Sally Brown · Kristen McIvor
Elizabeth Hodges Snyder *Editors*

Sowing Seeds in the City

Ecosystem and Municipal Services

Springer

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ISBN 978-94-017-7451-2 ISBN 978-94-017-7453-6 (eBook)
DOI 10.1007/978-94-017-7453-6

Library of Congress Control Number: 2016937712

Springer Dordrecht Heidelberg New York London

Printed on acid-free paper

Springer Science+Business Media B.V. Dordrecht is part of Springer Science+Business Media (www.springer.com)

Painting credit:
Seva Rzhondkovsky
http://sevaart.com

Book I
Part I
“A lifetime of accomplishments of which the dirt knows none,
only in death can one truly return
Return the carrots, the apples and potatoes,
The chickens, the cows, the fish and tomatoes.”
–Poi Dog Pondering
“Well I love that dirty water”
–Standells
Part II
“Let me tell ya ‘bout the birds and the bees
And the flowers and the trees”
–Herbert Newman
Well, you get the cherry, Jerry
Now look, don’t be so picky, Mickey
Cause everybody eats when they come to my house
–Cab Calloway
Part III
On the roof’s the only place I know
Where you just have to wish to make it so
Let’s go up on the roof (Up on the roof)
–Drifters

Preface

The two volumes of *Sowing Seeds in the City* were inspired by a National Academy of Science Keck Foundation (NAKFI) conference on ecosystem services (http://www.keckfutures.org/conferences/ecosystem-services_podcast_home.html). Each attendee was asked to select an area of inquiry from a potential list of nine topics. At the meeting we worked in groups to come up with innovative solutions to each question. I was struck by how urban agriculture has the potential to address so many of the questions on that list. When the conference was held, urban agriculture was not on the radar. Six of those nine areas of inquiry from the NAKFI conference are shown below, along with the related sections in *Sowing Seeds in the City*:

- *How ecosystem services affect infectious and chronic disease*: Volume 2, Section 1
- *Identify what resources can be produced renewably or recovered by developing intense technologies that can be applied on a massive scale*: Volume 1, sections on water and waste
- *Design agricultural and aquacultural systems that provide food security while maintaining the full set of ecosystem services needed from landscapes and sea-scapes*: Volume 1, all sections, and Volume 2, sections on food security
- *Design production systems for ecosystem services that improve human outcomes related to food and nutrition*: Volume 1, sections on ecosystems services and food production, and Volume 2, sections on health and food security
- *Design a federal policy to maintain or improve natural capital and ecosystem services within the United States including measuring and documenting the effectiveness of the policy*: Volume 1, sections on municipal infrastructure, and Volume 2, case studies and the sections on research, education, and programming
- *Develop a program that increases the American public's appreciation of the basic principles of ecosystem services*: Volume 2, case studies and the sections on research, education, and programming

The scientific community is starting to recognize the potential for urban agriculture to address the issues listed above, and a social movement in urban agriculture is already well underway. To be successful, this social movement also has to be embraced by public health officials, residuals managers, municipal governments, as well as the people who actually plant the seeds. Right now, urban agriculture is many things to many people. At a minimum it provides fresh tomatoes for salads and sandwiches for urban growers during hot summer months. From a broader perspective, urban agriculture has the potential to revolutionize our food systems, reintegrate both knowledge of and higher-level ecosystem services into our cities, change how our children learn, and have a broad impact on public health. The recent rebirth of urban agriculture began primarily as a social movement. With these two volumes we explore urban agriculture from a broad perspective. We hope that these books can encourage and inspire the broad range of individuals who stand to benefit from urban agriculture.

The first volume focuses on urban agriculture and ecosystem services and how growing food can be integrated into the physical and legal framework of cities in the United States. The first chapter describes a "city of the future" where agriculture is well integrated into the fabric of a municipality. This sets the tone for the remainder of the books. The next part focuses on the natural resources soil and water. A basic guide to soils in urban areas and how to improve them is the focus of the soil chapter. The water chapters describe the different types of water that can be recycled in urban areas with supporting regulations and guidelines; provide details on gray water, the water from homes used to wash our bodies, clothes, and dishes; and give a broad call on the importance of maximizing our use of recycled water in urban areas.

The next part of the first volume focuses on ecosystem services. Waste treatment is the first section. The first chapter provides an overview and guide to the role of organic residuals in urban agriculture. The next chapter provides an engineering perspective including infrastructure, economic and climate requirements, and costs for different waste management alternatives. The section closes with a case study of Seattle where food scraps are now composted along with yard waste. The discussion focuses on the political background that enabled landfill diversion of organics and describes the factors needed to compost the food and yard waste.

The next section describes how urban agriculture can impact climate change. The role of soils in climate change is the focus of the first chapter, followed by an analysis of the climate impacts of different waste management options. The section concludes with a life cycle assessment of lettuce grown in a community garden or on a large-scale farm.

Habitat is the next component of ecosystem services. This section begins with an introduction to microbial ecology and function in urban agriculture. It continues with a more theoretical consideration of the microbiome and urban agriculture. Moving up the food chain, the next chapters go from bees to birds to recommendations of how urban farms can be designed to provide optimal habitat.

One question that is frequently asked about urban farms is how much food can be produced on the small plots so typical of urban lots. The section on food production begins with a detailed description of the productivity of a lot in a community garden in Seattle. Permaculture, a tool for managing soil plant systems, is described for a home in Alaska. Seed preservation is discussed in the next chapter.

This section concludes with a detailed description of aquaponic systems, a potential means to grow fish in urban settings.

