Understanding and Applying Ecological Principles in Cities

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Abstract

Renaturing cities requires a thorough understanding of how plants and animals interact with the urban environment and humans. But cities are a challenging environment for ecologists to work in, with high levels of heterogeneity and rapid rates of change. In addition, the hostile conditions often found in cities mean that each city, and region of a city, can have their own unique geographical context. In this chapter, we contrast urban ecological research in the UK and Brazil, to demonstrate the challenges and approaches needed to renature cities. In so doing, we provide a platform for global transferability of these locally contextualised approaches. The UK has a long history of urbanisation and, as a result of increasing extinction debts over 200 years, well-established urban ecological research. Research is generally focused on encouraging species back into the city. In contrast, Brazil is a biodiversity hotspot with relatively rich urban flora and fauna. This rich ecosystem is imperilled by current rapid urbanisation and lack of support for urban nature by city-dwellers. By working together and transferring expertise, UK and Brazilian researchers stand a better chance of understanding urban ecological processes and unlocking renaturing processes in each location. We present one such method for applying ecological knowledge to cities, so-called Ecological Engineering, in particular by discussing ecomimicry—the adaptive approach needed to apply global ecological principles to local urban challenges. By reading the ecological landscape in which urban developments sit and applying tailored green infrastructure solutions to new developments and greenspaces, cities may be able to reduce the rate at which extinction debt is accumulated.

15.1.

Why Is Urban Ecology Important for Renaturing?

Constanza et al. (2014) determined that natural ecosystems provide $125 trillion of ecosystem service provision to human beings per year, more than twice as much as global gross domestic product (GDP). Nature provides us with the essential functions needed to support human life, from oxygen to climate regulation. The biophilia hypothesis (Wilson 1984) outlines that through our reliance on nature, as hunter-gatherers and agronomists, we have developed an innate affinity with the natural world. Evidence shows that regular contact with nature lowers stress-levels (Hartig et al. 2014). Yet, whilst cities can support surprisingly diverse natural communities (Aronson et al. 2014) and threatened species (Ives et al. 2016), urbanisation processes generally cause native species and natural habitats to decline. With more people moving into cities, it is essential that we renature cities effectively because most humans will primarily experience biodiversity through contact with urban nature (Dunn et al. 2006). Key decision-makers (i.e. the electorate and environmental leaders) are concentrated in cities and need to experience nature to incentivise conservation action.

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To renature cities effectively and ensure re-connection of urban populations with nature, it is essential to understand how plants and animals interact with the urban environment. Cities can pose a unique and hostile environment for many species, with extremes of climate and high levels of disturbance. Some species can thrive, exploiting new niches, escaping predation and, sometimes, forming relationships with humans—so-called synurbic species. A great many cannot, meaning that cities display a net extinction debt (Hahs et al. 2009). The prevalence of exotic species in cities can create unique ecological communities, interacting in a different way to their "natural" counterparts. Only by understanding the underlying ecological principles that drive or prevent urban colonisation will we be able to determine how to enable species to live in cities, which species will form a basis for this renaturing, and how to ensure ecological balances are in place to produce the ecosystem function we need to thrive. Information to apply to this challenge is lacking, however, with cities generally understudied compared to non-urban environments (Lepczyk et al. 2017). Their spatial heterogeneity and fast rate of change make them a difficult environment to study. Each city has a unique mix of social and physical factors that need to be understood in order to enhance biodiversity.

In this chapter, we contrast ecological research in two countries, the UK and Brazil, to elucidate general urban ecological principles in cities that have long been urban and in those that are rapidly urbanising. In both the UK and Brazil, the challenge is to understand how to conserve and enhance populations of existing species and encourage species to return to cities. Each country has its own challenges; Brazil needs to reconcile rapid urbanisation with the maintenance of habitats and species of conservation concern in a biodiversity hotspot. Contrastingly, the UK has a long history of urbanisation and has planning and policy resources for biodiversity conservation, despite having relatively impoverished ecosystems. We present here an overview of strategies relevant to rapidly urbanising countries, and those where urbanisation is more stable but ongoing over longer time periods, for example through densification. Once an understanding of the general urban ecological principles for species and habitats typical of a locale has been developed, aspects of the urban fabric can be engineered to maximise its biodiversity value. Thus, this chapter also discusses methods used to apply ecological knowledge to urban design ("Ecological Engineering"), to develop vibrant, biodiverse ecosystems and conserve key species. We focus on ecomimicry as a learning-by-doing approach that emphasises the use of local contextual information to increase and apply our knowledge of urban ecosystem processes, bringing us closer to developing resilient and effective methods for renaturing.

