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CHAPTER ABSTRACTS

Chapter 1
Perspectives and Prospects of Landscape Ecology

Richard Hobbs and Jianguo Wu

Landscape ecology has rapidly established itself as an interdisciplinary research field worldwide in the past few decades. However, diversification in perspectives and approaches has apparently caused some concerns with the "identity" of the field in recent years. We need continued improvement in our ability to collect and interpret spatial data. We need to ensure that effective metrics are developed which aid in this interpretation. We need to develop streamlined ways of feeding complex spatial data into land use planning and management decisions. And to do all this, we need to find ways of conducting our research in inter- and transdisciplinary settings which actually work. This set of requirements is surely enough to stimulate the field of landscape ecology to continue to develop its intellectual rigor and to mature as a science. The various chapters in this book explore the current status of endeavors in each of the areas outlined above, and we hope that they faithfully indicate the vigor and promise currently being shown within landscape ecology.

Chapter 2
Adequate Data of Known Accuracy are Critical to Advancing the Field of Landscape Ecology

Louis Iverson

Acquiring adequate data of known accuracy is the one of the priority research topics that pervades all the other topics presented in this book. The quality of raw data, metadata, and derived data products is critical to landscape ecology. Though massive strides have been made in data acquisition, technology, and management over the past two decades, there is still a long way to go. Many of today's global environmental challenges need additional reliable data with a known (and preferably high) degree of certainty to sustain the political will to implement practical solutions to the challenges. This paper presents a review of the advances of the past two decades, future directions, sources and issues associated with data uncertainty, and 14 research issues and three policy issues that require attention for our field to thrive into the future. Developing and testing methods of uncertainty analysis and assessing their effects on landscape pattern analysis and modeling is a primary research opportunity. Acquiring and maintaining high quality and spatially referenced raw data, metadata, and derived data products is imperative for landscape ecologists to make credible recommendations on the landscape issues facing society.

Chapter 3
Landscape Pattern Analysis: Key Issues and Challenges
Harbin Li and Jianguo Wu

The objectives of this chapter are: (1) to critically assess the current status of landscape pattern analysis (LPA), (2) to review the assumptions, behaviors, and limitations of commonly used LPA methods, (3) to discuss major challenges in LPA, and (4) to develop guidelines for the effective application of LPA. We will focus on the proper selection, use, and interpretation of various methods, based on key spatial pattern attributes, basic assumptions, general behaviors, and major limitations. We conclude that, to guarantee effective use of landscape pattern analysis, one must understand both the method itself and the data used in its implementation. It is certain that, with emerging new ideas and theories of spatially extended systems and rapidly developing technologies in computing and remote sensing, LPA will continue to make progress and play a pivotal role in landscape ecology.

Chapter 4
Spatial Heterogeneity and Ecosystem Processes
Monica G. Turner and Jeffrey A. Cardille

Enhancing knowledge of the patterns and causes of spatial heterogeneity in ecosystem function remains at the frontier of ecosystem and landscape ecology. Landscape ecology has contributed to tremendous progress in quantifying spatial heterogeneity and understanding how organisms and disturbances interact with spatial heterogeneity at varying scales. However, the spatial patterns, causes, and effects of ecosystem function across landscapes have received less emphasis. Integration of ecosystem and landscape ecology is needed and offers opportunities to generate new insights about how landscapes function. Key research questions are presented for understanding the causes and consequences of spatial heterogeneity in ecosystem process rates; the influence of land-use legacies on current ecosystem condition; horizontal flows of matter and energy in landscape mosaics; and the linkage between species and ecosystems. Examples to illustrate these research directions are drawn from the effects of fire on vegetation and ecosystem processes, effects of historical land use in forested landscapes, exchanges of nutrients between terrestrial and aquatic ecosystems, and trophic cascades involving large herbivores. A more synthetic understanding of spatial heterogeneity in ecosystem processes is a key research priority that should include both theoretical development and empirical study. We challenge landscape ecologists to embrace the functional complexity of ecosystem ecology, and ecosystem ecologists to similarly embrace the spatial complexity of their systems.

