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Connecting people with place-specific nature in cities reduces unintentional harm

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Abstract

There is an increasing disconnect between people and nature as we become more urbanised. Intensification in cities often results in a reduction of natural areas, more homogenised and manicured green spaces, and loss of biota. Compared to people in rural areas, urban dwellers are less likely visit natural areas and recognise and value biota. Reconnecting people with nature in the city not only benefits human mental and physical wellbeing but can also have positive effects on how people value biodiversity and act on conservation issues. However, in some contexts, the push to reconnect people with nature may have unintended negative outcomes on biodiversity, particularly if place-specific nature is not used in urban greening. In the current biodiversity crisis, using vegetation and green space design that is not reflective of the environmental context of a city can further disconnect residents, particularly Indigenous people, from their local environment and species, and further entrench extinction of experience and loss of environmental values. This disconnect can result in residents applying wildlife gardening practices, such as bird feeding, that are not specific to place, and benefit introduced species over indigenous species. Furthermore, cities are gateways for invasive species, and using species in greening projects that are not locally sourced has already left cities and their surrounding regions with a large weed legacy. Using place-specific nature and green space in cities can be less resource intensive, highly beneficial for biodiversity and give residents a unique sense of place. Rather than simply adding 'more nature' in cities, the messaging should be more complex, emphasising the need for urban greening to be context specific to avoid negative impacts on biodiversity and ecological and cultural services.

1. Urbanisation and the extinction of experience

Urbanisation is predicted to increase in scale and rate with which cities are expanding in both spatial extent and human population density (Marzluff 2001, Pejchar *et al* 2015, Zhou *et al* 2019, Kundu and Pandey 2020). The resulting densification of cities often results in more homogenised and highly manicured greenspace at the expense of natural areas, with acute effects on biodiversity (McKinney 2008, Wyse *et al* 2015, Richards and Belcher 2019). The degree to which biodiversity is negatively affected by urbanisation can be influenced by the distribution of human activities, infrastructure and vegetation composition (Pickett *et al* 1997, Chang *et al* 2021). Furthermore, loss of environmental consciousness in people living in cities can exacerbate impacts on biodiversity via planning and decision-making that does not incorporate the needs of functioning ecosystems within cities (Turner *et al* 2004, Miller 2005, Barragan-Jason *et al* 2023).

There is a growing disconnect between people and nature as we become more urbanised (Turner *et al* 2004). Increasingly, urban dwellers do not visit or interact with natural areas on a regular basis (Soga and Gaston 2016). This 'extinction of experience', a phrase coined by Pyle (1978) to describe the decline in people experiencing the outdoors and interacting with nature, results in a feedback loop in which the loss of urban biota exacerbates the human–nature disconnect, with the ensuing environmental apathy furthering

biodiversity decline (Miller 2005, Soga and Gaston 2016). Concurrent with increased urbanisation, urban dwellers are now less likely to recognise and value biota over time (Miller 2005, Kai *et al* 2014, Zhang *et al* 2014, Cox and Gaston 2016). Consequently, empathy for and protection of remaining biodiversity can be lost, with low motivation among urban dwellers to enhance nature within cities (Nord *et al* 1998, Collado *et al* 2015, Soga and Gaston 2016). This has been exemplified by a historical perception that cities and nature are separate entities, whereby cities are created by and for people, and nature should be encouraged outside of cities. However, in the past decade there has been a proliferation in research quantifying the benefits of nature to human health, and a resurgence in efforts to reconnect urban-dwellers with nature by providing additional greenspace in cities (Shanahan *et al* 2019, Martins 2022). More recently, lockdowns and lifestyle changes (e.g. an increase in working from home) during the COVID-19 pandemic resulted in more city-dwellers engaging with urban green spaces and wildlife, and having higher awareness of the importance of nature connection (Soga *et al* 2021).

2. Reconnecting people and nature

Reconnecting people with nature in cities not only benefits human mental and physical wellbeing but can also have positive effects on how they value biodiversity and act on conservation issues. There is a growing body of evidence that interacting with nature provides tangible physical and mental health benefits (Shanahan *et al* 2015). Those benefits are dose-dependent, with Shanahan *et al* (2016) demonstrating that just 30 min of exposure to nature per week can reduce rates of depression and reduce high blood pressure. Other physical health benefits of nature interactions include reduced hospital patient recovery times (Ulrich 1984), improved psychological wellbeing (Fuller *et al* 2007) and cognitive function (Berman *et al* 2008). Health innovations, such as 'green prescriptions' (written advice and support services given to a patient by a health professional to increase physical activity and/or relieve stress) and New Zealand's Mental Health Foundation partnering with New Zealand's Department of Conservation, encourage use of urban green spaces to connect with nature (Stanley *et al* 2015, Te Whatu Ora—Health New Zealand, www.tewhatuora.govt.nz/our-health-system/preventative-healthwellness/green-prescriptions/; www.doc.govt.nz/our-work/healthy-nature-healthy-people/).

