Cities and towns

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Key messages

- Loss of natural ecosystems and of species is a fact of life in densely populated cities.
- Some species can prosper in an urban environment, but urban populations of species are generally too small to have a significant influence on their overall conservation status.
- Urban biodiversity is important nevertheless: it can build an appreciation among city dwellers of biodiversity and its conservation, enhance recreational space, and serve practical functions such as helping to cool the air and reduce stormwater and pollutant run-off.
- Visionary urban design can significantly improve the status and trends of biodiversity in cities and their surrounding regions.
- Australian biodiversity science has expended too little effort on the urban environment, and information on which to base urban biodiversity strategies is generally lacking.
- Supporting urban communities in Australia with information and monitoring tools will benefit biodiversity, and help connect Australians with the environment that sustains them.

THE CHALLENGE

One of the greatest triumphs of civilisation – the city – is also seemingly among the biggest challenges to the maintenance of biodiversity. Cities occupy just 2% of Earth's surface but account for 75% of the resources consumed by humans.[1] In 2007, for the first time in history, more people were living in towns and cities than in rural areas, and the proportion will continue to increase over the coming decades. In Australia, by far the majority (87%) of us live in cities and towns, and within the next 50 years 10–20 million more people will inhabit them.[2] Urban development is a major driver of environmental change: cities draw in energy, water, food and materials, cause pollution, destroy habitats as they expand, and introduce new species as pets and ornamental plants. On the other hand, cities can allow per capita energy demand to be reduced through the use of public transport and high-density housing, concentrating the population and reducing overall pollution and requirement for space and materials. Most importantly, cities are engine-rooms of cultural change, and focal points for resources and creativity. If the Australian community is to be engaged in solving the biodiversity challenges described elsewhere in this book, then the urban population will be an especially important part of that process.

The process of urbanisation has serious consequences for biodiversity. First, and most obviously, urban development permanently replaces natural ecosystems. Second, and perhaps more insidiously, isolation from the natural world leads to an 'extinction of experience' that transforms how people value the natural world around them – if people don't experience biodiversity, they will not value it.[3] It is a challenge to reconnect people with the nature that sustains them while concentrating the 'ecological footprint' of the human population into urban settlements.

Cities are shaped both by their environment and by their social and economic histories. These shaping forces are themselves changing, through such factors as water scarcity, carbon pricing, population pressures, and globalisation. When we try to manage biodiversity in urban environments, therefore, we are doing so in an environment that is itself continually changing. Cities are becoming ever more dynamic crucibles of intense and, in environmental terms, rapid change.

A city street gang: rainbow lorikeets, Trichoglossus haematodus*, in a tree overlooking Sydney's CBD. Human populations often occupy the places where biodiversity tends to be richest. Photo: Gary P. Hayes (http://garyphayes.com/photography).*

BIODIVERSITY IN CITIES

The economic and social benefits of urbanisation – the creation of employment and housing – depend on the permanent replacement of whatever ecosystem was there before. Plants and animals typically thrive in places where water is plentiful and soil fertility is high. Human populations also require those same conditions, and so inevitably end up occupying precisely the places where certain aspects of biodiversity are richest. Indeed, the fastest growing cities tend to be in areas where numbers of species are also naturally the highest.[4] The 34 global 'biodiversity hotspots' – areas particularly rich in species of importance for conservation – all contain urban areas.[5] This poses a direct threat to biodiversity; for example, as many as 8% of endangered terrestrial vertebrate species are at risk because of urban development worldwide.[6] Cities containing rich biodiversity occur all over the world, including Cape Town, Chicago, Curitiba, Frankfurt, Mexico City and Singapore. Half of South Africa's critically endangered vegetation types and approximately 3000 plant species native to South Africa are found in Table Mountain National Park in the Cape Town region, while more than 100 species never before seen by scientists have been discovered in parks and reserves in Singapore.[5]

Cities are also the entry point for many introduced species, which are known to be a major threat to biodiversity. Frequently, the majority of birds that city dwellers see are not native to the area. Non-native invasive garden plants, introduced to Australia by and for the urban population, make up most of Australia's 1953 agricultural and environmental weeds, comprising 70% of the total.[7]

There are many examples of threatened species occurring within cities. In western Melbourne, 44% of the area of native grasslands was destroyed or degraded between 1985 and 2005,[8] and several of the grassland ecosystems around Melbourne are currently listed as nationally threatened. Cities affect biodiversity not simply because they contain large numbers of people – the way that the population is distributed, the physical layout of the city, the housing density, the area of roofs and paving, and the location of parks and green corridors, can either moderate or intensify the impact of humans on biodiversity. At any given density or size of human population in an urban setting, we can sustain biodiversity by modifying these factors, which collectively are referred to as 'urban form'. This is analogous to the influence of different patterns of land use on biodiversity in agricultural landscapes (Chapter 7).

