Temporal variation and effects of drought in coastal sage scrub plant-pollinator mutualisms

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Overview

The coastal sage scrub ecosystem of Riverside County is threatened due to agriculture and increasing urbanization (Minnich & Dezzani 1998). This ecosystem provides habitat for many rare and native plant species, which are monitored for conservation (MSHCP 2013). For management to be effective, it is valuable to consider multiple interactions and relationships within the ecosystem, such as proposed through the Multiple Species Habitat Conservation Plan (MSHCP 2003). One interaction particularly critical for plant conservation is the plant-pollinator relationship (Waser & Ollerton 2006). Pollinators play the essential role in plant reproduction for ~75% of floral plants globally, and this propagates plant populations (Committee on the Status of Pollinators in North America 2007). Therefore, pollinator management and identifying plant-pollinator relationships is necessary for maintaining a healthy ecosystem.

Research aims

Our research aims to support coastal sage scrub habitat and plant conservation by examining pollinators, particularly bees, which provide the essential ecosystem service of pollination. Our research goals are to: 1) Identify the plant-pollinator community of the coastal sage scrub habitat through continued sampling and expansion of study site locations to (a) examine the effects of drought on pollinator populations, and (b) capture temporal variation in plant and pollinator phenology; 2) Quantify the pollination requirements of selected plants of the coastal sage scrub community via both (a) field experiments and (b) manipulative greenhouse experiments.

Research methods and modifications

Objective 1: Identifying the plant-pollinator community of the Riverside coastal sage scrub habitat through continued and expanded sampling to (a) examine the effects of drought on pollinator populations, and (b) capture temporal variation in plant and pollinator phenology.

Methods: To first identify the pollinators present in the coastal sage scrub community (which has been understudied in southern California), we set out vane traps every three weeks during the winter season proceeding rainfall and continuing through peak bloom of several plant species. Vane traps are used to attract and collect insects (Rao et al. 2011). Vane traps were placed in 9 key sites at Motte Rimrock Reserve in Perris, CA. The 9 sites were selected based on the dominate presence of key plant species we focused on for this study (see Table 1). The vane trap collections will allow us to correlate pollinator communities with plant species present at each site, via multivariate analysis.

Table 1: *Sites sampled for pollinators at Motte Rimrock Reserve, and dominate flower species at each site.*

	Site name	Dominant plant species
1	CA broom patch	*Acmispon glaber*
2	Annual patch	*Calandrinia ciliata, Cryptantha sp.*
3	Buckwheat Gully	*Eriogonum fasciculatum*
4	Cactus patch	*Opuntia parryi*
5	Goldfield site	*Lasthenia californica*
6	Hilltop site	*Phacelia minor, Solanum xanti*
7	Poppy field	*Eschscholzia californica*
8	Sage site	*Salvia mellifera*
9	Squash patch	*Cucurbita palmate*

In addition, we collected pollinators directly from plants to record direct plant-pollinator interactions. This will be used to construct a plant-pollinator network to identify how the plant and pollinator community interacts with each other, and changes overtime (Bascompte & Jordano 2007).

Objective 2: Quantify the pollination requirements of selected plants of the coastal sage scrub community via both (a) field experiments and (b) manipulative greenhouse experiments.

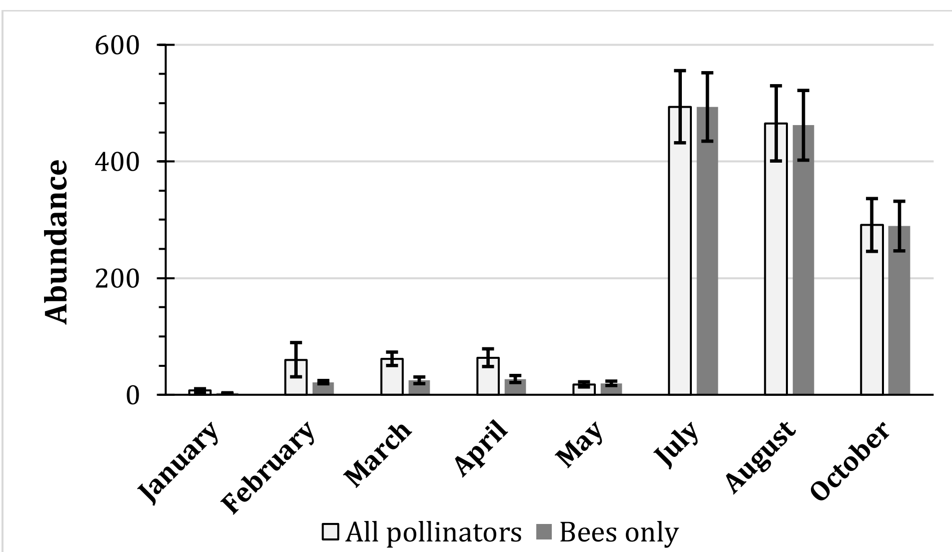
Methods: To measure the contribution of pollinators to plant reproduction, we excluded pollinators from flowers of select plants in the coastal sage scrub community. To exclude pollinators, ten flower buds were bagged using fine-meshed bags for medium to large flowers, or fine-mesh tents were erected over complete plants of small flowers (Kearns & Inouye 1993). Flowers were allowed to open and continue blooming within the bags. Upon plant seed-set, seedpods will be collected from bagged and adjacent unbagged plants to statistically compare seed set of pollinator-excluded and pollinator-accessible plants. This will allow us to evaluate the contribution of pollinators to reproductive success of coastal sage scrub plants. Reproductive success will be related to the pollinator community present at each site (as describe in Obj. 1) to identify potential pollinators.

