The Potential *for* Urban Agriculture *in* New York City

Growing Capacity, Food Security, & Green Infrastructure

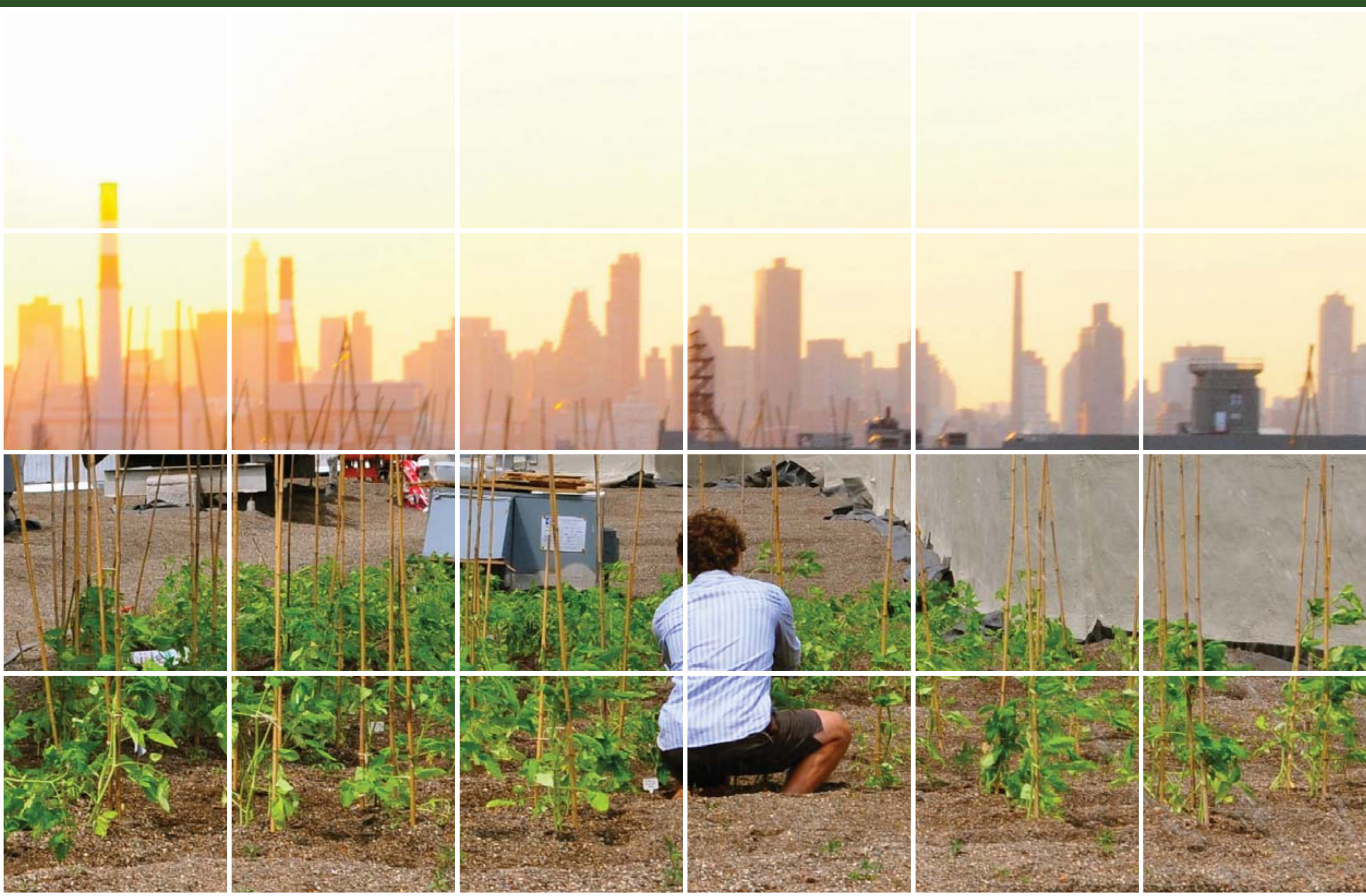

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Table of Contents

Executive Summary

With the generous support of the Doris Duke Charitable Foundation, the Urban Design Lab at the Earth Institute, Columbia University has conducted this comprehensive assessment of the potential for urban agriculture in New York City (NYC). This project is the first large-scale analysis of its kind for NYC, and while it is not definitive, we hope that the information and research will provide a baseline for understanding the critical issues related to urban agriculture in our city. The aim of this project is to outline and address a broad scope of issues that should be considered as public interest in urban agriculture continues to grow.

Study goals

There are two primary research questions that this study aims to address:

What is the capacity of NYC for urban crop production? Understanding how much land in NYC could be productively used for agriculture and horticulture, and how much could realistically be grown, are important steps toward increasing knowledge and establishing a baseline for evaluating the potential costs and benefits of urban agriculture. In this overview we considered which specific crops and products are most suitable for NYC's urban environment, and evaluated site availability for land-based and rooftop agriculture.

What are the potential benefits of urban agriculture in NYC? Ensuring that productive urban green space remains a lasting and indelible part of the urban landscape will require clear, quantitative assessments of its costs and benefits. Issues considered as part of this project include: 1) impacts of urban agriculture on food security, including an assessment of the relationship between potential urban agriculture sites and the existing "food environment," with the goal of diminishing disparities in access and improving public health; 2) Implications of agricultural land uses for stormwater runoff and combined sewer overflow (CSO) mitigation, focusing on the city's most polluted waterways; 3) impacts on energy use, including consideration of how urban agriculture could mitigate the urban heat island effect and reduce built environment energy consumption; and 4) implications for waste reduction, which include evaluations of the city's existing municipal and commercial waste streams and opportunities for composting for agricultural purposes.

Key findings in brief

- **Urban agriculture can play a critical role as productive green urban infrastructure**. There is significant potential for urban agriculture to provide critical environmental services to the city through stormwater runoff mitigation, soil remediation, and energy use reduction. At a time when municipalities are straining to address complex infrastructural challenges with limited budgets, productive urban green spaces will be increasingly important in their capacity to function as a cost-effective form of small scale, distributed green infrastructure.

- **Urban agriculture can play an important role in community development**. The benefits of urban agriculture are not limited to the provision of food, with many advocates citing community empowerment, environmental justice, public health, and education and training as primary goals. Urban agriculture can be a means of transforming underutilized or neglected space into a public resource, providing opportunities for social interaction, greater community cohesion and self-sufficiency, and engagement for young people in underserved neighborhoods.

- **There is a substantial amount of land potentially available for urban agriculture in NYC.** We have identified almost 5,000 acres of vacant land likely to be suitable for farming in the five boroughs, the equivalent of six times the area of Central Park. In addition to this land, there are many other potential sites, including over 1,000 acres of NYCHA green space, underutilized open spaces, and Greenstreets. There are also many other potentially suitable sites and properties that are not included in these designations that would greatly expand the total amount of land available for agricultural production. Each of these different types of sites would demand different approaches and strategies if they are to be deployed for agriculture. In this regard, existing data on land availability and suitability is inadequate to understand true capacity, and information on public (municipal) land is insufficiently accessible.

- **Intensive growing methods adapted to urban spaces can result in yields per acre which greatly exceed those of conventional production techniques.** More land under fruit and vegetable cultivation will be needed if the population is to shift to a healthier diet. Employing high-yield or "biointensive" production techniques characteristic of urban agriculture can contribute to this goal. Widely-practiced intensive farming techniques for small sites in urban areas, such as intercropping, intensive soil management, or hydroponic cultivation can convert underused or neglected urban space into a highly productive community asset.

- **While urban agriculture cannot supply the entire city with all of its food needs, in certain neighborhoods it can significantly contribute to food security**. There are a number of neighborhoods where a confluence of factors makes urban agriculture a particularly attractive and effective means of addressing multiple community challenges. These factors include low access to healthy food retail, high prevalence of obesity and diabetes, low median income, and comparatively high availability of vacant and other available land. These issues are all correlated, and it is in these areas where urban agriculture could have the greatest impact on food security.

- **There is a need for cost/benefit analyses that reflect the full complexity of the city's social and environmental challenges**. Unlike other forms of green infrastructure, urban agriculture has the potential to generate revenue and provide long-term employment as well as to provide environmental benefits such as decreasing stormwater runoff (both by harvesting rainwater and by increasing surface permeability). Conventional cost-benefit analyses that consider complex problems in isolation often miss potential synergistic solutions that address multiple problems at once. Urban agriculture clearly has the potential to provide such solutions for NYC.

- **NYC's rooftops are a vast, underused resource that could be transformed for food production.** NYC is one of the most advantageous places in the nation to establish rooftop agriculture due primarily to density, but also to public interest and support, access to capital, a robust transportation network, adequate infrastructure, proximity to institutions of higher education, and consumer demand. Existing green roof incentive programs have not been designed to support rooftop agriculture. Rapidly changing technologies and the skills and experience being developed by today's rooftop farming pioneers will likely make wider adoption much more feasible in the near future.

- **Bureaucratic challenges are a major barrier to the expansion of urban farming**. Uncertainties over land jurisdiction and management remain a major hurdle to prospective urban farmers. City agencies, already stretched by budget cuts, often don't have adequate capacity to provide oversight for this type of activity on their properties. Additionally, there is the added complication of using public land for commercial ventures (for farms intended as for-profit operations). Though not without precedent, these issues will need to be comprehensively addressed if more of our available public spaces are to be used for urban agriculture.

- **Existing infrastructure has the potential to support the expansion of urban agriculture**. There are substantial opportunities to take advantage of underused existing refrigeration, food processing, and distribution infrastructure within NYC, which are all critical to delivering food from the urban farm to the consumer. Churches, schools, and other institutions often have kitchen and refrigeration facilities that are not always in use, and assessing such resources and developing alternative networks for their use would assist in the expansion of agricultural activity in the city.

- **Urban farmers are establishing viable businesses by taking advantage of multiple revenue streams**. While farming in cities remains a challenging and low-profit margin activity, enterprising urban farmers are developing multiple-revenue stream models to adapt to urban conditions. In addition to selling food directly to the public, farmers have developed direct marketing relationships with restaurants and institutions, initiated revenue-generating education and training services, and can profit from the environmental services they are providing, such as tipping fees for collecting compostable waste.

- **Urban agriculture is part of a broader horticultural approach to urban greening that encompasses more than fruits and vegetables**. The capacity of the city for agricultural production includes the cultivation of non-crop food products to take advantage of the diversity of environments and urban fabric types that exist in NYC, including such products as honey, chickens, and fish. All of these approaches have proven successful in urban areas and can be symbiotically incorporated into more conventional fruit and vegetable production methods. Additionally, the production of non-food crops such as flowers and raw materials could allow for the economic and environmental benefits of urban horticulture to be more widely distributed to sites that are not suitable for food production.

- **Urban agriculture functions as a catalyst for larger food system transformations**. Urban farmers are developing vital connections between urban and rural communities. Already urban farms in the city are providing such linkages, particularly in low-income neighborhoods, by doing such things as inviting rural farmers to participate in and supplement their community-based farmers markets, providing a customer base for both the urban and rural farms simultaneously.

Next Steps

As is apparent from this research, urban agriculture in New York City is an integral component of larger environmental and social systems that will warrant more in-depth analysis. Clear opportunities are emerging from this project and work of others on this topic. The issue of how productive green spaces contribute to the city's social, economic, and environmental well-being by providing food, opportunities for community engagement, and critical environmental services is one that the UDL is committed to exploring beyond the scope of this project. The potential for enhancing the connections between emerging alternative urban and rural food systems is of particular interest, and should include the establishment of connective producer networks to assist with marketing and consumer outreach, assisting farmers markets and other programs which bring together urban and rural producers with urban consumers, and research and advocacy to articulate the links between urban and rural land use and land access issue for farmers. There are also ample opportunities for the development of community-based food access and land availability assessments to develop action plans for urban farming and gardening. All of these efforts will contribute to a greater understanding of the role of urban agriculture in a global context, including assessments of the potential benefits and drawbacks of establishing urban food production in the face of volatile commodity prices, rising fuel costs, and global climate change. The UDL is currently working on research to enhance understanding of the energy implications of controlled-environment agriculture on rooftops and in urban settings, which we believe will be a valuable contribution to the state of knowledge.

Urban agriculture has the capacity to address a variety of issues which are seen as critical to the ongoing sustainability and livability of our urban environments: public health, healthy food access, green space, air and water quality, economic development, and community engagement. It represents a tangible, accessible opportunity for city residents to become involved in issues of food provenance and food security, and functions as a "catalyst" to spur systemic changes to the food system and a culture of consumption that is increasingly viewed as untenable. As interest in urban agriculture continues to flourish, it is clear that different site conditions will require a wide variety of approaches to ensure that potential interventions adequately address the immediate and long-term needs of the communities within which they are located as well as broader goals for the city and region. The Urban Design Lab looks forward to continuing to contribute to this critical issue in the future through research and participation in a continuous and evolving dialogue.

I. Introduction

What is urban agriculture?

Urban agriculture is defined as growing food within cities. This simple definition, however, belies the complexity of the practice. The distinctions between horticulture, agriculture, and gardening are blurry. While there are over 500 community gardens in New York City, most people familiar with the issue would identify between 15 and 30 "farms," depending on the definition of the term. A distinction is often made on the basis of scale, though in NYC's dense neighborhoods this criterion is less useful as farmers are creatively transforming small lot and roof areas into surprisingly productive spaces. For the purposes of this report, we are defining a farm as a centralized operation dedicated primarily to producing food (or other agricultural products) for sale or donation. Most urban farmers view food production as only one of the goals of their operation, with community engagement, environmental justice, public health, education and training, and environmental services being other major motivations that are often cited. The term can encompass many different approaches to food production, including ground-level farming, rooftop farming, hydroponics, and greenhouses, as well as a variety of foodstuffs not typically included under the rubric of agriculture, such as aquaculture (fish), apiculture (beekeeping), and mycoculture (mushrooms). Additionally, plant cultivation in urban areas can incorporate non-food items with economic or infrastructural value, and there is increasing interest in commercial-scale cultivation of non-food crops in urban areas, such as flowers, raw materials (e.g. bamboo), and biofuels. There is also a recreational aspect to urban agriculture and horticulture, which is an important component of the NYC Dept. of Parks and Recreation's activities in the field as well as that of community gardens. This project will consider many of these approaches and factors. With all of the important work being done on community gardens in NYC, we are focusing primarily on urban farms, although we are maintaining an inclusive approach and are considering a variety of strategies to maximize the productivity and value of the contested commodity that is space in NYC.

Why urban agriculture now?

The idea of growing food in cities is by no means a new one; agriculture has been practiced in urban areas for millennia, often out of necessity or to provide a modicum of food security to protect against sudden food shortages attributable to drought or siege. Given that these are not factors which modern cities in the developed world typically need to contend with, the growing interest in urban agriculture can be attributed to other factors. The last few years have witnessed a veritable explosion of interest in all things related to urban agriculture in NYC and nationally, with exponentially more events, talks, symposia, etc., dedicated to urban agriculture, and increasing interest among young urban residents in particular. A quick review of the media environment demonstrates that it is increasingly being featured in mainstream print journalism and is being heavily covered by the online blogosphere. Why this sudden surge of attention?

Urban agriculture is undergoing a renaissance due to a confluence of factors. Most importantly, it lies at the nexus of a variety of issues which are seen as critical to the ongoing sustainability and livability of our urban environments: public health, healthy food access, green space, air and water quality, economic development, and community engagement. Urban agriculture represents a tangible, accessible opportunity for city residents to become involved in issues of food provenance and food security and to reconnect with a food system that many feel is somehow out of their grasp, with most food produced and processed hundreds or thousands of miles away and somehow miraculously appearing on the supermarket shelves for our consumption. Urban agriculture therefore functions primarily as a "catalyst" to spur systemic changes to the food system and a culture of consumption that is increasingly viewed as untenable. Additionally, urban agriculture is consistent with and is being bolstered by new approaches to urban design and development, which emphasize diffuse, informal, community-based initiatives, open space, green space and "soft edge" interventions over centralized master planning schemes. It embodies an understanding of urban environments, characterized by the landscape urbanism movement, which seeks to integrate cities into a continuous, productive landscape of ecosystem services to address food, water, soil, air, and human and animal environments comprehensively. This new conception of infrastructure as being inclusive of agriculture and other small-scale, dispersed approaches to the provision of critical services constitutes a radical departure from conventional urban planning. According to this line of thinking, all space must be evaluated according to existing or potential productivity, such that assessments of whether or how to develop a particular sites hinge not strictly on immediate economic benefits to the city or developers but considers the full range of costs and benefits to the community as a whole in terms of health, environment, and economy.

