BioSpace25 - Biodiversity insight from Space
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Vegetation structure and plant functional traits predict pollination networks at scale

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BioEO
Functional Biodiversity & Earth Observation Lab

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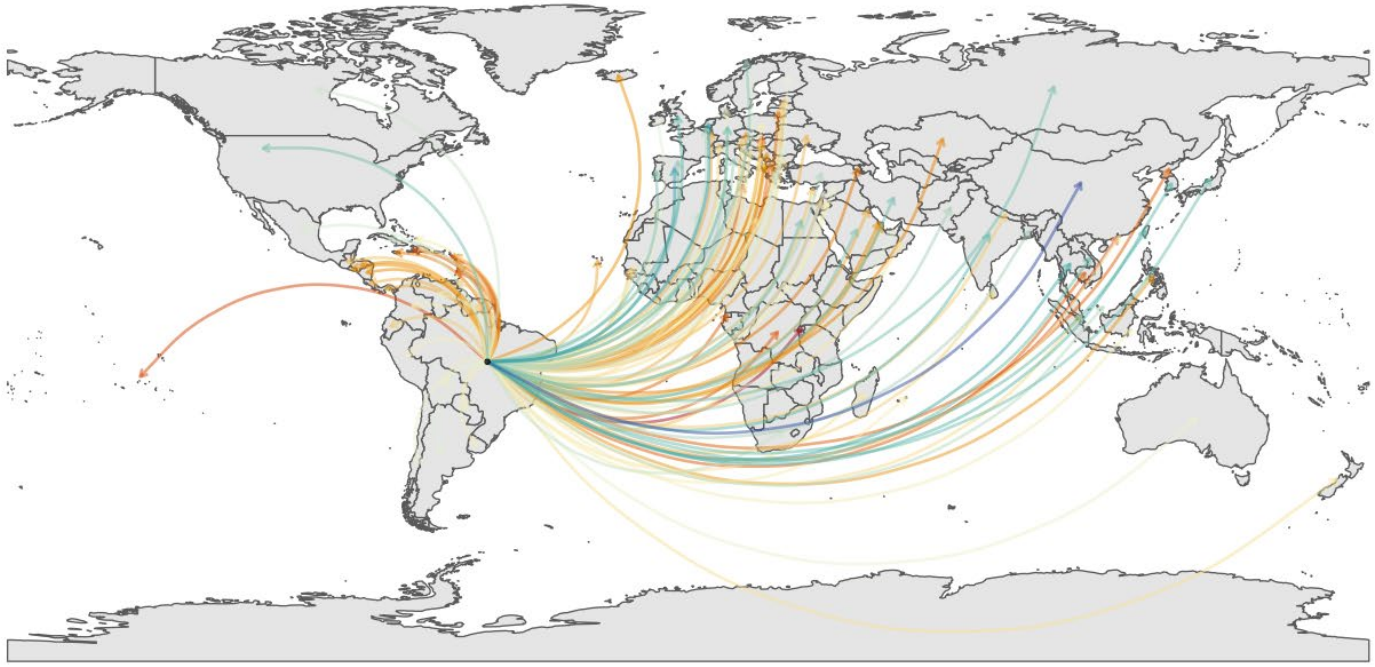
Pollinators are critical to ecosystem functions and crop production

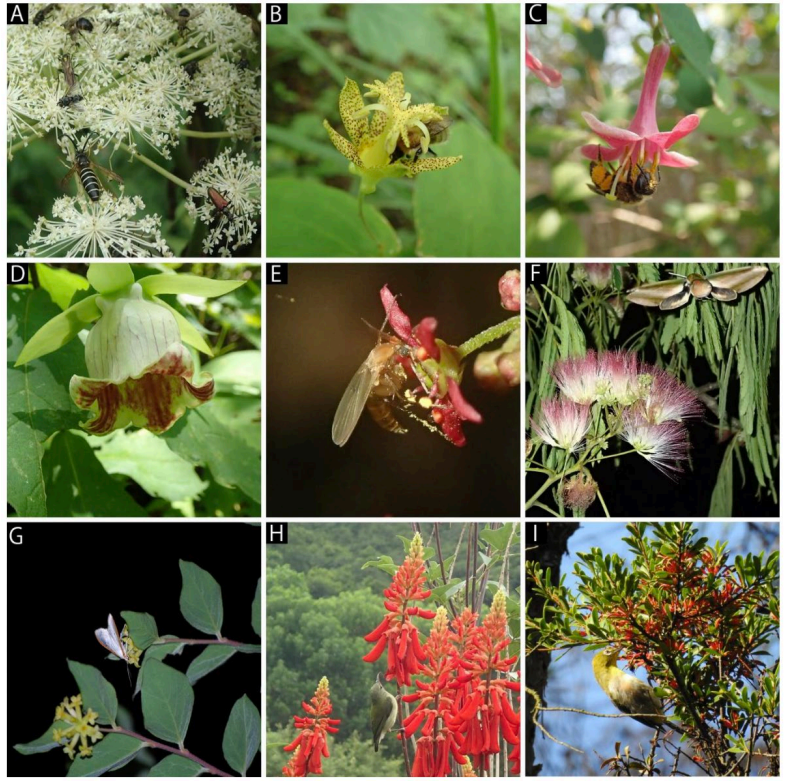


Virtual Biotic Pollination Flow
(color scheme applied to logarithmized values*)

16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0

* Check original values in the Data tab

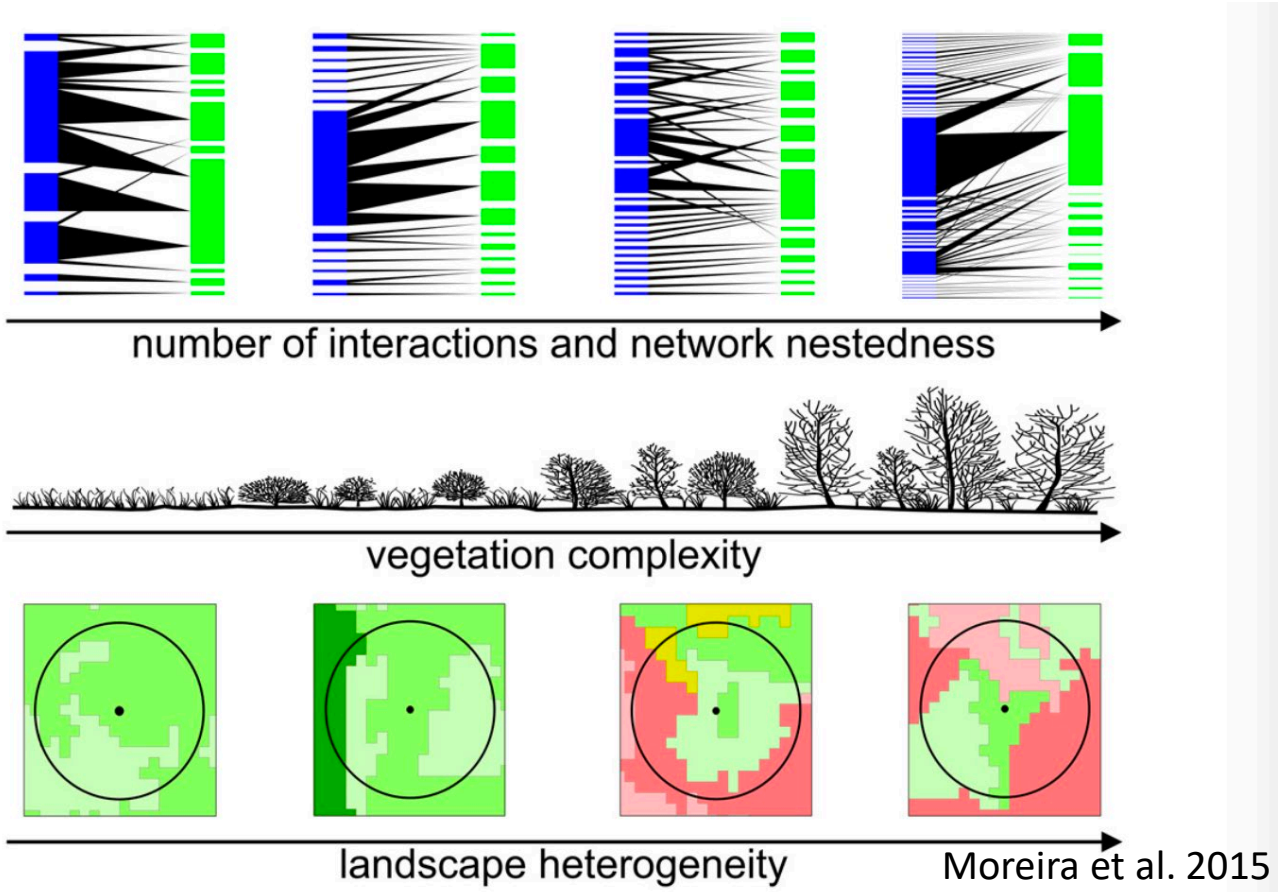
Original data on international market was obtained from www.fao.org/faostat/en/#data/TM