In addition to health benefits, there is growing recognition of the other ecosystem services provided by nature in cities, such as cultural services (e.g. recreation, tourism, aesthetic) and regulating services (e.g. flood mitigation, air pollution mitigation, carbon storage) (Gaston *et al* 2013, Richards *et al* 2022). In response to the growing body of evidence that nature in cities can provide humans with tangible health benefits and ecosystem services, cities around the globe have developed urban forest cover and biodiversity targets to increase the benefits received from nature connections (e.g. City of Toronto 2013, Blackwell *et al* 2014). Much effort has gone into valuing and quantifying the benefits provided by individual tree species to justify expenditure on planting and maintaining urban forests (e.g. City of Toronto 2013, Pothier and Millward 2013, Hotte *et al* 2015). In some cities this effort has extended beyond public land to trees in residential gardens, quantifying the services these trees provide to city authorities and encouraging nature retention in non-public spaces. For example, the city authorities in Portland, Oregon (USA) offer a proportional utility bill credit per individual tree ('Treebate') for residents (City of Portland) that recognises the ecosystem services provided by trees in residential gardens to the City of Portland (www.portland.gov/bes/grants-incentives/about-treebate). With the benefits of nature and nature-based solutions becoming increasingly clear, and the ensuing efforts to reconnect people with nature in cities, there has been a proliferation of nature-related messaging directed at the public. However, while positive outcomes are anticipated from the uptake of these messages, such as the physical and mental health benefits that accrue from exposure to nature (Shanahan *et al* 2019), there may well be unintentional impacts on biodiversity if the messaging in communications is not context-specific (figure 1). Place-specificity is a key principle of implementing nature-based solutions (Albert *et al* 2021). Urban greening and nature-based solutions can be designed and implemented to achieve multiple goals, including solving urban challenges such as flood mitigation, increasing human health and wellbeing, improving biodiversity outcomes, and giving people a sense of place though place-based greening (Frantzeskaki *et al* 2019). However, some studies have shown that residents must find urban greening to be aesthetically pleasing to be implemented, and this may be diametrically opposed to improving biodiversity outcomes in cities. Naturalness can be frequently misinterpreted as ecological quality, rather than a cultural concept (Nassauer 1995).

Figure 1. Unintended effects of not prioritising biodiversity and place-specific nature in urban greening programs: (a) people connecting with nature often results in more highly maintained spaces and a loss of vegetation complexity and wildlife habitat (photo: M.C.S); (b) the desire for lawn grass in low-rainfall cities can require high levels of irrigation and nutrient input or homeowners install artificial grass as pictured (photo: M.C.S); (c) most environmental weeds, such as *Rhododendron ponticum* in New Zealand tussock grassland, originate from introduced ornamental plants used in urban parks and gardens (photo: M.C.S); (d) loss of language and cultural practices, such as weaving, for Indigenous people through loss of connection with native species (photo: M.C.S); and wildlife gardening, such as (e) bird feeding (photo: J.A.G) and (f) gardening for bees can often favour introduced birds and honey bees, which can displace native species (photo: M.C.S).

3. Unintentional consequences of connecting people to nature

3.1. Pressures on urban green space

In some contexts, the push to reconnect people with nature may have unintentional harmful consequences for biodiversity (figure 1). Stanley *et al* (2015) identified health-associated demands on green space as an emerging threat to urban ecosystems and argued that the number of people using urban green spaces for exercise and stress relief is expected to rise as evidence of health benefits grow and more 'green prescriptions' are issued. However, the relationship between biodiversity and recreation is not always positive. Increased use of urban green spaces may well result in negative effects on biodiversity (figure 1). For example, increased visitation can be associated with demands for greater maintenance, which frequently includes the provision of pathways (often impermeable surfaces) and an increase in manicured lawns (Stanley *et al* 2015). Perceived safety risks and social fears can result in modification of the green space through lighting installation and the removal of dense vegetation and shrubs for clear sight lines (Sreetheran *et al* 2014, Evensen 2021). These societal demands on green spaces are likely to result in reduced biodiversity, impacting directly on vegetation through removal and modification (Crime Prevention through Environmental Design: CPTED; Cozens 2002), and indirectly on animals through the effects of habitat loss, increased noise and artificial light at night (Francis *et al* 2009, McNaughton *et al* 2022). However, Harris *et al* (2018) found that Melbourne residents ranked dense vegetation as highly preferred and suggest this may have been due to residents recognising the benefit of dense vegetation to wildlife, and that the vegetation in the photos was not close to a

path. They conclude that dense vegetation can be a preferred type of urban greening as long as it does not border paths, and therefore has a lower perceived safety risk (Harris *et al* 2018). Lis *et al* (2022) found that 'naturalness' of a park is not popular with residents in Wrocław as it lowers the perception of safety, but this can be mediated by the park having a clear layout that assists orientation through the park. The aesthetics and layout of green spaces and the services they provide people, rather than biodiversity itself, can strongly influence acceptability of green spaces and urban planning.

