12
URBAN GREEN INFRASTRUCTURES AND ECOLOGICAL NETWORKS FOR URBAN BIODIVERSITY CONSERVATION

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Introduction

As urban areas develop, native habitats are often degraded, fragmented, and replaced by impervious surfaces. These changes can lead to a suite of environmental problems, including the urban heat island effect, flooding, water and air pollution, and reduced biodiversity (Grimm *et al.* 2008). Green infrastructure has been proposed as a solution to these problems (Benedict and McMahon 2006). In this chapter, we focus on the benefits of green infrastructure networks for biodiversity, and suggest strategies for increasing the extent, performance, and connectivity of these networks to promote urban habitats and native species.

Although definitions of *green infrastructure* can vary across spatial scales, the term itself suggests that nature—just like our built infrastructure—is critical for society. At the local scale, the term is often applied to environmentally friendly stormwater management systems such as bioswales or permeable pavement. At the larger landscape scale, green infrastructure describes interconnected green spaces and strategically planned networks of natural and semi-natural areas across a region. This definition incorporates green and blue spaces in rural, urban, terrestrial, coastal, and marine systems (European Commission 2013). Importantly, this second definition also sees green infrastructure as multifunctional spaces that can benefit humans, wildlife, and the larger environment.

Over the last few decades, many cities and metropolitan areas have developed large-scale green infrastructure plans. These plans often aim to protect biodiversity and provide a wide array of other benefits by preserving and restoring large core habitats. The benefits, referred to as *ecosystem services* (Daily 1997), include stormwater management, urban heat island mitigation, and recreation opportunities. Another common goal of these plans is maintaining or increasing *connectivity* between the core habitats. Connectivity is seen as desirable ecologically because interconnected habitats are more likely to maintain natural communities and ecological processes (Fischer and Lindenmayer 2007). Connectivity may also be socially desirable, as linked green spaces can facilitate walking or cycling for recreation and transportation.

p.187

While green infrastructure can be structurally connected—for example, as contiguous *greenbelts* around some cities—structural connectivity may be difficult to attain in cities that have been built up for decades or centuries. On the other hand, functional connectivity, which refers to the movement of organisms and continuity of ecological processes (Tischendorf and Fahrig 2000), may be more achievable in most urban areas. Functional connectivity can be encouraged in landscapes that are not structurally connected by considering the area between large green spaces (called *the matrix*).

Cities typically include many small green spaces within the matrix, including home gardens, community gardens, and vacant lots. These small green spaces, in combination with other larger spaces such as cemeteries and golf courses, are often overlooked ecologically and have not typically been considered as green infrastructure in the same way as designated natural areas or forest preserves. But when embedded in larger green infrastructure networks, they can serve to increase functional connectivity by facilitating species movement between core habitats. Furthermore, these unconventional types of green infrastructure represent an opportunity to provide ecological and social benefits in built-out communities that have limited ability to create new parks.

The value of parks and preserves for urban biodiversity conservation has been written about extensively elsewhere. In the rest of this chapter, we focus on the role of smaller and less-conventional green spaces. We discuss four abundant types of green spaces that are found in cities around the world—home gardens, urban agriculture patches, vacant lots, and cemeteries—and the role they can play in urban green infrastructure networks. These smaller spaces, in the aggregate, are often underestimated in terms of their potential to contribute to urban green infrastructure networks and conservation of biodiversity. After introducing each type of green infrastructure and its potential benefits for biodiversity, we end the chapter with a section that considers them in combination with other green spaces, as part of the urban green infrastructure network. We aim to make broader conclusions and recommendations but draw many examples from our experience with green infrastructure in the Chicago metropolitan area (Illinois, USA).

The role of the matrix in urban green infrastructure networks

Vacant lots

Urban vacant lots—sometimes called wastelands, greenfields, or abandoned/derelict land—can serve as a multifunctional resource in cities (Anderson and Minor 2017). Vacant land has many definitions but here we refer to previously developed residential or commercial parcels that have fallen out of use and no longer contain buildings. By this definition, the City of Chicago owns >13,000 vacant lots and contains at least another 10,000 bank-owned lots. Most large cities currently have between 12.5 percent and 15 percent vacancy, but the American Rustbelt—comprised of Midwestern cities with a historically manufacturing-based economy—has seen a sizable increase in vacancy due to loss of industry and displacement of the working class. The most notorious example of contemporary vacancy in the United States is Detroit, Michigan, which has seen vacancy rates as high as 35 percent in the last decade (Gallagher 2010). Overall, this represents 100s to 1000s of hectares of land per city that could provide ecosystem services and wildlife habitat.