Map created using an interactive tool developed by Silva et al. (2021), photo from Funamoto et al. (2019).

Knowledge gap

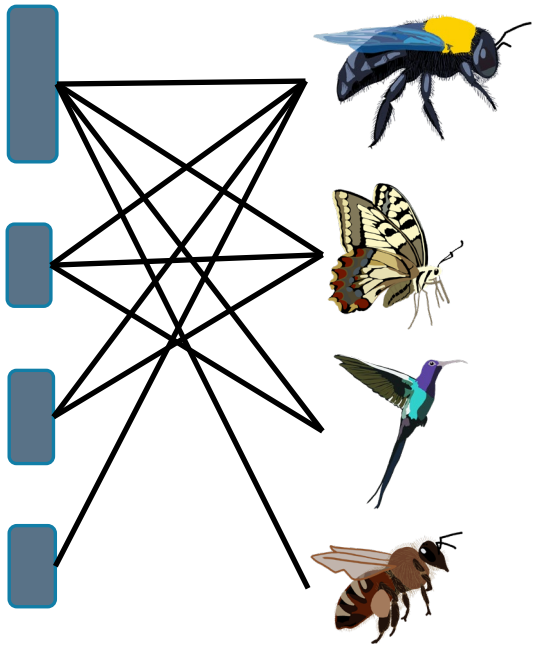
- The response of plant-pollinator networks to land use change and fragmentation has been well-studied
- **Yet little is known about the role of plant functional traits—beyond floral traits—in structuring plant-pollinator networks.**



