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

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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.

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

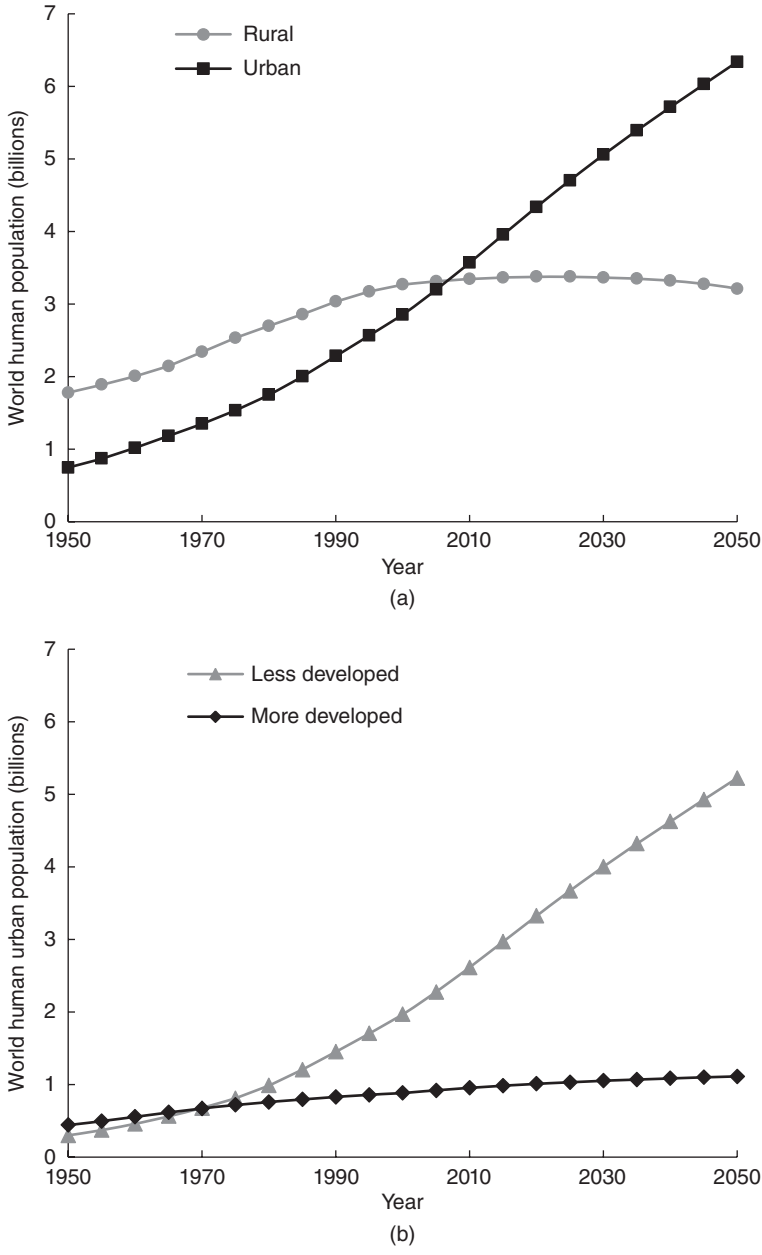

Figure 1.1 (a) World population of humans in urban and rural areas and (b) the urban population of humans in less developed and more developed regions of the world, 1950–2050. Data from United Nations, Department of Economic and Social Affairs, Population Division (2014).

Figure 1.2 An ordered suburb in Las Vegas, Nevada, USA. Picture has been straightened, cropped and converted to black and white. Photograph by ulybug. Used under CC-BY-2.0. https://creativecommons.org/licenses/by/2.0/.

Figure 1.3 Houses in the Kibera Slum, Nairobi, Kenya. Picture has been cropped and converted to black and white. Photograph by Colin Crowley. Used under CC-BY-2.0 https://creativecommons.org/licenses/by/2.0/.

