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RESEARCH ARTICLE

Improving city life: options for ecological restoration in urban landscapes and how these might influence interactions between people and nature

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Abstract The role of humans in the restoration of ecosystems has been emphasised since its inception. The human dimension of restoration is particularly well established in urban ecosystems because this is where people and nature co-exist. At the same time, the altered biophysical conditions that characterise cities place constraints on restoration in its strictest sense—assisting the recovery of historic ecosystems. Rather than viewing this as a shortcoming, in this paper, we discuss the ways in which such constraints can be viewed as opportunities. There is the chance to broaden traditional conservation and restoration goals for urban settings reflecting peoples' preferences for nature in their backyards, and in doing so, offer people multiple ways in which to engage with nature. In this paper, we consider four main restoration options—conserve and restore nature at the fringes, restore remnant patches of urban nature, manage novel ecosystems and garden with iconic species—in terms of their potential to contribute to promoting human-nature interactions in urban landscapes. We explore how these options are affected by environmental, economic, social and cultural factors, drawing on examples from cities around the world. Ecological restoration can contribute to the sustainability of urban landscapes, not just in terms of nature conservation, but also by providing opportunities for people to interact with nature and so increase our understanding of how people perceive and value landscapes.

Keywords Biodiversity conservation · Cultural services · Ecosystem services · Human-nature interactions · Human well-being · Novel ecosystems · Urban ecology · Urban ecosystems · Urban green space · Urban planning

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Introduction

> We must temper our romantic notion of untrammeled wilderness and find room next to it for the more nuanced notion of a global, half-wild rambunctious garden, tended by us
>
> Emma Marris 2011

Most people live in cities and so this is where they regularly experience nature (Miller and Hobbs 2002). As cities expand to accommodate more people, space for nature is shrinking and so too are the opportunities for people to experience it (Turner et al. 2004; Miller 2005). Indeed, these opportunities may diminish further for some people if their response to peak oil is to live and work in localised urban areas (Newman et al. 2009). Urbanisation has undeniably resulted in

the loss of native species worldwide (McKinney 2002; Hahs et al. 2009); however at their best, cities are a space-efficient solution to meeting the economic, environmental and social needs of human society with probably less impact on intact habitat for native species than the alternative world without cities (van den Berg et al. 2007; Wu 2010). So while cities host a number of environmental problems, they also offer solutions as they will remain hotspots of human industry and creativity (Grimm et al. 2008).

Ecological restoration emerged in urban landscapes as a solution to the twin problems of eroding biodiversity (Pickett et al. 1992; McDonnell and Pickett 1993) and the dwindling connection between people and nature (Rosenzweig 2003; Miller 2006). The traditional focus for restoration has been remnant patches of native vegetation and ruderal vegetation (*sensu* McKinney 2002) where the goal has been to assist the recovery of the degraded ecosystem so that its structure, species composition, and ecosystem function resembles that of the historic ecosystem (SER 2004). In addition, there has been increasing recognition of the value of private gardens and green space to biodiversity conservation in urban landscapes (Gaston et al. 2005; Goddard et al. 2010). The "regreening" of cities as part of an urban renewal process, for instance in US rustbelt cities such as Pittsburgh, is also an important trend in providing both human amenity value and potential habitat or food resources for wildlife (Platt 2004). In this paper, we argue for a broadening of the traditional goals of conservation and restoration in urban landscapes beyond that of biodiversity conservation to better encompass the diversity of ecological and social values of nature in cities. In this sense, 'restoration' is as much about reconnecting people with nature as it is about restoring and managing biodiversity in urban landscapes (Gobster 2007).

Why new goals for restoration in urban landscapes?

Increasingly, altered biotic and abiotic conditions constrain our ability to restore historic ecosystems (Hobbs et al. 2009). This constraint is particularly evident in cities where local scale drivers (e.g., urban heat island effect) can interact with regional and global scale drivers to effect persistent environmental change (Grimm et al. 2008). For example, nutrient enrichment, altered hydrology, and difficulty restoring or simulating natural disturbance regimes in urban wetlands can prevent their restoration to a historic state replete with the ecological functions that are characteristic of non-urban wetlands (Ehrenfeld 2000). Similarly, native seedling recruitment in urban vegetation can be limited by a lack of nearby seed sources and competition with non-native species (Lindig-Cisneros and Zedler 2000), particularly where these non-native species are favoured by land-use legacies (Lewis et al. 2006).