3.2. The role of public preference and aesthetics in acceptability of green spaces

Public preferences for green spaces can be directly at odds with requirements for protecting and enhancing biodiversity. Maintenance activities, such as lawn mowing, removal of understory vegetation, leaf litter removal and pesticide application can all negatively impact biodiversity (Aronson *et al* 2017). Despite these negative outcomes for biodiversity, acceptability of green spaces by residents is highly influenced by how well maintained the green spaces are, as well as accessibility and the structure of the vegetation within the green space (Hofmann *et al* 2012, Brun 2018). For example, Hofmann *et al* (2012) found Berlin residents preferred highly maintained, formal green spaces. Similarly, Qiu *et al* (2013) found visitors to a Swedish park preferred half-open park areas to areas of more complex vegetation, even though they were able to identify high biodiversity areas. However, the simplified vegetation with very little structure that is often preferred by visitors does not provide adequate habitat for wildlife. For example, sparse understorey and few indigenous plants substantially reduced the probability of indigenous birds, bats, beetles and bugs occurring in public parks, golf courses and residential neighbourhoods in Melbourne, Australia (Threlfall *et al* 2017). Threlfall and Kendall (2018) stress that wilder urban ecosystems (those with less human intervention and maintenance) are likely to improve ecological outcomes through habitat provision, have better health and human benefits through their spatial and temporal diversity, and generate more ecosystem services, such as stormwater mitigation. More recently, intense global flooding associated with climate change has stimulated an interest in 'sponge cities' and a desire to create more absorbent green spaces (Mercier 2023), which are generally more complex and somewhat contrary to residents' preferences for green spaces.

Implementing these wilder, urban green spaces with reduced maintenance can meet with some resistance. For example, attempts to restore areas of Mediterranean grassland vegetation within urban green spaces in Rome have been met with opposition from residents, who perceive these areas as 'untidy' and 'messy', and in response, they are often inappropriately managed from an ecological perspective (Filibeck *et al* 2016). Unmown or 'low-mow' lawns in public green spaces can also be a cause of contention among residents, and the source of complaints to local authorities (K. Beaufort, Auckland Council, pers. Comm.). While ecological services, such as pollination, can be drastically enhanced by reducing mowing frequency (Garbuzov *et al* 2015), unmanicured lawns can be perceived as unkempt, and evoke feelings of discomfort or disgust (Bixler and Floyd 1997). However, cues that show landscape design (e.g. no-mow zones) is intentional may increase acceptability (Nassauer 1995). There are numerous ways that appear to increase public understanding and acceptance of the lack of maintenance, such as 'acceptance stripes', mown transition zones which visually mark the boundaries of unmaintained or infrequently maintained meadows/lawns, information boards that explain the benefits of such meadow/lawn maintenance, and structures, such as sculptures (Zobec *et al* 2020).

Although park-like landscapes (those containing specific features, usually scattered trees with minimal understorey) are often highly preferred, there is some evidence that the general public's preferences for degree of maintenance of urban green spaces is changing, and less maintenance is becoming more acceptable (Harris *et al* 2018, Threlfall and Kendal 2018, Hwang *et al* 2019, Babington 2023). For example, Hwang *et al* (2019) found Singaporean residents are not averse to more wildness in their urban parks and streetscapes, while groups of residents with higher levels of ecological knowledge had a higher preference for wilder greenscapes. There were some indications that residents understood that wilder areas had lower maintenance requirements (Hwang *et al* 2019). Clearly, preferences for the characteristics of green spaces are likely to be place-specific and reflect differences in culture and the natural ecosystems specific to cities across the globe. This may also be reflective of differences in levels of endemism within cities, with residents in cities with high endemism, such as Singapore and Melbourne (Threlfall and Kendal 2018, Hwang *et al* 2019), more accepting of highly structurally complex vegetation and the wildlife habitat it provides, than in countries with relative low endemism and a longer history of formal parks, such as many European cities. Although this has not been tested comparatively, it does highlight the importance of considering place-specific nature, rather than encouraging a homogenised view of urban green spaces globally.

4. Place-specific nature

Given the overwhelming evidence for the benefits provided by nature in urban centres, current emphasis is quite rightly placed on reconnecting people with nature and increasing the amount of nature within cities.