Satterthwaite 1989; Tibaijuka 2005; Padhi 2007). An estimated 1 billion people, or one-sixth of the world's population, were living in informal settlements in 2005 (UN-Habitat 2006).

Other styles of urban development fall between these two extremes. Medium- and high-density townhouses and apartments are features of urban living in many parts of the world, providing a high standard of living with modern facilities and infrastructure but occupying less space than detached houses. Each type of urban expansion affects the biological diversity and ecosystem function of the newly-urbanized areas, and other associated habitats, in very different ways (Liu et al. 2003). For example, the materials and energy used to construct large, low-density houses on the outskirts of an Australian city and to maintain the lifestyle of their inhabitants are many times greater than those used by the inhabitants of a shantytown in South Africa or Bangladesh (Wackernagel and Rees 1996; McGranahan and Satterthwaite 2003). The health and wellbeing of the people living in each type of urban neighbourhood also varies dramatically (see later in this chapter for further discussion of this point). Therefore, we cannot think of urbanization (the construction of towns and cities) or urban expansion (an increase in the human population of cities) as uniform processes. In the coming decades, urban expansion in the developing world will present enormous ecological and social challenges. I argue that these challenges will be better met with an improved understanding of urban ecology.

1.3.2 Urban environments have inherent ecological interest

Urban environments are of intrinsic ecological interest, partly because they can be so different from the habitats they replace. How do ecosystems, communities, species and populations adapt to the dramatic changes associated with the conversion of wild or agricultural land into habitat for people? Which species and communities thrive and which suffer? Do novel biological communities arise when native species are lost and exotic species invade? If so, are these communities functionally similar to the ones they replace, even though they are compositionally different? Can urban areas function as urban ecosystems? Is there a particular level of urbanization at which ecosystem function breaks down? What are the relationships between human preferences and actions and the conservation of biological diversity in cities? And how is human health influenced by air pollution, tree cover or access to open space? We know the answers to some of these questions for some parts of the world, but there are many more relationships between non-human organisms, humans and their environment in cities to be further explored.

1.3.3 Urban environments are ideal for testing and developing ecological theory

Much ecological theory has been developed to explain the distribution, diversity, behaviour and interactions of organisms in relatively pristine habitats away from human disturbance. Examples include the theory of the ecological niche

(Hutchinson 1957), interspecific competition (Tansley 1917; Connell 1961), optimal foraging theory (Charnov 1976), predator-prey relations (Volterra 1926; Lotka 1932), the equilibrium theory of island biogeography (MacArthur and Wilson 1963, 1967), metapopulation theory and patch dynamics (Levins 1969; Pickett and White 1985), food webs (Hairston et al. 1960; Murdoch 1966), metacommunity theory (Gilpin and Hanski 1991; Leibold et al. 2004) and the neutral theory of biodiversity and biogeography (Hubbell 2001). Behavioural theories such as game theory (Maynard Smith and Price 1973) and those pertaining to animal communication, mate choice and sexual selection (e.g., Zahavi 1975; Marten and Marler 1977; Wells 1977; Kirkpatrick and Ryan 1991) have also been developed largely without reference to the behaviour of animals in urban settings.

As argued by Collins et al. (2000), any worthwhile ecological theory should apply to urban as well as rural or wild environments. Theories that have been put to the urban test, such as optimal foraging theory (Shochat et al. 2004), niche theory (Parris and Hazell 2005), the intermediate disturbance hypothesis (Blair and Launer 1997), metacommunity theory (Parris 2006), diversity–productivity relationships (Shochat et al. 2006) and food webs/trophic dynamics (Faeth et al. 2005), have all fared well. This suggests that much – if not all – existing ecological theory is applicable to urban areas. The dynamic nature of urban environments may also encourage the development of new ecological theory, as well as new ways to integrate ecological, social and economic theories to understand better the ecology of urban systems.