p.188

The ecology and ecosystem services in vacant lots are dependent on their history and management. Occasionally ornamental plants or garden features persist, but they are unlikely to be maintained. In fact, the level of environmental management is a critical difference between vacant lots and other types of green infrastructure. Management such as mowing or spraying weeds can be contextualized as an ecological disturbance where humans reset or manipulate the plant community. Certain plant species are better competitors under different conditions, and management actively changes these conditions over time. There is also some evidence that vacant lots can facilitate persistence of plant populations in changing climates, as dispersed seeds are more likely to survive in a vacant lot than in other heavily managed green spaces (Renton *et al.* 2014).

While individual lots are subject to various management activities, as a whole, vacant lots provide relatively consistent habitat across the city. People perceive many plants in vacant lots as weeds, but these communities support surprising wildlife diversity. For example, vacant lots are home to a large diversity of insects and other arthropods, and the composition of these communities differs significantly from those in other urban habitats (Gardiner *et al.* 2013). Vacant lots also provide habitat for small mammals (Magle *et al.* 2010), and various rare species have been found in vacant lots as well (Vessel and Wong 1987). Furthermore, trees in vacant lots may provide resources for arboreal species. These trees are more likely than street trees to have dead or decayed branches, which can be beneficial for birds such as woodpeckers that prefer softened wood for finding food and excavating nesting cavities. Finally, vacant lots can serve as *stepping-stones* for species moving between larger green spaces, mitigating the risks of isolating populations in preserves (i.e. *ecological traps*).

Some simple steps can improve environmental quality and biodiversity of vacant lots. The City of Chicago spends over $1.2 million annually on controlling weeds in vacant lots, and mowing and lawn care are significant sources of fossil fuel consumption and pollution (Robbins *et al.* 2001). Planting lower-maintenance trees or flowers in these spaces could reduce the economic and ecological costs of mowing, while increasing air quality and providing habitat for local species of wildlife to traverse the urban matrix.

p.189

A primary challenge with vacant lots is that they are disproportionately located in low-income and minority neighborhoods (Kremer *et al.* 2013). Environmental remediation and improvements create a risk of eco-gentrification (Dooling 2009), which is an environmental justice paradox in which the deliberate improvement of environmental quality draws in a higher economic class. Often the original residents—those whom the project was supposed to help—cannot afford the increased cost of living and are forced into areas of poorer environmental quality.

In light of this social issue, there are two primary mechanisms by which green infrastructure improvement in vacant lots can be socially and ecologically successful. Green infrastructure that is designed with input of community leaders and that engages and educates local residents is considered the gold standard (Pediaditi *et al.* 2010). These types of projects might include development of community gardens, nature play areas, or surrogate yards/parks where local residents can interact with and learn about nature in their own neighborhood. While these projects may or may not increase biodiversity on their own, increasing public awareness of environmental issues could potentially have trickle-down effects by building environmentally friendly behaviors and instilling an intrinsic or economic value for urban biodiversity.

The alternative option is to expand green infrastructure benefits in these areas in ways that are almost unnoticeable, yet still beneficial. This is referred to as the *just green enough* strategy for vacant lot greening and management (Curran and Hamilton 2012). For example, spreading seeds of robust and inexpensive native wildflowers might result in a plant community that is higher quality for wildlife without being visibly different from a weedy lot to an untrained eye. If these types of improvements are relatively unnoticeable, they can increase biodiversity and ecosystem service provision without incentivizing gentrification.

Home gardens

Private residential yards and gardens ("home gardens" from here forward) comprise a large portion of the green space in many cities. Unlike many other kinds of green infrastructure, which are either widely spaced (e.g., cemeteries) or clustered in certain areas of a city (e.g., vacant lots), home gardens are more evenly distributed and often structurally connected to each other. These small green spaces are the primary place where many humans come into contact with the natural world. They also provide numerous ecosystem services to urban residents, including absorbing stormwater, reducing cooling costs in the summer, and providing a place to relax and rejuvenate. And finally, they have the potential to contribute substantially to conservation of biodiversity (Davies *et al*. 2009).