Occasionally, towns and cities can improve conditions for some species. Examples from around the world include the irrigation of desert landscapes during the growth of Phoenix, Arizona, increasing habitat heterogeneity in Finnish cities,[9] and elevated numbers of cavity-nesting bee species in cities worldwide.[10] Some urban habitats such as railway lines, abandoned industrial lands and urban wetlands can be rich in wild species and can play an important role in maintaining the biodiversity of a city.

Cavity-nesting bees, like this Megachile aurifrons *investigating a bamboo cane, can benefit from urban development. Photo: Marc Newman.*

On the other hand, species that thrive in urban environments are often abundant and widespread outside cities, so cities rarely contribute to conserving rare and endangered species. Often, the species flourishing in cities have a history of interacting with humankind, but species able to live close to people will partition the city habitats with those that need something closer to the natural vegetation of the region. For example, in the suburbs of Sydney, the birds living in parks and remnant vegetation are a different set of species from those occupying residential areas nearby (see Box 8.1).[11] One intriguing discovery is that, of the bird species colonising European cities, it is the bigger-brained ones such as pigeons that tend to be the most successful[12] – it is not just humans that need to be streetwise in cities! However, as the intensity of urbanisation increases even those species most able to prosper may eventually begin to show declines.[13]

WHY DOES BIODIVERSITY MATTER IN CITIES?

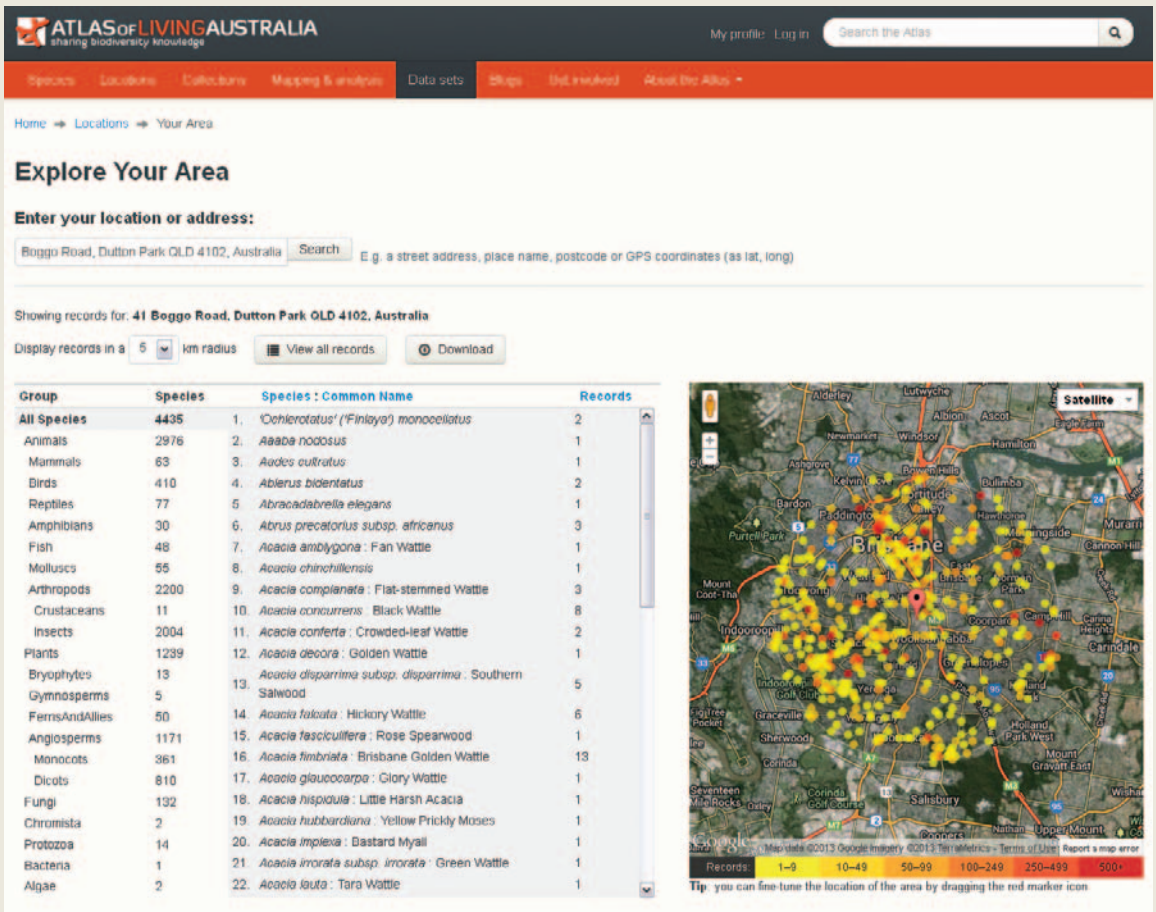
Australians should be concerned about biodiversity in cities first because of the value of the ecosystem services that it provides. Green spaces in cities can improve flood control by retaining and reducing stormwater run-off, saving money for flood control and protecting downstream natural ecosystems from the pollutants. Otherwise, built-up areas do not absorb rainwater well, leading to flooding by potentially polluted water.

