Ecological Complexity

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Viewpoint

Dimensions of ecosystem complexity: Heterogeneity, connectivity, and history

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Abstract

Biocomplexity was introduced to most ecologists through the National Science Foundation's grant program, and the literature intended to introduce that program. The generalities of that literature contrast with the abstract and mathematical sophistication of literature from physics, systems theory, and indeed even of pioneering ecologists who have translated the concept into ecology. This situation leaves a middle ground, that is both accessible to ecologists in general, and cognizant of the fundamentals of complexity, to be more completely explored. To help scope this middle ground, and to promote empirical explorations that may be located there, we propose a non-exclusive framework for the conceptual territory. While recognizing the deep foundations in the studies of complex behavior, we take ecological structure as the entry point for framework development. This framework is based on a definition of biocomplexity as the

degree to which ecological systems comprising biological, social and physical components incorporate spatially explicit heterogeneity, organizational connectivity, and historical contingency through time. These three dimensions of biocomplexity â€“ heterogeneity, connectivity, and history â€“ will be explored as axes of increasing complexity. Basing the description of spatial heterogeneity on either patch or continuous quantification, complexity of spatial structure increases as quantification moves from simple discrimination of patch types and the number of each type to assessment of configuration and the change in the mosaic through time. Organizational complexity reflects the increasing connectivity of the basic units that control system dynamics. At the simple end of the axis, the functional connectivity between units is low, and the processes within a unit are determined by structures or other processes within that unit. At the highest level of complexity along this axis, units in a mosaic interact through fluxes of energy, matter, organisms, or information, and the structure and dynamics of the mosaic can be altered by those fluxes. Temporal relationships in the system range from direct contemporary ones to indirect and historically contingent ones. The influence of indirect effects, legacies, the existence of lagged effects, and the presence of slowly appearing indirect effects constitute increasing temporal complexity. This framework embodies some features of both the structural approach to complexity and the approach of complexity of explanations that we extracted from the literature. It leaves the issue of what levels of each axis result in complex *behavior* as an important question for further research.

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Keywords

Biocomplexity; Framework; Coupled systems; Spatial heterogeneity; Legacies; Land cover classifications; Urban ecosystems

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