From here the book focuses on the pragmatic side of this issue. Where to farm and how to incorporate farming into the fabric of a city? The first question is addressed in a section on location options. This includes chapters on community gardens, rooftop gardens, and growing on brownfield sites and on parking strips. The final section of this volume gives examples from Michigan; Portland, OR; and Boston, MA, on how municipal codes were changed to encourage agriculture.

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About the Editors

Sally Brown is a research associate professor at the University of Washington School of Forest and Environmental Science. She is a fellow in the Soil Science Society of America, was a two-term member of the National Academy of Science Standing Committee on Soil Science, and is a member on the National Academy of Science Committee on the Bioavailability of Contaminants in Soils and Sediments. She has won multiple awards for her work on residual use in soils. Dr. Brown writes a monthly column for *BioCycle Magazine*, a journal that focuses on sustainable management of organics. She has a BA in political science from Williams College (1980) and an MS (1993) and PhD (1996) from the University of Maryland. Before returning to graduate school, she worked as a chef in New York City, New Orleans, and Connecticut. In 1986 she started a business delivering locally grown vegetables to stores and restaurants in New York City and Connecticut. She currently grows greens, onions, potatoes, and currants on two plots near her home with the assistance of her husband and TAGRO, the biosolids-based soil amendment from Tacoma, WA.

Kristen McIvor is the director of Harvest Pierce County, a program of the Pierce Conservation District. Their mission is to invest in people to foster and sustain an equitable and healthy community-based food system throughout Pierce County. She is also an adjunct professor at Pinchot University where she teaches classes on food systems. Dr. McIvor got her MS at Antioch University in environment and community and her PhD at the University of Washington. Her academic work has focused on improving soils in urban areas to support the growing of food, and much of her time is spent working with community groups to do just that. She lives in the soggy Pacific Northwest and loves its mild climate for year-round growing. In her spare time, she gets her hands dirty as often as she can and loves preparing and sharing the bounty of her garden with her family and friends.

Elizabeth Hodges Snyder is an assistant professor of public health and the Master of Public Health Program coordinator at the University of Alaska Anchorage. She also serves as cochair of the Alaska Food Policy Council (AFPC). Dr. Snyder is trained in environmental health (MPH, Global Environmental Health, Emory University, 2004) and soil and water science (PhD, Soil and Water Science, University of Florida, 2009). Her career began with a focus on environmental contaminant fate and transport and human and ecological risk assessment, but her research program and teaching agenda have since evolved to address the fields of food security and health impact assessment. She has coauthored several works on food security in Alaska; supervises graduate student projects addressing food access, availability, and utilization; and advocates for strengthened rural and urban food systems. Originally from Florida, Dr. Snyder has adjusted well to the climate of Alaska – successfully raising backyard chickens, utilizing vertical drip irrigation to produce greenhouse tomatoes, growing beautiful peonies, chasing moose out of her raised beds, and instilling in her children a love for Alaska-grown carrots made sugar-sweet in the cold soil.

Ecosystem Services from Urban Agriculture in the City of the Future

Corinne Cooley and Isaac Emery

What do we dream of when we imagine the City of the Future? Many science fiction portrayals have imagined cityscapes filled with hovercraft, immense and intricate architecture, dazzling lights and a bustlingly dense population. These technological wonderlands often neglect parks and green space, much less the concepts of urban agriculture. But researchers and visionaries are beginning to propose more and more alternative ideas for how cities of the future could embrace and integrate food production on a fundamental level. Attempts to clarify these ideas and their benefits to the humans within those cities offer a glimpse into a very different kind of a future; one where nature, sustenance, and human communities are deeply intertwined.

What Are Ecosystem Services, and How Do They Apply to City of the Future?

The language of ecosystem services provides a useful framework to discuss the benefits that might emerge in such a city. Ecosystem services build on the common economic concept of goods and services. Any ecosystem – even a human-created or influenced one, such as a farm – provides an array of services that may include but also go far beyond simply growing food or fuel. Ecosystems may clean air and regulate

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S. Brown et al. (eds.), *Sowing Seeds in the City*,
DOI 10.1007/978-94-017-7453-6_1

Fig. 1 A bee in a community garden. The borage was planted specifically to attract the pollinator (Photo by Michael McGoodwin)

temperatures, hold soil that would otherwise erode, provide sustenance to pollinators, and they are frequently central to culture and community of place (Fig. 1).

Ecosystem services are frequently broken into three major categories:

- *Provisioning*: Ecosystems provide goods such as food, feed, fuel, clean water, medical resources, ornamental resources, and so on.
- *Regulating:* Ecosystems regulate geophysical, biological, or atmospheric processes such as temperature and climate regulation, soil stabilization, water treatment, pest or invasive species control, disaster mitigation (hurricane buffering, flood control, reducing wildfire severity etc.) and so on.
- *Informational / Cultural:* Ecosystems have value directly to humans scientifically, educationally, aesthetically, culturally, spiritually, and through their direct contributions to better human health.

Different land cover types (a coniferous forest and a brackish marsh, for example) provide different ecosystem services. Conventional agriculture and urban green space have unique patterns of ecosystem services contributions, which are discussed below. In the City of the Future, a carefully designed combination of the two could provide food, water, habitat, and many other services, resulting in a healthier and more productive urban environment.

