

# Urban Ecology

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## Science of Cities

How does nature work in our human-created city, suburb, and exurb/peri-urb? Indeed how is ecology – including its urban water, soil, air, plant, and animal foundations – spatially entwined with this great human enterprise? And how can we improve urban areas for both nature and people?

*Urban Ecology: Science of Cities* explores the entire urban area: from streets, lawns, and parks to riversides, sewer systems, and industrial sites. The book presents models, patterns, and examples from hundreds of cities worldwide. Numerous illustrations enrich the presentation. Cities are analyzed, not as ecologically bad or good, but as places with concentrated rather than dispersed people. Urban ecology principles, traditionally adapted from natural-area ecology, now increasingly emerge from the distinctive features of cities. Spatial patterns and flows, linking organisms, built structures, and the physical environment highlight a treasure chest of useful principles.

This pioneering interdisciplinary book opens up frontiers of insight, as a valuable source and text for undergraduates, graduates, researchers, professionals and others with a thirst for solutions to growing urban problems.

**Richard T. T. Forman** is the PAES Professor of Landscape Ecology at Harvard University, where he teaches ecological courses in the Graduate School of Design and in Harvard College. His research and writing include landscape ecology, road ecology, urban ecology, land-use planning and conservation, the netway system, and linking science with spatial pattern to mesh nature and people on the land. His previous title, *Urban Regions: Ecology and Planning Beyond the City*, was published by Cambridge University Press in 2008.

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**Richard T. T. Forman**

Harvard University, USA



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## Foreword

The term “urban revolution” was introduced by Gordon Childe in 1936 to highlight the powerful process of transforming agricultural societies to large complex urban centers. His model describes how communities, beginning around 9000 years ago, grew from tens or hundreds to thousands of people. In 3100 BC, Memphis, Egypt was the largest city in the world with over 30 000 residents. Today, the Cairo metropolitan area has over 17 million inhabitants and ranks 15th on the list of the world’s largest cities. Mega-cities such as Tokyo, Seoul, Mexico City, and New York have over 20 million urban dwellers and continue to grow. The scale and complexity of the urbanization process originally depicted by Childe has little resemblance to what is happening today.

In the short history of humans on our planet, the number, population size, spatial extent, rate of growth, and degree of environmental impact of cities are unprecedented. Today, cities and towns face a myriad of formidable environmental challenges concerning food production, energy, water, waste management, and pollution, as well as social challenges in regard to jobs, poverty, and human health and wellbeing. I propose that as a result of the current rate and magnitude of urbanization around the globe, we are on the cusp of a new “urban revolution.” The goal and rallying call of this revolution is “We Want Healthy, Liveable, Sustainable, and Resilient Cities and Towns.”

Modern cities have developed primarily based on the best planning, engineering, architectural, and design standards of the day and have been driven by societal and economic requirements and constraints. This resulted in cities having largely been built and managed as distinct entities where people, buildings, roads, rails, nature, water, energy, and money were studied, planned, and managed separately in professional, academic, and administrative silos.

Over the past 25 years, human settlements have increasingly been regarded and treated as complex ecosystems. Ecosystems can be simply defined as

specific places on Earth along with all the organisms that live there and the associated nutrient and energy flows. The ecosystem concept implies a complex system of interacting components with discernible feedbacks between components. Thus, the vegetation in a city park can influence energy use in adjacent buildings and the wellbeing of the residents and workers in the neighborhood. Ecosystem boundaries are not fixed but depend on the questions or problems being addressed. Therefore, an entire city can be viewed as an ecosystem or its smaller components such as lake ecosystems, woodland ecosystems, and residential community ecosystems can be legitimate units of study and management. Ecologists propose that a healthy ecosystem is one that is stable and sustainable while maintaining its organization and autonomy over time and its resilience to stress. Hence, a key tool to achieving the goals of this new “urban revolution” is the incorporation of ecological knowledge and principles into the management and creation of cities in order to develop healthy, liveable, sustainable, and resilient urban ecosystems.

