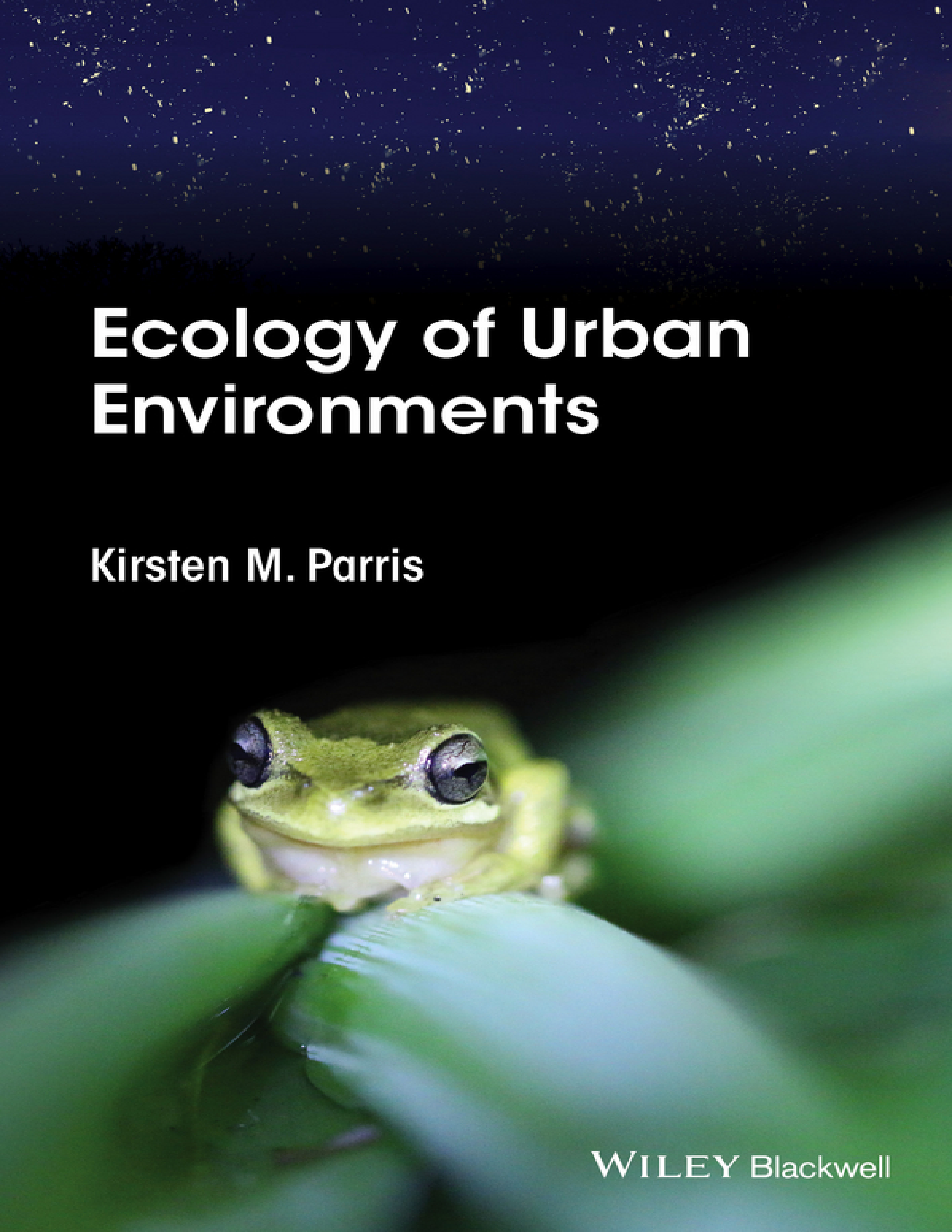
Ecology of Urban Environments

Kirsten M. Parris



WILEY Blackwell

Table of Contents

List of Illustrations

larger ecological niche than the species on the right, which is adapted to hotter, drier conditions.

Figure 4.2 A simplified urban food web showing (1) saprotrophs (fungi), (2) autotrophs (plants), (3) herbivores or primary consumers (ant, dove, moth), (4) primary predators (blackbird, insectivorous bat) and (5) secondary predators (cat, fox).