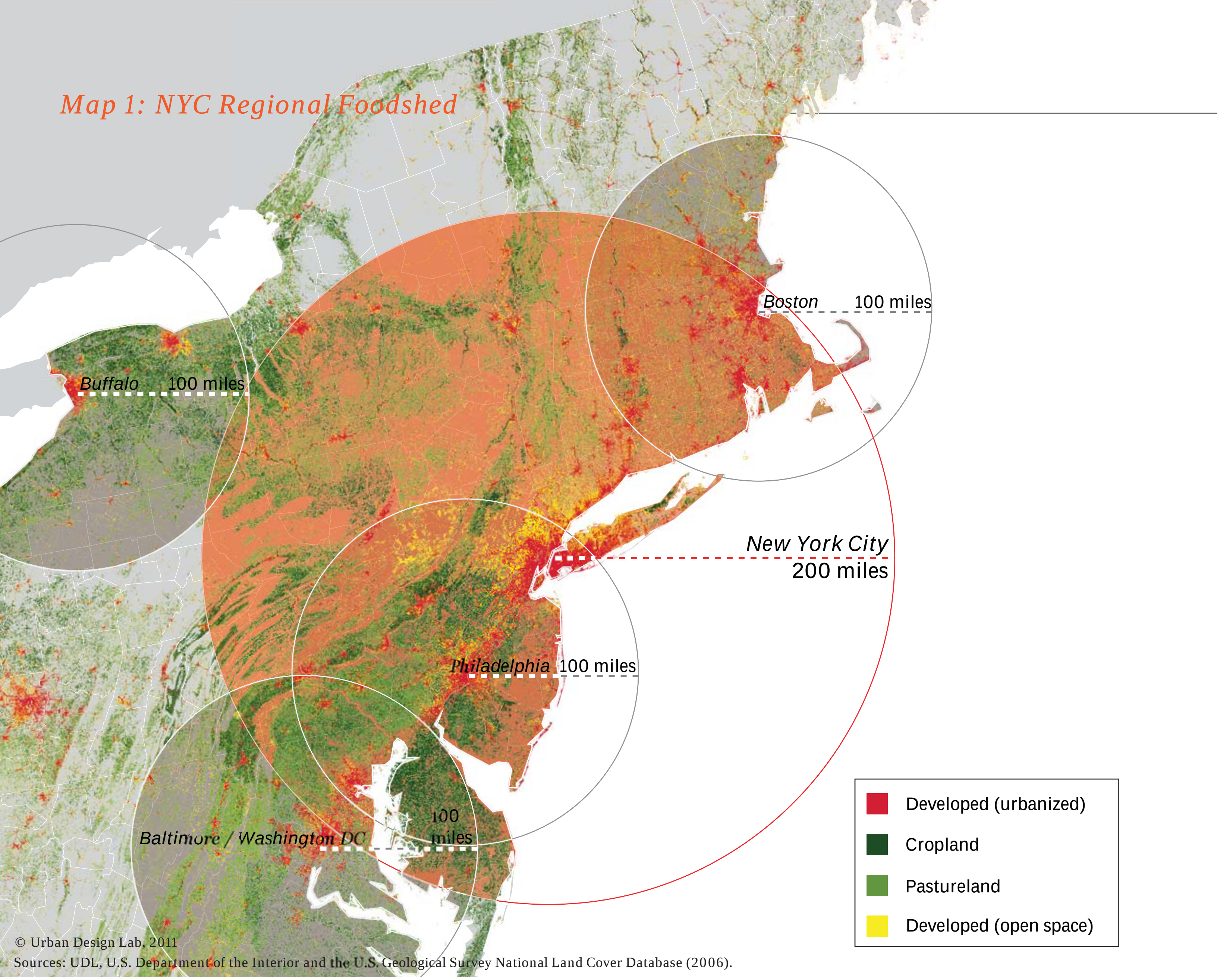
Additional support for urban agriculture is arising due to growing concerns over the capacity of the existing food system to continue to adequately supply our population centers with food in the future, given the many uncertainties surrounding the U.S. and the global economy, fossil fuel availability and prices, and climate destabilization. These concerns, along with the troubling trends of water depletion, fertilizer resources shortages, depletion of fish stocks, soil nutrient loss, and increasing population and consumption, have led many to conclude that urban agriculture is part of range of solutions that will contribute not only to the "livability" of urban areas but to their very survival.[1] Whether or not one agrees with some of the more dire predictions for what our common future holds, it is clear that we are facing very serious challenges. Urban agriculture will almost certainly increase in prominence as a manifestation of a new, emerging politics of space, fueled by the foreclosure crisis and the steady decline of the American suburban ideal, in which localism and regionalism; the reintegration of urban and rural economies; and resilience in the face of economic crises, natural disasters, and climate change are seen as central to the future of our cities.

The rapid growth of interest among the general public is attracting the attention of policymakers, some of whom recognize that urban agriculture could provide an opportunity to comprehensively address a number of interrelated problems in a potentially cost-effective manner, including the rise in chronic, diet-related diseases, unemployment, open space access, stormwater runoff, and waste. Unfortunately, among many governmental agencies, the institutional inclination to approach specific problems in isolation tends to result in cost-benefit analyses that don't consider complementary solutions, with a major challenge to an integrated approach being the difficulty of motivating various municipal agencies to effectively work together on these issues. Research projects such as this one present an opportunity to define the benefits of synergistic interventions that address several problems at once. Additionally, the urban agriculture movement is acting as a catalyst for partnerships between academics, municipal agencies, community leaders, nonprofits and farmers, and is generating new trans-disciplinary fields uniting agriculture, business, public health, engineering, architecture, planning, and media. As it becomes increasingly clear that the complexity of the issues facing urban areas in the 21st century will require unconventional partnerships and bold, creative strategies, the prospect of growing food within our cities will continue to challenge and inspire.

Why New York City?

Urban agriculture is gaining traction in many cities across the U.S. The movement is generating the greatest amount of excitement and interest places like Detroit, Cincinnati, and other Rust Belt cities suffering from decades of economic decline and population loss, where reclaiming the vast areas of vacant or abandoned land through farming is a component of renewed efforts toward revitalization. The situation in NYC, of course, is quite different. NYC is on of the highest-density U.S. cities, and has some of the nation's highest land values, making the prospect of farming in the five boroughs a more challenging proposition. On the other hand, NYC has particular advantages: the economic and cultural robustness that serve to maintain high property values are also associated with a high level of awareness and support (and potential access to investment capital) for projects that promote healthy food systems and sustainability. After all, urban farms are uniquely dependent on their surrounding communities to provide a strong customer base, and NYC's density and diverse and vibrant food culture make for an attractive context for aspiring urban farmers. NYC's industrial and manufacturing areas are highly suitable for rooftop agriculture, due to public interest and support, access to capital, a robust transportation network, adequate infrastructure, proximity to institutions of higher education, and consumer demand.[2] And despite what some might assume to be an inhospitable climate for agriculture, the five

Map 1: NYC Regional Foodshed



Sources: UDL, U.S. Department of the Interior and the U.S. Geological Survey National Land Cover Database (2006).

boroughs have a rich farming history, with Queens and Kings counties being among the most productive agricultural counties in the nation in the late 19th century, all before the advent of advanced season-extension techniques.[3] As with other urban areas, the demise of localized production began with the advent of modern food transport technologies such as refrigerated rail boxcars, interstate trucking, and air freight, which successively promoted the nationalization and then the globalization of the food system.

Urban agriculture has the potential to help mitigate critical public health and environmental problems faced by NYC. The city suffers from higher than average rates of obesity and diabetes,[4] which are correlated to inadequate access to fresh, healthy food retail,[5] and can contribute to positive health outcomes directly.[6] The prevalence of diet-related disease has been described as an “epidemic” by city health officials and threatens to severely undermine the city and state’s long-term budgetary prospects due to increase health costs. Perhaps the most striking characteristic of the public health environment in NYC are the stark disparities between neighborhoods, corresponding to socioeconomic inequalities. This is relevant to the issue of urban agriculture because the communities that suffer the most from diet-related disease and inadequate access to healthy foods are also the areas where much of the City’s vacant land is located.

Urban agriculture is also part of a broader range of horticultural strategies which involve the creation of productive green space to directly address some of the city's most intractable environmental problems, such as the issue of combined sewer overflow into the city's waterways during periods of high stormwater runoff. The NYC Department of Environmental Protection (DEP) recently announced a $1.5 billion green infrastructure initiative to address this issue, focusing primarily on stormwater retention and increasing areas of permeable surface.[7] Nowhere in the report is urban agriculture mentioned, despite the fact that, unlike the proposals in the plan, it has the potential to generate additional revenue and provide long-term employment as well as decrease runoff (both by harvesting rainwater and by increasing surface permeability). NYC is also facing the problem of increasing energy use during the summer due to air conditioner use and higher temperatures from global climate change, exacerbated by the urban "heat island" effect caused by the concentration of heat-absorbing materials such as concrete. This too is a problem mitigated by more green space, and urban agriculture is again unique in its ability to provide these benefits in addition to being a productive use of land in its own right. Additionally, urban agriculture could decrease the environmental and economic costs of dealing with the city's waste stream by providing alternative means of disposing of organic waste through composting. Although urban farms could realistically process only a small percentage of NYC's compostable waste, as with other issues, the greatest value lies in their potential as a catalyst for promoting shifts in consciousness and behavior that could greatly amplify their otherwise modest impacts.

Of course, any claims for the benefits urban agriculture will have to be balanced against potential costs and benefits of other types of land use and development. Plans to address issues such as stormwater mitigation often focuses on determining the most cost effective solutions to isolated problems, whereas systemic approaches that address multiple public health and environmental challenges simultaneously may be more costly initially but may ultimately be of much greater benefit. Which factors are considered and how exactly they are assessed will determine the future of urban agriculture in NYC. What is certain is that with the current focus on urban agriculture the city has an opportunity to establish itself at the vanguard of a new approach to urban space. Whether policymakers will take advantage of this opportunity is largely incumbent upon the public and their continued support of this issue.

Project collaborations

As a group of experienced researchers, designers and planners within the Earth Institute, Columbia University, the Urban Design Lab (UDL) has a unique perspective and approach to the issue of urban agriculture. This project is an example of how the UDL works to integrate and synthesize cutting-edge scientific research, much of which comes directly from Earth Institute scientists, and uses a design-driven methodology to apply this knowledge to solving complex problems at the community level. The urban agriculture project also benefits from our partnerships with the Lenfest Center for Sustainable Energy (also part of the Earth Institute), the Education Center for Sustainable Engineering at Columbia, and the Stone Barns Center for Food and Agriculture. In addition, the UDL has been coordinating with the Design Trust for Public Space, whose *Five Borough Farm* project is creating a framework to evaluate and quantify the benefits of urban agriculture and develop recommendations to city supporting urban agriculture. These projects will complement each other and together will provide a full picture of current agricultural activity and future potential.

The urban agriculture project is a critical component of a far-reaching research effort underway at the UDL focusing on food systems and urbanization. In 2007, the UDL, in conjunction with the Collaborative Initiatives at MIT, received funding for a multi-year project to examine the issue of childhood obesity through the lens of design and planning. From this research emerged a number of interrelated projects at a variety of scales, aimed at addressing the complex challenges of reforming the U.S. "food environment" to promote public health and sustainability. The direct outcome of the obesity work has been a national effort to create a framework for the integration of emerging regional food systems. Due to our increasing involvement and prominence in NYC's food research and policy circles, we are also undertaking an assessment of NYC's regional "foodshed," including evaluations of production and distribution capacity and its connection to the retail environment[8] (see **Map 1: *NYC Regional Foodshed***). A component of this project, focusing on innovative agricultural production strategies and food marketing in NY's Sullivan County and its connection to the larger metropolitan area, was the focus of a recent research seminar in the Urban Design Program at the Graduate School of Architecture, Planning, and Preservation at Columbia, facilitated by the UDL and the Open Space Institute in the Spring of 2010. This research has resulted in a recently released publication entitled *Ground Up: Cultivating Sustainable Agriculture in the Catskill Region*.[9] These latter projects in particular are integrally related to the urban agriculture research, as urban agriculture is a component of a larger food system which does not stop at the city limits, but is rather a critical connection between urban and rural communities. Already urban farms in the city are providing such linkages particularly in low-income neighborhoods by inviting rural farmers to supplement their community-based farmers markets. This project is designed to contribute to a greater understanding of these connections and aims to develop interventions that will impact not only those directly involved with urban agriculture but the entire population. The UDL food systems research projects, along with our other fields of research, which include climate change adaptation and green infrastructure, are all complementary to the urban agriculture project and form an interconnected network of innovative projects to rethink the form and function of cities in the 21st century.

Notes

1. Cribb, J. (2010). *The Coming Famine: The Global Food Crisis and What We Can Do to Avoid It*. Berkeley: University of California Press.
2. Rooftop agriculture specialist Lauren Mandel conducted an (unpublished) analysis of several cities nationwide and concluded that the Greenpoint neighborhood of Brooklyn was one of the best places in the nation for rooftop agriculture for the reasons cited.
3. Linder M. and Zacharias L.S. (1999). *Of Cabbages and Kings County: Agriculture and the Formation of Modern Brooklyn*. Iowa City: University of Iowa Press.
4. Raufman, J., Farley, S.M., Olson, C., Kerker, B. (2007). *Diabetes and Obesity, Summary of Community Health Survey 2007*. New York City Department of Health and Mental Hygiene.
5. Morland, K., Diez Roux, A.V., Wing, S. (2006). Supermarkets, Other Food Stores, and Obesity: The Atherosclerosis Risk in Communities Study. *American Journal of Preventive Medicine* 30(4), 333–339.
6. Brown, K.H. and Jameton, A.L. (2000). Public Health Implications of Urban Agriculture. *Journal of Public Health Policy* Vol. 21, No. 1, 20-39
7. New York City Department of Environmental Protection. (2010). *NYC Green Infrastructure Plan: A Sustainable Strategy for Green Waterways*. NYC Environmental Protection. Retrieved from: http://www.nyc.gov/html/dep/pdf/green_infrastructure/NYCGreenInfrastructurePlan_LowRes.pdf.
8. More information on this project available on the UDL website: http://www.urbandesignlab.columbia.edu/?pid=nyc_foodshed
9. Urban Design Lab, Columbia University. (2011). *Ground up: Cultivating Sustainable Agriculture in the Catskill Region*. Retrieved from: http://urbandesignlab.columbia.edu/?pid=catskills_foodshed

There is a wide variety of approaches to urban agriculture that must be considered in the context of NYC's environmental, social, and economic conditions. These range from small scale, dispersed, homegrown or community based efforts, such as urban homesteading or community gardening, to high-tech, capital-intensive, commercial projects such as rooftop greenhouses or "vertical farming." Of course, these different approaches reflect varying if overlapping priorities: Is urban agriculture a community development and empowerment tool? Is it an untapped business opportunity and a means of creating revenue and jobs? Should it aim to provide as much food as possible for urban populations? Although most proponents would argue for all of these goals, the prioritization of these aims will lead to different answers as to which methods are most appropriate for NYC or for urban areas in general. Fortunately, the movement is diverse enough and the opportunities are such that there is room for a multiplicity of approaches. Indeed, part of the aim of this study is to demonstrate that urban agriculture should not be approached with a one-size-fits-all attitude but that communities within the same city have widely divergent conditions and needs for which different models may be suitable. That said, certain approaches fall outside the purview of this study. Private backyard farming, which could be a significant contributor to the total food supply, particularly in neighborhoods in the outer boroughs where many residents have access to such spaces, is not considered in depth, as it is difficult to analyze from a land use or policy perspective given that it is essentially a private enterprise; nor is large-scale vertical farming, which is an interesting and provocative concept which has not yet demonstrated its feasibility from an economic or environmental perspective. [1]

Most urban farms are located on previously vacant, underused, or otherwise undeveloped lots. While ground-based urban food production involves many of the same challenges faced by conventional rural farming, in that weather, pests, and other environmental factors will go a long way towards determining the quantity and quality of what is grown, urban farming involves many unique considerations as well. Land is more difficult to obtain, and costs more whether leased or owned, and leases, where they do exist tend, to be of shorter duration. The scale of the average urban farm is much smaller than their rural counterparts, and consequently higher value crops tend to be grown with more intensive farming methods. Perhaps most importantly, urban farms are often intended as community-building spaces, meant to engage the public around issues relating to food and health, the environment and social justice.

Existing urban agriculture in New York City

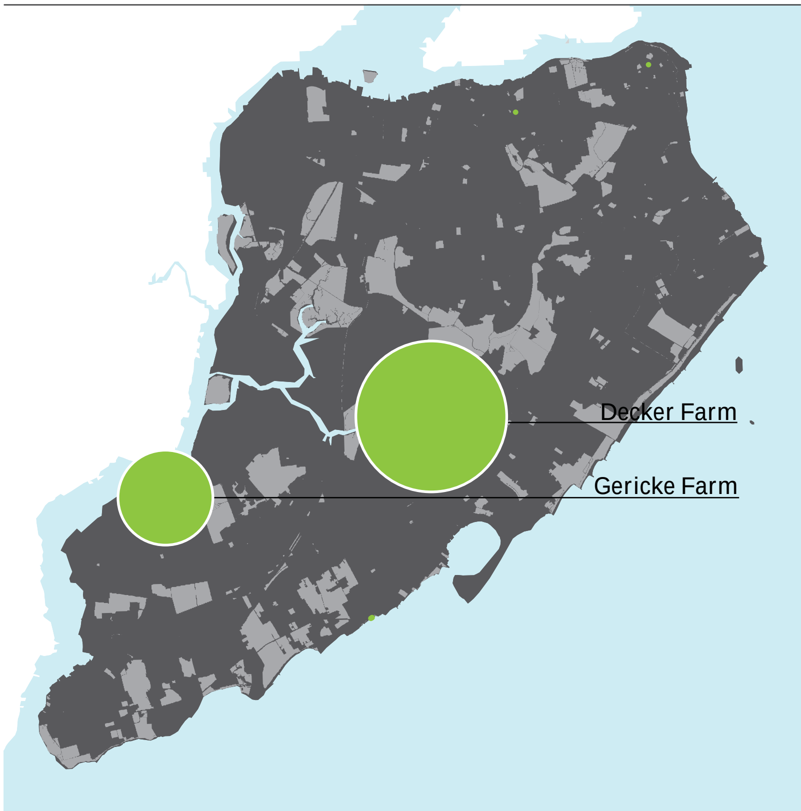
While there are over 1,000 community gardens in NYC,[2] there are between 15 and 30 "farms," depending on the definition of the term, many of which are indentified on **map 2: *Existing Farms in NYC*.** The map includes operations whose primary goal is growing food and that self-identify as farms; the distinction between a farm and a community garden is not clear cut, and in fact at least 10 of the farms on this map are community gardens. Other than the Queens County Farm Museum (the site with the longest continual agricultural designation in the five boroughs) and the farms on Staten Island, most are small- to medium-scale operations, and most are land-based, although rooftop farming is becoming established in some of the industrial zones of Queens and Brooklyn. Most of NYC's farms and community gardens can be found in the neighborhoods of East New York, Brownsville, Crown Heights, Bedford-Stuyvesant, and Bushwick in Brooklyn, the Lower East Side and East and Central Harlem in Manhattan, and Morrisania, Claremont Village, East Tremont, and Belmont in the Bronx. There is a clear relationship between concentrations of community gardens and farms in NYC and income levels, (see **Map 10: *Median Income in NYC***) which is due to the fact that many of the gardens were established with the help of Community Development Block Grants, which can only be used in low-income areas. Additionally, lower income areas have more vacant lots (see **Fig. 6**), have less access to fresh food retail and thus greater need for urban agriculture, and internal and external community development resources and engagement are more concentrated in these areas.