15.2.

Urban Ecology in the UK

15.2.1.

Urbanisation and Urban Greenspace in the UK

The UK has a long history of urbanisation. The proportion of people living in cities (around 80%) has changed little in the past half-century. In the UK, urban and developed land equates to just over 10%

of land cover (Nafilyan 2015). Within cities, urban greenspaces are important land covers, typically occupying between 17 and 41% of the total urban area (Dallimer et al. 2011). However, many of these cities are witnessing a reduction in greenspace coverage, a trend that reflects land use policy, which encourages compact urban development and densification.

15.2.2.

Urban Ecology as an Academic Discipline in the UK

Academic ecologists began to turn their attention to UK towns and cities in the 1970s as the importance of urban and industrial areas for wildlife conservation became clear (Davis 1976). Early research focused on the impact of urbanisation on fauna, most notably on birds (Batten 1972; Cramp 1980). UK urban vegetation and habitats have been particularly well researched, with seminal studies on domestic gardens (Thompson et al. 2003; Loram et al. 2008; Owen 2010), brownfield land (Gilbert 1983) and green roofs (Dunnett and Kingsbury 2004), in addition to pioneering work on urban land restoration (Bradshaw and Chadwick 1980). Urban ecological studies have become increasingly comprehensive and systematic. For example, Baldock et al.'s, (2015) study of urban habitats, farmland and nature reserves to determine the relative importance of urban areas for pollinating insects. Public engagement also became an important element of British urban ecological research, and "citizen science" has assisted urban ecologists with data collection, making a valuable contribution to our understanding of UK urban ecosystems (Cannon et al. 2005; Lye et al. 2008). We have also seen an increase in experimental ecology in an attempt to elucidate some of the mechanisms underlying urban ecosystem function (Bennie et al. 2018).

The Millennium Ecosystem Assessment (MEA 2005) and popularisation of the ecosystem services concept have increased awareness of the goods and services provided by urban ecosystems (Gaston et al. 2013). UK researchers have examined the relationship between urban form and ecosystem services (Tratalos et al. 2007), seeking to quantify city-scale urban ecosystem services such as carbon storage (Davies et al. 2011) and microclimatic regulation (Edmondson et al. 2016). The contribution of urban greenspace and its biodiversity to "cultural services" linked to human health and well-being has recently emerged as an active research area (Dallimer et al. 2012). The ecosystem services paradigm has been concomitant with understanding that urban green infrastructure (UGI) should be "multifunctional" such that there is a need to maximise synergies and minimise trade-offs between beneficial services (Bellamy et al. 2017; Connop et al. 2016). Building on its formative roots in the UK and elsewhere, urban ecology is now mainstream research that seeks to implement global Sustainable Development Goals relating to climate action, urbanisation and biodiversity. Achieving these lofty goals requires a holistic understanding of the patterns and drivers of biodiversity and ecosystem service provision in cities worldwide. Such understanding must be founded upon collaborative and comparative research that transcends national boundaries.

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15.2.3.

Urban Nature Conservation and Planning in the UK

The UK has always been at the forefront of the urban nature conservation movement (Goode 1989; Adams 2005). The London Natural History Society (LNHS) traces its roots as far back as 1858, with the society itself being created in 1913 (Edgington 2008). The LNHS produced the seminal work London's Natural History (Fitter 1945) and other notable contributions by urban naturalists (e.g.

Gilbert 1989; Mabey 2010). By the 1970s and 1980s, urban wildlife groups and programmes were commonplace across the UK, and ecological issues were increasingly integrated into urban planning and design (Goode 1989, 2014). Local authorities are now required to include biodiversity within their local plans with the result that the UK is in the vanguard of planning for urban biodiversity and ecosystem services (Evans 2004; Nilon et al. 2017).

15.3.

Urban Ecology in Brazil

15.3.1.

Urbanisation and Urban Greenspace in Brazil

In contrast to the UK's stable urban population, Brazil has undergone rapid urbanisation and a 40% increase in urban populations since 1960. Today, 83% of Brazilians live in cities, which occupy less than 1% of the country's land mass (Farias 2017). The inputs and outputs of these urban ecosystems are immense, in part because urban planning and management are precarious and consumption patterns increasingly resemble those of the cities of the northern hemisphere. Moreover, environmental legislation may not protect areas that are most important for biodiversity in urban areas (Guadagnin and Gravato 2009).

