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SPECIAL FEATURE

Crossing scales in ecology☆

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Ecological processes and patterns across scales

Understanding large-scale ecological patterns is a major aim of ecological research and has become even more pressing during the current period of rapid environmental change. Community-level patterns such as species distributions are shaped by dynamics occurring at different spatio-temporal scales and organizational levels. Patterns and dynamics at a given scale may develop from interacting lower-level units, but may also be imposed by large-scale constraints (Levin 1992). As a consequence, results from ecological investigations and predictions are critically affected by the scales addressed and their corresponding processes (Turner & Gardner 1991). In spite of this, the choice of the considered scales and aggregation levels is only rarely discussed explicitly in ecological investigations. This common neglect of scale-related questions may be the result of the scarcity of applicable methods for choosing appropriate levels of aggregation and for linking level-specific processes across scales (Kolasa 2005; Urban 2005). This lack of unifying concepts contrasts with the strong need for approaches that identify and connect aggregation levels. In this special feature, we intend to promote the discussion on scale-related issues in ecology by compiling the current knowledge on scales and aggregation and discuss approaches that facilitate dealing with across-scale phenomena.

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In the first paper (Meyer et al. 2010), we take an empirical point of view and exemplify the practical consequences of choosing different levels of aggregation for predictions of community-level patterns. For instance, in grassland community studies, the choice of aggregation type may alter the outcome of the study. If legumes are considered at the functional type level, results will show stronger community responses than if considered at the species level (Temperton, Mwangi, Scherer-Lorenzen, Schmid, & Buchmann 2007). It may even be appropriate to disaggregate further and choose the genotype as the focal aggregation type, because the ability to form a symbiosis varies considerably among legume genotypes. We develop a new framework linking ecological processes and properties to aggregation types and study objects and suggest a procedure for the selection of appropriate aggregation types.

In the second paper (Reuter et al. 2010), we discuss the theoretical implications of scale-explicit approaches in the frameworks of ecological hierarchy theory, self-organisation, and the theory of complex adaptive systems. A top-down view along the hierarchy of scales can be implemented by the statistical analysis of large-scale patterns. For instance, regression models have been applied to predict the occurrence probability of specific plant species with abiotic environmental factors as predictor variables (Damgaard 2008). Thereby, top-down analyses can help to identify higher-level constraints on lower level processes. Contrarily, bottom-up modelling approaches such as cellular automata and agent-based models emphasize the emergence of large-scale patterns from small-scale interactions. The successful analysis of the relevant processes driving rodent community interactions by an agent-based model (Reuter 2005) illustrates the great potential of bottom-up approaches. We argue that a large set of ecological problems cannot be solved by taking either a bottom-up or top-down view. Rather, bottom-up and top-down perspectives need to be integrated into a combined approach.

Future ecological studies may greatly benefit from increased scale-awareness, which can be achieved by combining empirical and modelling techniques to facilitate the implementation of scale-explicit approaches. Following the outlined approaches may be the first step towards a comprehensive, scale-explicit understanding of ecological processes and patterns.

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