Figure 4.3 (a) Pretoria, South Africa, (b) the rufous-naped lark *Mirafra africana*, a grassland specialist lost from Pretoria following urbanization, (c) the white-bellied sunbird *Cinnyris talatala*, which is found in suburban and urban areas of the city. Pictures have been cropped and converted to black and white.

Figure 4.4 Schematic diagram of common patterns observed in urban bird communities; changes in population densities (solid and dotted lines) and species diversity (dashed line) along a wildland-urban gradient. 1 In wildlands, native species (solid line) out-compete invasive, synanthropic species (dotted line). 2 At intermediate levels of urbanization, both groups of species are still present. Invasive species increase in density more rapidly than native species by exploiting novel, stable, and homogenized food resources (e.g., commercial seed mixture). Native species persist through spatial partitioning, exploiting remnant patches that still contain specialized food or other resources, but may decline in the longer term. 3 At high levels of urbanization, coexistence mechanisms collapse, predation pressure relaxes, invasive species become dominant foragers and specialist native species become locally extinct.

Figure 4.5 Estimated probability of local extinction (circles) with 95% credible intervals for a plant species with traits fixed at the reference class for each categorical trait (herbaceous, annual, non-clonal, abiotic pollination, no specialised dispersal, nitrogen fixing, C3 photosynthetic pathway, no spines), and having mean height and seed mass, for each of 11 cities. The graph shows strong variation in the probability of local extinction between cities.

Figure 4.6 Relationship between the abundance of tree frog (*Litoria* spp.) larvae (tadpoles) and the abundance of predatory fish in urban wetlands across Melbourne, Australia, both expressed as catch per unit effort (CPUE). The solid line shows the relationship predicted by a Bayesian, zero-inflated negative binomial regression model (ZINB), and the dotted lines show the 95% credible intervals.

Figure 4.7 (a) Percentage of passes in each of 18 towns and cities in south-eastern Australia by bats belonging to five functional guilds; open-adapted (open), clutter-adapted (clutter), edge-adapted with low-frequency echolocation calls (edge-low), and edge-adapted with medium- and high-frequency calls (edge-medium and edge-high). Clutter-adapted and edge-high species have been combined in this Figure Luck et al. 2013, Figure 3. Reproduced with permission of Springer Science + Business Media. (b) A long-eared bat *Nyctophilus gouldi*.

Figure 4.8 Schematic diagram of the composition of local, regional and global ecological communities. Through the dispersal of species, the composition of the local community is linked to that of the regional community, and the composition of the regional community is linked to that of the global community. However, in urban environments, the local species pool is also linked to the global species pool via the

List of Tables

Ecology of Urban Environments

Kirsten M. Parris
School of Ecosystem and Forest Sciences
The University of Melbourne
Melbourne, Australia

WILEY Blackwell

This edition first published 2016 © 2016 by John Wiley & Sons Ltd

Registered office: John Wiley & Sons, Ltd, The Atrium, Southern Gate, Chichester, West Sussex, PO19 8SQ, UK

Editorial offices: 9600 Garsington Road, Oxford, OX4 2DQ, UK

The Atrium, Southern Gate, Chichester, West Sussex, PO19 8SQ, UK

111 River Street, Hoboken, NJ 07030-5774, USA

For details of our global editorial offices, for customer services and for information about how to apply for permission to reuse the copyright material in this book please see our website at www.wiley.com/wiley-blackwell.

Library of Congress Cataloging-in-Publication Data applied for

ISBN: 9781444332643 (Hardback)

ISBN: 9781444332650 (Paperback)

A catalogue record for this book is available from the British Library.

Wiley also publishes its books in a variety of electronic formats. Some content that appears in print may not be available in electronic books.