Whilst few Brazilian cities have been studied from the viewpoint of urban ecology, several studies report high levels of environmental inequality, with vegetation cover lower in areas of poverty. This pattern has been observed in São Paulo (Lombardo 1985); Presidente Prudente (Gomes and Amorim 2002); Maringá and Sarandi (Angeoletto et al. 2017) and Rondonópolis (Duarte et al. 2017). Consequently, inhabitants of these areas experience less contact with nature and lower provision of ecosystem services, such as the amelioration of the urban heat island (Lombardo 1985).

15.3.2.

Urban Ecology as an Academic Discipline in Brazil

As seen in the UK, the ecological movement in Brazil also gained traction from environmentalism in the 1970s. By the 1980s, Brazilian ecologists in cities were sharing ecological theories with political groups in order to better understand how to halt the degradation of the environment and improve the health of citizens (Viola 1988). However, unlike in Europe and Australasia, where this movement documented the ecology "in" cities (Niemelä et al. 2011), ecological research in Brazil was still focussed on non-urban areas, with a strong delineation between the "city" and the "countryside". By the early 1990s, publications were emerging on urban populations of peregrine falcons (White et al. 1989), butterflies (Ruszczyk and Mellender De Araujo 1992) and trees (Conceicao 1994). Growing urban ecological research indicates that Brazilian cities support rich biodiversity. Hundreds of plant species (Angeoletto et al. 2017) and diverse bird communities (Reis et al. 2012) inhabit backyards in Brazilian cities. A recent study found that almost half Brazil's bat species have been recorded in cities (Nunes et al. 2017).

Research into the mechanisms controlling biodiversity in Brazilian cities mirrors results from UK cities; for instance, most bird studies conclude that complex vegetation cover strongly predicts avian biodiversity (Fontana et al. 2011; Lessi et al. 2016). Similar results have also been reported for bees (Antonini et al. 2013). Native plant species and connectivity have been shown to be important for urban ants (Pacheco and Vasconcelos 2007). These studies emphasise the importance of appropriate vegetation in cities for supporting higher trophic levels.

Despite the growing traction of urban ecological research in Brazil in the last 20 years, less than 10% of urban ecology studies have been conducted outside of Europe or the USA. There is, therefore, a pressing need for global collaboration to better understand ecological processes in cities worldwide.

15.3.3.

Urban Nature Conservation and Planning in Brazil

Urban biodiversity has only recently been considered in Brazilian urban planning, and ecology is still not fully incorporated into Brazilian urban, territorial and economic governance planning (Angeoletto et al. 2016). A broader understanding of urban ecosystems is needed (Pauleit and Duhme 2000), and this must be embedded in planning through interdisciplinary working practices (Terradas 2001).

Many of the urban environmental problems in Brazil result from a lack of targeted planning and urban policies, rather than from urbanisation process per se (Hardoy et al. 2001). In Brazilian cities, planning has not been an environmentally effective tool (Leitmann 1995; Angeoletto et al. 2016) and, often, lack of capacity can be a barrier to developing environmental public policies that effectively address the immense environmental challenges of Brazilian cities (Angeoletto et al. 2016).

Despite this, Brazil's high biodiversity and rapid urbanisation could present an opportunity for a best practise model to understand how sustainable urban development could be achieved through ecology and conservation. Few UNESCO Biosphere Reserves incorporate urban areas, but Brazil has two: the Mata Atlântica Biosphere Reserve, which surrounds Rio de Janeiro and includes the Sao Paulo green belt; and the Cerrado Biosphere Reserve situated around the capital Brasilia. These areas present an opportunity to develop new governance practises to promote sustainable development through an understanding and appreciation of ecology.

15.4.

Applying Urban Ecology to Cities: Ecological Engineering

Undertaking basic ecological research in cities to understand their form and function is the first step to increasing urban biodiversity and supporting sustainable urban development. Ecological engineering then offers techniques to utilise that knowledge to design urban ecosystems that benefit both humans and non-humans (Mitsch 2012). It is particularly important when discussing renaturing cities.