Ecosystem Services from Agriculture

All land used by humans has been at some point been converted from native land covers – sometimes in the distant past, sometimes quite recently. Agriculture has transformed the Earth's surface, with crop and pastureland now covering nearly 40 % of global land area (Foley et al. 2005). The fraction of land devoted to agriculture can vary dramatically between nations, but it is expected to continue to increase in order to meet the demands of a growing population and increasingly meat-heavy diets (Foley et al. 2005; Bank 2013). While agricultural land can provide a wide array of ecosystem services, current conventional practices go to an extreme, optimizing farmland for food provisioning to the near-exclusion of all else (Foley et al. 2005; Sandhu et al. 2010). High-density monoculture cropping may lead to very high corn or soy yields, but also leads to greatly increased erosion and runoff, the expulsion of native wildlife, greater vulnerability to pests, and many other problems. Leaving fields bare of living plants for up to 8 months per year leads to high rates of erosion and loss of fertilizers and pesticides in runoff. Fertilizer runoff from cropland leads to massive dead zones in estuaries around the world (Diaz and Rosenberg 2008). In almost all cases, converting land to 'conventional' agriculture greatly reduces the provision of all ecosystem services save those that directly result in marketable goods (Fig. 2).

A number of farming practices seek to reduce these impacts, some more successfully than others. No-till farming, practiced in a large and growing area of the United States, can reduce erosion, evaporative water loss, fuel use, and planting costs in many landscapes (Chiras and Reganold 2005). Leaving crop residues exposed, rather than tilling them into the soil, also provides habitat for wildlife. No-till

Fig. 2 A field of recently harvested lettuce in Monterey, CA (Photo by Sally Brown)

Fig. 3 Wheat growing in residue from a previous cropping is an example of no till agriculture (Photo by William Schillinger)

practices can also facilitate dual cropping or cover crops by reducing the number of passes over the field between harvest of one crop and planting of the next (Fig. 3).

In many temperate regions, growing multiple crops in a year is rare, but doing so can vastly reduce soil exposure to wind and rain erosion, improve soil quality, reduce fertilizer requirements, and in some cases provide additional income for the farmer. Organic farming, one of the fastest-growing agricultural programs in the United States and Europe, has the potential to improve soil quality, habitat and biodiversity. By reducing fertilizer application and runoff, and prohibiting the use of many toxic pesticides, organic farms have been shown to provide a broader range of ecosystem services than comparative conventional farms (Sandhu et al. 2008). Although they represent an investment of time, machinery, and financial resources, these activities can increase a range of ecosystem services from agricultural areas.

Other approaches go further still to integrate natural and agricultural systems. Perennial and polyculture agricultural systems differ from conventional practices by growing crops which continue to grow for many years without replanting, or by growing many different plant species in the same field. They can provide a much wider array of ecosystem services by maintaining biodiversity, habitat, and soil cover year-round. These systems also tend to require fewer chemical inputs and less energy-intensive farming, which reduces dependence on petroleum and other externalized ecological impacts (Brummer et al. 2011). For example, at the Land Institute, a non-profit organization in Kansas, ecologists and crop specialists work to develop a perennial polyculture of grains, legumes, and oilseeds that will require few inputs and virtually eliminate erosion and runoff (The Land Institute 2013). Rather than focusing on the developing new crops, permaculture farm systems utilize combinations of existing plants and technologies to provide a broad range of services, maximizing the self-sufficiency of each farm or homestead. Permaculture systems often integrate landscaping to maximize water recovery during droughts, renewable energy technologies, and cycle plant and animal wastes on-site to minimize costs and pollution (Permaculture Association 2013).

Polyculture systems are still rare. Many are labor-intensive, expensive, or limited to small-scale applications. Even the best large-scale organic farms still result in agricultural land that is good at producing food, but lag far behind native land cover in providing most other ecosystem services. As global populations continue to grow and demand for food and fuel continues to increase, solutions which increase food production, improve the supply of food when and where it is needed, and minimize the displacement of the ecosystems which provide vital services are becoming increasingly necessary.

Ecosystem Services from Urban Areas

Urban landscapes in their 'purest' form – buildings and streets – do not provide any ecosystem services at all. Even the most basic integration of nature, such as street trees, can make a big difference in temperature regulation, air quality, and aesthetic value. A small, tightly manicured lawn can reduce stormwater runoff in comparison with a rooftop or a patch of bare concrete. A forested hillside can protect properties above and below from erosion and landslides.

Parks and other larger scale urban refugia make an even bigger impact. In addition to playing a large and crucial role in air quality, stormwater regulation, climate regulation, and other benefits discussed above, parks play an essential role in human health and community, providing a space where people can exercise and gather together (Fig. 4).

A study done to quantify the value of urban parks in Tacoma, Washington, a city with a population of 200,000, arrived on economic values of over $20 million per year for the services provided by the parks (Christin et al. 2011). Although Tacoma's 2960 acres of parks and managed open space cover only 9 % of the city's land area, their value is greater than 10 % the city's GDP. While the integration of nature into urban settings can introduce problems, such as damage to concrete by tree roots, species that are toxic to pets, and so on, overall the consequences are overwhelmingly and quantifiably positive.

Agriculture in urban areas has the potential to provide an equal or greater value than parks or landscaped areas. Integrating agriculture in urban areas will both increase ecosystem services in urban areas while simultaneously easing agricultural pressure on native landscapes. There are other potential benefits as well. For example, integrating combined food production and wastewater management could vastly reduce the pressure of cities on the surrounding landscape (Fig. 5).