In the 1980s, Richard Forman’s ideas and research on landscapes started another revolution, in this case a “landscape ecology revolution” in the way we see, manage, develop, and use our world. His groundbreaking papers and books on landscape and road ecology changed my view of the world and I don’t think I am alone. When I ride in a car, bus, or plane, or even when I look out the windows of very tall buildings, I no longer see only static views of vegetation, waterways, buildings, and roads; I now see a dynamic, multidimensional landscape powered by the actions of humans and ubiquitous ecological processes. Richard has provided us with the terminology, tools, and methods to describe and analyze the towns and cities in which we live and work; the farmlands that produce our food; the forest, lake, and mountain regions in which we take our vacations; and the remote regions of the world where humans rarely tread. His pioneering patch–corridor–matrix, and subsequent land mosaic model of

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landscape structure has passed the test of time and has been adopted throughout the world in order to achieve more positive environmental outcomes. While the use of an ecosystem perspective appropriately represents cities as complex adaptive systems and provides the tools to assess levels of sustainability and resilience, the adoption of Richard’s land mosaic model provides the tools to create sustainable and resilient cities and towns.

Richard’s seminal book *Land Mosaics* summarizes the ecology of heterogeneous landscapes and includes comprehensive discussions of how landscape structure and composition (i.e., the land mosaic) affect the flows of water, nutrients, animals, wind, and people. A recent search of Google Scholar revealed that this book has been cited in over 4000 publications. Thus, Richard’s “landscape ecology revolution” has had far-reaching global effects that have influenced how ecological and social scientists conduct their research, how policy makers and land managers conserve plants and animals, and how planners, designers, and landscape architects create more sustainable human settlements.

The current worldwide interest in creating sustainable and resilient cities has resulted in an increasing call for locally relevant ecological information and principles to guide urban development and management. Unfortunately, there has been a mismatch between the questions that planners, designers, and decision-makers are asking urban ecologists, and the questions that urban ecologists are asking to advance the science of urban ecology. Planners, designers, and managers are asking questions that are relevant to their day-to-day decision-making such as: How much green space is necessary to reduce the impacts of climate change? What design and construction techniques can be put into practice to minimize energy consumption? How much connectivity is required in an urban landscape to support diverse plant and animal communities? How can we design cities to improve human wellbeing? In contrast, most urban ecologists are conducting basic research designed to attain a better understanding of the structure and function of urban ecosystems.

Over the past 25 years, urban ecologists have produced a large body of studies from cities around the world that provide important insights into how urbanization is affecting ecological and social patterns and processes. However, the results of these studies have proven to be somewhat lacking when called upon to address the pressing questions from practitioners. This

is because they have primarily been focused on single cities or single organisms and have been primarily funded and designed to advance the basic science of urban ecology, rather than to address the applied research questions being asked by practitioners. To be fair, there are urban ecologists working in cities around the world, especially in Europe, who have been actively addressing applied research questions. Recently, there have been calls within the discipline of urban ecology to bridge the gap between basic and applied urban ecology research by increasing the interactions between scientists and practitioners, by adopting a comparative approach to the study of cities and towns, and by identifying more general principles regarding the effects of urbanization on ecological patterns and processes.

As a result of this current state of affairs, there has been no urban ecology textbook published to date for students, planners, designers, and policy makers interested in the practical aspects of creating healthy, livable, sustainable, and resilient cities and towns. Of course that is until I began reading the book in your hand. I am very impressed with the content and approach of this volume and feel it will no doubt make a significant contribution to the future development of the study and practice of the discipline of urban ecology. As I have written in a recent history of urban ecology, Richard approaches the study and practice of urban ecology from a different perspective than the mainstream academics in the field.

Richard has utilized his extensive ecological knowledge and experience, as well as his two decades of teaching suburban and urban ecology at Harvard University in the Graduate School of Design to bring the full force of this revolutionary landscape scale approach to the study, design, and management of cities and towns. He has carefully chosen the appropriate topics for chapters to provide his readers with both the basic principles of his unique landscape mosaic approach to urban ecology and practical examples of how they can be applied. As with Richard’s previous books, the number of references he cites is indicative of the extent of his scholarship. I am certain that both students and professionals alike will find these references a valuable resource for years to come. The breadth of the subject matter and examples presented in the book no doubt came from the many scientists, landscape architects, planners, designers, engineers, and policy makers that Richard has worked with in cities around the world.

