# An Urban-Wildland Interface in Claremont Canyon, Berkeley, CA:

# Change in Avian Species Richness Over Time

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## ABSTRACT

The urban/wildland interface is a problem for wildland species. The urban area creates barriers and disturbances for wildlife species, as well as converts previously habitable land, with food and shelter, into a maze of streets and buildings. Some species have adapted to this new landscape and can feed on the discards and yards of humans. The urban/wildland interface is a transition zone where species from urban and wildland areas intermix and find a balance. To study the intricacies of this unique ecosystem, I performed a census of avian species in a 32-acre site of the 208-acre Claremont Canyon Regional Preserve during the winter months of 2014 and 2015. Finding the balance between the urban and wildland species can take a long time so I compared the results to a similar study performed in the years of 1991 and 1992, to identify if any significant changes had occurred during the 22-year time interval. Both censuses resulted in a similar number of species, 36 species in 1991-1992 and 34 in 2014-2015, but the actual species differ between the two censuses. In the 1991-1992 census there were more avian species in the Acciptriformes order and less in the Passeriformes order than was found in 2014-2015 census. There are many possible factors for the decrease in observations like changes in climate, increased competition amongst members of the same species, species that stay away from trails and humans due to their noise pollution, or observer bias. After looking at data on precipitation, temperature, and changing vegetation, it is likely that avian species populations are diminished due to the 2012 drought or human access to trails.

## KEYWORDS

Urban/Wildland Interface, Species Richness, Ecosystem, Transition zone, Species Accumulation

## INTRODUCTION

Urbanization disrupts wildland areas, changes landscapes, and limits habitat availability for avian species. Urban areas change landscapes from forests with canopies, foliage, and shrubs into cityscapes with buildings, telephone poles, and concrete, all of which decrease habitat available for avian species to forage and hide from predators (Beissinger and Osbourne 1982). Disruption of wildland areas fragments bird populations and makes it more difficult for birds to breed (Crooks et al. 2004). Species with omnivorous and granivorous feeding habits, and cavity nesting species (Chace and Walsh 2006), have an advantage in urban areas over bird species with select diets and specific nesting sites. Where wildland areas are fragmented, urban-wildland interfaces form at the borders creating a transition zone from urban to wildland. The fragmentation of wildland diminishes habitat area available for wildland species (Beissinger and Osbourne 1982).

Monitoring the number of species and their distribution in an area over time is critical to understanding how habitat disruption and fragmentation impacts bird species. Short-term experiments examining species responses to habitat fragmentation are limited in their ability to understand larger impacts of human manipulations and changes in the environment (Schmiegelow et al. 1997). A year-long study on habitat fragmentation in boreal forests observed little change in bird diversity (Schmiegelow 1997). The same study noted that fragments connected by corridors had higher bird density but less diversity: because fragments with more connections received higher traffic than those with limited or no connections, more social birds could thrive there and had a competitive edge over territorial, solitary birds. If the study had continued for another five or ten years, it may have been possible to determine if there were long term effects of habitat fragmentation on avian species and test their resiliency to change. Similarly, in urban areas, there is higher bird density, but less diversity; there are more birds of the same species in urban areas and fewer birds, but more species in wildlife areas. Urban environments provide nourishment for generalist species of birds that are able to consume trash, but specialist species are not able to digest certain types of food making them unable to adjust to urban environments (Beissinger and Osbourne 1982). Because generalist species reproduce offspring at a higher rate than specialist species and are able to live in more places, generalist species have outcompeted specialists in urban environments. Urban-wildland interfaces allow for generalist and specialist species of birds to live in close proximity to one another, which applies direct competition between the two categories of birds. Every urban-wildland interface has a different mix of generalists and specialists, which creates new interactions amongst species and their surrounding environment (Debinski and Holt 2000).

Claremont Canyon is a wildland area, connecting the cities of Berkeley and Oakland, California, with a rich management history. In the 1850's, American settlers originally used the canyon as a communication and transportation route which included transcontinental telegraph cables connecting the east and west coasts (EBRPD 2014). By 1903, the canyon was closed to major transportation. Instead, the canyon was used for herding and grazing cattle, eucalyptus plantations, and residential housing, taking advantage of the view of San Francisco Bay. In the 1970's, Claremont Canyon was added to the East Bay Regional Parks District. In October 1991, Claremont Canyon had an intense fire (Claremont Canyon Conservancy) that created a new vegetative mosaic (Eagen 1992). The fire altered the landscape of Claremont Canyon by burning eucalyptus and Monterey pine groves, which are highly flammable. An early study of Claremont Canyon birds was in 1992 (Dreher 1992) and included observations of resident winter species. Most of the species were found in the coastal scrub habitat, with old growth eucalyptus in second and all other habitats tied. The most common bird species were *Melozone crissalis*, *Junco hyemalis, Colaptes auratus* and *Cyanocitta stelleri* (Dreher 1992), which are all generalist species. Amongst the species list there are only a few specialist species like *Accipiter cooperii* and *Buteo jamaicensis*. Changes in bird diversity and distribution could demonstrate changes in the environment and indicate useful management applications.