Fig. 4 Wright Park in Tacoma, WA

Fig. 5 A garden in downtown Seattle. Raised beds were filled with a biosolids compost (Photo from Kate Kurtz)

Reduced energy and fuel consumption and greater land availability for wildlife habitat (both integrated with and external to urban green spaces) could minimize indirect land use change effects. As the global population grows, and becomes increasingly urban, massive investments in infrastructure loom. When the values of ecosystem services are considered, directing those investments to integrated urban agricultural systems could generate vast returns.

Combined Urban/Agricultural Landscapes

Many cities have already begun integrating agriculture into urban landscapes, privately and publicly. Homeowners cultivating kitchen gardens and fruit trees in their own yards is nothing new, and many of the recent developments in urban agriculture echo the strategies developed early in the twentieth century to supplement national food supplies during the first and second world wars (Brown and Jameton 2000). Food can be grown at a wide range of scales, by individuals, families, and public or private organizations. Apartment dwellers without yards may turn to window boxes or potted plants on balconies or windowsills, neighbors can work individual or collaborative plots in community gardens, and entrepreneurial urban farmers can transform vacant lots into farms. Long wait lists for community garden plots through programs in the US and the UK show the popularity of urban agriculture (Fig. 6).

Fig. 6 An apple tree grown on a parking strip, the area between the sidewalk and the street in a residential neighborhood in Seattle, WA (Photo by Kate Kurtz)

Seattle's P-Patch program oversees hundreds of plots on over 13 acres of community garden space. Since its inception in 1973, the program has become so popular that prospective stewards must wait a year or more for a plot to become available (City of Seattle 2013). Community gardens can go beyond private patches, as well; many programs around the United States are beginning to provide a network of small urban farms on private property and vacant lots, providing food for those who work the land, the public, and donating to local food banks. Many of these organizations are in disadvantaged areas, particularly in cities which were in poor financial shape before the real estate crash of 2008. Home Gr/own in Milwaukee, D-town Farms and Earthworks Urban Farm in Detroit, and Stone's Throw in Minneapolis/St Paul are just a few of many grassroots organizations looking for a place to plant that have turned to a growing number of vacant lots with an intention to turn them from neighborhood blights to local food oases. Many of these work in cooperation with city government, to ensure agreement with city codes and cooperation of local officials. In some cases, government has taken a more active role. The City of Cleveland and Ohio State Department of Agriculture, in cooperation the USDA and local community groups, have committed funding to transform a large number of vacant lots to urban farms in a newly minted 26-acre Urban Agriculture Zone. The initial 6-acre Kinsman farm project reportedly generated over 14,000 lbs of vegetables in its first harvest in 2012 (ICIC 2013).

Redeveloping existing open space is only the beginning. When considering a forward looking urban design approach that intentionally integrates agriculture, still more possibilities arise:

Green Rooftops

Some cities have already begun experimenting with permitting for green rooftops, where plant cover contributes significantly to reducing water runoff, cleaner air, better building temperature regulation, and more (Clark et al. 2008). But creating actual rooftop gardens goes a step farther, providing a new space for growing produce that takes no additional building footprint. This can be particularly appealing for restaurants. Uncommon Ground in Chicago is already having a great deal of success with this model, which could be readily expanded in other cities (Rosenthal 2013) (Fig. 7).

Green Buildings/Complexes

Integrating urban green space and food production into architecture is a developing focus area in the green building movement. The LEED certification program, run by the US Green Building Council, encourages the use of urban green space by providing certification points for projects with native vegetation covering at least half of each site (USGBC 2005). The Living Building Challenge 2.1, a more far-reaching green building certification system, requires projects meeting site sustainability criteria to

Fig. 7 Rooftop gardens at the Uncommon Ground restaurant in Chicago, IL (Photo by Zoran Orlic www.zoranorlic.com)

dedicate a fraction of the site area to urban agriculture (ILFI 2013). While no projects have yet been certified under these relatively new and aggressive standards, other noteworthy examples of integrated urban agriculture include the headquarters of the Rocky Mountain Institute in Snowmass, Colorado, in which banana trees and other tropical plants flourish at an elevation of 6800 ft in a building with virtually no space heating and minimal water use.

Vertical or Tower Farms

Entire city structures dedicated to farming are not common yet, but ideas abound. Many ideas have been proposed to multiply the available acreage for urban farming by creating tower farms or incorporating food production into multi-story apartment or commercial buildings. In existing buildings, adding high-density, often hydroponic farm space to balconies, roofs, or abandoned structures can serve many of the functions of outdoor green space: providing food for residents, serving as a catchment for rainwater, and beautifying the area. These indoor facilities can supplement or substitute for larger outdoor gardens in areas where such space is limited or in high demand.

More extensive modifications to existing buildings, or entire skyscrapers devoted to urban farming, have also been proposed. Concept plans for high-rise farms in London, New York, and other major cities would bring large-scale, high-tech food production to the inner city, using a variety of designs to maximize the use of urban real estate and sunlight (Doron 2005). Continuous Productive Urban Landscapes (Viljoen and Howe 2005) would use a combination of existing green space, modifications to existing structures, and new architectural designs to create a network of interconnected urban gardens to provide food, reduce and absorb stormwater runoff, and improve the effectiveness of existing urban wildlife habitat by connecting previously fragmented open space. The Vertical Farm project through Columbia University seeks to design a spiral tower farm which would integrate water treatment and re-use, composting and nutrient cycling, and energy production. The Vertical Farm could protect crops from disastrous weather, dramatically reducing many of the risks associated with farm operations, reducing fossil fuel use, and providing high-calorie and high-value crops near the point of consumption (Despommier 2010).