Although lawns comprise a dominant vegetation type around some homes, particularly in the former British Empire, people's preferences for garden plants are very diverse (Kendal *et al*. 2012). As a result, many residential areas have surprisingly high plant diversity. Studies in Chicago (unpublished data), Melbourne (Threlfall *et al*. 2016), and New Zealand (van Heezik *et al*. 2013) each revealed over 500 plant species while a study in the UK found over 1000 plant species in home gardens (Loram *et al*. 2008).

p.190

In addition to a diversity of plants, many home gardens contain other resources for wildlife such as bird feeders and baths, nesting and hibernating substrates, and outdoor pet food (e.g. Belaire *et al.* 2014). Those resources can contribute to the diversity of wildlife species. For example, in Chicago, migratory birds were observed in neighborhoods with more wildlife-friendly features in yards (Belaire *et al.* 2014). That same study showed that local vegetation in home gardens was a better predictor of the bird community in residential neighborhoods than larger-scale vegetation features. Home gardens may be especially good habitat for smaller animals such as invertebrates. A study of home gardens in Sheffield (UK) identified over 350 invertebrate species (Smith *et al.* 2006). In Norman, Oklahoma, 32 species of land snails were found in home gardens (Bergey and Figueroa 2016). Residential neighborhoods also support a diversity of pollinators (Lowenstein *et al.* 2014). In each case, the number of invertebrate species was related to management (such as watering or use of pesticides), vegetation, or resources in home gardens. Even lawns, if left to grow some flowering weeds, can contribute to wildlife biodiversity (Larson *et al.* 2014).

Although biodiversity can be high in home gardens, many plants in them are non-native. The impact of exotic vegetation on wildlife remains an area of debate but generally it is thought that native plant species promote higher diversity of native wildlife. This may be particularly true for insects, which often have specific plant hosts in certain life stages, but the effect can also trickle up to higher trophic levels (Burghardt and Tallamy 2013). One way to fulfill the full ecological potential of home gardens might be to increase the number of native plant species and other wildlife resources they contain.

Options for incentivizing wildlife-friendly gardening fall into two broad categories: (i) top-down, financial incentives or regulation; and (ii) bottom-up, community-led initiatives (Goddard *et al.* 2009). Formal top-down institutions such as homeowners associations (HOAs) can be effective vehicles for converting entire neighborhoods into wildlife-friendly zones. Research in Phoenix, Arizona demonstrated that neighborhoods with HOAs had significantly greater bird and plant diversity than neighborhoods without (Lerman *et al.* 2012). Some cities and non-governmental agencies (NGOs) offer optional incentives or rebates for gardeners who plant native plants or implement other environmentally friendly management practices. One such NGO is the National Wildlife Federation (NWF), whose Certified Wildlife Habitat Program has certified over 200,000 wildlife habitats to date. NWF's program focuses on five key garden components: food, water, shelter, places to raise young, and sustainable gardening practices. Researchers found that home gardens certified by this program provided more abundant and higher quality wildlife habitat relative to non-certified gardens (Widows and Drake 2014). Finally, social norms and networks can also be effective motivators for design and management of home gardens. A citizen science program called Habitat Network, a partnership between The Nature Conservancy and Cornell Lab of Ornithology, attempts to use social networks to motivate users to integrate wildlife habitat elements into backyards, parks, and other green spaces. In the Habitat Network website, users examine their landscape with aerial imagery and identify partial corridors or gaps in connectivity that could be filled with site-scale enhancements. Because so much land in cities is privately owned, finding ways like these to engage private landowners in enhancing biodiversity on their land will be crucial to conservation and urban sustainability.

p.191

Urban agriculture

Urban agriculture is a rapidly expanding source of green space in many cities (Tornaghi 2014). Although some definitions of urban agriculture include cultivation of ornamental or non-food crop species, for this chapter we define urban agriculture as food crop and livestock production for use within the urban area where they were produced. Urban agriculture may include residential food gardens, commercial or educational urban farms, and community food gardens (including both school and neighborhood gardens).

While globally most crops are grown in the ground, urban agriculture is unique in that it may also be found on rooftops or in raised beds or containers. Rooftop gardens allow for increased green space in densely built areas within cities, and raised bed or container gardens allow for cultivation without having to remove underlying impermeable surfaces. Both increase green infrastructure in locations where other types of green spaces would be impossible to introduce without major construction and planning.