Chapter 5
Landscape Heterogeneity and Metapopulation Dynamics
Lenore Fahrig

Landscape ecologists became interested in how landscape structure affects ecological responses during the mid-1980s. One ecological response of interest to landscape ecologists is population dynamics. In the mid-1980's, metapopulation ecology, the study of habitat spatial structure on population dynamics, had already been in existence for 14 years. It was therefore natural for landscape ecologists with an interest in population dynamics to take the metapopulation ecology perspective as a starting point in developing a landscape-scale population ecology. In this

chapter I review the original metapopulation model and describe how the spatial structure incorporated in metapopulation models has changed over the past 35 years. I then discuss limitations of the classical metapopulation framework for predicting population dynamics in heterogeneous landscapes, and I argue for continued development of landscape population models.

Chapter 6
Determining Pattern-Process Relationships in Heterogeneous Landscapes
Robert H. Gardner, James D. Forester and Roy E. Plotnick

Parsimonious measures of spatial patterns can provide useful descriptions of heterogeneous landscapes, allowing the consequences of landscape change to be quantified and compared in time and space. A multitude of pattern metrics have been developed to satisfy this critical need. However, the values of most metrics are dependent on the number and relative proportion of land-cover types, resulting in a high degree of redundancy of information among these metrics. Furthermore, the effect of landscape pattern on ecological process may not be well measured by these metrics. This chapter examines the effect of landscape heterogeneity on the effectiveness of corridors as links for isolated populations of annual plants and evaluates the utility of landscape metrics as predictors of dispersal success. The results of a wide variety of scenarios showed that biological variables (plant life history characteristics including fecundity and competitive ability) interacted with the heterogeneity of the corridor (corridor width and degree of fragmentation) to produce scale-dependent changes in dispersal success. The effect of landscape pattern was statistically explained by several different metrics, but only a few were needed to maximize the amount of variance explained (~62%). Although landscape description remains an open area of investigation, increased rigor in the use of metrics is needed, especially when collinearities and threshold phenomena exist.

Chapter 7
Scale and Scaling: A Cross-Disciplinary Perspective
Jianguo Wu

Scale and heterogeneity are two key concepts in landscape ecology which are inherently related. Scale would matter little in a world where entities and relationships remain invariant across space or time, or in a landscape that is spatially or temporally homogeneous (i.e., uniform or random). However, real landscapes are heterogeneous biophysically and socioeconomically, and they must be treated as such for most questions and problems that interest us as scientists or citizens. Spatial heterogeneity -- the diversity of entities and their spatial arrangement -- is one of the most essential and unifying features of all natural and anthropogenic systems. Landscape heterogeneity is the manifestation of patchiness (discrete patterns) and gradients (continuous variations) that are intertwined across multiple spatial scales. Thus, scale is indispensable for describing and understanding landscape pattern. The main goal of this chapter is to provide an overview of the key concepts, methods, and state-of-the-science of scale and scaling issues that are relevant to landscape ecology. Obviously, this is an extremely ambitious goal because of the enormous scope and complexity of this topic. I shall discuss both the conceptual and technical issues of scale and scaling, and identify major research questions and challenges in scaling across heterogeneous landscapes. Although the principal emphasis is placed upon spatial scale, most of the concepts and methods also apply to temporal scale.

Chapter 8
Optimization of Landscape Pattern
John Hof and Curtis Flather

The objective of this chapter is to present an overview of the state-of-the-science in spatial optimization of landscape pattern and to suggest research questions that are most critical for moving forward in this field. General treatment of stochastic variables in spatial optimization is in its infancy. Improved understanding and prediction of organism movement is the most fundamental ecological research need to support spatial optimization. Addressing landscape management problems involving multi-species objective functions and complex interactions between individuals or between species is currently beyond the state-of-the-science. These problems will require very creative optimization approaches that may be heuristic and open-ended in nature and thus can only suggest "good" landscape arrangements rather than truly optimal layouts. Synthesis of existing capabilities and monitoring methods for implemented spatial plans are also needed. In general, the challenge is to capture the state-of-the-science described in the other chapters in this book in spatial optimization models that are constructible and solvable with current or near-future software and hardware resources. This is a significant challenge indeed.

