Chapter 8
Urban Agriculture as a Productive Green Infrastructure for Environmental and Social Well-Being

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Abstract Urban agricultural (UA) systems appear in many forms, from community farms and rooftop gardens to edible landscaping and urban orchards. They can be productive features of cities, providing important environmental and social services that benefit and support urban communities. These benefits include the provision of high levels of biodiversity and ecosystem services that contribute to urban nature and environmental processes as well as a range of social benefits, such as food and nutrition, cultural resources and recreational benefits. However, there are a number of challenges that prevent UA from expanding despite various acknowledged benefits. Increasing competition for space and environmental constraints often limits the ability to establish UA systems in many city areas, and negative spillover from UA to urban areas can create hazards to the natural environment and the local community. Further expansion and development of UA as a productive green infrastructure will require win-win strategies that maximize environmental and social benefits while taking advantage of vacant or under-utilized pockets of urban land.

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8.1 Introduction

Of the range of green infrastructure types that are often studied and acknowledged in cities, one type gaining worldwide interest is urban farming or urban agriculture. Urban agricultural (UA) is common across continents with urban gardens covering hundreds of hectares in Amsterdam, Montreal, Beijing and Barcelona, amongst many other cities (reviewed in Lovell 2010), and such green spaces serve many environmental and social uses for urban citizens. UA is regarded as an important feature of the overall urban support systems at long-term and global scales (Barthel and Isendahl 2013), and thus important to the sustainability and resilience of cities. Additionally, because of the benefits to cities, urban policy and development have been increasingly adopted to introduce and maintain such systems (McClintock et al. 2012). However, some challenges are associated with agricultural systems in cities such as competition for land use. In this chapter, both the benefits and the challenges are reviewed for the on-going establishment and persistence of UA as an integral part of urban green infrastructure.

8.1.1 What Is Urban Agriculture?

UA is defined as the production of crop and livestock goods within cities and towns (Zezza and Tasciotti 2010), generally integrated into the local urban economic and ecological systems (Mougeot 2010). Conceptualizing what 'urban' precisely means remains a challenge in the urban green infrastructure literature (Montgomery 2008). Broadly speaking, urban areas consist of predominantly human-made surfaces, with high concentrations of people and are the hub of economic activities (Martezello et al. 2014). UA also often includes peri-urban agricultural areas around cities and towns, which may provide products and services to the local urban population (Mougeot 2010).

UA activities in and of themselves are diverse and can include the cultivation of vegetables, medicinal plants, spices, mushrooms, fruit trees and other productive plants, as well as keeping livestock for eggs, milk, meat, wool and other products (Lovell 2010). The different types of UA allow for a diverse set of ecosystem structures to contribute to the edible landscape in a range of community types and provide a broad array of services based on community desires (McLain et al. 2012). UA systems are highly heterogeneous in size, form and function and can be found in different types of urban green spaces.

8.1.2 Typology of Urban Agriculture

The list of UA examples below highlight how diverse urban farming can be. This diversity is based on some important factors including land tenure, management, types of food and service provision, and scale of production.

- **Community or allotment gardens** often represent small-scale, highly-patchy and qualitatively rich (vegetatively complex and species rich) semi-natural ecosystems that are usually located in urban or semi-urban areas for food production (Colding et al. 2006).
- **Private gardens** are primarily located in suburban areas and may be the most prevalent form of urban agriculture in cities (Loram et al. 2007). Privately owned gardens cover an estimated 22–27% of the total urban area in the UK (Loram et al. 2007), 36% in New Zealand (Mathieu et al. 2007), and 19.5% in Dayton, Ohio, USA (Sanders and Stevens 1984).
- **Easement gardens** are located within private or community properties, but are often regulated by the local government (Hunter and Brown 2012). Urban easements are established with the purpose of improving water quality and erosion control (Forman and Alexander 1998), but they can include a wide array of biodiversity, including food plants, depending on management type (Hunter and Hunter 2008). Gardening on verges may also be done as a form of 'guerrilla gardening' where local communities garden on small patches of soil when few unpaved spaces are available.
- **Rooftop gardens or green roofs** are any vegetation established on the roof of a building and can be used to improve insulation, create local habitat, provide decorative amenity, and cultivate food plants (Whittinghill and Rowe 2012).
- **Urban orchards** are tree-based food production systems that can be owned and run privately or by the community. Increasingly, schools and hospitals are establishing fruit trees that provide crops, erosion control, shade and wildlife habitat, and producing food for the local community (Drescher et al. 2006).
- **Peri-urban agriculture** usually exists at the outskirts of cities that largely serves the needs of the nearby urban population (Zasada 2011). Typically, these are multifunctional agricultural systems that include a large variety of activities and diversification approaches and contribute to environmental, social and economic functions.

Many UA systems may fit into more than one category. For example, both private gardens and community gardens may exist as rooftop gardens, and orchards may exist within community gardens. See Fig. 8.1 for photographs of examples of UA types.

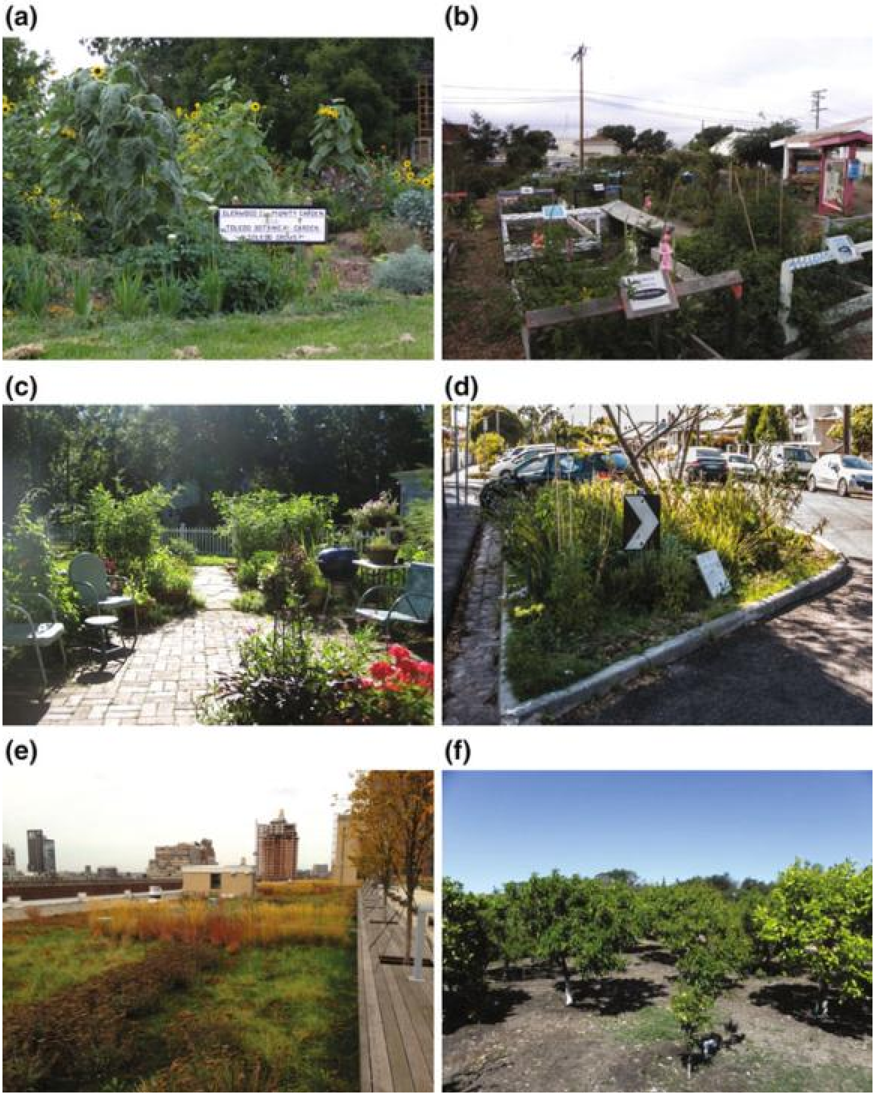

Fig. 8.1 Photographs of different types of UA. **a** Community garden in Toledo, Ohio, **b** Allotment garden in Salinas, California, **c** Private garden in Toledo, Ohio, **d** Easement garden in Melbourne, Australia, **e** Rooftop garden in New York City, **f** Urban orchard in San Jose, California. Photos courtesy of P. Bichier (**a**, **b**, **f**), P. Ross (**c**), G. Lokic (**d**), and K. McGuire (**e**) (From Lin et al. 2015)

8.2 Urban Agriculture: Contribution to Liveability, Sustainability and Resilience

UA offers multiple contributions to the liveability, sustainability and resilience of cities. Besides local food production, urban agricultural systems provide a place for recreation and social interaction, community engagement, biodiversity, and a range of ecosystem services to the community (Owen 1991; Baker 2004; Saldivar-Tanaka and Krasny 2004; Miotk 1996; Smith et al. 2006a; Matteson et al. 2008; Blaine et al. 2010; Aubry et al. 2012). Additionally, urban farming systems may be considered important as a means of maintaining or developing local employment and incomes and even landscape-scale environmental quality (Aubry et al. 2012). The range of benefits is reviewed below to show the contributions to: (1) local food production, health and nutrition, (2) biodiversity and environmental services, and (3) social and cultural services.

