Environmental Trends in the Distribution of California Bee Species

Jared T. Miller & Katja C. Seltmann

UCSB
UNIVERSITY OF CALIFORNIA
SANTA BARBARA

ABSTRACT

The distribution of bees can be estimated, in part, by environmental variables associated with geography. Using bee occurrence records, we quantified the estimated species richness of the EPA level 3 defined ecoregions using coverage-based rarefaction. Our study reveals that bee species richness is highest in ecoregions with warm dry summers. Furthermore, increased species richness was found to be significantly correlated with maximum mean temperature.

INTRODUCTION

Researchers have identified that bee diversity is driven by warm temperatures and low precipitation on a global scale (Orr et al. 2021). This project aims to assess whether bee species richness varies at the regional scale in the state of California and if increased species richness is associated with environmental variables.

METHODOLOGY

Occurrence data from the five local bee families was pulled from the Global Biodiversity Information Facility (GBIF) and the collaborative databasing of North American bee collections within global informatics network project (AMNH-BEE). This occurrence data includes both specimens from natural history collections as well as research grade observations. Bee occurrence data was filtered based upon error range and locality by removing any occurrences with more than one hundred meters of estimated error that did not retain a specified locality. To assure for taxonomic continuity, the Discover Life Bees species checklist was used to substitute the occurrence data's species names for the most recent taxonomic designations as of September 2022. Occurrence data was confined to the Environmental Protection Agency (EPA) level 3 ecoregions of California (Fig. 1).

