Shrub Composition and Bird Habitat Suitability in UCR's Southern California Chaparral Reserves

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ABSTRACT

The intricate dynamics between vegetation coverage, fire regimes, and habitat suitability heavily influence the resilience and stability of chaparral ecosystems. In this study, I investigate the relationship between shrub coverage and habitat suitability for chaparral-requiring bird species across different fire regimes in chaparral ecosystems. I conducted plot transects and used E-bird and Merlin to assess bird diversity at three University of California Riverside Reserves — Emerson Oaks, Motte Rimrock, and Box Springs, known for their chaparral and coastal sage scrub. I hypothesized that areas with denser shrub coverage exhibit higher fuel moisture and support a greater diversity of bird species. Conversely, I expected areas with fewer shrubs and lower fuel moisture content to host smaller bird populations. However, the findings indicated no significant correlation between fire regimes and shrub coverage, thus challenging my initial hypotheses. Through comparative analysis of "soft chaparral" at Motte Rimrock, "hard chaparral" at Emerson, and the mixed-use vegetation at Box Springs, I observed notable variations in shrub diversity. I found a positive correlation between bird species diversity and native shrub coverage. Also, the varying fire regimes with different fuel moisture contents significantly impacted shrub coverage. These results suggest a relationship between the diversity of shrub habitats and chaparral-requiring bird species. Therefore, fire regimes appear to have a significant effect, supporting previous research.

KEYWORDS

E-Bird/Merlin, bird species diversity, costal-sage scrub, fire regimes, fuel-moisture content

INTRODUCTION

California chaparral biome is the state's most extensive and distributed ecosystem within every county except Sacramento (Chaparral Institute. 2022). California's unique Mediterranean climate, one of the five Mediterranean-climate ecosystems in the world, is characterized by hot, dry summers and mild, wet winters. Historically, most shrubland ecosystems worldwide have been misunderstood and understudied (Calhoun et al. 2021). The chaparral continues to experience, including, but not limited to, extensive periods of drought, human activities and interactions, irregular rains, and frequent fires, making it vulnerable to short-interval fire that causes type conversion (Meng et al. 2014, Storey et al. 2021).

The most common type of vegetation type conversion (VTC) is native woody/soft shrublands becoming converted to invasive annual grasslands (Underwood et al. 2018). Traditionally, indigenous Californians depended on and stewarded fire on the chaparral, which benefited its mosaic medium-interval fire ecosystem (Anderson and Keeley. 2018). Post-colonization, humans have aided in the encroachment of exotics and non-natives in the chaparral. Millennia fire suppression across the state has altered historical fire patterns, leading to the chaparral experiencing fires more often or beyond its typical fire cycle of 30-90 years, with a historical mean interval of 55 years. If frequent fire or complete stand removal occurs, the thriving chaparral can easily be replaced with invasive grass and will likely not recover or return to its original chaparral form (Anderson and Keeley et al. 2018). Thus, it's crucial to understand the habitat composition and suitability of the chaparral to understand its vulnerability to abiotic and biotic factors to prevent complete type conversion post-fire.

Despite the chaparral being adapted to fire recurrence and stand removal, the frequency of wildfires has increased and has burned in unnaturally large patterns compared to the past. (Sugihara et al. 2019) These foreign plants and grasses have drastically changed the properties of the soil, which then affects the chaparral recovery system (Flory and Clay 2010). Irregular fire regimes have also threatened Chaparral's fire seed-based regeneration, critical for fire-required obligate and facultative seeders. Intense or frequent fires impede the growth cycle of species like Buckbrush (obligate seeder/fire-germininator) and California Scrub Oak (obligate sprouted/fire resprouter), as well as Chamise, a dominant facultative seeder (both a fire germinator and resprouter), by damaging seeds causing senescence conditions that alter the soil conditions, thereby risking the ecosystem's renewal process (Rundel et al. 1987). Determining shrub composition and vulnerability to fire is crucial for understanding fire risk and, thus, type-conversion risk post-fire.

Quantifying habitat suitability in the chaparral is challenging due to the overlap of several species with other ecosystems in California (Woolet et al. 2023). Certain granivores, including small mammals, birds, and other species, are specifically adapted to the chaparral environment (Woolet et al. 2023). The composition of bird species serves as a more accessible indicator for assessing habitat suitability in these areas. Bird species known to be obligate residents of the chaparral have experienced population declines as their preferred habitat becomes less available or entirely disappears (Woolet et al. 2023). The California Thrasher is a chaparral-requiring bird that lives and relies on dense chaparral for cover and foraging; when chaparral becomes type converted into grasslands, their specific habitat disappears entirely (Keeley et al. 2022). Loss of native plant species has also been known to affect the seed and insect populations that many bird species rely on for food (Woolet et. al 2023). The primary objective of this research project is to see if shrub coverage and biomass affect bird populations' habitat suitability and abundance, given the changing dynamics of chaparral ecosystems (different fire regimes and type conversion). Although chaparral ecosystems are inherently fire-adapted, the natural fire regime has been disrupted, leading to consequences for the fauna in habitat type conversion (Conlisk et al. 2016). Frequent fires in the chaparral have resulted in habitat loss and conversion to non-native grasslands (Pratt et al. 2014).

What are the chaparral shrubs?

The chaparral biome is characterized by dense vegetation comprising mainly hardy shrubs adapted to dry summers and wet winters. Prominent among the exclusive chaparral biome are species in the Genus Ceanothus, such as California lilac (*Ceanothus arboreus*) or horray leaf ceanothus (*Ceanothus crassifolius*). Other hardwood shrubs include scrub oak and chamise. Soft Sage Scrub is a type of shrubland/chaparral. It includes softer, more vascular plants such as sagebrush and brittlebush, known for their vivid yellow flowers, buckwheat with distinctive white flowers, and California sage/black sage. Several species can be seen within each other's environment, but the chaparral is distinctive, categorized with hard, waxy leaves with sclerophyllous and ceanothus plants. Although “soft chaparral” features soft, drought-deciduous, and aromatic leaves.(Chapparal Institute. 2022)

Understanding chaparral shrub composition and habitat suitability is significant for effective type-conversion management; this study aims to understand the shrub composition and moisture content along varied fire gradients and the importance of chaparral-requiring birds' abundance in determining a suitable chaparral habitat. It also addresses what happens to shrubs in these three different scenarios of fire regime (short-fire interval, moderate interval/chaparral natural regime, and fire suppression/long-term interval). Understanding the vulnerability of shrubs in their habitats from recent fires is crucial to predicting and managing type conversion (Pratt et al. 2014). In this thesis, I will mainly use the term "chaparral" to encompass various subtypes, including Chamise Chaparral, Soft Sage Scrub, and Mixed Chaparral.