While many of these ideas seem highly ambitious and beyond what might currently be economically feasible, one entrepreneurial urban farm in Chicago is showing they might not be so distant after all. FarmedHere is a windowless indoor farm in a previously abandoned warehouse where specialty greens are grown in stacked aquaponic growing beds (FarmedHere 2013). Already the largest vertical farm in the United States, FarmedHere will eventually use 3.5 acres of growing space, supplying basil, arugula, and other greens "on demand" with a turnaround time of less than 1 month (Irvine 2013).

Integrated Landscapes

As city planners become more aware of the values that ecosystems can provide to cities, and as permaculture approaches for farming become better understood and more widespread, the creation and integration of multi-functional, integrated landscapes becomes more and more possible. Urban agriculture, by definition, provides food, but there's a lot more to be gained from these spaces, and when we start thinking about how to weave them into city systems, we open ourselves to more fully realizing the potential benefits this integration can offer.

The Promise: What We Have to Gain from Urban Agriculture in the City of the Future

A forested hillside park that stabilizes the property of uphill landowners, provides habitat for local species, produces berries and fruit for local families, and provides a gathering place for local children to play and learn about the land; a wetland which provides stormwater collection and filtration, and which supplies the cleaned water to a nearby community garden; a playground buffered by an orchard where native bird species congregate, and adorned by a myriad of flower species specifically chosen to attract the native pollinators that fertilize the fruit trees… more and more possibilities emerge as we begin to conceive of a City of the Future that integrates natural and human systems together (Fig. 8).

Food production is obviously an important benefit of substantially investing in urban agriculture, but when **all** potential ecosystem service benefits are included the merit of the investment becomes even clearer. We will discuss three of the major categories of ecosystem service benefits and how they can be provided by urban agriculture:

- *Provisioning*
- *Regulating*
- *Informational/Cultural*

Provisioning Services: Food Production and Beyond

Having a local source of fresh vegetables, fruits, and other products of agriculture is of course the clearest benefit of urban agriculture. This can be particularly crucial in neighborhoods that lack easy access to these foods – a problem often found in lower income areas (Whelan et al. 2002). Whether individuals or families are producing their own fresh food or having greater availability through local markets (the profit from which then is returned to the local economy of growers), the community benefits. And particularly for culturally diverse communities whose preferred foods may not be readily available from big supermarkets, locally based agriculture which they participate in or heavily inform also provides a much greater opportunity to have access to the foods connected with their cultural heritage (Redwood 2009) (Fig. 9).

This is more than just a minor supplement; focused urban agriculture can provide a major portion of a city's total food needs. Particularly when it comes to vegetables and livestock products such as milk and eggs, cities around the world have already demonstrated they can produce a significant portion of what they consume. A study done in 2006 found Chinese cities making huge strides towards self sufficiency, with Shanghai producing 76 % of its vegetable intake locally, and Beijing even more at 85 %. Meanwhile Dar es Salaam in Tanzania sourced "as much as 90 % of leafy vegetables and 60 % of milk" using urban agriculture. A recent study modeling various urban agricultural scenarios in Cleveland, estimated that the city could produce almost 50 % of its fresh vegetables and 25 % of its poultry and eggs *just by using existing vacant lots.* Adding a portion of residential yards and open rooftops into the mix put the figures at up to 100 % of vegetable needs and 94 % of poultry and eggs (Grewal and Grewal 2012). In all scenarios, they were also able to include hives to supply 100 % of the city's honey. All this is possible without any new land for agriculture, or any of the more intensive options such as vertical farms (Fig. 10).

Fig. 8 Kids and community gardens (Photos by GRuB http://goodgrub.org/)

There are other crop possibilities beyond food as well, particularly when considering more ecologically diverse or permaculture focused options for urban agriculture and its integration with other forms of green space. Historically, urban forests in Europe were specifically cultivated for the production of non food items; building

Fig. 9 Bountiful greens from a garden in Tacoma, WA

Fig. 10 Chickens in urban gardens can provide a majority of the poultry and eggs that we consume (Photo by Kate Kurtz)

Fig. 11 A bicycle based delivery of produce grown in a community garden to a food bank in Seattle, WA (Photo by Kate Kurtz)

materials, fuel, and fodder for animals (Konijnendijk 2008). In some parts of the world these kinds of uses persist to the present day (Van Veenhuizen 2006).

In a City of the Future that fully integrates urban agriculture, the city's populace would be self sufficient for a major portion of their total food consumption, including vegetables, fruit, eggs, honey, and potentially milk and poultry. With easy access to participate in the production of their own food, either as growers or as active consumers engaging with their local farmers, the exact foods grown will be directly attuned to the desires of the denizens of the city. In addition, the city's own food waste and manures can be composted in turn to fertilize its gardens and farms. And equipment and facilities needed for certain types of food production can be fueled by locally produced biodiesel using agricultural waste, non-food crops, and other forms of food waste such as kitchen oil. Food is no longer a major import, but a locally grounded cycle. The City feeds itself and its own (Fig. 11).

Regulating Services: Air, Water, and More

Simply by producing food locally to where it is consumed, urban agriculture will have a serious impact on the air quality and carbon emissions of the City of the Future. Instead of the hundreds to thousands of miles that most food travels to reach our plates, the distance shrinks to, at most, a hop from one neighborhood to another. In addition to lower transportation distance, less packaging is needed, and the entire food supply chain becomes far more efficient; one study estimates that replacing the current import-heavy food system of the UK with organic, local urban and rural

Fig. 12 A load of compost produced from municipal biosolids and yard waste, about to be applied to community garden plots in Seattle, WA (Photo by Kate Kurtz)

food production could reduce national emissions by 22 %, which amounts to 143 million tons of CO_2 per year (Doron 2005). On top of this comes the carbon sequestration from increased gardening – particularly in polyculture systems that incorporate fruit or nut trees and other perennials (Grewal and Grewal 2012). Well tended soils, amended with composts from urban feedstocks, will also reduce emissions by diverting wastes from landfills and restoring soil carbon reserves (Fig. 12).