In this study, I ask: How has bird diversity changed in Claremont Canyon since the initial survey in 1992 in terms of species richness? What factors in the surrounding landscape have changed? If urbanization is altering habitat suitability for birds, I expect that birds will disperse farther into the hillsides away from trails and roadways. It is difficult to quantify urbanization and all of the impacts on nearby wildlands because of the multitude of possible interactions and feedback loops. I examine how the vegetation, precipitation, temperature, and management of Claremont Canyon have changed and how those events could impact species richness. If no significant changes have occurred in the landscape and climate of Claremont Canyon Regional Preserve, then I expect that avian species richness and species present to remain the same in the 2014-2015 census when compared to the 1991-1992 census.

# METHODS

## Study site

Claremont Canyon Regional Preserve is a 208-acre park maintained by the East Bay Regional Park District. Its boundaries are the University of California, Berkeley Clark Kerr campus to the west, Claremont Ave. to the South, Grizzly Peak Rd. to the east, and Strawberry creek to the north. Four main species of vegetation are found in the study area; *Eucalyptus globulus*, *Heteromeles arbutifolia*, *Quercus douglasii*, and *Pinus radiata*. Within Claremont Canyon, there is a 32-acre plot in the preserve, which is where I conducted field surveys of avian species. I parked in a small dirt lot on the side of Claremont Ave. at GPS location 37 52'18"N 122 13'26"W. From this parking lot, I accessed the fire trails of Claremont Canyon Regional Preserve and collected data on avian species from these trails. Figure 1 depicts a map of these trails and where the main species of vegetation are located.

## Data Collection Model

To survey the plot for birds, I surveyed the area 5 times in November and 10 times in January and February by following the methods of Dreher (1992). Each morning, I walked the transect at dawn for two hours to identify and record observations of birds. Along each transect, I walked on the trail for 10 minutes and then stopped and watched for 10 minutes. I made 6 of these observations for each survey over a 2-hour period.

For each bird I saw or heard, I recorded the size, shape, and tone and pitch of the call. I wrote down the type of vegetation the bird was found in. I used a bird identification guidebook (Whitman et al. 1986) to identify birds and their calls. For the birds that I was uncertain about their identity, I checked my observations against websites with local naturalist information, such as nhwildlife.net (NHWL), and noted my level of uncertainty.

## Data Analysis

To compare current biodiversity of Claremont Canyon with past biodiversity, I used R to compare the data collected in 2014-2015 with the data collected in 1991-1992. To avoid observer bias by two amateur birders in both censuses, I compared both censuses to the NHWL species list, which uses more experienced birders for their surveys. However, these surveys were done for the whole of Claremont Canyon Regional Preserve and were not limited to the study site in the censuses.

Species richness was used to analyze variation amongst the 2014-2015 census and the 1991-1992 census. I used life history information of the identified species to understand their diversity and natural habitat preference. I also compared the number of species seen and the overall total number of observations in the 2014-2015 census to the 1991-1992 census. The number of species observed gives some indication of the species richness at the study site and the total number of observations is the observed population size. To further show species richness, I made a species accumulation curve of the number of new species seen each week. The species accumulation curve was made using R, specifically BiodiversityR.

## RESULTS

### Avian Census

During the 30 hours of field surveys from November to mid-March. I observed 242 birds; of those birds I identified 34 different species, however I could not identify 61 of my observations (Table 1). In comparison, the 1992 dataset reported 36 different species out of 455 birds total bird observations, and 104 observations were not identified. To focus on resident avian species the censuses were conducted in the winter months. Then, I compared the two censuses to the NHWL data for December 2014.

**Table 1: Species richness and number.** The number of birds seen and identified in the field survey from November 2014 through mid-March 2015. * Some of the species identified in the 1991-1992 data do not have ranges in California and thus were changed to a more appropriate species of the same family.

| Species name | Common Name | 2014-2015 | 1991-1992 | NHWL 2014 |
|---|---|---|---|---|
| *Accipiter cooperii* | Cooper's Hawk | 0 | 4 | 1 |
| *Accipiter striatus* | Sharp-shinned Hawk | 0 | 2 | 1 |
| *Aegolius acadicus* | Northern Saw-whet owl | 0 | 0 | 1 |
| *Aeronautes saxatalis* | White throated swift | 0 | 0 | 1 |
| *Aimophila ruficeps* | Rufous-crowned Sparrow | 1 | 0 | 0 |