My hypothesis is that in sites with more abundant shrubbery, bird diversity will be greater, whereas areas with sparse vegetation will generally attract fewer bird species. Additionally, I expect the moisture content of fuel to be higher in areas with dense shrub cover, as these regions retain more ground moisture from the substantial water reserves held by the shrubs. Compared to more barren areas, thus habitat protection should be highest in areas with low moisture content, which are more vulnerable to fire and type conversion. The hypothesis posits that shrubs would be most vulnerable to type conversion in habitats that have experienced a fire within the last 20 years, making these areas least suitable for chaparral-requiring birds. My sub-questions will help determine the correlation between habitat suitability and shrub composition. (1) How do the chaparral sites differ in species composition and shrub cover? (2) How does moisture content correlate with shrub cover? (3) How does shrub cover correlate (or predict) species richness and abundance of birds? This research suggests what type of management plans should be prioritized for these sites, meeting these criteria to mitigate habitat degradation and type conversion.

METHODS

Three site study areas were conducted within the UC Reserve system in Riverside County, Southern California. The chaparral types consisted mainly of "coastal sage-scrub," characterized by California sagebrush *(Artemisia californica)*, California buckwheat (*Eriogonum fasciculatum)*, and black sage *(Salvia mellifera).* Sloped and seasonal riparian areas also had chamise, scrub oak, and other species. My thesis, "chaparral," will encompass all native scrub/chaparral habitats in the region.

Study sites

Site #1

Emerson Oaks Reserve, located in Temecula, CA, adjacent to the Aqua Tibia Wilderness, is a part of the University of California Riverside Reserve System. The reserve is managed to support a mix of coastal sage scrub, chaparral, and oak woodlands. Many of the key species at this site include coast live oak (*Quercus agrifolia*), California sagebrush (*Artemisia californica*), hawks (Cooper's, red-tailed, and red-shouldered), American kestrel, western scrub jays, wrentits and Hutton's vireo. The Nature Conservancy supports the management efforts, which are crucial in preserving these habitats while facilitating research and educational programs (NRS 2015).

Site #2

Box Springs Reserve, located in Moreno Valley, is a mixed-used site (hiking, biking, horseback riding, ect. One portion of the park is restricted to UCR's Reserve, and the majority is co-managed by Riverside Country Regional Parks District. Invaded grasslands, coastal sage scrub, chaparral, and rock outcrops dominate this area. Key species in this area include Hoary Leaf (*Ceanothus crassifolius*) and California Buckwheat (*Eriogonum fasciculatum*). This area has been frequently burned; common raptors in the region are red-tailed hawks,white-tailed kites, and other common birds, including rock wrens, California thrashers, and sage sparrows (NRS 2015). Management practices at Box Springs aim to restore and maintain these ecosystems, providing a rich environment for scientific study.

Site #3

Motte Rimrock Reserve, located in Perris, California, is primarily a soft sage chaparral with rocky outcrops. The University of California Riverside manages the reserve; it is one of the key protected habitats in Riverside County, earning an award for protecting a rare and endemic species, Stephens' kangaroo rat; other key species include the California gnatcatcher, Calypte Hummingbirds, California quails; plant species include BrittleBush (*Encelia farinosa*), Monkeyflower (*Diplacus aurantiacus var. puniceus*) and California Buckwheat (*Eriogonum fasciculatum*) (NRS 2015). The area has previously used pesticides to combat Stinknet invasion, as they noted they needed to preserve the “natural characteristics of these ecosystems” as species such as Stevens kangaroo rat or the cactus wren need more bare ground to be able to forage for food (Rodriguez et al. 2021).

Plot transects and shrub collection

The most effective method for measuring shrub composition and moisture content was creating transects and point plots (Sutherland. 2006). I used the plot-diagram transect method to gather the primary data for this study, utilizing three durable fiberglass measuring tapes to set up two 30-meter line transects at each study site (Figure 1). These transects were strategically placed within the reserves to represent the overall diversity of shrub composition, with a particular focus on areas with high species diversity. Along these transects, at 7.5 meters and 22.5 meters from the start point, my team and I established two circular plots, each with a diameter of 10 meters. We further divided each circular plot into four quadrants to use systematic sampling and ensure data consistency across the three sites.

Within these quadrants, our data collection focused on two main aspects: the percentage of ground covered by shrubs and the specific species present in each quadrant. This detailed vegetation count allowed us to effectively assess the shrubs' diversity and abundance. Additionally, we measured the diameter at breast height (DBH) for the predominant shrub species identified in these plots, which helped estimate shrub species cover.

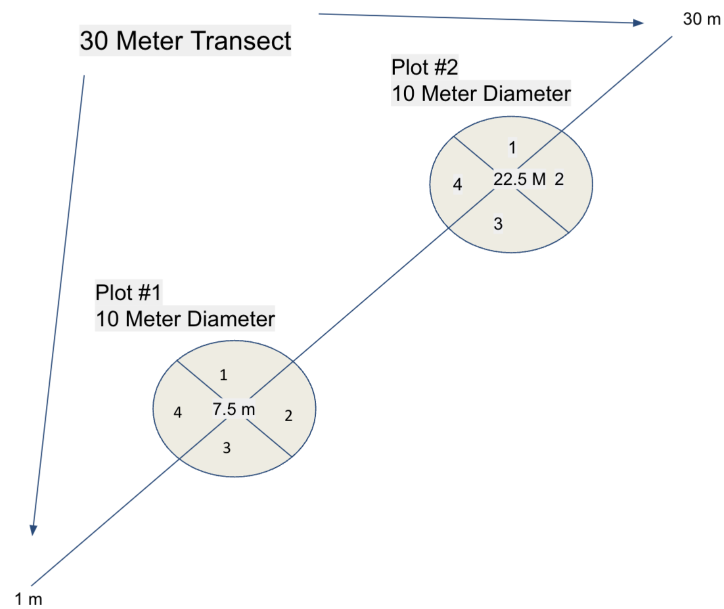

Figure 1. A model depicting how the 30-meter transects were created detailing how the plots were made, divided into quadrants, and how the plots were labeled per each transect.