8.3 Local Food Production, Health and Nutrition

Urban planners are increasingly interested in maintaining agriculture within and around cities due to food security concerns. Several US cities contain 'food deserts', where access to fresh produce is limited due to reduced proximity to markets, financial constraints, or inadequate transportation (Thomas 2010; ver Ploeg et al. 2009). For example, in Oakland, CA, positioned at the heart of the Bay Area's 'foodie' culture, 87% of school children receive free or reduced lunch due to financial need, and one third of Alameda County residents are food insecure (Beyers et al. 2008; OFPC 2010). Various assessments of the Oakland food system have underscored that affordability is the most important factor that influences where low-income residents shop for food (Wooten and Ackerman 2011), and limited access to transportation is another fundamental constraint to accessing healthy food (Treuhaft et al. 2009). In New Haven, CT, limited access to urban supermarkets co-varies with socio-economic indicators, thus highlighting the social justice implications of food deserts specifically for minority communities and the urban poor (Russell and Heidkamp 2011).

In response to food insecurity, UA in the US has expanded by >30% in the past 30 years, especially in under-served communities (Alig et al. 2004). UA has rapidly increased in developing countries all over the world, especially after the 2008 increase of global food prices (FAO 2014). In many African nations, for example, the percentage of low-income urban population participating in UA has grown from 20% in the 1980s to about 70% (Bryld 2003). A recent FAO report indicates an increasing number of Latin America cities are promoting and incentivizing UA through national governments, city administrations, civil society and non-governmental organizations (FAO 2014). This is because UA can be very productive, providing an estimated 15–20% of the global food supply (Hodgson et al. 2011; Smit et al. 1996). For example, UA provides 60% of the vegetables and 90% of the eggs consumed by residents in Shanghai, 47% of the produce in urban Bulgaria, 60% of vegetables in Cuba, and 90–100% of the leafy vegetables in poor households of Harare, Zimbabwe (Lovell 2010). Furthermore, with structural connectivity and governance, cities can provide good infrastructure, access to labour, and low transport costs for cost-effective local food distribution (Hodgson et al. 2011).

Additionally, as urban crop cultivation can also provide significant dietary contributions, communities around the world are using it to improve the health of urban residents (Beniston and Lal 2012) (Box 8.1). For example, there is an increasing desire to transform vacant land in post-industrial cities to address nutrition and childhood obesity issues in disadvantaged urban neighbourhoods (Yadav et al. 2012). Further, UA enhances food availability and quality across nations and economies; community members participating in UA in both developed and developing nations have been documented to exhibit greater dietary nutrition compared to non-participating community members (Zezza and Tasciotti 2010).

Many successful UA programmes have increased the food security of local residents. Existing UA programmes in Philadelphia produce over 900,000 kg of vegetables per year, worth more than US$4 million (Vitiello and Nairn 2009), and farms in Milwaukee gross more than US$200,000 per acre (4047 m^2) (Lovell 2010). New York City's (NYC) Green Thumb has become the largest community gardening programme in the US, with more than 600 gardens that support 20,000 urban residents (Lovell 2010). They are located in ethnically and culturally diverse neighbourhoods where a wide range of community members cultivate and manage the gardens. Ongoing expansion in Detroit's urban gardening scene is expected to produce 31% of the vegetables and 17% of the fruits currently consumed by city residents on just 100–350 ha of land (Colasanti and Hamm 2010). Cuba now has 383,000 urban farms, producing enough to supply 40–60% of fruits and vegetables to Havana and nearby cities (Funes et al. 2009), and the city of Quito currently has 140 community gardens, 800 family gardens, and 128 school gardens (FAO 2014).

Private gardens can also contribute significantly to local food production and food security. In Chicago, of the large number of community gardening projects reported by non-government organizations and government agencies, only 13% could be identified as food production sites via satellite image analysis, suggesting that many public spaces are supporting urban gardening projects without making notable physical changes to the environment. However, the food production area of home gardens identified by the study was almost threefold that of community gardens. This suggests that home food gardens can contribute significantly to enhancing community food sovereignty (Taylor and Lovell 2012) although it may be more difficult to regulate or incentivize.

Box 8.1

Unequal access to the available dietary diversity and calories leads to nutritional inequalities and diet-related health inequities in rich and poor cities alike. Three case studies presented by Dixon et al. (2007) illustrate how food insecurity can exist in cities regardless of the economic context of the city.

Case Study 1: In Nairobi, Kenya's capital, the poor constitute 55% of the population. Poverty and a reduction in agricultural production means that about 47% of the population is food-insecure. As in many parts of Africa, low- and medium-income households spend about three-quarters of their income on food. In urban areas, food is usually available but a nutritionally adequate diet is too costly for at least one third of households. In a context of low national GDP, under-nutrition is the major result of food insecurity, with 20% of Kenyan children underweight and 31% stunted. Anaemia and vitamin A deficiencies are also prevalent among children and women.

Case Study 2: Approximately 20% of Thailand's 65 million population lives in Bangkok, and per capita income differentials between the national capital and the rest of Thailand remain wide: 229,000 Bhat (US$6830) per annum compared to 74,600 Bhat (US$2225). Bangkok contains 70% of the country's supermarkets and superstores, whereas the rest of Thailand accesses food largely through Thai–Chinese shop houses, street stalls and wet markets. Urban wet markets cannot compete with supermarkets on price or perceived food safety, but they cater to the Thai population that is considered poor, of low education (55% of population in 2000), and who value a traditional diet. The major dietary issues in Thailand include undernutrition in rural areas, and growing over-nutrition or obesity in children amongst both rich and poor populations in urban areas.

Case Study 3: Australia is the world's most urban nation and has a population of 20 million people with a per capita GDP of US$25,353 in 2003. More than 75% of Australian women with families have paid employment, and nearly 27% of household food expenditure is on takeaway, fast foods and restaurant foods. On average 13% of total energy intake in the Australian diet comes from foods prepared outside the home. In some households this can be as high as 60%. Australians are among the most overweight and obese populations in the developed world. Obesity is more prevalent among poorer women and among richer men.

8.3.1 Biodiversity and Ecosystem Services

Urban green spaces such as UA can bring diverse green infrastructure back into the urban system by providing vegetative structure and biodiversity for ecosystem functions and services across fragmented habitats and spatial scales. UA provides many opportunities for re-vegetating the landscape at the local scale within a vegetatively depauperate urbanized landscape. Further, UA has the potential to support not only in situ biodiversity, but also nearby areas due to a landscape-mediated 'spillover' of energy, resources and organisms across habitats. Such spillover may be an important process for the persistence of wildlife populations in human-dominated landscapes because it allows for resource acquisition and re-colonization events (Blitzer et al. 2012). Movement of species between landscape elements can allow organisms to carry out functions at different points in space and time and maintain services that would otherwise be isolated (Lundberg and Moberg 2003). Thus, UA that provide landscape elements supportive of multiple species across time periods may be critical for the persistence of biodiversity in cities. Readers can refer to Chap. 7 in which Peter Werner and John Kelcey evaluated the relationship between urban greenery and biodiversity.