| | | | | |
|---|---|---|---|---|
| *Aphelocoma californica* | Western Scrub-Jay | 1 | 27 | 1 |
| *Baelophus iornatus* | Oak Titmouse | 0 | 0 | 1 |
| *Bombycilla cedrorum* | Cedar Waxwing | 0 | 0 | 1 |
| *Bubo virgianus* | Great Horned Owl | 2 | 4 | 1 |
| *Buteo jamaicensis* | Red-tailed Hawk | 2 | 7 | 1 |
| *Buteo lineatus* | Red-shouldered Hawk | 0 | 0 | 1 |
| *Buteo swainsoni* | Swainson's Hawk | 0 | 1 | 0 |
| *Calipepla californica* | California Quail | 0 | 0 | 1 |
| *Calypte anna* | Anna's Hummingbird | 4 | 6 | 1 |
| *Carduelis pinus* | Pine Siskin | 0 | 0 | 1 |
| *Cathartes aura* | Turkey Vulture | 0 | 7 | 1 |
| *Catharus guttatus* | Hermit Thrush | 0 | 4 | 1 |
| *Certhia americana* | Brown Creeper | 0 | 0 | 1 |
| *Chamaea fasciata* | Wrentit | 1 | 23 | 1 |
| *Colaptes auratus* | Northern Flicker | 0 | 37 | 1 |
| *Columba livia* | Rock Pigeon | 0 | 0 | 1 |
| *Corvus corax* | Common Raven | 4 | 0 | 1 |
| *Cyanositta stelleri* | Steller's Jay | 23 | 53 | 1 |
| *Elanus leucurus* * | White-tailed kite | 0 | 1 | 0 |
| *Empidonax difficllis* | Pacific-slope flycatcher | 6 | 0 | 0 |
| *Eupahgus cyanocephalus* | Brewer's Blackbird | 1 | 8 | 0 |
| *Falco sparverius* | American Kestral | 0 | 0 | 1 |
| *Haemorhous mexicanus* | House Finch | 0 | 0 | 1 |
| *Haemorhous purpureus* | Purple Finch | 0 | 0 | 1 |
| *Ixorus naevius* | Varied Thrush | 2 | 0 | 1 |
| *Junco hyemalis* | Dark-eyed Junco | 18 | 26 | 1 |
| *Megascops kennicottii* | Western Screech Owl | 0 | 0 | 1 |
| *Melanerpes formicivorus* | Acorn woodpecker | 0 | 0 | 1 |
| *Melazone crissalis* | California Towhee | 4 | 22 | 1 |
| *Meleagris gallopavo* | Wild Turkey | 0 | 0 | 1 |
| *Melospiza lincolnii* | Lincoln's Sparrow | 2 | 2 | 1 |
| *Melospiza melodia* | Song Sparrow | 1 | 15 | 1 |

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|---|---|---|---|---|
| *Mimus polygottos* | Northern mockingbird | 0 | 0 | 1 |
| *Molathrus ater* | Brown-headed cowbird | 2 | 0 | 0 |
| *Passerella iliaca* | Fox Sparrow | 8 | 0 | 1 |
| *Patagioenas fasciata* | Band-tailed Pigeon | 0 | 2 | 1 |
| *Pheucticus melanocephalus* | Black-headed Grosbeak | 10 | 0 | 1 |
| *Picoides nuttallii* | Nuttall's woodpecker | 0 | 0 | 1 |
| *Picoides pubescens* | Downy woodpecker | 2 | 2 | 1 |
| *Picoides villosus* | Hairy woodpecker | 2 | 0 | 1 |
| *Pipilo erythrophthalmus* | Eastern Towhee | 3 | 9 | 0 |
| *Pipilo maculatus* | Spotted Towhee | 6 | 0 | 1 |
| *Poecile gambeli* | Mountain chickadee | 20 | 0 | 0 |
| *Poecile rufescens* * | Chestnut-backed chickadee | 17 | 13 | 1 |
| *Polioptila caerula* | Blue-gray gnatcatcher | 2 | 0 | 0 |
| *Psaltriparus minimus* | Bustit | 1 | 0 | 1 |
| *Regulus calendula* | Ruby-crowned Kinglet | 0 | 8 | 1 |
| *Regulus satrapa* | Golden-crowned kinglet | 0 | 0 | 1 |
| *Sayonoris nigricans* | Black Pheobe | 3 | 0 | 1 |
| *Selasphorus rufus* | Rufous Hummingbird | 2 | 0 | 0 |
| *Selasphorus sasin* | Allen's Hummingbird | 0 | 1 | 0 |
| *Setophaga coronata* | Yellow-rumped Warbler | 0 | 0 | 1 |
| *Setophaga townsendi* | Townsend's Warbler | 0 | 4 | 1 |
| *Sialia mexicana* | Western Bluebird | 0 | 0 | 1 |
| *Sitta canadensis* | Red-breasted Nuthatch | 3 | 11 | 1 |
| *Sitta carolinensis* | White-breasted Nuthatch | 0 | 0 | 1 |
| *Sitta pygmaea* | Pygmy Nuthatch | 0 | 1 | 1 |
| *Sphyrapicus ruber* | Red-breasted sapsucker | 0 | 0 | 1 |

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|---|---|---|---|---|
| *Sphyrapicus varius* | Yellow-bellied sapsucker | 0 | 0 | 1 |
| *Spinus psaltria* | Lesser Goldfinch | 0 | 0 | 1 |
| *Sturnus vulgaris* | European starling | 0 | 3 | 0 |
| *Thryomanes bewickii* | Bewick's Wren | 11 | 23 | 1 |
| Total | | 242 | 455 | 60 species |
| *Toxostoma redivivum* | California Trasher | 0 | 0 | 1 |
| *Troglodytes aedon* | House wren | 1 | 0 | 1 |
| *Troglodytes pacificus* | Pacific wren | 0 | 0 | 1 |
| *Turdus migratorius* | American Robin | 7 | 5 | 1 |
| *Tyto alba* | Barn Owl | 0 | 1 | 0 |
| Unknown | | 61 | 104 | |
| *Vireo gilvus* | Warbling vireo | 0 | 0 | 0 |
| *Vireo huttoni* | Hutton's vireo | 0 | 9 | 1 |
| *Vireo solitarius* | Blue-headed Vireo | 0 | 1 | 0 |
| *Zenaida macroura* | Mourning Dove | 8 | 1 | 1 |
| *Zonotrichia atricapilla* | Golden-crowned Sparrow | 1 | 8 | 1 |
| *Zonotrichia leucophrys* | White-crowned sparrow | 0 | 0 | 1 |