Box 8.1: Explore Australia's urban biodiversity online

For people living in Australia's cities, it may not be obvious that there is a diverse range of plants and animals there as well. Use the *Atlas of Living Australia* to explore online the different species that are known to occur in your neighbourhood.

Through the 'Explore Your Area' function, simply enter your street address or location to display all known species-records within a 1, 5 or 10 km radius. For example, the address of the Ecosciences Precinct in the Brisbane suburb of Dutton Park brings up a list of 3432 different species within a 5 km radius (Figure 8.1). This connects you to occurrence records of plants, animals, insects and other life-forms, photos of the species, and more information on them.

You can engage in 'citizen science' by uploading your own sightings and photographs of species. You can contribute to science and give the scientific community access to data that it would not normally have. You will be building on the vast repository of data contained by the *Atlas* – currently about 40 million records. The information collected in the *Atlas* will help us to understand the status of biodiversity in Australia's urban areas and to analyse and predict trends over time.



▲ ***Figure 8.1****: The function 'Explore Your Area' in the* Atlas of Living Australia *lets users enter an address, place-name or GPS coordinates to find out what species occur in the area. Records can be filtered and downloaded for research, education or biodiversity management. Photo:* Atlas of Living Australia, *www.ala.org.au.*

Tree-planting and urban wetland renewal programs in Canberra are resulting in reduction in air pollution, stormwater interception and better flood management, and carbon storage.[5] The city contains more than 400 000 trees, constituting an urban forest that helps moderate the high temperatures associated with urbanisation, and in turn reducing the need for expensive and energy-consuming air-conditioning. The value of these services was predicted to reach between $20 million and $67 million in the period between 2008 and 2012.[5] Valuations such as these – where rigorously tested – help to highlight the contribution that urban ecosystems can make to the budget of a major city.

Having access to urban parks and green spaces has an important amenity value, influencing the physical and mental wellbeing of urban inhabitants. For example, access to a garden has been found to reduce sensitivity to stress, while a lack of access results in increased levels of depression and anxiety. Nearly 60% of householders in Perth felt that spending time in the garden was 'very important' or 'the most important' factor contributing to their overall wellbeing; further, it seems that the more diverse the green space, the greater the psychological benefits.[14] Since 2000, Parks Victoria, responsible for managing protected areas in Victoria, has been emphasising the benefits of visiting urban green spaces and other natural open spaces through its Healthy Parks, Healthy People program. The program promotes the idea that human health ultimately depends on healthy ecosystems.

There is another reason why biodiversity in cities matters. It matters because – as examples in the rest of this book show – our country's biodiversity matters, both to us and to the world. We are custodians of biodiversity for future generations, and, for many of us, biodiversity in urban areas

The simple act of gardening can help reduce levels of stress, depression and anxiety. Photo: Landcare Australia Limited.

represents the primary contact with the natural environment and our main means of connecting to it. Managing biodiversity in cities provides opportunities for many people to learn about and value it through activities in their own backyards and neighbourhoods, leading to novel planning and landscaping approaches to the urban form, and in turn to a reduction of negative impacts of cities on their surrounding environment.