However, the messaging is often simple, without differentiating or specifying the type of nature that is appropriate within the context of specific cities. Furthermore, many cities have a colonial history that has influenced urban planning, greenspace design and the choice of plant species used (Roman *et al* 2018, Shackleton and Gwelda 2021). Tourists are likely to experience biotic homogenization (*sensu* McKinney 2006) across many cities worldwide, with a similar set of trees planted in cities, often reflecting European colonisation. In Auckland, of the individual urban trees given legal protection, there is a much higher diversity of introduced species (193 spp.) than indigenous species (49 spp.), with the introduced *Quercus* spp. And *Platanus x acerifolia* making up 22% of all individually protected trees (Wyse *et al* 2015). This pattern is similar in other cities in Aotearoa–New Zealand, reflecting its colonial past (Quan 2021). The loss of connection with indigenous species due to colonisation and rapid urbanisation can have hugely negative consequences for Indigenous people living in cities; with loss of connection to indigenous biota comes loss of cultural practices, language and wellbeing (Walker *et al* 2019). Prioritising indigenous plant species over introduced plant species not only benefits biodiversity, but also contributes to the decolonisation of urban spaces (Rodgers *et al* 2023). Indeed, in Aotearoa–New Zealand, preference for indigenous plants in public spaces is likely to be increasingly entrenched in policy as the country moves towards decolonisation (Rodgers *et al* 2023). In terms of the general populace, New Zealanders are more willing to conserve indigenous species, even when introduced species are charismatic (Fern 2022). Elsewhere, there is increasing recognition that colonisation has played a key role in disconnecting urban residents with indigenous biodiversity, with particularly negative consequences for Indigenous people (Langton 2002, Roman *et al* 2018, Lyons *et al* 2020, Shackleton and Gwelda 2021). Where indigenous species are prioritised for planting, urban greening should not be implemented without Indigenous people as partners, so as not to intensify colonisation (Porter *et al* 2020).

4.1. Ignoring place-specific nature leaves a weed legacy

The colonial heritage of urban greening has left many cities with a weed invasion legacy that results in cities being gateways for weeds in many parts of the world (Pyšek 1998, Shackleton and Gwelda 2021, Potgieter *et al* 2022, figure 1). The impacts of invasive species on biodiversity are greater in places with higher levels of endemism, typically in more isolated regions or oceanic islands rather than continental, older cities (Myers *et al* 2000, Allen *et al* 2006). For example, approximately 80% of the Aotearoa–New Zealand flora is endemic (Lehnebach 2014), with similar levels in Australia (∼90%, Chapman 2009). Where 'uniqueness' of biodiversity prevails, a mandate exists under the Convention on Biological Diversity for the protection of the remaining unique flora and fauna (often highly impacted already), by reducing the impact of existing invasive species and preventing the arrival and establishment of new invasive species (Stanley and Bassett 2015, Essl *et al* 2020). In Aotearoa–New Zealand, more than 27 000 plant species have been introduced since 1840, with 8.5% of those having naturalised so far, at a rate of 20 species per year (Howell 2008, Hulme 2020). Two-thirds of those species were originally introduced as ornamental plants, and now the number of environmental weeds has almost reached 400 species, compared to 2158 indigenous vascular plant species (Stanley and Bassett 2015). Numbers of naturalisations are comparable to Australia, where 2741 plant species have naturalised (Diez *et al* 2009) and 66% of those species where garden plants (Groves *et al* 2005). Impact data is available for 22 weed species in Aotearoa–New Zealand, with demonstrated impacts typically consisting of reductions in indigenous plant and invertebrate diversity and/or changes in community composition (Stanley and Bassett 2015). A similar scale of naturalisations (∼10%) and types of weed impact have been found in Australia (Gallagher and Leishman 2015). Loss of biotic interactions through weed invasion, as well as habitat loss through urban homogenisation, is likely to further accelerate the current biodiversity crisis (Sandor *et al* 2022).

Since naturalisation of introduced species and their subsequent invasiveness is highly related to propagule pressure, continual planting of introduced species, following global gardening trends, increases the likelihood of establishment (Williams and Cameron 2006, Dehnen-Schmutz *et al* 2007, Simberloff 2009). Currently, plant nurseries in Aotearoa–New Zealand promote the sale of subtropical and tropical species (e.g. palms), to create the illusion of tropical resort holidays for homeowners (M.C.S., pers. Obs.). The increasing number of palms in Auckland gardens, combined with a predicted reduction in frosts due to climate change, indicates the invasion risk for these species (e.g. *Archontophoenix cunninghamiana*) is high and the management implications difficult (Sheppard *et al* 2016). While an argument could be made that cities are novel ecosystems and therefore the impacts of invasive species within cities would be low, important remnants of indigenous ecosystems and threatened species do occur within cities (e.g. Ives *et al* 2016, Potgieter *et al* 2022), and these are at risk from the impacts of weed invasion. Furthermore, urban developments are increasingly encroaching on natural areas. Sullivan *et al* (2005) found that the number of weed species found in forest patches was primarily explained by the number of houses within 250 m of the patches, but also by the number of introduced species in the neighbouring residential gardens. Moreover, at

least in Aotearoa–New Zealand, urban-dwellers often take cuttings and seeds from plants in their urban gardens to their holiday homes in or adjacent to natural areas, with local authorities attempting to prevent this spread of plant material (Bassett *et al* 2016).