Compared to the 1991-1992 census, there is a decrease in the number of birds from the 2014-2015 census. Table 1 compares the species in the field surveys in 1992 and 2015. Based off Table 1, it is clear that the number of observations have decreased. The bird species observed in the 1991-1992 census that were not seen in 2014-2015 census are *Elanus leucarus, Accipiter cooperii, Accipiter striatus, Buteo swainsonii, Tyto alba, Selasphorus sasin, Colaptes auratus, Vireo solitarius, Vireo huttoni, Sitta pygmaea, Regulus calendula, Sturnus vulgaris*, and *Setophaga townsendi*. There were some species identified only in the 2014-2015 census: *Selasphorus rufus, Picoides villosus, Corvus corax, Poecile gambeli, Pipilo maculatus, Spizella passerine, Passerella iliaca,* and *Pheucticus melanocephalus*. There were a number of species found only in the NHWL data: *Buteo lineatus, Falco sparverius, Meleagris gallopavo, Columba livia, Megascops kennicottii, Aegolius acadicus, Aeronautes saxatalis, Melanerpes formicivorus, Sphyrapicus ruber, Sphyrapicus varius, Picoides nuttallii, Calipepla californica, Vireo gilvus, Baelophus iornatus, Sitta carolinensis, Certhia americana, Troglodytes pacificus, Regulus satrapa, Sialia mexicana, Mimus polygottos, Toxostoma redivivum, Bombycilla cedrorum, Setophaga coronata,* *Zonotrichia leucophrys, Haemorhous purpureus, Haemorhous mexicanus, Spinus psaltria, Carduelis pinus.* Figure 1 shows the species accumulation curve for the 2014-2015 census. The first data point is the date of the first field survey and the number of new species seen that day, the next data point increase is the number of new species seen on that date and so on.