There have been two broad approaches for reducing negative impacts of cities on biodiversity: directly, by actively sustaining biodiversity in urban areas; and indirectly, by reducing the per capita environmental impact of city dwellers (the environmental footprint). We next deal with these in turn.

SUSTAINING BIODIVERSITY IN URBAN AREAS

Growing and connecting green spaces

As cities grow, the opportunity for people to interact with nature depends increasingly on the availability of green spaces such as parkland, and less formal ones such as street plantings, backyards and gardens. In nearly 400 European cities, the proportion of urban green space *increased* with city area across the whole range of city sizes, from roughly 10% of the area in cities of 10 km^2 to 23% of the area in cities of 1000 km^2.[15] Clearly there are historical reasons why such cities had compact centres, but as European cities have grown, their green space networks are also relatively larger. It remains to be seen whether the same trend holds true for Australia.

Green corridors can promote the movement of species into and around urban areas. This one follows Kedron Brook through Brisbane's northern suburbs, just 6 km from the CBD. Photo: Fiona Brown, CSIRO.

The benefits of green spaces are not just a function of their size and number but also depend on their connection to other such spaces. There is increasing effort around the world to link up green spaces across a city, just as we saw earlier in the broader landscape (Chapters 4 and 5). Such 'green corridors' promote the movement of native species into and around the city, although care is needed to avoid moving non-native species in the other direction.[16] Revegetation is useful where the original native vegetation has been lost and where remaining vegetation is rendered isolated and degraded. Hundreds of community groups are engaged in such urban revegetation projects across Australia. By contrast, focusing on making larger green spaces without worrying about the connectivity between them simply increases the abundance of species already present in a given area, so we need to set aside habitat as well as make connections between such areas. Along these lines, new urban development strategies combine urban corridors (key development areas involving 10% of the city, for high-density living and public transport routes) with suburbs (90% of the city) that become areas of stability, with strict guidelines on development, renewable energy generation, stormwater collection and green space.[17]

The potential for biodiversity-friendly cities depends on being able to resolve opposing views about high-density living – the so-called 'compact city debate' (Table 8.1).[18] On the one hand, some advocates suggest that 'living green' is only possible in a low-density rural or semi-rural setting. This approach, however, would spread the harmful impacts of human settlements on biodiversity over a much wider area, as well as increasing dependence on transport. Opposing this is the view that creating high-density urban development will concentrate the negative impacts of development into small areas, leaving more land for biodiversity and agriculture, and favouring greener transport through economies of scale. With Australian cities already among some of the most thinly populated in the world, it will be important to understand the implications of these opposite extremes for the way our cities develop. A case study in Brisbane suggested that high-density compact design would minimise reductions in bird populations as the city continued to grow,[19] but can we reasonably ask people to live in more crowded conditions so that birds can have more space? We do need better information on how best a compromise can be achieved between individual human needs and environmental impacts under different patterns of urban settlement. The latest research indicates that urban planners will need to be thinking at the scale of the entire city and its surrounds if we are to minimise environmental harm from urban expansion.[20]

Table 8.1: Some arguments for and against high- and low-density cities

Arguments for high-density cities	**Arguments against high-density cities**
▪ Reduced habitat destruction through urban sprawl ▪ Reduced per capita resource use ▪ Green transport favoured ▪ Economies of scale for services	▪ Traffic congestion ▪ Overcrowding leads to 'escape to suburbs' ▪ Increased crime, poverty and ill health ▪ High-rise blocks discourage community life
Arguments against low-density cities	**Arguments for low-density cities**
▪ Greater area of destruction of habitat ▪ Invasive species introduced across broader landscape ▪ Increased car use ▪ Conservation managed haphazardly via private gardens	▪ Engagement of community in conservation ▪ Potential for much larger public green spaces ▪ Less congestion and less concentrated pollution ▪ Village-like community life

Two cities that are towards opposite extremes of urban density – top, Canberra, and bottom, New York City. Photos: Mark Lonsdale, CSIRO.