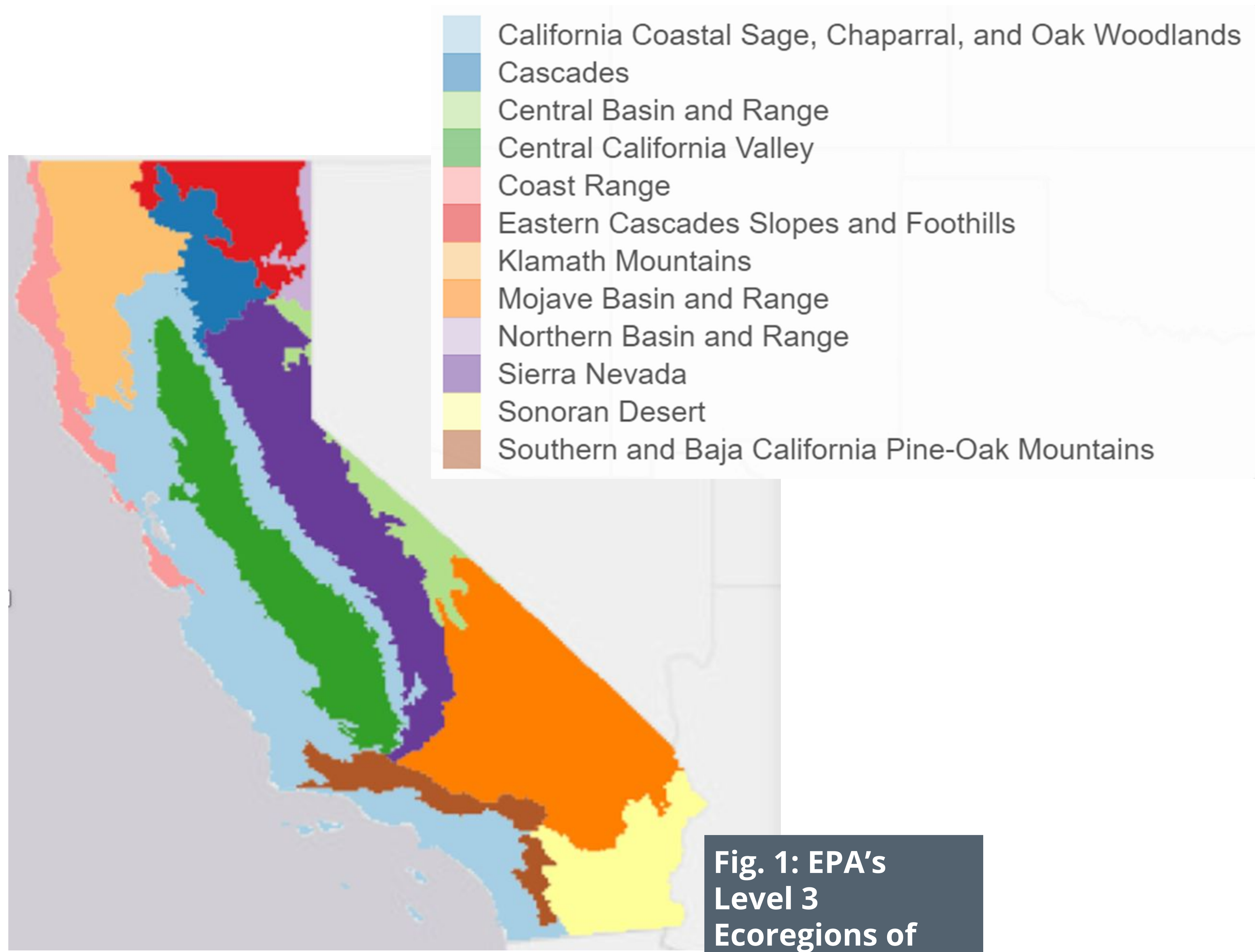

Fig. 1: EPA's Level 3 Ecoregions of California

To compare the species richness of bees between the 12 ecoregions, coverage-based rarefaction was performed. Coverage-based rarefaction estimates species richness based upon sample coverage rather than total number of samples, allowing for a more accurate comparison between regions with different sampling efforts. Within the ecoregion descriptions, summary statistics of the ecoregion's mean precipitation, mean maximum temperature, and mean minimum temperature were pulled and plotted with the estimated species richness for correlations. A Pearson's/Spearman's correlations tests were used to detect for significant relationships between the environmental variables and the ecoregion's estimated species richness.