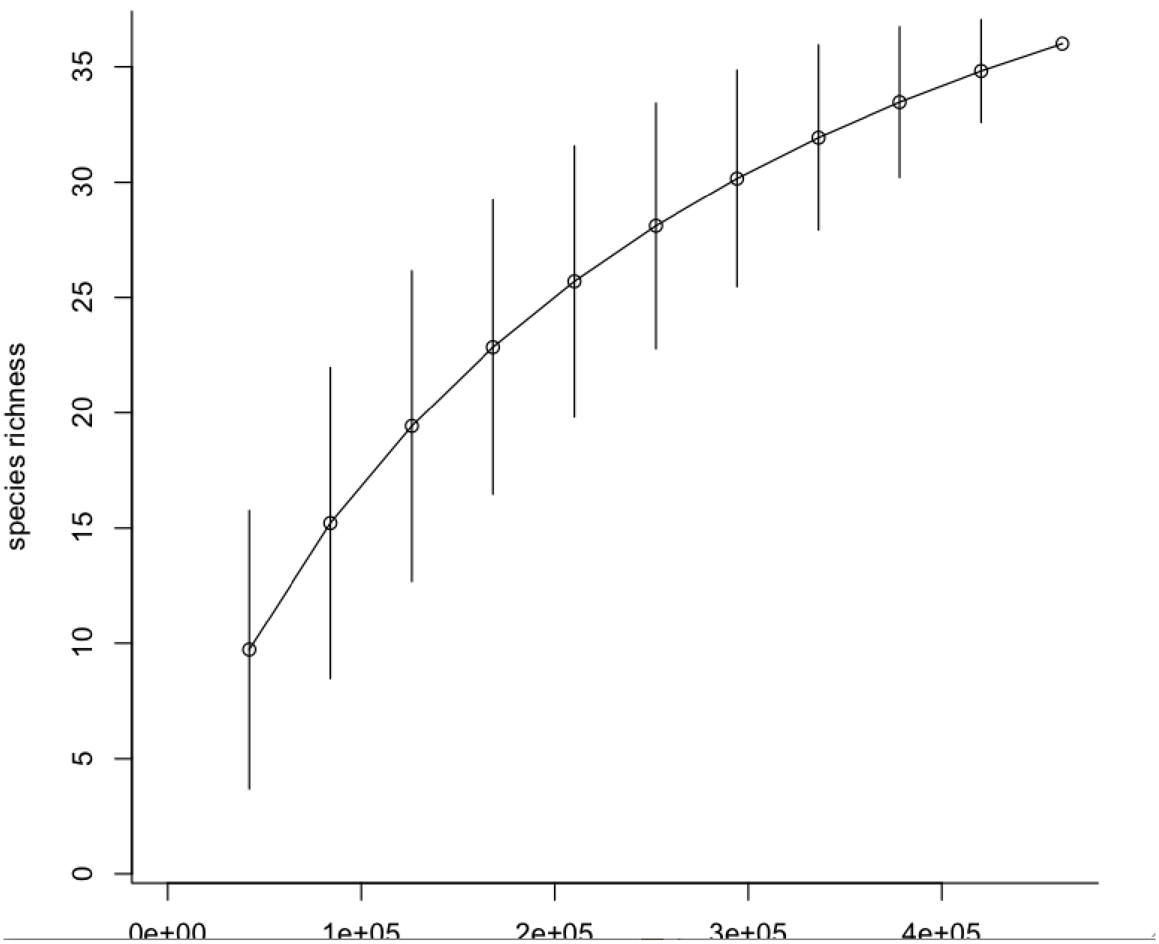


**Figure 1. Species Accumulation Graph.**

Table 2 organizes the avian species seen during the 2014-2015 census by their taxonomic order and details significant traits of each species: their preferred habitat, type of food, how many eggs laid, and any unique behaviors.

**Table 2. 2014-2015 census species traits. (http://www.allaboutbirds.org)**

| Order | Scientific name | Habitat | Food | Nesting | Behavior |
|---|---|---|---|---|---|

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|---|---|---|---|---|---|
| **Accipitriformes** | *Buteo jamaicensis* | **open fields** | **mammals and birds, 1 ounce- >5 pounds** | **1-5 eggs per clutch, 1 brood** | **territorial, mate for life** |
| **Columbiformes** | *Zenaida macroura* | **open country, scattered trees, and woodland edges** | **seeds, wild grasses, weeds, and berries** | **2 eggs per clutch, 1-6 broods** | **feed on ground and push leaf litter aside, mate for life** |
| **Strigiformes** | *Bubo virgianus* | **secondary growth woodlands** | **very diverse diet, eats skunks, geese, and raptors, as well as small mammals** | **1-4 eggs per clutch, 1 brood** | **roost in trees and snags, members of a pair roost seperately** |
| **Apodiformes** | *Calypte anna* | **common in urban as well as coastal scrub and oak woodland** | **nectar from flowering plants** | **2 eggs per clutch, 2-3 broods** | **Male courtship, no pair formed** |
| **Apodiformes** | *Selasphorus rufus* | **breed in open or shrubby areas** | **nectar and insects** | **2-3 eggs per clutch, 1 brood** | **aggressive, male courtship** |
| **Piciformes** | *Picoides pubescens* | **open woodlands** | **insects** | **3-8 eggs per clutch, 1 brood** | **Courtship displays by males and females, active woodpecker** |
| **Piciformes** | *Picoides villosus* | **mature woodlands** | **insects** | **3-6 eggs per clutch, 1 brood** | **male courtship** |
| **Passeriformes** | *Sayornis nigricans* | **near water sources** | **insects** | **1-6 eggs per clutch, 1-3 broods** | **monogamous pairs** |
| **Passeriformes** | *Cyanositta stelleri* | **coniferous-deciduous forests** | **insects, seeds, berries, small animals, eggs** | **2-6 eggs per clutch, 1 brood** | **steal from nests, social** |
| **Passeriformes** | *Aphelocoma californica* | **Scrub and suburban areas** | **insects and fruit** | **1-5 eggs per clutch, 1 brood** | **Vocal and playful, pairs stay together through the year** |
| **Passeriformes** | *Corvus corax* | **all types of habitat** | **anything** | **3-7 eggs per clutch, 1 brood** | **Playful and intelligent, known nest theives** |
| **Passeriformes** | *Poecile gambeli* | **evergreen forests** | **protein rich insects and spiders** | **5-9 eggs per clutch, 1-2 broods** | **quick, agile birds, like to sunbathe** |
| **Passeriformes** | *Poecile rufescens* | **dense coniferous forests, seen in urban area** | **insects and some seeds and berries** | **1-11 eggs per clutch, 1-2 broods** | **Hop through shrubs and trees** |
| **Passeriformes** | *Psaltriparus minimus* | **open woods and chaparral** | **small insects and spiders** | **4-10 eggs per clutch, 1-2 broods** | **Pairs nest together** |
| **Passeriformes** | *Sitta canadensis* | **coniferous forests** | **insects** | **2-8 eggs per clutch, 1 brood** | **create nests out of tree cavities** |