Vegetative diversity: The wide variety of UA types in practice allow for considerable variation in vegetative complexity and diversity. Domestic gardens vary widely in features that may promote plant biodiversity, such as ponds, moss, groundcover and varied vascular vegetative structures (Smith et al. 2005). For example, tropical home gardens have stratified vegetation similar to those seen in the multi-layered vertical structure of agroforestry systems (sensu Moguel and Toledo 1999) and can thus provide a large amount of planned and associated biodiversity (WinklerPrins 2002). The diversity of vegetation types within 21 home gardens has been documented in Santarem, Brazil, where 98 plant species including a large diversity of fruit trees and shrubs (comprising 34% of garden cover), ornamental plants (10%), vegetable or herb plants (13%) and medicinal plants (45%) were identified (WinklerPrins 2002). In Leon, Nicaragua, 293 plant species belonging to 88 families were recorded across 96 surveyed home gardens (González-García and Gómez-Sal 2008). In Hobart, Australia, 12 distinctly different garden types with different species, habits, and canopy heights were documented in front and backyard gardens (Daniels and Kirkpatrick 2006a), and a similar survey conducted in Toronto found an average of 25 woody plant species and 17 different herbaceous plant species per backyard garden (Sperling and Lortie 2010). In an example from five UK cities, more than 1000 species were recorded in 267 gardens, exceeding that recorded in all other local urban and semi-natural habitats (Loram et al. 2008).

Allotment and community gardens also provide substantial levels of vegetative biodiversity. In Stockholm, allotment gardens are older than many backyard gardens, often representing lush, well-managed flower-filled spaces covering large areas (3450–70,000 m^2). Such areas are often extremely rich in plant diversity, with more than 440 different plant species recorded in a single 400 m^2 allotment garden

(Colding et al. 2006). In Toronto, besides the typical local vegetables (cabbage, tomatoes, peppers and eggplant), farmers grew an additional 16 vegetable crops to supply the local community with foods unavailable in local grocery stores. These crops included Asian vegetables, such as bok choy, long bean, hairy gourd and edible chrysanthemums, and these plants substantially increased the vegetative diversity of the urban garden system (Baker 2004).

Arthropod diversity: In general, plant diversity is a principal predictor of arthropod diversity at small spatial scales (Southwood et al. 1979). Plant diversity and small-scale structural complexity have been shown to be important for tree-dwelling arthropods (Halaj et al. 2000), ground-dwelling arthropods (Byrne et al. 2008), web spiders (Greenstone 1984), grasshoppers (Davidowitz and Rosenzweig 1998), bees (Jha and Vandermeer 2010), and ground-dwelling beetles (Romero-Alcaraz and Ávila 2000) in natural and managed ecosystems.

Many studies have also shown that in urban systems plant diversity is highly correlated with insect diversity. For example, in urban backyard gardens in Toronto, invertebrate abundance and diversity was enhanced as the number of woody plant structures and plant species diversity increased, and backyard gardens had higher abundances of winged flying invertebrates when compared to urban grasslands and forests (Sperling and Lortie 2010). Likewise, within domestic gardens in the UK, invertebrate species richness was positively affected by vegetation complexity, especially by the abundance of trees (Smith et al. 2006b). In Pennsylvania, butterfly diversity increased with native plantings within suburban gardens (Burghardt et al. 2009), and parasitoid diversity increased with floral diversity within urban sites (Bennett and Gratton 2012).

Because of a rich abundance of flowering plants that prolongs the season for nectar supply, allotment gardens can support urban pollinators for long periods of time (Colding et al. 2006). In a survey of 16 allotment gardens in Stockholm, the number of bee species observed per allotment garden ranged between 5 and 11, including a large number of bumble bees, which were observed on a total of 168 plant species, especially those in the Lamiaceae, Asteraceae, Fabaceae, Boraginaceae and Malvaceae (Ahrne et al. 2009). However, bumble bee diversity decreased with increasing urbanization, from around eight species on sites in more rural areas to between five and six species in urban allotment gardens (Ahrne et al. 2009). In a survey of different garden types in Vancouver, a mean richness of 23 bee species was found (Tommasi et al. 2004). Similarly, community gardens in NYC provide a range of ornamental plants and food crops that supported 54 bee species, including species that nest in cavities, hives, pith and wood (Matteson et al. 2008). In another study in NYC community gardens, butterflies and bees responded to sunlight and floral area, but bee species richness also responded positively to garden canopy cover and the presence of wild or unmanaged areas in the garden (Matteson and Langellotto 2010). In Ohio, bee abundance in private, backyard gardens increased with native plantings, increases in floral abundance and taller herbaceous vegetation (Pardee and Philpott 2014). Additionally, a study of wild bee pollination of tomato plants in urban agricultural systems within San Francisco showed that wild bee pollination significantly increased overall production from the plants (Potter and LeBuhn 2015). This finding reinforces the idea that vegetation complexity within UA that can bring in more biodiversity can be beneficial to food production.

Overall, these studies support the idea that UA management with high vegetation diversity can have positive effects on invertebrate biodiversity in urban systems.

Vertebrate diversity: Wildlife friendly features implemented in UA can increase vertebrate diversity (Goddard et al. 2012). Practices such as planting fruit or seed-bearing plants, limiting the use of pesticides and herbicides, and constructing compost heaps and bird tables increase bird and vertebrate abundance and diversity (Good 2000). For avian diversity, garden heterogeneity that includes native plant species may be particularly important. Numerous avian studies show that gardens with sufficient native vegetation can support large populations of both native and exotic bird species at the local level (Daniels and Kirkpatrick 2006b) and at the landscape level, and garden heterogeneity can increase the overall diversity of insectivorous birds (Andersson et al. 2007). Heterogeneity that includes native plant species may be particularly important, as studies of suburban gardens in Australia show that nectarivorous birds prefer native genera over exotic ones as foraging sites (French et al. 2005).

For non-avian vertebrates, garden size, management style, and vegetation structure are critical for population persistence in urban areas. Baker and Harris (2007) reported 22 mammalian species or species groups in garden visitation surveys within the UK; however, mammal garden use declined as housing became more urbanized (e.g. more impervious habitat) and garden size and structural complexity decreased. Key findings from a range of garden studies show that in addition to high cultivated floral diversity, the three dimensional structure of garden vegetation is an important predictor of vertebrate abundance and diversity (Goddard et al. 2010). Increases in the vegetation structure and genetic diversity of domestic garden habitats have been shown to improve the connectivity of native populations currently limited to remnants (Doody et al. 2010) and aid conservation of threatened species (Roberts et al. 2007). For example, one study in Latin America documented that garden area and tree height were positively related to the presence and abundance of iguanas within urban areas, and increased patio extent allowed for greater iguana movement across the urban landscape (González-García et al. 2009). These studies show that garden management practices that provide food and nesting resources or movement corridors can be important strategies for maintaining vertebrate diversity in cities.

Ecosystem services: Ecosystem services are often a function of biodiversity levels (Loreau et al. 2001), thus the composition, diversity and structure of plant and animal communities within and around UA are important to consider for the delivery of urban ecosystem services. Specifically, biodiversity may enhance vital ecosystem services that city planners value—including energy efficiency, stormwater runoff, air pollution removal, carbon storage and sequestration, and water quality provision (McLain et al. 2012). Additionally, comparable to agricultural systems, where ecosystem services like water storage, pollination, and pest control increase US crop production resilience and protect production values by over US$57 billion per year (Daily 1997; Losey and Vaughan 2006), UA may strongly depend on biodiversity-mediated ecosystem services. However, there remains a large knowledge gap around the provisioning of services in UA systems. The key issues include increasing global food demands, climate-related crop failure, and consistent limitations in fresh food access within urban centres (Aubry et al. 2012; Thomas 2010; ver Ploeg et al. 2009).

Successful management and maintenance of ecosystem services within a city may need to extend beyond the city limits. For example, due to its large spatial extent, peri-urban agriculture can also play a key role in the management of the social, aesthetic and environmental functions of urban agglomerations nearby (Davoudi and Stead 2007). Depending on the type and intensity of the farming practise, peri-urban agriculture provides abiotic resources and ecosystem functions for the nearby urban areas. For instance, with its high water infiltration rates, pasture and arable land possess capacities for groundwater replenishment (Haase and Nuissl 2007) and flood control (Kenyon et al. 2008; Wheater and Evans 2009). Along with forest and wetlands, farmland including peri-urban agriculture, also contributes to urban-climate moderation (Lamptey et al. 2005) and carbon sequestration (Freibauer et al. 2004; Hutchinson et al. 2007) and thus should be incorporated into the large-scale management plans for sustainable cities.