For Mick and Owen, my biggest supporters

and

In memory of Joanne Ainley, urban ecologist

Foreword

In the first quarter of the 21st century, we are living in a unique time in history – we are witnessing the move to the Anthropocene, a geological period in which humans have become a major driver of planetary processes. This time has also been termed the “Great Acceleration”, a period of rapid increase in a large array of human activities with correspondingly large impacts on many environmental and biological processes. One of the clearest indicators of the changes underway is the emergence of the city as the main human habitat. For most of human history, the majority of the human population lived in rural or extensive landscapes, with only a few settlements that could be called “cities”. Rapid human-population increase and industrialization from the 1800s onwards has been paralleled by a dramatic increase in the number and size of cities and an ever-increasing proportion of the human population living in urban areas. For the first time in history, humans are predominantly an urban species.

Cities are therefore extremely important environments from a human perspective: they are where most people now live. They form the centres of economic and cultural activity and are as diverse as the economies and cultures that created them. Cities come in all shapes and sizes, some developing from early hubs of trade and navigation and some springing up in entirely new locations. Early cities tended to be compact and geared for travel by foot or horse. However, cheap cars and mass transit have released cities from their earlier spatial constraints and many now sprawl extensively in all directions. Planning and management of urban form and function have become increasingly important endeavours as cities evolve, grow and require more efficient and effective private buildings, public spaces and essential services.

Cities are not only home to humans, however. Most cities are mosaics of built infrastructure and open space – parks, gardens, waterways and remnants of the nature that was present prior to the city's construction. These spaces are inhabited by a wide range of species, some of which thrive in the urban environment and some of which struggle. The mix of species present can include many species native to the region and many that have been introduced or have adapted themselves to the urban environment. Just as the city provides a focus for human creativity, it can also act as a place where new biologies play out – new combinations of species, species doing new things, and species interacting in novel ways with humans and their built environment.

Given the increasing importance of the city environment and the richness and fascination of the biological systems that develop in cities, it might seem odd that the field of urban ecology has only blossomed quite recently. Indeed, a few decades ago, it would appear that cities were not regarded as places where ecologists would want to work – seeking out instead the remote, apparently untouched areas where the ecology was “intact”. Today, cities are seen more as one end of a spectrum of humanized landscapes and are increasingly the subject of research into their ecological function. How do all the species found in cities persist and thrive? How do ecological communities develop within the altered environments found in cities? How does the urban ecosystem “work” with respect to flows of water, nutrients and energy? How do humans relate to, modify, and live in these environments? And, finally, are there better ways to plan and manage cities and their components that lead to greater liveability for humans and diverse biological communities alike?

This is the stuff of urban ecology, a growing field that seeks to understand how cities work in terms of their ecology and in relation to both their human and non-human inhabitants. This book is, a very timely contribution that provides an accessible yet fascinating synthesis of the ecology of urban environments. Within a strong framework of existing ecological theory, it explores how the construction and expansion of cities influence the characteristics of urban environments and the dynamics of populations, communities and ecosystems. It considers the ecology of human populations in cities, and presents a compelling case for conserving biodiversity and maintaining ecosystem services in urban landscapes. Overall, it seeks to help us better understand, plan and manage our primary habitat – a task that gets more pressing and important by the minute, both for ourselves and for the other species with which we share our cities.

Richard J. Hobbs
University of Western Australia

Preface

A long time ago came a man on a track
Walking thirty miles with a sack on his back
And he put down his load where he thought it was the best
Made a home in the wilderness
He built a cabin and a winter store
And he ploughed up the ground by the cold lake shore
The other travellers came walking down the track
And they never went further, no, they never went back
Then came the churches, then came the schools
Then came the lawyers, then came the rules
Then came the trains and the trucks with their loads
And the dirty old track was the Telegraph Road
Then came the mines, then came the ore
Then there was the hard times, then there was a war
Telegraph sang a song about the world outside
Telegraph Road got so deep and so wide
Like a rolling river
And my radio says tonight it's gonna freeze
People driving home from the factories
There's six lanes of traffic
Three lanes moving slow
I used to like to go to work but they shut it down

I got a right to go to work but there's no work here to be found

Yes, and they say we're gonna have to pay what's owed

We're gonna have to reap from some seed that's been sowed

And the birds up on the wires and the telegraph poles

They can always fly away from this rain and this cold

You can hear them singing out their telegraph code

All the way down the Telegraph Road

Mark Knopfler,
Telegraph Road

Acknowledgements

I have many people to thank for their encouragement, support and enthusiasm, without which this book would have remained unwritten. Alan Crowden prompted me to consider writing a text book on urban ecology; Mark Burgman convinced me that it was a good idea. Alan facilitated the book's publication with Wiley-Blackwell, and both he and Mark have been important supporters and mentors from its inception to completion.