There are a number of organizations that support urban agriculture in NYC, including the Green Guerillas, Just Food, the New York and Brooklyn Botanical Gardens, and, perhaps most prominently, GreenThumb, which is a critical program of the NYC Dept. of Parks and Recreation whose future is currently in jeopardy due to projected funding cuts at the federal level for the Community Development Block Grant program. On a positive note, Just Food and others are establishing a Farm School NYC program to provide comprehensive training on all aspects of urban farming through a certificate program that will be an invaluable resource for knowledge sharing and skill-building among urban farmers and others interested in urban food production and community food security issues.

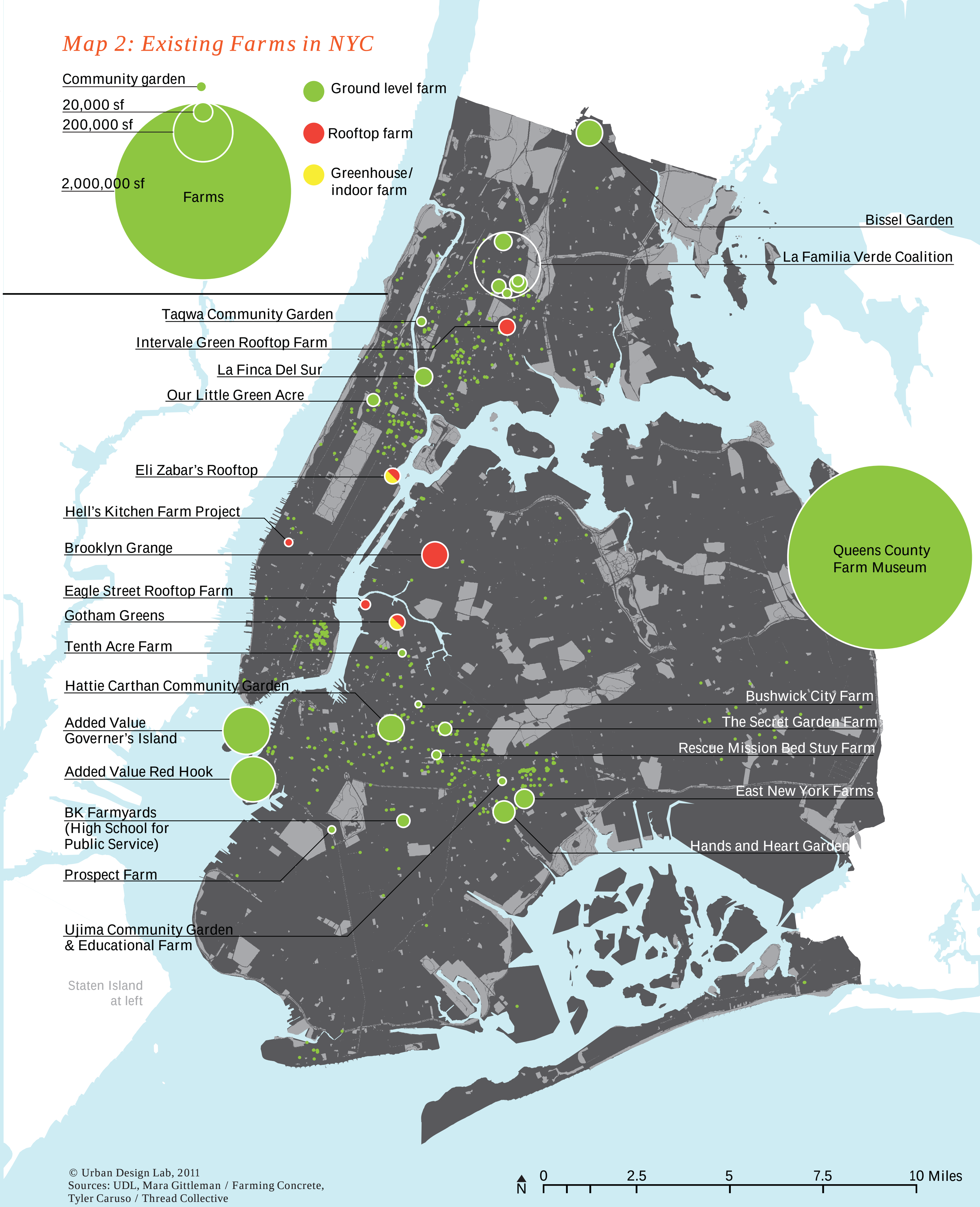
Ground-based agriculture

Ground-based food production can take a variety of forms. These include community gardens, which are grassroots institutions with varying degrees of organization. Some community gardens are dedicated to decorative or landscape gardening, although over 80% of community gardens grow food.[3] They can be loosely organized, divided into individual plots with different individuals deciding what they wish to grow (as is the case with NYC's largest community garden, the 3.25 acre Floyd Bennet Gardens), or more deliberate in their goals, with some being organized into coalitions (such as the La Familia Verde Coalition in the Bronx), and many growing enough food to feed not only their members but neighbors and members of the wider community as well. Some community gardens grow enough food to run farmers markets or supply food banks. Community gardens could be seen as providing the foundation for the urban agriculture movement, in that their proliferation and the ongoing struggles for their protection allowed for what is now a much more widespread acceptance of the role of food production in urban environments. In a city such as New York, where even during a recession development pressures remain high, it is important that such spaces be recognized for providing critical social, public health, and environmental services, and that they remain protected. The Community Garden Rules which went into effect in 2010 offer protection to gardens which are well maintained and are accessible to the public, which is an improvement over their previous status, but many gardeners are hoping for more permanent protection.

Some gardens and farms are have incorporated as non-profit organizations that farm on city-owned or donated land, such as Added Value, which operates on a Dept. of Parks and Recreation Site in Red Hook, Brooklyn, and recently started a farm on city-owned land on Governor's Island. These farms often run community supported agriculture (CSA) programs or farmers markets. A creative approach to the challenge of space for farming in the city is being pursued by BK Farmyards, which is developing a dispersed but organized network of sites which collectively supply enough food to support a CSA. Both Added Value and BK Farmyards have a strong education and training component and work directly with schools. Many urban farmers are directly involved in the development of school gardens or farms, whose educational value cannot be overstated. Not only does farming represent a hands-on application of knowledge and skills in almost all subject areas, but direct involvement in growing food can lead to lifestyle and behavior changes that can have lifelong effects not only for children but for their families as well. (For more on school gardening, see the **Site Availability** section.) These benefits are not limited to the school environment; increasingly, community centers, supportive and affordable housing organizations, and other social service institutions are looking to incorporate agriculture into their programs as a way to not only provide training and education but mental health benefits as well.



Map 2: Existing Farms in NYC



Sources: UDL, Mara Gittleman / Farming Concrete, Tyler Caruso / Thread Collective

Rooftop agriculture

The land constraints inherent to urban areas have led to the development of alternative methods of farming in urban areas, most notably rooftop farming. As mentioned previously, NYC's manufacturing districts are highly suited for rooftop agriculture, due to the number of large flat roofs combined with high land values, high density, and relatively little vacant land (discouraging on-the-ground farming). Other favorable factors include a high degree of demand and interest in local foods, high levels of available capital, proximity to schools and institutions of higher education (for research support), proximity to transportation and distribution infrastructure, and the fact that NYC is more import dependent compared to cities in the West or Midwest.

Rooftop farming presents its own set of challenges in that environmental conditions are often quite a bit harsher even just a few stories above ground, with stronger winds and sun exposure. Choosing the right soil for rooftop farming is a very complex endeavor, with nutrient contents, weight, permeability and porosity all being important factors, not to mention the challenge of getting all the soil onto a rooftop, which often requires a crane. Soil depths are often limited by the structural capacity of the roof (soil for rooftop farming can weigh up to 50 pounds or more per square foot when saturated), meaning that only relatively shallow root crops will grow and often at lower yields than with ground-based agriculture. Soil nutrients must be replenished often, as rooftop soils have little to no capacity for self-regeneration, and the combination of shallow soil and higher wind speeds makes installing trellises or tunnels very difficult. The advantages to rooftop soils include the fact that there is a much greater degree of control over potential contaminants, allowing for soil composition and nutrients to be managed quite effectively, and weeds are less likely to propagate to rooftops. Given the constraints, relatively large expanses are needed to make growing food on rooftops in a commercially viable enterprise - opinions on how much area is needed for commercial viability vary; Eagle Street Rooftop Farm has only 6,000 s.f. of growing area, though other rooftop farmers have indicated that an acre (c. 44,000 s.f.) or more is ideal. Rooftop farmers in NYC have successfully grown a wide variety of produce and are in the process of gathering valuable information on which crops do well in these unique environments. In addition to vegetables, Eagle Street Farm has chickens and bees.

The greatest issue for aspiring rooftop farmers is gaining affordable access to existing rooftop space. Property owners may be reluctant to deal with potential liability or maintenance concerns, and rooftop farming is still seen by many as a relatively untested enterprise. There remains a good deal of uncertainty regarding the long-term viability of rooftop farming, and landlords don't want to be stuck with hundreds of tons of soil on their roof and no one to farm it. Incentives for property owners could go a long way toward encouraging such activity (for more discussion of this issue, see the **Water** section of this report), and could help defray the often substantial costs associated with starting a rooftop farm. There are inherent advantages to landlords as well, including the energy savings provided by a green roof, the potential to receive rental revenue from a previously unoccupied space, and the additional distinction that comes from having a rooftop farm on a building that can lead to increased demand for units within the building. The existing rooftop farms in the city are acting as a critical "proof of concept" that will pave the way for wider acceptance on the part of property owners and are establishing important precedents for the streamlining of the permitting process at the Department of Buildings (DOB).

Controlled Environment Agriculture

Growing food in greenhouses is another approach to urban agriculture that has attracted increased interest, particularly given New York's relatively short growing season. Greenhouses range from simple structures used for seedling germination in the spring to complex environments engineered to provide optimal growing conditions year-round. This latter approach, often using hydroponic growing methods, is called Controlled Environment Agriculture (CEA). In urban areas, CEA often takes place on rooftops, not only because of the familiar challenge of land and land costs but also because greenhouses require ample access sunlight to work effectively, a condition which is difficult to find at ground-level in dense urban areas. In NYC, the largest example is Eli Zabar's rooftop farm on the East Side of Manhattan, though at least two other large scale rooftop CEA projects were in planning or constructions phases in spring of 2011: Gotham Greens in Greenpoint, Brooklyn, and Forest Houses in the South Bronx, designed by BrightFarm Systems. BrightFarms is also pioneering designs to build greenhouses directly on top of supermarket and grocery stores, eliminating any transportation (and most storage) costs.

At present, rooftop greenhouses are considered additional occupiable space that counts towards a building's Floor-to-Area Ratio (FAR) controls under NYC zoning laws, and therefore cannot be built on buildings which are already at or near their FAR limits. Proposals to exempt greenhouses from FAR controls would certainly help encourage their construction, although a workable vehicle for enforcement to ensure that such spaces are not subsequently converted or occupied for other uses would have to be developed (see the **Site Availability** section for further discussion of FAR). The cost of artificially heating a greenhouse during the winter months can be prohibitive; such costs can be defrayed if the greenhouse is able to actively or passively capture waste heat from the host building. For this reason, the most appropriate buildings on which to locate rooftop greenhouses are buildings housing activities that generate heat, including certain industrial or manufacturing buildings, but particularly kitchens and bakeries. The summer months present the opposite problem, with adequate ventilation necessary to prevent overheating. The difficulty and necessity of maintaining optimal growing temperatures mean that CEA climate control systems are almost always automated. Despite these challenges, greenhouse agriculture, and CEA in particular, has some advantages which make it well adapted for urban environments. As mentioned, rooftop greenhouses can make use of waste heat from buildings, can produce food year-round, and are well suited to vegetables such as greens for which freshness (and therefore proximity to retail and consumers) is especially important. Hydroponic growing systems can achieve much higher yields per square foot of growing area than other growing methods – double or triple the yields achieved even with intensive rooftop cultivation can be expected. The fact that such systems do not use soil means that they can be stacked or otherwise arranged in three dimensions, taking advantage of vertical as well as horizontal space, and nutrient levels applied as appropriate for each crop. Food can be grown year-round in hydroponic greenhouses, a significant advantage in New York's climate. Aquaponic systems, in which waste from tilapia or other fish raised in tubs is used to fertilize plant crops, have been developed at the High School for Food and Finance and at the rooftop greenhouse on the Manhattan School for Children on West 93rd St., indicating the potential of rooftop greenhouses to supply animal protein as well as plant-based nutrients.

If community gardens represent one approach to urban agriculture, one which emphasizes community empowerment and engagement while making full use of often limited resources, rooftop greenhouses lie at the other end of the spectrum. Because of their high initial capital costs (around $2 million for a one-acre greenhouse)[4] and by virtue of the fact that they are located on roofs which have limited public access, the development of rooftop greenhouses (and to a lesser degree, open rooftop farms) tends to be motivated more by the aim of establishing high-yield, innovate food production as a profitable enterprise in urban setting. This is not to say that there cannot be value to the community in terms of employment, and greenhouses are being effectively incorporated into science and sustainability education programs in several schools. As mentioned above, a city as large and diverse as New York can only benefit from a multitude of approaches to supplying its food needs.

Given the costs associated with their construction and operation, the commercial viability of rooftop hydroponic greenhouses depends on the production of high-value products, such as micro greens or tomatoes, which can be sold at a premium, especially in the off-season.[5] Some proponents of controlled environment agriculture cite increased yields, extended growing season, greater degree of control over nutrient levels and pests as reasons to believe that such techniques will be critical to feeding urban populations in the future, especially given concerns over soil nutrient depletion, desertification, water shortages, and climate change. Others point to the high material and energy costs of these operations (most analyses have found that growing food in artificially heated greenhouses in cold climates is more energy intensive than shipping it from warmer regions) to argue that they are unlikely to be a substantial source of food in the future. The potential for increased energy efficiency and productivity of rooftop greenhouses in urban areas that can take advantage of waste heat may alter the equation in favor of CEA. In densely populated suburban areas like New Jersey, profitable CEA ventures are becoming a well-established part of the agricultural landscape.[6] Over the next few years large-scale CEA operations will begin to supply more food to New Yorkers as well as residents of other cities, including Montreal, at which point the viability of deploying these methods at a larger scale in urban areas will begin to be better understood. Technological advances in the field combined with a rising demand for fresh produce year-round are contributing to an increasingly fertile environment for urban greenhouses, and in the near future we are likely to be seeing many more glass structures glinting on the rooftops of our cities.

Economic considerations

Agriculture is increasingly being seen as an emerging business opportunity in urban areas. While the economic challenges compared with farming in rural areas are considerable, a variety of factors are making farming in cities an increasingly viable enterprise from an economic perspective. The most significant of these is that consumers in urban areas are becoming increasingly conscious of the health, environmental, and social impacts of the industrial food system and are actively seeking alternatives.

Only a handful of existing urban farms in New York are for-profit ventures, and nearly all rely to some extent on volunteer labor or free or below-market rate rent and as such are difficult to compare with traditional businesses. Exceptions include Gotham Greens, which is completing construction on a large rooftop greenhouse in Greenpoint. In general, due to the relative novelty of urban agriculture, the economic viability of existing farms in NYC has yet to be conclusively demonstrated (studies in other locales, including Philadelphia,[7] have indicated that profitability in urban settings in the U.S. is possible, although the replicability of these examples is uncertain). This is not to say that urban agriculture is inherently unprofitable; indeed, Brooklyn Grange rooftop farm is aiming for profitability and apparently succeeding at breaking even during its first year of operation. The fact is, however, that urban agriculture is still an emerging, rapidly changing movement consisting of highly motivated, community-minded individuals for whom profit is but one of many objectives. There is in fact much to be learned from how existing practitioners have adopted creative and unconventional means of generating revenue and maintaining their operations that could be applied to other nascent community-based enterprises. These methods include direct marketing and sales at the farm, through community supported agriculture (CSA) programs, to restaurants and grocery stores, as well as grants and fees received for educational and youth development programs and job training, and leasing of land to other farmers and gardeners. Some farms have exclusive arrangements with local restaurants wherein a portion of the farm is dedicated to products requested by those establishments. These types of arrangements, in which chefs can request limited quantities of specific products, are an example of the types of opportunities that are afforded by both close physical proximity and personal relationships to the consumer/buyer that is a real advantage of urban farming. Additional programming on farms, such as tours, special events, and merchandise, all emerging manifestations of urban agritourism, are contributing to the bottom line of farms such as Brooklyn Grange as well. From the evidence it seems likely that demonstrably profitable business models will be developed by a new generation of farmers, many of whom are interested in developing businesses that are economically sustainable.

To our knowledge, farmers in NYC have not taken advantage of small business loan opportunities such as those available through the New York Business Development Corporation (although the NYBDC USDA loans are restricted to rural areas, other loans types may apply), the New York City Economic Development Corporation, or environmental justice or water protection grants available through the NYS DEP. Urban farmers may also be eligible for loans from the Farm Credit System or through the USDA Farm Service Agency. At least one farm is accepting tipping fees for accepting organic waste for conversion to compost, and while such activity now falls into a legal grey area, policy revisions could do much to encourage these types of services that could be advantageous to both the farms and the city as a whole. Establishing additional means of support would allow urban farms to benefit from the ecosystem services that they may be providing.