Figure 2. An image of one volunteer setting up a 30-meter transect at Emerson Oaks, creating the 30-meter transect.

Fuel moisture content

To determine fuel moisture content, I collected foliage clippings from selected chaparral and soft sage shrubs at each study site to determine the fuel moisture content. I used a systematic sampling approach to ensure a representative sampling of each shrub species within the study sites. Foliage clippings were obtained from the middle portion of each selected shrub to avoid bias associated with top or bottom foliage. We used a hand pruner to clip fresh foliage from each shrub. Freshly clipped foliage samples were weighed digitally to determine their normal/fresh weights. We then placed the clipped foliage samples in sealed brown paper bags to prevent moisture loss or contamination and carefully transported them to the laboratory. Upon arrival, samples were stored in a cool, dry environment awaiting further processing.

In the UC Berkeley Forestry Fire Lab, I used specialized drying ovens for the dehydration process commonly used to determine the fuel moisture content of various woods and foliage clippings. Fresh foliage samples were carefully arranged in aluminum tins and placed in the oven at a low temperature of 90°C for 48 to 72 hours. It's worth noting that the drying times varied slightly among samples, with some foliage achieving dryness more rapidly than others. Foliage samples were reweighed to determine their dry weights. The difference between the normal weights and dry weights indicated the moisture content present in the foliage.

Figure 3. A picture of field clippings arranged on air fryer paper, and placed in aluminum tins within a drying oven.

Figure 4. An image of assorted field clipping samples used to measure fuel moisture content that was recently removed from the drying oven.

Bird species observation

At each study site, I created a bird count chart at each transect, recording the birds I visually observed and those I detected by their calls. (Sutherland. 2006). I conducted direct visual counts for each transect in a 200-meter radius to record the number of birds observed. This method involved using binoculars to scan the area for around ten to twenty minutes and noting each bird spotted to ensure accurate and consistent data collection. I made twenty to thirty-minute recordings using an iPhone and citizen science apps to detect and identify birds I did not see. E-bird and Merlin were used to record and identify birds.

E-bird is a comprehensive app and citizen science project that allows birders to record and share observations of bird sightings, contributing to a vast, publicly accessible catalog of birds in certain areas. Merlin is an interactive bird identification app developed by the Cornell Lab of Ornithology. It is designed to help users identify bird species through photos, sounds, and descriptions. I primarily used Merlin to survey and detect what birds were in the area using their sound recording feature. Afterward, I would place these recordings into a program called RavenLite, where I could see the sonogram of my recordings and detect any birds that Merlin could not pick up on or identify.

These identification tools helped confirm the species observed during the fieldwork. E-bird allowed me to access historical data and compare it with current observations. At the same time, Merlin helped identify birds, especially for those species that are less well-known or more difficult to spot.

What are chaparral requiring birds?

There are three categories when considering which birds are chaparral and soft-sage scrub requiring (Soule et al. 1988)

1) birds that are either obligate or year-round chaparral birds that require the habitat for breeding are considered chaparral-requiring species

EX: California Thrasher (*Toxostoma redivivum*) or Wrentit (*Chamaea fasciata*)

Categories 2 and 3 are considered facultative chaparral feeders because they can feed and breed in other ecosystems or with exotics or converted vegetation compared to those in category one, who rely exclusively on the chaparral brush. It's important to highlight that this specific study's categorization of Chaparral Birds is unique, highlighting the necessity for additional research on birds reliant on chaparral habitats.

2) facultative and locally breeding species that are year-round residents but are not exclusive to the chaparral

   EX: House Finch (*Carpodacus mexicanus*), and Scrub Jay (*Aphelocoma coerulescens*)

3) migratory species that rarely, if ever, breed locally

   EX: White-crowned Sparrow (*Zonotrichia leucocephalus*).

Bird table composition organization

I created a species list, categorized by family and order, across three study sites. The table in (Appendix A) shows the distribution of how the birds were collected using visual counts, audio detections (birds heard/recorded), and an average of eBird submissions specific to February recording in or near the site.

The analysis treated each instance of a bird being audibly detected through the Merlin app as a single count unless it was also confirmed visually. The California Gnatcatcher's findings at site three are worth noting as this species is exclusively endemic to the coastal sage scrub habitat. The California Gnatcatcher's presence on this site proves it's a critical habitat that can house this niche bird. Integrating visual observations, audio records, and eBird entries — created a robust analysis of bird composition, revealing different insights into bird diversity at each study site.

ANALYSIS

I compared shrubs across the three sites to assess the distribution and abundance of different shrub types within each site. I then visualized the data by creating bar graphs.

Using a systematic approach, I performed analyses using linear regression in Excel to explore the relationship between shrub coverage and bird abundance and between fuel moisture content and shrub coverage. Initially, data were gathered as explained earlier and input into Excel, where each row represented a unique observation in each transect. Columns represented variables of interest, such as shrub coverage and bird abundance or fuel moisture content. The 'Data Analysis' tool pack in Excel, which must be enabled via the 'Add-Ins' option, was utilized for the analysis. This tool pack offers a straightforward method to conduct regression analysis, requiring the user to select the dependent (response) variable and one or more independent (predictor) variables.

In the case of shrub coverage and bird abundance, the regression analysis aimed to identify if there was a statistical relationship between the average native shrub coverage per transect (in percentage) and the observed number of birds. This outcome was derived from the regression output, which provided key metrics such as the correlation coefficient and p-value, guiding interpretations of the relationship's strength and significance.

Similarly, to investigate fuel moisture content's impact on shrub coverage, a regression analysis was conducted to ascertain the nature of their relationship. A statistically significant relationship is evidenced when ($p\text{-value}<0.05$). A substantial explanatory power suggests a meaningful ecological interaction between the independent and dependent variables.

RESULTS

Shrub Composition

The range of native shrub coverage per transect varied between the three sites, from 27.5% to 74.375%. Buckwheat was abundant in all sites (>20 in the first site, >15 in the second site, and

>40 in the third site). Black sage was the most common in the first and second sites (>20 shrubs); chamise covered most of the second site with 40 shrubs.

