Examining the Impact of Human Presence on Native Insect Pollinators in Coastal Sage Scrub Habitat in North San Diego County

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Aims of the Research

Today we experience the loss of biodiversity in many ecological communities, including pollinators. Pollinators hold special importance within our ecosystems as well as our economy. They are vital in the reproduction of flowering plants by transferring pollen from the male reproductive organ of the flower to the female organ. This allows for plants to fruit and provides food for humans and other animals.

Native plant communities throughout Southern California, rely on the interconnection between pollinators and their host plants. Numerous factors contribute to the decline in pollinator populations, some of which stem from human activities such as urbanization and agriculture (Rhodes, 2018; Kevan, 1999). While there are efforts to create and improve pollinator-supporting habitat, both in preserves and in urban gardens, little is known about the degree of impact of each of these human activities. Our research begins the process of examining the significance of one human activity on insect pollinator populations.

Literature Review

Coastal Sage Scrub Plant Community and Pollinator Networks

Coastal Sage Scrub (CSS) is a plant community found along the coast of California from San Francisco into Baja Mexico. Sometimes called "soft chaparral", this community is found at lower elevations than chaparral, generally from sea level to 1000 m (Cleland et al., 2016). Plants in this community include low, woody, soft-leaved, drought-deciduous subshrubs, with grasses and forbs found in open areas. The community is named after its dominant species, California sagebrush (*Artemisia californica*) (Westman, 1981). Southern sage scrub has three main subtypes primarily influenced by availability of moisture at different latitudes, with variations in plant species accordingly (De Becker, n.d.).

Historically it was the dominant plant community in San Diego County, but there is only approximately 20% left today (Beyers et al., 1995). Thirteen plant species within this plant community are recognized as threatened or endangered, with many more species in danger of extinction without formal recognition or listing ("Listing Species Under the Endangered Species Act", n.d.). Many of the associated animals and plants within this community are endangered due to human activity.

Pollinator conservation is an important field of research due to their essential performance in all ecosystems. The analysis of pollinator diversity is a key indicator of the overall health of an ecosystem (Albrecht et al., 2012; Fontaine et al., 2006). Today there is very little research on plant pollinator interactions within the coastal sage scrub plant community. Because of the lack of pollinator research and with an increase in human demand for undeveloped land, there is a urgency to deepen our knowledge of how pollinators function in our ecosystem, especially in native habitats.

Impact of Human Presence on Pollinator Activity

Human activity is focused in urban environments. Research on plant-pollinator interactions in urban environments is a topic within urban ecology that currently has limited data available (Silvia et al., 2020). From a comprehensive review on this topic, researchers have synthesized that urbanization has a wide variety of complex effects on pollinator behavior. Some effects include reduced number of pollinator interactions in urban green areas, changes in forage routes and floral resource selection (Silvia et al., 2020). Increasing urbanization results in habitat loss and habitat fragmentation, these anthropogenic disturbances led to a greater chance of invasive species that negatively impact the amount of native floral resources for native pollinators (Theodorou, 2020; Winfree et al., 2011). Additionally, urban green areas have been seen to reduce diversity of plants

resulting in a decrease in diversity of pollinator species (Bates et al., 2011; Fortel et al., 2014; Silvia et al., 2020).

In this study we will use footpaths as an indicator of human activity in an area. For any human activity to take place in an area, there must be human-scale access (Chan, 2017; Maina and Jackson, 2003). Presence of a formal walking path demonstrates human activity. In vegetated areas with less human activity, there would be fewer intentional walking paths, but may be trails through the vegetation created by animals.

Research Problem

In this study we are conducting a year-long survey of the insect pollinators of coastal sage scrub (CSS) habitat, while examining the effect of human presence on the diversity of those insect pollinators and the frequency of their plant interactions.

This study is Project 2 of the CSUSM Pollinator Monitoring Program (PMP), which is conducting an on-going longitudinal survey of plant-pollinator networks in coastal and inland sage scrub communities in northern San Diego County (CSUSM Pollinator Monitoring Program, 2019). Within each PMP project, there is a "Natural" site, located in a low-to-no access preserve, and a "Garden" site which is an intentionally planted horticultural area.