Urban agriculture policy

Compared with many other urban areas, NYC zoning codes are relatively permissive on urban agriculture, stipulating that farms or gardens can grow food in residential or commercial zones provided that they do not create offensive odor or dust, and that food sold from a "farm stand" must be produced on-site. Food can be grown and sold in manufacturing zones without such restrictions. Chickens and rabbits can be raised, provided they are kept in outdoor coops, and beekeeping is legal. Roosters are prohibited, as are cattle, pigs, sheep and goats (except adjacent to slaughterhouses or on farms on Staten Island).[8] Policy considerations related to urban agriculture in NYC are therefore less a matter of direct prohibition and more a question of developing incentives and programs that would help urban farmers overcome the substantial hurdles to growing food in the city. Given the number of programs already in existence to encourage other types of economic development and the potential additional health and environmental benefits of urban agriculture, there are compelling arguments for policy initiatives aimed at supporting this activity.

A number of policy documents from various city agencies released over the last few years address the issue of food systems and urban agriculture specifically, which is itself a notable measure of the degree to which this issue has entered the public consciousness. These include *Food in the Public Interest: How New York City's Food Policy Holds the Key to Hunger, Health, Job and the Environment*,[9] which was developed by the Office of Manhattan Borough President Scott Stringer in 2009; *FoodWorks: A Vision to Improve NYC's Food System*,[10] released by the New York City Council in 2010, which is a comprehensive and integrated set of food policy recommendations, many of which are aimed specifically at encouraging urban agriculture; and the 2011 update of PlaNYC from the Mayor's Office of Long Term Planning and Sustainability,[11] which includes a short section on food as a "cross-cutting topic," and includes food-related initiatives as part of other topics in the report. These documents include such recommendations as continuing protection for community gardens and encouraging urban farmers to participate in the Census of Agriculture (which would enable the release of more federal resources for agriculture in the city). Both *FoodWorks* and PlaNYC also recommend the creation of a database of city-owned property and of city-owned roofs that may be suitable for urban agriculture. This UDL report identifies public (city owned) vacant lots as well as roofs that may be suitable for urban agriculture; however, as discussed in the **Site Availability** section, there may be other types of city-owned land, such as easements, that are not covered by this study. Obtaining more detailed information on all public land would likely require each agency to do an internal audit of their properties, a mandate that has been successfully implemented in San Francisco as part of their citywide urban agriculture initiative. The importance of data accessibility is also not to be overlooked; while much of the MaPLUTO data that was used in this report is publicly accessible on such sites as the Oasis NYC map,[12] it can be difficult to use and search without the benefit of Geographic Information Systems (GIS) software. The *FoodWorks* document also addresses rooftop agriculture, recommending that FAR requirements and height restrictions not apply for food producing greenhouses on rooftops, changing the green roof tax credit to make rooftop farms eligible (for more on this issue, see the **Water** section of this report), and changing water rates and the green roof permitting process, both of which could encourage rooftop agriculture. Other proposals in the *FoodWorks* report aimed at regional agricultural production, such as expanding community supported agriculture (CSA), and tracking and encouraging regional food procurement, would be of clear benefit to growers in the city as well. This latter proposal, which sets up guidelines for city agencies to purchase food produced in New York State, has been introduced as legislation in the City Council, which is taking up the issue in 2011.[13] (See the **Recommendations** section of this report for more information on these issues.)

Notes

1. For an in-depth discussion of vertical farming, see Despommier, D. (2010). *The Vertical Farm: Feeding the World in the 21st Century*. New York: Thomas Dunne Books.
2. The exact number depends on one's definition of a community garden; various other estimates put the number at between 500 – 600, not including gardens on NYCHA property, for which there is little publicly available data. Including the more than 600 NYCHA gardens, the updated PlaNYC report states that there are over 1,000 community gardens in the city.
3. Farming Concrete. (2010). *Farming Concrete 2010 Report*. Retrieved from: http://www.scribd.com/doc/53285030/FC-2010-Report
4. Rifkin, G. (2011, May 18). Cash Crops Under Glass and Up on the Roof. *The New York Times*, p. B5.
5. Man, D. (2011). *Rooftop Greenhouses in New York City: An Economic, Environmental and Social Overview*. Unpublished independent study.
6. Clurfeld, A. (2011, May 23). N.J. farmers pioneer new technologies, spaces. *The Daily Journal*. Retrieved from: http://www.thedailyjournal.com/article/20110523/NEWS01/105230316.
7. Urban Partners. (2007). *Farming in Philadelphia: Feasibility Study and Next Steps*. Retrieved from: http://www.spinfarming.com/common/pdfs/STF_Inst._for_Innovations_in_Local_Farming_Study_Dec07.pdf
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9. Office of Manhattan Borough President Scott M. Stringer. (2009). *Food in the Public Interest: How New York City's Food Policy Holds the Key to Hunger, Health, Jobs, and the Environment*. Retrieved from http://www.citylimits.org/images_pdfs/pdfs/StringerFood.pdf.
10. New York City Council. (2010). *Food Works: A Vision to Improve NYC's Food System*. Retrieved from http://council.nyc.gov/html/food/files/foodworks_fullreport_11_22_10.pdf.
11. The City of New York. (2011). *PlaNYC Update: A Greener, Greater New York*. The Mayor's Office of Long-Term Planning and Sustainability.
12. Center for Urban Research (2010). NYC Oasis. Available at: http://www.oasisnyc.net/map.aspx
13. New York City Council. (2011). *Purchase of New York State Food*. The New York City Council, Legislative Research Center. Retrieved from: http://legistar.council.nyc.gov/LegislationDetail.aspx?ID=828460&GUID=8B484573-3BE2-4A2D-8C13-425453936D04&Options=ID%7CText%7C&Search=food

Fruit and vegetable crops

Given what many assume to be an inhospitable climate, a surprising variety of crops are being cultivated in New York City's community gardens and farms. That said, there is a limit to what can be grown, and ideal crops for NYC include products that are climate-suitable, high yield, high value, can be harvested multiple times during the season, can do well in marginal soils, and spoil quickly (giving a competitive advantage to freshness and therefore localized production). According to one farmer, using season-extension techniques makes the dormant winter season "shorter than most people imagine,"[1] and the growing season and range of crops that can be grown is somewhat expanded by the urban heat island effect (see the **Energy** section of this report). There are even anecdotes of some gardeners in the Bronx who have had success with tropical fruits in areas with particularly high heat-island indices. Many urban farmers are making use of greenhouses for germination and hoop houses or tunnels to extend the season, particularly for leafy greens, which can do well in colder weather. Rooftop greenhouses are capable of producing food year-round, often passively or actively benefiting from waste heat, and there are unexplored opportunities for capturing waste heat from adjacent buildings for non-rooftop agriculture as well.

Vegetables represent the bulk of agricultural activity in the city. Many urban farmers focus production on vegetables not only because they are well suited to urban conditions, but also because they wish to contribute to increased access to fresh, healthy foods (particularly vegetables) which are critical to addressing many of the public health problems that are affecting low income urban communities. Fruit cultivation is taking place as well. Berries are often well suited to urban conditions, being a high-value crop that spoils quickly (unless preserved), and blueberries, a hardy native plant, could do particularly well on rooftops. Fruit trees are more a challenge, at least at a commercial scale; despite doing well in sub-par urban soils, fruit trees require lots of space and maintenance. Pests are also a problem for many fruit trees, and trees often have to be sprayed to control insects. Despite these limitations, there are sites where having trees as opposed to ground crops could be an advantage, and at least one organization, Newtown Pippin,[2] is working to increase the number of apple trees in the city. Other cities such as Philadelphia[3] and Calgary[4] also have programs dedicated to fruit tree cultivation.

Legumes are being used on some farms as a natural means of fixing nitrogen in the soil, decreasing the need for synthetic or other fertilizer, though legume yields per area are generally low, and harvesting is labor intensive. Corn and other grain crops can be seen in some community gardens in the city, although the low yields and labor required for harvesting generally make such crops impractical or economically uncompetitive for larger scale production in urban areas where land values are often exponentially higher than in the large swaths of the country where such production is concentrated.

Yields and capacity

Understanding the capacity of urban agriculture to feed urban populations necessarily hinges on estimations of how much food can be grown in a given area. This is a critical question in that the viability of urban agriculture and the degree to which it is afforded political and cultural support is at least somewhat dependent on perceptions of whether it can have a significant impact on food availability and food security in urban areas. While we do our best to estimate the potential capacity of NYC to grow food, it is important to again note that producing food is but one of the many functions of urban agriculture, and that many farmers and particularly gardeners are not in the business of maximizing yields, especially if doing so could compromise or undermine other priorities. While we believe that this report will demonstrate that more land is potentially available for urban agriculture in NYC than is generally assumed, and that with intensive growing techniques a great deal of food could be produced in the five boroughs, the aim is not to suggest that urban agriculture policy or practice should necessarily be designed to maximize food production. Urban farmers and gardeners will generally strive to make land under cultivation as productive as possible while ensuring long-term soil health and maintaining sensitivity to ecological constraints and the needs and preferences of the communities within which the land is located.

Estimating potential yields is a notoriously unreliable exercise, in that there are many variables to consider, including environmental conditions (soil, water, sunlight, etc.) and growing techniques, not to mention what types of crops or food are being evaluated. The question of how much land area is needed to feed a certain population therefore has no straightforward answer, and all estimates to such effect must involve a large number of assumptions. When discussing urban agriculture, the problem becomes even thornier, as most reliable yield data is collected by the USDA and is applicable primarily to large-scale industrial farming techniques, which bear little relation to urban agriculture. Conventional farming often involves large inputs of chemical fertilizer and pesticides, tends to be highly mechanized, and benefits from economies of scale, all of which results in yields that are often argued to be higher than those for large-scale organic farming, if measured strictly by how much of any one particular product can be grown on an acre of land. (There have been multiple studies with conflicting outcomes which compare yields for conventional vs. organic farming, a contentious issue given the implications for agricultural aid and program priorities for the developing world.)[5] Not as much research has focused on potential yields in urban and peri-urban settings where agricultural activity tends to be of the small-scale and labor intensive variety. Urban farmers use highly intensive growing methods to maximize the productivity of small plots of soil, and yields per area tend to be much higher than with conventional farming. This is because space is used much more efficiently (rows can be planted close together as there is no need to accommodate tractors and other machinery, and vertical space is cultivated through the use of trellises, cages, or other supports), several harvests of multiple complementary crops are possible through intercropping, and soil fertility is often managed more extensively. Unlike large-scale conventional agriculture, which consists from large concentrations of single crops, urban farmers are often involved with creative crop planning throughout the season, which further complicates yield comparisons, as each square foot will produce yields of multiple products during the course of a year. With hydroponic growing methods, yields can be orders of magnitude higher, at least for specific crops, as the environmental and nutrient mix is carefully calibrated for maximum production, and in hydroponic greenhouses production can take place year-round. There are other ways to approach the issue of yields as well, such as by considering yields per unit of input, such as water, fertilizer, fuel, etc., and using these methods, smaller-scale, intensive growing techniques often prove to be more productive, given that the application of inputs tends to be more targeted compared to conventional agriculture. If, however, yields are measured against such factors as labor or operational costs the results may be very different.

A number of studies have evaluated crop yields from urban farming, and specific methods for maximizing productivity on small plots have been developed, including the SPIN, or Small-Plot Intensive, farming approach (essentially a distillation of widely-practiced techniques packaged and sold for accessible replicability).[6] In NYC, the *Farming Concrete* project has mapped all of the city's community gardens and is in the process of measuring how much food they produce; preliminary results indicate that 87,690 lbs. of vegetables were grown on 71,950 square feet in 67 gardens in 2010, which comes out to just over 1.2 lbs./sq.ft. of produce.[7] In Philadelphia, Dominic Vitiello and other researchers have been involved in an ongoing project to measure fruit and vegetable production in community gardens in that city;[8] Vitiello found that on some plots farmers were able to grow yields of up to 1.4 lbs. of vegetables per square foot, which is a very high yield, due to the small size of the plots in question (under 5,000 s.f.), which were producing primarily tomatoes, a highly productive vertically cultivated crop. Other, more anecdotal sources indicate that average yields of around 0.5 lbs./s.f. of a diverse array of vegetables can be achieved over larger areas using intensive production methods. Brooklyn Grange rooftop farm achieved yields of approximately 0.3 lbs/s.f. during its first year of operation (which started late into the growing season) and hopes to increase to 0.5 lbs./s.f. with some adjustments in their second year;[9] while a survey by the National Gardening Association reported that respondents (backyard gardeners) achieved an average 0.5 lbs./s.f. on food gardens (again, presumably small scale).[10] An assessment of urban agricultural potential in Oakland, CA, used a figure of 10 tons/acre for expected yields,[11] which amounts to 0.46 lbs./s.f. Several studies, including an evaluation of the production potential of vacant land in Detroit,[12] cite the book *How to Grow More Vegetables* by John Jeavons,[13] which has been a touchstone for farmers and gardeners practicing

Fig 1: Food Crop Average Yields and Estimated Acreage for NYC Retail

	Food Group	USDA / Conventional Average Yields (lbs./s.f.)	"Bio-intensive Low" Average Yields (lbs./s.f.)	Estimated NYC annual retail (x 1,000,000 lbs.)	Estimated Land area needed for cultivation: USDA / Conventional Average Yields (acres)*	Estimated Land area needed for cultivation: "Bio-intensive Low" Average Yields (acres)*
Vegetables	**Dark Green** broccoli, collard greens, escarole, kale, lettuce (leaf), mustard greens, spinach, turnip greens	0.49	0.95	210	10,983	8,671
	Orange carrots, pumpkin, squash, sweet potatoes	0.43	0.70	193	10,321	6,323
	Dry Beans & Peas dry edible beans, dry peas and lentils, lima beans	0.03	0.07	62	46,804	34,490
	Starchy green peas, potatoes, sweet corn	0.35	0.47	731	35,672	33,525
	Other Artichokes, asparagus, bell peppers, brussel sprouts, cabbage, cauliflower, celery, cucumbers, eggplant, garlic, lettuce (head), okra, onions, radishes, snap beans, tomatoes, misc. vegetables	0.60	0.83	1,120	56,140	32,406
Fruit	**Tree Fruit** Apples, cherries, figs, peaches, pears, plums	0.28	0.32	470	27,132	24,311
	Grapes	0.20	0.45	102	11,761	5,227
	Berries Blackberries, blueberries, cranberries, raspberries, strawberries	0.20	0.23	94	25,940	7,635
	Melons Cantaloupe, honeydew, watermelon	0.52	0.50	208	9,462	9,551
	Warm weather / Citrus Apricots, avocados, bananas, dates, grapefruit, kiwi, lemons, limes, mangoes, olives, oranges, papaya, pineapple, tangerines	N/A	N/A	886	N/A	N/A
Total				**4,076**	**232,215**	**162,139**

* The figures in the "total acres" column are derived by multiplying yields and estimated consumption separately for each fruit and vegetable listed (not the averages), and therefore does not correspond to the average figures. See **Appendix 1: Methodology** for data sources and more information.