4.2. Disservices generated by using introduced species for urban greening

While the ecosystem services of urban greening, such as mitigating the urban heat island effect, are well known (Quaranta *et al* 2021), using plant species that are not indigenous to a city can produce a number of disservices, some of which are exacerbated by a changing climate. For example, in some xeric cities, such as Phoenix, USA, there is an expectation of a lush, green 'oasis' in the desert that is a cultural legacy persisting as a social norm, particularly among long-term residents (Larson *et al* 2017). Residents in these types of landscape often plant mesic trees and resource-intensive lawns not specific to that landscape (Andrade *et al* 2021). However, grass lawns and trees in xeric cities, such as Phoenix, USA, and Adelaide, Australia, require high resource input, particularly irrigation (Wentz and Gober 2007, Nouri *et al* 2019). In contrast, indigenous vegetation that is adapted to local conditions presents a very low-cost management option (Klaus 2013) and is much more sustainable in terms of water consumption, which is critical in a changing climate. Furthermore, keeping water and nutrient input to a minimum is essential to maximising indigenous plant species that require dry, nutrient poor conditions to thrive, even those these might not always be the type of urban greening that residents prefer (Filibeck *et al* 2016).

The introduction of plant species that are far more flammable than indigenous plants, can also present a much higher fire risk to communities, particularly under more frequent extreme conditions associated with climate change (Matos *et al* 2002, Blackhall and Raffaele 2019). In Aotearoa–New Zealand, where pre-human fire frequency was low, the introduction of highly flammable, fire-adapted invasive species such as *Eucalyptus* spp., *Pinus* spp., and *Hakea sericea*, have increased fire risk and pose an increasing risk to indigenous plant communities, and human populations where they are widely distributed (Perry *et al* 2014, Wyse *et al* 2018). In Patagonia, introduced species that have spread both from urban residential gardens and plantations have modified the wildland–urban interface and increased flammability of the landscape (Blackhall and Raffaele 2019). Green firebreaks, consisting of strips of low flammability plant species have been implemented around urban areas globally to protect people and infrastructure from fire; and if they consist of indigenous plant species, they also provide additional benefits for biodiversity (Curran *et al* 2018, Cui *et al* 2019). Selection of these low flammability plant species must be prioritised for urban parks and gardens for increasingly fire-prone areas (Murray *et al* 2018). For areas with low fire frequency histories, indigenous plants are likely more suitable than introduced species and also provide biodiversity benefits (Curran *et al* 2018). More research is required on which place-specific (indigenous) plant species might be best used for climate change mitigation and adaptation, rather than applying a few well-studied plants from well-resourced countries to other contexts; this further intensifies colonisation and unintentional impacts (Rodgers *et al* 2023).

5. The unintended consequences of wildlife gardening

Wildlife gardening (actions taken by urban residents to directly facilitate wildlife in their gardens, usually via habitat and food supplementation) is one of the ways people engage with nature in cities (Gaston *et al* 2007). Watching animals and their behaviour provides people with pleasurable, relaxing feelings, and a sense of being connected to nature (Galbraith *et al* 2014, Cox and Gaston 2016). However, manipulating animal populations (generally increasing them) via wildlife gardening is likely to result in a range of negative indirect outcomes.

Bird feeding is one of the most prevalent, deliberate wildlife gardening actions taken by people in cities (Jones and Reynolds 2008). In the US alone, 59.1 million people engage in bird feeding every year, making it a more popular activity than fishing (U.S. Department of the Interior *et al* 2016). Furthermore, participation in bird feeding and the associated industry both appear to be growing internationally. In many countries, including the US and the UK, bird feeding is actively promoted by conservation agencies (Jones and Reynolds 2008). It is viewed by many as a pastime which benefits nature, both in the sense there may be advantages for the birds being fed, and from the connections forged between people and wildlife that may encourage greater environmental responsibility. While there is certainly increasing evidence that connecting with wild birds via feeding has direct human benefits in terms of health and well-being, the evidence that bird feeding translates into an overall gain in biodiversity is lacking.

There are, however, studies which indicate feeding can have a variety of effects on the ecology of birds (Ishigame *et al* 2006, Robb *et al* 2008, Amrhein 2013), including negative impacts on bird communities (Galbraith *et al* 2015) with unintended outcomes for human–nature connections. Bird feeding in Aotearoa–New Zealand is a prime example. The application of Eurocentric bird feeding traditions—where offerings for wild birds are typically grain-based—to Aotearoa–New Zealand benefits granivorous and

omnivorous species (Galbraith *et al* 2014). The indigenous bird species that persist in urban Aotearoa–New Zealand, however, are largely frugivorous, nectarivorous, or insectivorous. Instead, these additional grain-based resources provided by people are being consumed by granivorous and omnivorous invasive birds, facilitating a shift in bird communities toward a structure more heavily dominated by these species (figure 1; Galbraith *et al* 2015). The abundance and diversity of indigenous species suffers in comparison to the burgeoning invasive community. Far from providing any sort of conservation benefit for Aotearoa–New Zealand's indigenous birds, current feeding practices are working against indigenous birds attempting to maintain a foothold in cities. There is an additional unintended outcome of applying bird feeding practices that are not specific to place. The connections people can forge with species in their backyards and gardens become increasingly limited as bird communities become saturated by a few dominant urban exploiter species. This 'extinction of experience' means fewer direct connections with a diversity of bird species, and as a result, familiarity, knowledge, and concern for these species will diminish. Where these species are indigenous, lack of connection through changes in density and distribution can massively impact cultural practices and identity for Indigenous people (Turvey *et al* 2010, Bond *et al* 2019).