RESULTS

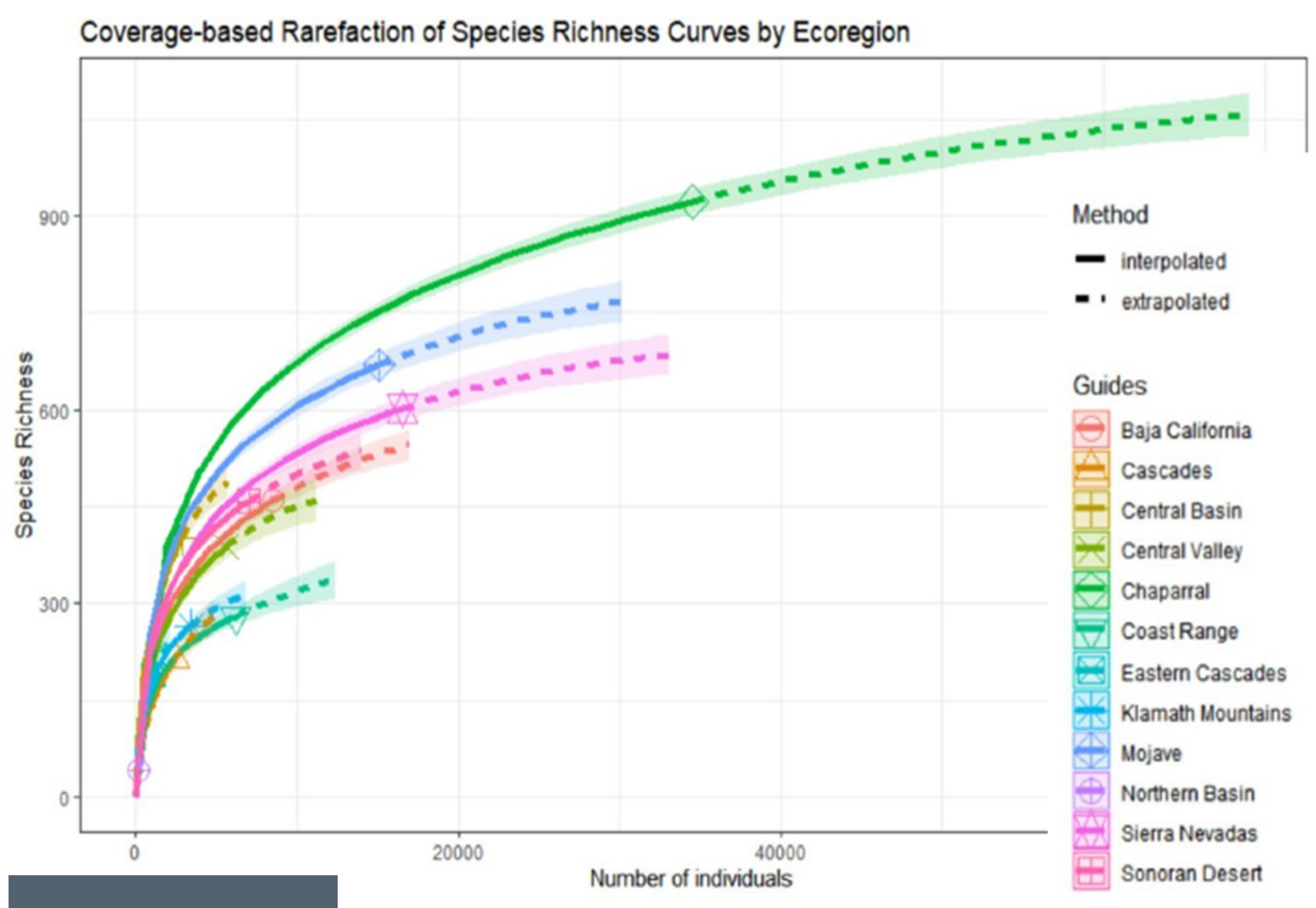

Fig 2. Coverage-based Rarefaction species accumulation curves.