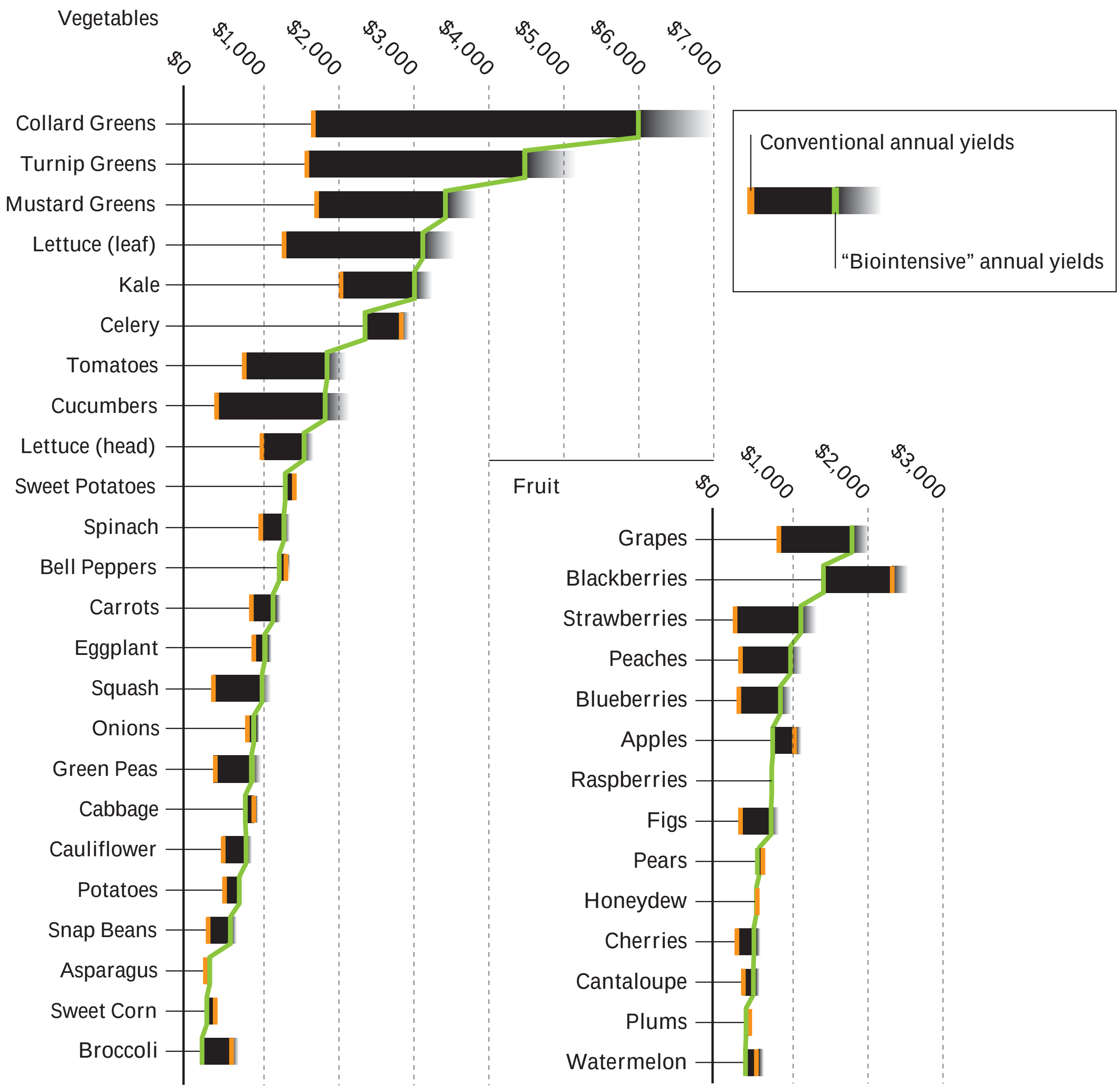
"biointensive" growing methods (organic, high-yield farming with a focus on improving soil quality) since its first printing in 1974, and has been regularly updated since. The book includes extensive charts documenting yields for a large variety of crops, and is a very comprehensive and useful resource for urban farmers. Though its utility for researchers is limited as all data is derived primarily from one site in California, the broad range of food crops included in the book makes for an interesting comparison with data on conventionally grown crops available from the USDA. ***Fig. 1: Food Crop Average Yields and Estimated Acreage for NYC Retail*** shows average yields, estimates of NYC retail purchases by crop, and land requirements for conventionally grown vegetables and fruits groups defined by the USDA and other sources[14] as compared to the "low biointensive" yields, described by Jeavons as sub-optimal soil conditions or climate, which is a fair characterization of NYC's growing conditions (figures are derived by averaging yields of all listed crops). (See the **Appendix 1: Methodology** for more on how this chart was created). Again, it must be stressed that these comparisons should not be given undue weight, given that different geographic regions are being compared and the conventional yields have a large sample size while the biointensive yields, while based on long-term experiments, have a very small sample size. Based on the anecdotal evidence, most farmers growing in New York's climate can expect yields somewhere between the USDA figures and the "biointensive low" figures, with more experienced growers approaching and perhaps exceeding the higher ranges of yields projected by Jeavons. The chart shows that dark green vegetables have some of the highest yields, averaging about ½ lb. per square foot for conventional production and almost a pound per square foot for biointensive production. The "other" vegetables category includes cabbages and celery, which are very high yield vegetables as well. These figures do not reflect other growing methods such a hydroponic, for which good data does not exist across a wide variety of crops (only certain crops are suited for hydroponic production). Hydroponic yields can be expected to be appreciably higher than the biointensive yields, not only because of the high productivity of the method but also because hydroponic systems can be arranged vertically and in other configurations to maximize use of space, which would make yield per square foot calculations almost meaningless (a more useful measure for such systems might be yields per cubic foot of greenhouse space).

Fig. 1 also includes estimates of amount of each fruit and vegetable category needed to supply NYC's retailers annually. The volume estimates indicate the amount of each food type delivered to NYC retailers to supply the population of the city, and accounts for food spoilage in stores and in the home; it does not take into account food spoilage on farms and en route to retail, as it is likely food produced on urban farms sold locally would have a lower spoilage rate than food transported from great distances. According to these estimates, the most-consumed vegetables are potatoes (574 million lbs. to retail), tomatoes (360 million lbs.) and onions and head lettuce (155 million lbs. each), while the most-consumed fruits are oranges (413 million lbs.), apples (338 million lbs.), and bananas (208 million lbs.). Figures include processed foods such as sauces and juice.

The "estimated land area" columns are calculated using the yields information and the supply data, and indicate that between 162,000 and 232,000 acres are needed to supply NYC's stores with fruits and vegetables, not including the approximately 886 million lbs. of tropical or warm-weather fruit consumed annually by New Yorkers which cannot be grown locally. It should be noted that these areas represent actual areas under cultivation; for example, a typical one-acre plot that include paths between beds, access, equipment storage, etc., may have 0.7 acres of under cultivation. For reference, NYC's five boroughs encompass about 195,000 acres (154,000 acres excluding streets and water bodies).[15] Converting all of the potentially suitable vacant land in the city (conservatively estimated at 4,984 acres; see the **Site Availability** section of this report for our methodology) to agriculture with an average growing area of 70% of lot area could supply the produce needs of approximately 174,000 people with biointensive yields, which is a substantial number but obviously not sufficient to feed the entire city. While there is much more land potentially available than just vacant lots, it is clear that NYC should not nor cannot strive to be anywhere close to self-sufficient in supplying its fruit and vegetable needs (much less all foods). For specific high value, healthful crops suited to urban farming, however, a significant portion of production could theoretically take place within the city. Crops such as beans and potatoes need a great deal of land area and are not particularly well suited to small-scale, urban production, whereas crops such as leafy greens and tomatoes may be able to be grown in large quantities in urban areas. For dark green vegetables, for example, we estimate that 8,671 acres are needed to supply NYC using biointensive growing methods, and we estimate that the approximately 360 million pounds of tomatoes consumed annually by New Yorkers could be grown on 8,260 acres. Considerably less area would be needed for these vegetables to be grown hydroponically. This means that it is plausible that with support for and expansion of urban farming, "grown in NYC" greens could be a common sight on our supermarket shelves. Of course, because one of the potential benefits of urban agriculture is its impact on consumption habits, one could hope that its increased visibility would result growing demand for fruits and vegetables (which would decrease the percentage of such foods supplied from within the city).

Fig. 2: *Potential Annual Crop Value – 1000 s.f. bed* shows potential values of vegetable and fruit crops that can be grown locally based on USDA and biointensive yields and organic prices.[16] Organic price estimates were used with the assumption that most crops grown in urban areas will be marketed at a price range that is closer to organic than conventional prices, due primarily to the price premium often associated with small-scale, sustainable pro-

Fig. 2: Potential Annual Crop Value – 1000 s.f. bed



 Sources: USDA Economic Research Service (2011), USDA National Agricultural Statistics Service (2010), Jeavons, J. (2006)

duction methods. It is important to note that while most urban food production would meet or exceed organic standards, few urban farms are certified organic; the cost and inconvenience of certification is as much a deterrent as is increasing skepticism among some farmers regarding the relevance of the organic label, particularly as it applies to urban agriculture. The prices used in the chart also do not reflect price differences between grocery stores and farmers markets (contrary to popular assumption, farmers market prices are often lower[17]),nor do they reflect the fact that farmers markets suppliers and grocers often adjust prices based on a neighborhood economic status. The chart is therefore a rough estimate intended primarily for comparative purposes; however, the indication that leafy greens are the most profitable vegetable is borne out by the accounts of many urban farmers. Leafy greens are generally high yield, nutritious, often must be consumed fresh, and can be very profitable in urban settings. On the fruit side berries are the highest value – they also spoil quickly, which can be a challenge, although they are ideal for value added processing, and often do well in difficult environments such as might be found on rooftops. Many vegetable farmers in both rural and urban areas have found that a sound business strategy is to focus on greens in the spring and fall and tomatoes during the height of the summer (while also growing an assortment of other vegetables), to ensure continuous production of high value crops. **Fig. 3: *Estimated NYC Fruit and Vegetable Demand*** shows what type of demand might be expected for various products, as well as which products are primarily purchased fresh as opposed to frozen or otherwise processed. Again, dark green and orange vegetables (as designated by the USDA) would benefit from the freshness factor, and while they are consumed in far lesser quantities than starchy vegetables, the latter are less suitable for urban environments. Furthermore, USDA dietary recommendations call for an increase in dark green and orange vegetables consumption and a decrease in starchy vegetable consumption.

Other food production

Some urban farmers are expanding their repertoire of production to include foods other than fruits and vegetables, with the aim of providing more of the necessary foods for a complete diet.

Mycoculture (mushroom cultivation)

Mycoculture is a complex science. Mushrooms can be grown in a variety of different conditions, but are particularly suited for damp, dark areas with low sunlight where other crops might not thrive. Mushrooms can be selectively paired with other food crops through mycorrhizal symbiosis, in which the fungi surround plant roots and assist with the uptake of key nutrients, as well as help protect against pests. Many types of mushrooms are grown by inoculating logs with spores. While mushrooms are a high value and highly nutritious food that could be widely adaptable to urban settings, the long gestation times (often 3- 5 years before fruiting, although some species can fruit for 5-7 years once mature) make mushroom cultivation a committing prospect. The Secret Garden Farm in Bushwick has been growing mushrooms for years and is experimenting with new methods.[18]

Apiculture (beekeeping)

Beekeeping has long been a clandestine hobby for certain dedicated New Yorkers, but as of March 2010, bees have been removed from the list of “venomous insects” whose cultivation is prohibited by the Dept. of Health, and beekeeping in New York is now an aboveground activity. Honey from bees raised in urban areas can often have fewer contaminants than honey from outside the city because of widespread pesticide use in agricultural areas,[19] and there are indications that eating honey produced near where one lives can help with allergies through a kind of inoculation effect. The benefits of apiculture go beyond the production of honey; bees are prolific pollinators and are a critical part of urban ecosystems. Bee cultivation is a way for humans to actively participate in the complex and often underappreciated symbiotic relationships that allow for other life to thrive within our overbuilt environment. Their role in urban agriculture is especially important; a study on bees in NYC found that 92% of crops grown in community gardens were dependent, to some degree, on bee pollination.[20] Challenges to more widespread viticulture in NYC include the fact that bees are still often unfairly regarded as a potentially dangerous nuisance, although that perception may also be slowly changing. Ideal hive placement is on a rooftop of a 2-5 story building, and care must be taken to ensure that the roof can support the weight of the hives.

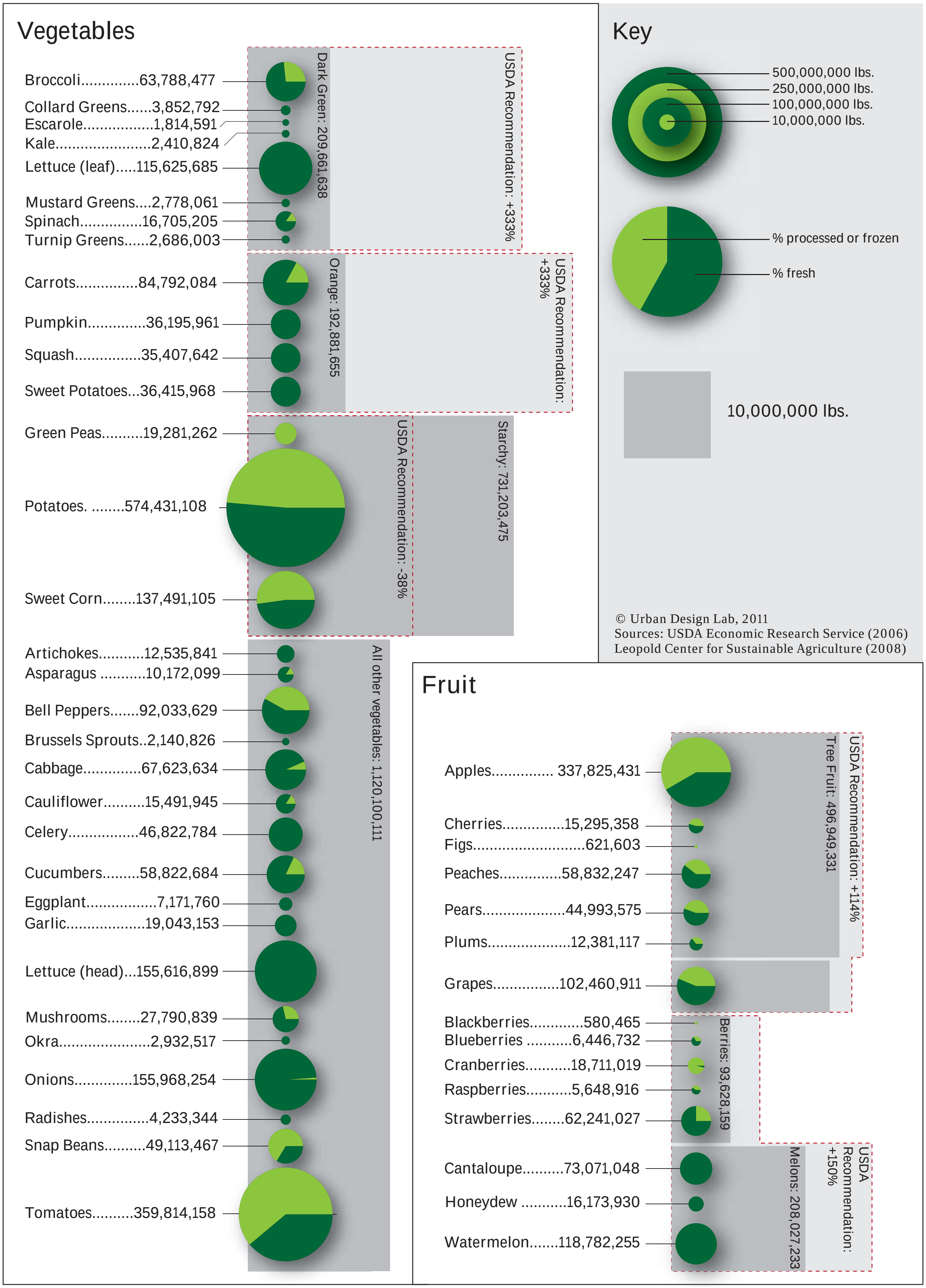
Chickens

Chickens can now be seen rooting around in several community and backyard gardens in the city and even on rooftops, in the case of the Eagle Street Farm (roosters are illegal due to noise restrictions). Besides providing eggs, which are a good source of protein and other nutrients, chickens can help fertilize soil the soil with their droppings and aerate the soil through scratching. Chickens must be kept out of certain fruit and vegetable crops, as they will eat leaves, seeds, and fruits, and must be provided coops to shelter them from the elements and from birds of prey, which are common in NYC.

Aquaculture (seafood farming)

There are several factors that are contributing to an increased interest in aquaculture, including the disastrous overfishing of the planet’s oceans, as a consequence of which many aquatic species are facing ecosystem collapse, and the environmental impacts of rising global meat consumption, particularly beef, which is very resource-intensive compared to other protein sources such as fish. Much of the fish that is available in markets today is farmed, however, conventionally farmed fish, which is often raised on a diet of wild-caught fish, is not a solution to these

Fig. 3: Estimated NYC Fruit and Vegetable Demand (lbs./year)



problems. More environmentally sustainable forms of aquaculture, most commonly involving freshwater species such as catfish, tilapia, or carp, is less resource intensive and operations can be set up indoors, making it an attractive prospect for urban or peri-urban environments. The fact that aquaculture does not require large tracts of outdoor open space, and in practice resembles a manufacturing operation more than a "farm" perhaps makes it especially attractive to proponents of economic development who would not necessarily otherwise be advocates of urban agriculture. Other advantages to growing fish in or near NYC include the freshness factor; currently, a majority of fish such as tilapia sold in New York comes from overseas.[21] Fish raised closer to the consuming public would have the advantage of not having to be frozen as well as significant savings on transportation costs. There are a number of methods of farming fish, including setting up enclosed areas within existing waterways, setting up outdoor pools or tanks, or, most suitably for cold winter environments like New York's in indoor farms. Consisting primarily of plastic tanks, indoor fish farms could be set up in large warehouse or industrial spaces, taking advantage of vacant or underutilized manufacturing infrastructure, or in building basements. In the New York area, a 40,000 s.f. operation in the town of Hudson is producing sea bream and flounder, while Professor Martin P. Schreibman is experimenting with systems that could be deployed more widely in urban areas at the Aquatic Research and Environmental Assessment Center at Brooklyn College.

A more complex and holistic approach to agriculture, called "aquaponics," is an integration of fish farming with hydroponic vegetable production in a highly-resource efficient, almost closed-loop system. Waste from the fish is processed to provide nutrients for growing vegetables, which in turn filter the water for the fish. In fully integrated aquaponic systems, cuttings from the vegetables are composted to create food for worms, which are then fed to the fish. This system, functioning as a self-enclosed distillation of ecosystem processes, requires precise calibration (and often lots of trial and error to perfect), and is especially attractive to some advocates of urban farming who are interested in community self-sufficiency because of its combination of animal and vegetable cultivation. While aquaponics has been around for a while, the development of recent larger-scale operations at in Milwaukee (including the non-profit Growing Power and the for-profit Sweet Water Organics) have led to renewed interest in the potential for aquaponics in urban areas. In NYC, a greenhouse with an aquaponic system was completed on the roof of the Manhattan School for Children, and aquaculture specialist Philson Warner, who started by raising fish in a basement in the Bronx, now directs aquaponics programs at the Food and Finance High School in Manhattan and on Rikers Island. Although aquaponic systems are relatively low-tech, they do require a fair amount of equipment and continual maintenance. The fact that the system requires little in the way of external inputs, provides a range of key nutrients (including protein), and can be adapted to a variety of urban spaces (though, unlike indoor aquaculture, sunlight or other strong light sources are needed for the hydroponic component) makes it an increasingly attractive option for those who are committed to the idea of producing a wider range of foods in urban areas.

New York Harbor was once a prime oyster growing location, before the advent pollution from heavy industry destroyed the oyster beds in New York's waterways. Over the past several decades, water quality has improved to the point where efforts are currently underway to restore oysters to the area. Oysters are capable of filtering out impurities in water and have the potential to remediate polluted waterways (provided that the water is not so contaminated as to kill them; the success of the reintroduction efforts in the worst affected water such as the Gowanus Canal are uncertain). It will likely be many years, if not decades, before oysters grown in the five boroughs will be farmed for consumption, but oyster farming may one day be a crucial part the ongoing project to restore the aquatic ecosystem of New York Harbor.

