The Influence of Distance on Modularity in Multilayer Spatial Networks

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1 Introduction

- In ecological communities, species and their interactions form complex networks characterized by non-random structures[1].
- Modularity is a pattern in which species interactions are organized into groups (modules) of species more tightly linked to one another than to species outside their group[1]. Modularity promotes stability by containing perturbations within a module[2].
- Previous research on single-layer networks has suggested that distance may affect modularity[3], but this hypothesis has never been tested on multilayer networks, which connect different communities of species in space or time[4].

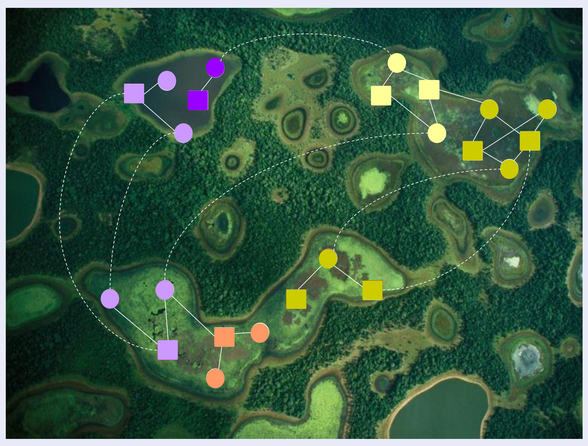

Fig. 1: Visual representation of a spatial multilayer network. Squares and circles depict nodes of different types (e.g., plants and pollinators), and their color depicts module affiliation. Intralayer and interlayer links are in solid and dashed lines, respectively. Interlayer links connect instances of the same species between patches (layers).

2 Research Objective

To explore the influence of distance on the modularity of spatial multilayer networks.

3 Experimental strategy

- Use plant-pollinator data collected in 7 different islands, each sampled in 2 sites (14 total), in the Canary Islands[5]. Create a multilayer network and analyze its modularity using infomap (1.7.1) and infomapecology (1.0.4).
- Create 3 null model versions (each with 1000 iterations) of the network:

1. **Shuffling Plants**- Only plants identities are shuffled between layers.
2. **Shuffling Pollinators**- Only pollinators identities are shuffled between layers.
3. **Shuffling both plants and pollinators**- All species identities are shuffled between layers.

- Comparing the empirical network to these null models to determine whether unique patterns were created as a result of randomness or biological processes, and which groups of species have a greater effect on these patterns.

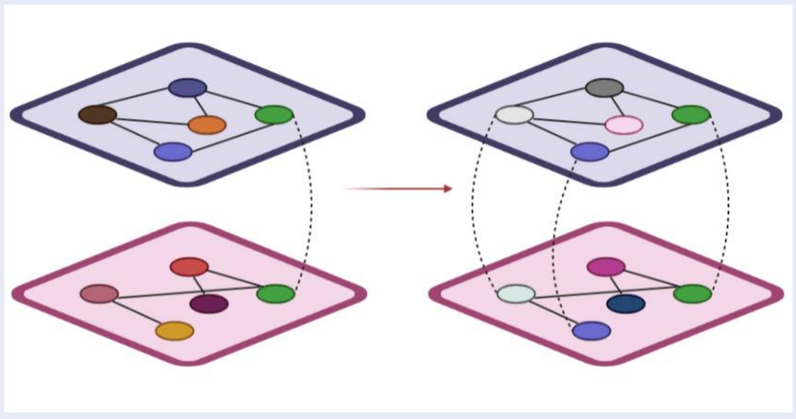

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Fig. 2: Visual representation of the creation of the null models.

4 Results

- A non-random pattern of distance decay in species similarity with geographical distance.
- A pattern of distance decay is module similarity with geographical distance was not different than random.