8.3.2 Social and Cultural Resilience

In a number of ways, UA can enhance social and cultural resilience within cities. Urban gardening and urban social movements can build local ecological and social response capacity against major collapses in urban food supplies, helping to ensure food security in times of crisis (Barthel et al. 2013). Such systems allow for redundant food production solutions as a response to uncertain environmental, economic, or political futures. Hence, they should be incorporated as central elements of sustainable urban development. Additionally, communal garden spaces like allotment gardens can serve as conduits for transmitting collective social-ecological memories of food production. Specifically, they provide a venue for discussing roles and strategies for protecting urban green space, thus allowing communities to maintain local knowledge in the face of global change.

Urban agriculture can provide social safety nets to combat food insecurity, allowing healthy foods to be produced and shared by individuals and communities. Urban agriculture mapping initiatives, such as Fallen Fruit, created in Los Angeles, CA, where artists have mapped fruit trees in their neighbourhoods, create resources for the public to easily find and benefit from the local and free produce (Fallen Fruit 2014). This initiative, which has created over 60 neighbourhood and city maps from all over the US, is a great example of how UA can be combined with art, community strengthening activities, and neighbourhood beautification projects to help communities question and process themes such as public versus private land and the representation of ownership (Fallen Fruit 2014) in order to improve community well-being.

Social and cultural resilience of potentially underserved communities can particularly benefit from UA by making culturally relevant food and medicinal plants more accessible than traditional pathways. For example, as discussed above, in Toronto, surveys showed that besides the typical local vegetables (cabbage, tomatoes, peppers and eggplant), urban farmers grew an additional 16 vegetable crops (e.g. bok choy and hairy gourd) to supply the local community with foods unavailable in local grocery stores (Baker 2004).

In many cities, wet market stallholders and street vendors, principally women, have lost income as more commercial markets have expanded (FAO 2014), and the subsequent rise of income inequity acts with food insecurity to exacerbate diet-related health inequities. The phasing out of fresh produce markets, largely because of urban development pressures and the entry of supermarket and convenience store chains diminishes food access for poorer communities (Dixon et al. 2007). In contrast, the development of a vigorous UA system can provide enhanced opportunities for selling produce and accessing more nutritious foods. Specifically, aside from the act of cultivation and harvesting, the many employment opportunities associated with urban farming systems can boost the local economy by providing thousands of employed positions, from local food processing initiatives, to food distribution centres, to the establishment and management of healthy food market services (Dixon et al. 2007). For example, the proportion of the income coming from UA for the poorest communities can be as high as 30% in Africa, 20% in SE Asia and 10% in Latin America (Zezza and Tasciotti 2010). The provision of reliable flows of household income, via UA development, also improves access to nutritious foods in the cities via trade with other informal and small food producers.

Urban farming may also provide recreation and leisure opportunities that contribute to the quality of life (Antrop 2004). As inner cores of urban regions reach their limitations in complying with the increasing demand in green urban areas, the open spaces within and around cities, including urban and peri-urban farmland, provide valuable potential to deliver these services and functions and become increasingly important as the level of urbanisation increases (de Vries et al. 2003). Even if agricultural production represents the dominating land use in the peri-urban area, it still provides a 'breathing space' for the city nearby (Bryant and Johnston 1992) and access to the peri-urban landscape to enjoy open-space activities (Boulanger et al. 2004; Sharpley and Vass 2006). Matsuoka and Kaplan (2008) also found in their review of people's needs in the urban landscape, that individuals greatly prefer urban landscapes that are dominated by naturalistic features and elements. Particularly organic farming is highly appreciated by urban residents, as argued by Brink (2003). Similarly, in the Brussels metropolitan region, more than half of the population support the protection of agricultural land use in the peri-urban fringe as a mechanism to preserve green space in the face of development (Boulanger et al. 2004).

Furthermore, urban gardening has been suggested as an effective tool for enhancing social cohesion and bridging racial divides by bringing people from different ages, races and income levels together (Shinew et al. 2004; Blaine et al. 2010). As such, UA can be linked to crime reduction, maintenance of cultural diversity, community empowerment, and promotion of civic participation (Warner and Hansi 1987; Murphy 1999). Community gardens can also serve as vehicles for education outreach programs for children and adults where they can learn about ecological processes, biodiversity and food production (Blaine et al. 2010). Learning gardens, in particular, have gained increased attention as efficient outdoor classrooms to foster healthy eating habits, increase physical activity, and demonstrate the importance of land stewardship and biological diversity (Williams and Brown 2013).

8.4 Challenges and Strategies in Promoting Urban Farming

During World War II, the US Department of Agriculture promoted Victory Gardens, which supplied in 1944 40% of the country's vegetables and 8 million tons of food (Nordahl 2009). Victory Gardens also produced self-reliance, self-respect, economic independence, community, and financial, physical and spiritual well-being (Nordahl 2009). However, these goals and benefits were not carried on after the war, and many of these benefits eroded in the face of industrialized agriculture and have not returned. Currently, urban farming challenges exist in urban areas, even in places that used to have significant support for urban food production.

Though public and scientific interest in UA has re-emerged and grown dramatically in the past two decades, there are significant challenges for integrating UA in an increasingly competitive urban landscape (Rural 2006). Much of the debate is centred around land-use trade-offs of UA versus other types of urban development, environmental constraints of the urban environment, and ecosystem dis-services that may come with UA.

8.4.1 Space Availability

Increased urbanization has led to greater competition for space in cities, making it difficult to make an argument to set aside land for urban farming. The question is how to best take advantage of the limited space available for urban gardens and maximize the benefits within these areas. We present a number of possibilities below.

Private yards. Private yards make up a significant proportion of green space in a city and do not require the acquisition of new space for urban farming. Even at a small-scale, private gardens can provide significant area for gardens and support complex vegetation structures in the urban matrix (Sperling and Lortie 2010). Strategies to incentivize wildlife-friendly gardening activities such as the National Wildlife Federation's certification for 'wildlife-friendly' gardens (National Wildlife Federation 2013) help encourage urban gardening in private households. More research is needed to understand the effectiveness of these incentives to support larger scale delivery of social and environmental benefits, such as food production, as many of the techniques are focused on the augmentation of ornamental or floral plants rather than food crops. Furthermore, due to lack of land tenure in poor communities, this type of gardens may not help in combating food insecurity for those who suffer from it.

Public spaces. Because greater housing density has been linked to smaller garden sizes, there is an acute need to better understand how UA can be supported within public green spaces, such as community gardens and easements (Smith et al. 2009). Although, zoning regulations often serve as obstacles to UA's expansion, a number of cities are working to understand how to move beyond these obstacles. For example, the Oakland Food Policy Council (OFPC) (in Oakland, CA) is fostering UA's expansion in public spaces by developing specific recommendations for urban agriculture zoning (McClintock et al. 2012). The city of Chicago, IL has recently passed a municipal code allowing community gardens, indoor, outdoor and rooftop operations in public, civic and commercial areas (Mayor Emanuel 2011). Additionally, the Chicago Urban Agriculture Mapping Project has inventoried and mapped all the metro area urban farms, community gardens, residential vegetable gardens, school gardens, etc. in order to assess current distributions. San Francisco, CA, created the first Urban Agricultural Zone allowing and promoting by means of tax reductions, plots between 0.1 and 3 acres (405 m^2 and 1.21 ha) to be converted to agricultural purposes for at least 5 years. This new ordinance requires public benefit to help knit the community together and give residents access to local produce. However, many compact cities are still facing land use debates about keeping urban gardens versus converting the land to much needed low-income housing in city centres, thus magnifying the environmental justice issues surrounding lower socio-economic communities and their access to green spaces and the benefits gained from them.

Vacant lots. Vacant lots provide opportunities to create functional green spaces where industrial redevelopment is not likely to happen (Beniston and Lal 2012). UA in these areas can be utilized to provide physical and psychological health for people in cities (Tzoulas et al. 2007). However, a better understanding of how to successfully rehabilitate vacant lots is needed in order to promote these spaces as options for urban farming. For example, creating gardens in abandoned lots has implications for urban land tenure for garden management, and it would be helpful to investigate whether temporary gardens can make positive contributions to the social and environmental health of cities in the same ways that more permanent gardens do. In many cases, the use of vacant lots for urban farming will add substantially more to the city than leaving the lot as an unused piece of land. In Buffalo, Metcalf and Widener (2011) showed that urban gardens on vacant lots were able to motivate community based farming initiatives and contribute to the social movement of 'local food' and 'healthy food' in the urban centre.