The bar graph compares the number of shrub species across two transects in Site #1 (Figure 5). The transects show diversity in shrub species, as Black Sage dominates the first transect with 23 brushes, and Sage Brush dominates most of the second transect with 44 shrubs.

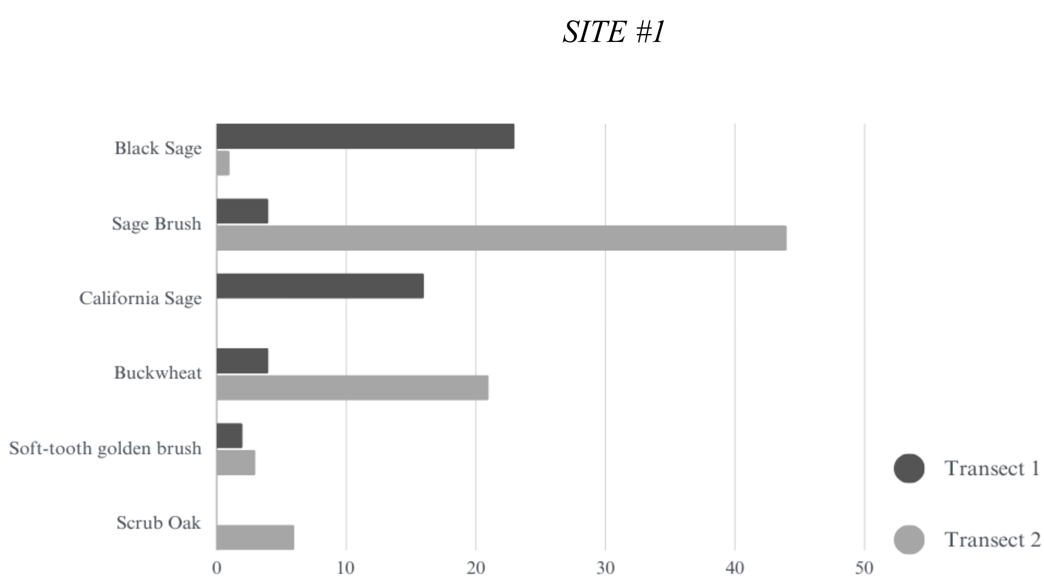

Figure 5. Number of each shrub type per transect in Emerson Oaks

Several shrub species in Site #2 (Fig. 6) are cataloged, including Black Sage, Chamise, Buckwheat, Horehound Leaf, Sage Brush, and Blue Elder. Chamise is one of the most prevalent species in this figure (23 and 17). Black Sage is almost equally present in the first and second sites. Although, Blue Elder, Sage Brush, and Horry leaf are not sparse in the transects, the visual arrangement here facilitates an understanding of species prevalence within and between transects, reflecting the diversity of the shrub community..

SITE *#2*

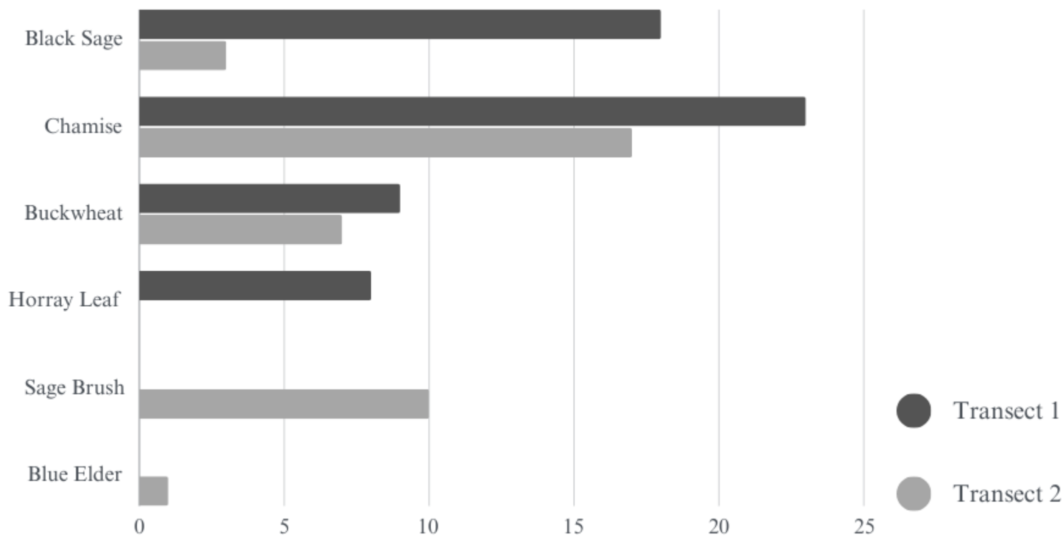

Figure 6 . Number of each shrub type per transect in Box Springs

The transects in the first and second sites show more shrub diversity than the third sites' transects (Figure 7). Buckwheat appears to be abundant in all transects, dominating the third site. The transects almost have the same number and type of shrubs with 13 Brittle Brushes, and 21 Buckwheats in the first transect compared to 20 in the second.

