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A Top-Down Approach to Landscape Ecology

Sanderson, Jim, and Larry D. Harris, editors. 2000. **Landscape ecology: a top-down approach.** Landscape Ecology Series. CRC Press, Boca Raton, Florida. 246 p. $69.95, ISBN: 1-56670-368-9 (acid-free paper).

The term ''landscape ecology'' was coined by Carl Troll, a German geographer, in 1939. Recalling that the word ecosystem was made up by Arthur Tansley only four years earlier, one has to wonder why landscape ecology is often said to be so much younger. One reason is that landscape ecology was not introduced to the United States until the early 1980s. But, more importantly, in the past two decades landscape ecology has experienced unprecedented rapid developments in both theory and applications, and become a recognized discipline, not just regionally, but worldwide. With its fast-rising status, landscape ecology continues to diversify in ideas, perspectives, and approaches, in spite of the fact that some leading landscape ecologists have urged for ''unification'' to avoid an ''identity crisis.''

The book by Sanderson and Harris, *Landscape ecology: a top-down approach*, is certainly different in perspectives and emphases from other texts in landscape ecology. The book is organized into three parts: ''The presence of the past,''

''The ecology of landscapes,'' and ''Landscape theory and practice,'' with a total of 12 chapters. Six of the 12 chapters (1, 2, 3, 4, 5, and 7) are written by Sanderson and Harris. Chapter 1 briefly reviews the history of landscape ecology, primarily focusing on North America. The authors characterize the pattern-process-scale and hierarchical perspectives as ''the slicing-and-dicing approach,'' suggesting that they are at best inadequate. They further indicate that ''the paradigm of bottom-up thinking as espoused by a half-century of IBP ecosystem studies'' can not lead to an ''understanding of landscape ecology.'' Thus, they instead advocate a ''top-down approach'' that ''seeks to explain how the distribution and abundance of organisms affects the entire collection of biodiversity and processes on the landscape.'' They also mention multilevel species selection theory as one of the ''functional pillars'' for their approach, claiming that ''all organisms have equally important, but perhaps less obvious impacts upon the landscape.'' The authors' perception of hierarchy is apparently at odds with the common notion that hierarchy theory facilitates the integration between top-down and bottom-up approaches and between context and content. Chapter 2 discusses definitions, ecological theories, and examples of landscape ecological studies. ''Landscape'' here is narrowly defined as ''two or more ecosystems'' at spatial scales of tens or hundreds of square kilometers. Many have argued that such a rigid definition of landscape is hardly justifiable scientifically and that it impedes rather than facilitates the development of landscape ecology. Despite their ''true landscape'' definition and emphasis on a ''regional'' approach, the authors discuss at length Huffaker's microcosm experimental study of predator-prey interactions with oranges and mites, and conclude that ''these results suggest that environmental heterogeneity and connectivity are essential in maintaining predator-prey populations.'' Chapter 3 discusses ''the presence of the past'' with the premise that a theory of landscape ecology must adopt an evolutionary approach that permits the inclusion of past events. The reciprocal effects of landforms and biological processes in landscapes are the focus of Chapter 4. It is confusing that the authors distinguish between biotic and landscape processes, but use animal movement as an example of a landscape process. Isn't animal movement a biotic process?

Part II has only two chapters. In Chapter 5, Sanderson and Harris discuss the ''ecology in landscape ecology.'' They define landscape ecology as ''the study of processes and organisms that promote and maintain the natural functioning of more than one ecosystem.'' They repeatedly make the distinction between ''landscape effects'' and ''landscape ecology.'' In their view, landscape ecology so far has focused primarily on landscape effects—how landscape structure affects biology, while the ''top-down'' effects of mobile organisms on spatial heterogeneity are at least as important, but rarely studied. Chapter 6, by Hansson, focuses on landscape effects on populations and consists mostly of empirical examples mainly from Scandinavia. From these examples, the author generalizes that ''heterogeneity evidently improves persistence'' and thus ''heterogeneity and clumped distributions may be general indicators of population stability.'' It is interesting to notice that Hansson sees landscapes even more ''precisely''—''5 $\times$ 5 km areas''! While the bulk of the literature indicates that scale multiplicity and hierarchical linkages are essential in landscape ecology, Hansson defines landscape ecology as ''a consideration of structures and processes at one particular spatial scale.''

