024	0.00	0.026	0.00	0.024	0.00	0.031	0.00	0.010
ROWR	Rock Wren	0.01	0.008	0.03	0.073	0.01	0.080	0.01	0.085	0.02	0.073	0.02	0.117
RWBL	Red-winged Blackbird	0.65	0.030	0.65	0.004	0.58	0.007	0.84	0.003	0.65	0.007	0.29	0.006
SAGS	Sage Sparrow	0.01	0.012	0.01	0.083	0.01	0.090	0.01	0.093	0.02	0.084	0.02	0.116
SAVS	Savannah Sparrow	0.19	0.051	0.34	0.189	0.25	0.207	0.34	0.197	0.30	0.179	0.05	0.183
SOSP	Song Sparrow	0.34	0.032	0.23	0.014	0.37	0.021	0.82	0.001	0.27	0.028	0.14	0.012
SPTO	Spotted Towhee	0.14	0.038	0.17	0.011	0.50	0.014	0.13	0.004	0.35	0.014	0.14	0.005
SWTH	Swainson's Thrush	0.01	0.015	0.01	0.094	0.03	0.115	0.01	0.090	0.01	0.104	0.01	0.078
TRBL	Tricolored Blackbird	0.03	0.012	0.06	0.068	0.04	0.087	0.04	0.083	0.01	0.090	0.01	0.092
TRES	Tree Swallow	0.47	0.041	0.46	0.029	0.61	0.030	0.40	0.021	0.52	0.034	0.14	0.022
WAVI	Warbling Vireo	0.04	0.022	0.06	0.174	0.12	0.188	0.05	0.133	0.11	0.172	0.01	0.092
WBNU	White-breasted Nuthatch	0.08	0.023	0.15	0.081	0.19	0.098	0.03	0.064	0.14	0.123	0.01	0.059
WCSP	White-crowned Sparrow	0.33	0.064	0.34	0.271	0.51	0.252	0.36	0.255	0.46	0.200	0.21	0.295
WEBL	Western Bluebird	0.05	0.022	0.06	0.139	0.13	0.175	0.05	0.123	0.14	0.161	0.02	0.102
WEKI	Western Kingbird	0.58	0.032	0.62	0.027	0.59	0.035	0.48	0.029	0.60	0.044	0.29	0.038
WEME	Western Meadowlark	0.65	0.034	0.94	0.003	0.52	0.007	0.84	0.002	0.42	0.006	0.71	0.007
WESJ	Western Scrub-Jay	0.29	0.038	0.22	0.080	0.41	0.098	0.15	0.099	0.48	0.075	0.29	0.032
WETA	Western Tanager	0.06	0.046	0.09	0.205	0.07	0.213	0.05	0.217	0.11	0.216	0.17	0.143

	Common Name	OCCUPANCY											
		Overall		Grass/Oak Savannah		Mixed		Riparian & Wetland		Urban & Agriculture		Shrub	
		Mean	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*
WEWP	Western Wood-Pewee	0.06	0.023	0.05	0.115	0.22	0.154	0.10	0.066	0.13	0.163	0.15	0.045
WIWA	Wilson's Warbler	0.09	0.031	0.18	0.179	0.16	0.200	0.09	0.172	0.13	0.186	0.05	0.168
WREN	Wrentit	0.03	0.013	0.01	0.083	0.15	0.094	0.04	0.068	0.07	0.084	0.01	0.055
WTSW	White-throated Swift	0.01	0.010	0.01	0.083	0.03	0.096	0.01	0.081	0.01	0.096	0.01	0.076
YBCH	Yellow-breasted Chat	0.01	0.006	0.00	0.039	0.02	0.045	0.03	0.036	0.00	0.039	0.14	0.014
YBMA	Yellow-billed Magpie	0.04	0.013	0.04	0.052	0.02	0.061	0.03	0.049	0.08	0.075	0.00	0.050
YEWA	Yellow Warbler	0.04	0.016	0.09	0.113	0.10	0.148	0.04	0.115	0.05	0.132	0.15	0.062
YHBL	Yellow-headed Blackbird	0.09	0.020	0.17	0.099	0.14	0.115	0.21	0.124	0.04	0.107	0.02	0.135
YRWA	Yellow-rumped Warbler	0.15	0.059	0.20	0.303	0.24	0.309	0.16	0.281	0.34	0.277	0.05	0.200

Appendix S2. Songbird species in the Great Valley ecoregion of California and their site-level detection probabilities (± 95 credible intervals).

Species Code	Common Name	P*		
		Mean	*95% CI*	
AMCR	American Crow	0.90	0.842	0.938
AMGO	American Goldfinch	0.89	0.839	0.926
AMPI	American Pipit	0.44	0.247	0.644
AMRO	American Robin	0.99	0.985	0.995
ATFL	Ash-throated Flycatcher	0.98	0.964	0.991
BANS	Bank Swallow	0.50	0.080	0.927
BARS	Barn Swallow	0.52	0.318	0.696
BESP	Bell's Sparrow	0.99	0.939	0.999
BEWR	Bewick's Wren	1.00	0.995	0.999
BGGN	Blue-gray Gnatcatcher	0.53	0.067	0.950
BHCO	Brown-headed Cowbird	0.97	0.961	0.981
BHGR	Black-headed Grosbeak	0.97	0.935	0.984
BLGR	Blue Grosbeak	0.71	0.569	0.820
BLPH	Black Phoebe	0.95	0.930	0.970
BRBL	Brewer's Blackbird	0.88	0.835	0.915
BTYW	Black-throated Gray Warbler	0.94	0.483	1.000
BUOR	Bullock's Oriole	0.98	0.962	0.984
BUSH	Bushtit	0.91	0.853	0.947
CAKI	Cassin's Kingbird	0.98	0.638	1.000
CALT	California Towhee	0.99	0.982	0.995
CATH	California Thrasher	0.34	0.054	0.764
CAVI	Cassin's Vireo	0.50	0.078	0.919
CEDW	Cedar Waxwing	0.57	0.283	0.797
CHSP	Chipping Sparrow	0.46	0.068	0.892
CLSW	Cliff Swallow	0.70	0.570	0.812
CORA	Common Raven	0.93	0.893	0.951
COYE	Common Yellowthroat	1.00	0.995	0.999
DEJU	Dark-eyed Junco	0.37	0.081	0.797
EUST	European Starling	0.97	0.960	0.984
FOSP	Fox Sparrow	0.51	0.069	0.946
GCSP	Golden-crowned Sparrow	0.38	0.205	0.577
GRSP	Grasshopper Sparrow	0.91	0.408	0.999
GTGR	Great-tailed Grackle	0.87	0.730	0.949
HETH	Hermit Thrush	0.41	0.102	0.831
HOFI	House Finch	0.99	0.990	0.995
HOLA	Horned Lark	1.00	0.999	1.000
HOSP	House Sparrow	0.90	0.806	0.957
HOWR	House Wren	1.00	0.999	1.000
HUVI	Hutton's Vireo	0.73	0.314	0.955
LASP	Lark Sparrow	0.75	0.526	0.885
LAZB	Lazuli Bunting	0.47	0.226	0.712
LCTH	Le Conte's Thrasher	0.93	0.567	0.998
LEGO	Lesser Goldfinch	0.86	0.769	0.924
LISP	Lincoln's Sparrow	0.24	0.066	0.526
LOSH	Loggerhead Shrike	0.96	0.916	0.981
MAWR	Marsh Wren	1.00	1.000	1.000
MGWA	MacGillivray's Warbler	0.42	0.078	0.802
NAWA	Nashville Warbler	0.54	0.069	0.962
NOMO	Northern Mockingbird	1.00	0.998	0.999
NRWS	Northern Rough-winged Swallow	0.52	0.212	0.807
OATI	Oak Titmouse	0.78	0.594	0.897
OCWA	Orange-crowned Warbler	0.96	0.916	0.980
PHAI	Phainopepla	0.51	0.318	0.694
PSFL	Pacific-slope Flycatcher	0.65	0.246	0.925
PUFI	Purple Finch	0.95	0.651	0.998
RCKI	Ruby-crowned Kinglet	0.50	0.133	0.842
RCSP	Rufous-crowned Sparrow	0.44	0.102	0.878
ROWR	Rock Wren	0.98	0.694	1.000
RWBL	Red-winged Blackbird	0.67	0.208	0.956
SAGS	Sage Sparrow	1.00	1.000	1.000
SAVS	Savannah Sparrow	0.58	0.082	0.964
SOSP	Song Sparrow	0.74	0.533	0.903
SPTO	Spotted Towhee	1.00	1.000	1.000
SWTH	Swainson's Thrush	1.00	0.998	1.000
TRBL	Tricolored Blackbird	0.51	0.068	0.939
TRES	Tree Swallow	0.83	0.528	0.963
WAVI	Warbling Vireo	1.00	0.993	0.997
WBNU	White-breasted Nuthatch	0.55	0.285	0.798

Species Code	Common Name	P*		
		Mean	*95% CI*	
WCSP	White-crowned Sparrow	0.92	0.844	0.963
WEBL	Western Bluebird	0.41	0.250	0.572
WEKI	Western Kingbird	0.72	0.508	0.865
WEME	Western Meadowlark	1.00	0.995	0.998
WESJ	Western Scrub-Jay	1.00	1.000	1.000
WETA	Western Tanager	0.96	0.945	0.978
WEWP	Western Wood-Pewee	0.46	0.149	0.749
WIWA	Wilson's Warbler	0.84	0.646	0.954
WREN	Wrentit	0.61	0.420	0.786
WTSW	White-throated Swift	0.89	0.718	0.968
YBCH	Yellow-breasted Chat	0.53	0.093	0.938
YBMA	Yellow-billed Magpie	0.96	0.684	0.999
YEWA	Yellow Warbler	0.94	0.844	0.984
YHBL	Yellow-headed Blackbird	0.74	0.487	0.904
YRWA	Yellow-rumped Warbler	0.88	0.781	0.945

Appendix S3a. Mean and 95% credible interval estimates for covariate effects on occupancy (PSI) and detection (P) for 84 songbird species in the Great Valley ecoregion of California, 2016-17. Results are based on model 1; covariate effects that do not overlap 0.0 are highlighted in yellow.