SITE *#3*

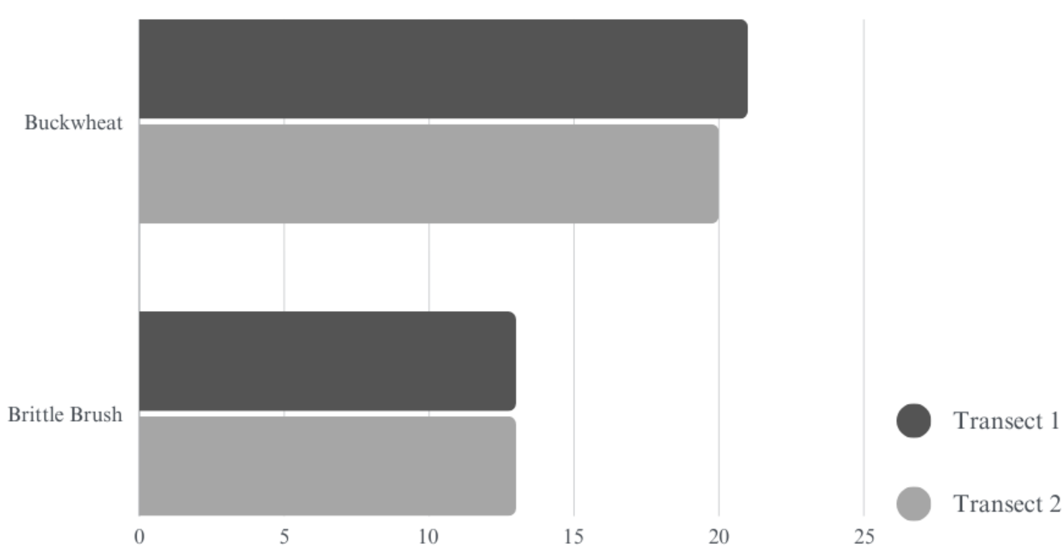

Figure 7 . Number of each shrub type per transect in Motte Rimrock

Shrub coverage and bird species richness

The R-squared value (R=0.9027, R-squared=0.815, p-value=0.01374) suggests a strong positive correlation between shrub coverage and bird species richness. The (p-value=0.0137) indicates that the average native shrub coverage (Figure 5) is a significant predictor of the number of bird species observed (p-value<0.05).

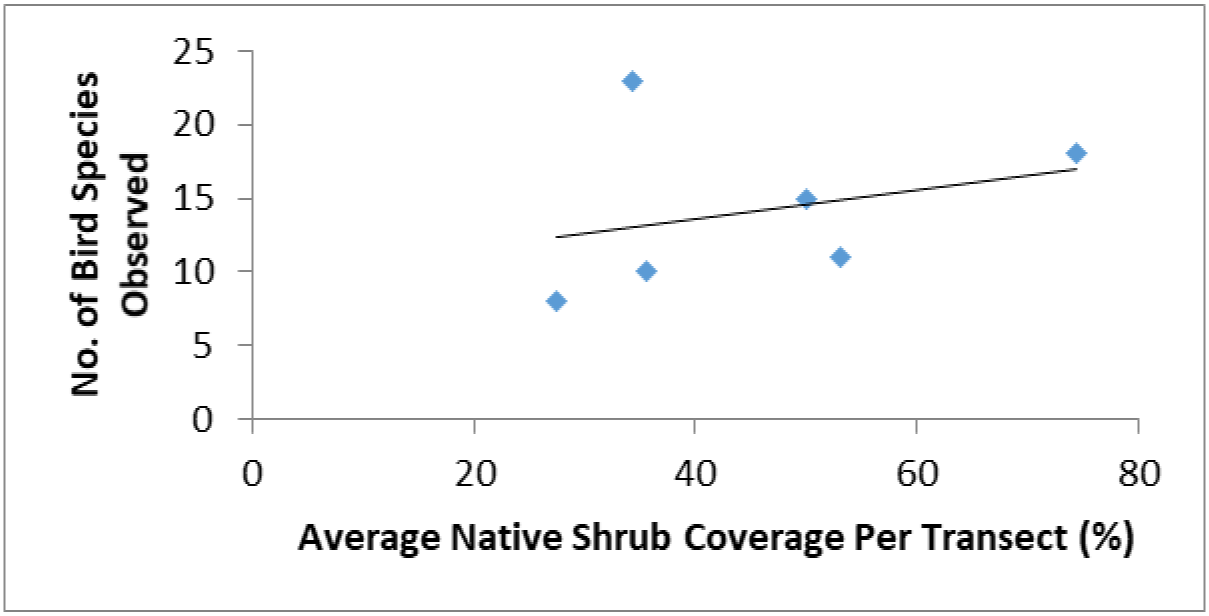

Figure 8 . Number of bird species observed with the average shrub coverage per transect in percentage.

Shrub coverage and bird abundance.

The results (R=-0.244, R-squared=0.0595, p-value=0.641) indicate a weak negative correlation. The calculated p-value is not statistically significant (p > 0.05), indicating that the regression model as a whole is not significant. This means that the average native shrub coverage per transect does not significantly relate to the number of birds observed.

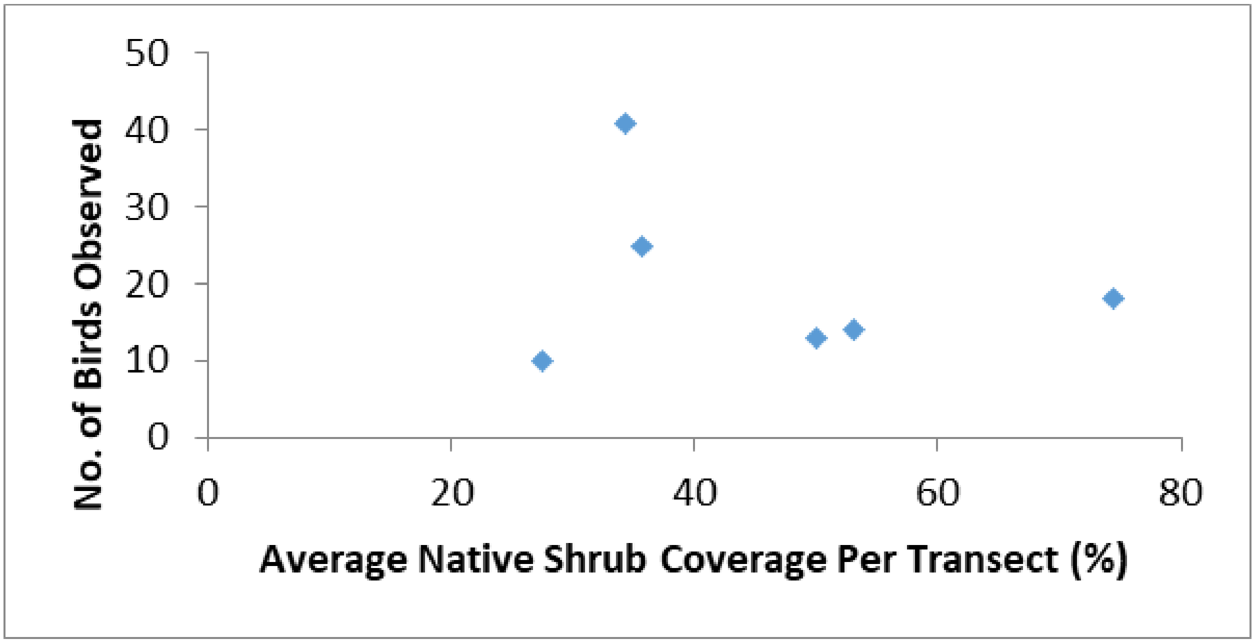

Figure 9. Number of birds observed about the average shrub coverage per transect in percentage

Species distribution by chaparral-requirement

I recorded 18 species at site#1, with a notable prevalence of birds from the facultative Corvidae family, except for the California Scrub-Jay, an obligate chaparral bird. This site had four obligate chaparral species, indicating moderate specialization of chaparral-requiring and non-chaparral-requiring species. I observed 11 species at site#2, featuring several obligate species from the Troglodytidae family and facultative species from the Passerlidae family. This site supported three obligate chaparral species, highlighting a slightly lesser degree of chaparral habitat specialization than site #1. Site #3 is noted to be the most species-rich; we recorded 23 different species, with a diverse representation from Passerlidae, Polioptilidae, Corvidae, and Odontophoridae families. This site boasted six obligate chaparral species, suggesting a highly specialized community.