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In conclusion, I would have to say that Richard Forman has had the unique education, university environment, and international experience to write the first comprehensive urban ecology text book that will guide the new urban revolution. This innovative book provides the foundation and inspiration for creating

healthy, livable, sustainable, and resilient cities and towns in the future.

Mark J. McDonnell  
*Director, Australian Research Centre for  
Urban Ecology  
Associate Professor, University of Melbourne*

## Preface

Most of us call urb our home. Today's giant urban areas grow upward in population, with a fast-march outward. Now urban footprints, the agricultural and natural lands needed to sustain us, more than cover the globe. This great urban enterprise thoroughly interacts with ecology, reflecting a yet more powerful force. Nature molds our urban world, from "natural disasters" and resource scarcities to treasured plants and wildlife around us. Even pollutant and waste accumulation, green marketing, and natural landscapes pictured on our walls and in our dreams highlight the ecological dimension. The clashing and collaborating of these two giants – urb and ecology – lead to this book.

My lens focuses on spatial pattern, how it molds and responds to flows/movements, and how they all change. The pattern and process of mosaics, now a centerpiece of ecology from which most other components nicely follow, are central. Indeed, spatial pattern emerges as an especially useful handle for planners, engineers, landscape architects, park managers, pollution experts, architects, transportation specialists, hydrologists, and more. All can easily use the principles of urban ecology to build more-promising futures.

Although other sciences underpin cities – chemistry, soil science, meteorology, microbiology, and more – ecological science fills the core. Indeed, ecology incorporates key features of these fields. Ecology as metaphor, marketing, sociology, or motherhood receives bare mention. Ecologists use the central concept of ecology – interactions among organisms and the environment – to study and understand the ecology of forests, lakes, populations, ecosystems, soils, whole landscapes, even regions. Tying this core theme to urban areas produces the highly useful concept of urban ecology used in this book:

*Interactions of organisms, built structures, and the physical environment, where people are concentrated.*

Plants, animals, and microbes are the organisms, roads and buildings the predominant built structures. Soil,

water, and air comprise the physical environment. Cities, towns, and adjacent built areas are the prime human concentrations.

Of course, many other interactions highlighted in sister disciplines, professions, and human activities are important in urban areas. For instance, public health, urban agriculture and bird watching emphasize human–organism interactions. Architecture, engineering, and construction link humans and built structures. Water supply, flood disasters and meteorology link humans and the physical environment. Sociology, employment, and retail shopping highlight human–human interactions. Adding "interactions with built structures" and "where people are concentrated" to the traditional core of ecology pinpoints urban ecology as a basic science, promising a diversity of highly useful applications. This intriguing subject offers challenge, discovery, and societal solutions now.

The perspective is global. Limiting our view to a single nation or region feels like a Mozart symphony with most of the orchestra missing. But using models, data, examples, and figures from a breadth of cities worldwide, we gain understanding, and discover great patterns for our own places. I have lived in urban regions of ten nations, and while writing, visited numerous US cities, five Chinese cities, five Spanish cities, four Brazilian cities, three English cities, two Mexican cities, Calgary, Dublin, Berlin and Paris. To feel my subject, I lived temporarily in a balconied old-narrow-street apartment at the heart of several million people, observing street trees change, birds in a courtyard, successional habitats, scores of industrial sites, soil under streets, plenty of parks, water flows, restaurant wastes, spatial patterns galore, even cracks underfoot. I became a keen city watcher.

For convenience, the general term "urban area" is used for all scales, from megalopolis and city to neighborhood and housing development. The chapters ahead include parks and other greenspaces, but ecologically explore essentially the entire urban area – streets, walls,

lawns, industrial sites, sewer systems, artifact-rich soil, aerial components, roofs, commercial centers, parks, dumps, and much more. Also, rather than outlining the newest hypotheses, I emphasize patterns and processes with reasonable evidence and broad application. Together, these approaches open up frontiers of insight and provide dependability for users.