MAINTAINING REMNANT VEGETATION

The development of Australian cities has, of course, resulted in a significant loss of the original native bushland that had occupied the land. Nevertheless, there is still a significant amount of this 'remnant vegetation' in some cities. For example, 28% of the area of Perth's metropolitan region was remnant vegetation in 2003, while the figure was 13% for western Sydney, 16% for Melbourne's outer suburbs, and 12% for Adelaide.[21] This is a resource for species such as small native mammals, but it is also very susceptible to being converted to suburbs – between 1986 and 1993, at least 1600 km^2 of native vegetation was built on in areas around Australia's capital cities.[22] Its loss may be minimised by reducing low-density sprawl and maintaining green space and corridors.[21] Much Australian vegetation relies on periodic bushfires to regenerate itself, but of course it is very difficult to reintroduce fires into remnant vegetation that is surrounded by houses.

Engineered urban greenery: vertical gardens and green roofs

Techniques for adding greenery to buildings have become increasingly popular in cities around the world. Structures range from the 'green roof', in which a soil layer is added to a roof-top and planted with vegetation,[23] through vertical green walls fitted with vertical soil or non-soil structures that hold a variety of plants, to purpose-built green buildings that integrate living features into their design.[24]

This roof garden of drought-tolerant succulents and grasses is located on a commercial building in Melbourne's Docklands. Photo: Gardens by Fytogreen Australia Pty Ltd.

A vertical garden provides an attractive facade for a multi-storey car park in a large apartment block in Melbourne. Photo: Fytogreen Australia Pty Ltd.

Green roofs and walls are believed to protect facades against environmental extremes while becoming a new habitat for flora and fauna, and the technology is spreading fast. For example, in some parts of Berlin between 5% and 30% of the roof space is 'green', while Germany as a whole is adding about 1100 ha of green roofs each year. As with all emerging industries, setting quality standards for design and installation is a key issue.

Potential benefits from engineered urban greenery include stormwater management, reduction of the urban heat-island effect, and air quality improvement. While biodiversity benefits have also been claimed, supporting evidence for positive change is limited. Although engineered urban greening would not justify the clearance of vegetation in cities, such infrastructure can be used as a remediation tool in some of the most heavily urbanised areas. Unfortunately, retrofitting green infrastructure to buildings can be extremely expensive, and we still lack a sound basis for analysing the costs and benefits of such approaches to urban greening.

REDUCING THE URBAN ENVIRONMENTAL FOOTPRINT

Techniques have recently been developed to measure the ecological footprint of countries or cities, this being the amount of land required to sustain the lifestyle of an average inhabitant. The aim is to establish the biological impact that each dweller has on the wider landscape, mostly in terms of conversion of natural habitat for resource extraction and agriculture. For example, the findings of the Global Footprint Network suggest that each average human being requires 2.7 ha of land to sustain him or her. Australians generally require 6.6 ha per person; a person in East Timor

has the lowest footprint on the planet at 0.4 ha; and the largest footprint is claimed by citizens of the United Arab Emirates at 10.7 ha per person.[25] We can use this approach to calculate the area required by a city to sustain its inhabitants (Table 8.2).

Table 8.2: Ecological footprints of various cities[25,26,27]

City	Population[27]	Average individual footprint (ha)[25,26]	City ecological footprint (km^2)	City area (km^2)[27]	Ratio of footprint area to city area
Sydney	3 956 000	6.6	261 096	2037	128
Washington DC	4 825 000	8.0	386 000	3424	113
London	9 576 000	4.9	469 224	1623	289
Beijing	18 241 000	2.2	401 302	3497	115
Tokyo–Yokohama	37 239 000	4.7	1 750 233	8547	205

This analysis shows that the population of Sydney requires over 260 000 km^2 of land to sustain it, roughly half the area of Spain, and about 128 times the geographical area it occupies as a city. Tokyo has nearly ten times the population of Sydney, but needs only seven times as much land to sustain its population because the average Japanese consumes less than the average Australian. Even so, the area of land required to support Tokyo – the city's ecological footprint – is five times the area of Japan!