Species Code	Common Name	PSI (# natural types)			PSI (# agricultural types)			PSI (distance to forest)		
		Mean	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*	
AMCR	American Crow	0.38	0.100	0.694	0.38	0.102	0.672	-0.60	-1.117	-0.155
AMGO	American Goldfinch	0.13	-0.160	0.428	0.32	0.031	0.609	-1.35	-2.058	-0.752
AMPI	American Pipit	-0.26	-0.668	0.151	0.00	-0.352	0.367	0.26	-0.194	0.730
AMRO	American Robin	0.29	0.003	0.581	0.54	0.278	0.840	-1.37	-2.038	-0.819
ATFL	Ash-throated Flycatcher	0.36	0.070	0.661	0.07	-0.189	0.331	-1.15	-1.794	-0.625
BANS	Bank Swallow	0.15	-0.460	0.755	0.18	-0.322	0.692	-0.78	-2.500	0.623
BARS	Barn Swallow	-0.07	-0.507	0.333	0.04	-0.330	0.381	0.50	0.059	0.984
BESP	Bell's Sparrow	0.08	-0.501	0.660	-0.19	-0.673	0.252	1.19	0.671	1.778
BEWR	Bewick's Wren	0.63	0.335	0.949	0.04	-0.199	0.282	-0.23	-0.598	0.110
BGGN	Blue-gray Gnatcatcher	0.04	-0.618	0.662	0.05	-0.449	0.554	0.14	-1.174	1.278
BHCO	Brown-headed Cowbird	0.32	0.010	0.658	0.12	-0.136	0.372	-0.47	-0.779	-0.172
BHGR	Black-headed Grosbeak	0.56	0.211	0.906	0.22	-0.073	0.508	-1.80	-2.889	-0.864
BLGR	Blue Grosbeak	0.23	-0.119	0.610	0.19	-0.128	0.497	0.11	-0.324	0.535
BLPH	Black Phoebe	0.07	-0.210	0.340	0.30	0.048	0.558	-0.87	-1.307	-0.459
BRBL	Brewer's Blackbird	-0.24	-0.527	0.030	-0.03	-0.274	0.228	-0.04	-0.351	0.290
BTYW	Black-throated Gray Warbler	0.12	-0.489	0.733	0.04	-0.442	0.532	-0.74	-2.375	0.589
BUOR	Bullock's Oriole	0.15	-0.111	0.429	0.15	-0.095	0.398	-0.32	-0.656	-0.002
BUSH	Bushtit	0.24	-0.075	0.578	0.17	-0.127	0.468	-1.98	-3.113	-1.007
CAKI	Cassin's Kingbird	0.09	-0.516	0.702	-0.01	-0.549	0.454	0.05	-1.084	0.947
CALT	California Towhee	-0.02	-0.288	0.243	0.32	0.061	0.579	-1.20	-1.835	-0.639
CATH	California Thrasher	0.03	-0.570	0.583	0.15	-0.336	0.611	0.26	-0.725	1.192
CAVI	Cassin's Vireo	0.11	-0.539	0.711	0.08	-0.430	0.554	-0.69	-2.231	0.657
CEDW	Cedar Waxwing	0.06	-0.415	0.545	0.03	-0.379	0.442	-0.81	-1.938	0.082
CHSP	Chipping Sparrow	0.10	-0.521	0.693	0.03	-0.484	0.506	-0.09	-1.347	0.973
CLSW	Cliff Swallow	-0.15	-0.524	0.197	-0.15	-0.459	0.149	0.01	-0.374	0.379
CORA	Common Raven	-0.17	-0.491	0.149	0.23	-0.056	0.525	1.22	0.799	1.742
COYE	Common Yellowthroat	0.24	-0.031	0.506	-0.06	-0.312	0.189	-0.30	-0.693	0.025
DEJU	Dark-eyed Junco	0.18	-0.323	0.693	0.12	-0.350	0.586	-1.28	-2.922	0.062
EUST	European Starling	0.39	0.117	0.683	0.22	-0.025	0.472	-1.17	-1.762	-0.678
FOSP	Fox Sparrow	-0.03	-0.655	0.583	0.19	-0.307	0.708	-0.76	-2.369	0.621
GCSP	Golden-crowned Sparrow	-0.09	-0.498	0.304	0.42	0.048	0.825	-0.73	-1.529	-0.071

Species Code	Common Name	PSI (# natural types)			PSI (# agricultural types)			PSI (distance to forest)		
		Mean	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*	
GRSP	Grasshopper Sparrow	-0.16	-0.738	0.381	-0.05	-0.523	0.408	-0.99	-2.479	0.145
GTGR	Great-tailed Grackle	-0.19	-0.628	0.206	0.22	-0.140	0.563	-0.25	-0.872	0.280
HETH	Hermit Thrush	0.06	-0.472	0.572	0.27	-0.181	0.734	-1.17	-2.712	0.041
HOFI	House Finch	0.01	-0.266	0.287	0.39	0.137	0.657	-0.69	-1.014	-0.392
HOLA	Horned Lark	-0.40	-0.816	-0.018	-0.33	-0.683	-0.003	0.93	0.620	1.256
HOSP	House Sparrow	-0.47	-0.887	-0.099	0.52	0.211	0.845	0.25	-0.148	0.632
HOWR	House Wren	0.45	0.159	0.740	0.09	-0.168	0.350	-1.98	-3.017	-1.135
HUVI	Hutton's Vireo	0.45	-0.089	1.009	0.10	-0.372	0.573	-1.00	-2.538	0.285
LASP	Lark Sparrow	-0.12	-0.580	0.306	0.01	-0.371	0.374	-1.25	-2.448	-0.309
LAZB	Lazuli Bunting	0.10	-0.389	0.571	-0.04	-0.458	0.362	-0.60	-1.472	0.136
LCTH	Le Conte's Thrasher	0.07	-0.540	0.653	-0.03	-0.519	0.448	0.46	-0.461	1.307
LEGO	Lesser Goldfinch	0.38	0.047	0.715	0.19	-0.111	0.494	-1.66	-2.810	-0.719
LISP	Lincoln's Sparrow	-0.03	-0.535	0.475	-0.06	-0.525	0.392	-1.29	-2.681	-0.101
LOSH	Loggerhead Shrike	-0.21	-0.625	0.163	-0.17	-0.514	0.153	0.74	0.399	1.086
MAWR	Marsh Wren	0.10	-0.193	0.377	-0.11	-0.384	0.157	-0.18	-0.561	0.161
MGWA	MacGillivray's Warbler	0.11	-0.476	0.686	-0.01	-0.499	0.444	-1.01	-2.562	0.223
NAWA	Nashville Warbler	0.26	-0.340	0.895	0.11	-0.381	0.582	-0.69	-2.318	0.689
NOMO	Northern Mockingbird	-0.35	-0.623	-0.094	0.08	-0.144	0.315	0.19	-0.092	0.479
NRWS	Northern Rough-winged Swallow	0.13	-0.266	0.532	0.33	-0.012	0.691	-0.56	-1.419	0.124
OATI	Oak Titmouse	0.20	-0.111	0.516	0.12	-0.179	0.418	-1.87	-3.018	-0.835
OCWA	Orange-crowned Warbler	-0.14	-0.527	0.255	0.08	-0.298	0.446	-0.97	-1.888	-0.253
PHAI	Phainopepla	0.13	-0.421	0.654	-0.06	-0.557	0.403	-0.71	-1.978	0.387
PSFL	Pacific-slope Flycatcher	-0.04	-0.601	0.487	-0.01	-0.489	0.438	-1.09	-2.576	0.070
PUFI	Purple Finch	0.17	-0.380	0.733	0.23	-0.242	0.722	-1.06	-2.574	0.219
RCKI	Ruby-crowned Kinglet	0.40	-0.110	0.916	0.12	-0.330	0.586	-1.22	-2.780	0.045
RCSP	Rufous-crowned Sparrow	0.02	-0.595	0.625	0.00	-0.507	0.492	-0.34	-1.785	0.797
ROWR	Rock Wren	0.06	-0.563	0.678	-0.02	-0.539	0.463	0.69	-0.238	1.592
RWBL	Red-winged Blackbird	-0.08	-0.328	0.186	0.12	-0.112	0.362	0.04	-0.236	0.315
SAGS	Sage Sparrow	0.02	-0.607	0.628	0.14	-0.356	0.646	0.54	-0.610	1.672
SAVS	Savannah Sparrow	-0.50	-0.883	-0.139	-0.10	-0.429	0.228	0.10	-0.305	0.501
SOSP	Song Sparrow	0.35	0.087	0.607	0.10	-0.136	0.350	-0.10	-0.413	0.198
SPTO	Spotted Towhee	0.77	0.428	1.114	0.29	0.016	0.570	-2.50	-3.732	-1.468
SWTH	Swainson's Thrush	0.19	-0.444	0.814	0.11	-0.390	0.622	-0.72	-2.278	0.647
TRBL	Tricolored Blackbird	0.05	-0.472	0.566	0.06	-0.373	0.499	0.31	-0.384	0.942
TRES	Tree Swallow	0.72	0.393	1.067	0.34	0.071	0.606	-1.04	-1.533	-0.600
WAVI	Warbling Vireo	0.23	-0.202	0.682	-0.09	-0.513	0.314	-1.60	-3.043	-0.415