And it's not just about carbon – all those trains, trucks and ships that are no longer bringing food into the city also no longer add to the burden of the city's air pollution. Meanwhile, every acre of green space – particularly trees, whether through agro-forestry, fruit orchards, or permaculture-oriented spaces including forest cover – will provide hundreds of dollars worth of pollution removal per year (Christin et al. 2011).

Temperature regulation is an additional benefit, particularly in warmer climes – urban green space in general, including urban agricultural space, can give shade, moderate wind, regulate humidity (Bakker et al. 2000), and overall reduce the urban heat island effect (EPA 2008), making for cooler, happier city residents both indoors and out.

Urban agriculture can reintroduce the hydrological cycle to urban areas. For example, stormwater runoff, frequently a serious problem in cities, can become a boon for urban agriculture rather than a burden for the city's infrastructure (Grewal and Grewal 2012). Rooftop gardens absorb the water before it ever reaches the ground, and earthbound urban farms and gardens retain the rain that falls on them. Well designed, integrated landscapes can include wetlands that act as stormwater sinks and drainage areas which prevent flooding of nearby homes and businesses, then provide water to nearby growers (Christin et al. 2011). Use of alternative water sources, including stormwater and greywater, for growing crops can reduce demand for potable water resources and allow for a larger portion of urban water to enter the hydrological cycle via subsurface flow.

Such integrated systems, particularly when they include native species, can also contribute to the local conservation of biodiversity (Bernholt et al. 2009) as well as providing habitat for wildlife, including pollinators (Holzschuh et al. 2008). In many cities, residential gardens are a major fraction of total urban green space. Across the UK, gardens comprise between 20 % and 47 % of green space (Loram et al. 2007). The figure varies widely between cities and countries, but in all cases gardens contribute substantially to urban biodiversity (Goddard et al. 2010).

The City of the Future, then, has cleaner air, lower emissions, a more moderate climate, fewer difficulties with water runoff and flooding, and boasts greater biodiversity. Adding these benefits on top of the locally produced food already paints a compelling picture, but further benefits can be found – those that touch us most directly in our bodies, minds, and hearts.

Cultural Services: Health, Happiness, Community

While the concrete benefits of provisioning services are clear, and the value of regulating benefits is immense, some of the most powerful benefits derived by the residents of the City of the Future from urban agriculture will be far more direct; impacts on health, happiness, and relationships with the world and one other.

It is not surprising that having direct access to fresh, healthy, nutritious food would be a benefit to physical health. This, however, is particularly crucial for lower income populations, who typically have less access to fresh vegetables and fruits, which may not be readily found in whatever markets do exist in these neighborhoods. In Seattle, a variety of community and private gardens donate hundreds of pounds of produce to “Lettuce Link”, a program which coordinates harvest and delivery of locally grown produce and seeds for distribution to two dozen food banks across the city (McLain et al. 2012) (Fig. 13).

For those citizens who participate directly in their own food production, additional health benefits arise. Community garden work tends to actually increase vegetable intake (Alaimo et al. 2008; Blaine et al. 2010), provides physical exercise (Brown and Jameton 2000), and can relax or serve as an outlet for stress, thus also improving psychological health (Kaplan 1973; Malakoff 1995). This is often particularly true for retirees and the elderly, especially those who previously lived in more rural areas (Milligan et al. 2004; Pudup 2008).

But the benefits of participating in urban agriculture go beyond personal health, into the health of the community. Studies in San Francisco and Philadelphia found that urban food gardens provided a revitalizing influence in troubled communities (Ferris et al. 2001), notably reducing theft and overt drug dealing (Malakoff 1995).

Fig. 13 A group of co-op gardeners celebrates the harvest in Tacoma, WA

And community gardening has been found to "cut across social, economic, and racial barriers and [to bring] together people of all ages and backgrounds." (Patel 1991)

Even as relationships within a community are strengthened, so too may be the relationships between these human individuals and nature itself. Direct, sensual encounters with the environment arise, and as citizens participate in the process of growing their own food, they develop their own awareness and reflections of what that means to them (Bhatti and Church 2001; Delind 2006). This process of engagement and learning can extend to children and young adults, as well; in parks today we can see models for mutually beneficial arrangements where students aid in the creation, restoration, or upkeep of shared green space, enhancing the environment of their community and learning biology and ecology in the process. The enhancement in beauty through the creation of urban gardens – particularly in contrast with urban lots going vacant and unused – is not only visually and emotionally appealing but has a material impact on property values, providing an aesthetic benefit with real economic consequence (Malakoff 1995) (Fig. 14).

Through a deep integration of urban agriculture into not only its physical layout but the fabric of its community, the City of the Future becomes more beautiful and enables its citizens to live happier, healthier, more connected lives, with one another and with the place in which they live.

Fig. 14 Neighbors get a tour of the Gallucci Learning Garden after a workshop, in Tacoma, WA

Transformative Action

Integrating urban agriculture into the City of the Future will take a dramatic shift in the paradigm of urban planning and commitment from the city's residents. Even the simplest forms of urban agriculture – residential gardens – will require a shift in expectations. In some areas, neighborhood and city codes will need to be altered to allow lawns to be replaced with vegetable gardens, and to permit the keeping of chickens or other small animals.

