Behavior of Competitive Ecosystems Beyond the Niche-Neutral Regimes

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***Short Abstract* — We examine the multi-species competitive ecosystems under demographic noise, based on birth-death-immigration process. Using simulations and analytical arguments, we define and investigate various behavioral phases of the stationary abundance distribution. Noteworthy, these regimes exhibit different behaviors of extinction and invasion, the dynamics of which we quantify. Our work presents a rich phase-space for the stationary behaviors in a competitive ecosystem. These results provide a framework for interpreting the discrepancies of abundances in ecological data of populations and inferring the underlying dynamics that shape the communities of interacting species.**

***Keywords* — competition, multi-species ecosystem, neutral-niche paradigm, phase diagram, demographic noise**

NEUTRAL theories of biodiversity assume that all individuals are functionally identical regardless of the species, whereas symmetrical non-neutral theories forego the assumption of equivalent individuals and distinguish solely between self and non-self-interactions, namely between intra-species and inter-species interactions. The interplay between these inter- and intra-species interactions, together with other system properties such as immigration, carrying capacity, and more, within the presence of demographic noise, shape the structure, composition and stability of ecological populations.

We investigate an ecological process involving multiple species, where the individuals within the ecosystem interact via competition. The competition strength parameter is defined by the ratio between inter- and intra-species competition. The considered model evolves solely by demographic noise; thus, it serves as a `null model', exhibiting minimal stochastic requirements. We define and investigate behavioral regimes which correspond the properties of species abundance distribution and the species richness. We find that the complete phase diagram exhibits rich behavior with multiple regimes that go beyond the classical `niche' and `neutral' regimes, extending and modifying the `neutral-like' or `niche-like' dichotomy. In particular, we observe novel regimes that cannot be characterized as either `niche' or `neutral' where a multimodal species abundance distribution is observed. We characterize the transitions between the different regimes and show how they arise from the underlying kinetics of the species turnover, extinction and invasion.

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