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What about biodiversity? Redefining urban sustainable management to incorporate endemic fauna with particular reference to Australia

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Abstract An estimated 50 % of the world's population live in urban areas and this is expected to rise to 70 % by 2050. Urban developments will thus continue to encroach on non-urban landscapes and native biodiversity (flora and fauna). Although much has been written on sustainable urban development, the biodiversity component has been largely ignored. Consequently, sustainable development of biodiversity is poorly understood within urban confines by planners and designers, community developers and social planners, activists and social movements, and even academics and consultants. When native flora and fauna are incorporated deliberately or ad hoc, for example due to landscaping fashions, the outcome may create on-going issues for authorities which could be minimised with sustainable management. For example, green urban infrastructure including parks and gardens, 'backyards', remnant bushland and even wastelands can be more effectively developed to sustainably support biodiversity, typically at reduced on-going cost. However, due to the lack of understanding of this aspect of sustainable development and on-going issues of 'pest management', the focus has been on only a small sub-set of the overall biodiversity. In addition, these changes in species' dynamics often lead to the decline of local amenity for humans, and endemic species (e.g., small-bodied birds). Other taxa are typically neglected because they are cryptic, innocuous, dangerous, a nuisance, feral, or just not 'sexy'.

Keywords Biodiversity conservation · Urban landscape · Homogenisation of biodiversity · Landcare

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Introduction

Since the United Nations Convention on Biodiversity in 1992 (UNCED 1992), biodiversity has become a 'fundamental conservation value' with a recognised need for its protection in the context of sustainable development (Kong et al. 2010). Internationally, attempts to conserve biodiversity have typically involved the formal protection of lands that encompass significant biodiversity values and/or species at risk (Burgin 2016; Burgin and Zama 2014; Chiesura 2004; McDonald et al. 2008). Subsequently, over the past 25 years, countries have embraced the need for such biodiversity conservation, evidenced by the 'exponential' growth in lands protected under International Union for the Conservation of Nature (IUCN) protected lands classifications (Burgin 2015; Burgin and Zama 2014; Dudley and Parrish 2006).

However, of all landuse types, it is urban areas that have the greatest local species extinction rates and, often, most of the local native species and their habitats are lost with the initial development and subsequent further encroachment of urbanisation on adjacent non-urban landscapes (Kowarik 2008; Marzluff 1997; McKinney 2002, 2008). When measured in extent and intensity, the effect has typically resulted in 'biotic homogenization' of biodiversity (Aronson et al. 2014; McKinney 2006). Such changes in community dynamics and associated loss of biodiversity in urban areas are also likely to be more enduring than alternative types of habitat loss. But with an estimated 50 % of the world's population living in urban areas in 2010, and an expectation that these numbers will rise to 70 % by 2050 (Parfitt et al. 2010), cities will continue to encroach on non-urban landscapes and, increasingly, impact on native biodiversity. For example, in the United States of America, by 2001, urban and other built-up areas encompassed over 5 % of the total surface area of the country. This was more land area than was contained within the combined total of the country's national and state parks and other lands protected by the Nature Conservancy. It was also observed that the rate of urban-related expansion was greater than that of parks/conservation areas (US Census Bureau 2001). On this trajectory, native biodiversity will continue to decline unless sustainable city management better addresses biodiversity conservation.

The United Nations General Assembly charged the World Commission on Environment and Development (more recently known as the Brundtland Commission) with developing 'a global agenda for change' (Brundtland Commission, 1987, p. 11) that would '… rally countries to work and pursue sustainable development together' (p. 24). The outcome was the publication of 'Our Common Future' in 1987. It was within this publication that the concept of sustainable development (i.e., the concept of meeting '… the needs of the present without compromising the ability of future generations to meet their own needs' (Brundtland Commission 1987, p. 24) was first defined and subsequently biodiversity conservation has had a higher profile throughout the world than previously among politicians, administrators and professionals including urban planners. For example, Næss (2001) suggested that, within their specific field, many planners now perceive their greatest challenge to be to endeavour to embrace sustainable development over the emphasis on resource development and other environmentally straining activities.