I am grateful to many colleagues for their interest in this project and for helpful discussions about the ecology of urban environments, including Sarah Bekessy, Stefano Canessa, Jan Carey, Yung En Chee, Martin Cox, Danielle Dagenais, Jane Elith, Carolyn Enquist, Brian Enquist, Fiona Fidler, Tim Fletcher, Georgia Garrard, Leah Gerber, Gurutzeta Guillera-Arroita, Amy Hahs, Josh Hale, Andrew Hamer, Geoff Heard, Samantha Imberger, Claire Keely, Jesse Kurylo, José Lahoz-Monfort, Pia Lentini, Steve Livesley, Adrian Marshall, Mark McDonnell, Larry Meyer, Joslin Moore, Alejandra Morán-Ordóñez, Raoul Mulder, Emily Nicholson, Cathy Oke, Joanne Potts, Hugh Possingham, Dominique Potvin, Peter Rayner, Tracey Regan, John Sabo, Caragh Threlfall, Reid Tingley, Rodney van der Ree, Peter Vesk, Chris Walsh, Andrea White, Nick Williams and Brendan Wintle.

I thank all my family, friends and colleagues for their support throughout the process of writing this book. Particular thanks to Michael McCarthy, Owen Parris, Ann Parris, John Gault, Bronwyn Parris, Monica Parris, Bridget Parris, Susan McCarthy, David McCarthy, Margery Priestley, Liz McCarthy, Tom McCarthy, Kirsty McCarthy, Sarah Bekessy, Michael Bode, Gerd Bossinger, Lyndal

Borrell, Janine Campbell, Jan Carey, Jane Catford, Tasneem Chopra, Glenice Cook, Martin Cox, Kylie Crabbe, Karen Day, Jane Elith, Louisa Flander, Jane Furphy, Georgia Garrard, Cindy Hauser, Colin Hunter, Helen Kronberger, Rachel Kronberger, Min Laught, Sue Lee, Prema Lucas, Pavlina McMaster, Ruth Millard, John Moorey, Anne Macdonald, Meg Moorhouse, Sarah Niblock, Lisa Palmer, James Panichi, Rebecca Paton, Joanne Potts, Tracey Regan, Di Sandars, Anna Shanahan, Peter Vesk, Graham Vincent, Terry Walsh, Andrea White, Brendan Wintle and Ian Woodrow.

The Australian Research Council, the Faculty of Science at The University of Melbourne, the Australian Research Centre for Urban Ecology, and the NESP Clean Air and Urban Landscapes Hub have provided valuable support for my research on urban ecology. I thank my intrepid and enthusiastic Research Assistant, Larry Meyer, who has helped me with many aspects of this project. I am very grateful to Mark Burgman, Michael McCarthy, Caragh Threlfall, Chris Walsh and the 2014 Graduate Seminar: Environmental Science class at The University of Melbourne for reading and providing insightful comments on the draft manuscript. Lastly, I thank Ward Cooper, Delia Sandford, Kelvin Matthews, Emma Strickland and David McDade at Wiley-Blackwell and Kiruthika Balasubramanian at SPi Global for their assistance and patience as this book became a reality.

Chapter 1 Introduction

1.1 Setting the scene

Reading this book, there is a good chance that you live in an urban environment – a town or a city. And if you look out of your window or door, you might see buildings, roads, cars, fences and street lights, as well as people, cats, dogs, trees or flowers. You might hear a train rumbling, a jackhammer hammering, a violin playing, children laughing or birds singing. You might smell diesel exhaust from a passing truck, risotto cooking at a nearby restaurant, newly-mown grass from the park across the road, or the stench of a rubbish heap or an open drain. These are the contrasts of life in the city, where the best and worst of human existence can be found, and where habitats constructed for people can complement or obliterate the habitats of other species. Ecologists strive to understand the processes of and patterns in the natural world. Until recently, many ecologists practised their science in places far from cities, considering human activity to be a disruption – rather than a part – of nature. But ecological principles apply in urban environments too, and the separation of humans from the rest of nature occurs to our detriment. Urban ecology is a relevant and valuable discipline in the highly-urbanized world of the 21st century.