The area studied in Project 2 is the San Diego Safari Park (SDSP), an 1,800 acre zoo in Escondido, California. In 2018, over 1.5 million people visited the zoo. (Newsroom, 2019). SDSP is located within the San Pasqual Valley which includes the CSS plant community (County of San Diego, n.d. & SANDAG GIS Open Data Portal, n.d). Begun in October 2021, this survey focuses on two different locations at the SDSP, the Nativescapes Garden exhibit and the Biodiversity Reserve.

Garden Site: The Nativescapes Garden Exhibit

We monitor the Nativescapes Garden, an exhibit at the SDSP that features over 1,500 individual plants from 500 species that are native to California (Nativescapes Garden, n.d.). Plant communities like chaparral and coastal sage scrub are represented throughout the exhibit and help provide structure for pollinators. The SDSP Horticultural Department oversees the exhibit conditions, while volunteers tend to the Nativescapes Garden on a weekly basis. Some examples of work that is performed throughout the gardens includes watering and cutting back plant growth to maintain the footpaths. Additionally, the exhibit experiences daily visitors along the footpaths. The amount of daily visitors varies throughout the season and week, but the SDSP has been seen to receive more than 1.5 million guests in a year (Newsroom, 2019).

Natural Site: The Biodiversity Reserve

Adjacent to the SDSP is the Safari Park Biodiversity Reserve (SPBR) with 900 acres of chaparral and CSS habitat. The SPBR was established in 1997 as part of the San Diego Multi Species Conservation Plan (MSCP). The land set aside for conservation efforts is an integral component of the larger network of habitat and open space efforts done throughout San Diego to protect and enhance biodiversity. The SPBR is managed by the SDSP Conservation Department. The habitat is mature and established, and the only active management currently performed in the SPBR is as-needed invasive plant removal (*Safari Park Biodiversity Reserve,* 2021).

Methods

Coastal Sage Scrub Plant Community

The PMP has developed a master list of coastal sage scrub (CSS) plants that is used in all project sites, to allow comparison of data between sites and between projects. The specific plants included in this project are shown in the plot or transect descriptions (Tables 1 and 2).

Insects

Of the approximately 29 orders of insects, the PMP focuses on those which include known or possible pollinating insects, native or non-native, in San Diego County (see Appendix). Due to the large numbers of pollinators in each, two orders were further separated into families, including *Apidae, Bombidae, Vespidae* and *Sphecidae* for order Hymenoptera, and *Syrphidae*, *Bombyliidae* and *Asilidae* for order Diptera. Additionally, the ant family *Formicidae* was separated from Hymenoptera and noted as native or non-native ant species, so that we could discuss the presence and activity of native ants within the context of the California super colony of Argentine ants (*Linepithema humile*). This distinction is important because the vast majority of ant species encountered are invasive Argentine ants, and they are more prevalent in areas with greater human activity (Van Wilgenburg et al., 2010). Finally, we noted spiders (order Araneae) which have varied interactions and impacts on plant-pollinator networks, being incidental pollinators, but also predators of pollinating insects, and of plant-eating insects (Knauer, et al. 2018).

In this study we define non-native pollinator insects as Argentine ants, the red imported fire ant (*Formicidae*), and the European honey bee (*Apis mellifera*) (Table 3). *Formicidae* and *A. mellifera* are categorized as non-native insects because they are the most common non-native insect species found in all the PMP project sites since 2019, and in the southern California region generally. There were no significant instances of other non-native insects interacting with blooms in our data (Young, 2020).

Monitoring Protocol

We will carry out our pollinator monitoring study for a total of 12 months to allow for a complete picture of seasonal activity. While monitoring each plant for five minutes, we record any insects that land on the flowers of the plants. We define a pollinator interaction as when an individual insect touches a flower in such a way that it could gather pollen or deliver pollen.

We began weekly data collection at each site in October 2021, monitoring each transect between the hours of 8 am and 3 pm. It is important to monitor when it is warm enough for the pollinators to move around and feed on the plants (Nabors, 2019). Data is not collected when plants are not flowering nor in windy or rainy weather because these conditions would impede them from collecting nectar (Nabors, 2019).

In the Natural site, at the Biodiversity Reserve, Natural Transect 1 is a 50 square meter plot transect in a mature, dense CSS habitat. Natural Transect 2 is a 25 meter linear transect along a south facing slope mountain on the other side of the access path (Map 1).

