ADVANCES IN URBAN ECOLOGY

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ECOLOGY
Integrating Humans and
Ecological Processes in Urban
Ecosystems

by

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*To Antonio, Leda
and Matteo*

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PREFACE

Natural and social scientists face a great challenge in the coming decades: to understand the role that humans play in ecosystems, particularly urban ecosystems. Cities and urbanizing regions are complex coupled human-natural systems in which people are the dominant agents. As humans transform natural landscapes into highly human-dominated environments, they create a new set of ecological conditions by changing ecosystem processes and dynamics. Urbanization changes natural habitats and species composition, alters hydrological systems, and modifies energy flows and nutrient cycles. Although the impacts of urban development on ecosystems occur locally, they cause environmental changes at larger scales. Environmental changes resulting from urbanization influence human behaviors and dynamics and affect human health and well-being.

Remarkable progress has been made in studying the impact of urban development on ecosystem functions (McDonnell and Pickett 1993, McDonnell et al. 1997, Grimm et al. 2000, Pickett et al. 2001, Alberti et al. 2003), yet the interactions and feedback between human processes and ecosystem dynamics in urbanizing regions are still poorly understood. In this book I argue that new syntheses across the natural and social sciences are necessary if urban and ecological dynamics are to be successfully integrated into a common framework to advance urban ecology research. If we remain within the traditional disciplinary boundaries, we will not make progress towards a theory of urban ecosystems as coupled human-ecological systems, because no single discipline can provide an unbiased and integrated perspective. Questions and methods of inquiry specific to disciplinary domains yield partial views that reflect different epistemologies and understandings of the world.

It is critical that we develop an integrated approach at a time when urbanizing regions are faced with rapid environmental change. Planners and managers worldwide face unprecedented challenges in supporting urban populations and improving their well-being while simultaneously maintaining ecosystem functions. Agencies must devise policies to guide urban development and make decisions about investing in infrastructure that is both economically viable and ecologically sustainable. An integrated framework is required to assess the environmental implications of alternative urban development patterns and to develop policies to manage urban areas in the face of change. In particular, strategies for urban growth management will require such integrated knowledge to maintain ecological

resilience by preventing development pressure on the urban fringe, reducing resource use and emissions of pollutants, and minimizing impacts on aquatic and terrestrial ecosystems.

Scholars of urban ecology have started to recognize the importance of explicitly linking human and ecological processes in studying the dynamics of urban ecosystems. Not only are human decisions the main driving force behind urban ecosystems; changes in environmental conditions also control some important human decisions. Integrated studies of coupled human-natural systems have started to uncover new and complex mechanisms that are not visible to either social or natural scientists who study human and natural systems separately (Liu et al. 2007, Collins et al. 2000, Alberti et al. 2003). Simply linking scientific disciplines is not enough to achieve the level of synthesis required to see the urban ecosystem as a whole. Yet virtually no plan exists for synthesizing these processes into one coherent research framework.

The idea that humans are an integral part of ecosystems and that cities cannot be fully understood outside of their ecological context is hardly new. The evolution of cities as part of nature dates back at least to Geddes (1915) if not much earlier. Anne Spirn (1985) noted that an understanding of the interdependence between cities and nature was already present in the writings of Hippocrates (ca. 5th century BCE), Vitruvius (ca. 1st century BCE) and Leon Battista Alberti (1485). During the last century, the idea took form and evolved in initial areas of study in various disciplines including sociology (Park et al. 1925, Duncan 1960), geography (Berry 1964, Johnston 1982, Williams 1973, Zimmerer 1994), ecology (Odum 1953, Wolman 1971, Sukopp 1990, McDonnell et al. 1993), anthropology (Rappaport 1968, Kemp 1969, Thomas 1973), history (Cronon 1991), and urban design and planning (McHarg 1969, Spirn 1984, Lynch 1961), only to mention some of the earlier scholars. More recently, new attempts at interdisciplinary studies have emerged (McDonnell et al. 1997, Grimm et al. 2000, Pickett et al. 2001, Alberti et al. 2003).

What is new today is the acknowledgment that the sciences of ecology and of cities have pretty much ignored each other until very recently. The theoretical perspectives developed to explain or predict urban development and ecosystem dynamics have been created in isolation; neither perspective fully recognizes their interdependence. Ecologists have primarily studied the dynamics of species populations, communities, and ecosystems in non-urban environments. They have intentionally avoided or vastly simplified human processes and institutions. Landscape ecology is, perhaps, the first consistent effort to study how human action (i.e., changing spatial patterns) influences ecological processes (e.g., fluxes of organisms and materials) in urbanizing environments. Social scientists, on the other hand, have only primitive ways to represent ecological processes. Neoclassical economics, for example, uses

the theory of land rent to explain the behaviors of households, businesses, and governments that lead to patterns of urban development, completely disregarding the dynamic interactions between land development and environmental change.

In studying the ways that humans and ecological processes interact, we must consider that many factors work simultaneously at various levels. If we simply link traditional disciplinary models of human and ecological systems, we may misrepresent system dynamics because system interactions may occur at levels that our models fail to consider. This is particularly true in urban ecosystems, since urban development controls ecosystem structure and function in complex ways. Furthermore, these interactions are spatially determined. The dynamics of land development and resource uses and their ecological impacts depend on the spatial patterns of human activities and their interactions with biophysical processes at various scales. Humans generate spatial heterogeneity as they transform land, extract resources, introduce exotic species, and modify natural agents of disturbance. In turn, spatial heterogeneity, both natural and human-induced, affects resource fluxes and ecological processes in urbanizing ecosystems.