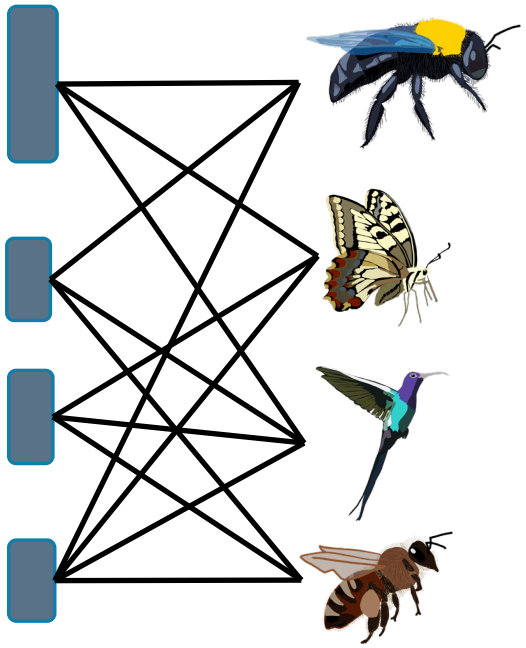
Moreira et al. 2015

Network metrics

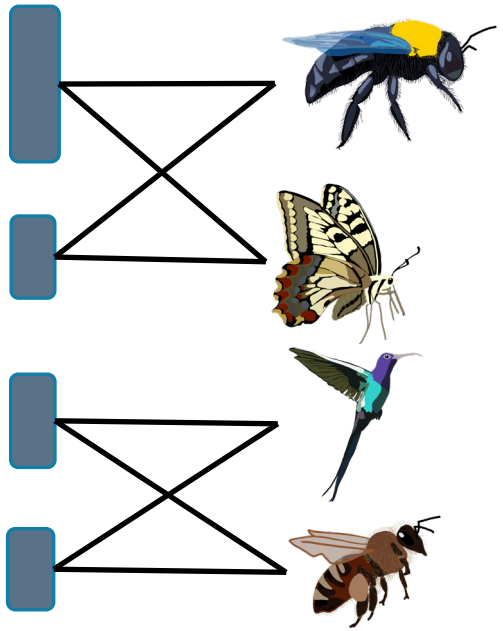
Nestedness



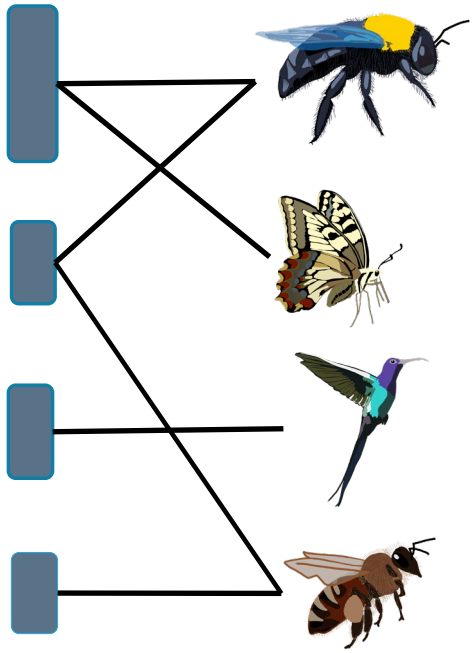
Connectance



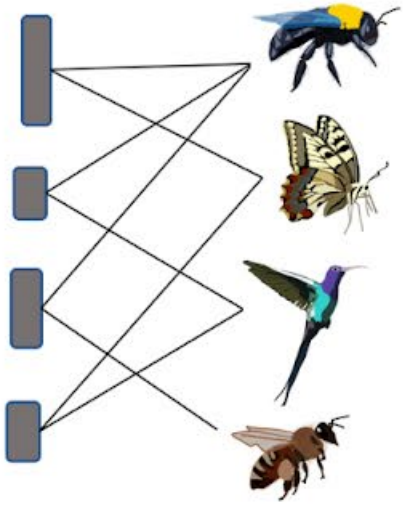
Modularity



Specialisation

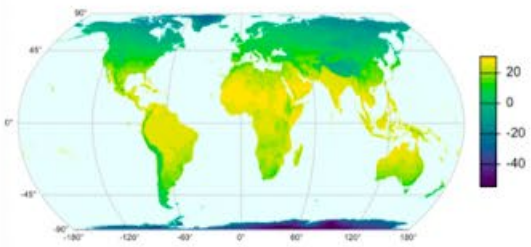


Tropical pollination networks



Network structure & resilience

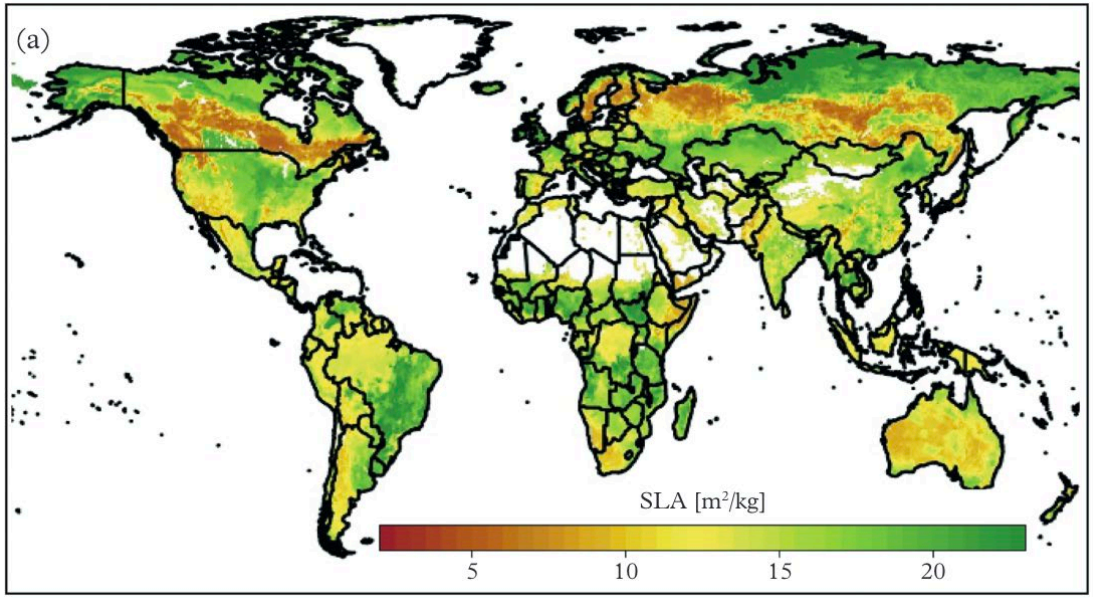
Plant functional traits

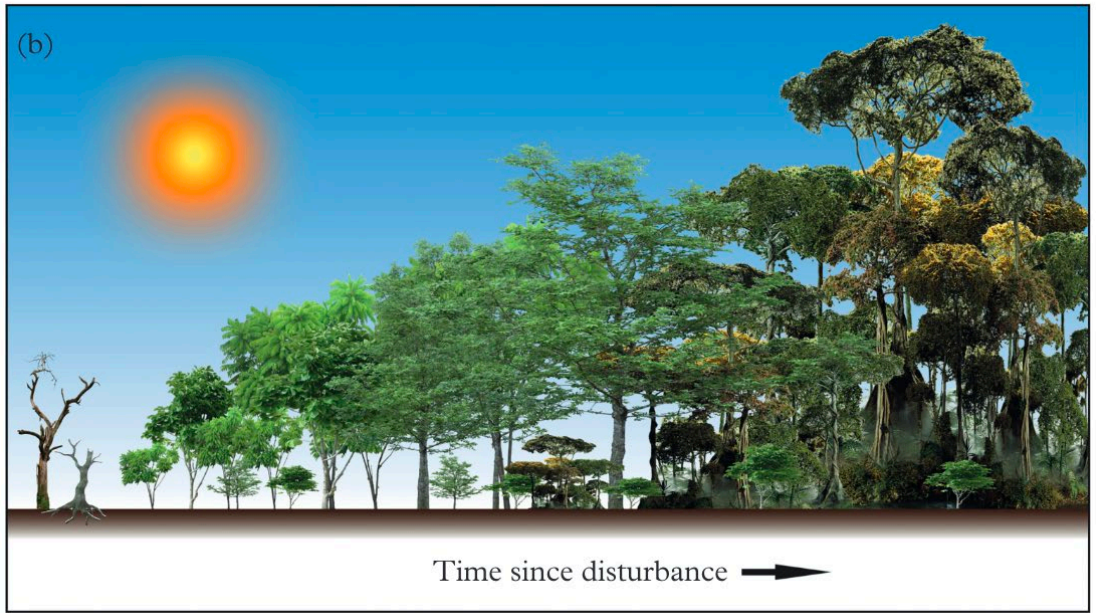


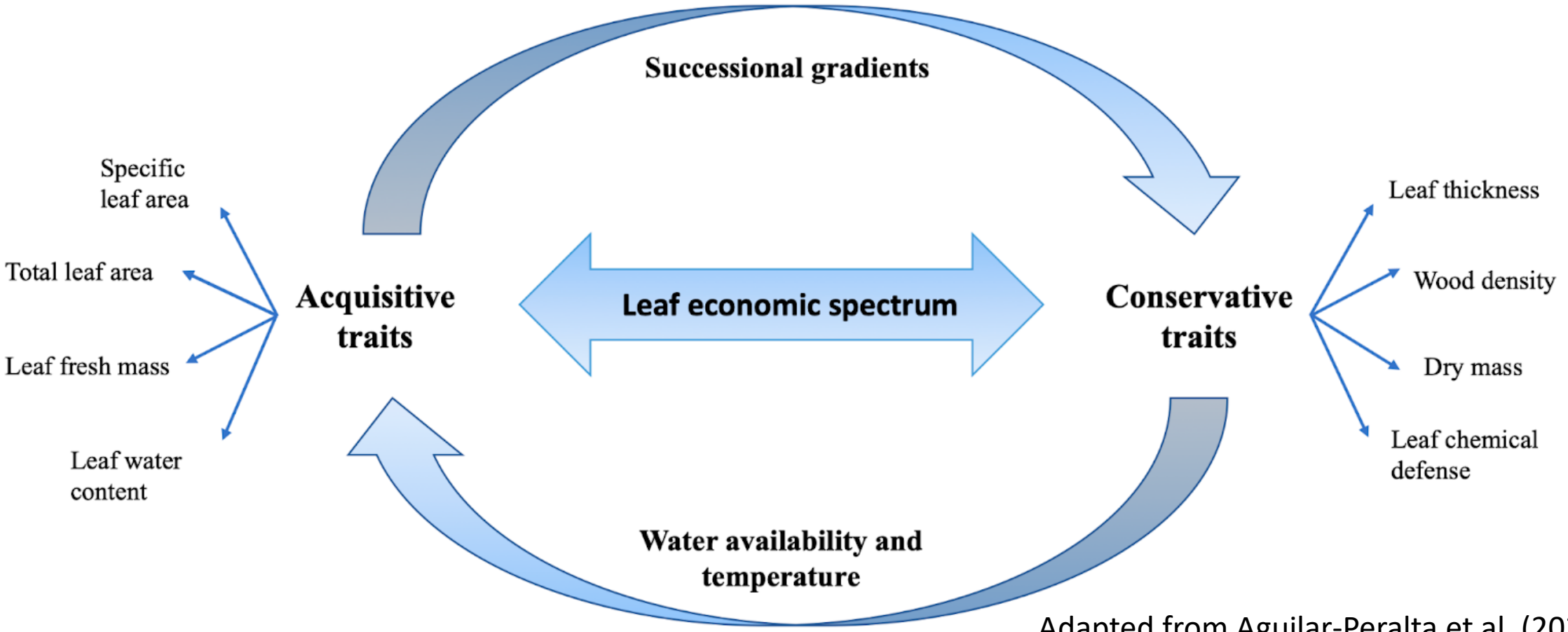
Environmental variables

What are plant functional traits?