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|---|---|---|---|---|---|
| **Passeriformes** | *Thryomanes bewickii* | **bushy areas and scrub** | **eggs, larvae, pupae, and adult insects** | **3-8 eggs per clutch, 1-3 broods** | **uses twig perch as a napkin** |
| **Passeriformes** | *Chamaea fasciata* | **Coastal scrub and chaparral** | **Insects, spiders, fruits, and seeds** | **1-5 eggs per clutch** | **Gleans insects from twigs and bark** |
| **Passeriformes** | *Turdus migratorius* | **found in urban environments and forested areas** | **invertebrates and fruit** | **3-5 eggs per clutch, 1-3 broods** | **pairs only form in spring** |
| **Passeriformes** | *Pipilo maculatus* | **found in urban areas and chaparral** | **insects, berries, and seeds** | **2-6 eggs per clutch, 1-3 broods** | **rummage in leaf litter** |
| **Passeriformes** | *Pipilo erythrophthalmus* | **forest edges, overgrown fields and woodlands** | **insects, fruits, and seeds** | **2-6 eggs per clutch, 1-3 broods** | **rummaging in leaf litter** |
| **Passeriforemes** | *Melazone crissalis* | **dense chaparral scrub** | **seeds and insects** | **2-5 eggs per clutch, 1-3 broods** | **foraging, double-scratch maneuver** |
| **Passeriformes** | *Molathrus ater* | **grasslands and woodland edges** | **seeds and insects** | **1-7 eggs per clutch** | **forage on ground with other black-birds** |
| **Passeriformes** | *Aimophila ruficeps* | **open chaparral** | **insects and seeds** | **2-5 eggs per clutch, 1-2 broods** | **wary birds that stay close to ground** |
| **Passeriformes** | *Empidonax difficllis* | **humid coniferous forest** | **insects** | | **Insects caught in air or from foliage** |
| **Passeriformes** | *Ixorus naevius* | **wet, mature forests** | **insects, berries, and nuts** | **1-6 eggs per clutch, 1-2 broods** | **males establish territories prior to mating season** |
| **Passeriformes** | *Troglodytes aedon* | **live all over, require tree, shrubs and tangles in habitat** | **Variety of insects** | **3-10 eggs per clutch, 1-2 broods** | **busy forger** |
| **Passeriformes** | *Polioptila caerula* | **wooded habitats** | **small insects and spiders** | **3-5 eggs per clutch, 1-2 broods** | **very territorial and aggressive** |
| **Passerifromes** | *Passerella iliaca* | **chaparral** | **insects** | **2-5 eggs per clutch, 1 brood** | **hopping on ground, scratching leaf litter** |
| **Passeriformes** | *Melospiza melodia* | **forest edges and suburbs** | **seeds and fruits, some insects** | **1-6 eggs per clutch, 1-7 broods** | **primarily monogamous** |
| **Passeriformes** | *Melospiza lincolnii* | **woodlands and forest edges** | **insects and spiders** | **3-5 eggs per clutch, 1-2 broods** | **spend a lot of time foraging** |
| **Passeriformes** | *Zonotrichia atricapilla* | **chaparral** | **seeds and insects** | **3-5 eggs per clutch, 1-2 broods** | **defend breeding territory** |

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|---|---|---|---|---|---|
| **Passeriformes** | *Junco hyemalis* | **woodlands and parks** | **seeds and insects** | **3-6 eggs per clutch, 1-3 broods** | **territorial during summer** |
| **Passeriformes** | *Pheucticus melanocephalus* | **varied habitat with nearby water source** | **seeds and insects** | **2-5 eggs per clutch, 1 brood** | **get most of their food in treetops** |
| **Passeriformes** | *Eupahgus cyanocephalus* | **chaparral** | **seeds, grains, and some insects** | **3-7 eggs per clutch, 1-2 broods** | **flock with other species** |

## Vegetation and Avian Species

Of the four vegetation types, coastal scrub/chaparral was the site with the highest number of observations, followed closely by eucalyptus, and less so by oak/bay woodland and Monterey pine (Table 3). In the 1991-1992 census, eucalyptus was the site with the highest number of observations, followed closely by coastal scrub, and less so by oak/bay woodland and Monterey pine.

**Table 3. Number of sightings per vegetation type in the 1991-1992 census and 2014-2015 census.** * In the 1991-1992 study, old and new eucalyptus were separate categories and to make the results closer to my own study I combined the two numbers.

| **Vegetation** | **2014-2015** | **1991-1992** |
|---|---|---|
| Eucalyptus | 74 | **163*** |
| Coastal scrub | **81** | 153 |
| Oak/Bay woodland | 24 | 76 |
| Monterey Pine | **21** | **63** |

## Changes in Vegetation

In images from Google Earth (retrieved 2/17/15 at 9:30pm), the vegetation in my study area appeared to increase since the 1992 study. In 1993, vegetation was scarcer than all the other images indicated by the lighter coloring (Figure 2a). In 2014, vegetation was denser than in 1993 as indicated by the darker coloring (Figure 2b). From the field surveys, the vegetation preference did not shift from the 1992 study, and birds (2015) were seen most often in the Coastal Sage/Scrub area. The second most common vegetation type to see birds in is the Eucalyptus groves, third is the Oak/Bay landscape, and fourth is Monterey Pine.