Non-food crops

Although interest in urban agriculture has spread primarily due to increased interest in food systems in general, it is important to consider the role of cultivation of productive non-food crops as an important component of urban horticulture. There are sites in the city, particularly in areas that are be heavily contaminated, that may not be suitable for food production (even raised beds on highly contaminated sites cannot prevent the potential spread of pollutants through wind-borne dust). In sites such as these phytoremediation strategies may be most appropriate (for more on this approach see the **Site Suitability** section). Other considerations regarding what types of crops are most suitable for any particular site include community support, economic factors, or opportunities for employment.

Floriculture (flowers)

While the idea of growing flowers commercially in urban areas may seem like an unlikely use of precious land resources, there may be cases where flower growing operations could be a welcome source of revenue and employment. Greenhouse and nursery products, which include flowers, are New York State's second largest agricultural commodity (after dairy),[22] and flower farms can be quite profitable, despite what can be high energy costs for year-round greenhouse production. The potential advantage of more localized flower production, other than providing more local jobs in what is a relatively labor-intensive agricultural sector, could be to provide more sustainable alternatives to conventional flowers, which are often transported by air from places operations that are have poor records on labor rights and pesticide use.

Fiber Crops and Biomaterials

There is increasing demand for alternative sources of fiber and other raw material for clothes, products, and buildings, and growing such crops can contribute to the self-sufficiency of urban areas. In most cases, the space required to grow to justify the energy and labor of cultivation, harvesting, and processing is fairly large, making these crops impractical for most small-scale urban lots. Medium or larger-scale operations could provide important sources of employment, however, that would allow for this type of horticulture to contribute to the revitalization of manufacturing districts. Fiber crops that can be grown in New York's climate include flax, hemp, kenaf, and milkweed, although all of these crops would have a limited growing season compared to areas where they are traditionally cultivated. Bamboo also can be grown in New York. Bamboo can be used as a fiber crop and is increasingly popular as a building material, particularly for flooring, as it is considered a durable and easily replenished substitute for hardwood.

Biofuels

With ongoing environmental and social crises stemming from the rising global demand for energy derived from fossil-fuels, the prospect of growing plant crops that can be converted into fuel has become more attractive. Due in part to federal subsidies for the production of fuel crops, biofuels such as corn-based ethanol are increasingly a part of our national energy portfolio. Unfortunately, biofuel production increases pressure on soil, cropland and forest land resources, contributes to global food price spikes and shortages, and in the case of corn-based ethanol, often requires more energy to produce than can be derived from the fuel. Any proposal to convert land that can be suitable for growing food into fuel production must be evaluated according to the full range of social, economic, and environmental consequences. This is not to say that biofuels are inherently unsustainable, however; there are fuel crops, such as switchgrass, which require less intensive soil fertilization than corn, and there may be situations even in urban areas where it could be appropriate to grow fuel crops. Such cases could include contaminated sites (although more research would have to be done on whether such contaminants would be absorbed by the plants and subsequently released during the process of conversion to fuel or combustion) or if a particular community decides it is in its best interest to promote biofuel production, whether for economic reasons, ecological reasons, or to promote greater self-sufficiency. Biofuel production can be a relatively small-scale, low tech operation compared to other types of fuel, and as such can contribute to the efforts to develop alternative, distributed forms of community-based urban infrastructure. In Salt Lake City, for example, large tracts of long-vacant land are being converted to safflower for biofuel.[23] In denser urban areas such as NYC, it would be more difficult to find concentrations of large sites for fuel crop production that would provide the critical mass necessary to make processing infrastructure economically viable. Additionally, in areas where food security is an issue, as is the case with NYC and most urban areas in the U.S., it would be difficult to justify cultivating fuel crops if precious land resources could be used for food production. In such areas it may be more appropriate to develop facilities for converting used cooking oil and other forms of organic waste to fuel and thus concentrate on recovering energy already embedded in our waste stream. In any case, fuel crop production cannot be discounted as a potential means of increasing local self-sufficiency and contributing to economic development in the future, particularly as technologies for conversion of organic material to fuel become more advanced and affordable at smaller scales.

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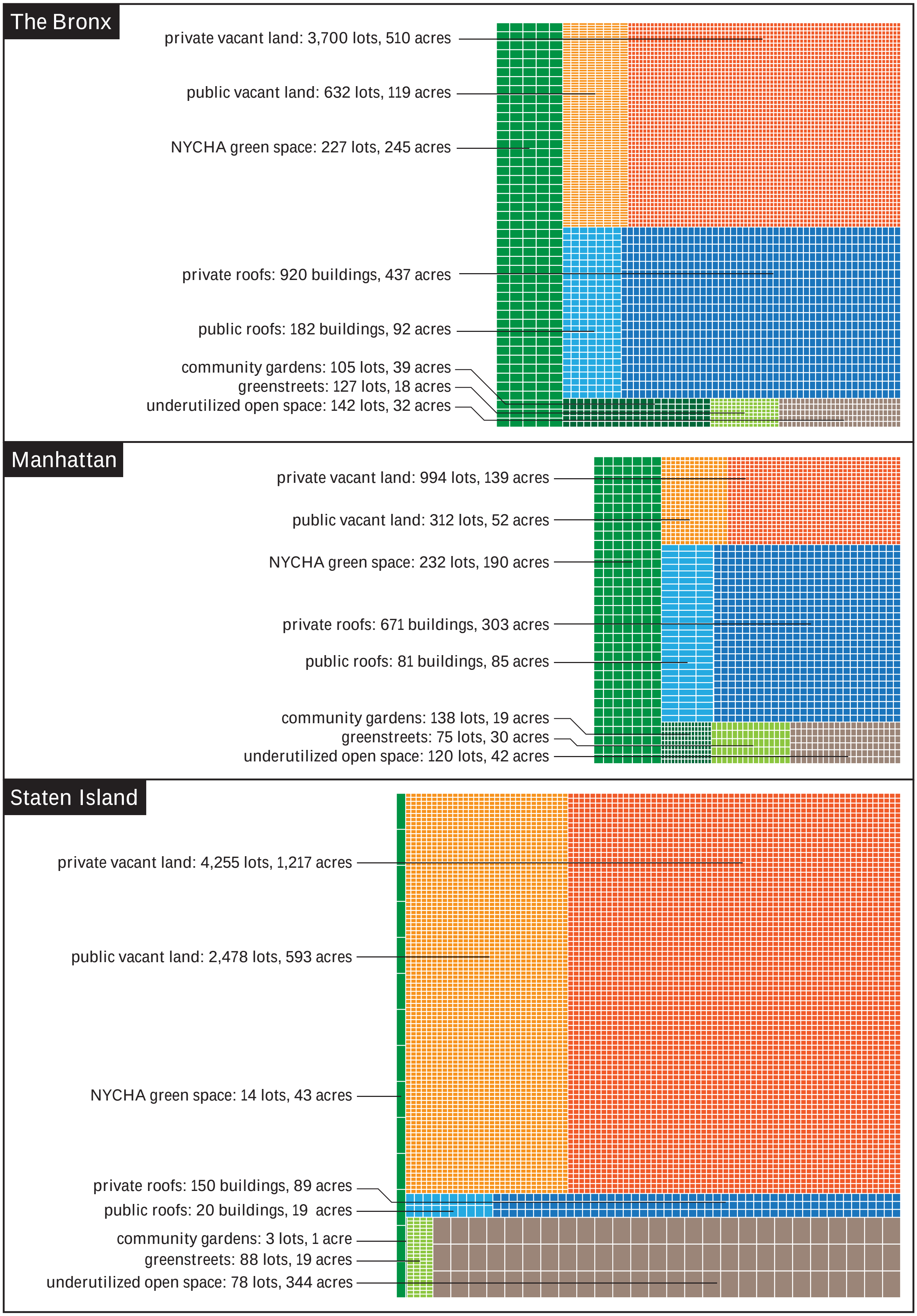
IV. Site Availability and Distribution

Given New York's Status as one of the most densely developed metropolises in the U.S., site availability and land values are primary factors limiting the expansion of urban agriculture in the city. Despite the decline in new real estate development in the city over the past few years,[1] property values in NYC remain among the highest in the nation (among cities over 1 million), and the city continues to grow.[2] NYC Department of City Planning (DCP) rezoning plans continue to focus on upzoning in a response to increasing demand for housing and commercial development, and the City's remaining underdeveloped areas will continue to dwindle in the face of increasing densification. In the near term, it is unlikely that urban farming will be able to compete with other land uses such residential development on the open market by purchasing land to farm. For any unused or underutilized space in there are often many interested parties with competing interests, including private developers in search of profit, municipal agencies or community groups wishing to increase supportive housing or other key public services, or neighborhood residents who wish to have more open space or recreational facilities. All of the above programs are vital to maintaining a livable city, and urban agriculture should not necessarily be prioritized over these other potential uses. The determination as to what types of resources are most appropriate for a community to maintain and develop ultimately depends on a complex interplay between community desires, public sector priorities, and private capital. As this report indicates, however, increasing the presence of agriculture in urban areas is compatible with many of these other interests and priorities. It can be a source of income generation and economic development, and although it may not be as profitable as other types of development, it can have a positive effect on surrounding land values, especially in low-income communities, as indicated by a study examining the relationship between community gardens and land values in NYC.[3] Urban gardening can provide opportunities for recreation and physical activity as well as increased food security, and as we discuss in the **Water**, **Energy**, and **Waste** sections of this report, it can serve as a form of green infrastructure to fulfill key environmental services functions that are the purview of the city government. For these reasons it is important that urban agriculture be seriously considered as a viable and beneficial activity, particularly in cities as dense as NYC, where the creation of such multi-functional productive spaces have significant advantages. Despite the land access challenges discussed above, there remains a substantial amount of potentially available land in the five boroughs. What follows is a breakdown of the different types of urban spaces that could be used for agriculture, including vacant lots, open space, NYCHA property, parking lots, Greenstreets, backyards, and rooftops. This is by no means a comprehensive or definitive survey of all available land: transportation and utility easements,[4] for example, are not included, nor are underdeveloped or underutilized areas that for various reasons do not fall under one of these categories. The analysis represents an attempt to come up with as accurate figures as possible for available land within the limitations of the existing data. This information, while far from complete, can begin to inform decisions that could encourage targeted approaches to the development of urban agriculture in NYC.

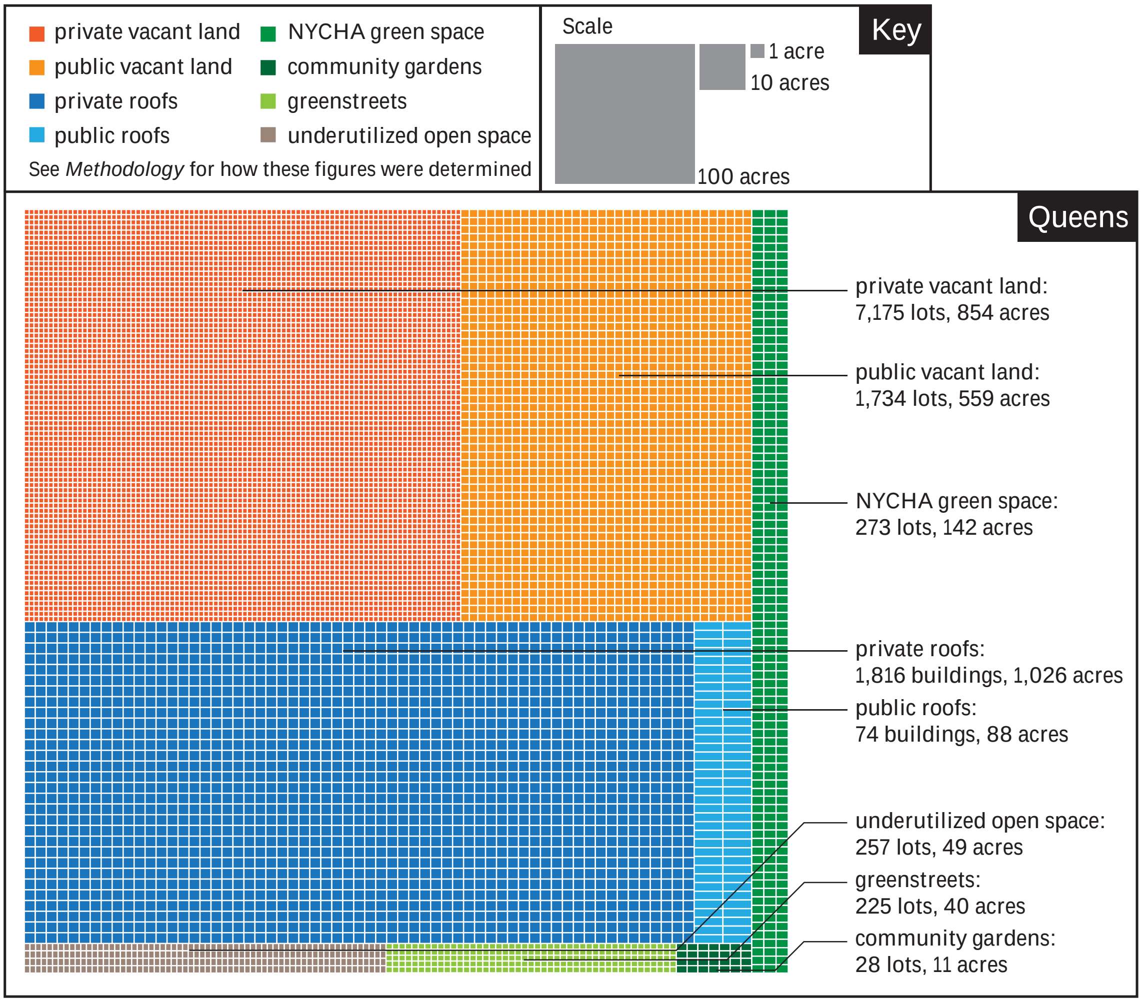
Vacant land

Broadly speaking, vacant lots are lots on which there are no buildings or which have no other currently designated use. According to the DCP MaPLUTO 2009 database, there are 8,465 acres of vacant land in NYC, of which 3,621 acres are public land, meaning that they belong to a municipal, state, or federal agency. The rest is private property. While vacant land is the City's greatest opportunity for conversion to urban agriculture, not all of the land classified as vacant is in fact available or suitable for such use. The DCP vacant land figures include many community gardens, lots that have an existing designated use, and lots that include both vacant land and existing structures. On Staten Island in particular, much of the land classified as vacant is either federally designated wetland or heavily forested land owned by the DEP. Neither of these environments are likely to be suitable for farming, due to the difficulty of establishing a farm on such sites as well as the problems inherent in converting valuable ecological resources in our urban areas such as wetland or forest to food production. After subtracting wetlands, forested areas, community gardens that are designed as vacant land, and other lots which in reality are occupied by buildings or other active uses, there remain 4,984 acres (1,663 acres of public land and 3,321 acres of private land), much of which could be used productively for urban agriculture. (continued on pg. 32)

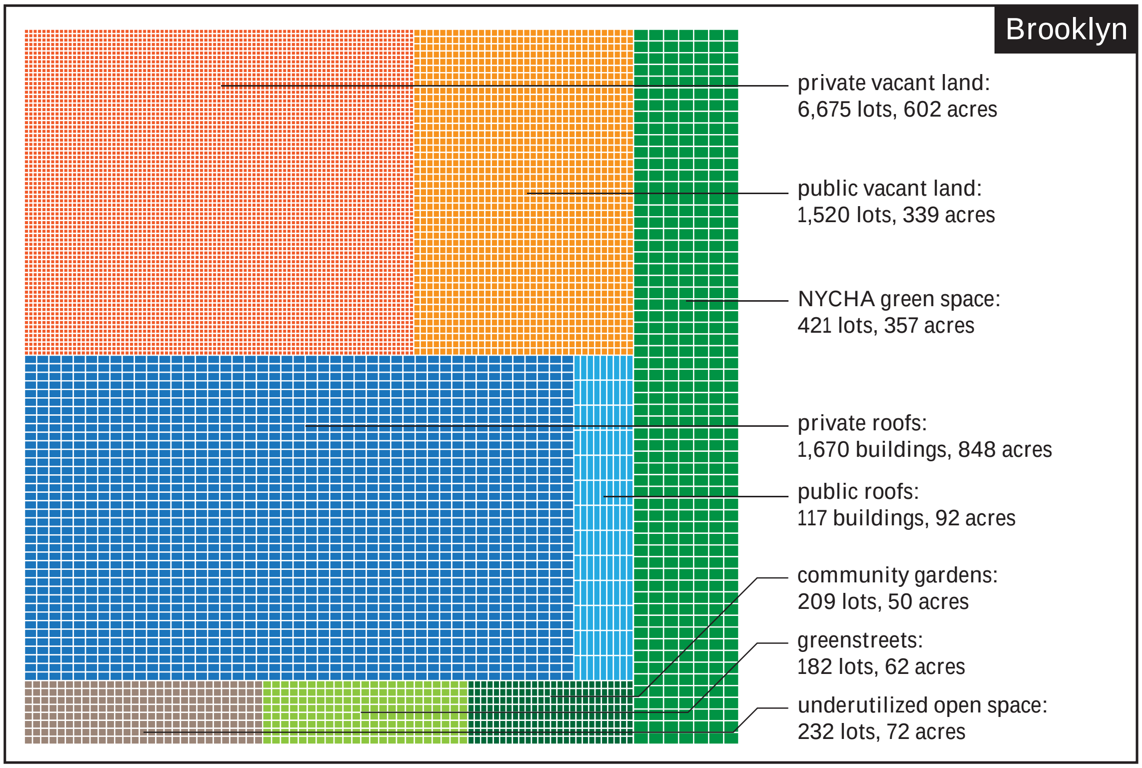
Fig. 4: Potential Available Land in the Five Boroughs



© Urban Design Lab, 2011. Sources: UDL, New York City Department of Information Technology and Telecommunications (2007), MaPLUTO © New York City Department



Central Park (scale comparison): 843 acres

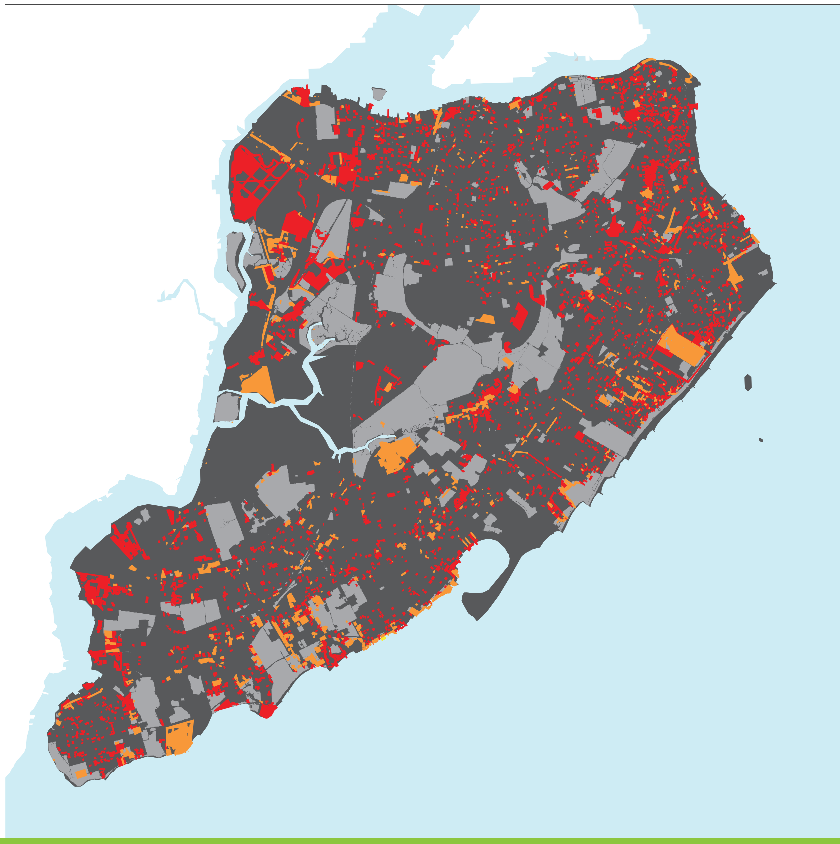


of City Planning (2009), Mara Gittleman / Farming Concrete.