- Plant functional traits can be considered part of plant's evolved responses to disturbances as well as climate and resource availability (nutrients and water).
- Plant functional traits make up *plant strategies* (Laughlin, 2023).

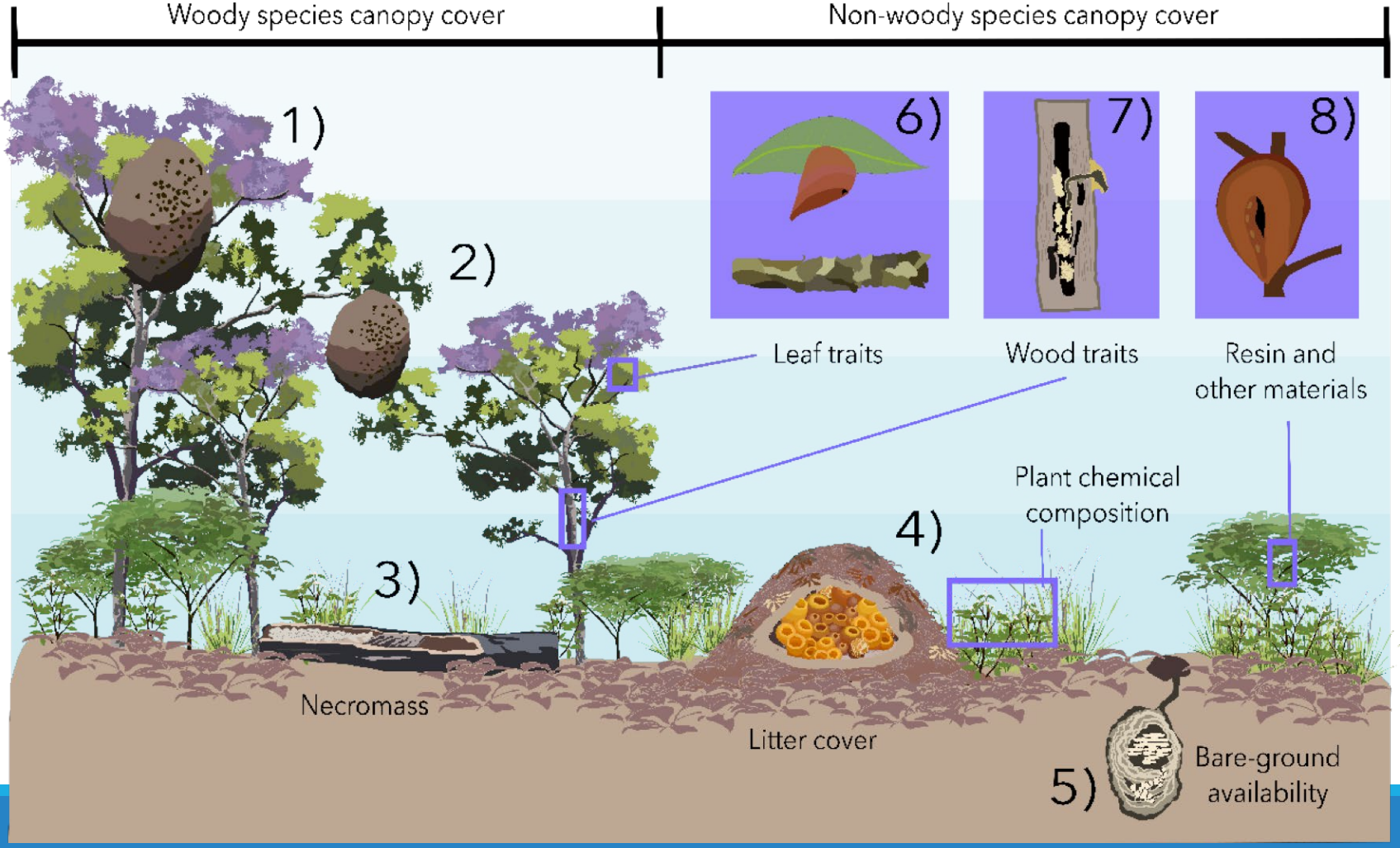






Adapted from Aguilar-Peralta et al. (2022)

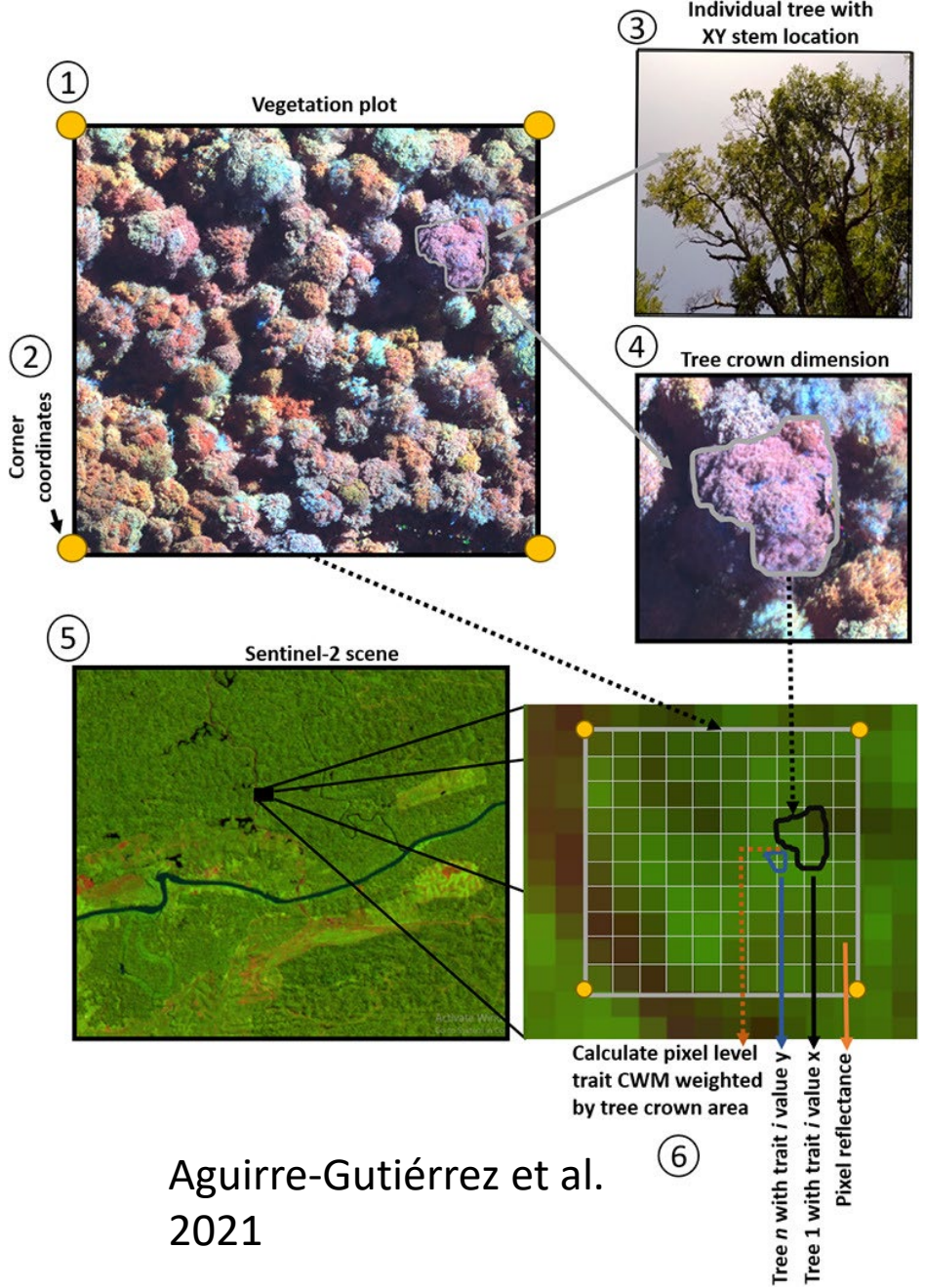
Plant functional traits and pollinator ecology