Species Code	Common Name	PSI (# natural types)			PSI (# agricultural types)			PSI (distance to forest)		
		Mean	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*	
WBNU	White-breasted Nuthatch	0.09	-0.242	0.437	0.13	-0.197	0.450	-1.42	-2.485	-0.531
WCSP	White-crowned Sparrow	0.08	-0.303	0.486	0.36	-0.012	0.723	-0.02	-0.455	0.478
WEBL	Western Bluebird	0.21	-0.183	0.613	0.16	-0.203	0.527	-1.63	-3.036	-0.511
WEKI	Western Kingbird	-0.13	-0.399	0.126	0.05	-0.174	0.287	-0.32	-0.605	-0.056
WEME	Western Meadowlark	-0.10	-0.366	0.160	-0.43	-0.698	-0.180	0.83	0.436	1.260
WESJ	Western Scrub-Jay	0.21	-0.071	0.497	0.32	0.065	0.587	-1.31	-1.963	-0.757
WETA	Western Tanager	-0.14	-0.684	0.371	0.01	-0.421	0.433	-0.22	-1.145	0.549
WEWP	Western Wood-Pewee	0.30	-0.086	0.702	0.11	-0.246	0.441	-1.84	-3.159	-0.680
WIWA	Wilson's Warbler	0.16	-0.228	0.538	0.05	-0.315	0.406	-0.43	-1.123	0.149
WREN	Wrentit	0.49	0.090	0.909	0.26	-0.107	0.636	-1.61	-3.113	-0.362
WTSW	White-throated Swift	0.04	-0.579	0.677	0.06	-0.439	0.536	-0.64	-2.215	0.669
YBCH	Yellow-breasted Chat	0.09	-0.438	0.644	0.07	-0.411	0.525	-0.98	-2.497	0.236
YBMA	Yellow-billed Magpie	-0.05	-0.510	0.383	0.21	-0.162	0.604	-0.62	-1.615	0.154
YEWA	Yellow Warbler	0.40	-0.023	0.843	-0.04	-0.464	0.337	-0.87	-1.969	0.014
YHBL	Yellow-headed Blackbird	0.09	-0.298	0.491	0.04	-0.314	0.383	0.62	0.247	0.996
YRWA	Yellow-rumped Warbler	-0.21	-0.656	0.211	0.31	-0.104	0.745	-1.23	-2.339	-0.333

Species Code	Common Name	PSI (distance to water)			PSI (year)			P (max temperature)		
		Mean	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*	
AMCR	American Crow	0.15	-0.204	0.540	0.17	-0.156	0.491	-0.33	-0.604	-0.070
AMGO	American Goldfinch	0.03	-0.283	0.317	0.07	-0.236	0.371	0.07	-0.170	0.333
AMPI	American Pipit	-0.18	-0.661	0.260	1.20	0.519	2.020	-0.18	-0.532	0.177
AMRO	American Robin	0.00	-0.320	0.295	0.20	-0.092	0.489	-0.11	-0.270	0.063
ATFL	Ash-throated Flycatcher	-0.20	-0.575	0.134	-0.28	-0.578	0.005	-0.25	-0.452	-0.050
BANS	Bank Swallow	-0.04	-0.631	0.498	0.34	-0.580	1.347	-0.11	-0.655	0.437
BARS	Barn Swallow	-0.21	-0.680	0.215	-0.19	-0.698	0.307	-0.22	-0.656	0.208
BESP	Bell’s Sparrow	0.22	-0.181	0.597	0.83	0.111	1.667	-0.33	-0.920	0.208
BEWR	Bewick's Wren	-0.07	-0.411	0.218	-0.09	-0.366	0.192	0.06	-0.148	0.272
BGGN	Blue-gray Gnatcatcher	0.00	-0.555	0.536	0.34	-0.567	1.296	-0.11	-0.669	0.443
BHCO	Brown-headed Cowbird	-0.23	-0.526	0.039	0.00	-0.293	0.295	0.23	0.070	0.397
BHGR	Black-headed Grosbeak	-0.13	-0.578	0.253	-0.18	-0.520	0.165	0.10	-0.144	0.347
BLGR	Blue Grosbeak	-0.20	-0.627	0.173	-0.12	-0.487	0.262	0.13	-0.184	0.466
BLPH	Black Phoebe	0.16	-0.112	0.448	-0.06	-0.351	0.213	-0.01	-0.200	0.182
BRBL	Brewer's Blackbird	-0.11	-0.382	0.154	0.08	-0.215	0.368	-0.33	-0.550	-0.115

Species Code	Common Name	PSI (distance to water)			PSI (year)			P (max temperature)		
		Mean	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*	
BTYW	Black-throated Gray Warbler	-0.07	-0.623	0.439	0.32	-0.593	1.257	-0.03	-0.577	0.527
BUOR	Bullock's Oriole	-0.24	-0.580	0.052	0.11	-0.152	0.375	0.20	-0.001	0.407
BUSH	Bushtit	-0.18	-0.618	0.208	-0.24	-0.586	0.111	-0.06	-0.349	0.224
CAKI	Cassin's Kingbird	-0.14	-0.728	0.355	0.44	-0.416	1.430	-0.15	-0.706	0.373
CALT	California Towhee	0.19	-0.082	0.481	-0.03	-0.317	0.258	0.09	-0.109	0.295
CATH	California Thrasher	0.04	-0.485	0.592	0.23	-0.570	1.132	-0.19	-0.742	0.326
CAVI	Cassin's Vireo	-0.08	-0.686	0.479	0.35	-0.601	1.327	-0.10	-0.656	0.458
CEDW	Cedar Waxwing	0.24	-0.217	0.792	0.88	0.145	1.710	-0.01	-0.433	0.421
CHSP	Chipping Sparrow	-0.06	-0.633	0.462	0.46	-0.453	1.426	-0.10	-0.659	0.444
CLSW	Cliff Swallow	-0.10	-0.440	0.235	-0.41	-0.766	-0.058	0.15	-0.157	0.475
CORA	Common Raven	0.55	0.072	1.054	-0.18	-0.507	0.156	-0.28	-0.504	-0.070
COYE	Common Yellowthroat	-0.47	-0.922	-0.090	0.16	-0.112	0.455	-0.48	-0.709	-0.253
DEJU	Dark-eyed Junco	0.07	-0.496	0.625	0.64	-0.175	1.604	-0.17	-0.686	0.353
EUST	European Starling	0.23	-0.034	0.544	-0.13	-0.423	0.167	-0.03	-0.216	0.162
FOSP	Fox Sparrow	-0.07	-0.645	0.470	0.35	-0.583	1.352	-0.11	-0.676	0.443
GCSP	Golden-crowned Sparrow	0.18	-0.140	0.569	1.20	0.491	2.064	-0.20	-0.544	0.140
GRSP	Grasshopper Sparrow	-0.02	-0.537	0.431	0.54	-0.271	1.435	0.05	-0.494	0.625
GTGR	Great-tailed Grackle	-0.23	-0.739	0.159	0.13	-0.325	0.615	0.12	-0.290	0.546
HETH	Hermit Thrush	-0.09	-0.660	0.430	0.65	-0.181	1.561	-0.36	-0.938	0.177
HOFI	House Finch	0.13	-0.134	0.417	-0.14	-0.426	0.128	0.20	0.052	0.338
HOLA	Horned Lark	0.09	-0.179	0.362	-0.14	-0.464	0.185	-0.43	-0.699	-0.163
HOSP	House Sparrow	-0.06	-0.414	0.262	0.26	-0.131	0.669	-0.13	-0.470	0.197
HOWR	House Wren	0.10	-0.211	0.388	-0.02	-0.309	0.275	-0.17	-0.375	0.031
HUVI	Hutton's Vireo	-0.06	-0.622	0.466	0.16	-0.602	0.979	-0.15	-0.678	0.413
LASP	Lark Sparrow	0.08	-0.351	0.522	0.00	-0.500	0.514	0.13	-0.293	0.585
LAZB	Lazuli Bunting	0.33	0.005	0.733	0.27	-0.369	0.913	0.12	-0.364	0.578
LCTH	Le Conte's Thrasher	0.16	-0.332	0.632	0.45	-0.399	1.395	-0.18	-0.755	0.385
LEGO	Lesser Goldfinch	-0.03	-0.447	0.333	0.26	-0.140	0.652	0.10	-0.195	0.408
LISP	Lincoln's Sparrow	-0.22	-0.822	0.285	0.74	-0.094	1.694	-0.39	-0.922	0.080
LOSH	Loggerhead Shrike	0.23	-0.048	0.547	-0.27	-0.626	0.087	0.21	-0.112	0.542
MAWR	Marsh Wren	-0.45	-0.895	-0.058	0.00	-0.288	0.290	0.02	-0.237	0.305
MGWA	MacGillivray's Warbler	-0.12	-0.732	0.427	0.52	-0.311	1.448	-0.06	-0.595	0.469
NAWA	Nashville Warbler	-0.07	-0.671	0.466	0.34	-0.570	1.338	-0.11	-0.630	0.430