What often appears to be missing from such discussion is that the continued loss of biodiversity within the urban footprint is not simply an issue of aesthetics (McKinney 2008). In addition to amenity values (e.g., aesthetic enjoyment, and recreation - Burgin and Hardiman 2014; Miller 2005, 2006), it is also a valuable contributor to ecosystem services including air and water purification (Bolund and Hunhammar 1999). Conversely, to ignore the impacts on biodiversity in urban areas typically results in on-going expenditure to deal with, for example, over-abundant (often feral) species, and does not truly provide sustainable cities.

In the introduction to this paper I have briefly outlined the link between increasing urbanisation and biodiversity loss. In the following section, examples (predominantly Australian) will be provided of the current status of biodiversity conservation in cities. Subsequently, I will consider some examples of the issues and retrofitting for biodiversity conservation in urban areas, and conclude with remarks on incorporating biodiversity into sustainable cities of the future.

Examples of the current status of biodiversity conservation in cities

The development and expansion of urban areas may have substantial impacts on the local biodiversity. As a consequence, worldwide, greater density of some taxa (e.g., birds) is found in non-urban sites compared with urban areas. For example, across 54 cities worldwide, Aronson et al. (2014) found the density of bird species declined substantially with urbanisation. Only 8 % of 10,052 species were estimated to be at non-urban density, and the situation is generally worst in the Australasian cities they studied than elsewhere. While intuitively nuisance or super-abundant species in urban areas may be assumed to have originated from founding populations that have originated from outside of the country this is not always the situation. Native species, local or from elsewhere within the species native range, may become super-abundant in urban areas and impact, more generally, on the viability of native biodiversity (flora and fauna). The outcome of the introduction of feral species, 'new' native species, and/or the over-representation of local native species changes the dynamics of the local natural biodiversity, usually to its detriment. In parallel, the surfeit of new or expanded populations that become established in urban areas, and the impact that they have in such landscapes, both in terms of competition with less competitive species and, often, the potential nuisance and economic costs (direct and indirect) to humans is typically effectively ignored, at least until the species has become a major issue. With respect to biodiversity considerations there has, therefore, typically been a lack of consideration of this aspect of sustainable management of cities.

As an example of the changes that may occur, the avifauna provides the most conspicuous example of a taxon that is positively (Parsons and Major 2004; Saunders and Burgin 2007), and negatively (Anderson and Burgin 2002, 2008), affected by urbanisation. In Australia, the most striking taxon in terms of colour, strident call, large body-size and, often, in terms of abundance and flock size is the parrots. The population dynamics of species within this bird taxon has been greatly influenced by urbanisation with major changes in the population dynamics of some species over time. For example, in Australia, prior to the 1900s, there were two parrot (both inconspicuous) species (Turquoise Parrot [*Neophema pulchella*], Ground Parrot [*Pezoporus wallicus*]) recorded within 10 km (approximately 6 miles) of the core of Sydney's Central Business District [CBD]). Neither species is now present in this central area of the city. Both species are now only found beyond the city boundaries. The nearest habitat of the Ground Parrot to the CBD is approximately 50 km north while the Turquoise Parrot is no longer known from the Sydney Region, and is classified as 'Vulnerable' (Schedule 2, New South Wales Threatened Species Act 1995). In contrast to the demise of these two species, 15 other species of parrot are now established in Sydney. The most usual mode of introduction of these species to the city landscape has been aviary escapees, deliberate release, and/or vagrant flocks, particularly those that have become established during extended periods of inland drought (Saunders and Burgin 2007).