1.2 What is urban ecology?

As a natural science within the broader discipline of biology, ecology is the study of the distribution, abundance and behaviour of organisms, their interactions with each other and with their environment. Ecology traverses many scales, from within individual organisms to whole individuals, populations, communities and ecosystems. Organisms are living things, such as bacteria, fungi, plants and animals. Human animals (people) have not generally been studied alongside other organisms as part of ecology (but see human behavioural ecology: Winterhalder and Smith 2000; Borgerhoff Mulder and Schacht 2012). This is the first point of difference between urban ecology and other ecological disciplines; the second is its focus on urban environments, which can be considered as habitats designed by people for people.

In this book, I define urban ecology as the ecology of all organisms – including humans – in urban environments, as well as environments that are impacted by the construction, expansion and operation of cities, such as forested watersheds (catchments) that supply drinking water to urban populations. Urban ecology includes people because the presence, population dynamics and behaviour of people, and the environmental changes that occur when they construct towns and cities, are central to our understanding of how urban systems function. Urban ecology has a different meaning in the social sciences, where it describes an approach to urban sociology that uses ecological theory to understand the structure and function of cities (e.g., Park and Burgess 1967). Some authors also use the term urban ecology to describe an interdisciplinary field that brings together the natural sciences, social sciences and humanities (e.g., Dooling et al. 2007; see Chapter 8 for further discussion of this point). However, the motivation for and focus of this book are strongly grounded in the natural science of ecology. Ecology has much to offer the study of cities and towns, and this book provides a conceptual synthesis of the extensive but often disparate urban-ecological literature. In combination with other disciplines in the natural sciences, social sciences and humanities, an improved understanding of urban ecology will make a vital contribution to improved urban planning, design and management, for the benefit of all species that live in cities.

Urban ecology is a relatively young discipline and there has been some debate about what it should encompass and how the term “urban” should be defined (e.g., Collins et al. 2000; McIntyre et al. 2000; Pickett et al. 2001). For example, should we recognize an urban area by the number or density of people living there, by certain characteristic landscape patterns, by the density of features such as buildings and roads, or a combination of these things (McIntyre et al. 2000; Luck and Wu 2002; Hahs and McDonnell 2006)? Is there a single definition of urban that everybody should use, or are there a number of acceptable definitions that are suitable for different research questions? Wittig (2009) supports a very narrow definition of the term urban, as inner-city neighbourhoods dominated by concrete, asphalt and buildings, with no original vegetation remaining. This excludes other parts of cities, such as streams, private gardens and areas of remnant vegetation. It also excludes environments outside towns and cities that are nonetheless impacted by them. Pursuit of one definition of “urban” to be used in all urban-ecological studies may not be very useful, as definitions are likely to change with the scale of a study and the questions being asked. What is urban for a stream or an owl may differ from what is urban for a person, a beetle or a fungus. However, it is important that the definition is both clear and quantitative to allow the methods of a study to be replicated, and to assist comparison between studies and formal meta-analysis (McIntyre et al. 2000).