Modifications: We originally planned to measure pollination efficiency by observing pollinators visiting flowers and subsequently limiting pollination (i.e. allowing 3, 6, or 12 pollinator visits before bagging flowers and relating visitation number to seed set). However, although we have found floral visitor diversity at our research sites, bee visitation activity has been low so we had to modify the methods to address our objective. Instead, we used the bagged vs. unbagged flower method described above to measure the value of insect-mediated pollination without measuring visitation rate, because of low bee activity at the sites.

Progress, to-date

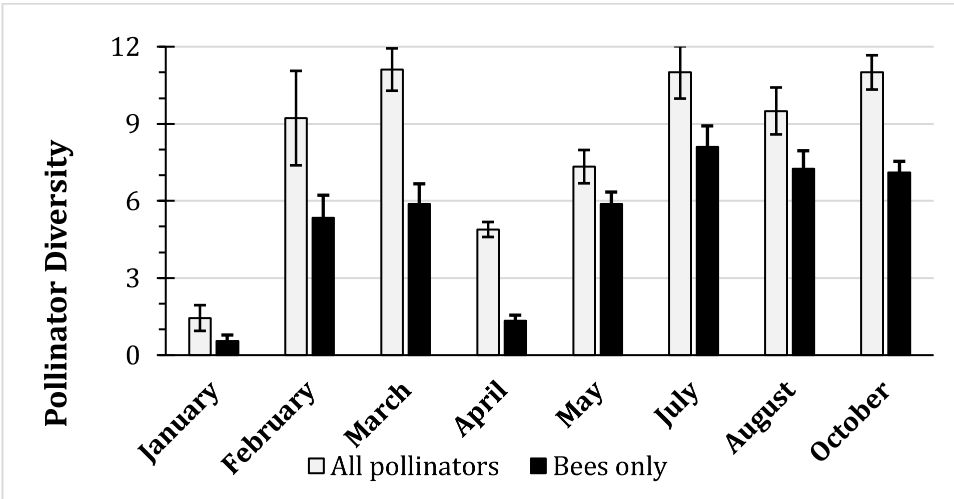
Total pollinator abundances were lowest in January through May with highest numbers collected in summer and fall months. We also observed a peak in pollinator diversity in late spring and a decline in diversity as floral resources decline throughout the summer and fall.

Figure 1*: Average number of pollinators collected from vane traps each month (2015)*



Bee abundance was highest in the warmer months, mostly due to large numbers of small bees including *Agapostemon*, *Andrena* and *Augochlora* species that did not appear in large numbers until July. Total pollinator and floral visitor abundance also increased over the summer coinciding with the emergence of many wasps, including *Polistes* sp. and *Vespula pensylvanica*, which are nectarivorous as adults. Due to the large number of pollinators, we are continuing to process samples from November and December 2015 and spring 2016.

Figure 2: *Pollinator diversity by month for all pollinators and for bees only (2015)*