Species Code	Common Name	PSI (distance to water)			PSI (year)			P (max temperature)		
		Mean	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*	
NOMO	Northern Mockingbird	0.01	-0.232	0.277	0.02	-0.222	0.266	-0.12	-0.284	0.044
NRWS	Northern Rough-winged Swallow	-0.18	-0.703	0.252	0.32	-0.154	0.857	-0.08	-0.500	0.337
OATI	Oak Titmouse	0.19	-0.140	0.524	-0.07	-0.408	0.281	-0.16	-0.447	0.133
OCWA	Orange-crowned Warbler	0.19	-0.137	0.545	-0.10	-0.619	0.421	-0.48	-0.915	-0.088
PHAI	Phainopepla	-0.10	-0.657	0.407	0.18	-0.571	1.010	-0.07	-0.577	0.457
PSFL	Pacific-slope Flycatcher	-0.12	-0.695	0.354	0.50	-0.299	1.441	-0.43	-0.938	0.044
PUFI	Purple Finch	-0.09	-0.655	0.454	0.51	-0.330	1.426	-0.04	-0.551	0.494
RCKI	Ruby-crowned Kinglet	-0.13	-0.710	0.372	0.69	-0.148	1.655	-0.35	-0.821	0.100
RCSP	Rufous-crowned Sparrow	-0.04	-0.617	0.442	0.33	-0.551	1.274	-0.19	-0.752	0.356
ROWR	Rock Wren	-0.12	-0.701	0.384	-0.32	-1.157	0.519	-0.09	-0.648	0.446
RWBL	Red-winged Blackbird	-0.08	-0.324	0.169	0.28	0.024	0.532	0.23	0.077	0.389
SAGS	Sage Sparrow	-0.06	-0.652	0.464	-0.11	-1.036	0.780	-0.09	-0.645	0.482
SAVS	Savannah Sparrow	-0.36	-0.818	0.022	1.41	0.768	2.214	-0.12	-0.383	0.138
SOSP	Song Sparrow	-0.55	-1.004	-0.165	-0.08	-0.350	0.178	-0.59	-0.814	-0.357
SPTO	Spotted Towhee	-0.18	-0.640	0.206	-0.30	-0.618	0.029	-0.08	-0.293	0.127
SWTH	Swainson's Thrush	-0.06	-0.635	0.523	0.35	-0.559	1.325	-0.09	-0.621	0.445
TRBL	Tricolored Blackbird	-0.11	-0.643	0.325	0.14	-0.504	0.832	0.02	-0.520	0.561
TRES	Tree Swallow	-0.35	-0.729	-0.026	0.14	-0.150	0.438	-0.06	-0.236	0.098
WAVI	Warbling Vireo	0.23	-0.154	0.584	0.89	0.165	1.758	-0.15	-0.545	0.258
WBNU	White-breasted Nuthatch	-0.06	-0.489	0.331	0.11	-0.273	0.515	-0.03	-0.380	0.312
WCSP	White-crowned Sparrow	0.12	-0.206	0.523	1.69	1.042	2.509	-0.50	-0.732	-0.258
WEBL	Western Bluebird	0.03	-0.435	0.451	-0.13	-0.606	0.339	0.00	-0.408	0.391
WEKI	Western Kingbird	-0.13	-0.397	0.115	-0.28	-0.550	-0.030	0.03	-0.129	0.190
WEME	Western Meadowlark	-0.24	-0.558	0.037	0.31	0.050	0.573	-0.07	-0.224	0.084
WESJ	Western Scrub-Jay	0.11	-0.179	0.404	-0.27	-0.560	0.013	-0.35	-0.564	-0.127
WETA	Western Tanager	0.00	-0.497	0.490	0.82	0.032	1.732	-0.07	-0.529	0.392
WEWP	Western Wood-Pewee	-0.27	-0.844	0.193	0.19	-0.242	0.650	-0.04	-0.405	0.310
WIWA	Wilson's Warbler	0.30	-0.021	0.667	1.09	0.397	1.948	0.02	-0.326	0.360
WREN	Wrentit	0.00	-0.480	0.465	-0.44	-0.958	0.048	-0.12	-0.604	0.376
WTSW	White-throated Swift	-0.08	-0.680	0.461	0.35	-0.574	1.360	-0.11	-0.666	0.463

Species Code	Common Name	PSI (distance to water)			PSI (year)			P (max temperature)		
		Mean	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*	
YBCH	Yellow-breasted Chat	-0.14	-0.760	0.358	0.11	-0.669	0.943	-0.05	-0.602	0.503
YBMA	Yellow-billed Magpie	0.16	-0.269	0.619	-0.08	-0.582	0.428	-0.27	-0.780	0.202
YEWA	Yellow Warbler	0.01	-0.493	0.462	0.93	0.240	1.767	-0.06	-0.495	0.372
YHBL	Yellow-headed Blackbird	-0.41	-0.933	0.027	0.38	-0.065	0.873	0.07	-0.353	0.507
YRWA	Yellow-rumped Warbler	-0.13	-0.662	0.387	1.10	0.352	1.950	-0.51	-0.906	-0.140

Species Code	Common Name	P (Julian day)			P (Julian day^2)			P (Noise)		
		Mean	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*	
AMCR	American Crow	0.96	0.165	1.733	-0.63	-1.448	0.189	0.21	-0.045	0.469
AMGO	American Goldfinch	0.58	-0.260	1.397	-0.54	-1.329	0.285	0.06	-0.156	0.269
AMPI	American Pipit	0.25	-0.694	1.214	-1.63	-2.743	-0.654	-0.60	-0.952	-0.283
AMRO	American Robin	0.22	-0.558	0.936	-0.53	-1.275	0.260	-0.07	-0.222	0.085
ATFL	Ash-throated Flycatcher	1.53	0.647	2.549	-1.08	-1.984	-0.293	-0.06	-0.217	0.088
BANS	Bank Swallow	0.87	-0.323	2.105	-0.92	-2.149	0.263	-0.14	-0.656	0.390
BARS	Barn Swallow	1.09	0.179	2.025	-0.70	-1.600	0.189	0.10	-0.211	0.417
BESP	Bell's Sparrow	1.18	0.203	2.129	-0.75	-1.697	0.255	-0.03	-0.482	0.430
BEWR	Bewick's Wren	0.87	0.141	1.675	-1.17	-1.998	-0.424	-0.44	-0.625	-0.260
BGGN	Blue-gray Gnatcatcher	0.86	-0.274	2.045	-0.92	-2.113	0.189	-0.13	-0.663	0.424
BHCO	Brown-headed Cowbird	0.82	0.082	1.537	-0.81	-1.511	-0.084	-0.19	-0.317	-0.074
BHGR	Black-headed Grosbeak	1.77	0.873	2.817	-1.03	-1.968	-0.191	-0.54	-0.772	-0.321
BLGR	Blue Grosbeak	1.52	0.589	2.487	-0.52	-1.370	0.364	-0.10	-0.422	0.221
BLPH	Black Phoebe	0.60	-0.212	1.359	-0.70	-1.470	0.100	-0.14	-0.302	0.015
BRBL	Brewer's Blackbird	0.80	0.010	1.591	-0.75	-1.557	0.054	0.05	-0.119	0.217
BTYW	Black-throated Gray Warbler	0.80	-0.497	2.043	-1.05	-2.367	0.166	-0.20	-0.752	0.334
BUOR	Bullock's Oriole	0.78	-0.036	1.536	-0.65	-1.416	0.161	0.08	-0.076	0.234
BUSH	Bushtit	0.78	-0.007	1.570	-0.90	-1.737	-0.100	-0.38	-0.627	-0.151
CAKI	Cassin's Kingbird	1.39	0.122	2.765	-0.48	-1.646	0.804	-0.05	-0.576	0.473
CALT	California Towhee	1.35	0.602	2.189	-1.07	-1.890	-0.328	-0.19	-0.360	-0.018
CATH	California Thrasher	0.76	-0.300	1.805	-1.04	-2.134	-0.007	-0.15	-0.645	0.322
CAVI	Cassin's Vireo	0.90	-0.278	2.148	-0.93	-2.134	0.235	-0.15	-0.687	0.399
CEDW	Cedar Waxwing	1.03	-0.111	2.132	-0.90	-1.977	0.186	-0.20	-0.635	0.233
CHSP	Chipping Sparrow	0.87	-0.349	2.068	-0.95	-2.041	0.207	-0.14	-0.658	0.390

Species Code	Common Name	P (Julian day)			P (Julian day²)			P (Noise)		
		Mean	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*	
CLSW	Cliff Swallow	1.33	0.483	2.250	-0.96	-1.820	-0.142	-0.28	-0.473	-0.086
CORA	Common Raven	1.35	0.589	2.189	-1.09	-1.960	-0.303	-0.11	-0.290	0.075
COYE	Common Yellowthroat	1.09	0.279	1.937	-0.65	-1.472	0.161	-0.33	-0.518	-0.137
DEJU	Dark-eyed Junco	0.60	-0.418	1.596	-1.15	-2.223	-0.146	-0.18	-0.653	0.295
EUST	European Starling	1.01	0.257	1.792	-1.18	-1.982	-0.416	0.15	0.016	0.288
FOSP	Fox Sparrow	0.84	-0.323	2.047	-0.95	-2.137	0.207	-0.13	-0.653	0.407
GCSP	Golden-crowned Sparrow	0.20	-0.770	1.180	-1.64	-2.809	-0.588	-0.19	-0.498	0.121
GRSP	Grasshopper Sparrow	0.80	-0.478	2.053	-1.06	-2.305	0.109	-0.28	-0.840	0.251
GTGR	Great-tailed Grackle	0.84	-0.062	1.790	-1.11	-2.093	-0.199	-0.311	-0.738	0.095
HETH	Hermit Thrush	0.40	-0.765	1.438	-1.31	-2.511	-0.265	-0.075	-0.553	0.425
HOFI	House Finch	1.15	0.433	1.914	-1.42	-2.185	-0.685	0.070	-0.041	0.181
HOLA	Horned Lark	1.37	0.518	2.318	-1.19	-2.170	-0.370	-0.038	-0.198	0.114
HOSP	House Sparrow	1.29	0.400	2.255	-0.67	-1.561	0.152	0.211	-0.113	0.557
HOWR	House Wren	0.46	-0.324	1.212	-0.60	-1.367	0.169	0.077	-0.084	0.236
HUVI	Hutton's Vireo	1.12	0.143	2.208	-0.70	-1.797	0.381	-0.188	-0.733	0.330
LASP	Lark Sparrow	1.10	0.110	2.122	-0.88	-1.808	0.019	0.183	-0.220	0.607
LAZB	Lazuli Bunting	0.99	-0.011	2.005	-1.00	-2.090	0.001	-0.269	-0.697	0.151
LCTH	Le Conte's Thrasher	1.01	-0.244	2.385	-0.85	-2.201	0.469	-0.242	-0.821	0.308
LEGO	Lesser Goldfinch	0.87	0.040	1.712	-0.96	-1.857	-0.115	-0.334	-0.570	-0.099
LISP	Lincoln's Sparrow	0.46	-0.589	1.465	-1.25	-2.346	-0.265	-0.102	-0.549	0.340
LOSH	Loggerhead Shrike	0.80	-0.075	1.654	-0.61	-1.463	0.261	0.367	0.142	0.589
MAWR	Marsh Wren	1.43	0.584	2.390	-1.22	-2.207	-0.344	0.043	-0.186	0.275
MGWA	MacGillivray's Warbler	0.94	-0.210	2.143	-0.90	-2.043	0.251	-0.169	-0.698	0.368
NAWA	Nashville Warbler	0.85	-0.311	2.009	-0.97	-2.135	0.155	-0.110	-0.632	0.402
NOMO	Northern Mockingbird	1.25	0.482	2.015	-0.83	-1.623	-0.094	-0.022	-0.144	0.094
NRWS	Northern Rough-winged Swallow	1.14	0.244	2.080	-0.81	-1.784	0.097	-0.379	-0.848	0.096
OATI	Oak Titmouse	0.34	-0.628	1.140	-0.34	-1.178	0.670	-0.198	-0.423	0.025
OCWA	Orange-crowned Warbler	0.66	-0.204	1.554	-1.22	-2.247	-0.303	-0.062	-0.349	0.243
PHAI	Phainopepla	0.59	-0.463	1.656	-1.14	-2.276	-0.130	-0.126	-0.611	0.371
PSFL	Pacific-slope Flycatcher	0.23	-0.866	1.312	-1.42	-2.647	-0.383	-0.280	-0.844	0.242
PUFI	Purple Finch	0.97	-0.060	2.030	-0.83	-1.910	0.247	-0.223	-0.745	0.316
RCKI	Ruby-crowned Kinglet	0.40	-0.684	1.435	-1.31	-2.522	-0.281	-0.038	-0.523	0.462