Five of the most common of these parrot species increased their numbers dramatically over the 20 year period between 1977 and 1981 and 1998–2001 (Saunders and Burgin 2007), and their abundance continues to increase (pers. obs.). For example, the numbers of the Rainbow Lorikeet (*Trichoglossus moluccanus*) have changed dramatically over the history of European presence in Australia. Anecdotal reports indicate that the species was common in Sydney until the late 1800s (Crome and Shields 1992). Subsequently, numbers declined dramatically in the first half of the 1800s (Hindwood 1939; Keast 1995; Waterhouse 1997), and they became sufficiently rare for the species to be recorded as 'first breeding' in Sydney in 1947 (Hoskin 1991). Indeed, the Rainbow Lorikeet remained uncommon in Sydney until 1950 but has more recently dramatically increased its abundance throughout the city of Sydney (Saunders and Burgin 2007). Similar historical trends have also been recorded for the Rainbow Lorikeet in Melbourne (Fitzsimons et al. 2003), and since the 1970s their numbers have 'spectacularly' increased in major cities of Australia including Melbourne (Fitzsimons et al. 2003; Shukuroglou and McCarthy 2006); Canberra (Shukuroglou and McCarthy 2006); Brisbane (Woodall 1995); in addition to Sydney (Saunders and Burgin 2007). Even outside of their natural range (e.g., Perth), they are now one of the 'ubiquitous' bird species of the city landscape (White et al. 2005), and outcompete indigenous species for nesting resources.

This pattern of increase in abundance across capital cities is not restricted to the Rainbow Lorikeet. For example, at least in Sydney, Perth, and Brisbane, the Galah (*Cacatua roseicapilla*) has greatly increased in abundance in recent decades, together with the Sulphur-Crested Cockatoo (*Cacatua galerita*, Saunders and Burgin 2007). However, the expansion of the range of parrot species in urban areas is not restricted to Australia. Seven species of parrots have become naturalised in urban areas of Buenos Aires (Argentina, Chebez and Bertonatti 1991). Parrots have also become established in other cities of the Americas, for example, in Southern Texas, Chicago, New York, and Connecticut to name but a few (Moskoff 2003).

Many factors (inter-related and synergistic) of the bird-human interactions (direct and indirect) influence the ability of a species to colonise and/or increase in abundance in cities. For example, Shukuroglou and McCathy (2006) identified as important to such invasions and/or expansion of populations dietary requirements, breeding resources, adaptations [sic] to local climate, together with the extent of predation, competition, and/or disease. However, a major influence on bird species' presence and abundance is supplemental feeding (Howard and Jones 2004; O'Leary and Jones 2006), a widespread practice across the more affluent countries of North America, Britain and Australia (Saunders and Burgin 2007). In addition to the intended supplementation of food for specific species, food may be obtained by scavenging in urban areas, anywhere from the backyard to the municipal rubbish disposal sites.

In Australia, a major factor influencing the explosion of Rainbow Lorikeets and other honeyeaters such as the native Noisy Miner (*Manorina melanocephala*; Parsons and Major 2004; Saunders and Burgin 2007) has been the popularity of providing supplemental food that has occurred due to the widespread planting of cultivars of native *Callistemon* spp. and *Grevillea* spp. especially bred for profuse flowering as 'wildlife friendly plants' (Burgin 2004; Saunders and Burgin 2007). As a consequence, many walkways, parks, golf courses, and urban home gardens include such cultivars although not necessarily even derived from local indigenous stock (pers. obs.). Prior to European settlement, however, plant species of these genera were typically much more restricted in their distribution in the landscape and while their presence encourages honeyeaters (Burgin 2004), the prolific flowering of developed 'bird plant' cultivars, and the popularity of such cultivars within urban landscapes undoubtedly out-competes even the local

indigenous plants of the same genus while greatly advantaging honeyeaters over even other native bird species including non-honeyeater parrots.

While some species may complete successfully with parrots for resources, others that have been advantaged by the fashion of planting native cultivars are typically the more directly aggressive omnivores (e.g., Currawong [*Strepera* spp.], Noisy Miner). These, and other species that also cross forage between the urban and local bushland remnants, may have a significant impact on prey (e.g., small reptiles, small-bodied birds) in urban areas, and especially in the edges of native vegetation remnants (Anderson and Burgin 2008).