1.3.4 The nature of urban environments affects human health and wellbeing

The nature of our surroundings affects human health and wellbeing in obvious and subtle ways. In urban areas, the starkest contrast in health and wellbeing is between people living in secure, well-constructed housing and those who are homeless or living in informal settlements. Inadequate sanitation, limited access to clean drinking water and poor protection from extremes of weather dramatically increase the risk of disease in slum communities, while a lack of privacy and security exposes women to violence and sexually-transmitted infections such as HIV-AIDS (Amuyunzu-Nyamongo et al. 2007; UNFPA 2007). But characteristics of the urban environment also affect the health of the adequately-housed urban dweller. Access to green nature and open space in cities provides opportunities to exercise and improves mental health (Giles-Corti et al. 2005; Gidlöf-Gunnarsson and Öhrström 2007). Recent research has shown that urban sprawl is correlated with increased rates of obesity and an increased risk of traffic and pedestrian fatalities (Ewing et al. 2003, 2006, 2016; Smith et al. 2008; Mackenbach et al. 2014). Sprawling neighbourhoods often have few footpaths, and facilities such as schools and shops are separated from residential areas. As a consequence, residents are more likely to drive their cars than to walk or cycle (Ewing et al. 2016).

At its best, urban living provides opportunities for social interaction and a sense of community (social capital), which are both important for human wellbeing. However, social capital can be eroded in cities with high crime rates, overcrowded living conditions, or conversely, when sprawling development leads to social isolation (Leyden 2003). High social disorder in urban areas is correlated with an increased risk of clinical depression among residents (Kim 2008). An intriguing area for further research is the relationship between biodiversity and human health in cities; recent studies have found that the psychological benefits of parklands and other green space for human visitors increase with increasing biodiversity (Fuller et al. 2007; Carrus et al. 2015).

1.3.5 Urban environments are important for conserving biological diversity

In the past, many towns and cities were established next to rivers, estuaries or sheltered harbours, which provided both attractive surroundings and opportunities to transport goods and people. Such sites also tended to be high in biological diversity (biodiversity) because of their high productivity, relatively mild climate, and position at the confluence of terrestrial, riverine and marine habitats (Luck 2007). The correlation between human population density and biodiversity continues today, with species-rich areas still being preferentially settled by people (Cincotta et al. 2000; Luck et al. 2004; but see Box 2.1). For example, urban development in Australia is proceeding along the coastal fringe of the continent, where rainfall, primary productivity and biodiversity are high. Because of the dramatic environmental changes it entails, urbanization often creates a conflict between the needs of humans and the needs of other species.

Throughout human history, urbanization has probably caused the local extinction of thousands of species. McDonald et al. (2008) estimated that 420 species (8%) of those included on the IUCN Red List are threatened by urbanization. Currently, 11 of the world's 825 ecoregions have over half their area urbanized (Figure 1.4) and 29 ecoregions have over one-third of their area urbanized (McDonald et al. 2008). These 29 ecoregions are home to 3056 species including 213 endemic terrestrial vertebrate species, 89 of which are included on the IUCN Red List. Particular functional groups are more likely to be lost from urban areas, such as ground-dwelling arthropods, insectivorous birds, large-bodied carnivores and ground-dwelling vertebrates that are vulnerable to introduced predators (Sewell and Catterall 1998; van der Ree and McCarthy 2005; Bond et al. 2006; Riley 2006). Short, shade-loving plants that require high levels of soil moisture are more likely to be lost from urban areas in Britain, while tall plants that favour open, dry habitats thrive (Thompson and McCarthy 2008; Duncan et al. 2011).