Species Code	Common Name	P (Julian day)			P (Julian day²)			P (Noise)		
		Mean	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*	
RCSP	Rufous-crowned Sparrow	0.98	-0.328	2.347	-0.89	-2.222	0.337	-0.247	-0.800	0.289
ROWR	Rock Wren	1.12	0.066	2.334	-0.71	-1.816	0.437	-0.260	-0.774	0.226
RWBL	Red-winged Blackbird	0.02	-0.853	0.789	-0.05	-0.844	0.857	-0.147	-0.267	-0.027
SAGS	Sage Sparrow	0.86	-0.344	2.101	-0.96	-2.184	0.187	-0.104	-0.622	0.414
SAVS	Savannah Sparrow	0.59	-0.303	1.578	-1.90	-3.042	-0.835	-0.29	-0.537	-0.046
SOSP	Song Sparrow	0.69	-0.120	1.426	-0.41	-1.164	0.427	-0.51	-0.683	-0.354
SPTO	Spotted Towhee	1.20	0.462	2.006	-1.05	-1.876	-0.285	-0.20	-0.356	-0.047
SWTH	Swainson's Thrush	0.92	-0.256	2.153	-0.90	-2.123	0.290	-0.14	-0.673	0.383
TRBL	Tricolored Blackbird	1.39	0.424	2.433	-0.39	-1.315	0.643	-0.17	-0.688	0.349
TRES	Tree Swallow	0.76	-0.014	1.514	-0.72	-1.503	0.101	-0.09	-0.230	0.050
WAVI	Warbling Vireo	0.88	-0.119	1.914	-0.99	-2.000	0.018	-0.27	-0.730	0.178
WBNU	White-breasted Nuthatch	1.04	0.126	1.895	-0.42	-1.227	0.476	-0.23	-0.519	0.051
WCSP	White-crowned Sparrow	-0.16	-1.183	0.828	-2.14	-3.374	-0.968	-0.06	-0.259	0.122
WEBL	Western Bluebird	0.92	0.036	1.815	-0.69	-1.586	0.180	0.00	-0.436	0.408
WEKI	Western Kingbird	0.84	0.072	1.578	-0.67	-1.398	0.093	-0.25	-0.367	-0.136
WEME	Western Meadowlark	0.70	-0.041	1.409	-0.64	-1.359	0.124	0.09	-0.021	0.198
WESJ	Western Scrub-Jay	0.97	0.172	1.725	-0.48	-1.237	0.304	0.23	0.072	0.378
WETA	Western Tanager	1.08	0.040	2.162	-0.86	-1.882	0.180	-0.01	-0.444	0.429
WEWP	Western Wood-Pewee	1.63	0.701	2.664	-0.70	-1.643	0.133	-0.75	-1.092	-0.412
WIWA	Wilson's Warbler	0.58	-0.371	1.544	-1.30	-2.352	-0.390	-0.30	-0.729	0.104
WREN	Wrentit	0.59	-0.285	1.457	-1.13	-2.100	-0.196	0.01	-0.336	0.351
WTSW	White-throated Swift	0.91	-0.356	2.221	-0.91	-2.113	0.244	-0.13	-0.656	0.419
YBCH	Yellow-breasted Chat	0.66	-0.529	1.821	-1.19	-2.453	-0.126	0.11	-0.386	0.636
YBMA	Yellow-billed Magpie	1.41	0.499	2.403	-0.85	-1.860	0.056	-0.02	-0.332	0.300
YEWA	Yellow Warbler	1.07	-0.003	2.156	-0.89	-1.954	0.161	-0.07	-0.516	0.388
YHBL	Yellow-headed Blackbird	0.81	-0.091	1.718	-0.88	-1.811	0.021	0.13	-0.270	0.561
YRWA	Yellow-rumped Warbler	-0.04	-1.068	0.914	-1.64	-2.809	-0.609	-0.24	-0.610	0.111

Appendix S3b. Mean and 95% credible interval estimates for covariate effects on occupancy (PSI) and detection (P) for 84 songbird species in the Great Valley ecoregion of California, 2016-17. Results are based on model 2; covariate effects that do not overlap 0.0 are highlighted in yellow.

Species Code	Common Name	PSI (crop cover)			PSI (natural evenness)			PSI (agricultural evenness)		
		Mean	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*	
AMCR	American Crow	0.22	-0.089	0.543	0.38	0.070	0.708	0.36	0.068	0.653
AMGO	American Goldfinch	0.44	0.133	0.766	0.42	0.119	0.736	0.23	-0.028	0.514
AMPI	American Pipit	-0.17	-0.592	0.207	-0.64	-1.099	-0.197	0.17	-0.157	0.488
AMRO	American Robin	0.51	0.235	0.804	0.35	0.074	0.632	0.34	0.080	0.601
ATFL	Ash-throated Flycatcher	0.22	-0.083	0.513	0.71	0.432	1.012	-0.05	-0.315	0.208
BANS	Bank Swallow	0.11	-0.522	0.760	0.17	-0.673	0.981	0.19	-0.242	0.635
BARS	Barn Swallow	-0.09	-0.502	0.302	-0.34	-0.777	0.100	0.06	-0.272	0.398
BESP	Bell's Sparrow	-0.46	-1.025	0.038	0.08	-0.469	0.650	0.45	0.081	0.872
BEWR	Bewick's Wren	0.25	-0.048	0.556	0.89	0.573	1.211	0.35	0.090	0.627
BGGN	Blue-gray Gnatcatcher	0.11	-0.554	0.750	0.42	-0.378	1.264	0.15	-0.299	0.597
BHCO	Brown-headed Cowbird	0.31	0.028	0.613	0.81	0.513	1.142	-0.08	-0.349	0.186
BHGR	Black-headed Grosbeak	0.36	0.021	0.704	0.78	0.462	1.145	0.22	-0.077	0.518
BLGR	Blue Grosbeak	0.17	-0.223	0.548	0.41	0.041	0.813	0.16	-0.158	0.485
BLPH	Black Phoebe	0.38	0.100	0.667	0.26	-0.023	0.549	0.14	-0.120	0.385
BRBL	Brewer's Blackbird	0.15	-0.150	0.444	-0.13	-0.416	0.168	-0.06	-0.339	0.197
BTYW	Black-throated Gray Warbler	0.20	-0.425	0.852	0.39	-0.370	1.204	0.14	-0.288	0.569
BUOR	Bullock's Oriole	0.09	-0.186	0.378	0.27	0.009	0.534	0.27	0.021	0.513
BUSH	Bushtit	0.21	-0.119	0.543	0.48	0.155	0.814	0.21	-0.088	0.490
CAKI	Cassin's Kingbird	-0.13	-0.769	0.471	0.02	-0.747	0.735	0.10	-0.339	0.513
CALT	California Towhee	0.60	0.304	0.907	0.39	0.120	0.674	0.19	-0.079	0.458
CATH	California Thrasher	-0.12	-0.704	0.467	-0.08	-0.823	0.644	0.21	-0.206	0.631
CAVI	Cassin's Vireo	0.01	-0.634	0.660	0.12	-0.714	0.951	0.10	-0.335	0.535
CEDW	Cedar Waxwing	0.28	-0.208	0.798	0.20	-0.335	0.741	0.06	-0.351	0.450
CHSP	Chipping Sparrow	-0.07	-0.720	0.565	0.18	-0.575	0.952	-0.01	-0.466	0.400
CLSW	Cliff Swallow	-0.19	-0.539	0.169	-0.34	-0.702	0.035	-0.01	-0.324	0.281
CORA	Common Raven	-0.16	-0.447	0.125	-0.49	-0.790	-0.207	0.21	-0.041	0.461
COYE	Common Yellowthroat	-0.09	-0.399	0.208	0.51	0.230	0.805	-0.20	-0.489	0.076
DEJU	Dark-eyed Junco	0.17	-0.408	0.736	0.06	-0.677	0.739	0.16	-0.246	0.589
EUST	European Starling	0.33	0.037	0.615	0.65	0.370	0.945	0.21	-0.042	0.465
FOSP	Fox Sparrow	0.10	-0.587	0.774	-0.04	-0.881	0.790	0.17	-0.259	0.615
GCSP	Golden-crowned Sparrow	0.49	0.075	0.937	0.03	-0.433	0.457	0.16	-0.184	0.510