Although the avifauna mentioned in the examples outlined above may have a significant impact on the biodiversity of small-bodied birds, small reptiles, and many invertebrates, they typically have limited negative impact on humans and are frequently a welcome guest in city landscapes. Although there are exceptions, for example, in large numbers they may potentially cause disease problems for humans due to their droppings (Burgin and Webb 2011), and some species (e.g., sulphur-crested cockatoo) may be destructive of local vegetation and even wooden structures associated with urban dwellings (e.g., verandas/balconies). Some other native species, Torresian Crow (*Corvus orru*), Silver Gull (*Chroicocephalus novaehollandiae*), and Royal Spoonbill (*Platalea regia*), are also typically in greater numbers in many Australian urban areas than in their natural environment, and scavenge around food outlets, and wherever else food scraps are available (e.g., home rubbish bins, pet food, municipal tip, carrion). Such species are thus typically considered nuisance species when they occur in substantial numbers. They are also more likely to cause a health hazard than species that are strictly honeyeaters and, therefore, do not scavenge from humans eating outdoors or from their refuse (Burgin 2015).

Other bird species are a nuisance for different reasons. For example, much has been written about magpies swooping on those who pass near to the tree where they are perched in the Austral spring (i.e., nesting season), in areas where there are appropriate perches (trees, overhead service lines) often in association with expanses of lawn, in parks and along footpaths (Burgin 2015; Jones et al. 1980; Jones and Thomas 1999; Temby 2004). They feed in the low grass (i.e., lawn), and protect their offspring from those who pass ‘too close’ to their nest. They may also attack family pets, and even consume uneaten pet food left outdoors (Burgin 2015).

A less welcome non-avian taxon that is a widespread feral species across the Pacific, including Australia, is the Cane Toad (*Rhinella marinus*). Despite being introduced to many of these areas as an insect biological control agent of sugar cane pest species, the species is actually an open savannah taxon in its national habitat of South America, and prefers urban lawns and other mown areas to cane fields. The toads bred to incredibly high numbers in urban wetlands including garden ‘frog ponds’, may consume leftover pet food, and hydrate in water left for birds or pets. Their toxin will kill household pets and, in Australia, effectively any native wildlife that attempts to prey on them. Its generalist diet results in its consumption of a wide range of small native species, particularly invertebrate species. Indeed, the species first came to notice as a pest species in Australia when it was recognised that it was consuming large numbers of honey bees in sufficient numbers to impact the local honey industry (Burgin 2015).

Examples of issues and retrofitting for biodiversity conservation in urban areas

The reason/s for the introduction and/or expansion of urban populations of fauna and flora, and their sometimes subsequent increase to, at least, nuisance levels may not be readily

identifiable, although often it is the same set of circumstances (or very similar) across cities (e.g., Common Brushtail Possum [*Trichosurus vulpecula*], Van Dyck 2004), and even countries (e.g., Pigeon [*Columba livia domestica*], Sparrow [*Passer domesticus*], Cane Toad [*Rhinella marina*], Burgin 2015). However, no species 'explodes' in number without access to appropriate levels of resources, just as populations will ultimately decline due to limited access to resources. For example, it has been said that 'almost anywhere with a tree and a ceiling' in the inner suburbs of Brisbane there will be (Common Brushtail Possum; Van Dyck 2004), and the same issue occurs elsewhere in the older suburbs of Australian cities, for example in Sydney (Mathews et al. 2004), although they are typically not a nuisance in 'new' suburban developments. However, while they also may cause some consternation when they treat on backyard fruit and vegetables, the most common problem with Possums is their predilection for nesting in roof cavities. Older homes are more likely to have a breach that will, for example, allow Possums and some bird species (e.g., Noisy Miners, Pigeons, Sparrows; Burgin 2015), ingress into the ceiling cavity (Mathews et al. 2004), whereas homes in 'new suburbs' are less likely to allow such access. Sealing of openings to the ceiling cavity, combined with a lack of supplementary feeding, will result in these species becoming less prevalent and, indeed, there is now concern at the loss of Sparrows from urban areas worldwide (Daniels 2008). At least for the native Common Brushtail Possum that is in comparatively low abundance in many non-urban areas, an appropriate alternative to providing ceiling cavities for nesting sites would be to introduce appropriate nesting boxes.