Chapter 9
Advances in Detecting Landscape Changes at Multiple Scales: Examples from Northern Australia
John A. Ludwig

As humans continue to impact and change our globe, landscape ecologists face bold challenges in developing methods that detect changes before they become irreversible. From my perspective, three key challenges are: (1) detecting changes in landscape cover and condition (health), and its spatial heterogeneity, at scales useful for environmental reporting, (2) quantifying the flow-on effects caused by landscape changes, and (3) understanding the ecological processes driving landscape changes so that effective management actions can be taken. Monitoring the condition of landscapes in northern Australia illustrates how changes in vegetation cover, and its pattern, can now be routinely detected using field- and satellite-based time-series data. However, landscape metrics are needed as indicators that relate changes in landscape patterns to changes in ecological processes so that we can better understand the effects of these changes, and predict the outcomes of management actions. Indicators are needed at different scales. For example, at finer-scales, people on the land need to know when soil erosion is occurring in paddocks so that control actions can be taken. Coarser-scale indicators are needed by people in public land management agencies to know, for example, where in the region signs of general degradation are appearing so that regional land management strategies can be altered. Perhaps our greatest challenge is to develop remotely-sensed indicators that provide early warnings so that immediate threats to landscapes can be efficiently and effectively addressed.

Chapter 10
The Preoccupation of Landscape Research with Land Use and Land Cover
Marc Antrop

Purpose of this paper is to explore the general context in which the terms land use/cover and land use/cover changes occur in relation to landscape research, planning and design activities, different landscape types and processes related to change. The goal is to detect correspondences and differences between different approaches and activities dealing with the landscape and land use/land cover at a global scale. As many disciplines and agents are involved in landscape and land-use change, an Internet search with Google was used to analyze a variety of related keywords. Although this is a crude approach, which uses mainly English terms and only one search engine and no evaluation of the quality and scientific significance of the content of the results can be given, the outcome indicates some interesting associations, which are relevant when a broad transdisciplinary approach in landscape studies is aimed as stated in the mission of the International Association for Landscape Ecology. Comparing disciplines shows that landscape architecture has most common hits with landscape planning, landscape ecology and landscape history. The term land use is 8.5 times more common than land cover. The term land use is more used in landscape ecology, landscape planning and landscape geography, and issues of landscape protection and conservation. It is less common in landscape architecture and landscape history. The term land cover is relatively more associated with keywords related to causes and processes of change. This is very clear in the association with development, population, agriculture and forestry, and processes such as fire, climate and land degradation. Changes in land use/land cover are equally associated with development, climate and agriculture. Domains dealing with the rural landscape and the countryside use almost exclusively the term land use, while land cover is most common in forestry. In landscape ecology and applications such as land evaluation, land cover is used relatively more frequently than in other disciplines and so is also the combined term land use/cover. Both concepts are less common in planning and landscaping. Change is an important issue in all disciplines and activities, but remarkably least of all in landscape architecture and landscape planning. Landscape ecology and landscape planning score highest of all disciplines within the total hits on landscape management. Associations between the terms used differ a lot and indicate contexts for a better integration of theoretical and applied aspects in landscape science. The focus should be on linking scientific research studying processes at a global scale with decision-making of actors at the local scale.

Chapter 11
Applying Landscape-Ecological Principles to Regional Conservation: The Wildcountry Project in Australia
B. G. Mackey, M. E. Soulé, H. A. Nix, H. F. Recher, R. G. Lesslie, J. E. Williams, J. C. Z. Woinarski, R. J. Hobbs, and H. P. Possingham.