Species Code	Common Name	PSI (crop cover)			PSI (natural evenness)			PSI (agricultural evenness)		
		Mean	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*	
GRSP	Grasshopper Sparrow	-0.20	-0.820	0.372	0.05	-0.386	0.486	0.01	-0.406	0.404
GTGR	Great-tailed Grackle	0.05	-0.386	0.458	0.08	-0.564	0.742	0.11	-0.242	0.455
HETH	Hermit Thrush	0.36	-0.197	0.952	0.21	-0.063	0.483	0.23	-0.173	0.659
HOFI	House Finch	0.34	0.069	0.617	-0.80	-1.186	-0.460	0.34	0.095	0.596
HOLA	Horned Lark	-0.37	-0.680	-0.053	-0.11	-0.479	0.247	-0.10	-0.378	0.172
HOSP	House Sparrow	0.19	-0.157	0.544	0.69	0.407	0.966	0.16	-0.143	0.458
HOWR	House Wren	0.31	0.014	0.607	0.50	-0.243	1.256	0.33	0.069	0.593
HUVI	Hutton's Vireo	0.03	-0.561	0.624	-0.11	-0.620	0.354	0.16	-0.262	0.604
LASP	Lark Sparrow	0.16	-0.295	0.642	0.44	-0.095	0.985	0.21	-0.140	0.593
LAZB	Lazuli Bunting	0.26	-0.228	0.745	0.04	-0.745	0.796	0.00	-0.395	0.357
LCTH	Le Conte's Thrasher	-0.14	-0.785	0.480	0.58	0.221	0.970	0.06	-0.362	0.480
LEGO	Lesser Goldfinch	0.28	-0.072	0.659	-0.30	-0.943	0.319	0.26	-0.044	0.565
LISP	Lincoln's Sparrow	0.21	-0.321	0.753	-0.45	-0.812	-0.094	0.07	-0.328	0.450
LOSH	Loggerhead Shrike	-0.49	-0.861	-0.146	0.48	0.152	0.794	0.25	-0.035	0.533
MAWR	Marsh Wren	-0.32	-0.648	0.020	0.36	-0.392	1.134	-0.22	-0.524	0.052
MGWA	MacGillivray's Warbler	0.14	-0.480	0.759	0.35	-0.485	1.159	0.10	-0.337	0.508
NAWA	Nashville Warbler	0.17	-0.474	0.822	-0.23	-0.497	0.007	0.15	-0.288	0.582
NOMO	Northern Mockingbird	0.04	-0.222	0.310	0.16	-0.274	0.592	0.12	-0.116	0.347
NRWS	Northern Rough-winged Swallow	-0.04	-0.483	0.395	0.63	0.275	1.006	0.21	-0.131	0.562
OATI	Oak Titmouse	0.37	0.008	0.749	0.07	-0.383	0.534	0.33	0.027	0.653
OCWA	Orange-crowned Warbler	0.12	-0.313	0.526	0.22	-0.489	0.891	0.12	-0.204	0.462
PHAI	Phainopepla	-0.18	-0.799	0.387	0.11	-0.565	0.778	0.03	-0.402	0.435
PSFL	Pacific-slope Flycatcher	0.35	-0.218	0.951	0.22	-0.520	0.988	0.13	-0.284	0.559
PUFI	Purple Finch	0.09	-0.525	0.693	0.60	-0.053	1.252	0.24	-0.172	0.682
RCKI	Ruby-crowned Kinglet	0.38	-0.187	0.964	0.39	-0.371	1.209	0.20	-0.218	0.605
RCSP	Rufous-crowned Sparrow	-0.02	-0.667	0.609	-0.11	-0.882	0.655	0.05	-0.388	0.463
ROWR	Rock Wren	0.07	-0.534	0.663	0.09	-0.171	0.344	0.03	-0.404	0.443
RWBL	Red-winged Blackbird	0.03	-0.243	0.296	-0.05	-0.868	0.766	0.01	-0.230	0.255
SAGS	Sage Sparrow	0.16	-0.485	0.842	-0.61	-0.979	-0.240	0.17	-0.254	0.602
SAVS	Savannah Sparrow	0.04	-0.317	0.379	0.66	0.392	0.928	0.07	-0.228	0.358
SOSP	Song Sparrow	-0.18	-0.472	0.105	0.87	0.569	1.176	0.03	-0.227	0.280
SPTO	Spotted Towhee	0.27	-0.039	0.586	0.26	-0.564	1.105	0.31	0.038	0.593
SWTH	Swainson's Thrush	0.04	-0.647	0.695	0.10	-0.542	0.717	0.17	-0.281	0.616
TRBL	Tricolored Blackbird	-0.16	-0.712	0.372	0.73	0.463	1.016	0.14	-0.247	0.535
TRES	Tree Swallow	0.18	-0.103	0.458	0.21	-0.331	0.729	0.18	-0.066	0.425
WAVI	Warbling Vireo	0.32	-0.144	0.808	0.21	-0.331	0.729	0.15	-0.225	0.516

Species Code	Common Name	PSI (crop cover)			PSI (natural evenness)			PSI (agricultural evenness)		
		Mean	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*	
WBNU	White-breasted Nuthatch	0.08	-0.286	0.454	0.30	-0.085	0.674	0.12	-0.184	0.427
WCSP	White-crowned Sparrow	0.40	0.001	0.794	0.23	-0.170	0.663	0.38	0.061	0.718
WEBL	Western Bluebird	0.41	-0.020	0.869	0.68	0.224	1.168	0.15	-0.214	0.530
WEKI	Western Kingbird	0.02	-0.252	0.278	0.08	-0.167	0.340	0.19	-0.049	0.423
WEME	Western Meadowlark	-0.75	-1.052	-0.454	-0.56	-0.867	-0.276	-0.34	-0.634	-0.061
WESJ	Western Scrub-Jay	0.42	0.110	0.715	0.47	0.182	0.759	0.17	-0.077	0.434
WETA	Western Tanager	0.27	-0.239	0.835	0.23	-0.337	0.813	0.04	-0.368	0.424
WEWP	Western Wood-Pewee	0.09	-0.334	0.523	0.81	0.371	1.294	0.27	-0.058	0.624
WIWA	Wilson's Warbler	0.06	-0.359	0.471	0.28	-0.139	0.727	0.07	-0.260	0.385
WREN	Wrentit	0.12	-0.367	0.596	0.97	0.416	1.550	0.39	0.006	0.791
WTSW	White-throated Swift	0.10	-0.547	0.718	0.27	-0.539	1.150	0.13	-0.321	0.557
YBCH	Yellow-breasted Chat	-0.18	-0.808	0.424	0.35	-0.367	1.092	0.09	-0.327	0.500
YBMA	Yellow-billed Magpie	0.23	-0.250	0.687	-0.08	-0.597	0.423	0.22	-0.144	0.610
YEWA	Yellow Warbler	-0.09	-0.573	0.413	0.67	0.136	1.210	-0.03	-0.410	0.329
YHBL	Yellow-headed Blackbird	-0.42	-0.849	0.001	0.32	-0.100	0.750	0.26	-0.058	0.594
YRWA	Yellow-rumped Warbler	0.63	0.133	1.137	-0.02	-0.510	0.472	0.19	-0.180	0.569

Species Code	Common Name	PSI (distance to urban)			PSI (year)			P (max temperature)		
		Mean	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*	
AMCR	American Crow	-0.30	-0.580	-0.027	0.17	-0.142	0.503	-0.04	-0.463	0.334
AMGO	American Goldfinch	-0.34	-0.623	-0.081	0.10	-0.182	0.394	0.28	-0.085	0.664
AMPI	American Pipit	0.17	-0.141	0.496	1.16	0.502	1.978	0.15	-0.242	0.558
AMRO	American Robin	-0.33	-0.585	-0.082	0.20	-0.076	0.473	0.09	-0.240	0.400
ATFL	Ash-throated Flycatcher	-0.02	-0.271	0.214	-0.24	-0.501	0.017	0.14	-0.221	0.504
BANS	Bank Swallow	-0.11	-0.552	0.323	0.34	-0.569	1.319	0.18	-0.343	0.671
BARS	Barn Swallow	-0.12	-0.458	0.206	-0.22	-0.745	0.260	0.13	-0.339	0.572
BESP	Bell’s Sparrow	-0.18	-0.583	0.183	0.76	0.096	1.553	0.02	-0.522	0.506
BEWR	Bewick's Wren	-0.03	-0.288	0.212	-0.13	-0.401	0.160	0.36	0.018	0.731
BGGN	Blue-gray Gnatcatcher	-0.09	-0.532	0.355	0.34	-0.587	1.304	0.17	-0.319	0.693
BHCO	Brown-headed Cowbird	-0.09	-0.342	0.157	0.01	-0.280	0.290	0.33	0.015	0.675
BHGR	Black-headed Grosbeak	0.08	-0.187	0.346	-0.22	-0.542	0.085	0.35	-0.003	0.734
BLGR	Blue Grosbeak	0.13	-0.160	0.432	-0.13	-0.510	0.238	0.28	-0.096	0.723
BLPH	Black Phoebe	-0.22	-0.474	0.030	-0.04	-0.328	0.235	0.20	-0.122	0.525
BRBL	Brewer's Blackbird	0.03	-0.217	0.288	0.11	-0.180	0.380	0.05	-0.311	0.408