Peri-urban areas. In peri-urban areas, farming has to compete on the land market with other non-agricultural land uses, such as housing with its higher rents (Robinson 2004). As the price for a piece of farmland with an associated building permit rises dramatically, there is a strong financial incentive for farmers to sell land for purposes of urban development. Thus there is a decreasing amount of land reserved for peri-urban farming under many urban growth scenarios (Munton 2009); however, peri-urban areas remain as necessary areas to feed the local food economy and contribute to the urban metabolism of the city.

Rooftops. Although previously regarded as unusable space, the landscape of rooftops is being reclaimed for productive and sustainable purposes across many highly compact cities (Dunnett and Kingsbury 2008; Luckett 2009; Weiler and Scholz-Barth 2009). In Chap. 11, C.Y. Jim discusses the development of green roofs in cities and associated technological advances. Rooftops can be replenished to provide open space for social interaction in an increasingly depleted public realm and densifying city (Pomeroy 2012). Their use as alternative social and amenity spaces should be included alongside the conventional urban spaces of the street and square (public) or alternative social spaces of the mall, arcade, court or hotel lobby (semi-public) in the broader open space infrastructure of city development. However, rooftops are treated differently in different neighbourhoods—often as forgotten spaces for the underprivileged while providing leisure and recreation spaces for the affluent (Pomeroy 2012). For example, in Hong Kong, growing concerns about environmental issues and the need to promote sustainable urban environment, have led to growing development of green roofs in recent years (Hui 2009; Urbis Limited 2007). It is believed that green roofs can help mitigate the adverse effects of urban heat island in the city by lowering urban temperatures, but they also bring nature back to urban areas and improve urban aesthetics while reducing pollutant concentrations and noise (Hui 2006). Additionally, in Singapore, a proposal to develop rooftop farming in public housing estates has been developed to address the issue of food security and reduce the carbon footprint associated with food imports (Lim and Kishnani 2010). If such a scheme was to be implemented extensively in Singapore, it could result in a 700% increase in domestic vegetable production, satisfying domestic demand by 35.5% (Lim and Kishnani 2010). An example of a rooftop garden that is serving multiple purposes in Singapore is the rooftop garden of Khoo Teck Phuat Hospital which opens its rooftop garden for community garden and school use, but it also serves as a green space for hospital patients to enjoy (http://www.greenroofs.com/projects/pview.php?id=1622).

8.4.2 Environmental Constraints

Environmental changes brought on urbanization affect the agroecological conditions for food production, such as water availability, nutrient supply, soil degradation and pest pressure (Eriksen-Hamel and Danso 2010; Kaye et al. 2006). Thus, we need to understand the particular environmental conditions needed to support the safe and sustainable production of food in urban areas.

Climatic extremes. Cities tend to have higher air and surface temperatures than their rural surroundings because urban form and materials store and trap heat. This is a phenomenon known as urban heat island (Oke 1997). Evyatar Erell reviewed in Chap. 4 the role of greenery in modifying urban climate. The presence and management of garden trees, shrubs, and other plants in urban farming systems influence air and surface temperatures and has the potential to lower energy use and costs in urban environments. Additionally, UA plantings could enhance carbon sequestration while allowing enough light for cultivating ground crops and could assist in reducing the carbon footprint of cities. However, very little is known about how different UA respond to climate change or climate extremes, and how the urban environment in which UA is embedded may exacerbate or buffer climate effects. Thus, more research is needed to understand how plants in UA will respond to increasing temperature and drought, and changing rainfall amount, nutrient deposition and weather extremes.

Water use. Research on environmental constraints related to water use is also needed in UA, as irrigation is often required to provide water necessary for urban farming, and local supplies of water may be highly dependent on regional water systems (Mawois et al. 2011). Rainwater or grey water can be used for garden irrigation, and it is cheaper and at times more available than potable water-based irrigation, but UA gardeners must be aware of the potential pathogens and heavy metal contaminants that can cause human and environmental health problems (Qadir et al. 2010). For example, concentrations of potentially toxic elements were measured in soils in five tropical leafy vegetables grown in contaminated urban agriculture sites in Kampala City, Uganda, with soil contamination from poor waste disposal practices leading to considerable metal uptake in the crops (Nabulo et al. 2012).

Soil ecology. Urban soils are usually compacted, have low levels of organic matter, altered soil moisture characteristics, and sometimes have lead or other heavy metal contamination due to urban environmental processes (Beniston and Lal 2012). A number of methods, such as cover cropping, mulching, producing in raised beds, and changing subsurface drainage through piping, can improve soil conditions to support food production (Beniston and Lal 2012). However, more research must be done to understand how to sustainably rehabilitate urban soils. Alternative methods, such as ‘organoponics’, where organic compost is used as a growing medium instead of existing soils, need to be further explored to develop farming methods that are successful in the urban environment (Drescher et al. 2006).

Pest control and pollination. Food production requires important ecosystem services provided by vertebrate and invertebrate animal species to be ecologically and economically sustainable. Pollinator density and diversity are essential for optimal fruit and seed setting of many crop species (Klein et al. 2007), while insectivorous birds and arthropod predators and parasites can keep crop pests below damaging levels (Letourneau et al. 2009). These ecosystem services are particularly important in UA systems, where most of the crops depend upon bee pollination (Matteson and Langellotto 2009; Oberholtzer et al. 2014), and urban gardeners and growers greatly rely on natural pest control since they often face severe restrictions in using chemical pesticides. Nevertheless, habitat fragmentation, lack of vegetation cover, and constant disturbances make cities inhospitable habitats for many animal species (McKinney 2006; Goddard et al. 2010) that mediate important ecosystem services to UA such as pest control and pollination. Furthermore, even though food-web dynamics of crops commonly found in UA have been widely studied in rural settings, human forces may alter environmental stressors and create unique interactions in urban ecosystems (Shochat et al. 2006). Consequently, there is a great need for research on animal population persistence and food-web dynamics for the successful management of animal-mediated ecosystem services in UA.

8.4.3 Potential Ecosystem Disservices and Tradeoffs of Urban Agriculture

Besides many potential benefits provided by urban farming, the potential negative impacts on ecosystem functioning and human health should be evaluated.

Spillover into natural systems. In some cases, there is the possibility of negative spillover from managed farms to natural systems or vice versa of weed, pathogen or pest populations, potentially harming native ecosystems and damaging ecosystem-service delivery from natural systems (Blitzer et al. 2012; Zhang et al. 2007). The juxtaposition of natural systems to urban farm systems also potentially leads to an increased opportunity for biological invasions and detrimental competition with native species (Niinemets and Penuelas 2008). Genetic introgression within natural ecosystems by urban garden plants can negatively alter the genetic composition of native vegetative patches and affect the long term viability of these systems (Whelan et al. 2006). At the same time, chemical, water, and animal movement is bi-directional, and intensified management implemented in backyards, such as pesticide application, extensive pruning, frequent mowing and other disturbances, can limit the capacity of gardens to maintain rare or sensitive insect species (Matteson and Langellotto 2011). The problem of chemical spillover may be especially prevalent in developing nations where there may be a lack of governmental support or where UA has been considered an illegal activity until recently (Smith 1996; Færge et al. 2001; Deelstra and Girardet 2000). Urban farmers are thus often forced to hide their gardens by planting only less conspicuous and short-cycled crops and using more chemical inputs to reduce the length of the growth cycle (Bryld 2003). These situations, combined with the lack of tenure and constant danger of evictions, make urban farmers in many developing countries less motivated to practise urban agriculture in a sustainable manner (Bryld 2003).

Negative impacts on human health. If managed carelessly, urban farm areas may also lead to increased human health issues and greater disease transmission to urban populations. For example, UA systems provide increased mosquito breeding sites due to the presence of standing water from irrigation or rainwater, and this may potentially increase the rate of mosquito borne diseases in certain areas of the city (Matthys et al. 2010). Additionally, in non-organic UA systems, there is the potential for spillover of chemicals into natural and human habitats, leading to environmental pollution and air or water borne health risks, as discussed in the previous sub-section (Robbins et al. 2001). Additionally, UA in many countries remains largely unregulated, with very little official support or technical assistance provided by local governments. This creates environmental and health hazards due to frequent use and misuse of chemical fertilizers and pesticides (Smith 1996), and irrigation with contaminated water (FAO 2014).