Prevailing landscaping fashion, in public and/or private gardens, also advantage particular native and feral species (flora and fauna) and thus disadvantage or exclude other components of native biodiversity due to direct or indirect competition for, or exclusion from, resources. For example, initially, largely due to the encouragement of 'Birds Australia' to provide food plants for birds (Parsons and Major 2004), the vegetation of Australian cities has become increasingly homogenised with, in many local government areas, large numbers of plantings dominated by species of just two genera, *Grevillea* and *Callistemon* (pers. obs.).

The outcome has been that some honeyeaters (e.g., parrots; Saunders and Burgin 2007) have established and prospered within Australian cities. Some of these species, for example, the Noisy Miner, are omnivorous and may be extremely aggressive. For example, Parsons and Major (2004) observed that when they were present in an area, small-bodied bird species, Superb Fairywren (*Malurus cyaneus*), Eastern Spinebill (*Acanthorhynchus tenuirostris*) and Eastern Yellow Robin (*Eopsaltria australis*), were absent.

There is no doubt that plantings for honeyeaters have been a success in enhancing populations of this taxon in many Australian cities. However, a greater diversity of plants could also provide ground cover, for example, for small reptiles (e.g., *Lampropholis* spp.; Burgin 2015), and dense shrubs that provided habitat for small-bodied bird species (e.g., Superb Fairywren, Eastern Spinebill, Eastern Yellow Robin; Parsons and Major 2004). By introducing multiple strata and a greater diversity of plants, habitat would be provided for a wider range of species, flora and fauna, and thus better support biodiversity. This would be more desirable than simply relying on encouraging, albeit unintentionally, a greater abundance of a small range of species and thus lowed biodiversity overall.

On-going fragmentation of local native vegetation remnants without concern for edge effects and thus core to edge ratio, has been demonstrated to benefit carnivorous and omnivorous large-bodied bird species such as the Currawong, Noisy Miner, and Kookaburra (*Dacelo novaeguineae*). These species cross-forage between urban areas and the edge of

vegetation remnants. Their impact may be devastating to the small-bodied birds, and the small reptiles that are associated with such areas (Anderson and Burgin 2002, 2008). The resulting loss of these components of the biodiversity is evidenced, for example, by the decline in reptile species within Sydney, even in the larger native vegetation remnants (Joshi 2009; White and Burgin 2004). Reinstatement of the ground and shrub layers at the edges of such areas could reduce exposure of the smaller species to predation and thus act to enhance native biodiversity not only for birds but also, for example, small reptiles and butterflies.

Greater awareness of the issues caused by the homogenisation of landscapes due to the focus on a single aspect of biodiversity is required as a first step to overcome the issues associated with developing habitat for a few species and ignoring the broader range of biodiversity. Changes may also reduce, rather than increase management costs. For example, the reduction in the great expanse of lawns in cities forms effectively a desert for most native species. Development of 'meadow' landscapes would provide habitat and protection for species that are currently excluded from lawn areas, and thus enhance biodiversity. For example, in response to the decline of honey bees in many developed countries, 'bee highways' have begun to emerge in European cities (Blakemore and Norway 2015; Gibbs 2005). Appropriately considered these could also readily provide resources for a range of native flora and associated pollinators, and other small species.