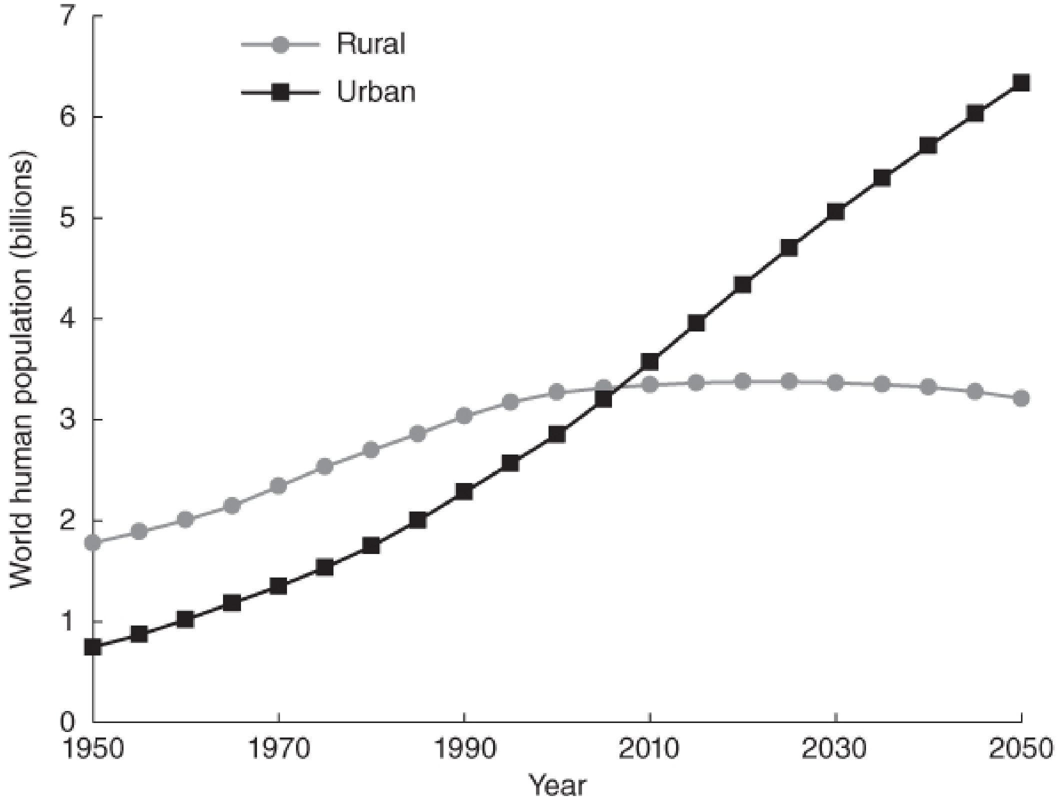
1.3 Why is urban ecology interesting?

Urban ecology is interesting for at least five reasons: (i) urban environments are extensive and growing; (ii) their ecology is inherently interesting; (iii) they are ideal for testing and developing ecological theory; (iv) the nature of urban environments affects the health and wellbeing of their human inhabitants and (v) they are important for conserving biological diversity. An improved understanding of urban ecology will not only advance the discipline of ecology as a whole, it will help us to save species from extinction, maintain ecosystem functions and services, and improve human health and wellbeing. Particularly in these times of rapid human-population growth and urbanization, a better understanding of urban environments will help us to create more liveable cities that provide high-quality habitat for humans and non-humans alike. I address each of these points in more detail below.

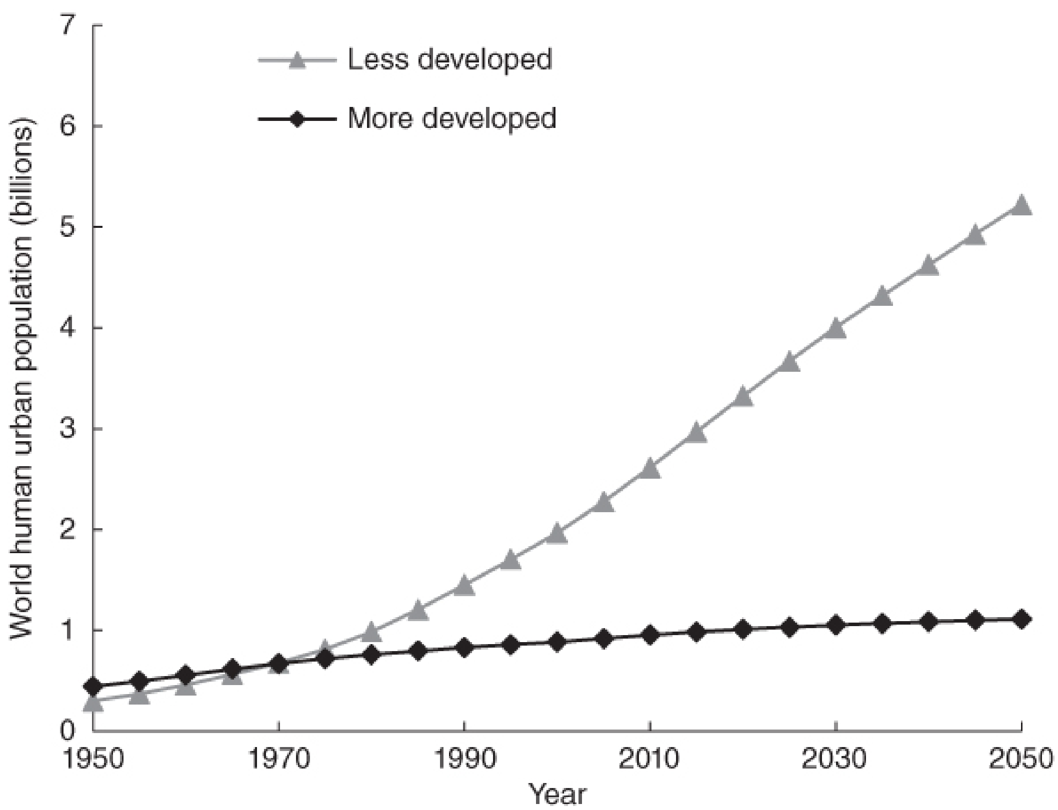
1.3.1 Urban environments are extensive and growing