Within cities, the extent and distribution of urban agriculture is variable. Urban agriculture is often distributed unevenly across space, socio-economic gradients, and cultural lines. For instance, in Chicago, approximately 26 ha is used for some form of urban agriculture and community gardens are concentrated on the economically disadvantaged south and west sides (Taylor and Lovell 2012). Furthermore, neighborhoods with high concentrations of Chinese-origin, Eastern- or Southern-European, and Polish residents seem to be hot spots for home food gardens. In Philadelphia, Pennsylvania (USA), community gardens are also concentrated in low-income neighborhoods, but they are distributed even more unevenly than in Chicago, with most located in very poor neighborhoods (Kremer and DeLiberty 2011). Similarly, in developing countries, the poorest urban households often show higher percentages of agricultural activity (Thebo *et al.* 2014). This uneven distribution of urban agriculture may, in some cases, simply be correlated with availability of land, or may be directly influenced by the efforts of NGOs to increase local food availability or the cultural values and norms of the residents.

Because of the large variety of urban agriculture types, and the fact that most plots are managed by different people or groups in different ways, urban agriculture tends to be heterogeneous in both structural and plant diversity. Most urban gardens and farms grow a large variety of crops (e.g. Bernholt *et al.* 2009), especially when compared to large-scale rural agriculture. While the reasons for this may be social or economic, the resulting ecological effect is increased diversity of micro-habitats for wildlife. Fruit trees, climbing vines, and low row crops all contribute to structural diversity, and growing a combination of these crop types within a garden supports wildlife across a variety of taxa. A study in Niger found that the ethnicity of the gardener may determine both the number and type of species grown within the urban garden (Bernholt *et al.* 2009). Community gardens in particular may have very high levels of vegetative biodiversity (Lin *et al.* 2015), because different community members are free to grow crops according to their own tastes or interests.

p.192

All agricultural systems support agricultural pests, but urban agriculture tends to also support healthy populations of *natural enemy* arthropods as well (Lowenstein and Minor, in review). Urban agriculture may also provide habitat for a variety of pollinators (e.g. Matteson *et al.* 2008), and urban apiculture directly provides pollination services to nearby areas. Unfortunately, although there is some documentation of insect diversity in urban agriculture (likely because of the obvious services and disservices that insects provide in agriculture), specific information on other taxa is currently lacking. We do know, however, that in many cities urban agriculture tends to use more wildlife friendly practices than large-scale rural agriculture. Many urban farms use organic practices, and many community gardens restrict the use of chemicals such as pesticides and fertilizers (Brown and Jameton 2000). Moreover, community and school gardens often have plenty of participants willing to provide manual labor such as hand weeding and pest removal, which decreases the need for chemical inputs.

Future improvements to urban agriculture that benefit biodiversity can come from both top-down and bottom-up sources. While chemical fertilizers and pesticides are not often used in large quantities in most urban agriculture, the effect of any chemical runoff is intensified because there are generally no buffers between the gardens and neighboring green spaces or development. Top-down regulation of chemical inputs could increase the value of urban agricultural sites as habitat for wildlife, especially in home gardens where there is less accountability. Bottom-up changes in management and crop selection could also increase the value of urban agriculture habitat. For instance, where possible urban gardeners and farmers could increase the structural diversity of crops to provide more micro-habitats for wildlife. At the same time, urban gardeners must ensure that these sites do not become reservoirs only for common urban pest species, such as rats (*Rattus* species), raccoons (*Procyon lotor*), house sparrows (*Passer domesticus*), or cabbage white butterflies (*Pieris rapae*). Rats and raccoons, in particular, are attracted to easy food sources, and may actually harm other native wildlife through either competition or predation. To support native biodiversity within cities, urban gardeners should consider methods of controlling these urban-adapted pest species for the sake of other native wildlife.

Cemeteries

In some cities, cemeteries are among the oldest and most established components of urban green infrastructure. The *rural cemetery* movement in the United States was sparked in 1831 by the establishment of Mount Auburn, a 29 ha landscaped cemetery outside of Boston, Massachusetts (French 1974). At a time when cities were rapidly industrializing, these cemeteries (more accurately called *garden cemeteries*) were intended not only as a place to bury the dead, but also as a bucolic respite to those living in cities. Originally located outside of a city's limits, many large cemeteries remained even as the city expanded (e.g. Pattison 1955). Cities that developed during this garden cemetery movement tend to have similar patterns in extent and distribution of cemeteries. Today, the remaining cemeteries offer refuges to city-dwelling humans and wildlife alike (Barrett and Barrett 2001).