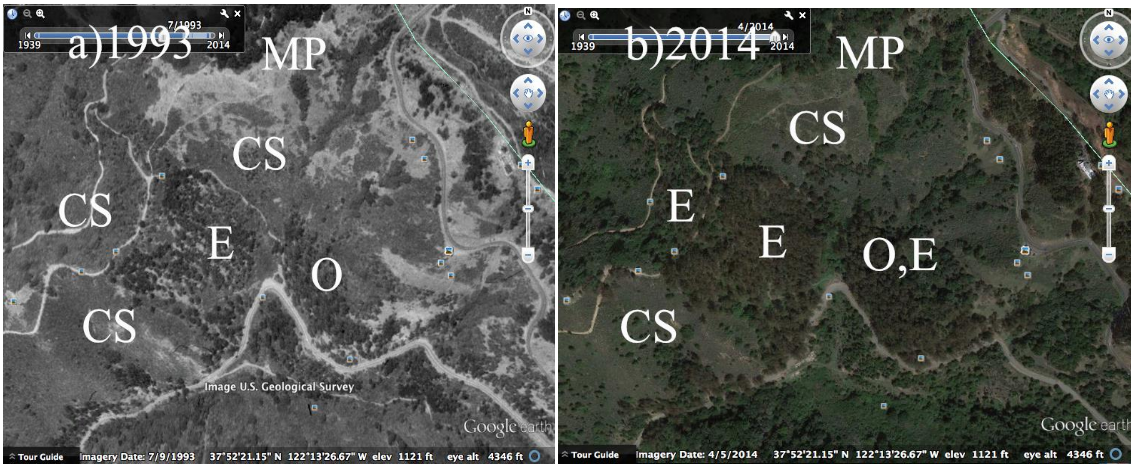


**Figure 2. Historic Images of Claremont Canyon.** (a) 1993 and (b) 2014.

## DISCUSSION

Proximity to urban environments and increasing temperatures alters avian species composition and behavior (Anderies et al. 2007) and habitat structures (Tingley et al. 2012). To further understand the effects and impacts of the urban/wildland interface, I conducted a field study in Claremont Canyon Regional Preserve, which is in close proximity to the urbanized spaces of Berkeley and Oakland in Alameda County, CA. I hypothesized that no significant changes occurred in avian species richness from the 1991-1992 census to the 2014-2015 census. In the 1991-1992 census 36 species were observed of 455 bird sightings, while in the 2014-2015 census I observed 34 species out of 242 bird sightings. There was little variation observed in the number of species, but the species composition and the number of individuals observed over the 22-year interval between surveys. These subtle observations show little change to avian species richness suggesting that Claremont Canyon Regional Preserve is a stable habitat.

### Avian Diversity & Ecology

In the 1991-1992 and the 2014-2015 censuses, 36 and 34 species were observed, respectively, however these species counts are below the 60 species observed and recorded on NHWL for the winter of 2014 and 40 species in the winter of 2005. Although the 1991-1992 and 2014-2015 censuses were each performed by single amateur observers, the website includes observations from a group of avid bird watchers to record, take pictures, and observe the wildlife found in Claremont Canyon Regional Preserve. In addition, NHWL observes avian species over the whole 208-acre preserve, eight times larger than the study site. The 1991-1992 census also observed 217 more birds than the 2014-2015 census. The larger amount of observations in the 1991-1992 census suggests that birds were either easier to spot or they were more abundant. It is difficult to know the abundance of the bird population at the time of either census because they are both based solely on observational methods, not using a mark-recapture method.

The richness from the current study is clearly an underestimate of the resident avian species richness. The Species Accumulation Curve (Figure 1) does not have a clear asymptote suggesting that 34 species is an underestimate of the true species richness. In addition, more observations are required to estimate the total avian species richness. Although there isn't a clear asymptote, the rarefaction curve has an inflection point at around 30 avian species, indicating a trend in the species richness data (Gotelli and Colwell 2001). Based off of the NHWL data, I expect the asymptote is close to 60 species. To confirm this more surveys and more experienced birders would be needed.

Of the 34 species I observed, 66% were from the Passeriformes order, an increase of 16% over the 1991-1992 census. Table 2 shows species traits for the avian species observed in the 2014-2015 census. The NHWL data has 64% of their species in the Passeriformes order. Passeriformes, commonly called "perching birds," is a diverse group of birds that contains small to medium sized birds, which typically feed on seeds, fruits, and grains. Their variety and smaller range size, enables them to adapt to changes on a small scale and exploit every niche available to them (Rotenberry et al. 1980). Many Passeriformes can also thrive in urban environments (Anderies et al. 2007), providing that there are nutritional resources available to them. These species in Claremont Canyon may have the ability to adapt and forage elsewhere (Crooks 2004).

Unlike the Passeriformes, Accipitriformes species richness has decreased since the 1991-1992 census from 5 species: *Elanus leucarus, Accipiter cooperii, Accipiter striatus, Buteo swainsonii,* down to the 1 species: *Buteo jamaicensis,* observed in the 2014-2015 census. In the NHWL data, 10% of their species were Acciptriformes: *Accipiter cooperii, Accipiter striatus, Buteo jamaicensis, Buteo lineatus, Falco sparverius* and *Cathartes aura.* In general, Accpitriformes are predatory birds that require abundant prey and occupy large ranges. Avian species can be sensitive to any kind of change in their habitat and are able to move from habitat to habitat more freely than any other animal (Schmiegelow et al. 1997). Anthropogenic alterations to the landscape, vegetative composition, and air pollution could be responsible for the decreased number of observations in the 2014-2015 census.