Fuel moisture content and shrub coverage

The results indicate a strong negative correlation between the two variables (R=-0.881, R-squared=0.777, p-value= 0.020). The R-squared value suggests that approximately 77.7% of the variance in the average native shrub coverage per transect can be explained by the average fuel moisture content variation. The standard error of 9.020 represents the average distance between the observed values of the shrub coverage and the predicted values based on the regression model. The calculated p-value of 0.020 indicates that the regression model is statistically significant ($p < 0.05$), suggesting a meaningful relationship between the average fuel moisture content and the shrub coverage. These findings suggest higher fuel moisture content is correlated with less shrub coverage.

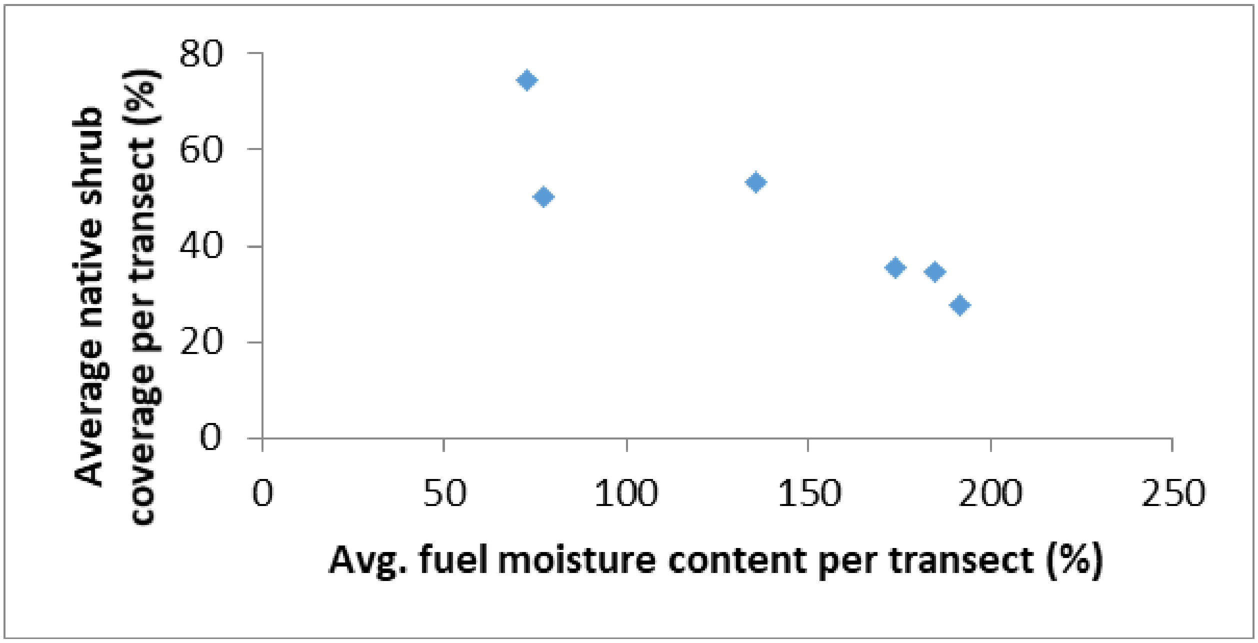

Figure 10. Average shrub coverage per transect in percentage in relation to the average fuel moisture content in each transect.

DISCUSSION

The results provided a complex conclusion regarding the hypotheses. While there is a weak negative correlation between shrub coverage and the number of birds observed, there is a strong positive correlation, which is statistically significant, between shrub coverage and bird richness. On the contrary, the analysis shows a strong negative correlation between fuel moisture content and shrub cover.

Adapting fire management for chaparral and coastal sage scrub resilience

When fuel moisture content is high, the moisture in the vegetation makes it less susceptible to ignition and reduces the likelihood of wildfires. Consequently, this can promote the survival and growth of shrubs, potentially leading to increased shrub coverage. On the other hand, during dry periods or in regions with low fuel moisture content, the vegetation becomes more prone to ignition, and wildfires can spread more easily. Intense wildfires can destroy shrubs and reduce shrub coverage in the affected areas.

One of the study's findings suggests a relationship between fire frequency and shrub density within Southern California's chaparral ecosystems. The study revealed that areas with lower fire frequencies appear to have higher fuel moisture content, which relates significantly to denser shrub compositions. The data provide valuable preliminary insights into potential fire management strategies (Pratt et al. 2014), highlighting the need for adaptive management practices that consider fire prevention and preserving chaparral, suggesting the creation of housing or commercial development regulations in areas with old growth or vulnerable chaparrals. A few ways to maintain chaparral include mosiac-controlled burns, grazing, and restoration to combat type-conversion. Fernandes and Botelho (2003) and Newman et al. (2018) indicate that chaparral-prescribed burns reduce the risk of large, frequent fires. Other studies have also noted that the benefit of prescribed burning is creating ideal/suitable bird habitats and, most importantly, reintroducing fire in areas where severe fire suppression and implementation of a prescribed burn created less dense vegetation, Which is vital for allowing seedlings of diverse shrubs, and more open spaces needed for certain chaparral-requiring birds.(Potts and Stephens. 2009) Fire has also been shown to be the most effective in maintaining bird population retention compared to manual mastication.(Potts and Stephens. 2009)

