What is Landscape Ecology?

Landscape ecology, as the name implies, is the study of landscapes; specifically, the composition, structure and function of landscapes. But what's a 'landscape'? Although there are myriad ways to define 'landscape' depending on the phenomenon under consideration, suffice it to say that a landscape is not necessarily defined by its size; rather, it is defined by an interacting mosaic of elements (e.g., ecosystems) relevant to some phenomenon under consideration (at any scale). Thus, a landscape is simply an area of land (at any scale) containing an interesting pattern that affects and is affected by an ecological process of interest. Landscape ecology, then, involves the study of these landscape patterns, the interactions among the elements of this pattern, and how these patterns and interactions change over time. In addition, landscape ecology involves the application of these principles in the formulation and solving of real-world problems.

Landscape ecology is perhaps defined best by its focus on spatial heterogeneity and pattern; specifically, how to characterize it, where it comes from, why it matters, how it changes through time, and how we manage it. As such, landscape ecology has five central themes:

- Detecting pattern and the scale at which it is expressed, and summarizing it quantitatively.
- Identifying and describing the agents of pattern formation, which include the physical abiotic template, demographic responses to this template, and disturbance regimes overlaid on these.
- Understanding the ecological implications of pattern; that is, why it matters to populations, communities, and ecosystems.
- Characterizing the changes in pattern and process over space and time; that is, the dynamics of the landscape, and summarizing it quantitatively.
- Managing landscapes to achieve human objectives.

Why is a Landscape Perspective Useful?

As Dean Urban, a leading landscape ecologist at Duke University, points out, ecology strives to understand the interactions of organisms and their environment–and the environment is profoundly spatial (everything happens somewhere). Indeed, Dean observes that our casual observations of spatial heterogeneity (e.g., "this is a great spot to go birding!") celebrates this spatial variability. He further notes that ecology is also defined in terms of interactions, and one thing that seems to be true of interactions in general is that their strength varies with distance: this is true of planetary gravitation, it's true of people standing in elevators, and it's true of competition for resources between individual plants. And distance implies spatial location. The landscape perspective provides this important spatial perspective on organism-environment relations.

Land managers have also recently embraced the landscape perspective. In response to growing concerns over the loss of biodiversity, land managers are seeking better ways of managing ecosystems at a variety of spatial and temporal scales. In particular, growing evidence that habitat fragmentation is detrimental to many species and may contribute substantially to the loss of regional and global biodiversity (Saunders et al. 1991) has provided empirical justification for the need to manage entire landscapes, not just the components. The developing field of landscape ecology has provided a strong conceptual and theoretical basis for understanding landscape structure, function, and change (Forman and Godron 1986, Urban et al. 1987, Turner 1989, Turner et al. 2001). The development of GIS technology, in particular, has made a variety of analytical tools available for analyzing and managing landscapes. In response to this growing theoretical and empirical support and technical capabilities, public land management agencies have begun to recognize the need to manage natural resources at the landscape level. Notably, landscape ecology has become one of the cornerstones of the emerging "ecosystem management" paradigm (Boyce and Haney 1997, Grumbine 1994, Kohm and Franklin 1997, Vogt et al.1997).

History of Landscape Ecology

Landscape Ecology as a discipline has two evolutionary lines, which might be characterized as the "European School" (which is also strongly represented in the United States and elsewhere), and the "American School" (which is also common in Australia and elsewhere).

> The European school has a very long history (as long as ecology itself, almost). It has an emphasis on typology, classification, nomenclature, and mostly is concerned with "built" systems. In the U.S., it is found more often in Landscape Architecture, Planning, or Design schools than in Biology departments.
>
> The American school is comparatively young, gaining a high profile in the U.S. only after the early 1980's. It was launched, for practical purposes, by a workshop at Allerton Park (Risser et al. 1984). This was a pivotal meeting because the meeting decided what landscape ecology was about: its intellectual domain (what would be considered "interesting") and the tools of the trade (officially sanctioned approaches). In contrast to the European school, the American school has much more of a focus on natural systems (or at least, semi-natural ones such National Parks), and is much more invested in theory and models.