Machida et al. 2024, in review.

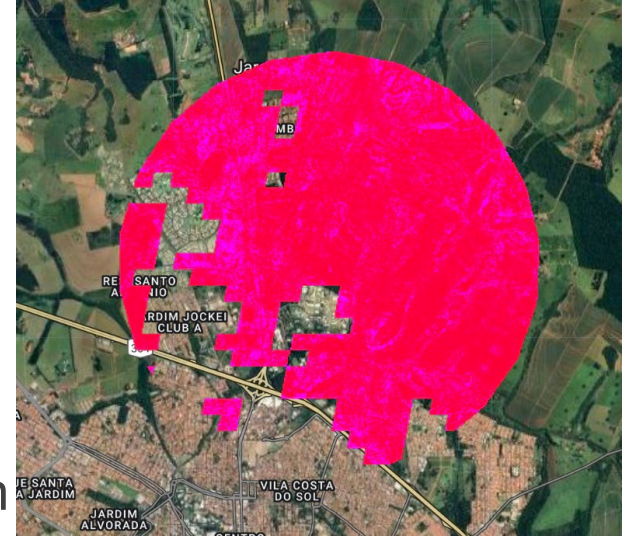
Remote sensing of plant functional traits

- One major knowledge gap has been how to predict plant functional traits at broad spatial scales (Jetz et al. 2016)
- We can now do this utilizing remote sensing techniques (Aguirre-Gutiérrez et al. 2021).