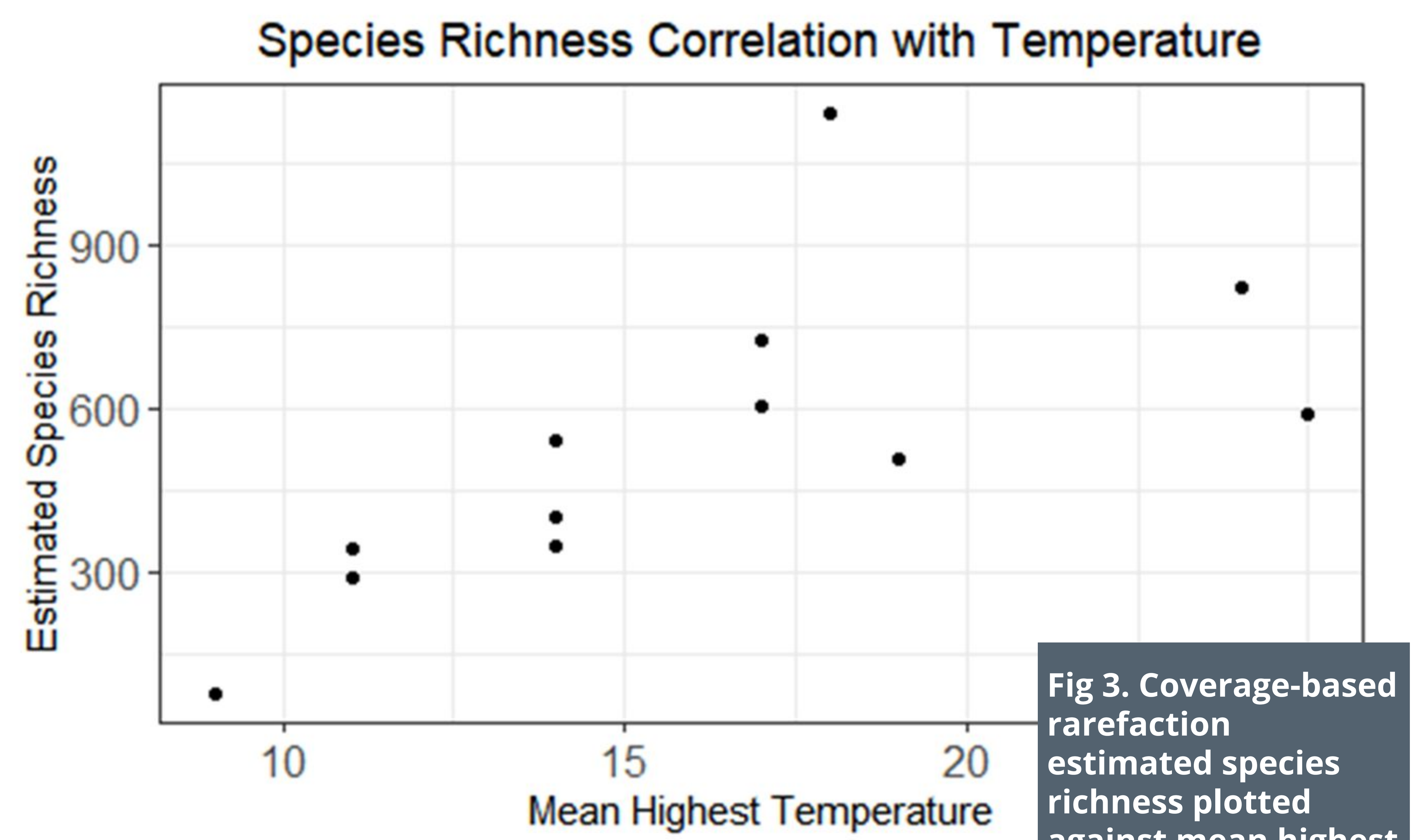

Fig 3. Coverage-based rarefaction estimated species richness plotted against mean highest temperature

Figure 2 and Figure 3 Demonstrate:

- A significant difference between ecoregions in species richness of bees as interpreted by the shaded 95% confidence intervals of the species accumulation curves in figure 2.
- The Coastal Sage, Chaparral, and Oak Woodlands ecoregion contains the most bee species in California, followed by the Mojave and Sierra Nevadas ecoregions (figure 2)
- A significant positive correlation between the ecoregions estimated bee species richness and mean maximum temperature (figure 3). P-value = 0.01742

DISCUSSION

Our findings suggest that bee species richness is highest in ecoregions associated with warm summers. The three ecoregions, the Coastal Sage, Chaparral, and Oak woodlands, the Mojave, and the Sierra Nevadas, contain significantly higher bee species richness compared to the rest of California. The presence of a significant positive correlation between estimated species richness of the ecoregions and their mean maximum temperature further suggests a positive relationship between warm temperatures and bee diversity at a regional scale. This finding provides support for recent global scale trends in bee diversity drivers (Orr et al. 2021). It is important to note however that bee species richness cannot be fully explained by warm temperatures. The Coastal Sage, Chaparral, and Oak woodlands ecoregion holds the highest diversity of bees, but does not have the highest mean maximum temperature. This could suggest that either there is a thermal peak in what drives bee diversity, or more likely, there are more environmental variables that control bee diversity associated with these ecoregions. One key difference between these ecoregions are their respective levels of urbanization. Interestingly, intermediate levels of urbanization has been found to contribute to increases in bee diversity (Fortel et al 2014), though this increase is rarer in other invertebrate taxa (Mckinney 2008). Intermediate levels of urbanization causes heterogeneity in environments, possibly opening up niches to be utilized by the bees. Another aspect that could drive bee diversity is the native flora associated with each ecoregion. Increased floral diversity would provide resources for oligolectic bees that specialize on pollen acquisition from select plant species. More research is needed to quantify how the present flora compares across California's ecoregions and how bees interact with them.

References:

Fortel L., Henry M., Guilbaud L., Guirao A. L., Kuhlmann M., Mouret H., Rollin O., Vaissiere B. E. 2014. Decreasing Abundance, Increasing Diversity and Changing Structure of the Wild Bee Community (Hymenoptera: Anthophila) along a Urbanization Gradient. Plos One. https://doi.org/10.1371/journal.pone.0104679

Mckinney M. L. 2008. Effects of urbanization on species richness: A review of plants and animals. Urban Ecosystems. 11: 161-176.

Orr M. C., Hughes A. C., Chesters D., Pickering J., Zhu C.D., Ascher J.S. 2021. Global patterns and drivers of bee distribution. Current Biology. 31: 3. 451-458.

This project was supported by the National Science Foundation projects Extending Anthophila research through image and trait digitalization (Big-Bee) project (DBI2102006) and the UCSB Undergraduate Research and Creative Activities (URCA) Grant

UC SANTA BARBARA Undergraduate Research & Creative Activities

NSF

CBER