In this book I seek to bring together—systematically—a wide range of theories, models, and findings by scholars of urban ecosystems in both the natural and social sciences.¹ What sets this work apart from other efforts to assess the human role in ecosystems is my specific focus on urban areas. Although interest in urban ecosystems is growing, no single theory incorporates the different processes and approaches. A major obstacle to integration is the absence of a consistent understanding of related concepts and a common language (Tress et al. 2004). I address several disciplinary perspectives—ecology, economics, geography, landscape ecology, and planning—each with its own assumptions, methods of analysis, and standards of validation. Without the previous work of scholars from these many disciplines I could not have possibly covered all the areas of research or touched on the complex scientific problems emerging in these fields. Many aspects remain outside the scope of this book, since an attempt to address them all would have made the task impossible. My goal is to explore the opportunities for a synthesis and provide a framework that can stimulate scholars in these disciplines to generate theories and hypotheses, and identify areas for future research. Using the Puget Sound as a case example I present a range of theoretical issues and methodological implications.

When I started writing this book I thought I could synthesize the challenges that the study of urban ecosystems poses to both social and natural

¹ I focus primarily on North America and only in part on the European schools. There are important contributions in many parts of the world that are not included in this book—not because they are not relevant to the study of urban ecology—but simply because they are outside the scope of this book.

scientists; I aimed at the “consilience,” or unity of knowledge across fields, that Wilson (1998) argues has eluded science. As this work proceeded, it became clear that many syntheses are possible—at least one for each team of scientists and practitioners that comes together to study urban ecology. All are potentially accurate accounts, but all are incomplete views of urban ecology. In this book, I attempt to provide one of these possible syntheses, building on the collective work and thoughts of the Urban Ecology team of faculty and students at the University of Washington in Seattle. I propose that cities are hybrid phenomena—driven simultaneously by human and biophysical processes. We cannot understand them fully just by studying their component parts separately. Thus urban ecology is the study of the ways that human and ecological systems evolve together in urbanizing regions.

To fully integrate humans into ecosystems, ecology must deal with the complexity and diversity of human cultures, values, and perceptions, and their evolution over time. Culture and values play a key role in the ways that humans build cities and shape the built environment. As Lynch (1961,79) put it in *A Theory of Good City Form*, “we must learn what is desirable so as study what is possible.” In this book I do not explicitly address culture and values, not because I do not consider them essential to an understanding of how urban ecosystems work, but because I could not possibly do justice to the complexity of relationships that culture and values bring to the study of urban ecosystems. I leave this task to those scholars in anthropology, sociology, planning, and political science who study culture and values and can more effectively and thoroughly build a bridge with the perspective proposed here. I hope that by bringing humans into the study of the ecosystems this book will lead the way in efforts to fully integrate them.

The book starts with a review of urban ecological theory and the evolving concept of the urban ecosystem. Chapter 1 examines existing approaches for integrating human and ecological systems and articulates the rationale for a new synthesis, based on the fact that humans are driving the dynamics of urban ecosystems. Chapter 2 explores the role of humans and societal processes, and identifies human-induced stresses and disturbances. Major human driving forces are demographics, socioeconomic organization, political structures, and technology. Human behaviors—the underlying rationales for the actions that give rise to these forces—directly influence the use of land, as well as the demand for and supply of resources. In urban areas these forces combine to affect the spatial distribution of activities, and ultimately affect the spatial heterogeneity of ecological processes and disturbances. Chapter 3 focuses on how urban patterns affect ecosystem dynamics. I summarize what we do and do not know about the relationships between urban patterns and ecosystem functions.

To study urban ecosystems and test hypotheses about mechanisms that govern their dynamics, we need to detect and accurately quantify the urban landscape pattern and its change over time. In Chapter 4, I propose that hybrid landscapes in urbanizing regions have distinctive signatures and propose an approach to quantify them. Chapters 5 through 8 examine the impacts of urban patterns on the biophysical environment and the resulting effects on ecosystem dynamics. Throughout these chapters I explore the connections between human and ecological processes and their implications for integrated research. Chapter 9 addresses the complexity and uncertainty in modeling urban ecosystems, their variability and dynamics, and the causes and effects of heterogeneity on ecological and economic processes at various scales. Many important ecological processes are sensitive to spatial heterogeneity and its effects on fluxes of organisms, materials, and energy. Spatial heterogeneity also affects the fluxes of economic resources that ultimately control the underlying urban pattern. Scale is a critical factor in understanding the interactions between human and natural disturbances, since spatial heterogeneity may affect the outcome of changes in driving forces only at certain scales. I discuss the challenges of predicting future dynamics of coupled human-ecological systems. Then, I explore scenario planning as an approach to adaptive planning and management. In Chapter 10 I provide a synthesis and a research agenda for the future.

An integrated knowledge of the processes and mechanisms that govern urban ecosystem dynamics will be crucial if we are to advance ecological research, and to help new generations of planners and managers solve complex urban environmental problems. This is a book aimed at ecologists, economists, geographers, engineers, political scientists, and planners interested in understanding the dynamic of coupled human-natural systems in urbanizing regions and the resilience of urban ecosystems under alternative scenarios of urban development and environmental change.

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