For the first time in history, more than half the world's human population lives in urban areas. The number of people living in cities has risen dramatically since the industrial revolution, as opportunities for employment have expanded in urban areas and the demand for agricultural labour has declined with increasing mechanization. The United Nations Population Fund (UNFPA) estimates that the world's current urban population of 3.9 billion people will expand to 4.9 billion by 2030 and 6.4 billion by 2050 (Figure 1.1a), compared to an urban population of just 220 million at the beginning of the 20th century (UNFPA 2007; UN 2014). This equates to a 22-fold increase in only 130 years. Urban areas in the developed world will grow slightly, while much of the expected increase in the number of people living in towns and cities will occur in developing countries in Africa, Asia, Latin America and the Caribbean

(Fig 1.1b; UNFPA 2007). The social and environmental implications of the shift to urban living are profound, but they also vary dramatically between regions.


Rural
Urban
World human population (billions)
0
1
2
3
4
5
6
7
1950
1970
1990
2010
2030
2050
Year

(a)


Less developed
More developed
World human urban population (billions)
0
1
2
3
4
5
6
7
1950
1970
1990
2010
2030
2050
Year

(b)

Figure 1.1 (a) World population of humans in urban and rural areas and (b) the urban population of humans in less developed and more developed regions of the world, 1950–2050.

Data from United Nations, Department of Economic and Social Affairs, Population Division (2014).

Urban expansion in developed countries such as Australia and the USA is typically accommodated through the construction of houses on individual blocks of land on the outskirts of towns and cities (Figure 1.2). Most houses are inhabited by a single family, and have electricity, potable tap water, one or more bathrooms connected to a closed sewage system, a telephone and a sealed road at their front door. Some houses have swimming pools; many have air-conditioners. Relatively large areas of land accommodate only a few people, and the resulting expansion of cities across the landscape is known as urban sprawl (Soule 2006). In contrast, many people moving to urban areas in sub-Saharan Africa, Latin America, India and China are accommodated in informal settlements (also known as slums or shanty towns) within or on the edges of cities (UNFPA 2007). These are characterized by a high density of people living in makeshift dwellings with poor sanitation, little or no access to clean drinking water, and uncertain tenure (Figure 1.3). Hundreds of people may share a single bathroom; water used for drinking can be contaminated with human waste; dwellings often have no electricity or ventilation; and there are no paved roads or facilities for waste disposal (Geyer et al. 2005; UNFPA 2007). Informal settlements are frequently built in areas subject to natural disasters, such as floods and landslides, and because the people who live there have no contractual right to do so, their dwellings can be demolished at short notice (Hardoy and Satterthwaite 1989; Tibaijuka 2005; Padhi 2007). An estimated 1 billion people, or one-sixth of the world's