Part III consists of six chapters. Harris and Sanderson in Chapter 7 present ''four fundamental theories of landscape ecology'' (edge theory, juxtaposition theory, external impact theory, and corridor theory) that together are called ''the general theory of insular biogeography.'' None of these ''theories'' is absent in the existing literature. The authors then illustrate how to calculate total population, habitat quality, habitat connectivity, and habitat fragmentation using simple algebraic equations and weighting schemes based on raster maps. They state that ''the case for movement corridors is by now well established,'' and reiterate their point made in Chapter 5 that the ''hot spot'' approach to biodiversity conservation is ''preposterous'' because ''context matters.'' They conclude the chapter with three hypotheses stressing the importance of multilevel species evolution operating on landscapes and top-down effects of organisms. Chapter 8 by Ulanowicz introduces the concept of ''ascendency,'' which is ''an amalgamated measure of the tendency for a system to increase in both activity and structure (constraint) via internal autocatalysis.'' The author extends the ecosystem ascendency concept he developed earlier to spatially explicit landscape ascendency, and demonstrates how it can be used to quantify flows in landscapes. He further hypothesizes that without major perturbations populations distribute themselves across a landscape to achieve progressively higher system ascendency. In Chapter 9, Turner and Rylander review the history and pattern of land use in America, assert that ''the U.S. land regulatory system is a failure,'' and offer seven ''principles'' for developing a systems approach for land use planning. Chapter 10, by Jongman and Smith, presents the scientific basis and pragmatic development of ecological networks in European countries that are composed of core areas, buffer zones, and corridors. In contrast with the view against hierarchical approaches expressed in Sanderson and Harris's chapters, Jongman and Smith state that landscape hierarchy is ''the first basic principle'' for establishing the system of ecological networks. Chapter 11, by Pijanowski et al., presents the conceptual framework and model structure of a land transformation simulator for a watershed in Michigan. Although their effort for a better integration between GIS and simulation modeling should be applauded, one has to guess how this model is used to address research questions in landscape ecology. Much of the information in this chapter has been published elsewhere, but some of these references dated 1995 and 1996 are still cited as ''in review'' in a book published in 2000! The last chapter, by DeAngelis et al., is on individual-based models (IBMs) as applied to the Everglades landscape. Some excellent points are made about ecological models in general. However, the chapter contains little mathematical or computational detail, and is presented as more a rebuttal against some recent criticisms on IBMs (e.g., requiring more data than realistically available and possibly providing ''an unjustified sense of verisimilitude''). They argue that the high degree of realism that IBMs provide is a minimum prerequisite in any useful model in conservation

ecology, and that ''the basing of population modeling on individual behavior is a step toward the consolidation and simplification of ecological theory.''

This book shows that ''landscape ecology'' is defined in many ways. To many, if not most, landscape ecologists, landscapes are spatially heterogeneous areas that may be as large as thousands of square kilometers or as small as tens of square meters, depending on organisms or ecological processes under consideration. Accordingly, landscape ecology is simply the study of the relationship between spatial pattern and ecological processes over a range of spatial scales. Of course, human-scale landscapes that span over tens or hundreds of square kilometers are more familiar and convenient to humans, and often are relevant geographic domains for dealing with many ecological and environmental issues. Many have argued that fixing the spatial dimension of landscape at a particular size is arbitrary, and may impede rather than facilitate the development of landscape ecology as a science. Although landscape ecologists still can not agree on the spatial dimension of the very object they study, they do converge on the most essential feature of a landscape: spatial heterogeneity. They also tend to agree that spatial heterogeneity exhibits different patterns at different scales, and that organisms and ecological processes with distinctive characteristic scales respond to spatial heterogeneity at different scales.

The major messages one gets from this book include: the effects of mobile organisms on landscape heterogeneity are as important as the effects of landscape structure on ecological processes; landscape context is as important as or more important than content itself; and evolutionary processes and constraints should be considered in landscape ecology. These are all good points. However, the pattern-process-scale and hierarchical perspectives in landscape ecology, labeled as ''the slicing-and-dicing approach'' by Sanderson and Harris, are completely compatible with these ideas, and indeed already contain them. To most landscape ecologists, landscape ecology is not just the study of pattern on process, but the interactions between pattern and process. In fact, studies of how animals affect and are affected by spatial patterns are numerous in the literature. Although one can find many pieces of interesting, occasionally exciting, information, most chapters are too brief and lack ''corridors'' to remember ''fragments,'' to use some of the editors' favorite words. Chapters written by invited contributors, although individually valuable readings, can hardly be regarded as complementary parts that help achieve the admirable, but still elusive, goal of the whole—to develop a sound, coherent paradigm of landscape ecology. Overall, the book provides many wonderful case studies in landscape ecology and conservation biology from many parts of the world, but presents a partial and distorted picture of what landscape ecology has become. Nevertheless, a valuable message from this book is clear and loud: the role of mobile organisms and evolutionary theory deserves more attention in the development of landscape ecology.

JIANGUO (JINGLE) WU

Arizona State University-West
Department of Life Sciences
P.O. Box 37100
Phoenix, Arizona 85069-7100

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