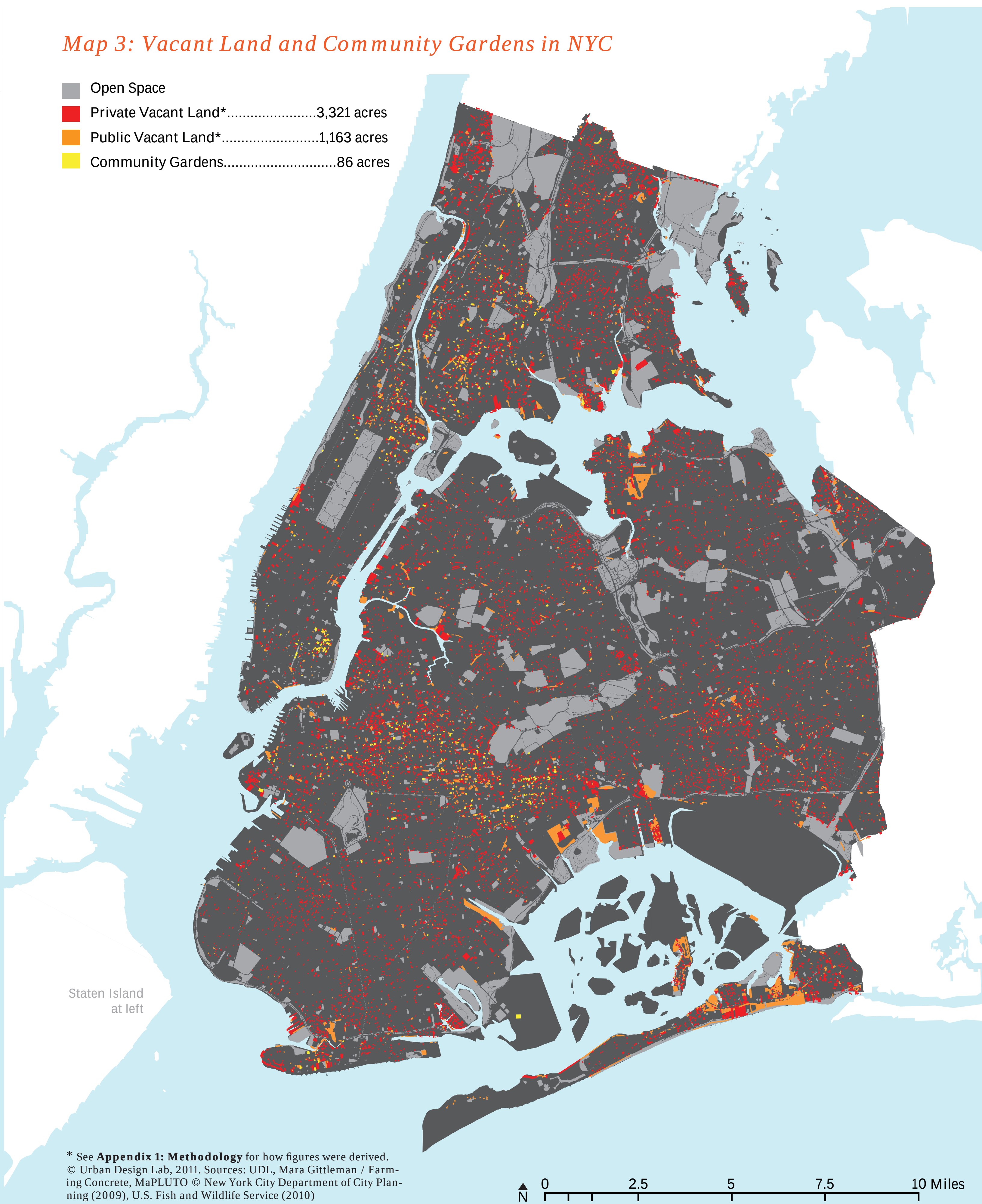
(See **Appendix 1: Methodology** for more detail.) As shown in ***Fig. 4: Potential Available Land in the Five Boroughs*** (previous pages), Staten Island has the greatest amount of vacant land by area, and Manhattan the least. The distribution of these sites can be seen on ***map 3: Vacant Land and Community Gardens in NYC***. There are many small-scale vacant sites scattered throughout the neighborhoods of Brownsville, East New York, and Crown Heights in Brooklyn, East Harlem in Manhattan, Ozone Park and Jamaica in Queens, the South Bronx, and Northern Staten Island, while large vacant sites are located primarily in Staten Island, but also in the Queens neighborhoods of College Point and the Rockaways, and East New York. Because of decades of development pressure, many vacant lots in NYC are sites which are either too small or otherwise not suited for residential or commercial development. Urban agriculture could be an ideal means with which to rehabilitate such areas and transform them from a potential blight into an asset for the community.

Public vacant land represents the proverbial low-hanging fruit when it comes to land availability because specific uses can be directly determined or incentivized through municipal land-use policy changes. The sites shown in ***map 4: Public Vacant Land in NYC*** consists primarily of land owned by municipal agencies such as the Department of Housing, Preservation and Development (HPD), Department of Parks and Recreation, the Department of Transportation, the Department of Education, etc., but also land under the jurisdiction of state and federal agencies. Excepting Staten Island, much of these sites are concentrated in low-income neighborhoods which stand to benefit the most from the establishment of urban agriculture. While public land may represent the clearest opportunity increasing urban agriculture in NYC, there are many questions that will have to be resolved prior to increased policy support. For one thing, there is the issue of for-profit activity taking place on public land (not that urban agriculture would have to be for-profit; as noted above, there are many different models). This is an issue which is not insurmountable - other cities, including Buffalo and Detroit, have allowed for for-profit farms on municipal land. In NYC, Greenmarkets farmers markets operate in public areas – part of the justification for this allowance is that they are recognized to be providing access to critical public services, such as SNAP benefits, which can be used at many of the markets. One could certainly make similar arguments for urban agriculture. A more difficult problem is the fact that municipal agencies may be unwilling or unable to take on the responsibility of managing or overseeing such activity on lands under their jurisdiction, for a number of reasons. Currently, most of the city's community gardens receive management and material support from GreenThumb, which is a program of the Dept. of Parks and Recreation. If adequate funding is maintained, GreenThumb could be an ideal agency to oversee further expansion of urban agriculture and to assist with management of land in other public agencies being used for that purpose.

Another issue that must be addressed is water use; on public property, the costs of additional water use as a result of gardening or farming would be borne by the relevant agency. In many cases, community gardens are allowed to use municipal water from hydrants if practicable, but any large-scale increase in farming or gardening would require more formal arrangements. There may also be concerns about health and safety liability, costs of soil remediation soil in case of contamination, and concerns that once a farm or garden becomes established on a particular



Map 3: Vacant Land and Community Gardens in NYC



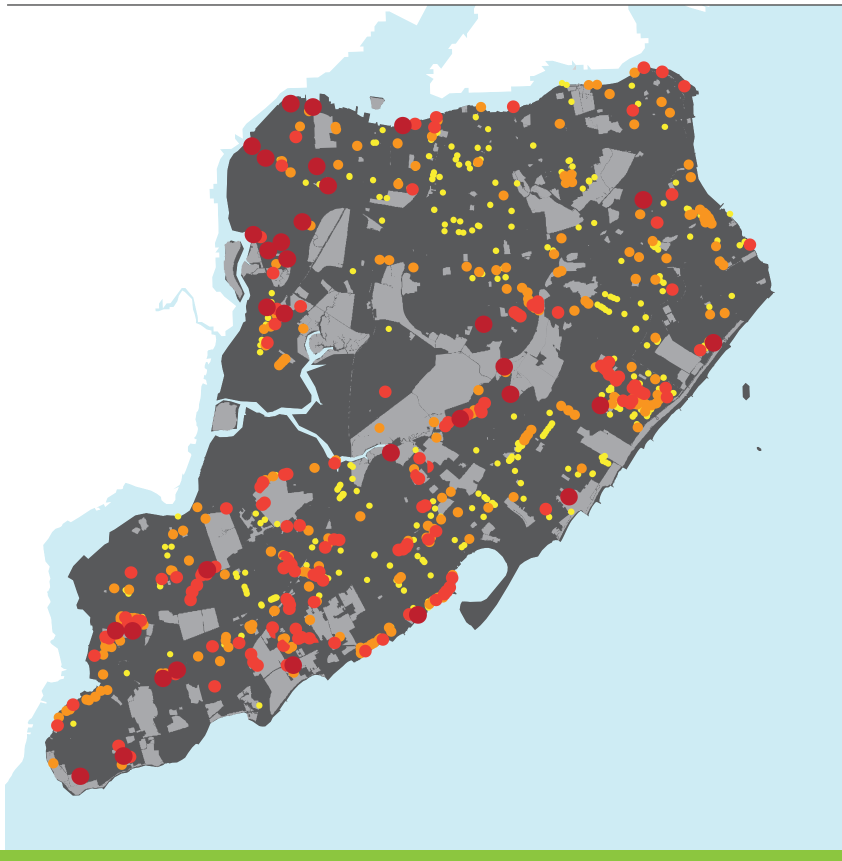
* See **Appendix 1: Methodology** for how figures were derived.
© Urban Design Lab, 2011. Sources: UDL, Mara Gittleman / Farming Concrete, MaPLUTO © New York City Department of City Planning (2009), U.S. Fish and Wildlife Service (2010)

site any future plans for that site may face increased community opposition. The Department of Parks and Recreation has proven to be supportive of urban agriculture on some of its underused land – Added Value Red Hook is a Parks Dept. site – and other agencies have similarly allowed such activity to take place on their properties, while other agencies are less amenable to the prospect (see **Fig. 5: *Vacant Land by City Agency***.) The fact is that vacant land that is owned by these agencies is ultimately public land, meaning that "the public," however defined, should have influence over whether and how such land is used. Of course, political realities and competing public interests make true public input a difficult goal to achieve, but as interest in urban agriculture increases, vacant public land presents a clear opportunity for aspiring farmers and gardeners.

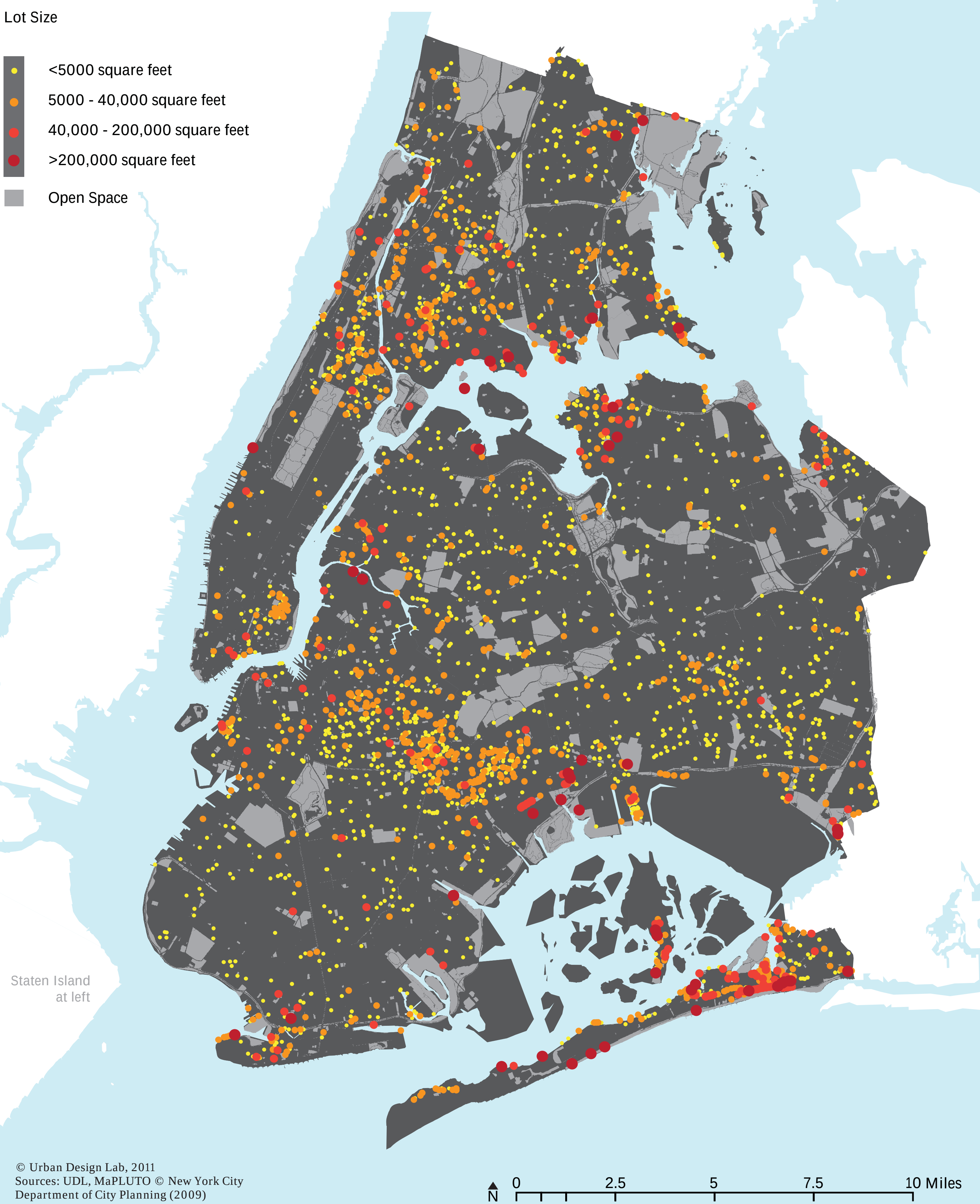
Private vacant land also presents ample opportunities for growing food. Policies that could be considered to encourage the use of such land for food production include either tax incentives or a combination of a vacant lot tax penalty and farming exemption that could be cost neutral or even beneficial to the city, especially given that property values surrounding cultivated green areas tend to be higher than those surrounding unkempt vacant lots.[5] One of the complicating issues is that establishing a viable farm involves a great deal of sweat equity, often invested over the course of years, in building up healthy soils (especially in urban areas) and establishing a productive landscape, and urban farmers may be loath to undertake such an effort on a privately owned lot where there is no guarantee of long-term tenure. Precedents such as the new community garden rules which were rewritten in 2010 and offer some long-term protection from development, are important in this regard, even though many community garden advocates view the new rules as inadequate. Paradoxically, such protections may act as disincentives for private property owners, who rightly or wrongly may assume that allowing urban agriculture on their property may jeopardize future plans for the property or property values, whether due to actual legal protection for existing farms or because of community opposition to the removal of an existing farm. Some urban farmers are dealing with potential land insecurity by developing modular, moveable farming systems, such as transportable beds. Such creative approaches are one way to increase the potential for farming on private property, although their implications for increasing land security for farmers in the long-term are mixed. There is much to be learned from other cities on how to incentivize farming on vacant private land; San Francisco, for example, has a policy whereby developers who obtain building permits but do not have adequate financing in place can receive extensions to the permits if they allow for urban agriculture to take place on the site in the meantime (as opposed to having to re-file for permits). For many private vacant lots, especially those that have been vacant for several years or longer, urban agriculture could be an attractive, low to no cost (for the owner) means of rehabilitating or using the space.