Where historic ecosystems degrade and our efforts to restore them fail under the novel conditions experienced in urban landscapes, novel ecosystems thrive. Novel ecosystems are comprised of non-historical species assemblages that arise due to environmental change, species invasion or both (Hobbs et al. 2006). Novel ecosystems result from human activity but do not depend on continued human intervention for their maintenance. Ellis et al. (2010) estimated that in the year 2000, novel ecosystems accounted for 37 % of the ice-free land on earth compared with just 25 % wildlands. Their rising prominence in urban landscapes presents an opportunity to re-assess whether it is practical or desirable to restore historic ecosystems to these landscapes.

Novel ecosystems may be perceived as having limited value for the traditional practice of ecological restoration, yet there is potential for these ecosystems to be valued if the goals for urban restoration were broadened to include social as well as ecological values. Such goals allow for the possibility of valuing non-native species, and it is this issue in particular that is likely to cause conflict with those people who think non-native species generally serve no purpose in urban landscapes (e.g. Flannery 2002). In reality, some non-native species serve valuable ecological functions (see examples in novel ecosystems section below). Additionally, people living in cities define urban nature differently and respond to its various forms in complex ways (e.g. Davidson and Ridder 2006; Trigger and Head 2010). By placing social values on equal footing to ecological values, and by assessing the latter using function as well as species composition, we open the door to an array of restoration options that offer people multiple ways in which to engage with novel ecosystems and urban nature more generally.

Options for restoration in urban landscapes

In the following section we describe four options for ecological restoration in urban landscapes in developed and developing regions of the world. We assess each for its potential to deliver outcomes for both biodiversity conservation and human society and particularly to facilitate interaction between the two. We draw on our combined experiences of the cities of Perth and Chicago as well as examples from the literature to contextualise each of the options and to consider if there are tradeoffs that could prevent some options from working in some landscapes.

Conserve and restore nature at the urban fringes

This option has goals that are consistent with the traditional goals of biodiversity conservation. From a social perspective, it offers people the opportunity to connect with large tracts of relatively undisturbed nature in close proximity to the city. There is uncertainty associated with this option in that native vegetation at the urban fringe risks being cleared for housing as the adjacent city expands. Such was the case as the city of Seattle expanded, where policies to increase housing densities within the existing urban areas were effective but did not prevent sprawl into the fringing rural and wildland areas (Robinson et al. 2005). Fringing vegetation can serve multiple functions including the provision of ecosystem services for human well-being (i.e., supporting, provisioning, regulating and cultural services; Millennium Ecosystem Assessment 2005), and promoting these is one way to reduce the risk of its being converted to land for housing. For example, the jarrah forest that fringes most of the length of Perth's urban sprawl is managed for its conservation values, recreational opportunities, and mineral resources and is an important water catchment for people living in the city and adjacent rural areas. The benefits of promoting positive interactions between people and nature are potentially far reaching for both biological diversity and human well-being (Rosenzweig 2003; Chapin et al. 2009; Goldman and Tallis 2009).

Unfortunately, public support for conserving remnants on the urban fringe may only manifest when development pressure is high. This means that the cost of acquiring such parcels will also tend to be high, perhaps prohibitively so, as conservation goals are essentially competing with development interests (Snyder et al. 2007). In the Chicago metropolitan area, for example, this situation has imposed severe limitations on the capacity of conservationists to acquire parcels of sufficient size to serve as habitat for some vertebrate species (Snyder et al. 2007). Nonetheless, options to acquire and restore smaller properties remain viable, and these may still have high conservation value (Miller et al. 2009). Where possible, the acquisition of such properties in the urban fringe can be optimised so as to maximise outcomes for biodiversity conservation at the landscape scale (Zipperer et al. 2000). For example, the quality, quantity and connectivity of remnant vegetation were found to be important for the conservation of seven red-listed forest birds around the city of Stockholm (Mörtberg and Wallentinus 2000). Indeed, these landscape attributes are likely to be important for the conservation of species other than birds, particularly under climate change (Hodgson et al. 2009).