p.193

Garden cemeteries are the predecessors to the first public parks in the United States (Shelton 2008). Like public parks, cemeteries confer multiple green infrastructure benefits including air filtration, retention of contaminants and sediment, and mitigation of urban heat island effects. Cemeteries contain some of the oldest and largest trees found in cities. In Dayton, Ohio for example, a champion 27 m tall sassafras tree (*Sassafras albidum*) grows in the Woodland Cemetery (Barrett and Barrett 2001). Some cemeteries, such as Chicago's Graceland Cemetery, are certified arboretums. Graceland manages over 2,000 trees, 50 of which are unique species mapped for visitors who wish to take a tree tour.

Cemeteries also offer unique biodiversity benefits. Many cemeteries have walls and gates that are closed from evening to early morning, when avian activity is at its highest (Lussenhop 1977). This allows breeding birds to sing for mates and nocturnal species to hunt with reduced human disturbance. Insectivorous birds will sometimes use headstones and other monuments as perches while hunting for insects. There are perhaps fewer social and aesthetic constraints on dying trees in cemeteries; a snag in a cemetery may go unnoticed, whereas a snag in front of someone's home raises concerns about lowered property values, or a tree limb falling on a person or a parked car. These large old trees provide crucial habitat for many species (Cockle *et al.* 2011). For lichen species, cemeteries provide a broad range of substrates in the form of trees, headstones, and monuments. In places such as Illinois where exposed stone is rare, headstones can be important substrates for saxicolous lichens (Wachholder *et al.* 2004). Many cemeteries are large in area and experience low levels of human disturbance, attributes that allow them to serve as habitat to larger mammals and birds, such as coyotes and owls.

It should be noted, however, that some aspects of cemeteries can detract from their value as green spaces. To maintain their appearance, cemeteries are often landscaped using chemical inputs and lawnmowers. The chemicals used to preserve the buried are toxic, and caskets are often placed in concrete vaults (Basmajian and Coutts 2010). Tree species found in cemeteries are not always native and some, such as Norway Maples (*Acer platanoides*), are even invasive. Horizontally oriented black headstones may function as an ecological trap for dragonflies, because they polarize light in a similar way to the surface of water, where dragonflies lay their eggs (Horváth *et al.* 2007). These examples demonstrate that although cemeteries play a valuable role in urban green infrastructure networks, there is certainly room for improvement.

Newer cities that did not grow during the garden cemetery movement often overlook planning for the dead (Basmajian and Coutts 2010). The certainty of human mortality and the finite nature of land demand that future planning for the dead should take place, and there is potential for such planning to be incorporated in green infrastructure networks. Moreover, revenues from "green" burials, which forego flesh preservatives and concrete, on a small parcel of land could be used to preserve or restore larger natural areas (Basmajian and Coutts 2010).

p.194

Networks of green infrastructure

Ecological land-use complementation is the idea that land uses in urban areas could synergistically interact to support biodiversity and realize emergent ecological functions when clustered together in different combinations (Colding 2007). Vacant lots, home gardens, urban agriculture, and cemeteries, in conjunction with remnant habitats, parks, and preserves, have different spatial distributions, offer different types of habitat, and make unique contributions to urban biodiversity (Table 12.1, Figure 12.1). But together, in a network of interconnected green infrastructure, they can be greater than the sum of their parts. Collectively, the various land uses within the city form a mosaic, and more green infrastructure within that mosaic can enhance functional connectivity and support species movement across the landscape.