Species Code	Common Name	PSI (distance to urban)			PSI (year)			P (max temperature)		
		Mean	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*	
BTYW	Black-throated Gray Warbler	-0.11	-0.556	0.320	0.34	-0.531	1.332	0.25	-0.235	0.791
BUOR	Bullock's Oriole	0.01	-0.220	0.248	0.11	-0.142	0.366	0.29	-0.055	0.647
BUSH	Bushtit	-0.24	-0.524	0.030	-0.18	-0.482	0.147	0.18	-0.185	0.540
CAKI	Cassin's Kingbird	0.03	-0.373	0.469	0.40	-0.420	1.267	0.14	-0.362	0.617
CALT	California Towhee	-0.04	-0.299	0.207	-0.03	-0.299	0.243	0.37	0.023	0.743
CATH	California Thrasher	-0.09	-0.519	0.336	0.21	-0.539	1.025	0.12	-0.364	0.603
CAVI	Cassin's Vireo	-0.10	-0.563	0.342	0.35	-0.578	1.355	0.17	-0.340	0.686
CEDW	Cedar Waxwing	0.01	-0.360	0.387	0.84	0.103	1.687	0.24	-0.179	0.704
CHSP	Chipping Sparrow	-0.07	-0.501	0.358	0.44	-0.428	1.456	0.17	-0.330	0.668
CLSW	Cliff Swallow	0.07	-0.207	0.345	-0.39	-0.766	-0.044	0.37	-0.018	0.824
CORA	Common Raven	-0.01	-0.257	0.242	-0.19	-0.485	0.097	0.20	-0.139	0.554
COYE	Common Yellowthroat	0.13	-0.106	0.382	0.16	-0.114	0.434	-0.02	-0.393	0.335
DEJU	Dark-eyed Junco	-0.21	-0.650	0.188	0.61	-0.180	1.568	0.14	-0.353	0.638
EUST	European Starling	-0.21	-0.462	0.033	-0.10	-0.369	0.167	0.20	-0.114	0.529
FOSP	Fox Sparrow	-0.12	-0.567	0.318	0.35	-0.563	1.335	0.17	-0.313	0.677
GCSP	Golden-crowned Sparrow	-0.30	-0.655	0.035	1.15	0.473	2.012	0.13	-0.287	0.540
GRSP	Grasshopper Sparrow	0.04	-0.352	0.470	0.52	-0.284	1.383	0.27	-0.214	0.804
GTGR	Great-tailed Grackle	-0.14	-0.486	0.189	0.18	-0.279	0.666	0.33	-0.104	0.812
HETH	Hermit Thrush	-0.24	-0.676	0.144	0.63	-0.129	1.542	-0.01	-0.554	0.444
HOFI	House Finch	-0.16	-0.391	0.062	-0.12	-0.387	0.153	0.47	0.148	0.830
HOLA	Horned Lark	0.21	-0.058	0.474	-0.15	-0.449	0.150	0.00	-0.402	0.365
HOSP	House Sparrow	-0.01	-0.310	0.286	0.22	-0.157	0.621	0.15	-0.242	0.554
HOWR	House Wren	-0.21	-0.471	0.043	-0.02	-0.296	0.251	0.05	-0.300	0.391
HUVI	Hutton's Vireo	-0.11	-0.550	0.300	0.15	-0.603	0.952	0.14	-0.387	0.642
LASP	Lark Sparrow	-0.12	-0.490	0.218	0.03	-0.462	0.547	0.33	-0.090	0.820
LAZB	Lazuli Bunting	-0.01	-0.371	0.375	0.28	-0.330	0.907	0.32	-0.091	0.817
LCTH	Le Conte's Thrasher	-0.16	-0.611	0.257	0.41	-0.380	1.353	0.10	-0.420	0.596
LEGO	Lesser Goldfinch	-0.12	-0.419	0.171	0.24	-0.156	0.649	0.31	-0.065	0.722
LISP	Lincoln's Sparrow	0.09	-0.298	0.511	0.72	-0.093	1.634	-0.01	-0.494	0.434
LOSH	Loggerhead Shrike	-0.05	-0.349	0.234	-0.25	-0.573	0.077	0.29	-0.120	0.725
MAWR	Marsh Wren	0.08	-0.158	0.343	0.02	-0.265	0.299	0.28	-0.077	0.688
MGWA	MacGillivray's Warbler	-0.05	-0.496	0.359	0.53	-0.279	1.495	0.19	-0.290	0.686
NAWA	Nashville Warbler	-0.10	-0.536	0.328	0.34	-0.544	1.302	0.16	-0.331	0.680

Species Code	Common Name	PSI (distance to urban)			PSI (year)			P (max temperature)		
		Mean	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*	
NOMO	Northern Mockingbird	-0.08	-0.299	0.135	0.05	-0.196	0.292	0.21	-0.091	0.551
NRWS	Northern Rough-winged Swallow	-0.12	-0.472	0.222	0.33	-0.163	0.851	0.19	-0.237	0.637
OATI	Oak Titmouse	0.00	-0.305	0.284	-0.08	-0.414	0.280	0.05	-0.339	0.416
OCWA	Orange-crowned Warbler	-0.22	-0.584	0.106	-0.01	-0.511	0.482	-0.06	-0.543	0.368
PHAI	Phainopepla	-0.08	-0.495	0.325	0.21	-0.530	1.016	0.20	-0.264	0.660
PSFL	Pacific-slope Flycatcher	-0.16	-0.585	0.227	0.51	-0.236	1.400	-0.07	-0.623	0.380
PUFI	Purple Finch	-0.14	-0.556	0.269	0.52	-0.298	1.492	0.22	-0.257	0.733
RCKI	Ruby-crowned Kinglet	-0.09	-0.513	0.308	0.64	-0.136	1.563	0.00	-0.507	0.423
RCSP	Rufous-crowned Sparrow	0.04	-0.378	0.495	0.29	-0.549	1.218	0.10	-0.440	0.587
ROWR	Rock Wren	0.01	-0.411	0.452	-0.32	-1.178	0.514	0.18	-0.317	0.694
RWBL	Red-winged Blackbird	0.04	-0.182	0.269	0.27	0.027	0.515	0.16	-0.168	0.487
SAGS	Sage Sparrow	-0.07	-0.533	0.383	-0.11	-1.036	0.795	0.17	-0.323	0.660
SAVS	Savannah Sparrow	0.28	-0.010	0.592	1.39	0.794	2.144	0.24	-0.122	0.639
SOSP	Song Sparrow	0.11	-0.117	0.356	-0.07	-0.336	0.194	-0.15	-0.568	0.233
SPTO	Spotted Towhee	-0.27	-0.551	-0.016	-0.24	-0.523	0.034	0.31	-0.018	0.704
SWTH	Swainson's Thrush	-0.12	-0.585	0.306	0.34	-0.547	1.305	0.19	-0.302	0.718
TRBL	Tricolored Blackbird	0.05	-0.324	0.437	0.14	-0.479	0.815	0.28	-0.212	0.836
TRES	Tree Swallow	-0.15	-0.383	0.089	0.10	-0.155	0.356	0.19	-0.139	0.518
WAVI	Warbling Vireo	-0.03	-0.413	0.332	0.88	0.169	1.776	0.14	-0.296	0.562
WBNU	White-breasted Nuthatch	-0.14	-0.453	0.150	0.12	-0.249	0.521	0.20	-0.177	0.608
WCSP	White-crowned Sparrow	-0.27	-0.591	0.042	1.64	1.036	2.399	0.02	-0.381	0.417
WEBL	Western Bluebird	-0.28	-0.670	0.067	-0.09	-0.554	0.385	0.24	-0.173	0.664
WEKI	Western Kingbird	-0.01	-0.240	0.210	-0.25	-0.502	-0.001	0.12	-0.180	0.436
WEME	Western Meadowlark	0.12	-0.130	0.379	0.33	0.059	0.599	-0.04	-0.387	0.271
WESJ	Western Scrub-Jay	-0.40	-0.673	-0.137	-0.21	-0.473	0.054	-0.03	-0.400	0.323
WETA	Western Tanager	0.12	-0.268	0.527	0.79	0.043	1.667	0.20	-0.225	0.650
WEWP	Western Wood-Pewee	0.14	-0.173	0.468	0.12	-0.305	0.539	0.18	-0.241	0.589
WIWA	Wilson's Warbler	-0.04	-0.347	0.271	1.06	0.410	1.875	0.28	-0.117	0.683
WREN	Wrentit	-0.22	-0.624	0.144	-0.41	-0.923	0.075	0.16	-0.317	0.631
WTSW	White-throated Swift	0.01	-0.433	0.442	0.32	-0.522	1.299	0.17	-0.353	0.692

Species Code	Common Name	PSI (distance to urban)			PSI (year)			P (max temperature)		
		Mean	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*	
YBCH	Yellow-breasted Chat	-0.06	-0.475	0.339	0.12	-0.622	0.906	0.22	-0.248	0.732
YBMA	Yellow-billed Magpie	-0.21	-0.604	0.157	-0.08	-0.579	0.432	0.11	-0.370	0.569
YEWA	Yellow Warbler	-0.01	-0.359	0.339	0.87	0.191	1.686	0.20	-0.239	0.629
YHBL	Yellow-headed Blackbird	0.22	-0.103	0.553	0.35	-0.078	0.812	0.28	-0.166	0.770
YRWA	Yellow-rumped Warbler	-0.32	-0.715	0.033	1.09	0.371	1.952	-0.06	-0.528	0.372

Species Code	Common Name	P (Julian day)			P (temp * JD)			P (Noise)		
		Mean	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*	
AMCR	American Crow	0.60	0.208	1.014	-0.53	-1.167	0.108	0.17	-0.078	0.432
AMGO	American Goldfinch	0.25	-0.200	0.687	-0.39	-1.028	0.264	0.05	-0.164	0.273
AMPI	American Pipit	-0.43	-1.155	0.275	-0.98	-1.833	-0.216	-0.58	-0.915	-0.268
AMRO	American Robin	-0.11	-0.498	0.263	-0.38	-0.975	0.250	-0.08	-0.231	0.069
ATFL	Ash-throated Flycatcher	0.69	0.255	1.142	-0.69	-1.314	-0.082	-0.05	-0.197	0.095
BANS	Bank Swallow	0.32	-0.718	1.284	-0.58	-1.557	0.345	-0.14	-0.666	0.366
BARS	Barn Swallow	0.69	0.098	1.339	-0.67	-1.445	0.050	0.06	-0.254	0.390
BESP	Bell's Sparrow	0.71	-0.028	1.488	-0.80	-1.710	0.078	-0.03	-0.465	0.437
BEWR	Bewick's Wren	0.08	-0.310	0.476	-0.63	-1.271	-0.031	-0.46	-0.647	-0.277
BGGN	Blue-gray Gnatcatcher	0.29	-0.713	1.315	-0.59	-1.540	0.296	-0.13	-0.650	0.417
BHCO	Brown-headed Cowbird	0.10	-0.276	0.460	-0.18	-0.785	0.422	-0.19	-0.314	-0.074
BHGR	Black-headed Grosbeak	0.97	0.465	1.491	-0.51	-1.167	0.108	-0.55	-0.773	-0.331
BLGR	Blue Grosbeak	1.01	0.440	1.582	-0.21	-0.888	0.438	-0.09	-0.405	0.203
BLPH	Black Phoebe	0.16	-0.270	0.582	-0.43	-1.070	0.182	-0.14	-0.303	0.014
BRBL	Brewer's Blackbird	0.51	0.077	0.946	-0.79	-1.434	-0.137	0.04	-0.133	0.206
BTYW	Black-throated Gray Warbler	0.24	-0.872	1.334	-0.48	-1.471	0.536	-0.21	-0.748	0.307
BUOR	Bullock's Oriole	0.23	-0.188	0.636	-0.17	-0.795	0.471	0.07	-0.078	0.223
BUSH	Bushtit	0.18	-0.273	0.649	-0.51	-1.162	0.112	-0.38	-0.630	-0.138
CAKI	Cassin's Kingbird	0.79	-0.254	1.872	-0.50	-1.505	0.430	-0.07	-0.592	0.473
CALT	California Towhee	0.61	0.211	1.037	-0.58	-1.226	0.030	-0.19	-0.356	-0.025
CATH	California Thrasher	0.23	-0.665	1.118	-0.69	-1.623	0.166	-0.14	-0.627	0.344
CAVI	Cassin's Vireo	0.33	-0.727	1.349	-0.57	-1.494	0.378	-0.14	-0.664	0.376
CEDW	Cedar Waxwing	0.42	-0.498	1.304	-0.46	-1.328	0.376	-0.20	-0.642	0.222
CHSP	Chipping Sparrow	0.29	-0.683	1.293	-0.58	-1.483	0.357	-0.13	-0.628	0.379