**Links between habitat and avian diversity**

Changes in temperature and precipitation have been linked with decreasing bird density in the nearby Coyote Hills Regional Park and an overall trend of decreasing bird density with increasing temperatures (Riensche et al. 2010). Changes in temperature and precipitation can have large impacts on the amount and quality of vegetation. Avian species depend upon the vegetation for their food and shelter, and stressed plants produce less seed and leaf cover for species nutrition and habitat then fewer numbers of birds will be able to live in the changing habitat. Precipitation during the 1991-1992 census was only 50.8mm less than that the 2014-2015 census, bit it is prone to cyclical fluctuations due to the Mediterranean climate, however the mean temperature of 1991 was 60.1 Fahrenheit and 63.4 in 2014. California has been in a drought since 2012, which could be negatively impacting vegetation and the presence of seeds and berries.

The type of vegetation also has a big impact on avian species. The 1991-1992 census had the highest number of observations in the eucalyptus groves and the lowest in Monterey pine. In the 2014-2015 census, the highest number of observations was in chaparral and the lowest in Monterey pine. The Monterey pine area is located at the highest elevation point of Claremont Canyon and receives higher wind speeds than the rest of the canyon. It is also much easier to observe avian species when they are nearer to the ground in bushes, like in a chaparral ecosystem. Eagen (1992) found a correlation between eucalyptus removal and vegetation diversification, which could create more varied habitat structures for avian species. Further study on the impacts of eucalyptus trees on avian species is necessary before any management occurs. Eucalyptus has often been a topic of concern for the human residents of Claremont Canyon. Many residents are concerned with the flammability of eucalyptus trees and call for the removal of the eucalyptus. Any changes to the landscape must first be approved by the East Bay Regional Park District, and then implemented by maintenance staff.

Trail management is another source of disturbance in Claremont Canyon Regional Preserve. When a tree falls across the trail or into a roadway, the EBRPD clears the pathway of any debris in the way of park visitors. This means that a maintenance crew drives up in a vehicle, to pick up the debris. Although this disturbance appears to be a small event to a human being, a bird may be alarmed by the noise of the vehicle and confused by the clearing of habitat resources (Rheindt 2003). Human presence, alone, can disrupt and alter species composition near trails (Miller et al.). The trails in Claremont Canyon Regional Preserve are a popular site for nature and exercise enthusiasts (EBRPD). The humans hiking and biking on the trails are out enjoying nature, but their presence has a negative impact on birds and their habitat structure (Reed et al. 2014). When I was out in the field, I saw an average of 10 hikers and 2 dogs on each trip and this was early in the morning and one of the less popular trails in Claremont Canyon regional Preserve. People should enjoy hiking and being outdoors, but there are negative impacts to the wildlife along the trail systems.

Just as hikers and vehicles in Claremont Canyon Regional Preserve are disturbances to avian species, so are the homes, businesses, and roadways that border the preserve. The proximity of Claremont Canyon Regional Preserve to the urban areas of Berkeley and Oakland, CA creates areas where many avian species are not able to survive. This limits the number of species that can live in Claremont Canyon Regional Preserve because they cannot forage everywhere in the nearby vicinity. Also, cars and people can harm avian species in accidents by running over or hitting birds. In addition, avian species are dependent on calls and songs to communicate with one another, however the loud noises of construction and cars on roadways make it difficult for avian species to hear (Rheindt 2003). These noises can have an effect on mating rituals dependent on song, especially for the "song birds" of passeriformes. Urban areas and wildland areas both have their dangers, but avian species have been experiencing the dangers of predation and starvation for centuries whereas the dangers of car accidents are unknown to them.

**Limitations**

Both the 1991-1992 census and the 2014-2015 census were conducted by amateur birders, and the species identifications may have been limited by our limited experience level (Kremen 2011). By comparing the two censuses with observations made by NHWL, there were more species in the total area of Claremont Canyon than in either study. Observer bias and the amount of time given to complete the study limited the number of identifications and the number of observations. In addition, both censuses were conducted during the winter months, from November to February, and were thus focusing the resident bird species. Some disadvantages are that birds tend to be less active in the winter due to decreasing temperatures and less abundant resources. Birds are also more vocal during the spring for mating rituals, which can make them easier to identify. One advantage of a winter census is not worrying about identifying migratory birds, which could make the resident species richness appear higher and thus skew the resident estimates.

**Future Directions**

Understanding the impacts of urbanization and climate change on avian species in this area would require a larger scale census at different times of the year. The census could cover all 208 acres of Claremont Canyon Regional Preserve and possibly include Strawberry Creek as a comparison site, which likely has a similar composition of avian species. It would also be helpful to know more about the management of trails and vegetation of Claremont Canyon Regional Preserve from the people who maintain the trails and the administrative board. Many people in the community want to remove the eucalyptus trees due to fire and safety concerns. More information on the number of visitors to the trails could point to how big of an impact human presence is on avian species.

**Broader Implications and Conclusion**

The effects and impacts of the urban/wildland interface on species richness and diversity is a relevant topic, as more densely populated cities become a necessity with growing human populations. Less of the natural landscape lays intact, which leaves many species vulnerable in new anthropogenic environments (Beissinger and Osbourne 1982). As humans change the landscape and climate, we need to consider how these changes affect other species and learn how to manage landscapes to protect other species (Chace and Walsh 2006). Avian species are one of the few taxonomic groups that have an increased capacity for migration and change, by observing how they respond to changes we can more easily see growing trends in range shifts and species movement (Tingley et al. 2012).

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