Current zoning restrictions often do not facilitate multiple-use properties which might produce food, process wastewater, and generate energy in addition to serving a conventional residential, commercial, or industrial function. The City of the Future will have a code system that encourages a diversity of functions, while maintaining a safe and pleasant environment (Fig. 15).

Many of the urban spaces which could most readily be converted to food production are public property – parks, rights-of-way, and the landscaping of city-owned infrastructure and utilities. Making use of these areas requires action to prioritize urban agriculture at the local level, and outreach programs to communicate the benefits of such programs. In the City of the Future, city council members, community leaders, and urban planners will have the technical, economic, and social resources to maximize the production of food and other ecosystem services from public lands.

Fig. 15 One version of the city of the future- as depicted on a mural on the side of a building in Seattle, WA (Note that the curbside strip in front of the building are being used to compost and grow food. Photo by Sally Brown)

Conclusion

Urban agriculture shows tremendous promise. Current projects in cities across the globe have provided food, reduced stormwater, pollution, and heat island burdens, and improved the physical, mental, and social health of residents through urban agriculture. The economic success of private enterprises shows the potential to transform urban spaces into productive farms.

In the City of the Future, residents everywhere will have access to farm space – on balconies, roofs, courtyards, or community plots. Homeowners with large backyard gardens will have easy access to the training and tools they need to produce a substantial fraction of their own food. Those uninterested in doing the work themselves can rent the space, or hire professional urban farmers to do all of the dirty work. These same farmers may also tend the fertile rights-of-way which connect neighborhood gardening districts, growing fruits and nut trees, berry-laden bushes, and tending grain crops.

Abandoned and disused lots do not stay empty for long. As more people move to the cities, towers rise to meet new demand, growing staple and luxury crops year-round in high-rise farms. Customers save money buying direct from a producer within walking distance, getting higher-quality produce and reducing the need for costly transportation. Utilities purchase electricity and integrate heating systems and wastewater treatment with compost and agricultural waste processing facilities, reducing their carbon footprint, increasing efficiency, and eliminating untreated overflows into nearby rivers. By reducing pressure on conventional farmers to maximize production in the face of uncertain weather, pests, and fuel prices, the City of the Future paves the way for greater protection of ecological resources around the world.

The urban farms in the City of the Future do much more than produce food. Tighter integration of food production with the rest of society allows effective cycling of nutrients, improving air and water quality; expanding urban green space brings cooler temperatures and happier, healthier citizens; reducing runoff lowers the cost of water treatment and risk of flooding; and finally, more closely connecting people with their food sources gives citizens greater understanding and control over their food, employing farmers who work directly with, and for, their neighbors.

References

Alaimo K, Packnett E, Miles RA, Kruger DJ (2008) Fruit and vegetable intake among urban community gardeners. J Nutr Educ Behav 40(2):94–101

Bakker N, Dubbeling M, Gundel S, Sabel Koschella U, de Zeeuw H (2000) Growing cities, growing food: urban agriculture on the policy agenda. A reader on urban agriculture. DSE, Feldafing

Bernholt H, Kehlenbeck K, Gebauer J, Buerkert A (2009) Plant species richness and diversity in urban and peri-urban gardens of Niamey, Niger. Agrofor Syst 77(3):159–179

Bhatti M, Church A (2001) Cultivating natures: homes and gardens in late modernity. Sociology 35(02):365–383

Blaine TW, Grewal PS, Dawes A, Snider D (2010) Profiling community gardeners. J Ext 48(6): 1–12.http://ohiostate.pure.elsevier.com/en/publications/profiling-communitygardeners(d5f06588-640a-4f22-9d7a-29ca7f152428).html

Brown KH, Jameton AL (2000) Public health implications of urban agriculture. J Public Health Policy 21(1):20–39

Brummer EC, Barber WT, Collier SM, Cox TS, Johnson R, Murray SC, Olsen RT, Pratt RC, Thro AM (2011) Plant breeding for harmony between agriculture and the environment. Front Ecol Environ 9(10):561–568

Chiras DD, Reganold JP (2005) Natural resource conservation. Pearson Education, New York

Christin Z, Batker D, Harrison-Cox J (2011) Economic impact of metro parks Tacoma ecosystem services: economic impact study phase II. Earth Economics, Tacoma

City of Seattle (2013) P-patch community gardens. Retrieved December 8, 2013, from http://www.seattle.gov/neighborhoods/ppatch

Clark C, Adriaens P, Talbot FB (2008) Green roof valuation: a probabilistic economic analysis of environmental benefits. Environ Sci Technol 42(6):2155–2161

Delind LB (2006) Of bodies, place, and culture: re-situating local food. J Agric Environ Ethics 19(2):121–146

Despommier D (2010) The vertical farm: feeding the world in the 21st century. Picador, New York

Diaz RJ, Rosenberg R (2008) Spreading dead zones and consequences for marine ecosystems. Science 321(5891):926–929