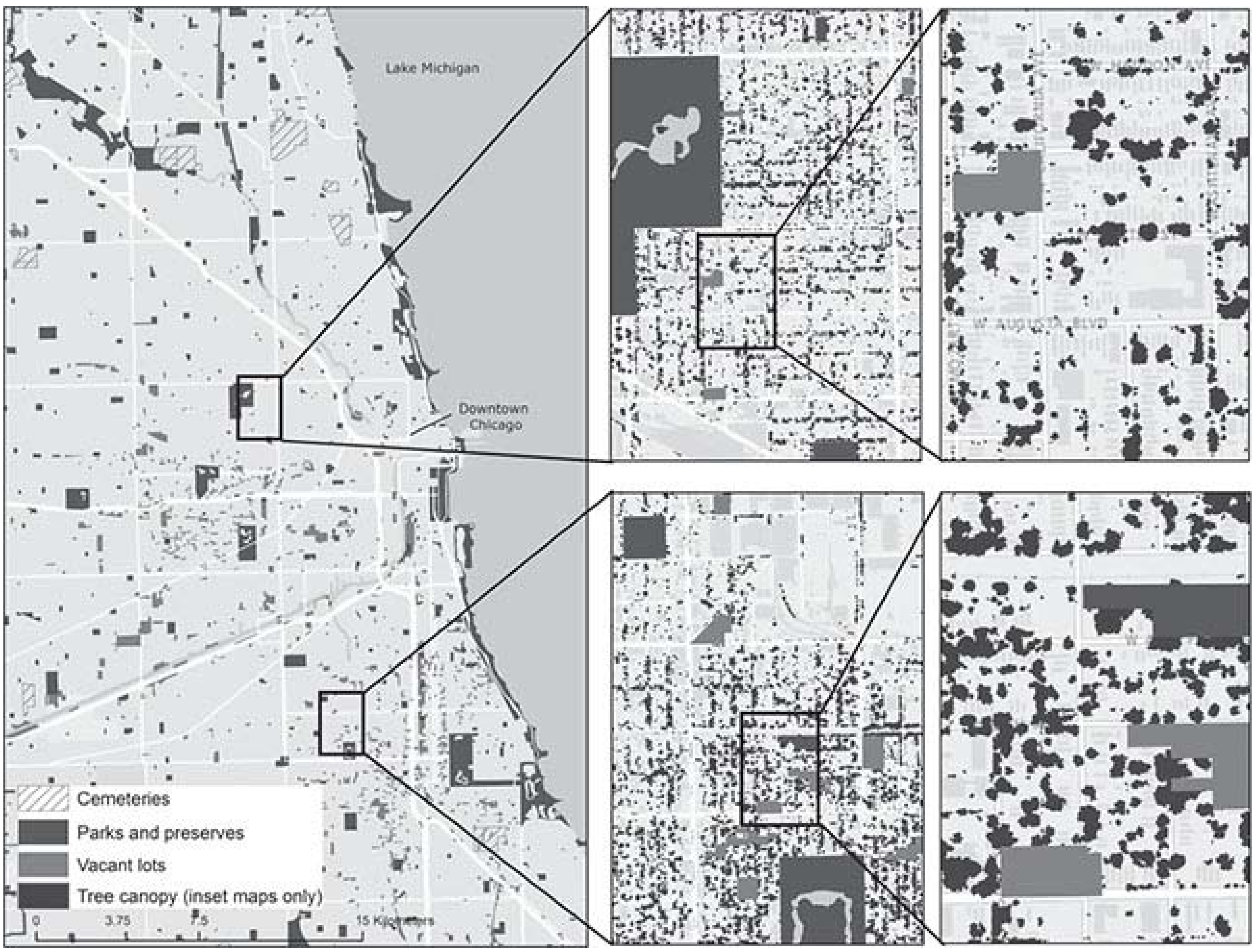

FIGURE 12.1 Green infrastructure networks at different spatial scales across Chicago. At broad spatial scales (larger map), cemeteries, parks and preserves, and vacant lots appear to dominate the green infrastructure network. At smaller spatial scales (inset maps), tree canopy and other vegetation in home gardens and residential neighborhoods provides habitat connectivity between the larger green spaces. (Source: Emily Minor, unpublished.)

Strategies that address multiple spatial scales are necessary to enhance green infrastructure networks and functional connectivity. At regional scales, government agencies and planning organizations can dedicate open space in locations that enhance connectivity across the landscape, including riparian corridors, habitat remnants, and small stepping-stone patches that facilitate movement. For example, in Austin, Texas (USA), government partners worked to preserve over 16,000 hectares of land through outright purchases and conservation easements, with the goal of protecting high quality habitat for biodiversity and water quality in face of rapid urbanization in the region. The preserved habitats are distributed across much of the county and include remnant woodland patches and an 11 km long riparian corridor in the city limits. Collectively, they harbor eight federally listed endangered species and more than 20 species of conservation concern.

