Introduction

Ecologists have long been conscious of the importance of scale (e.g., Allen and Starr 1982, O'Neill and King 1998). A major finding has been that ecological patterns at any given scale are often influenced by processes at larger or finer scales in ways that may not be obvious. Consequently, the findings of ecological studies are often scale-dependent, with results that may vary depending on the spatial and temporal scale that is analyzed. Thus, to fully understand ecological dynamics, research must include data from many spatial and temporal scales. For example, one of the effects of scale on species diversity, is that species richness is best explained by different variables depending on the spatial scale of the studies (Willis and Whittaker 2002).

In the past, such studies across many scales have been rare. Studies typically focus on one scale, most commonly at small scales (Levin 1992). As a result, we know relatively little about the dynamics of large-scale processes and how to integrate results across scales. Fortunately, this is changing as more studies explicitly incorporate considerations of scale (Willis and Whittaker 2002, Crawley and Harral 2001).

As biological invasions increase, inclusion of scale into research and management is imperative. The idea to compile this special issue originated in 2002 after realizing that much research on biological invasions appeared to be focused on single scales. Mechanistic approaches have tended to analyze invasions at scales where experiments can be conducted (plots, microcosms, etc.). On the other hand, more descriptive approaches have been used to determine patterns and processes over larger, more realistic scales. However, little effort has been documented in the literature to link findings across spatial scales. We know this is no easy task, especially because the current scientific reductionism and the difficulties in integrating methodologies at different spatial scales. Nonetheless, we feel sure that most ecologists agree that we need to move forward in integrating our knowledge of natural phenomena across scales.

This collection of papers was selected in order to not only capture efforts to integrate knowledge across scales, but also a wide variety of non-native organisms, from plants to animals. Aníbal Pauchard and Katriona Shea reviewed many examples demonstrating how several aspects of invasion are scale-dependent, most notably dispersal and ecological impacts of invaders. Their discussion documents how understanding and control of invasions requires study across several scales. In the large United States national scale, Michael McKinney found that area, native species diversity, human population size and latitude significantly correlate to non-native species richness. But he asserts that it is difficult to know whether this relationship implies causality or just a reflection of human settlement preferences for more productive sites. Thomas Stohlgren and others, in a similar national scale for the United States, found comparable correlations when using multiple sets of data for plants, birds and fishes. They also point out that large-scale environmental factors appear to be the major constraint for biological invasions. Julie Lockwood's study of the birds of Hawaii found that biological homogenization is scale-dependent, with important variations in alpha, beta and gamma diversity being dependent on the spatial scale examined.

Looking at dispersal mechanisms, John Havel and Kim Medley analyzed cladoceran zooplankton at many spatial scales: local, regional and intercontinental. Their study is an exemplary illustration of how processes among several scales can be interrelated. Ladd Johnson and others examined zebra mussel dispersal into isolated watersheds in the central United States. Craig Allen's study of the birds of South Florida showed that introduced avian species whose body mass placed them nearer to a body-mass aggregation edge and further from their neighbor were more likely to become successfully established. This suggests that community interactions, and community level phenomena, may be better understood by explicitly incorporating scale.

By studying spatially explicit processes, Nicole Heller and others show how Argentine fire ant nests spread at scales of a few meters and how this translates into annual spread of hundreds of meters. Michael Allen and Katriona Shea studied two species of *Carduus* and found that they are negatively correlated in space, which may indicate species-specific environmental requirements. At smaller spatial scales, Lisa Rew and others analyzed the most efficient survey method to detect non-native species in natural areas. They concluded that a targeted transect method could be more efficient and more accurate when dealing with the aggregated patterns of non-native species in natural areas.

Finally, Sarah Ward explored how measuring genetic diversity requires selection of a spatial scale. At a continental and global scale genetic structure of invasive plant populations is significantly affected by founder effect and propagule transport via human vectors.

We believe this special issue will strengthen the discussion about scale and biological invasions, also promoting the integration of results from a range of taxa, which ultimately will help to find the elusive generalities in invasion biology.

References

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