Type conversion limitations

Type conversion within chaparral ecosystems, exacerbated by frequent fires, has been the primary cause of the replacement of native coastal sage scrub and chaparral with extensive non-native grassland or other vegetation types. It's been noted above that this could be prevented through strategic fire management practices, reintroducing the chaparral to fire through prescribed burns mimicking natural fire regimes (Keeley and Fotheringham, 2001). However, various research recognizes that such conversion may be unavoidable in some regions due to some regions having intensified fire frequency and invasives becoming more resistant and being lighter seeds, choking out native seedlings. (source) For example, in this study, Motte Rimrock is considered to have an ideal fire frequency for the coastal sage chaparral. However, for this site, land management still decided that many areas needed to be sprayed with pesticide, as change was inevitable given its proximity to urbanized environments, houses, and the rapid spread of exotics. The inevitability of type conversion calls for a nuanced understanding of how chaparral ecosystems can be managed in the face of such transitions. While the study did not focus on the potential spread of invasive species post-fire, Box Springs chaparral bird species were primarily living only where there was shrubbery and rarely heard or seen in the open grasslands; other literature also points this as a significant concern. (Conlisk et al., 2016) It's worth noting that the transects at Box Springs were primarily done in areas with shrubbery, as I felt I wouldn't have been able to analyze data in type-converted areas. However, this data set can skew the amount of shrub coverage in the park; thus, excluding completely type-converted areas from the analysis could mean an underrepresentation of shrub coverage in such regions. Future research should include these areas to accurately represent the chaparral's current state and resilience.

Obligate vs. Facultative Species

Obligate Species depend highly on chaparral habitats for survival, with Site #3 hosting the most, followed by Site #1 and Site #2. This suggests varying degrees of habitat specialization and different environmental pressures or resource availability at each site; at each site, we recorded them at different times, unlike how I originally planned, creating inconsistencies with my data. Facultative species birds are more adaptable and can thrive in multiple habitats, including scrublands, woodlands, and grasslands. The high number of facultative species across the sites shows several species' versatility in varied environments within California but also notes how resource competition or availability can be limited within these sites.

Native vs. Invasive Species

Although no invasive bird species were specifically observed in this study, mentioning the Brown-headed Cowbird—a native but obligate parasitic bird—highlights an important ecological interaction. Notably observed at one site, their parasitism notably affects vulnerable obligate native species like the California Thrasher and the Gnatcatcher. This interaction between the two species poses significant conservation concerns for the native obligate birds of the chaparral.

Enhancing habitat analysis through more comprehensive transects

The implementation of more comprehensive transects has the potential to substantially improve our understanding of shrub composition variability across chaparral ecosystems. This study employed transects to collect data representing different levels of shrub composition, which provided information on the ecological dynamics within the study areas. Creating larger and more comprehensive transects as a future direction would offer a more nuanced picture of these ecosystems, aiding in developing more effective conservation and management plans. However, challenges such as dense vegetation and difficult terrain underscore the necessity for innovative data collection methods. Using satellite imagery or developing canopy analysis software tailored to chaparral could circumvent these obstacles, allowing for broader and more accurate data collection. The implications of this research extend beyond academic interest; they inform land management and conservation strategies. Understanding the relationship between shrub composition and bird populations and the resilience of shrubs to fire is fundamental to preserving chaparral ecosystems.' biodiversity. (Newman et al. 2018) reinforce the importance of this relationship, noting the responsive behavior of chaparral bird communities to fire and shrub removal. In conclusion, this discussion synthesizes the complexities and interdependencies within chaparral ecosystems, reflected in fire management, type conversion, and vegetation analysis. The research provides a foundation for future inquiry and management strategies, highlighting the importance of ecological integrity and the need for adaptable, data-driven approaches to conservation in the face of environmental challenges.

Alternative land management techniques

Herbicides

It's worth noting that previous land management at Motte Rimrock Reserve looked at containing and eliminating Stinknet, an invasive annual forb with herbicide treatment. Researchers noted that pre-emergent herbicides have been proven highly effective at reducing Stinknet cover to nearly zero a year after treatment; however, the efficacy of post-emergent has varied with annual rainfall, showing less effectiveness in wetter years like 2019. Given the unpredictability of recent rainfall patterns, with dry years like 2018 and 2022, the reliance on pesticides at this site raises concerns about their suitability under changing climatic conditions. Therefore, selecting an appropriate herbicide strategy must carefully consider these environmental variables and broader management goals and constraints, acknowledging pesticide use's potential benefits and drawbacks in such fluctuating weather conditions (Rodriguez et al. 2021).

Grazing

Grazing has been proven as another alternative management strategy. Research (Huntsinger et al. 2021) on grazing in similar ecosystems, such as all hardwood chaparral and coastal forests, has shown its potential to reduce wildfire risks by managing fuel loads. However, the impact of extensive grazing on fuel reduction in coastal sage scrub habitats still needs to be explored, especially since most of our sites are compromised by coastal sage scrub. If grazing is incorporated, it must use targeted grazing practices such as goats or sheep for woody plant consumption or cows for invasive grass management. This strategy addresses fuel loads and adapts to the specific conditions of extensive rangelands like those in San Diego County, offering a sustainable management alternative.

Data collection limitation

My study can be considered to lack a complete in-depth analysis since I didn't have a more diverse set of transects to depict if this data is accurate. More transect data must be collected to create an effective land management plan and explore how sufficient prescribed fire can prevent type conversion in the chaparral. Utilizing satellite and GIS data can create a more comprehensive approach to fire management at this site.