However, the change in species dynamics (and thus biodiversity) within cities is not confined to changes in fashion due to landscaping within cities. Heightened awareness of the issues associated with supplementary feeding, and better husbandry of pets that result in fewer free-ranging animals, would also be an advantage to sustainable management of cities. For example, it has been estimated that Australia has 20 million feral cats, and this excludes home or stray cats which also have an impact on native species. A feral cat may consume up to 20 native animals daily, conservatively 80 million native animals daily across Australia (Cordon 2015). This species alone is threatening the survival of more than 100 species of native wildlife in Australia. While, in comparison, pet cats tend to consume a small number of native species, their impact on urban biodiversity may be substantial. For example, in a study undertaken over a 12 month period in Canberra, 70 % of cats presented fewer than 10 animals over the period although the number varied with 6 % presenting more than 50 prey items to their owner (Barratt 1998). Fewer cats, and greater control of cats, would clearly support biodiversity conservation in urban cities.

Conclusions

In this paper I have focused on current examples of taxa, mainly birds, with particular reference to Australian 'backyards', to demonstrate the issues that may arise by not considering the integrated management of biodiversity in the sustainable management of cities. However, as could be expected, the issues are far more complex than identified by focusing on a limited number of taxa.

It is only with the recognition that biodiversity is an important component of sustainable cities, and that it is possible to better incorporate conservation of biodiversity into the sustainable management of cities, that sustainable cities will be truly achieved. For example, even in established areas of cities, the major focus of this paper, much can be achieved to encourage more sustainable management of biodiversity than typically currently occurs. Even in the denser human populated, longer established, inner city suburbs it is possible to

encourage greater attention to biodiversity, for example, by reducing lawn areas in local parks, managing rail corridors, cemeteries, playing fields (including golf courses) and other 'waste land' or otherwise 'forgotten' areas leftover from urban development (see e.g., Burgin and Wotherspoon 2009). Also in densely populated areas, for example, roof, window/balcony or wall gardens also have the potential to support biodiversity by providing connectivity between larger areas of 'open space'.

In cities, the conservation of biodiversity therefore goes beyond the realm of governments and into the 'backyards' of the city. For example, across Australia there are several thousand volunteer groups of 'land carers' ('everyone, everywhere, landcare'; Landcare Australia n.d.) that undertake restoration and management of remnant native vegetation and may otherwise be concerned with biodiversity conservation. These care groups are often supported and coordinated by government instrumentalities that provide them with modest resources including expertise and equipment, while funding is available, predominantly, through 'Landcare' grants. The efforts of such groups have provided biodiversity outcomes across all types of urban landscapes from coastal fore-dunes to mountain tops and beyond. However, while undoubtedly much has been achieved by these landcare groups to support biodiversity conservation in their chosen area, governments' concept of such groups is to support 'grass roots', self-selected community groups who identify and manage an area of their personal interest. While extremely valuable, this has resulted in an ad hoc approach to biodiversity conservation although, to some extent, this has been negated by local government authorities 'sponsoring' multiple groups within their jurisdiction.

The weakness of this approach as a tool for the restoration and/or conservation of biodiversity in cities is that it lacks a holistic, integrated approach to biodiversity management. However, the presence of such dedicated teams of volunteers and their supporting government organisations does provide an excellent basis on which to develop a more strategic approach to biodiversity conservation within cities. Although, as has already been reported above, how to achieve the incorporation of biodiversity conservation into the sustainable management of cities is poorly understood by urban planners and designers, community developers and social planners, activists and social movements, and academics and consultants. Thus although many people are interested in 'native species', when flora and fauna are incorporated accidently or ad hoc into the urban landscape, for example due to landscaping fashion, the outcome can create on-going issues for authorities and, often, for the humans who live, work and/or visit the city.

As a consequence of the current approach, while much has been achieved, at least in Australia, a large component of biodiversity is typically neglected because it is cryptic, innocuous, dangerous, a nuisance, feral, or just not 'sexy'. The challenge is to recognise that biodiversity conservation is critical to sustainable cities, and to develop approaches to restore and conserve this important component of urban sustainability along with the other aspect of sustainable management of urban areas.

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