Gentrification of low-income neighbourhoods. Recognizing many local benefits to the community, cities around the world have implemented strategies to increase urban green space, especially in lower socioeconomic neighbourhoods where the supply is usually inadequate. However, these actions can actually exacerbate the existing problem. While the creation of new green space to address environmental injustice can make neighbourhoods healthier and more aesthetically attractive, it also can increase housing costs and property values, forcing residents to find cheaper housing elsewhere. Ultimately, this can lead to gentrification and a displacement of the very residents the green-space strategies were designed to benefit (Wolch et al. 2014). Given that urban community gardening has been sometimes been linked to gentrification of urban areas (Martinez 2010), their development has been received with skepticism in many poor and minority communities (Shinew et al. 2004). Thus, the development of urban gardens across communities must be considered carefully to avoid displacing the extant communities.

8.5 Conclusion

Despite multiple environmental and social benefits to promoting urban agriculture within cities, maintaining and increasing this specific type of green space remain challenging in the face of other urban processes. Identifying win-win areas for urban farming, where environmental and social benefits can be maximized in otherwise unused land, will be necessary to build support and acceptance for these urban farming systems both socially and politically. On the research side, projects that map and collate data on urban farming systems (e.g. Taylor and Lovell 2012) will help develop a database of farm attributes and the benefits provided by each system. On the policy side, major changes to zoning regulations that allow communities to take advantage of otherwise unused land to develop urban farms will be necessary to transform vacant lots or overlooked public spaces into active UA systems. Understanding how the transformation of land into UA systems affects other social and economic processes in surrounding communities will also be necessary to prevent unintended consequences of chemical spillover or displacement. We posit that such knowledge will be required to develop local urban agriculture systems that allow people the opportunity to interact with the natural landscape around them while improving the environment and social health of the communities around them.

References

Ahrne K, Bengtsson J, Elmqvist T (2009) Bumble bees (*Bombus* spp.) along a gradient of increasing urbanization. PLoS ONE 4(5):e5574

Alig RJ, Kline JD, Lichtenstein M (2004) Urbanization on the US landscape: looking ahead in the 21st century. Landscape Urban Plan 69(2):219–234

Andersson E, Barthel S, Ahrné K (2007) Measuring social-ecological dynamics behind the generation of ecosystem services. Ecol Appl 17(5):1267–1278

Antrop M (2004) Landscape change and the urbanization process in Europe. Landscape Urban Plan 67:9–26

Aubry C, Ramamonjisoa J, Dabat MH et al (2012) Urban agriculture and land use in cities: an approach with the multi-functionality and sustainability concepts in the case of Antananarivo (Madagascar). Land Use Policy 29(2):429–439

Baker LE (2004) Tending cultural landscapes and food citizenship in Toronto's community gardens. Geogr Rev 94(3):305–325

Baker PJ, Harris S (2007) Urban mammals: what does the future hold? An analysis of the factors affecting patterns of use of residential gardens in Great Britain. Mammal Rev 37(4):297–315

Barthel S, Isendahl C (2013) Urban gardens, agriculture, and water management: Sources of resilience for long-term food security in cities. Ecol Econ 86:224–234

Barthel S, Parker J, Ernstson H (2013) Food and green space in cities: a resilience lens on gardens and urban environmental movements. Urban Stud 57:1321–1338

Beniston J, Lal R (2012) Improving soil quality for urban agriculture in the North Central U.S. In: Lal R, Augustin B (eds) Carbon sequestration in urban ecosystems. Springer, Netherlands, pp 279–313

Bennett AB, Gratton C (2012) Local and landscape scale variables impact parasitoid assemblages across an urbanization gradient. Landscape Urban Plan 104(1):26–33

Beyers M, Brown J, Cho S et al (2008) Life and death from unnatural causes: health and social inequity in Alameda County. Alameda County Public Health Department, Oakland, CA

Blaine TW, Grewal PS, Dawes A, Snider D (2010) Profiling community gardeners. J Extension 48 (6):1–12

Blitzer EJ, Dormann CF, Holzschuh A et al (2012) Spillover of functionally important organisms between managed and natural habitats. Agric Ecosyst Environ 146(1):34–43

Boulanger A, Meert H, Van Hecke E (2004) The societal demand for public goods in peri-urban areas: a case from the Brussels urban region. In: Conference proceedings 90th EAAE seminar multifunctional agriculture, policies markets: understanding the critical linkage, Rennes, France, 28–29 Oct 2004

Brink A (2003) Welche Rolle spielt der ökologische Landbau für eine Großstadt. In: Rahmann G, Nieberg H (eds) Ressortforschung für den ökologischen Landbau. Bundesforschungsanstalt für Landwirtschaft, Braunschweig, pp 80–83

Bryant CR, Johnston TRR (1992) Agriculture in the city's countryside. Belhaven Press, London

Bryld E (2003) Potentials, problems, and policy implications for urban agriculture in developing countries. Agric Hum Values 20(1):79–86

Burghardt KT, Tallamy DW, Shriver GW (2009) Impact of native plants on bird and butterfly biodiversity in suburban landscapes. Conserv Biol 23(1):219–224
Byrne L, Bruns M, Kim K (2008) Ecosystem properties of urban land covers at the aboveground–belowground interface. Ecosystems 11(7):1065–1077
Colasanti KA, Hamm MW (2010) Assessing the local food supply capacity of Detroit, Michigan. J Agri Food Syst Commun Dev 1(2):41
Colding J, Lundberg J, Folke C (2006) Incorporating green-area user groups in urban ecosystem management. Ambio 35(5):237–244
Daily G (1997) Nature's services: societal dependence on natural ecosystems. Island Press, Washington, DC
Daniels GD, Kirkpatrick JB (2006a) Comparing the characteristics of front and back domestic gardens in Hobart, Tasmania, Australia. Landscape Urban Plan 78(4):344–352
Daniels GD, Kirkpatrick JB (2006b) Does variation in garden characteristics influence the conservation of birds in suburbia? Biol Conserv 133(3):326–335
Davidowitz G, Rosenzweig ML (1998) The latitudinal gradient of species diversity among North American grasshoppers (Acrididae) within a single habitat: a test of the spatial heterogeneity hypothesis. J Biogeogr 25(3):553–560
Davoudi S, Stead D (2007) Urban–rural-relationships: an introduction and brief history. Build Environ 28:269–277
Deelstra T, Girardet H (2000) Urban agriculture and sustainable cities. In: Bakker N, Dubbeling M, Gündel S, Sabel-Koshella U, de Zeeuw H (eds) Growing cities, growing food. Urban agriculture on the policy agenda. Zentralstelle für Ernährung und Landwirtschaft (ZEL), Feldafing, Germany, pp 43–66
de Vries S, Verheij RA, Groenewegen PP, Spreeuwenberg P (2003) Natural environments—healthy environments? An exploratory analysis of the relationship between greenspace and health. Environment and Planning A 35:1717–1731
Dixon J, Omwega AM, Friel S, Burns C, Donati K, Carlisle R (2007) The health equity dimensions of urban food systems. J Urban Health 84(1):118–129
Doody B, Sullivan J, Meurk C, Stewart G, Perkins H (2010) Urban realities: the contribution of residential gardens to the conservation of urban forest remnants. Biodivers Conserv 19 (5):1385–1400
Drescher A, Holmer R, Iaquinta D (2006) Urban homegardens and allotment gardens for sustainable livelihoods: management strategies and institutional environments. Tropical Homegardens, Springer, The Netherlands, pp 317–338
Dunnett N, Kingsbury N (2008) Planting green roofs and living walls, revised and updated edition. Timber Press, Oregon
Eriksen-Hamel N, Danso G (2010) Agronomic considerations for urban agriculture in southern cities. Int J Agricu Sustain 8(1–2):86–93
Færge J, Magid J, de Vries FW (2001) Urban nutrient balance for Bangkok. Ecol Model 139 (1):63–74
Fallen Fruit Biography (2014). Retrieved 25 Sept 2014, from http://fallenfruit.org/about/
FAO (2014) Growing green cities in Latin America and the Caribbean. Food and Agriculture Organization of the United Nations, Rome
Forman RT, Alexander LE (1998) Roads and their major ecological effects. Annu Rev Ecol Syst 29:207–231
French K, Major R, Hely K (2005) Use of native and exotic garden plants by suburban nectivorous birds. Biol Conserv 121:545–559
Freibauer A, Rounsevell MDA, Smith P, Verhagen J (2004) Carbon sequestration in the agricultural soils of Europe. Geoderma 122:1–23
Funes F, Altieri MA, Rosset P (2009) The Avery diet: the Hudson Institute's misinformation campaign against Cuban agriculture. http://www.landaction.org/IMG/pdf/The-Avery-Diet.pdf
Goddard MA, Dougill AJ, Benton TG (2010) Scaling up from gardens: biodiversity conservation in urban environments. Trends Ecol Evol 25(2):90–98