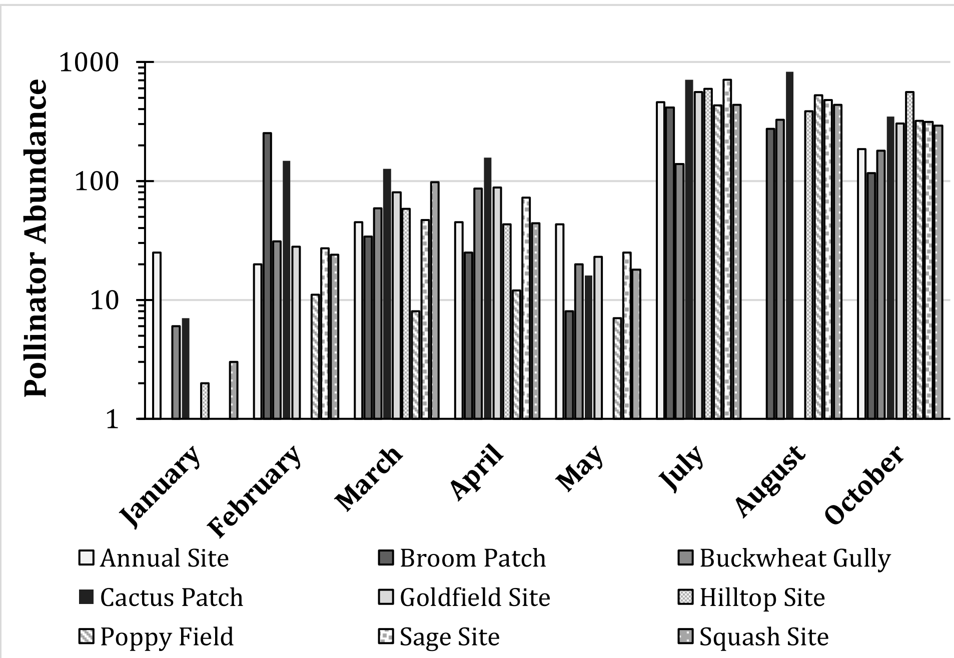
Pollinators have been preliminarily categorized into morpho-species groups, and will later be identified to the species level prior to multivariate analyses (Table 2).

Table 2: *Pollinators collected from vane traps, identified by morpho-species categories*

	Order	**Morpho-species ID**	**Common name**
1	Coleoptera	small Coleoptera	small black beetle
2	Coleoptera	ladybird beetle	ladybird beetle
3	Diptera	small house fly	small house fly
4	Diptera	small Diptera	small fly
5	Diptera	small syrphid	small flower fly
6	Diptera	large muscid	house fly
7	Diptera	Bombyliidae	bee fly
8	Hemiptera	Hemiptera	true bug
9	Hymenoptera	*Anthidium* sp.	wool carder bee
10	Hymenoptera	Vespidae	wasp
11	Hymenoptera	*Polistes* sp.	paper wasp
12	Hymenoptera	*Vespula pensylvanica*	western yellowjacket
13	Hymenoptera	Halictid	sweat bee
14	Hymenoptera	small Halictid	small sweat bee
15	Hymenoptera	*Andrena* sp.	mining bee
16	Hymenoptera	*Melissodes* sp.	long-horned bee

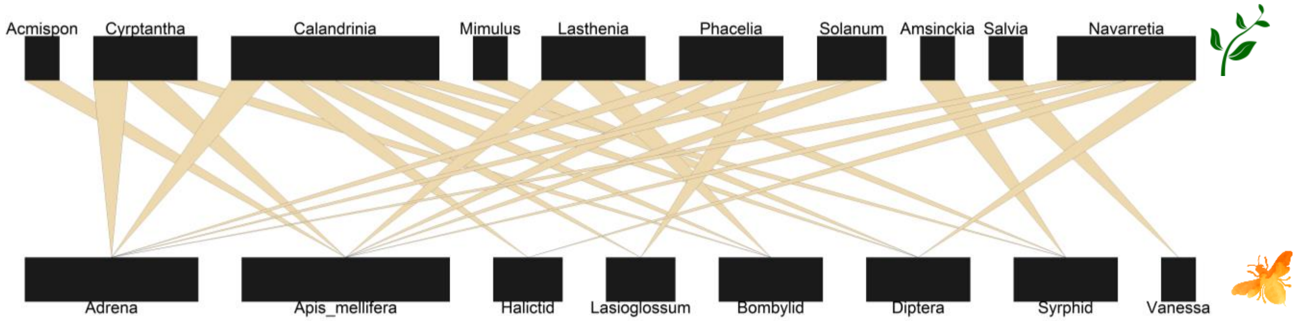
17	Hymenoptera	*Apis mellifera*	honey bee
18	Hymenoptera	green Halictid	green sweat bee
19	Hymenoptera	*Xylocopa* sp.	carpenter bee
20	Hymenoptera	*Diadasia* sp.	cactus bee
21	Hymenoptera	*Bombus* sp.	bumble bee
22	Hymenoptera	*Lasioglossum* sp.	small sweat bee
23	Hymenoptera	*Agapostemon* sp.	small sweat bee
24	Hymenoptera	*Augochlora* spp.	green sweat bee
25	Lepidoptera	Lepidoptera	moth
26	Lepidoptera	Sphingidae	hawk moth
27	Lepidoptera	*Vanessa* sp.	brush-footed butterfly

Figure 3: *Pollinator abundance by site, each month shown on a log scale (2015).*



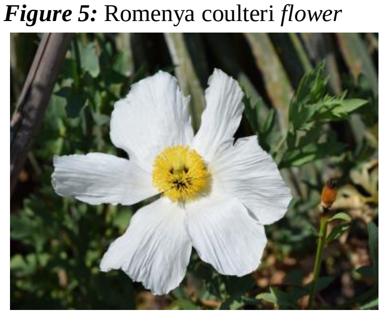
Based on collecting pollinators directly from plants to document plant-pollinator interactions, we have completed preliminary network analyses to identify the interactions of the plant-pollinator community, see Figure 4 for example. All analyses will be completed following pollinator species-level identification and seed count to produce publications and species lists (see *Outputs*).