At smaller spatial scales, city governments can increase habitat connectivity with strategies such as enhancing roadway right-of-ways, incorporating small pocket parks into urban plans, and supporting greater densities of street trees. For example, the insect conservation organization Xerces has developed best management practices for transportation agencies to support pollinators within highway rights-of-way. These best management practices, such as reducing mowing frequency, planting native species, and reducing herbicide use in rights-of-way, can help pollinators move through the landscape for daily foraging or for dispersal between larger habitat patches. In addition, strategies such as "*pocket parks*" and other small greening initiatives have been shown to enhance bird species richness in urban areas (Strohbach *et al.* 2013), especially if these strategies are part of broader greening initiatives. Other creative city interventions, such as Sheffield, England's "Grey to Green Corridor," New York City's "High Line," and Chicago's "Bloomingdale Trail," convert abandoned spaces such as rail lines or redundant roadways into corridors planted with native vegetation that can make the dense urban matrix more hospitable and traversable to mobile species such as birds and bees.

Several cities have taken creative approaches to enhancing green infrastructure networks on private lands, such as the "Pollinator Pathway" project in Seattle, Washington. The Pollinator Pathway pilot project is a 1.6 km long, 3.6 m wide corridor of pollinator-friendly plantings in front of residential yards. The pathway creates a backbone of connectivity between two green spaces near downtown Seattle. It is especially beneficial when these kinds of approaches incorporate native plants species that are also found in nearby habitat remnants. This helps to better "fit" the small-scale green infrastructure within the local ecosystem and broader habitat network (Cerra and Crain 2016).

It is important to note that green infrastructure enhancements within one land use type can generate effects that *spill over* or extend into other adjacent or nearby areas. For example, increasing floral resources in home gardens could increase pollination services at community gardens (Davis *et al.* 2017). Enhancing habitat in home gardens, boulevards, and utility rights-of-way could extend the width of riparian corridors and functionally connect large green spaces (Rudd *et al.* 2002). And conversely, connecting home gardens by woody corridors could enhance biodiversity in the home gardens themselves (Vergnes *et al.* 2012).

p.196

p.196

TABLE 12.1 Different kinds of green space in the urban green infrastructure network. Size and spatial coverage data are specific to Chicago, Illinois (USA).

Green space	*Approx. size of individual green space*	*Approx. spatial coverage*	*Contributions to biodiversity conservation*	*Typical management activities*	*Possible ecological problems and disservices*
Home gardens	~50 m^2	3,000 ha[†]	High plant diversity and density of floral resources; may be especially good habitat for insects and birds	Can include herbicides, pesticides, fertilizers, mowing. Might have high temporal turnover of plant species (and soil disturbance) due to gardening activities	Perceived garden or house pests (e.g., rodents, deer), or 'scary' animals (wasps, spiders, etc.), non-native plant species
Cemeteries	<1 – 131 ha	700 ha	Larger habitats with reduced human disturbance due to walls and restricted hours; diversity of substrates for lichen; older, larger trees than typically found in cities	Relatively frequent and intense management: mowing, pruning, chemical fertilizers and/or pesticides	Chemical inputs, non-native plant species, headstones as ecological traps
Vacant lots	~300 m^2, but highly variable	780 ha	Relatively low-disturbance habitat, potential for pollinator provisioning and stopover habitat	Relatively little management: occasional mowing and/or herbicide	Harboring unwanted pests and/or weed species
Urban agriculture sites	<5 – 24,000 m^2	26 ha	High plant diversity and structural heterogeneity; rooftop and container gardens can provide green infrastructure in highly developed areas	Herbicide and/or insecticide use (although typically less than in residential gardens); hand weeding; chemical fertilizers and/or manure	Insect pests are often actively removed, but gardens may provide easy food source for vertebrate pests such as rats
City parks	<1 – 500 ha	3200 ha	Often larger habitats, some include native plant gardens	Can range from ecological restoration to frequent and intense management: mowing, pruning, chemical fertilizers and/or pesticides	"Lawn" type parks and sports fields may not provide useful habitat for many species. Some species might be isolated in natural areas surrounded by high human recreation or traffic.

†rough estimate based on ~30,000 ha of residential land in Chicago

There is clearly a benefit to integrating the design and management of home gardens, urban agriculture, vacant lots, and cemeteries into city-wide biodiversity strategies. However, this task is complicated by the fact that different stakeholders have different goals and constraints. Many urban green spaces are managed at the local scale, but collaboration and communication between a range of stakeholders across all sectors of society is required to maximize the ecological potential of green infrastructure. The concept of "*scale-crossing brokers*" (Ernstson *et al*. 2010), in which individuals or organizations help make connections between local- and landscape-scale processes, can help address the mismatch between stakeholders operating at different scales and thereby maximize conservation of urban biodiversity.

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