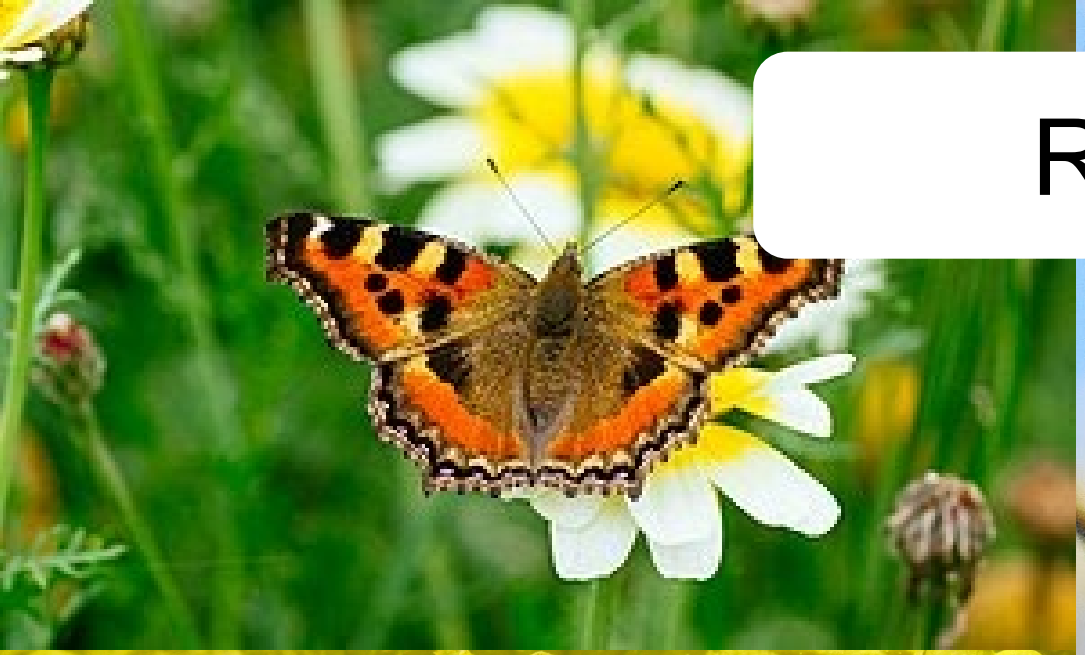
Aguirre-Gutiérrez et al. 2021

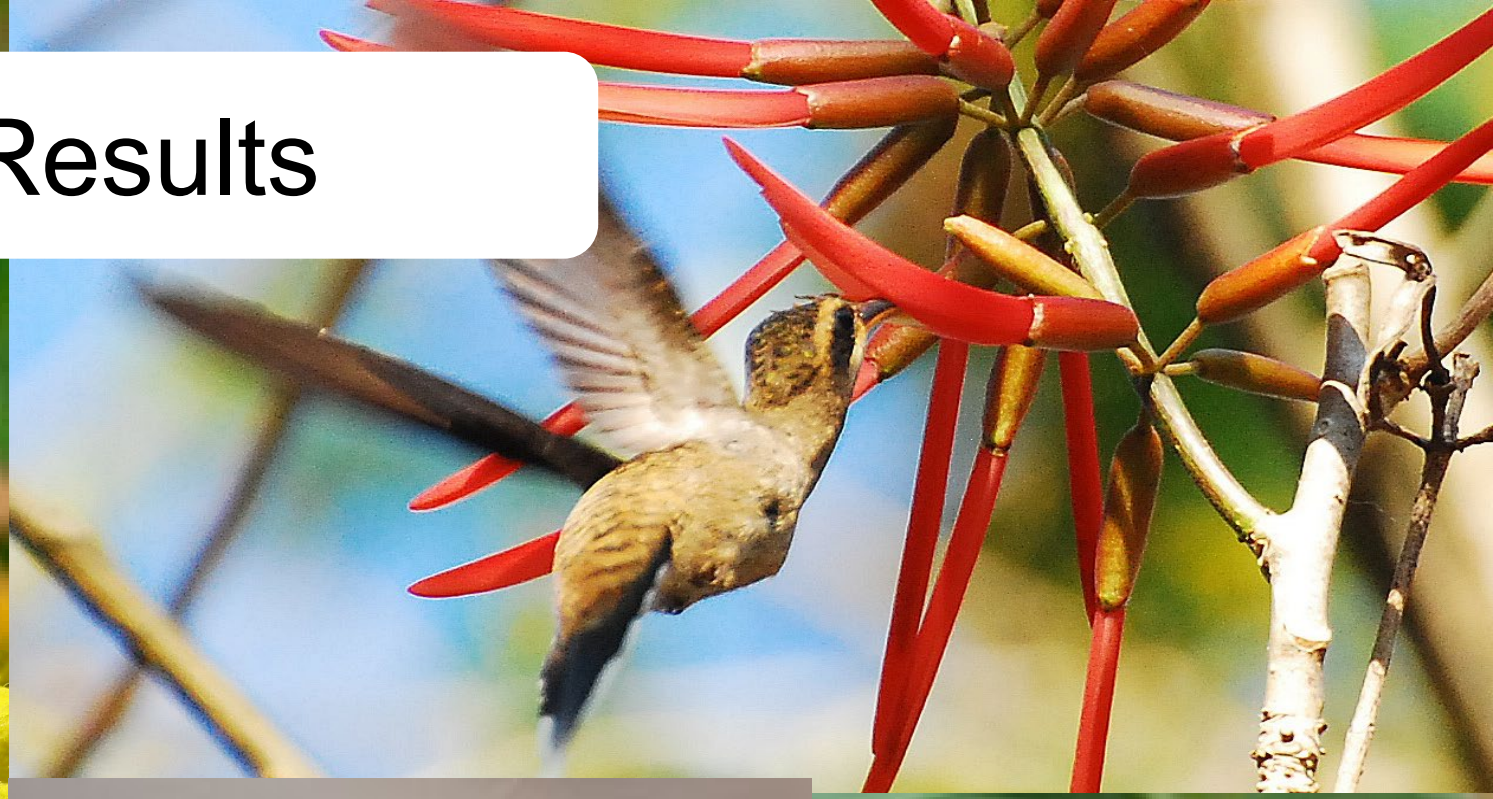
Methods



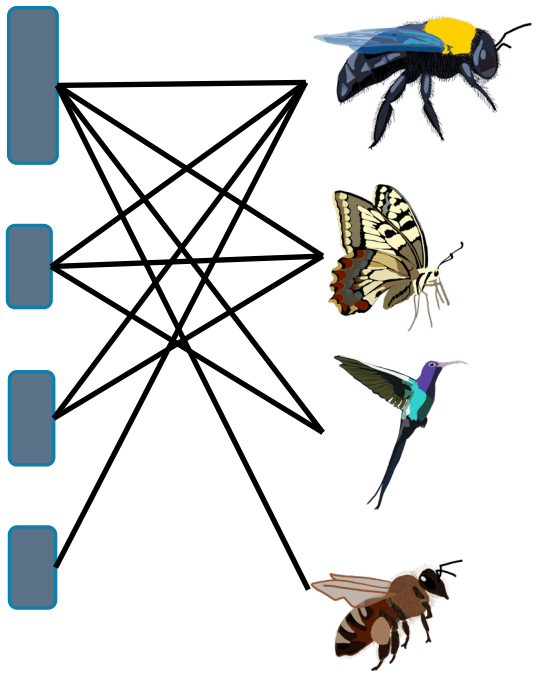
- Plant trait predictions (Aguirre-Gutierrez et al. 2021)
  - Combines **Sentinel-2 satellite remote sensing data, TerraClimate and Global Environmental Monitoring (GEM) database**, and high-resolution elevation data.
  - Vegetation structure: **LiDAR** from GEDI
  - Calculated plant trait (mean and SD) in 3km buffer zone around each pollination network using **Google Earth Engine**.
- Plant-pollinator network data
  - **209 plant-pollinator networks** in **48 sites**, sampled repeatedly over time across the tropics.
- Linear mixed effect models
  - Network metrics **connectance, nestedness, specialisation and modularity**