Ecological engineering can encompass habitat restoration or remediation. However, because of their uniqueness as a habitat, cities offer no simple "natural" proxy for ecosystem engineers to draw upon or pose challenges that require a deeper understanding of these natural environments than we currently have. Whilst "renaturing cities" suggests Roof Roof restoring cities to some baseline natural state, in reality, ecological engineers can and must apply creativity and imagination to urban renaturing within the parameters and conditions of the city's given character. These conditions encompass the physical and social (e.g. economy, urban morphology, cultural and political issues) environment, creating a complex set of limitations (Grimm et al. 2000).

There are many examples of ecological engineering being implemented and used effectively to renature cities. At the "naturalistic" end of the spectrum, ecomimicry takes inspiration from the local ecological landscape for renaturing, to maximise urban biodiversity and deliver multiple ecosystem services (discussed below). Ecological engineering also encompasses approaches with narrower ecosystem service provision, often falling under the subdivisions of ecotechnology and bioengineering. A large-scale example is Burlington Eco Park (Vermont) which integrates multiple ecologically engineered units to treat wastewater and grow crops (Todd et al. 2003). A smaller-scale example is the localised use of plants to uptake heavy metal contamination in composts and soils (Zhao et al. 2011).

Ecological engineering can therefore be applied in different ways to provide benefit. Within cities, it is vital that social benefits are embedded into the design process. This marks out ecological engineering as a special area of ecology, and ensuring renaturing is accepted and appreciated by the public.

Whilst creating novel ecosystems that provide functionality for humans and non-humans shows great promise, it also poses significant challenges. Recreating or introducing new habitats requires a detailed understanding of the processes at large within it, and there are still many non-urban habitats for which we have limited understanding on key abiotic and biotic conditions that enable the habitat to function and flourish. Soil ecology and specifically the use of fungi in UGI projects provide a case in point. Many plants form symbiotic relationships with fungi called mycorrhizas. Mycorrhizas can reduce the effects of drought (Ruiz-Lozano et al. 2016), and pests and diseases (Song et al. 2015) on plants, desirable functions for application in urban ecosystems. Whilst we know that different types/species of these fungi provide these functions to different degrees (Averill et al. 2014) and that this can be affected by specific plant/fungi pairings (Lekberg et al. 2015), the technology and knowledge base needed to apply this knowledge is in its infancy. This example is one of many that demonstrate that the key to ecological engineering is an in-depth understanding of the ecosystems involved. Such insight can be gained from both the study of organisms in cities and through detailed “traditional” comparative ecological studies in natural and semi-natural environments. Ecomimicry presents an integrated approach to achieving this, combining locally contextual information, well-studied ecological principles gained from non-urban environments, continual monitoring and adaptive management.

15.4.1.

Enhancing Urban Habitats for Biodiversity: Ecomimicry

Ecological engineering can provide diverse habitats or narrowly focused elements of nature. The “gold standard” is to achieve both. Urban greenspace can vary considerably in terms of biodiversity value. Areas that contain native species in remnant natural habitat support greater diversity than cultivated and manicured greenspace (Chong et al. 2014). Nonetheless, long-established approaches to landscaping have resulted in much UGI across the globe having a homogenous character, typically comprising short, frequently mown grass and manicured, ornamental trees (Lepczyk et al. 2017). This widespread urban “blandscaping” has largely been motivated by cultural services (primarily aesthetics/recreation) and economics, and the simplified habitat structure offers insufficient complexity to support multiple taxa, contributing to biotic homogenisation (McKinney 2008). If a renaturing cities strategy is to maximise ecosystem service provision and UGI multifunctionality, including supporting biodiversity as an ecosystem service in its own right, ecological functionality should be the foundation for UGI design and implementation. Biodiversity loss negatively impacts ecosystem functioning and ecosystem services (Hector and Bagchi 2007); therefore, failure to ensure benefits to biodiversity in UGI design can constrain potential ecosystem service benefits. Balancing ecological functionality, aesthetics and multifunctionality is one of the emerging challenges for nature-based solution innovators (Fig. 15.1; Connop et al. 2016).

Fig. 15.1

A green roof shelter (Grass Roof Company) showcasing how innovative nature-based solutions can balance ecological functionality, aesthetics and multifunctionality. © Little, J.