Mitigating these unintended outcomes requires more than a simple 'do not feed the birds' message. Experiences from areas where bird feeding is actively opposed and discouraged by conservation organisations, notably Australia, tell us that outright prohibition of feeding does not automatically equate to reduced participation in the activity (Jones 2011). Instead, messaging around bird feeding can be more complex and adapted specifically to place. As a minimum, more complex messaging can serve to communicate potential impacts and provide alternatives to current feeding practices which may minimise these impacts. Conservation-minded New Zealanders use sugar water feeders as an alternative supplementary food to attract indigenous nectarivorous birds to their gardens and support their populations through winter when nectar is scarce (Erastova *et al* 2021). However, there are concerns about disease spread associated with sugar water feeders and other issues, such as dependency and heightened predation risk (Coetzee *et al* 2018). Current messaging is that sugar water feeding is more place-specific and benefits indigenous Aotearoa–New Zealand birds, but that feeders must be specifically designed for honeyeaters to exclude introduced birds, such as house sparrows (*Passer domesticus*), must be thoroughly cleaned regularly and feeder posts positioned to minimise predation by domestic cats (Erastova *et al* 2023).

Gardening for bees has become another popular form of wildlife gardening in cities around the globe and, as with bird feeding, provides a nature connection and health and wellbeing benefits (Egerer and Kowarik 2020). However, Smith and Saunders (2016) found articles in the Australian mainstream media to be heavily biased towards European honey bees (*Apis mellifera*), with very few studies on the importance of the huge diversity of other Australian pollinators, including more than 1600 indigenous bee species. While domesticated European honey bees have been used as crop pollinators for hundreds of years, evidence is mounting that diverse communities of wild pollinators can improve yields more than managed honey bees alone, and pollinator diversity reduces risks of crop failure due to population collapse of one pollinator species (Garibaldi *et al* 2013, Rader *et al* 2016). However, a popular culture has developed around 'save the bees' endeavours, and urban beekeeping has flourished as an 'ecologically inspired urban lifestyle phenomenon' (Lorenz and Stark 2015, Hall and Martins 2020), which, apart from a few excellent examples (Wilk *et al* 2019), is often based around planting introduced plant species in cities as food resources for European honey bees (e.g. https://treesforbeesnz.org/gardens; www.sweetreehoney.co.nz/blog/post/65390/feed-the-bees–plant-bee-friendly-plants/; Iwasaki and Hogendoorn 2021, 2023), giving them a competitive advantage over indigenous pollinators (Wilk *et al* 2019, Prendergast *et al* 2021). As an introduced species in many regions, the European honeybee can have a range of negative impacts on indigenous biodiversity, for example, displacing indigenous pollinators (Geerts and Pauw 2011) and reducing indigenous plant reproductive success (Paini and Roberts 2005, Torné-Noguera *et al* 2016, Iwasaki and Hogendoorn 2022). Furthermore, in Aotearoa–New Zealand and Australia, European honey bees are primarily responsible for the pollination of some invasive weeds, such as scotch broom (*Cytisus scoparius*), leading to increased weed spread and impacts on biodiversity (Simpson *et al* 2005, Paynter *et al* 2010). Increasing awareness of place-specific indigenous pollinators among city-dwellers, and emphasising resources that residents could use to help support indigenous pollinator populations (e.g. indigenous flowering plant species; retaining leaf litter; Pardee *et al* 2023) in urban gardens could enhance pollinator diversity in urban green spaces and reduce the unintentional harm caused by European honey bees to indigenous biodiversity. National pollinator strategies for the conservation of wild pollinators have been released in countries such as Ireland (Stout and Dicks 2022). A key aspect of Ireland's strategy is to encourage all sectors of society, including schools, businesses and gardeners, to take clear, science-informed actions, such as providing nesting sites, that enhance pollinator conservation (All-Ireland Pollinator Plan 2021–2025 2021). This is an approach that should be adopted more widely, but with recommendations specific to place, rather than a mono-pollinator philosophy of supporting honey bees (Egerer and Kowarik 2020). Furthermore, Liang *et al* (2023), Egerer

and Kowarik (2020) call for urban beekeeping (European honey bee) to be regulated to manage the effect of the honey bees on urban pollinators.