Goddard MA, Dougill AJ, Benton TG (2012) Why garden for wildlife? Social and ecological drivers, motivations and barriers for biodiversity management in residential landscapes. Ecol Econ 86:258–263

González-García A, Belliure J, Gómez-Sal A, Dávila P (2009) The role of urban greenspaces in fauna conservation: the case of the iguana *Ctenosaura similis* in the 'patios' of León city, Nicaragua. Biodivers Conserv 18(7):1909–1920

González-García A, Gómez-Sal A (2008) Private urban greenspaces or 'patios' as a key element in the urban ecology of tropical Central America. Human Ecol 36(2):291–300

Good R (2000) The value of gardening for wildlife-what contribution does it make to conservation? Br Wildlife 12(2):77–84

Greenstone M (1984) Determinants of web spider species diversity: vegetation structural diversity vs. prey availability. Oecologia 62(3):299–304

Haase D, Nuissl H (2007) Does urban sprawl drive changes in the water balance and policy? The case of Leipzig (Germany) 1870–2003. Landscape Urban Plan 80:1–13

Halaj J, Ross DW, Moldenke AR (2000) Importance of habitat structure to the arthropod food-web in Douglas-fir canopies. Oikos 90(1):139–152

Hodgson K, Campbell MC, Bailkey M (2011) Urban agriculture: growing healthy, sustainable places. Am Plann Assoc, Washington, DC

Hui SCM (2006) Benefits and potential applications of green roof systems in Hong Kong. In: Proceedings of the 2nd megacities international conference 2006, 1–2 Dec 2006, Guangzhou, China, pp 351–360

Hui SCM (2009) Study of thermal and energy performance of green roof systems: final report. Department of Mechanical Engineering, The University of Hong Kong, Hong Kong

Hunter MCR, Brown DG (2012) Spatial contagion: gardening along the street in residential neighborhoods. Landscape Urban Plan 105(4):407–416

Hunter MCR, Hunter MD (2008) Designing for conservation of insects in the built environment. Insect Conserv Div 1(4):189–196

Hutchinson JJ, Campbell CA, Desjardins RL (2007) Some perspectives on carbon sequestration in agriculture. Agric For Meteorol 142:288–302

Jha S, Vandermeer JH (2010) Impacts of coffee agroforestry management on tropical bee communities. Biol Conserv 143(6):1423–1431

Kaye JP, Groffman PM, Grimm NB, Baker LA, Pouyat RV (2006) A distinct urban biogeochemistry? Trends Ecol Evol 21(4):192–199

Kenyon W, Hill G, Shannon P (2008) Scoping the role of agriculture in sustainable flood management. Land Use Policy 25:351–360

Klein AM, Vaissiere BE, Cane JH et al (2007) Importance of pollinators in changing landscapes for world crops. Proc Royal Soc B: Biol Sci 274(1608):303–313

Lamptey BL, Barron EJ, Pollard D (2005) Impacts of agriculture and urbanization on the climate of the Northeastern United States. Global Planet Change 49:203–221

Letourneau DK, Jedlicka JA, Bothwell SG, Moreno CR (2009) Effects of natural enemy biodiversity on the suppression of arthropod herbivores in terrestrial ecosystems. Annu Rev Ecol Evol Syst 40:573–592

Lim YA, Kishnani NT (2010) Building integrated agriculture: utilising rooftops for sustainable food crop cultivation in Singapore. J Green Build 5(2):105–113

Lin BB, Philpott SM, Jha S (2015) The future of urban agriculture and biodiversity ecosystem-services: challenges and next steps. Basic Appl Ecol 16(3):189–201

Loram A, Tratalos J, Warren P, Gaston KJ (2007) Urban domestic gardens (X): the extent & structure of the resource in five major cities. Landscape Ecol 22(4):601–615

Loram A, Warren PH, Gaston KJ (2008) Urban domestic gardens (XIV): the characteristics of gardens in five cities. Environ Manage 42(3):361–376

Loreau M, Naeem S, Inchausti P et al (2001) Biodiversity and ecosystem functioning: current knowledge and future challenges. Science 294(5543):804–808

Losey JE, Vaughan M (2006) The economic value of ecological services provided by insects. Bioscience 56(4):311–323

Lovell ST (2010) Multifunctional urban agriculture for sustainable land use planning in the United States. Sustainability 2(8):2499–2522

Luckett K (2009) Green roof construction and maintenance. McGraw-Hill, New York

Lundberg J, Moberg F (2003) Mobile link organisms and ecosystem functioning: implications for ecosystem resilience and management. Ecosystems 6(1):0087–0098

Martellozzo F, Landry JS, Plouffe D et al (2014) Urban agriculture: a global analysis of the space constraint to meet urban vegetable demand. Environ Res Lett 9(6):064025

Martinez MJ (2010) Power at the roots: gentrification, community gardens, and the Puerto Ricans of the Lower East Side. Lexington Books, Plymouth

Mathieu R, Freeman C, Aryal J (2007) Mapping private gardens in urban areas using object-oriented techniques and very high-resolution satellite imagery. Landscape Urban Plan 81(3):179–192

Matsuoka RH, Kaplan R (2008) People needs in the urban landscape: analysis of landscape and urban planning contributions. Landscape Urban Plan 84:7–19

Matteson KC, Ascher JS, Langellotto GA (2008) Bee richness and abundance in New York City urban gardens. Ann Entomol Soc Am 101(1):140–150

Matteson KC, Langellotto GA (2009) Bumble bee abundance in New York City community gardens: implications for urban agriculture. Cities Environ 2(1):5

Matteson KC, Langellotto GA (2010) Determinates of inner city butterfly and bee species richness. Urban Ecosyst 13(3):333–347

Matteson KC, Langellotto GA (2011) Small scale additions of native plants fail to increase beneficial insect richness in urban gardens. Insect Conserv Divers 4(2):89–98

Matthys B, Koudou BG, N'Goran EK et al (2010) Spatial dispersion and characterisation of mosquito breeding habitats in urban vegetable-production areas of Abidjan, Côte d'Ivoire. Ann Trop Med Parasitol 104(8):649–666

Mawois M, Aubry C, Le Bail M (2011) Can farmers extend their cultivation areas in urban agriculture? A contribution from agronomic analysis of market gardening systems around Mahajanga (Madagascar). Land Use Policy 28(2):434–445

Mayor Emanuel R (2011) Amendment of Chapter 17-2 of municipal code regarding urban agriculture uses. City Council Document Tracking Sheet, City of Chicago, Office of the Chicago City Clerk

McClintock N, Wooten H, Brown A (2012) Toward a food policy 'First Step' in Oakland, California: a food policy council's efforts to promote urban agriculture zoning. J Agri Food Syst Commu Dev 2(4):15–42

McKinney ML (2006) Urbanization as a major cause of biotic homogenization. Biol Conserv 127:247–260

McLain R, Poe M, Hurley PT et al (2012) Producing edible landscapes in Seattle's urban forest. Urban For Urban Greening 11(2):187–194

Metcalf SS, Widener MJ (2011) Growing Buffalo's capacity for local food: a systems framework for sustainable agriculture. Appl Geogr 31(4):1242–1251

Miotk P (1996) The naturalized garden—a refuge for animals? first results. Zoologischer Anzeiger 235:101–116

Montgomery MR (2008) The urban transformation of the developing world. Science 319:761–764

Moguel P, Toledo VM (1999) Biodiversity conservation in traditional coffee systems of Mexico. Conserv Biol 13:11–21

Mougeot LJ (ed) (2010) Agropolis: the social, political and environmental dimensions of urban agriculture. Routledge, London

Munton R (2009) Rural land ownership in the United Kingdom: changing patterns and future possibilities for land use. Land Use Policy 26:S54–S61

Murphy C (1999) Cultivating Havana: urban agriculture and food security in the years of crisis. Food First, Oakland, CA