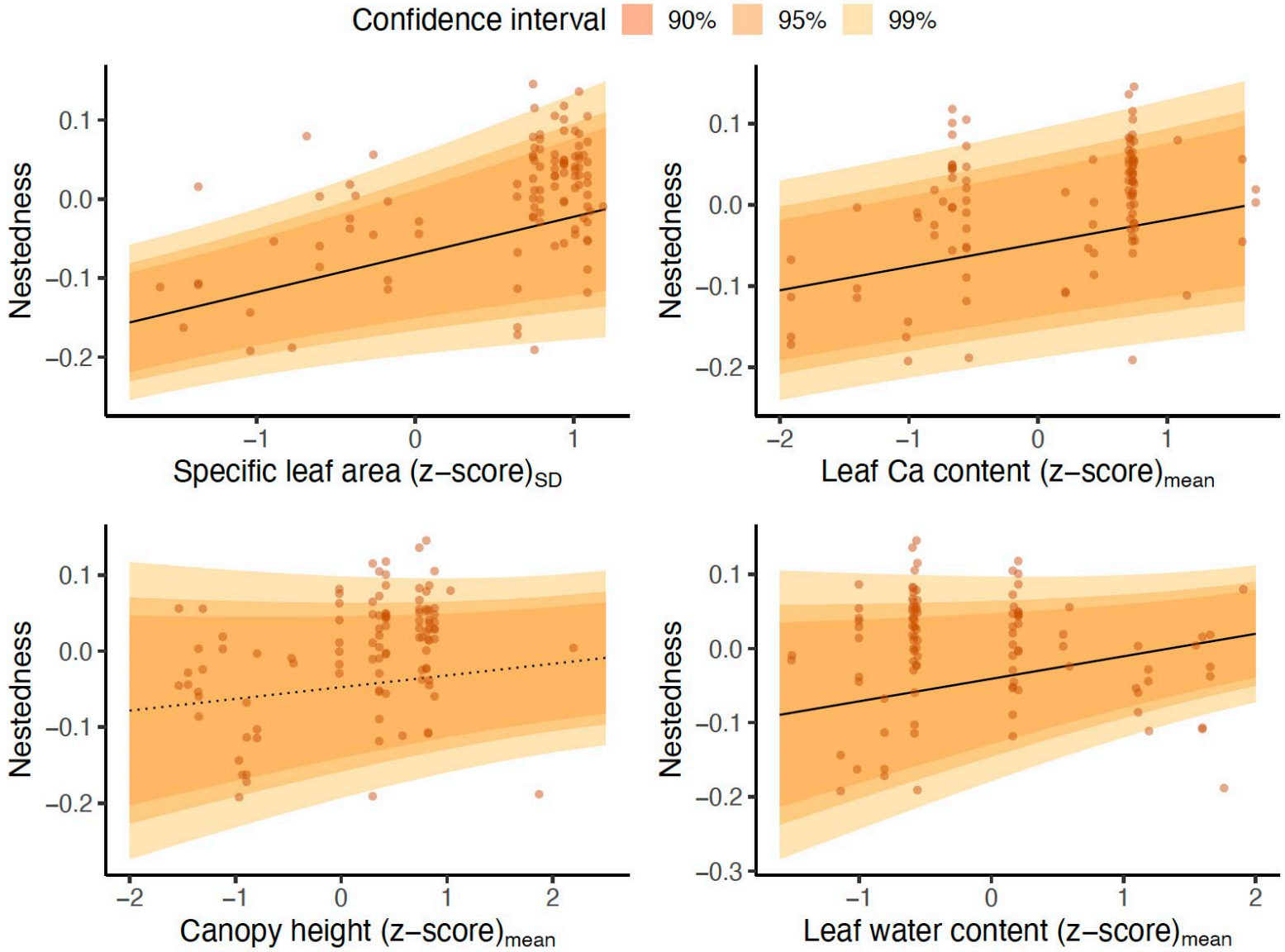
Results



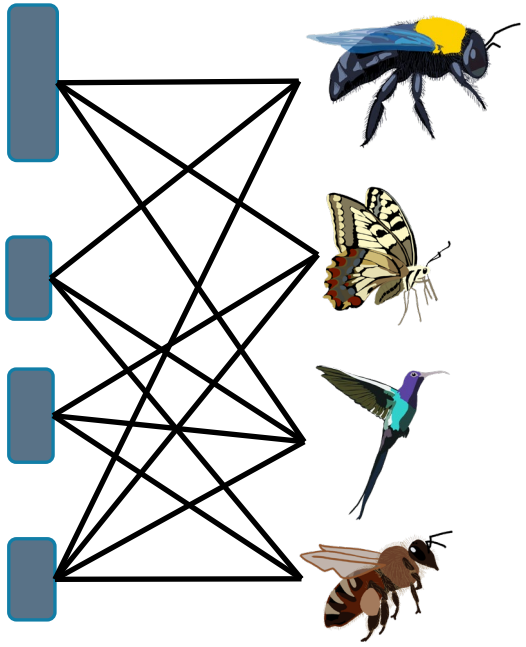


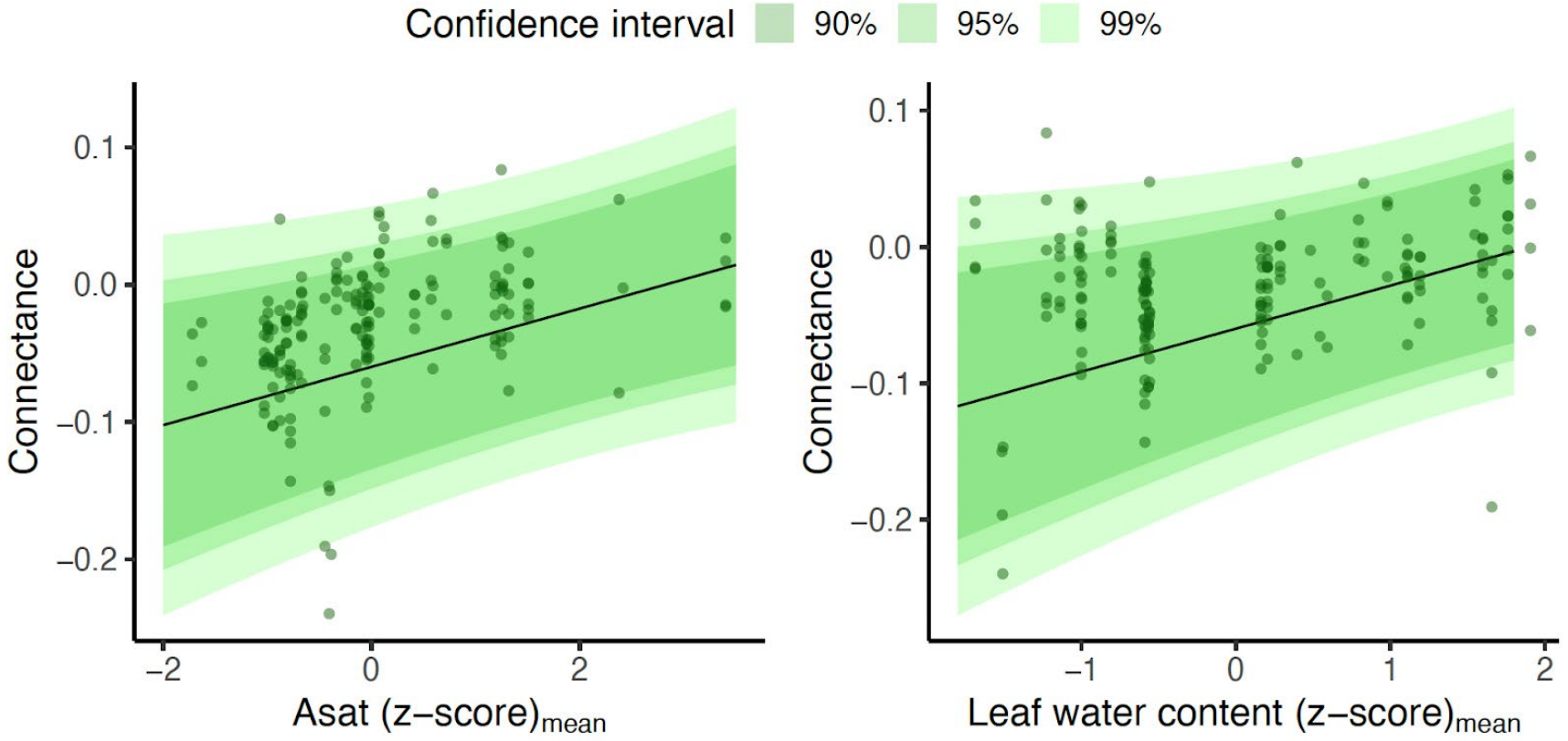
Nestedness



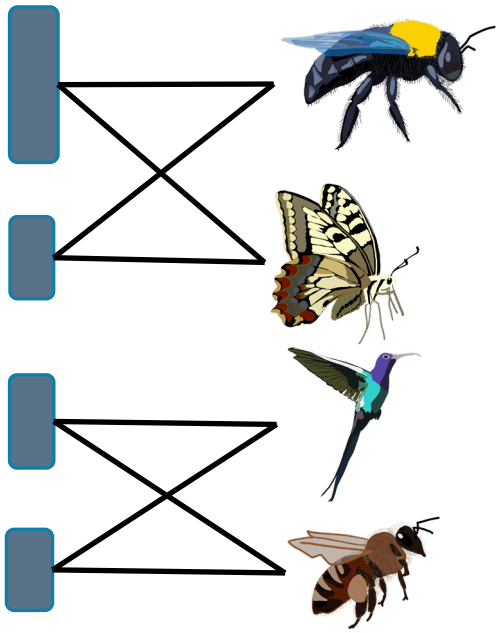

Confidence interval
90%
95%
99%
Nestedness
Specific leaf area (z–score)SD
Leaf Ca content (z–score)mean
Canopy height (z–score)mean
Leaf water content (z–score)mean