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As with ecosystems, natural communities that develop on UGI will be a function of the niches embedded into the design. Newly created, suitably designed UGI can offer unexploited resources for urban biodiversity. Structurally complex habitats provide a greater range of niches and resources, enhancing species richness and biodiversity (Tews et al. 2004). Habitat heterogeneity should therefore be a key consideration for UGI design. Additionally, to restore locally attuned, ecologically functioning UGI into cities, it is essential to consider regional context (Connop et al. 2016). This will ensure UGI compatibility with the local climate and regional biodiversity and contribute to retention of locally distinctive habitats, potentially assuaging processes of biotic homogenisation (McKinney 2006). "Ecomimicry" (Marshall 2007) offers a mechanism to achieve this approach; it considers local ecology as the basis for design and innovation because flora, fauna and ecosystems characteristic of a region will have co-evolved with, and be adapted to, local conditions. As such these would be most resilient to local environmental challenges. Adopting an ecomimicry approach to urban greenspace design can enable locally contextualised, biodiversity-focused UGI implementation that contributes to the functioning and resilience of urban areas through restoration of heterogeneous habitat resources.

15.4.2.

Preparing for Ecomimicry Approaches: The Urban Macaws of Rondonópolis Case Study

In order to apply the principals of ecomimicry, a detailed survey of a species needs must first be undertaken, to gain an understanding of the key barriers that species has to flourishing in an urban environment. In Rondonópolis, Brazil, sightings of charismatic blue-and-yellow macaws (Ara ararauna) and red-and-green macaws (Ara chloropterus) are common, and these species are highly appreciated, in a biophilic sense, by the residents of Rondonópolis. Birds have been found to be an excellent measure of environmental quality in terms of well-being provision for city-dwellers. Fuller et al. (2007) found that the emotional attachment and well-being gained from greenspaces are well correlated to the biodiversity of bird communities in greenspaces. Macaws make an excellent target species for conservation in densifying cities because conservation measures to enhance macaw habitat should benefit other species, such as their food plants. A. ararauna and A. chloropterus are not on the IUCN endangered species list, but their populations have been experiencing a marked decline, due to myriad factors including urbanisation and animal trafficking. Additionally, data on the ecology of wild birds in tropical urban environments remains scarce (Tinoco 2015), so this knowledge gap must be addressed before ecomimicry can be applied.

The Urban Macaws of Rondonópolis project aims to map and characterise the surroundings of current nests of A. ararauna in the urban area of Rondonópolis, to better understand key factors for this species in cities. In the surrounding Cerrado Biome, the species nests in the palm tree Mauritia flexuosa within swamp areas and their populations seem to be limited by the density of nest sites, as well as the density of competing macaws (Brightsmith and Bravo 2006). In the Rondonópolis project, the researchers are cataloguing the land use type surrounding nests, the presence (or not) of arboreal and shrub vegetation contiguous to nests, and human population density to determine if urban limiting factors resemble non-urban ones. Additionally, researchers are documenting the plant species used by blue-and-yellow macaws as food sources in the urban area to understand how best to apply ecomimicry approaches.

Preliminary results indicate a nesting preference for dead palm species of the Caribbean royal palm, Roystonea oleracea, an exotic species, on which the macaws also feed (Fig. 15.2). This is a common ornamental plant in Brazilian cities, typically grown in backyards of upper-middle-class houses. Observations of intense competition for these dead palm trees between nesting pairs of blue-and-yellow and red-and-green macaws suggest that these sites could be a limiting factor for the reproductive success of these species within cities.

Fig. 15.2

Pair of blue-and-yellow macaws, Ara ararauna, nest in a dead Caribbean royal palm, Roystonea oleracea. ©Bohrer, J.

The findings from this study have important implications for the application of ecomimicry in conservation. Whilst in non-urban habitats, species may be governed by specific inter-species relationships, their presence in cities typically suggests a degree of adaptation to the urban environment. In the case of A. ararauna, this is demonstrated by the utilisation of a non-native plant for nesting, challenging the simplistic but widespread argument that “native plants are desirable and exotic plants are undesirable”. Urban ecosystems are complex, influenced not only by environmental factors, but also by social, political, economic, urban and cultural dynamics. Therefore, conservation approaches must consider the “wild” ecology of the species, but also what is available and possible within this novel urban habitat. Additionally, ecological engineering does not always involve replication of an entire habitat within a city, but sometimes simply replicating processes that would occur in nature. In the current example, the process of removing deadwood, which is common in cities, removes a key habitat requirement for A. ararauna. This is the case for many other species worldwide, including the stag beetle, Lucanus cervus, for which similar ecomimicry and ecological engineering approaches are being implemented for conservation in the UK. This deadwood is vital for the reproductive success of these species, and a more "naturalistic" approach needs to be taken in its management to achieve conservation aims.