National Wildlife Federation (2013) Garden for wildlife: making wildlife habitat at home. http://www.nwf.org/How-to-Help/Garden-for-Wildlife/Create-a-Habitat.aspx?campaignid=WH10BGHF&adid=54466

Niinemets U, Penuelas J (2008) Gardening and urban landscaping: significant players in global change. Trends Plant Sci 13(2):60–65

Nordahl D (2009) Public produce: the new urban agriculture. Island Press, Washington, DC

Oakland Food Policy Council [OFPC] (2010) Transforming Oakland food system: a plan for action. Oakland Food Policy Council and Food First, Oakland, CA. Available at http://www.oaklandfood.org

Oberholtzer L, Dimitri C, Pressman A (2014) Urban agriculture in the United States: characteristics, challenges and technical assistance needs. J Extension 52(6):61

Oke TR (1997) Urban climates and global environmental change. In: Thompson RD, Perry AH (eds) Applied climatology: principles and practice. Routledge, New York, pp 273–287

Owen J (1991) The ecology of a garden: the first fifteen years. Cambridge University Press, Cambridge

Pardee G, Philpott S (2014) Native plants are the bee's knees: local and landscape predictors of bee richness and abundance in backyard gardens. Urban Ecosyst 17(3):641–659

Pomeroy J (2012) Room at the top: the roof as an alternative habitable/social space in the Singapore context. J Urban Des 17(3):413–424

Potter A, LeBuhn G (2015) Pollination service to urban agriculture in San Francisco, CA. Urban Ecosyst 18:885–893

Qadir M, Wichelns D, Raschid-Sally L et al (2010) The challenges of wastewater irrigation in developing countries. Agric Water Manag 97(4):561–568

Robbins P, Polderman A, Birkenholtz T (2001) Lawns and toxins: an ecology of the city. Cities 18 (6):369–380

Roberts DG, Ayre DJ, Whelan RJ (2007) Urban plants as genetic reservoirs or threats to the integrity of bushland plant populations. Conserv Biol 21(3):842–852

Robinson GM (2004) Geographies of agriculture: globalisation, restructuring and sustainability. Pearson Education, Harlow, UK

Romero-Alcaraz E, Ávila JM (2000) Landscape heterogeneity in relation to variations in epigaeic beetle diversity of a Mediterranean ecosystem: implications for conservation. Biodivers Conserv 9(7):985–1005

RURAL (2006) Rural areas under pressure. Case studies of rural–urban relationships across Europe. In: Overbeek MM, Terluin IJ (eds), European report. Agricultural Economics Research Institute, Den Haag, The Netherlands

Russell SE, Heidkamp CP (2011) 'Food desertification': the loss of a major supermarket in New Haven, Connecticut. Appl Geogr 31(4):1197–1209

Saldivar-Tanaka L, Krasny ME (2004) Culturing community development, neighborhood open space, and civic agriculture: the case of Latino community gardens in New York City. Agric Hum Values 21:399–412

Sanders RA, Stevens JC (1984) Urban forest of Dayton, Ohio: a preliminary assessment. Urban Ecol 8(1–2):91–98

Sharpley R, Vass A (2006) Tourism, farming and diversification: an attitudinal study. Tour Manag 27:1040–1052

Shinew KJ, Glover TD, Parry DC (2004) Leisure spaces as potential sites for interracial interaction: community gardens in urban areas. J Leisure Res 36(3):336

Shochat E, Warren PS, Faeth SH et al (2006) From patterns to emerging processes in mechanistic urban ecology. Trends Ecol Evol 21(4):186–191

Smit J, Nasr J, Ratta A (1996) Urban agriculture: food jobs and sustainable cities. United Nations Development Programme (UNDP), New York

Smith C, Clayden A, Dunnett N (2009) An exploration of the effect of housing unit density on aspects of residential landscape sustainability in England. J Urban Des 14(2):163–187

Smith D (1996) Urban agriculture in Harare: socio-economic dimensions of a survival strategy. In: Grossman D, van den Berg LM, Ajaegbu HI (eds) Urban and peri-urban agriculture in Africa: proceedings of a Workshop: Netanya, Israel, 23–27 June 1996, Ashgate, Aldershot, UK

Smith RM, Gaston KJ, Warren PH, Thompson K (2005) Urban domestic gardens (V): relationships between landcover composition, housing and landscape. Landscape Ecol 20 (2):235–253

Smith RM, Thompson K, Hodgson JG et al (2006a) Urban domestic gardens (IX): composition and richness of the vascular plant flora, and implications for native biodiversity. Biol Conserv 129:312–322

Smith RM, Warren P, Thompson K, Gaston KJ (2006b) Urban domestic gardens (VI): environmental correlates of invertebrate species richness. Biodivers Conserv 15(8):2415–2438

Southwood TRE, Brown VK, Reader PM (1979) The relationships of plant and insect diversities in succession. Biol J Linn Soc 12(4):327–348

Sperling C, Lortie C (2010) The importance of urban backgardens on plant and invertebrate recruitment: a field microcosm experiment. Urban Ecosyst 13(2):223–235

Taylor JR, Lovell ST (2012) Mapping public and private spaces of urban agriculture in Chicago through the analysis of high-resolution aerial images in Google Earth. Landscape Urban Plan 108(1):57–70

Thomas BJ (2010) Food deserts and the sociology of space: distance to food retailers and food insecurity in an urban American neighborhood. Int J Human Social Sci 5(6):400–409

Tommasi D, Miro A, Higo HA, Winston ML (2004) Bee diversity and abundance in an urban setting. Can Entomol 136(06):851–869

Treuhaft S, Hamm MJ, Litjens C (2009) Healthy food for all: building equitable and sustainable food systems in Detroit and Oakland. PolicyLink, Oakland, CA

Tzoulas K, Korpela K, Venn S et al (2007) Promoting ecosystem and human health in urban areas using green infrastructure: a literature review. Landscape Urban Plan 81(3):167–178

Limited Urbis (2007) Study on green roof application in Hong Kong, final report. Architectural Services Department, Hong Kong

ver Ploeg M, Breneman V, Farrigan T et al (2009) Access to affordable and nutritious food: measuring and understanding food deserts and their consequences. Report to Congress on access to affordable and nutritious food: measuring and understanding food deserts and their consequences. USDA Economic Research Service, Washington, DC

Vitiello D, Nairn M (2009) Community gardening in Philadelphia: 2008 harvest report. Penn planning and urban studies. University of Pennsylvania, PA

Warner SB, Hansi D (1987) To dwell is to garden: a history of Boston's community gardens. Northeastern University Press, Boston

Weiler S, Scholz-Barth K (2009) Green roof systems: a guide to the planning, design and construction of building over structure. Wiley, Hoboken, NJ

Wheater H, Evans E (2009) Land use, water management and future flood risk. Land Use Policy 26:S251–S264

Whelan RJ, Roberts DG, England PR, Ayre DJ (2006) The potential for genetic contamination vs. augmentation by native plants in urban gardens. Biol Conserv 128(4):493–500

Whittinghill LJ, Rowe DB (2012) The role of green roof technology in urban agriculture. Renew Agric Food Syst 27(04):314–322

Williams D, Brown J (2013) Learning gardens and sustainability education: bringing life to schools and schools to life. Routledge, London

WinklerPrins AGA (2002) House-lot gardens in Santarém, Pará, Brazil: linking rural with urban. Urban Ecosyst 6(1–2):43–65

Wolch JR, Byrne J, Newell JP (2014) Urban green space, public health, and environmental justice: the challenge of making cities 'just green enough'. Landscape Urban Plan 125:234–244

Wooten H, Ackerman A (2011) Seeding the city: land use policies to promote urban agriculture. Public Health Law & Policy/NPLAN, Oakland, CA. Available at http://changelabsolutions.org/publications/seeding-city

Yadav P, Duckworth K, Grewal PS (2012) Habitat structure influences below ground biocontrol services: a comparison between urban gardens and vacant lots. Landscape Urban Plan 104 (2):238–244

Zasada I (2011) Multifunctional peri-urban agriculture: a review of societal demands and the provision of goods and services by farming. Land Use Policy 28(4):639–648

Zezza A, Tasciotti L (2010) Urban agriculture, poverty, and food security: Empirical evidence from a sample of developing countries. Food Policy 35(4):265–273

Zhang W, Ricketts TH, Kremen C et al (2007) Ecosystem services and dis-services to agriculture. Ecol Econ 64(2):253–260