The emergence of the American school of landscape ecology as a subdiscipline of ecology in the early 1980's corresponds to the major paradigm shift in ecology from the "equilibrium" view of ecosystems to a "dynamic" view. Coupled with the view that ecosystems are dynamic, characterized more by their dynamics than by their tendency towards a stable equilibrium, is the notion that ecosystems are not isolated systems and cannot be understood without considering the flow of energy and material across ecosystem boundaries. This view of ecosystems as "open" systems required an understanding of how mosaics of ecosystems interact to effect ecosystem processes, and this led to the emergence of landscape ecology.

Landscape ecology is now firmly rooted as a scientific discipline and in fact represents one of the most rapidly expanding ecological subdisciplines. As remote sensing, GIS, and computer technologies continue to develop, the science and application of landscape ecology will undoubtedly continue to blossom.

What is Landscape Ecology, Really?

As Dean Urban notes, John Wiens, as an editor of the journal Landscape Ecology, undertook a meta-analysis of papers published in the journal over its first 5 years as a means of trying to better define the discipline (Wiens 1992). His findings showed some definitive biases:

- Most studies are large scale: landscapes are pretty big;
- Most studies are descriptive or conceptual, indicative of a discipline just finding itself;
- Methodologically, it is logistically difficult to do experiments with landscapes (the exceptions are spectacular);
- There is a considerable investment in models, which might seem unusual in such a young discipline; but the logistics of field studies are a bit daunting;
- As study objects, there is a preoccupation with vegetation pattern and land use pattern: the stuff you can easily resolve at large scales;
- In particular, landscape ecologists tend to recognize humans as being an important part of the system (again, a consequence of scale: you can find a pocket of wilderness, but if you back away enough, you encounter the effects of people).

Richard Hobbs (1997) took another look at this analysis, summarizing the second 5 years of the journal. His findings:

- Less description, much more methodological studies and more modeling, still no experiments;
- A decrease in purely descriptive work (i.e., with no quantification), and much more statistical analysis of patterns (landscape ecology discovers spatial statistics);

The implication is that we are maturing as a discipline, although we have a ways to go still. In particular, Hobbs (1997) admonishes that landscape ecology has thus far offered precious little of practical utility. He calls for a renewed emphasis on applying the concepts and theory of landscape ecology to real-world applications.

Literature Cited

Boyce, M. S., and A. Haney. 1997. *Ecosystem Management: Applications for Sustainable Forest and Wildlife Resources*. Yale University Press, New Haven & London. 361 pp.

Forman, R. T. T., and M. Godron.1986. *Landscape ecology*. Wiley, New York.

Grumbine, R. E. 1994. What is ecosystem management. Conservation Biology 8:27-38.

Hobbs, R. 1997. Future landscapes and the future of landscape ecology. Landscape and Urban Planning 37:1-9.

Kohm, K. A., and J. F. Franklin. 1997. *Creating a Forestry for the 21st Century: The Science of Ecosystem Management.* Island Press, Washington, D.C. 475 pp.

Risser, P. G., J. R. Karr, and R. T. T. Forman.1984. Landscape ecology: directions and approaches. Special Publ. No. 2, Ill. Natural Hist. Surv., Champaign.

Saunders, D. A., R. J. Hobbs, and C. R. Margules. 1991. Biological consequences of ecosystem fragmentation: a review. Cons. Biol. 5:18-32.

Turner, M. G. 1989. Landscape ecology: the effect of pattern on process. Ann. Rev. Ecol. Syst. 20:171-197.

Turner, M. G., R. H. Gardner, and R. V. O'Neill. 2001. *Landscape Ecology in Theory and Practice: Pattern and Process*. Springer, New York.

Urban, D.L., R.V. O'Neill, and H.H. Shugart. 1987. Landscape ecology. BioScience 37:119-127.

Vogt, K. A., J. C. Gordon, J. P. Wargo, and others. 1997. *Ecosystems: Balancing Science with Management*. Springer, New York. 470 pp.

Wiens, J.A. 1992. What is landscape ecology, really? Landscape Ecol. 7:149-150.