Leveraging local efforts to solve regional-scale ecological questions: using multiple sources of data and a multi-species occupancy model to explore bee-plant interactions

**Running title:** Multi-species occupancy model for interactions

Authors: Michelle J. Lee1☨, Graziella V. DiRenzo2☨, Yolanda Diao3, & Katja C. Seltmann3\*

1 Ecology, Evolution and Marine Biology, University of California Santa Barbara, USA

2 U.S. Geological Survey, Massachusetts Cooperative Fish and Wildlife Research Unit, University of Massachusetts Amherst, USA

3 Cheadle Center for Biodiversity and Ecological Restoration, University of California Santa Barbara, USA

☨ Both authors contributed equally to leading this study

\* Corresponding author; email seltmann@ucsb.edu

**Target journal:**

Methods in Ecology & Evolution - Research article (7000-8000 words)

Ecological Applications - 60 page max

**Competing interest statement**

We have no competing interests.

*This draft manuscript is distributed solely for purposes of scientific peer review. Its content is deliberative and predecisional, so it must not be disclosed or released by reviewers. Because the manuscript has not yet been approved for publication by the U.S. Geological Survey (USGS), it does not represent any official USGS finding or policy.*

*Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government.*

**Abstract (350 words max)**

1: Bees are declining globally, imperiling many ecosystem services they provide, such as plant pollination. Unfortunately, many bee-plant interactions are understudied, producing an incomplete picture of system-level losses resulting from bee declines. Today, we have the opportunity to learn more about bee-plant interactions via opportunistic data coalesced across natural history collection records, published ecological datasets, and community science initiatives in online databases, such as GloBI (Global Biotic Interactions).

2: Here, we used the GloBI database, curated local checklists of bee and flowering plant species, phenology data, and a multi-species occupancy model (MSOM) alongside stochastic search variable selection to explore hypotheses related to bee-plant interactions and detection processes. Accounting for some forbidden links (unobservable interactions), we hypothesized that leveraging bee and floral traits would impact the number and detection of interactions. We hypothesized that our MSOM approach would increase our understanding of network structure relative to the raw interaction occurrences, resulting in a more complete network and reflecting a more realistic depiction of bee-plant interactions.

3: We demonstrate the utility of our MSOM approach on an example bee-plant dataset from Santa Cruz Island. We found a strong effect of bee sociality on the probability of bee-plant interaction, where solitary bees had a lower probability of bee-plant interactions than non-solitary (i.e., social) bees. We did not find an effect of bee size, flower color, or flower shape on the probability of bee-plant interaction. We found a strong effect of source citation type and floral traits on bee-plant detection probability, where the probability of detecting a bee-plant interaction was much higher for observational citations (e.g., iNaturalist) than for natural history collections. Our modeled interaction network showed a higher level of evenness, nestedness, and specialization relative to the interaction network of raw GloBI occurrences.

4: Observations of species interactions dictate our ability to predict and protect ecosystem structure and function. Our study is the first to utilize occupancy modeling to better understand species interactions, leveraging aggregated, open-source databases and expert checklists. Our findings, while largely counterintuitive, stress the importance of investigating the effect of detection and collection biases on our understanding of ecological interactions.

**Keywords:** imperfect detection, occupancy modeling, community science, opportunistic data, presence-only, bee-plant interactions, pollinators, stochastic search variable selection, Santa Cruz Island, California, Global Biotic Interactions