High winds, scorching sun, frigid nights, big floods, insect outbreaks, and the seasonal flower explosion periodically highlight the power of nature. Meanwhile, the day-to-day expression of urban nature – pleasant temperatures, pouring rain, tree shading, venerable trees, birds singing, flies flying, soil growing grass, stormwater running off, microbes decomposing, clouds moving over us – permeates the city. People and nature are thoroughly intertwined in cities.

Most urban residents like the nature around them. In contrast, most ecologists consider urban nature and ecological conditions to be severely degraded, bulging with bad contaminants, invasive weeds, waste sites, sewage overflows, traffic pollutants, pigeons, pests, and pathogens. While I cannot eradicate my own tiltings, cities and ecological conditions are inherently neither good nor bad. Rather than judging urban nature, I attempt to objectively analyze and portray the distinctive ecological dimensions. Occasionally, urban areas are compared with natural or agricultural landscapes mainly to enhance our understanding of urban patterns. The book is urbanocentric rather than natural-land-centric.

Urban ecology has roots in many related fields, and benefits from the obvious goal of improving conditions for people packed together. Two recent salutary trends have been especially important. In one, a few integrated studies, notably in and around Berlin, Baltimore, Phoenix, Melbourne, Seattle, and Sheffield/London, have combined multi-investigator, multi-disciplinary, and relatively long-term study. In the second, several edited books and an occasional authored one on urban ecology have appeared, each containing useful information and insights, and together suggesting a rich promising picture. Publications with strong applied dimensions provide additional perspectives.

The time has arrived to pull the science together in a coherent and comprehensive form, pinpointing synergies where pieces of the picture are juxtaposed. The pages ahead attempt to catalyze urban ecology as accessible and appealing to students who will carry the field to greater heights, to research scholars pushing exciting frontiers,

and to professionals improving the built areas around us. Moreover, the informed public can gain “eurekas,” while pursuing a better future in ever-more-crowded urban living space. Discovery and delight pop off the pages.

In 1992 I began teaching a Harvard course on urban and suburban ecology. From the outset we attempted to discover or develop an intellectual core of urban ecology. Landscape ecology emerged as a key integrative ingredient, along with fine-scale urban pattern, process and, change. Gradually that core coalesced. Urban ecology principles, traditionally adapted from natural-area ecology, now increasingly emerge from the distinctive features of cities.

Broadening the perspective from city to urban region, another key step, was catalyzed by an analysis-and-planning project for the Barcelona urban region (*Mosaico territorial para la region metropolitana de Barcelona*; Forman 2004b). That challenge convinced me, an ecologist, that urban regions are really important globally for natural systems and their human uses, and especially as cities expand outward in the years just ahead. So, to help jumpstart our understanding of urban ecology, I analyzed the spatial ecological and human patterns in urban regions of 38 small-to-large cities worldwide (*Urban Regions: Ecology and Planning Beyond the City*; Forman, 2008). Using scores of spatial analyses, this effort highlighted patterns and principles, plus the importance of the ring-around-the-city to the city, and vice versa.

The book in your hand is the essential complement to the urban region work. In effect, peeling back our familiar human layer reveals the fundamental natural and built patterns of a city, how it works, and how it changes. Lots of lucid patterns and processes appear. The world of eternal flows, especially in urban networks, emerges. Plenty of principles based on these are articulated. Worldwide forms of repeated spatial patterns, such as road network, city center, building plot, even cracks in a surface, are compared ecologically. Lacunae and research frontiers galore are evident. Scores of solutions for human application are mentioned, but left for applied experts and professionals to develop and use.

Today urban regions are the place for most of us, “*Homo sapiens urbanus*,” and for many more in the years just ahead. Cultural and natural resources within the region enrich us. It is our annual home range; over years we become familiar with and care about it. Our sense of place is increasingly the urban region. Here ecology is in our heart, and on our lips. The pages ahead move urban ecology to the forefront of our mind.

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