Restore remnant patches of urban nature

Remnant patches of nature are often the focus of management efforts aimed at conserving and promoting biodiversity in urban landscapes (McDonnell 2007; Florgård 2009). Urban streams and wetlands are also often the focus of restoration efforts, even in very large cities such as Seoul (Busquets 2011). Here, the emphasis is on the social and educational values of urban remnants as much as their biodiversity values (Miller and Hobbs 2002; Miller 2006; McDonnell 2007). Restoration can be an important conduit for maximising these values. From a social perspective, restoration is a community-based activity that brings people into contact with nature. From an ecological perspective, people can intervene so as to alleviate some of the factors that make it difficult for native species to grow in cites and so play a critical role in their conservation. Furthermore, there is scope for this intervention to become increasingly important for conserving relictual species as global change continues to alter the ecology of our cities, thereby giving future generations the opportunity to interact with these species. In this way, remnant patches of urban nature could be developed as living museums in our cities.

Biologically diverse remnant patches of nature feature prominently in cities where urban expansion

occurred into relatively intact native vegetation rather than into abandoned agricultural lands (Hahs et al. 2009). At the same time, these cities potentially carry a higher extinction debt than cities with a history of land use, as species decline in response to the habitat loss and fragmentation that occurs with urbanisation (Hahs et al. 2009; Ramalho and Hobbs 2012). These data suggest that Perth, an internationally recognised biodiversity hotspot (Hopper and Gioia 2004), might be carrying a higher extinction debt than cities in the northern hemisphere such as Chicago or Glasgow. If this is the case, then intervention has a particularly important role to play in mitigating the extinction debt in cities like Perth (e.g., Cape Town; Rebelo et al. 2011). For example, there is scope for the development of new policy that stipulates remnant patches of nature are to be included in newly established urban areas much like the customary requirement for public open space (Grose 2009).

Restoration has an equally important role to play in mitigating people's extinction of experience of nature and this goal is relevant to every city. In fact, Jordan and Lubick (2011) suggest that restoration's role as a form of land management is in providing people with a mechanism for negotiating a more meaningful relationship with the natural world. However, data to assess the extent to which restoration activities do in fact forestall the extinction of experience are generally lacking. Such data would have immense value in developing the capacity of restoration activities to achieve such goals in urban landscapes.

Novel ecosystems: where to manage and where to transform to green space?

The emphasis on restoration as an activity that fulfils social as well as biodiversity goals in urban landscapes, and the increasing occurrence of novel ecosystems in these landscapes, brings into question the notion that native species are the only means to achieve these goals. Behaviour of people towards nature is complex and guided by their cognitive and affective responses to it (Clayton and Myers 2009). Understanding how to channel this behaviour through restoration in a way that strengthens the link between people and nature will be an ongoing challenge. Some authors have argued that it is far more important that people value growing something, whether it be native or non-native, and that we risk turning people away from nature if we criticise their preference for non-native species (Kendle and Forbes 1997). While these authors were referring to gardening rather than restoration, we view gardening as a form of restoration in urban landscapes for its capacity to bring people into contact with nature. So while the assumption that *all* non-native species are undesirable is embedded in traditional restoration practice, we question its validity in the urban context given the potential role for non-native species in strengthening the link between people and nature. Interestingly, other initiatives to get people enthused about nature, such as citizen science programs, include both native and non-native species among the species for which they collect data (e.g., Climate Watch 2010).