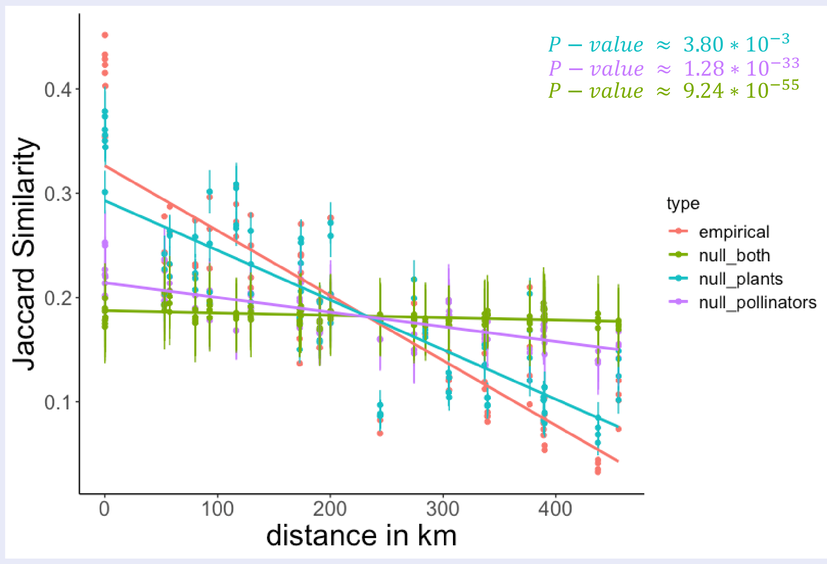
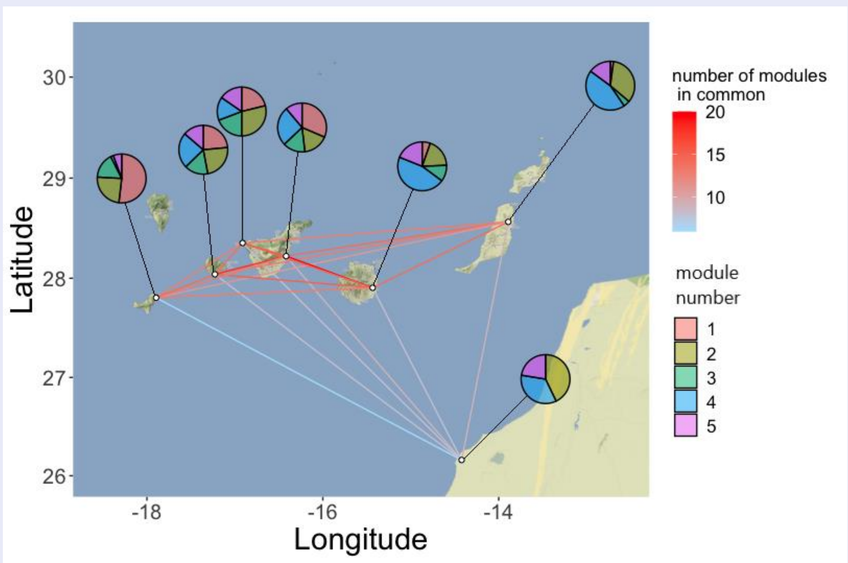


Fig. 3: Distance decay in species similarity (Jaccard Index) with geographical distance in the empirical network and the null model versions of the network. The empirical network is significantly different than the null models.

Fig. 4: A map of the 7 locations in the network showing the amount of shared modules between them and the identity of the 5 biggest modules in the network.



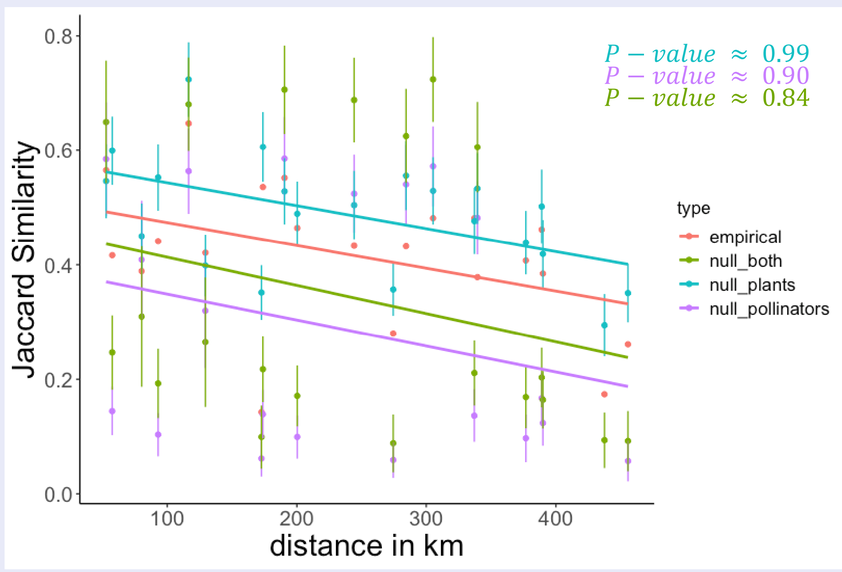


Fig. 5: Distance decay in module similarity (Jaccard Index) with geographical distance in the empirical network and the null model versions of the network. The empirical network is not significantly different than the null models.

5 Conclusions

- distance decay in module similarity with geographical distance is not a product of distance decay in species similarity with geographical distance.
- Testing the generality of this result requires similar analysis on a large set of spatial networks.

References

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