6. Multifunctional green spaces provide opportunities to enhance biodiversity

Cities can have multifunctional green spaces that are designed and implemented to meet the needs of people and increase ecosystem services, but they should also align their urban greening goals with sustainability goals and their obligations under the Convention on Biological Diversity. Biodiversity is declining globally, and cities provide opportunities to increase indigenous biodiversity (Ives *et al* 2016, Lepczyk *et al* 2023, McDonald *et al* 2023). For example, some threatened plants, including the 'Nationally Endangered' shrubby tororaro (*Muehlenbeckia astonii*), are now included in plans for traffic island plantings in Aotearoa–New Zealand cities (figure 2, de Lange and Jones 2000). However, in many cities, the biodiversity aspect of urban greening is downplayed; while some make the distinction between nature-based vs semi-natural vs artificial green spaces (e.g. Germany; Daniels *et al* 2018), most studies do not specifically talk about biodiversity values in planning for city green spaces. In particular, there appears to be unwillingness to preserve indigenous vegetation in Central European cities (Breuste 2004), with more emphasis on preserving trees, rather than habitat, and highly maintained green spaces. Breuste (2004) suggests better information and education for residents on urban nature could result in better outcomes for the preservation and restoration of indigenous habitats in European green spaces. The extinction of experience that residents undergo as they become disconnected from their local indigenous environment makes it difficult to achieve buy-in for enhancing biodiversity if the emotional connection to indigenous biodiversity is not present (Soga and Gaston 2016). Some studies have found increased suggested psychological benefits for park visitors associated with high plant biodiversity within green spaces (Fuller *et al* 2007, Lindemann-Matthies *et al* 2010, but see Dallimer *et al* 2012), so there are opportunities to use this information to engage with the public.

Residents with a higher concern for nature generally have a higher preference for green spaces that are more biodiverse and ecologically sustainable (e.g. Zheng *et al* 2011), although preferences are likely to reflect place-specific values. People who live in cities and regions with high endemism may have preferences for the type of vegetation they perceive as indigenous and therefore more likely to support local wildlife. Plant blindness, whereby humans more readily detect, appreciate and support animal conservation compared to plants (Balding and William 2016), often means providing habitat for charismatic local wildlife, rather than valuing indigenous plants themselves, can be the lever for increasing indigenous and wilder urban green spaces. For example, Caula *et al* (2009) found that Montpellier residents were more likely to prefer more natural green spaces when they were given information about the birds that were likely to use them. The presence of wildlife in green spaces adds to the visitor experience (Gobster and Westphal 2004), but if the vegetation is not place-specific, it can reduce the attractiveness of greenspace to wildlife. Of the individual indigenous trees protected in Auckland under the notable tree schedule, 90% provided food sources for nectarivorous or frugivorous birds, compared to only 27% of the introduced species (Wyse *et al* 2015). This mismatch between introduced plant species and the resource requirements of indigenous birds means that residents are less likely to see and connect with a diversity and abundant indigenous bird community. Coupled with wildlife gardening that facilitates introduced birds and pollinators, the opportunities for connections with indigenous biodiversity are missed. This is changing in Aotearoa–New Zealand; Quan *et al* (2021) found newer plantings in Christchurch residential gardens were indigenous species, while Auckland's Urban Ngahere (Forest) Strategy outlines 'Preference for Native Species' as a key principle (Auckland Council 2019). In Melbourne, introduced London plane trees (*Platanus x acerifolia)* have been widely planted as street trees, but offer limited resources to indigenous wildlife (Watson *et al* 2023). Watson *et al* (2023) used this an opportunity to enrich existing urban greening by successfully establishing indigenous mistletoe species onto these trees to make them more useful resources for local wildlife.

Aesthetics and acceptability are influenced by culture and place-based history, and a diverse body of residents will value the environment in different ways (Kendal *et al* 2012). Currently, green space planning and implementation appears weighted to residents' preferences for green space attributes, often at the detriment to biodiversity and Indigenous peoples. Although residents' preferences and resulting acceptability are important, valuing biodiversity in cities requires more complex messaging to residents and planners. Hu and Gill (2016) suggest that encouraging urban gardeners to foster a positive attitude toward planting indigenous plants, and fostering knowledge about the harm of invasive plants, is the best way to increase beneficial biodiversity outcomes. Although these messages are more complicated than simply encouraging people to plant trees, it is the best way to reduce harm to indigenous biodiversity and to reconnect people with indigenous biodiversity. There are also multiple opportunities for awareness and education programmes, such as encouraging people to reduce lawn mowing frequency or how to develop and grow more biodiverse, grass-free lawns (Smith and Fellowes 2014). These could be paired with displays of low

Figure 2. Multifunctional green spaces provide opportunities to enhance biodiversity: (a) traffic island plantings include threatened species in Aotearoa–New Zealand (photo: Reproduced with permission from R. Simcock); (b) playgrounds can be multifunctional spaces that incorporate biodiversity with the primary play functions (photo: M.C.S); (c) and (d) green spaces co-designed with Indigenous people can incorporate biodiversity, cultural significance and education (photos: M.C.S).

maintenance green spaces and opportunities for parks staff to interpret these spaces for residents and provide them with simple financial and emissions costings for continual high maintenance of green spaces. For example, Auckland Council has recently consulted its residents on reducing parks mowing frequency (resulting in 25 mm longer grass if frequency is reduced) and increasing park meadows as a way of reducing its post-Covid budget deficit and avoiding increasing rates (Auckland Council 2023).