Remnant patches of native vegetation and ruderal vegetation that exist in urban landscapes are often a mix of native and non-native species. While a minority of non-native species transform ecosystems and need to be removed in order to restore community or ecosystem functions, a larger number of non-native species have a neutral effect on the native systems they inhabit and in some cases, can fulfill important ecological and social functions (Trigger and Head 2010; Schlaepfer et al. 2011). For example, plantations of non-native pines have become an important food source for the rare and iconic Carnaby's black cockatoo in Perth with the decline in native food sources that has occurred with urban development (Valentine and Stock 2008). There is concern that the cockatoos will decline as the pine plantations are removed as part of a strategy to recharge one of the underground aquifers that supplies water to people living in the city. The novel ecosystems that tend to develop on sites where pines have been removed—comprised of pines and native species—offers a possible food source to ensure the cockatoos persist in the city. In turn, the cockatoos evoke a sense of place among the city's residents.

Urban novel ecosystems could potentially provide a diversity of benefits to people, including health benefits, psychological and spiritual benefits, as well as providing opportunities for education, recreation and play (Perring et al. 2012). The specific qualities of urban nature that offer the greatest benefits to people are largely unknown (Dallimer et al. 2012) and so it is difficult to assess how urban novel ecosystems might contribute. However, we know some of the qualities that people respond to and can think how these might

apply in the case of people adopting and so deriving benefits from urban novel ecosystems. For example, we know that proximity is important (Matsuoka and Kaplan 2008) and so are 'cues to care' (Nassauer 1995). Additionally, novel ecosystems could be utilised by children as nature playgrounds (Keil 2005) and by people wanting to learn about ecological processes (Dearborn and Kark 2010). While the biological diversity of novel ecosystems might be important from an ecological perspective, this quality is less important in determining how people value urban nature (Gill et al. 2009; Dallimer et al. 2012). Beyond these few examples, further research is needed to understand the specific qualities of novel ecosystems that might promote well-being so that these can be maintained or enhanced.

In contrast, the 'trashed' novel ecosystem has limited values in either a biodiversity or social context, and we argue that these sites be transformed so as to maximise their functionality. For example, the patch of remnant bush whose size compromises its ability to function ecologically and that has become a dumping ground for old cars and rubbish might be prized by the local community if it were re-developed as a park or sports facility. Such a transformation would be regarded as 'giving up' under the paradigm of biodiversity conservation (but see Fuller et al. 2010). Yet sites that lack aesthetic appeal and are perceived to be unsafe are unlikely to foster people's appreciation for nature. Deciding whether or not an ecosystem is trashed is likely to be challenging, but at least considering both ecological and social values in the decision-making process facilitates a wider range of management options that reflect society-held beliefs and views on nature.

Gardening with iconic species for sense of place

It might seem contrary to argue for people to garden with iconic native species given our previous arguments supporting a place for non-native species in urban landscapes. Yet novel ecosystems are comprised of local native species as well as non-native species. Of particular importance to some people is invoking a sense of place, perhaps partly in response to the homogenising effect of urbanisation on the local flora and fauna (McKinney 2006). House sparrows and dandelions occur in most cities and therefore do little to invoke a sense of place whereas gardening with native iconic species can serve this purpose (e.g., Wasowski and Wasowski 2002; Nowakowski 2002; Hill 2007; Fig. 1).

More generally, the high species diversity evident in urban landscapes owes a great deal to the varied management decisions of its household gardeners (Gaston et al. 2005; Grimm et al. 2008). Indeed, gardens reveal a diversity of preferences for nature, which are often driven by socio-economic status (Hope et al. 2003; Pedlowski et al. 2003) or cultural norms (Head et al. 2004). Modern multi-cultural cities are likely to include a wide variety of gardens and gardeners. So rather than prescribing management options for gardens, we can probably assume that some people will choose to plant native species in their gardens while others will choose non-native species. Choosing native species may be part of a civic effort to reduce water use whereas non-native species may be selected to grow food in community gardens. Collectively, this gardening effort will result in a wide variety of opportunities for city folk to interact with nature.

Fig. 1 Iconic *Banksia menziesii* invoke a sense of place in Perth, Western Australia (photo by Rachel J. Standish)

Vegetable gardens have long been a feature of urban landscapes worldwide, particularly in developing countries where they play an important role in food security and nutrition (Marsh 1998). A broader aspect of urban restoration in the developed world is the resurgence of urban vegetable gardens as part of the move towards more locally-produced, organic food (Lovell 2010). A countervailing trend, especially in parts of the UK and Australia, is the move towards bigger houses with less outdoor space (Loram et al. 2007; Hall 2010). Although, gardens can be grown on rooftops and walls if ground space is limited (Francis and Lorimer 2011; Fig. 2). Clearly, the value of urban gardens for biodiversity and people will depend on the relative balance of these trends in any particular city.