In the Garden site, located within the Nativescapes Garden exhibit, Garden Transect 1 is a 25 meter linear transect along the pathway of the coastal sage scrub plant community exhibit. Garden Transect 2 is a 25 meter linear transect located along the pathway of the chaparral plant community exhibit (Map 2).

Results

Native versus non-native pollinator diversity

We are examining the relative abundance of native and non-native pollinators in both our Garden and Natural sites. As the blooming season for CSS habitat has only begun in March, we have positive data for the Garden site, but not enough for the Natural site to analyze statistically.

At the end of the study we will compare the Natural and Garden site data to note any statistically significant variability between them, to determine if there is any effect on pollinating activity that may be correlated to the level of human presence or activity.

Currently at both sites we have minimal activity. The first 6 months of data collection consist of 128 interactions at both sites. At the Biodiversity Reserve we have experienced only 6 interactions, all from the order Diptera. Frequent observations of Diptera not interacting with flowering plants have been observed at the Biodiversity Reserve. The species that have been noted to frequent the Biodiversity Reserve but not interact are from the family *Sarcophagidae* and *Calliphoridae*.

There have been 122 interactions at the Nativescapes Garden. Of these 122 interactions, 23 involved native insects, accounting for 19% of interactions. The remaining 99 interactions were non-native insect pollinators, accounting for 81% of total interactions. The European honey bee (*Apis mellifera*) accounted for 96 of the 99 non-native interactions . The most common native insects at the Nativescapes Garden are native bees from *Clade Anthophila*, and insects from the order *Syrphidae*, specifically hover flies.

At the Nativescapes Garden there were frequent blooms from several plant species. Black sage (*Salvia mellifera*) received the majority of native and non-native pollinator interactions. There were a total of 40 pollinator interactions with black sage (*Salvia mellifera*), making up 33% of all interactions at the Nativescapes Garden transects. The other 67% of pollinator interactions came from other plants listed in the plant list (Table 1). Plants at the Nativescapes Garden began blooming on October 29, 2021, and plants at the Biodiversity Reserve began to bloom on February 11, 2022.

Discussion

Differences in start of blooming season

Winter dormancy and lack of blooms are expected in CSS between November and February (Cleland et al., 2016), and this has been true at both our Garden and Natural site. We have noted the start of blooming and pollinator activity has been later at the Natural site, with a few blooms beginning in late February and early March. At the Garden site, we saw greater number of blooms and pollinator activity beginning earlier, at the start of February.

Native vs non-native insect pollinators

Native pollinators account for a small percentage of the total pollinator interactions at the Nativescapes Garden. Non-native pollinators, particularly *A. mellifera*, are out-competing the native pollinators in obtaining floral resources, resulting in putting more pressure on the native pollinators who depend on the native plant species for survival.

We expect to see increasing pollinator activity at the Natural site as the blooming season gets underway. We have noted that flies from the order Diptera frequent the area, and these types are common in areas with animals and agriculture, such as we find in this area. While these flies are known to feed on nectar, we suspect that they are being drawn away from the flowers and distracted by our presence and movement in the area. It still remains to be seen if there is variability between the Natural and Garden sites in terms of the effect of human activity on pollinating insect activity. To determine this we will use the full 12-month's data when complete to look at the differences between species richness, evenness, and interaction frequencies at both sites. After a full year of monitoring data, we will also have compiled a survey of insect pollinators associated with CSS in San Diego County, which currently is not available in the literature.

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Appendix

Table 1: Plant and transect list for Garden site

Plant List: The Nativescapes Garden			
Transect 1 *Coastal Sage Scrub habitat within the Nativescapes Garden*			
# of Plants	**Common Name**	**Scientific Name**	**Plant Code**
Up to 5	Sages (choose from any that are blooming)	*Salvia spp.*	
	White Sage	*Salvia apiana*	SAAP
	Cleveland Sage	*Salvia clevelandii*	SACL
	Black Sage	*Salvia mellifera*	SAME
5	California Buckwheat	*Eriogonum fasciculatum*	ERFA
5	Bush Sunflower	*Encelia californica*	ENCA
2	Bush Monkeyflower	*Mimulus aurantiacus*	MIAU
2	Coyote Bush	*Baccharis pilularis*	BAPI
2	California Sagebrush	*Artemisia californica*	ARCA
2	Chamise	*Adenostoma fasciculatum*	ADFA
2	Bush Rue	*Cneoridium dumosum*	CNDU
Total plants: 25			