7. Synthesis

Reconnecting urban residents with nature has many benefits for people, such as improved mental and physical health, and a variety of ecosystem (e.g. flood mitigation) and cultural (e.g. recreation) services. However, not all urban greening practices are beneficial for biodiversity and may cause unintentional harm, particularly if place-specific nature is not used. In the current biodiversity crisis, using vegetation and green space design that is not reflective of the environmental context of a city can have multiple impacts on indigenous biodiversity (table 1).

The opportunities are many to improve urban greening practices, facilitate multifunctional spaces, and encourage place-specific nature. However, key messages for both residents and planners include: (a) promote planting of indigenous species to bolster people's connection with their environment and species and to restore urban indigenous ecosystems, (b) prohibit planting of invasive species (often listed as such by local authorities), (c) implement and promote less manicured green spaces, which are better for biodiversity and more cost-effective to maintain, (d) support local wildlife by not applying unsuitable overseas wildlife gardening practices to your own city, and (d) consider local conditions, including shifting green spaces towards climate-adapted vegetation, and co-design with Indigenous people when implementing urban greening.

Table 1. Urban greening practices that do not use place-specific nature disconnect residents from their local environment and can result in unintentional harm.

Disconnect between urban dwellers and their local environment	Harmful outcomes	Key references
Residents prefer local green spaces that are highly maintained (e.g. paths, clear sight lines, open lawns)	Dense, highly structured vegetation provides more habitat for local biodiversity	(Evenson 2021,Lis 2022, Aronson *et al* 2017, Threlfall and Kendall 2018)
Species used for urban greening and gardening are not locally sourced	Cities have become a source of weed invasion—results in homogenisation of biodiversity through weed impacts on indigenous biodiversity	(Pysek 1998, Stanley and Bassett 2015)
	Plants not adapted to local environments often require large resource inputs (e.g. water for lawns in xeric cities)	(Larson *et al* 2017, Nouri *et al* 2019, Andrade *et al* 2021)
	Introduced plants that have higher flammability than indigenous plants can present a high fire risk when planted in/near urban areas	(Perry *et al* 2014, Blackhall and Raffaele 2019)
	Indigenous peoples in cities are further disconnected from cultural practices and language associated with local species. Exacerbates colonisation impacts	(Walker *et al* 2019, Lyons *et al* 2020, Rodgers *et al* 2023)
Residents use wildlife gardening practices not specific to place	Importing bird feeding practices from elsewhere can give introduced species a competitive advantage (e.g. feeding grain where indigenous species do not eat grain)	(Galbraith *et al* 2014, 2015)
	Gardening for bees is biased towards European honey bees (and consequently planting introduced flowering species)—honey bees can displace native pollinators and pollinate weed species	(Paynter *et al* 2010, Geerts and Pauw 2011, Iwasaki and Hogendoorn 2022)

8. Conclusion

The current impetus to promote the importance of nature in cities is critically important for both intrinsic environmental reasons and for the ecosystem and cultural services that nature provides humans. There has been a proliferation of nature-related messaging directed at the public, much of it simply recommending 'more nature'. While researchers and practitioners often argue that messages associated with urban greening and connecting people to nature should be kept simple, we argue that the public can understand more complex messages that reduce unintended negative outcomes for biodiversity and Indigenous people, while still promoting nature in cities. Rather than simply 'more nature' in cities, we need to add more complexity to the messaging, particularly emphasising the need for urban greening to be context specific to avoid negative impacts on biodiversity. Urban green spaces can be designed and implemented to achieve multiple goals, including solving urban challenges such as flood mitigation, increasing human health and wellbeing, improving biodiversity outcomes, and giving people a sense of place by using indigenous species in urban greening. However, the balance has tipped towards green space design being implemented only when residents find the design aesthetically pleasing and acceptable; these design preferences are often diametrically opposed to the structure and design required to achieve positive biodiversity outcomes. Although perceptions and preferences reflect differences in the history and culture of cities, we cannot accept urban greening in cities uncritically: there must be some basic requirements to ensure positive outcomes for Indigenous people and indigenous biodiversity. Therefore, the challenge for researchers and practitioners is to present more complex messages about urban greening to the public and planners in a way in which they can embrace and implement more specific messages and biodiversity-friendly designs. The implementation of nature-based solutions to mitigate the challenges of extreme weather events in cities provide an opportunity to engage with residents and reset expectations. Researchers that explicitly adopt and integrate

science communication strategies and participatory approaches into their research programs will make the biggest difference in turning around the 'extinction of experience' and halting biodiversity loss in cities.

Data availability statement

No new data were created or analysed in this study.

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The authors have confirmed that any identifiable people in images used in this publication have given their consent for publication.

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