Finally, translocation has been suggested as an option for the conservation of species at risk of extinction due to climate change, but there is debate about where species should be relocated (Webber et al. 2011; Thomas 2011). Could botanic gardens become places for ex-situ species conservation? As leaders in the science and practice of plant-species reintroductions (Hardwick et al. 2011) botanic gardens are uniquely placed to contribute to ex-situ species conservation. Botanic gardens offer a less risky alternative to wildlands because there is less potential for non-target impacts and unexpected ecological surprises. At the same time, gardens offer a wild and more publicly accessible alternative to seed banks and cryogenic storage and so provide valuable educational opportunities. Indeed, these suggested roles of botanic gardens reinforce their value as places of cultural as well as ecological significance (Ward et al. 2010).

Conclusions

We live in a world where most people live in cities and novel ecosystems outnumber wildlands. We do not mean to suggest abandoning the traditional practice of biodiversity conservation, but at the same time, we agree with other authors who have suggested other

Fig. 2 Living wall in the city of Madrid, Spain. Photo by Rachel J Standish

options for the management of urban ecosystems (Lundholm and Richardson 2010; Kowarik 2011). Further, in urban landscapes we have the opportunity to consider how management options affect people's interactions with nature. We have come a long way from the early days of the conservation movement when people and nature were considered as separate entities and nature was considered to be in equilibrium; however, there is still much to learn about how to manage ecosystems for the benefit of both ecology and society. Integrating people's value systems, cultural traditions and socioeconomic activities into landscape ecology is a key topic of the discipline—and clearly one that can be readily explored in urban landscapes (Wu and Hobbs 2002). These are the motivations for the restoration options we have presented in this paper (Fig. 3).

Cities have limitations on the space available for urban nature, which together with the incentive to improve human well-being through the provision of local opportunities to interact with nature (Tzoulas et al. 2007), calls for maximum precision in decisions regarding land use in urban landscapes. These incentives requires ecologists to work together with urban planners, developers, architects and other stakeholders including members of the local community to optimise land use in urban landscapes. As the most recent members of these working groups, it is generally the case that ecologists are still learning how to best integrate the growing body of ecological knowledge, and as such it is yet to be fully incorporated into urban design and planning (Yli-Pelkonen and Niemelä 2006; Miller et al. 2009; Nilsson and Florgård 2009; Musacchio 2009; but see Gordon et al. 2009). Equally, scenarios for sustainable cities (e.g., Newman et al. 2009) need to encompass options for management of the urban nature that will exist in the cities of the future. It is critical that we keep trying to bridge this gap because achieving urban sustainability, including the opportunity for future generations to interact with urban nature, will require such a trans-disciplinary approach (Wu 2008).

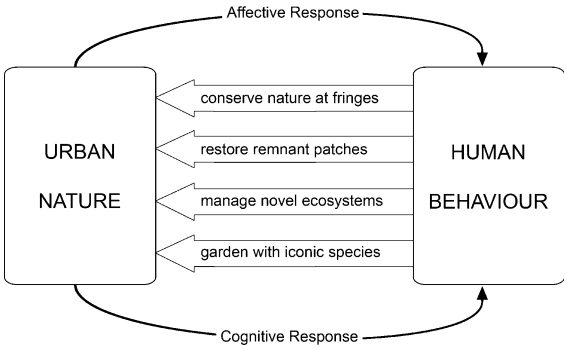

Fig. 3 Schematic showing the restoration options for urban nature we have discussed in this paper and how these feed back to effect human behavior through their influence on our affective and cognitive responses to nature. Affective responses include likes, dislikes and fears with regards to nature and cognitive response are according to a personal beliefs and definitions of nature. Behaviour can include energy conservation, political action as well as participating in ecological conservation and restoration. Adapted from Clayton and Myers (2009)

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