Transect 2 *Chaparral habitat within the Nativescapes Garden*			
# of Plants	**Common Name**	**Scientific Name**	**Plant Code**
5	California Buckwheat	*Eriogonum fasciculatum*	ERFA
5	Bush Sunflower	*Encelia californica*	ENCA
2	Bush Monkeyflower	*Mimulus aurantiacus*	MIAU
1	Coyote Bush	*Baccharis pilularis*	BAPI
2	Black Sage	*Salvia mellifera*	SAME
3	Menzies' Goldenbush	*Isocoma menziesii*	ISME
3	Laurel Sumac	*Malosma laurina*	MALA
2	Chamise	*Adenostoma fasciculatum*	ADFA
1	California Sagebrush	*Artemisia californica*	ARCA
1	Bush Rue	*Cneoridium dumosum*	CNDU
2 Anywhere on site	Narrow Leaf Milkweed	*Asclepias fascicularis*	ASFA
2 Anywhere on site	California Poppy	*Eschscholzia californica*	ESCA
Total plants: 29			

Table 2: Plant and transect list for Natural site

Plant List: Biodiversity Reserve			
Transect 1 *West facing slope on the left side of the vehicle trail*			
# of Plants	**Common Name**	**Scientific Name**	**Plant Code**
5	Chamise	*Adenostoma fasciculatum*	ADFA
5	White Sage	*Salvia apiana*	SAAP
5	California Sagebrush	*Artemisia californica*	ARCA
2	Menzies' Golden Bush	*Isocoma menziesii*	ISME
3	Bush Rue	*Cneoridium dumosum*	CNDU
5	California Buckwheat	*Eriogonum fasciculatum*	ERFA
Total plants: 25			
Transect 2 *South facing slope on the right side of the vehicle trail*			
# of Plants	**Common Name**	**Scientific Name**	**Plant Code**
1	Brickle Bush	*Brickellia californica*	BRCA
14	California Buckwheat	*Eriogonum fasciculatum*	ERFA
3	Laurel Sumac	*Malosma laurina*	MALA
7	Prickly Pear	*Opuntia chlorotica*	OPCH
Total plants: 25			

Table 3: Insect list with common and scientific names and monitoring codes

Insect Code Name & Order	Insect Common Name
ODON (Odonata)	Dragonflies, Damselflies
ORTH (Orthoptera)	Grasshoppers, Katydids, Crickets
PHAS (Phasmatodea)	Stick-Insects, Walking Sticks
COLE (Coleoptera)	Flower longhorn beetle, Tumbling Flower Beetle, Stink Beetle, Darkling Beetle, Black Rain Beetle, Asian Lady Beetle, Convergent Lady Beetle
HEMI (Hemiptera)	Aphids, Cicadas/ small milkweed Bug, Say's Stink Bug, Leafhopper
NEUR (Neuroptera) (Hymenoptera)	Lacewings Bees, wasps, ants
HANT (Clade Anthophila)	Carpenter bees, Digger bees, mining bees, leafcutter bees, Colletidae, Andrenidae, Halictidae, Melittidae
HAPI (*Apis Mellifera*)	Honey Bees
HBOM (*Bombus*)	Bumble Bees
HVES (*Vespidae*)	Yellow Jackets, Paper Wasps,
HSPH (*Sphecidae*)	Mud Daubers
HYME (Sphecidae)	Other Wasps
FONO (*Formicidae*) non-native	Argentine Ant, Red Imported Fire Ant
FONA (*Formicidae*) native	Large Red California Harvester Ant, Southern Fire Ant, Small Honey Ant/ Winter Ant, Field Ant, Odorous House Ant
LEPI (Lepidoptera)	Moths, Butterflies
DIPT (Diptera)	Flies
DSYR (*Syrphidae*)	Hover Flies, Flower Flies
DBBY (*Bombyliidae*)	Bee Flies
DASI (*Asilidae*)	Robber Flies
ARAN (Araneae)	All spiders
ARMA (Araneae)	Pill Bugs
MANT (Mantodea)	Mantids

Map 1: Garden Transects 1 and 2 at the SDSP Nativescapes Garden.

Map 2: Natural Transects 1 and 2 at the SDSP Biodiversity Reserve.