With a greater understanding of the limitations placed upon macaws within Brazilian cities, it is hoped that ecological engineering approaches can be applied to increase nesting sites throughout cities, through a combination of reduced clearance of deadwood and building new, artificial nesting sites. In the long term, augmentation of the city palm population by capitalising on the popular exotic palms already planted and by applying ecomimicry approaches to enhance palm species commonly found in the local Cerrado Biome will further aid conservation.

15.4.3.

Applying Ecomimicry: The Barking Riverside Wetland Green Roof Case Study

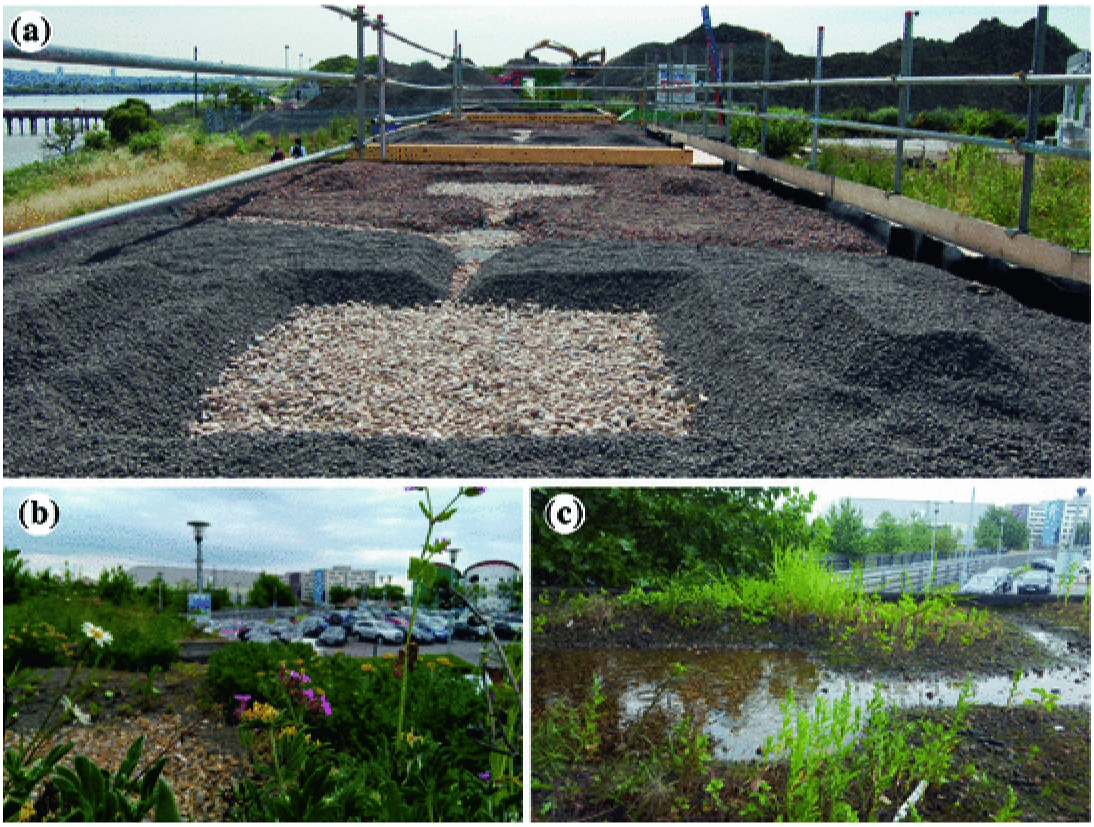
The concept of ecomimicry has been used to mitigate the loss of valuable brownfield sites to development in London, UK. In the London and East Thames Corridor region, brownfield sites (previously developed land) have become important reservoirs for biodiversity that can no longer find suitable resources in the "natural landscape" due to habitat loss or degradation (Harvey 2000). Their heterogeneous topography and soil conditions, and lack of frequent management, result in unique habitat mosaics that are flower-rich and structurally diverse. Invertebrates particularly benefit from this mosaic as many need several habitat resources in close proximity to complete their complex life cycles (Gibson 1998). Species from deteriorating natural ecosystems, including many nationally rare and scarce invertebrates, now depend on brownfield mosaics for their persistence because they provide ecologically analogous functions to declining natural habitats such as chalk grassland and seasonal wetlands (Eversham et al. 1996). The conservation importance of biodiverse brownfield sites was recognised when open mosaic habitat was designated a UK Biodiversity Action Plan Priority Habitat (Maddock 2010).