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APPENDIX A

Index

M/S- Merlin/Sound Identification

V/B- Visual Count up close or through Binoculars

Eb- Ebird Average in February

	Site #1					Site #2					Site #3				
	Transect 1		Transect 2			Transect 1		Transect 2			Transect 1		Transect 2		
Bird Species Latin and Common Name	M/S	V/B	M/S	V/B	Eb	M/S	V/B	M/S	V/B	Eb	M/S	V/B	M/S	V/B	Eb
Order: Anseriformes															
Family: Accipitridae															
Red-shouldered Hawk/Buteo lineatus	N/A	1	N/A	N/A	2	N/A	N/A	N/A	N/A	1	N/A	N/A	N/A	N/A	1.25
Red-Tailed Hawk/Buteo jamaicensis	N/A	1	N/A	1	2.111111111	N/A	N/A	N/A	N/A	2.458333333	N/A	N/A	N/A	1	2.2
Cooper's Hawk/Accipiter cooperii	N/A	N/A	N/A	N/A	1.125	N/A	N/A	N/A	N/A	1.272727273	N/A	1	N/A	N/A	1
Order: Falconiformes															
Family: Falconformes															
American Kestrel/Falco sparverius	N/A	N/A	N/A	N/A	1.2	N/A	N/A	N/A	N/A	1.166666667	X	1	N/A	N/A	1
Order: Caprimulgiformes															

Family: Trochilidae															
Anna's Hummingbird/Calypte anna	N/A	1	N/A	N/A	5.25	X	1	X	1	2.272727273	N/A	N/A	N/A	N/A	2
Order: Columbiformes															
Family: Columbidae															
Mourning Dove/Zenaida macroura	X	N/A	X	N/A	3.714285714	N/A	1	N/A	1	5.75	N/A	N/A	X	N/A	2.333333333
Order: Cuculiformes															
Family: Cuculidae															
Geococcyx californianus (Greater Roadrunner)	N/A	N/A	X	N/A	1.6	N/A	N/A	N/A	N/A	1.25	N/A	1	N/A	N/A	1
Order: Piciformes															
Family: Picidae															
Melanerpes formicivorus (Acorn Woodpecker)	X	1	X	N/A	3	N/A	N/A	N/A	N/A	2.25	N/A	N/A	N/A	N/A	N/A
Order: Galliformes															
Family: Odontophoridae															
Callipepla californica (California Quail)	X	N/A	N/A	1	4	N/A	N/A	N/A	N/A	6.5	N/A	9	X	1	12.5
Order: Passeriformes															
Family: Aegithalidae															
Bushtit/Psaltriparus minimus	N/A	N/A	N/A	1	9.333333333	N/A	N/A	N/A	N/A	7.272727273	X	N/A	X	N/A	4

Family: Corvidae															
California Scrub Jay/Aphelocoma californica	X	3	X	N/A	3	N/A	N/A	N/A	N/A	1.545454545	N/A	N/A	N/A	N/A	N/A
Common Raven/Corvus corax	X	2	x	N/A	5.857142857	X	3	X	N/A	5.055555556	X	7	x	2	14.25
American Crow/Corvus brachyrhynchos	X	1	X	N/A	3.888888889	N/A	N/A	N/A	N/A	3.75	N/A	N/A	N/A	N/A	N/A
Family: Fringillidae															
Haemorhous mexicanus (House Finch)	N/A	N/A	N/A	N/A	8.714285714	N/A	N/A	N/A	N/A	12	N/A	N/A	X	1	5
Spinus psaltria (Lesser Goldfinch	N/A	1	N/A	N/A	10.28571429	N/A	N/A	N/A	N/A	3.5	N/A	N/A	N/A	N/A	N/A
Family: Paradoxornithidae															
Wrentit/Chamaea fasciata	X	N/A	N/A	N/A	1.4	N/a	N/A	N/A	N/A	2.1	N/A	N/A	N/A	N/A	N/A
Family: Mimidae															
California Thrasher/Toxostoma redivivum	X	N/A	X	N/A	1.333333333	X	N/A	N/A	N/A	2.363636364	N/A	N/A	N/A	N/A	1.333333333
Northern Mockingbird/Mimus polyglottos	N/A	2	x	N/A	1.833333333	N/A	1	N/A	N/A	1.909090909	X	N/A	N/A	N/A	1.666666667
Family: Passerellidae															
California Towhee/	N/A	N/A	N/A	N/A	3.333333333	X	N/A	N/A	2	7.461538462	X	N/A	N/A	N/A	2

Melozone crissalis															
White-crowned Sparrow/ Zonotrichia leucophrys	N/A	N/A	N/A	N/A	10.8	X	2	X	1	6.285714286	N/A	N/A	X	N/A	4.25
Savannah Sparrow/ Passerculus sandwichensis	N/A	N/A	N/A	N/A	2	X	N/A	N/A	N/A	4.666666667	N/A	N/A	X	N/A	7.666666667
Rufous-crowned Sparrow Aimophila ruficeps	N/A	N/A	N/A	N/A	1	N/A	N/A	N/A	N/A	2.818181818	X	3	X	N/A	3
Lincolns Sparrow/ Chondestes grammacus	N/A	N/A	N/A	N/A	1	N/A	N/A	N/A	N/A	1.8	X	N/A	N/A	N/A	1
Lark's Sparrow/ Chondestes grammacus	N/A	N/A	N/A	N/A	2.5	N/A	N/A	X	N/A	1	X	N/A	N/A	N/A	2.333333333
Family : Paridae															
Oak Titmouse/ Baeolophus inornatus	X	N/A	X	N/A	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Family: Parulidae															
Common Yellowthroat/Geothlypis trichas	N/A	1	N/A	N/A	1	N/A	N/A	N/A	N/A	1.333333333	N/A	N/A	N/A	N/A	N/A
Family: Polioptilidae															

Blue-gray Gnatcatcher Polioptila caerulea	x	N/A	x	N/A	2	N/A	N/A	N/A	N/A	1.5	X	2	N/A	N/A	1
California Gnatcatcher Polioptila californica	N/A	N/A	N/A	N/A	1	N/A	N/A	N/A	N/A	1	N/A	X	N/A	X	2.5
Family: Turdidae															
American Robin/turdus migratorius	X	N/A	X	N/A	5.25	N/A	N/A	N/A	N/A	10.75	N/A	N/A	N/A	N/A	N/A
Family: Icteridae															
Western Meadowlark/Sturnella neglecta	N/A	N/A	N/A	N/A	6	N/A	N/A	N/A	N/A	4	X	N/A	X	1	13.5
Brown-headed Cowbird (parasitic) /Salpinctes obsoletus	N/A	N/A	N/A	N/A	2	X	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Family: Troglodytidae															
Rock wren/Salpinctes obsoletus	N/A	N/A	N/A	N/A	1	X	N/A	X	2	3.727272727	N/A	N/A	N/A	N/A	2
Bewick's wren/Thryomanes bewickii	x	N/A	x	N/A	1	X	N/A	X	1	2.545454545	N/A	N/A	N/A	N/A	1.5
Family: Tyrannidae															
Say's phoebe/Sayornis saya	N/A	N/A	x	N/A	1.5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2.25