Even as urbanization leads to the loss of native species, many non-native plants and animals are introduced to towns and cities – either inadvertently or deliberately as pets and garden plants (McKinney 2002, 2008; Tait et al. 2005). A few species show a strong positive response to the resources provided

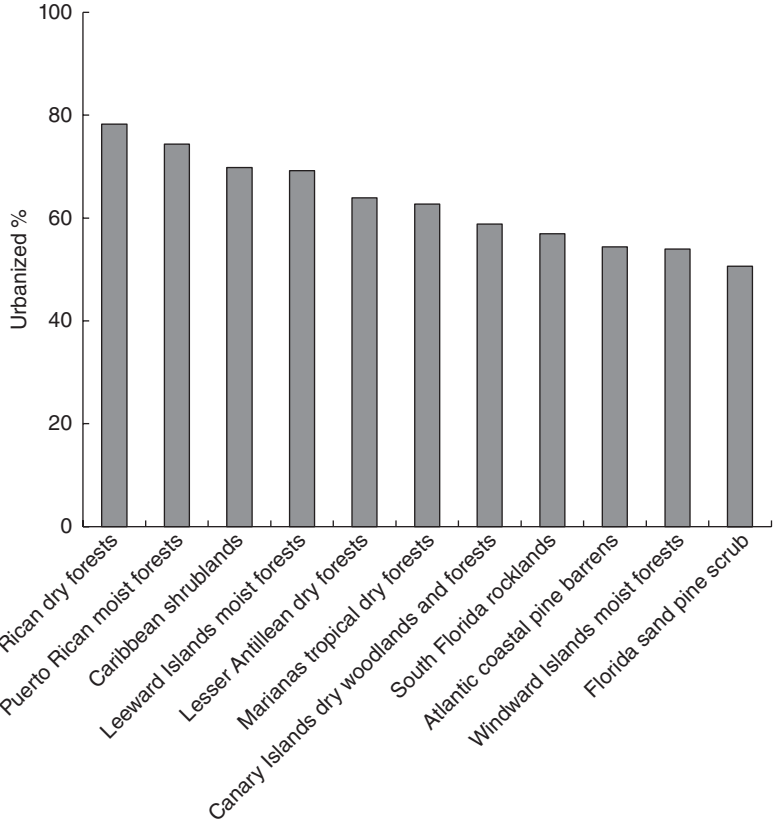

Figure 1.4 Ecoregions of the world with more than half their area urbanized; note the strong bias towards islands and coastal areas. Endemic species in these regions are threatened by continued urban expansion. Data from McDonald et al. (2008), supplementary information.

by humans in cities, where they obtain very high population densities. These are known variously as commensal species, synanthropes or urban adapters (see Chapter 7). However, this should not lead us to dismiss urban areas as insignificant for biological conservation. Many threatened, native species and ecological communities persist in or on the margins of towns and cities (e.g., Williams et al. 2005; Marchetti et al. 2006; Ives et al. 2016), particularly those that have developed slowly (Vähä-Piikkiö et al. 2004). Continuing urban expansion is likely to jeopardize the persistence of these species and communities, plus others that are currently at a comfortable distance from urban centres (McDonald et al. 2008), unless we change the way we construct and manage cities. A combination of ecological knowledge and careful urban planning both inside and outside nature reserves is required to minimize the loss of biodiversity from existing and future urban areas (Luck et al. 2004).

1.4 The aims of this book

This book has two aims. The first is to provide an accessible introduction to urban ecology, by synthesizing existing knowledge and using established ecological theory to identify generalities in the complexity of urban ecosystems. The second is to make urban ecology interesting and relevant to students, researchers and policy-makers in the developed and developing world. To date, much urban-ecological research has focussed on the affluent countries of North America and Europe and, to a lesser extent, Australia and New Zealand. But as outlined above, the coming decades will see a tremendous expansion of urban populations in developing countries, with a range of accompanying social and environmental challenges. A better understanding of urban ecology is vital for the future of the Earth, including the conservation of biodiversity, the maintenance of ecosystem function, the preservation of social cohesion, and the improvement of human health and wellbeing. I hope this book will inform and inspire budding urban ecologists around the world.

Study questions

1 How would you define the term "urban"? Consider both qualitative descriptions and quantitative metrics.
2 Which aspects of urban ecology interest you most, and why?
3 Describe the contrasts between formal and informal settlements in cities.
4 Are urban areas important for the conservation of biodiversity? Justify your answer with examples from at least three cities around the world.
5 How would you increase contact between people and nature in a city or town that you know? Consider a number of different strategies.

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