Species Code	Common Name	P (Julian day)			P (temp * JD)			P (Noise)		
		Mean	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*	
CLSW	Cliff Swallow	0.57	0.040	1.103	-0.42	-1.074	0.190	-0.28	-0.473	-0.087
CORA	Common Raven	0.76	0.328	1.217	-0.88	-1.555	-0.298	-0.11	-0.288	0.077
COYE	Common Yellowthroat	0.85	0.431	1.304	-0.85	-1.487	-0.214	-0.32	-0.509	-0.123
DEJU	Dark-eyed Junco	0.11	-0.791	1.021	-0.74	-1.677	0.109	-0.18	-0.646	0.258
EUST	European Starling	0.17	-0.216	0.568	-0.50	-1.150	0.098	0.14	0.004	0.272
FOSP	Fox Sparrow	0.31	-0.731	1.304	-0.60	-1.539	0.305	-0.13	-0.659	0.394
GCSP	Golden-crowned Sparrow	-0.46	-1.176	0.255	-0.94	-1.797	-0.197	-0.18	-0.504	0.122
GRSP	Grasshopper Sparrow	0.20	-0.840	1.257	-0.48	-1.398	0.466	-0.26	-0.805	0.258
GTGR	Great-tailed Grackle	0.10	-0.583	0.750	-0.45	-1.204	0.297	-0.308	-0.721	0.085
HETH	Hermit Thrush	-0.03	-0.980	0.917	-0.97	-1.970	-0.135	-0.094	-0.586	0.390
HOFI	House Finch	0.09	-0.235	0.447	-0.57	-1.208	-0.012	0.061	-0.053	0.172
HOLA	Horned Lark	0.68	0.227	1.173	-0.86	-1.493	-0.240	-0.033	-0.182	0.109
HOSP	House Sparrow	0.81	0.204	1.436	-0.45	-1.111	0.179	0.222	-0.095	0.559
HOWR	House Wren	0.08	-0.314	0.468	-0.39	-0.993	0.234	0.070	-0.087	0.229
HUVI	Hutton's Vireo	0.58	-0.247	1.462	-0.56	-1.488	0.380	-0.177	-0.680	0.345
LASP	Lark Sparrow	0.39	-0.393	1.172	-0.31	-1.031	0.446	0.161	-0.225	0.569
LAZB	Lazuli Bunting	0.31	-0.458	1.062	-0.40	-1.249	0.465	-0.260	-0.672	0.155
LCTH	Le Conte's Thrasher	0.40	-0.670	1.579	-0.68	-1.725	0.275	-0.238	-0.790	0.292
LEGO	Lesser Goldfinch	0.23	-0.258	0.734	-0.49	-1.222	0.209	-0.335	-0.571	-0.101
LISP	Lincoln's Sparrow	0.03	-0.811	0.890	-0.96	-1.909	-0.148	-0.102	-0.538	0.331
LOSH	Loggerhead Shrike	0.12	-0.373	0.629	-0.02	-0.641	0.587	0.344	0.126	0.557
MAWR	Marsh Wren	0.55	0.093	1.009	-0.55	-1.210	0.077	0.032	-0.200	0.271
MGWA	MacGillivray's Warbler	0.34	-0.668	1.337	-0.52	-1.488	0.374	-0.165	-0.667	0.349
NAWA	Nashville Warbler	0.30	-0.698	1.307	-0.61	-1.542	0.269	-0.114	-0.640	0.422
NOMO	Northern Mockingbird	0.78	0.407	1.165	-0.65	-1.274	-0.058	-0.018	-0.134	0.104
NRWS	Northern Rough-winged Swallow	0.61	-0.078	1.301	-0.55	-1.328	0.191	-0.342	-0.826	0.113
OATI	Oak Titmouse	0.17	-0.338	0.640	-0.34	-1.006	0.375	-0.199	-0.421	0.019
OCWA	Orange-crowned Warbler	0.10	-0.486	0.722	-1.05	-1.906	-0.269	-0.049	-0.345	0.253
PHAI	Phainopepla	0.05	-0.823	0.932	-0.68	-1.574	0.161	-0.108	-0.594	0.379
PSFL	Pacific-slope Flycatcher	-0.17	-1.222	0.743	-1.13	-2.077	-0.326	-0.300	-0.831	0.214
PUFI	Purple Finch	0.39	-0.493	1.283	-0.46	-1.335	0.422	-0.205	-0.715	0.300

Species Code	Common Name	P (Julian day)			P (temp * JD)			P (Noise)		
		Mean	*95% CI*		*Mean*	*95% CI*		*Mean*	*95% CI*	
RCKI	Ruby-crowned Kinglet	-0.06	-0.935	0.834	-0.99	-1.934	-0.162	-0.048	-0.526	0.432
RCSP	Rufous-crowned Sparrow	0.38	-0.708	1.517	-0.73	-1.811	0.217	-0.272	-0.831	0.250
ROWR	Rock Wren	0.49	-0.484	1.516	-0.49	-1.443	0.454	-0.284	-0.779	0.183
RWBL	Red-winged Blackbird	-0.15	-0.527	0.198	0.20	-0.406	0.827	-0.152	-0.267	-0.037
SAGS	Sage Sparrow	0.29	-0.679	1.307	-0.58	-1.556	0.370	-0.107	-0.632	0.415
SAVS	Savannah Sparrow	-0.22	-0.866	0.541	-1.04	-1.908	-0.286	-0.28	-0.530	-0.027
SOSP	Song Sparrow	0.67	0.256	1.090	-0.77	-1.437	-0.100	-0.51	-0.680	-0.348
SPTO	Spotted Towhee	0.62	0.239	1.032	-0.82	-1.484	-0.236	-0.21	-0.358	-0.056
SWTH	Swainson's Thrush	0.33	-0.709	1.329	-0.54	-1.529	0.359	-0.16	-0.671	0.365
TRBL	Tricolored Blackbird	0.84	0.074	1.625	-0.10	-0.898	0.767	-0.17	-0.690	0.336
TRES	Tree Swallow	0.34	-0.007	0.709	-0.51	-1.106	0.107	-0.08	-0.218	0.054
WAVI	Warbling Vireo	0.34	-0.477	1.135	-0.63	-1.413	0.136	-0.29	-0.720	0.151
WBNU	White-breasted Nuthatch	0.74	0.220	1.261	-0.34	-1.054	0.329	-0.24	-0.513	0.040
WCSP	White-crowned Sparrow	-1.08	-1.666	-0.467	-1.41	-2.339	-0.583	-0.06	-0.262	0.124
WEBL	Western Bluebird	0.43	-0.163	1.042	-0.43	-1.162	0.299	-0.01	-0.439	0.411
WEKI	Western Kingbird	0.22	-0.130	0.581	-0.13	-0.671	0.419	-0.26	-0.375	-0.146
WEME	Western Meadowlark	0.06	-0.322	0.394	-0.01	-0.560	0.600	0.08	-0.021	0.193
WESJ	Western Scrub-Jay	0.77	0.343	1.190	-0.57	-1.222	0.078	0.23	0.069	0.380
WETA	Western Tanager	0.49	-0.313	1.311	-0.50	-1.330	0.331	-0.01	-0.415	0.429
WEWP	Western Wood-Pewee	1.08	0.469	1.708	-0.51	-1.227	0.162	-0.69	-1.020	-0.377
WIWA	Wilson's Warbler	-0.21	-0.929	0.504	-0.63	-1.411	0.132	-0.27	-0.680	0.114
WREN	Wrentit	0.00	-0.623	0.623	-0.79	-1.644	-0.003	-0.01	-0.337	0.344
WTSW	White-throated Swift	0.36	-0.677	1.382	-0.57	-1.542	0.396	-0.14	-0.663	0.404
YBCH	Yellow-breasted Chat	0.08	-0.926	1.062	-0.59	-1.522	0.339	0.13	-0.342	0.639
YBMA	Yellow-billed Magpie	0.94	0.172	1.714	-0.73	-1.510	-0.031	-0.03	-0.356	0.296
YEWA	Yellow Warbler	0.37	-0.518	1.252	-0.58	-1.422	0.265	-0.05	-0.486	0.407
YHBL	Yellow-headed Blackbird	0.16	-0.510	0.820	-0.41	-1.159	0.359	0.16	-0.233	0.573
YRWA	Yellow-rumped Warbler	-0.52	-1.324	0.212	-1.26	-2.241	-0.410	-0.23	-0.595	0.114