The ecological footprint is usually calculated from the consumption of an average individual, but we can calculate an estimation of our own footprint using online calculators (e.g. the Victorian EPA footprint calculator[26]). The Australian Conservation Foundation has provided ecological footprint calculations for every Statistical Local Area across Australia and an online Consumption Atlas for querying this database by postcode.[28]

The two biggest opportunities for reducing the footprint of Australian cities lie in reducing demands on water and energy. Households use 70–80% of total urban consumption.[29] Australia's increasing urban population will have a growing demand for water. By the year 2050, scientists forecast that our largest cities will require 73% more water than currently; and, in addition, climate change will likely cause a reduction in supply to our major cities (e.g. around a 20% reduction to Melbourne's supply by 2050).[30] So our nation has its work cut out. Furthermore, to understand the full demand on water resources it is also necessary to factor in the water used in rural areas to supply food and fibre for city residents, as well as that used to generate electricity. The efficiency of water used in agriculture and power generation for cities is beyond the scope of this chapter, but it is dealt with in CSIRO's book, *Water: Science and Solutions for Australia* (see Further Reading).

PROGRESS REPORT: HOW ARE WE DOING?

Australian science has until recently largely ignored biodiversity in cities, and we lack the necessary data to allow comparison among different cities across the nation, or to compare our cities with those across the globe. A comparison of 20 of Australia's largest cities found that Townsville, Darwin, Sydney, Newcastle and Wollongong were the most favourable for biodiversity[31] (Table 8.3) – but this is a far cry from knowing how we should expand our cities in the future in a way that is most biodiversity-friendly.

The management of biodiversity in general suffers from a lack of standard measures (see Chapter 3), leading to a patchwork of trends that are not strictly comparable. Likewise, when measuring urban biodiversity we are viewing our cities through a blurry lens. For example, earlier we mentioned that 44% of native grassland areas were destroyed or degraded in Melbourne between 1985 and 2005;[8] the nearest comparable published data for Perth (Figure 8.2) show that remnant vegetation (including, but not confined to, grassland) declined by 23% between 1994 and 2003.[32] The vegetation categories and the time-frames, however, are different, so that we are left comparing apples with oranges. Such measures need to be developed not only so that we can make comparisons, but also as a means of learning what works well and can be more widely applied.

Table 8.3: Ranking of Australia's top ten cities in terms of potential to sustain biodiversity. Note that six are capital cities (Adelaide and Melbourne were ranked at 12 and 14 out of the 20 cities studied)[31]

City	Ranking of favourability for biodiversity
Townsville	1
Darwin	2
Sydney; Wollongong; Newcastle	3
Brisbane	4
Perth	5
Hobart	6
Gold Coast–Tweed; Sunshine Coast	7
Toowoomba	8
Cairns	9
Canberra	10

Australia's most recent State of the Environment Report[33] (Chapter 10, 'Built Environment') shows that more than 75% of residents in Australian capital cities feel they have access to a wide range of outdoor recreational environments, and that between 63% (Sydney) and 85% (Canberra and Hobart) of residents were satisfied with the natural environment of their cities. This is not very useful for knowing the state of urban biodiversity, however, because people may be satisfied with a low quality of natural environment – when it comes to objective measures of biodiversity itself, the data are simply not yet available. New ways of monitoring biodiversity are being developed, therefore, that can be applied to cities as well as to the broader landscape.

▲ ***Figure 8.2****: Scientists are developing increasingly powerful image-processing techniques for monitoring biodiversity. This picture shows vegetation change in Perth between 2007 and 2009. The loss of trees is shown in red, yellow indicates no change, and green is an increase in tree cover. Grey areas have no vegetation. Source: CSIRO.*

CONCLUSIONS: THE WAY FORWARD

Highly urbanised countries often enjoy higher incomes and more stable economies, and cities generate a disproportionate share of a country's wealth. Consequently, cities are in a good position to achieve biodiversity conservation and pursue innovation in order to explore new ways of reducing environmental impacts. While biodiversity loss is a global concern, the local actions of urban populations engaging in biodiversity conservation within and outside cities can contribute to solving global problems.

Australian cities are continuing to grow – the population of Sydney is expected to double to about seven million people by 2056. The impact of cities on biodiversity, however, will not necessarily increase as fast as population growth if we plan this growth sensitively. In fact, this growth

More than 75% of residents in Australian capital cities feel they have access to a wide range of recreational outdoor environments. Photo: courtesy of Brisbane Marketing.

represents a great opportunity to do things differently. If we are imaginative and forward-looking, Australian cities could emerge as a contributor to the conservation of biodiversity, not only through parks and green spaces that are well connected to biodiversity across the broader landscape but also, more importantly, through support by city dwellers for national conservation efforts.

FURTHER READING

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