WildCountry assumes that, for much of Australia, voluntary changes based on partnerships between stakeholders will be the way forward. NGOs such as the Wilderness Society are well placed to help such partnerships. Governments can be constrained by inertia, vested interests or prior policy decisions. NGOs, on the other hand, can have greater flexibility and, often, greater longevity, than governments. This approach to conservation will invariably need to mesh with other programs that aim at redesigning agricultural and pastoral systems to ensure sustainability.

In order to facilitate such a partnership approach, education of and engagement with local communities will be key components of a WildCountry framework. Whilst acknowledging the importance of these social dimensions to WildCountry, our focus in this chapter is on the necessary scientific components of a WildCountry framework – though the social dimensions are touched upon in those sections below that address broad scale threatening processes and approaches to systematic planning.

Chapter 12
Using Landscape Ecology to Make Sense of Australia's Last Frontier
David Bowman

In this chapter I draw on my experience in working on the north Australian frontier, reflecting on the potential of landscape ecology to contribute to the quest for sustainability in a time of tremendous environmental change. In such a culturally contested and rapidly changing region, the holistic and integrative approaches of landscape ecology are clearly apparent. So to is the power of story telling. Indeed, I explore these ideas by telling a number of 'stories' about northern Australia, and my impressions of the practice of landscape ecology.

Chapter 13
Transferring Ecological Knowledge to Landscape Planning: A Design Method for Robust Corridors
Claire C. Vos, Paul Opdam, Eveliene G. Steingröver, and Rien Reijnen

The aim of this chapter is to discuss the development of planning guidelines for effective corridors, based on the best available ecological knowledge, and the effective implementation of these guidelines in a complex multi-actor planning process. We will analyze the different steps in the implementation process from basic landscape ecology to on-the-ground application, and identify different types of knowledge and skills required in each phase. We are aware that no single 'best method' exists for the implementation of landscape ecology in landscape planning. Strategies are, for instance, strongly dependent on the nature policy and planning traditions in various countries. However we do think that our approach might be helpful to better understand the prerequisites for the integration of landscape ecology in planning.

Chapter 14
Integrative Landscape Research: Facts and Challenges
Gary Fry, Bärbel Tress, and Gunther Tress

Integrative research approaches are currently very popular and generally considered more likely than disciplinary studies to solve management problems in multifunctional landscapes. This paper explores the nature of inter- and transdisciplinary research and the potential and limitations of such research approaches. Our overview on the facts and challenges of integrative landscape research includes definition of concepts, research motivations and policy expectations as well as the products of integrative research approaches. Stakeholder participation is seen as the critical factor in the growth of transdisciplinary approaches where academic and non-academic participants work together to solve complex land management problems. However, as a result of the rapid growth of transdisciplinary approaches, the line between research and application is becoming blurred. We therefore discuss organisational barriers, ways to improve the theory base

as well as education and training needs for integrative research. As a framework for discussing integrative projects and their products, we present data gathered from interviews with funding bodies, project leaders and participants involved in integrative projects on European landscapes, as well as contact with 156 journal editors and the results from an international web-based survey of 150 researchers. Based on this information we develop a code of good practice for integrative research. Finally, we look ahead at the challenges arising from the widespread adoption of integrative research, what we can realistically expect from it and its limitations.

Chapter 15
Landscape Ecology: The State of the Science
Jianguo Wu and Richard Hobbs

Two major schools of thought in landscape ecology have widely been recognized: the European approach that is more humanistic and holistic and the North American approach that is more biophysical and analytical. To increase the synergies between the two approaches, not only do we need to appreciate the values of both approaches, but also to develop an appropriate framework in which different perspectives and methods are properly related. Toward this end, in this chapter we shall compare and contrast the European and North American approaches through several exemplary definitions. We shall argue that both approaches can be traced back to the original definition of landscape ecology, and that recent developments seem to show a tendency for unification of once diverging perspectives. Then, we shall propose a hierarchical and pluralistic cross-disciplinary framework for promoting interactions and synergies between different perspectives and methods. Finally, the relevance of this framework to the admirable but elusive goal of unification will be discussed.