Figure 4: *Plant-pollinator network of interacting species at Motte Rimrock. The network is constructed similar to a classic "food web" with only two levels. Here, pollinators are listed on the bottom of the network, and plants listed at the top, where the length of the (black) blocks represents the relative number of interactions observed per individual species (i.e. the larger the block, the more interactions observed. The tan lines connecting pollinators and plants represent the interactions observed.*



We also assessed the services provided by wild pollinators by setting up a series of pollination experiments on native and rare plants. For *Romneya coulteri* (Fig. 5), we paired bagged floral buds (pollinator-excluded), and pollinator-accessible (no bag or tent) floral buds during peak bloom and observed the effect of pollinator visitation on subsequent seed set. *R. coulteri* blooms exposed to pollinator visitation had 17-fold higher mean seed mass ($F_{1,27} = 265$, $p < 0.0001$), 7% longer seed pods ($F_{1,26} = 2.98$, $p = 0.10$), and 19-fold higher seed set per pod ($F_{1,27} = 324$, $p < 0.0001$) than did *R. coulteri* blooms that were bagged and only permitted to self-pollinate.

Figure 5: Romenya coulteri *flower*



For *Camissonia bisorta* (Fig. 6), permitting pollinators access to flowers resulted in 14-fold higher seed set than when pollinators were excluded (32.8 ± 9.4 seeds vs 2.3 ± 0.9 seeds, respectively). While overall seedset was significantly affected by opening access of flowers to pollinators ($F_{1,12} = 41.0$, $p < 0.0001$), there was no difference in floral display between plants in the bagged (pollinator excluded) and open (pollinators permitted) treatments (4.6 ± 0.8 flowers vs 3.5 ± 0.4 flowers, respectively, $F_{1,12} = 2.8$, $p = 0.12$).

Figure 6: Camissonia bisorta *flower.*

We currently have similar experiments ongoing for *Acmispon glaber*, *Phacelia minor,* and *Satureja chandleri.* Collectively, these experiments will provide a quantification of how important pollination services are to the native and rare species that comprise our Riversidian sage scrub communities.

Outputs

1) Publication of bee and pollinator records and plant-pollinator interactions

- This will provide a published record of pollinators associated with coastal sage scrub found in Riverside County, which may inform future coastal sage scrub management
- We will highlight any new species records for Riverside County, and the unique inland coastal sage scrub community
- We anticipate submitting the resulting manuscript to *Pan Pacific Entomologist*

2) Bee species list for Motte Rimrock Reserve
- This will aid future researchers and is a valuable contribution to this relative young UC Natural Reserve
- List will include all observed floral relationships

3) Present findings at scientific conferences and share results with conservation organizations
- Plant-pollinator interaction information can be used by plant conservation organizations such as California Native Plant Society and insect conservation organizations, such as Xerces Society for Invertebrate Conservation to promote native floral plantings and habitat management to support pollinators, which contribute to a healthy ecosystem

4) Training for UC Riverside undergraduates
- We will continue scientific training of 3-4 UC Riverside undergraduates
- This provided mentoring and management experience for postdoctoral researcher (lead PI)

References

Bascompte J, Jordano P (2007) Plant-Animal Mutualistic Networks: The Architecture of Biodiversity. *Annual Review of Ecology, Evolution and Systematics.* **38,** 567-593.

Committee on the Status of Pollinators in North America NRC (2007) *Status of Pollinators in North America*. National Academy Press.

Kearns CA, Inouye DW (1993) *Techniques for Pollination Biologists*. University of Texas Press.

Minnich RA, Dezzani RJ (1998) Historical decline of coastal sage scrub in the Riverside-Perris Plain, California. *Western Birds*, **29**, 366–391.

MSHCP WRC (2003) Multiple Species Habitat Conservation Plan.

MSHCP WRC (2013) Western Riverside County Multiple Species Habitat Conservation Plan (MSHCP). *Western Riverside County Regional Conservation Authority*.

Rao S, Stephen WP, Kimoto C, Debano SJ (2011) The Status of the “Red-Listed” Bombus occidentalis (Hymenoptera: Apiformes) in Northeastern Oregon. *Northwest Science*, **85**, 64–67.

Waser NM, Ollerton J (2006) *The Ecological Consequences of Complex Topology and Nested Structure in Pollinator Webs* (NM Waser, J Ollerton, Eds,). University Of Chicago Press.