Doron G (2005) Urban agriculture: small, medium, large. Archit Des 75(3):52–59

EPA (2008) Heat island effect. Retrieved December 9, 2013, from http://www.epa.gov/hiri/
FarmedHere (2013) FarmedHere: sustainable indoor farming. Retrieved December 8, 2013, from http://farmedhere.com/2012/farmedhere-the-first-commercial-scale-indoor-vertical-farm-in-chicagoland-receives-usda-organic-certification
Ferris J, Norman C, Sempik J (2001) People, land and sustainability: community gardens and the social dimension of sustainable development. Soc Policy Adm 35(5):559–568
Foley JA, DeFries R, Asner GP, Barford C, Bonan G, Carpenter SR, Chapin FS, Coe MT, Daily GC, Gibbs HK, Helkowski JH, Holloway T, Howard EA, Kucharik CJ, Monfreda C, Patz JA, Prentice IC, Ramankutty N, Snyder PK (2005) Global consequences of land use. Science 309(5734):570–574
Goddard MA, Dougill AJ, Benton TG (2010) Scaling up from gardens: biodiversity conservation in urban environments. Trends Ecol Evol 25(2):90–98
Grewal SS, Grewal PS (2012) Can cities become self-reliant in food? Cities 29:1–11
Holzschuh A, Steffan-Dewenter I, Tscharntke T (2008) Agricultural landscapes with organic crops support higher pollinator diversity. Oikos 117(3):354–361
ICIC (2013, July 29) Cleveland urban Ag zone breathes life into vacant land. ICIC Blog. Retrieved December 9, 2013, from http://www.icic.org/connection/blog-entry/what-works-clevelands-urban-ag-zone-breathes-life-into-vacant-land/bp
ILFI (2013) Living building challenge: site. Retrieved December 2, 2013, from http://living-future.org/node/137
Irvine M (2013, March 28) In a Chicago suburb, an indoor farm goes 'mega' The big story. Yahoo News. Retreived December 8, 2013 from http://news.yahoo.com/chicago-suburb-indoor-farm-goes-062525036.html
Kaplan R (1973) Some psychological benefits of gardening. Environ Behav 5(2):145–162
Konijnendijk CC (2008) The forest and the city: the cultural landscape of urban woodland. Springer, New York
Loram A, Tratalos J, Warren PH, Gaston KJ (2007) Urban domestic gardens (X): the extent & structure of the resource in five major cities. Landsc Ecol 22(4):601–615
Malakoff D (1995) What good is community greening? ACGA Community Greening Rev 5:4–11
McLain R, Poe M, Hurley PT, Lecompte-Mastenbrook J, Emery MR (2012) Producing edible landscapes in Seattle's urban forest. Urban For Urban Green 11(2):187–194
Milligan C, Gatrell A, Bingley A (2004) Cultivating health: therapeutic landscapes and older people in northern England. Soc Sci Med 58(9):1781–1793
Patel IC (1991) Gardening's socioeconomic impacts. J Ext 29(4):7–8
Pudup MB (2008) It takes a garden: cultivating citizen-subjects in organized garden projects. Geoforum 39(3):1228–1240
Redwood M (2009) Agriculture in urban planning: generating livelihoods and food security. Earthscan, Sterling
Rosenthal J (2013, July 12) 2013 farm report. Retrieved December 2, 2013, from http://www.uncommonground.com/pages/2013_farm_report/278.php
Sandhu HS, Wratten SD, Cullen R, Case B (2008) The future of farming: the value of ecosystem services in conventional and organic arable land. An experimental approach. Ecol Econ 64(4):835–848
Sandhu HS, Wratten SD, Cullen R (2010) Organic agriculture and ecosystem services. Environ Sci Pol 13(1):1–7
The Land Institute (2013) Developing a perennial solution. Retrieved December 9, 2013, from http://www.landinstitute.org
The Permaculture Association (2013) Principles. Retrieved December 9, 2013, from http://www.permaculture.org.uk/knowledge-base/principles
The World Bank (2013) Agricultural land (% of Land Area). Data Catalog. Retrieved December 3, 2013, from http://data.worldbank.org/

USGBC (2005) LEED for new construction and major renovations version 2.2, United States Green Building Council, Washington, DC

Van Veenhuizen R (2006) Cities farming for the future: urban agriculture for green and productive cities. RUAF Foundation/IDRC/IIRR, Leusden

Viljoen A, Howe J (2005) Continuous productive urban landscapes. Routledge, London

Whelan A, Wrigley N, Warm D, Cannings E (2002) Life in a 'food desert'. Urban Stud 39(11):2083–2100

Part I
Soil and Water Resources

Soil Formation and Nutrient Cycling

Craig Cogger and Sally Brown

Soil Development, Biological Physical and Chemical Properties including Nutrients

Soil Health and Ecosystem Services

Soil is the foundation of terrestrial life – a complex ecosystem that supports plant growth and a living filter that binds and removes contaminants. Soil is also a fragile natural resource, and its mismanagement leads to lost productivity and a degraded environment. Soils play a critical role in a range of ecosystem services. These services include production of raw materials such as food and fiber, supporting natural processes including nutrient cycling, cultural services, and regulating services including waste treatment and air and water regulation (Costanza et al. 1997). Each of these can be related directly or indirectly to soil. A soils' ability to hold and store water, to transform wastes and nutrients, to store carbon (soil is the third largest carbon sink, behind oceanic reserves and fossil fuels), and to support plant growth are clear services attributed to soils (Clothier et al. 2009; Costanza et al. 1997; Doran 2002; Robinson et al. 2013). There have been recent efforts to quantify the value of soils in relation to these services. One study attributed 17 % of the gross national product of New Zealand directly to soil resources (Kirkham and Clothier 2007). The value of macropores; the larger void spaces in soils that allow for movement of water and diffusion of gas to and from the atmosphere into the soil, in soils

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S. Brown et al. (eds.), *Sowing Seeds in the City*,
DOI 10.1007/978-94-017-7453-6_2