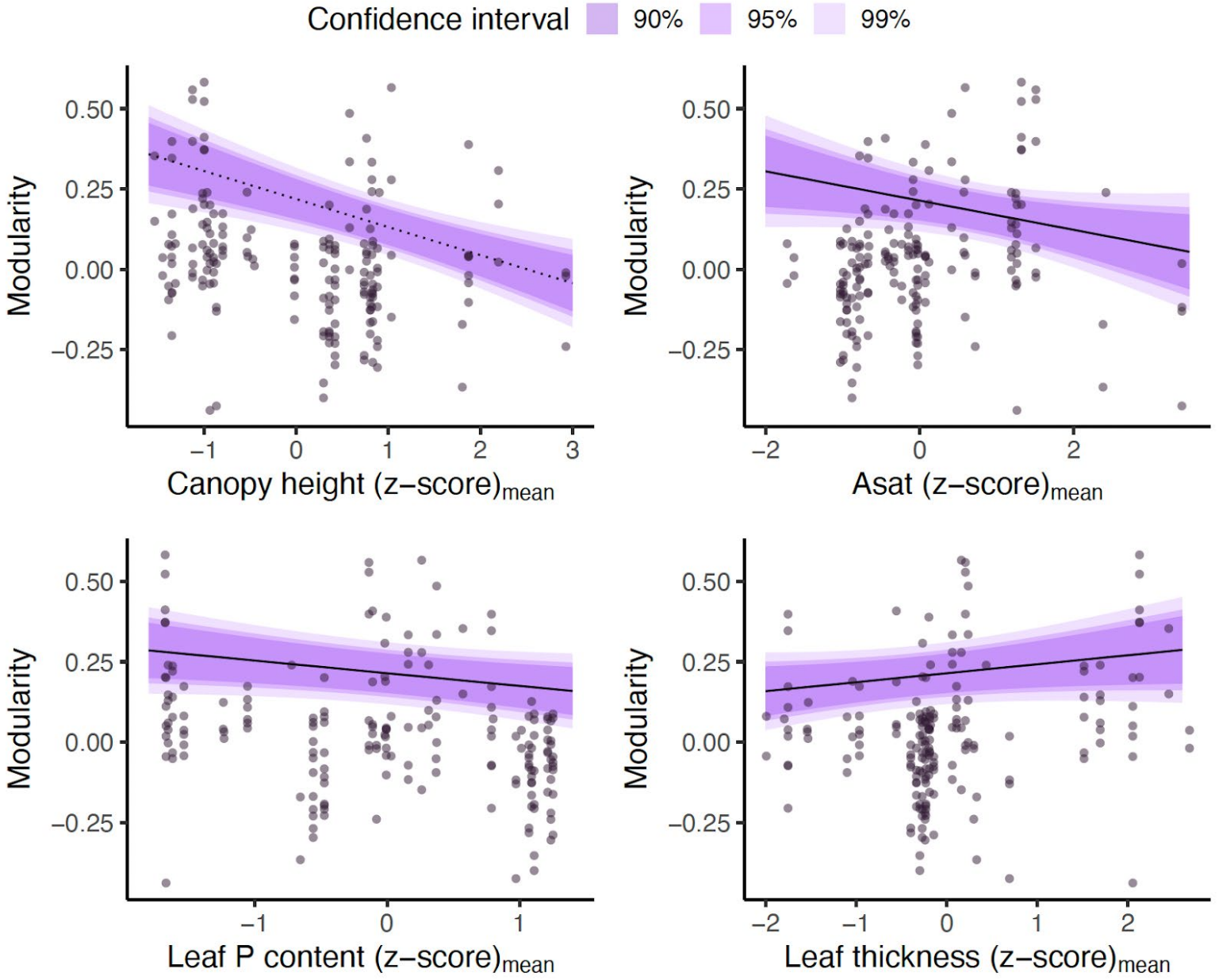
Connectance



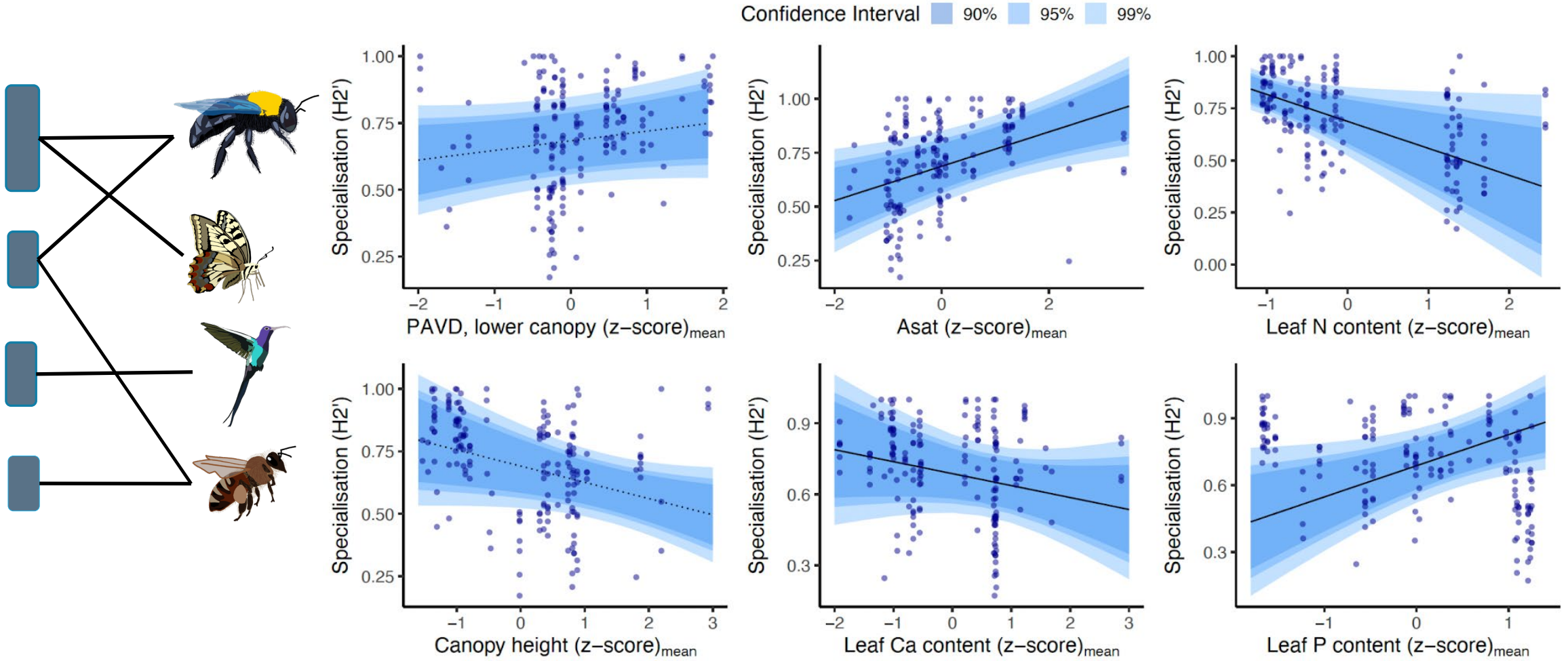


Modularity



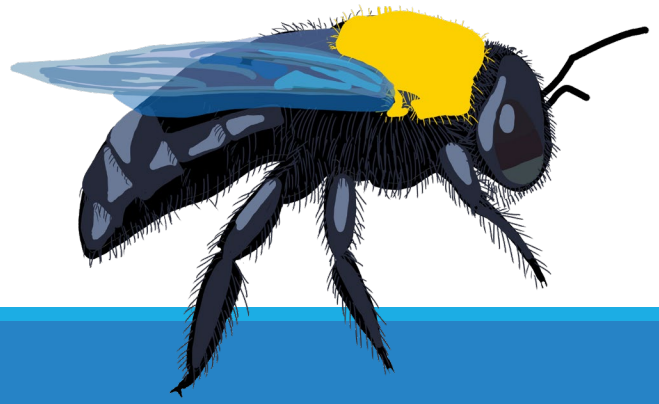

Confidence interval
90%
95%
99%
Modularity
0.50
0.25
0.00
−0.25
−1
0
1
2
3
Canopy height (z−score)mean
−2
0
2
Asat (z−score)mean
−1
0
1
Leaf P content (z−score)mean
−2
−1
0
1
2
Leaf thickness (z−score)mean

Specialisation



Conclusions & Future Work

- **Plant strategies play an important role in structuring biotic interactions**, such as those between plants and pollinators
- **Potential of remote sensing to predict plant-pollinator interactions** at broad scales
- **Future Directions**
  - 1. More field-based studies to better understand mechanisms between plant functional traits, vegetation structure, and plant-pollinator interactions
  - 2. Expanding plant functional trait data coverage
  - 3. Pollination services: relating plant functional traits and vegetation structure to yield



Acknowledgments

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Pollinator drawings Waira S. Machida