Despite recognition of their nature conservation value, planning policy in the UK continues to target brownfield sites for redevelopment to meet the demands of growing urban communities (Robins et al. 2013). To help urban developments meet sustainability goals and ensure no-net-loss of biodiversity and ecosystem services in this development process, researchers are partnering developers to investigate targeted UGI solutions to compensate for the loss of brownfield habitat mosaics.

One such development is Barking Riverside, in the London Borough of Barking and Dagenham, UK. This housing development is being constructed on a large brownfield site of high biodiversity value. Planning consent for the development required conservation of key biodiversity through innovative UGI creation, in particular, through provision of extensive green roofs (EGR). Such consent is linked to the Mayor of London guidance recommending green roofs on major developments for stormwater management and no-net-loss of biodiversity. The site was considered to be of regional importance for invertebrates, and these were a target faunal group for habitat compensation at roof level. As part of the EU FP7 project TURAS, a Knowledge Transfer Partnership was established to trial biodiverse green roofs using a targeted brownfield habitat mosaic ecomimicry approach to design. In order to apply ecomimicry, data from an extensive study of brownfield invertebrate assemblages on local brownfield sites was analysed using an invertebrate analysis tool (Webb and Lott 2006). This characterised the local habitat and identified key features of value to species in the region. The process identified ephemeral wetland as a key habitat niche for creation on EGRs to enhance their value for regionally important brownfield invertebrates (Fig. 15.3).

Fig. 15.3

Brownfield mosaic ecomimicry extensive green roof comprising: a locally typical substrates of varied depths creating microtopography and structural diversity, increasing niches for plants and providing refugia for biota during hot, dry or cold spells; b locally attuned, diverse wildflower assemblages planted to provide a range of foraging resources and enhance habitat heterogeneity through structurally complex plant architecture; c innovative drainage mechanisms used to recreate seasonally wet brownfield habitat niches. ©Connop, S.



Within two years of construction, there were significant differences in plant development in the various habitat niches created by the ecomimicry design (Nash 2017). This approach had positively contributed to creating a habitat mosaic with a novel wetland component. Many invertebrate species recorded on the EGRs were national nature conservation priorities and characteristic of the pre-development brownfield site at Barking Riverside. Using ecomimicry to read the local landscape, and incorporating ecological understanding into the design, produced locally contextualised UGI of value to target biodiversity. It also expanded the habitat niches provided by standard EGR design approaches.

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Whilst the design used for this case study may not be appropriate for all locations, the process of incorporating the floral diversity and habitat heterogeneity of locally important habitats into UGI design is universally applicable. Locally contextualised and adapted UGI is a successful renaturing strategy to make cities more permeable to biodiversity and conserving habitat connectivity and ecosystem service provision.

15.5.

Conclusions

Examining urban ecological research and the application of this research in UK and Brazilian cities demonstrates that locally contextualised UGI, built upon a foundation of a sound ecological understanding, is key to renaturing cities. UGI represents a unique opportunity to improve the sustainability of our cities and the well-being of our communities and to ensure that the urban fabric represents a rich source habitat for biodiversity. This opportunity can be realised through a combination of creating networks of new UGI (e.g. green roofs and green walls) and improving the multifunctionality of existing UGI (e.g. making better use of low value ecological/ES-providing open space in cities). It is not sufficient, however, to provide “greenery” and assume that biodiversity benefits and associated ecosystem services will ensue. To unlock the full potential of such spaces, informed design must be used to create functioning ecosystems underpinned by a detailed understanding of urban ecological processes. From ecomimicry to ecotechnology, the range of tools provided by an ecological engineering approach represents mechanisms to achieve this potential.

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In order to ensure that such renaturing occurs on a scale sufficient to reconnect all urban communities with nature, these designs must also provide multifunctionality in terms of ecosystem service provision. This is now the great challenge facing innovators in nature-based solutions. Once such practices become established, innovation in terms of design, financing and management needs to be shared globally. By doing so, it is possible to ensure that urban areas become critical components of global biodiversity, that urban communities are reconnected with broader nature conservation issues and that the quality of life of all residents in cities is improved through truly sustainable urban development.

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