Of rodents and randomness: macroecological approaches to community structure

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Abstract

The system-wide attributes of ecological communities - such as community-level abundance and metabolic flux, and how these are distributed among species and organisms - emerge from a web of environmental constraints, complex species interactions, and ubiquitous mathematical rules. This dissertation uses a telescoping perspective to explore how these factors shape community properties and determine how they change over time, building from a granular focus on species interactions in a well-studied experimental system, to successively broader spatial and conceptual scales in pursuit of general insights.

In chapter 1 (in review (Diaz and Ernest 2021)), I use 30 years' of accumulated data and natural history knowledge to explore the effects of species loss on community function in an experimentally manipulated desert rodent community. Understanding how community function responds to species loss, and how the effects of species loss interact with shifting environmental conditions, is a key problem for biodiversity science in the current era of unprecedented ecological change. In this system, I find that compensation due to functional redundancy temporarily buffered community function against species loss. However, because similar, but non-identical, rodent species have responded differently to changes in environmental conditions over time, this compensatory effect has broken down, leaving community function highly sensitive to the loss of keystone species.

In chapter 2 (in prep), I undertake a continental-scale comparison across communities to explore how shifts in community-wide body size modulate the long-term dynamics of total abundance, biomass, and energy use in North American breeding birds. Although total abundance and size and energy-based currencies are intrinsically linked, they capture different dimensions of community function, and shifts in community size structure can decouple the dynamics of different currencies. I find that, in nearly 1/3 of communities, changes in the community size structure result in qualitatively different trajectories for biomass and total abundance over the past 30 years. In nearly 80% of instances, total abundance has decreased, but community-wide mean body size has increased, partially offsetting the decline in biomass expected due to declines in individual abundance.

In chapter 3 (published (Diaz et al. 2021)), I step further back to examine how fundamental mathematical constraints inform our understanding of ecological "laws". Common patterns in community ecology, such as the "hollow-curve" or J-shaped species abundance distribution, emerge from a combination of biological processes and ubiquitous mathematical constraints on the emergent properties of complex systems. Disentangling the signal of ecological processes from these mathematical constraints can provide new sources of inferential power linking pattern to process in community ecology. I use combinatorics to characterize the mathematical constraint on the SAD, and compare the SADs of 22,000 empirically-observed communities to these "statistical baselines". This reveals that, while empirical SADs often match their statistical baselines, a substantial minority of real SADs deviate from these baselines - leaving an important role for ecological processes in shaping these distributions.

References

Diaz, R. M., and S. K. M. Ernest. 2021. Maintenance of community function through compensation breaks down over time in a desert rodent community. Preprint, bioRxiv.

Diaz, R. M., H. Ye, and S. K. M. Ernest. 2021. Empirical abundance distributions are more uneven than expected given their statistical baseline. Ecology Letters 24:2025–2039.