Spatial scaling of biodiversity and ecosystem stability with a simple model

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Abstract

Scaling in ecology is a classic question of both fundamental interest and applied relevance. While the spatial scaling of biodiversity patterns has been widely studied, to date, most of the studies on ecosystem functioning and stability were performed at relatively small spatial scales. As a result, the relationship between biodiversity and the stability of communities and ecosystems functions across spatial scales is poorly understood.
We developed a simple spatially explicit model to investigate the scaling of stability, measured as the inverse of temporal variability for the ecosystem total biomass, in a simulated continuous landscape. As main drivers of ecosystem variability, we integrated species diversity and spatial synchrony patterns by considering both intra- and interspecific correlations between individuals' biomass fluctuations.

We found that the Stability-Area Relationship (StAR) exhibits a triphasic curve - the curve switches from a fast increase to a slower one, following a linear increase, and switches again to a fastest increase. While more species diversity increased stability across all spatial scales, synchrony patterns affected differently small and large scale stability. We also identified specific conditions of spatial synchrony under which the StAR is closely related to the widely studied Species-Area Relationship (SAR).
With this simple model, we have been able to produce theoretical insights into the effects of diversity and synchrony on ecosystem stability across spatial scales. Moving towards the integration of species dispersal and interactions, population dynamics and habitat heterogeneity should add further understanding and have important implications for ecological conservation and biodiversity management.

Keywords: Scaling, stability, area relationship, species, area relationship, spatial synchrony, variability, point process.

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