Schools

Land owned by the Department of Education presents a unique case because of the surge of interest in establishing school gardens in NYC and elsewhere in the nation. (There are 40 acres of "vacant" land listed as belonging to the Dept. of Education, but most relevant are areas or lots in or directly adjacent to schools.) Following the example set the Edible Schoolyard in Berkeley, California, many schools and parents are recognizing the rich educational potential hands-on

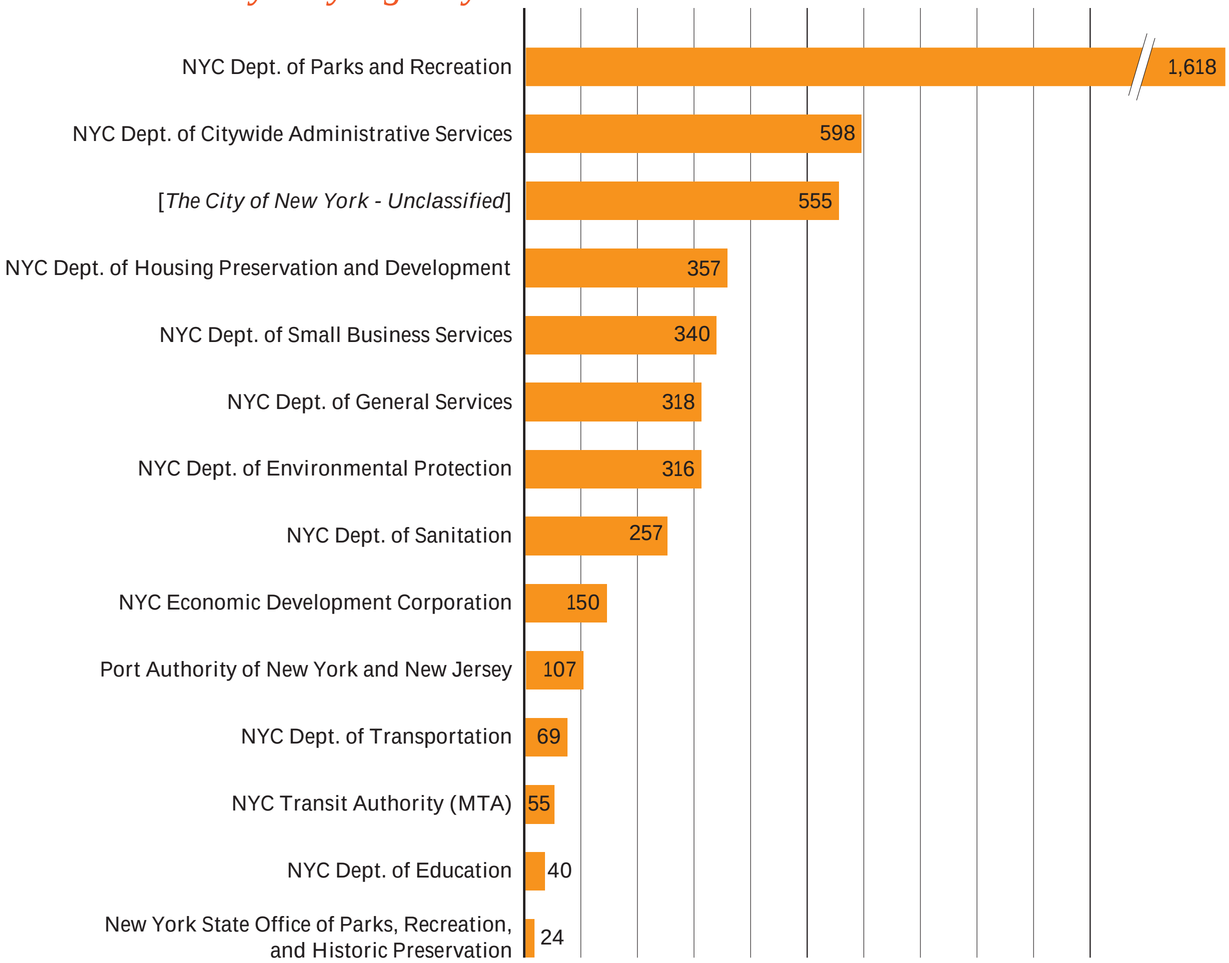


Map 4: Public Vacant Land in NYC



Sources: UDL, MaPLUTO © New York City Department of City Planning (2009)

Fig. 5: Vacant Land by City Agency*



*Agencies with >10 acres of vacant land. Figures represent total land classified as vacant, and do not necessarily indicate areas suitable for farming or gardening.

experience with growing, and in some cases processing and cooking, food, particularly for those children in cities who do not often get out to rural areas. *Grow to Learn NYC*, a public-private partnership between the Mayor's Fund, GrowNYC, and other government partners, was launched in 2010 to promote gardening in NYC's schools, and the ultimate goal of the program is to establish a garden in "every school"[6] (as of October 2010, there were 285 school gardens in the city, 70 of which are registered with the Grow to Learn program).[7] Some schools with limited outdoor space (and parents or staff with good fundraising abilities) are establishing rooftop gardens or even greenhouses, such as the aforementioned facility at the Manhattan School for Children, which offer an expanded array of educational opportunities. School gardens' impact on food system and health awareness can be substantial, leading to larger changes in consumption that could help transform the food system.

Open space

Open Space, as defined by the DCP, includes public parks, playgrounds and nature preserves, cemeteries, amusement areas, beaches, stadiums and golf courses. There are 52,938 acres of open space in the city, which represents over one-quarter of the city's total area, making New York one of the "greenest" cities in nation. Most of this is parkland, including municipal parks such as Pelham Bay Park (the city's largest), the Staten Island Greenbelt, Van Cortland Park, and Central Park; state parks such as East River State Park and Roberto Clemente State Park, and federal parkland, which consists primarily of the Gateway National Recreation Area. Most of this land is well-used by the public and provides critical wildlife habitat and other ecosystem services, and in such areas it would be inappropriate to farm. There could be an important role for urban agriculture within parkland, however, as it could complement the public uses, assist with environmental restoration, and contribute to other economic and cultural activity. The redevelopment plan for Governor's Island is an interesting example of how to creatively assimilate these various priorities and programs, including urban agriculture. Another interesting opportunity is the 1,358-acre Floyd Bennett Field, which is part of the Gateway National Recreation Area, and which is the target of a major soil cleanup project as well as a strategic planning process. Already a consortium of interested parties has developed a strong plan for the creation of a farm and urban agriculture education and training center on the site.

With so much land designated as open space, there are inevitably areas that are underused, and the appropriateness of locating farming within urban parkland would have to be evaluated on a case-by-case basis. Other than parkland, potential underutilized open space areas include areas within parks, triangle spaces within intersections, and other underdeveloped areas. Collectively these categories in MaPLUTO account for 324 acres, after the subtraction of wetlands. This figure certainly represents a very low estimate of underutilized open space, as it includes only lots that are entirely classified as such – underused or neglected areas within larger parks or open space lots could add up to hundreds of additional acres. See ***Map 5: Other Potential Sites for Urban Agriculture in NYC***.

New York City Housing Authority

There is significant potential for cultivation of land on NYCHA property, which is concentrated in the low income neighborhoods of the South Bronx, East Harlem, Bedford-Stuyvesant, Crown Heights, Brownsville, and East New York. The agency's Gardening and Greening Program has helped to establish 645 gardens in housing developments, of which 254 grow vegetables. NYCHA is looking to expand farming and gardening in green spaces in housing developments, with the aim of establishing 129 additional community gardens and at least one urban farm.[8] Based on detailed assessments of ten NYCHA housing clusters in various parts of the city, we estimate that approximately 50% of developed NYCHA property, not including building footprints, consists of green space, amounting to a total of about 978 acres (this figure does not include parking, walkways, or recreation areas on NYCHA property; nor does it include vacant NYCHA property, which is part of the vacant land inventory). Some of that space is well maintained and appreciated by residents for its recreational value, and much of the green area is shaded by trees and buildings. Some open space areas are also being considered for the construction of new facilities. There is, however, open space in many of the developments which is difficult to access, poorly maintained, or underutilized. These are the areas that would be most appropriate for the creation of new gardens and farms should residents support such measures.

Surface parking

While it may seem hard to believe when searching for a parking spot on a typical weekday in Manhattan, there are over 1,084 acres of surface parking lots in the five boroughs. (This figure includes only surface lots that are entirely parking; street parking and parking areas that are on commercial or residential properties, such as for office buildings or malls, are not included in this figure; nor are indoor parking facilities or garages, so the amount of actual parking area is much greater.) Some of these lots, particularly in the outer boroughs, are underused, not used at all (essentially vacant), or used for temporary storage of equipment or material. Surface parking is an important asset in any city, but because such spaces consists of large paved surfaces, they contribute disproportionately to stormwater runoff (and hence CSO events) and urban heat island effect. Parking lots are a key target for stormwater mitigation, and the NYC Green Infrastructure Plan[9] calls for creating planted permeable swales on more of these sites. Partial or total conversion of parking area to urban agriculture and other forms of green infrastructure could be encouraged by the imposition of fees for stormwater runoff from properties with large uninterrupted swaths of impermeable area, combined with credits or other incentives for onsite mitigation. Calculating how much existing surface parking is underutilized is beyond the scope of this report, but there are certainly tens if not hundreds of acres that could be productively converted to farming and gardening without seriously impacting parking availability.

Greenstreets

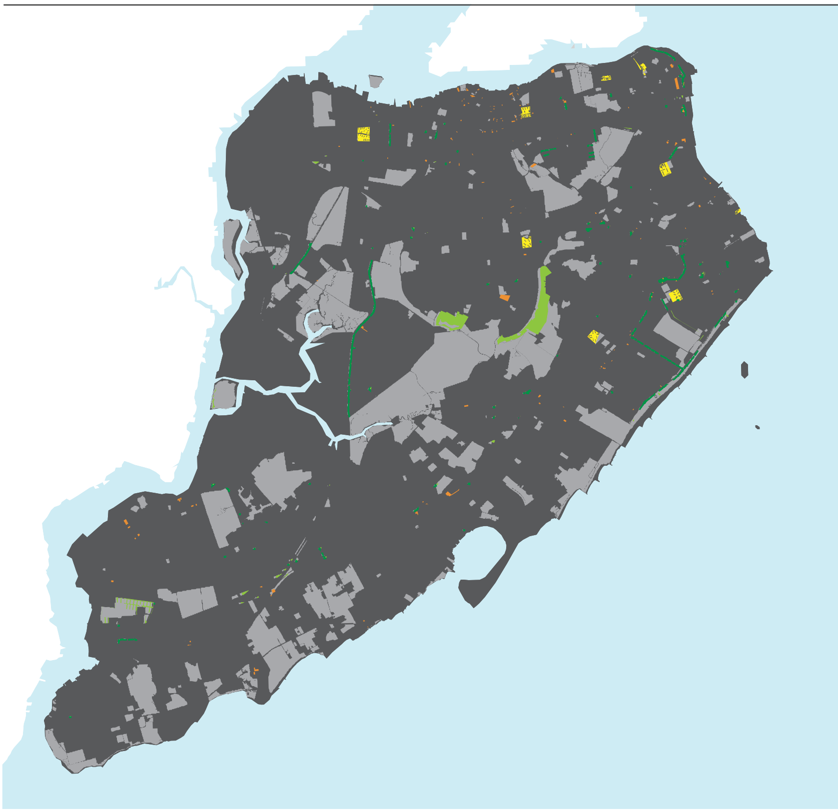
Greenstreets such as Park Avenue, Ocean Parkway, and Eastern Parkway are planted traffic islands and medians, some of which could be suitable for fruit tree cultivation. Our analysis using MaPLUTO identified 170 acres of greenstreets in the five boroughs. The major issue with converting Greenstreets for food production would be access and pollution. On busy thoroughfares, accessing the medians could pose a safety hazard, while the opposite problem also would need to be resolved: unless any agricultural activity taking place in such spaces is designed to be completely open to the public for participation and harvesting (and potential vandalism), access would have to be restricted, which is contrary to the spirit of the program. Pollution from adjacent vehicular traffic could also pose a risk, primarily for anyone working in these medians, though also because of potential contamination of the produce. Exhaust particulates getting into food is a concern in any urban area, and is often simply a matter of thorough washing, though as far as we are aware the issue of growing food in close proximity to such pollution sources has not been adequately studied. Despite such these challenges, cities such as Seattle have had some success with food cultivation in (somewhat wider, and not heavily trafficked) street medians. PlaNYC has committed funding for 80 new Greenstreets each with the goal of reaching a total of 3,000 such streets by 2017.[10] Another related initiative is the DOT Plaza Program, which aims to create public-use open space in the right of way. There may be potential to incorporate urban agriculture into such plazas, although given that the priority of the program is to create easily accessible open space, it could be a challenge to establish any sort of large scale food production on such sites.

Privately Owned Public Spaces

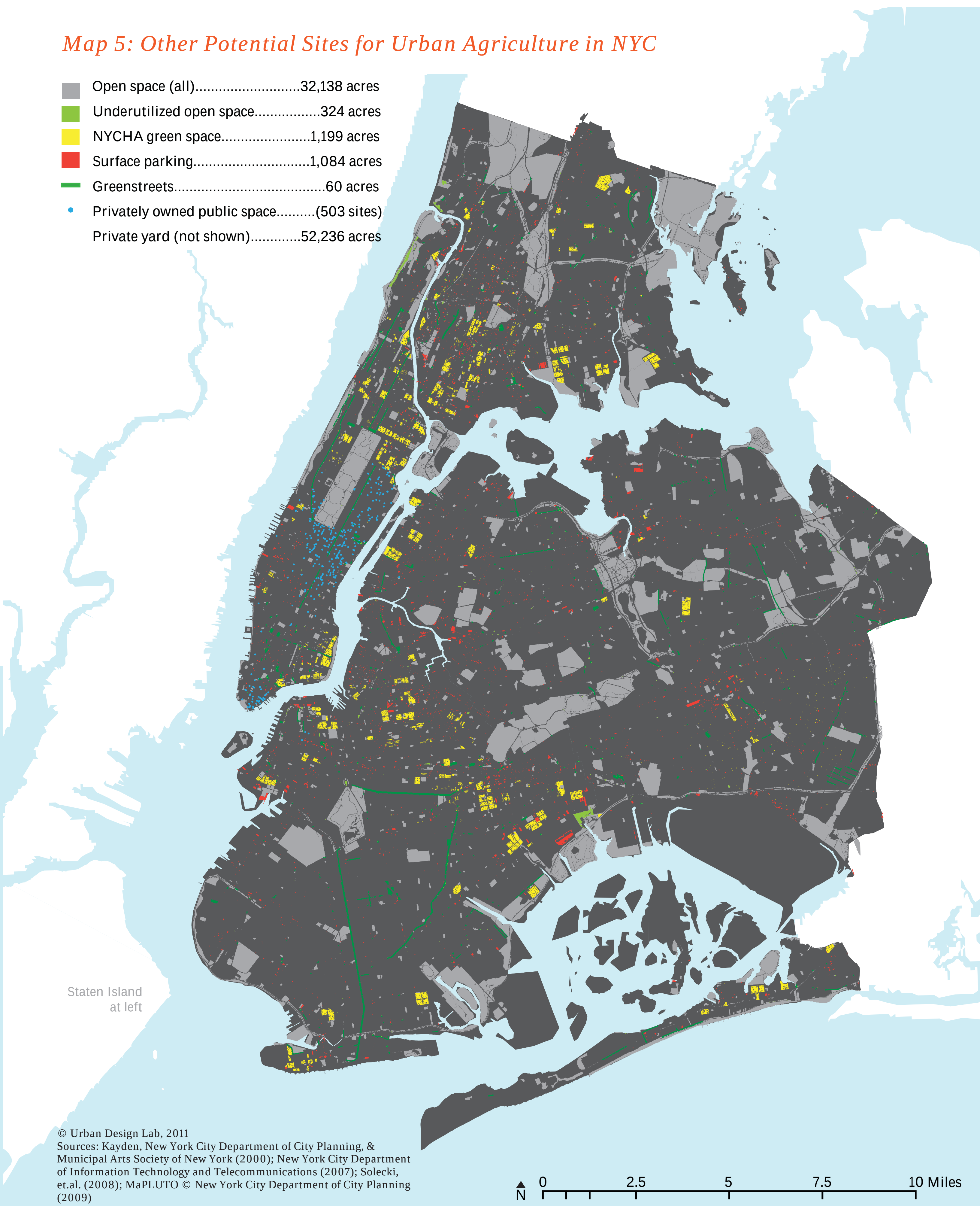
Privately owned public spaces (POPs) are commercial sites receiving an FAR exemption in return for providing ground-level publicly accessible space. A percentage of this is mandated to be green space, which is often in the form of planters. These 503 sites are all large corporate properties, with all but two located in midtown and downtown Manhattan, and they often consists of large, underutilized, mostly paved areas.[11] Given their location and layout, these are not spaces that would be suitable for farming per se, but small-scale planter-based food cultivation could take place in the designated green areas if willing gardeners could be recruited from the ranks of employees out on a lunch or coffee break.

Yard space

While New York is not often thought of as a city with many backyards, there is more private yard space than many people imagine. A report from 2008 used a GIS analysis to calculate that there are 52,236 acres of residential yard space in the five boroughs,[12] an area almost equal to the area of public open space (this figure essentially includes the area on residential lots that is not covered by the building footprint; it does not indicate how much of this area is currently green space or planted). This represents a huge opportunity for food production in the city, and many residents are already using such space for private gardens. During the First and Second World Wars, the Victory Garden program, designed to relieve food shortages and boost morale during wartime, was so successful in motivating citizens to use their backyards (and in some cases, rooftops) for food cultivation that during the height of the program in the



Map 5: Other Potential Sites for Urban Agriculture in NYC



Sources: Kayden, New York City Department of City Planning, & Municipal Arts Society of New York (2000); New York City Department of Information Technology and Telecommunications (2007); Solecki, et.al. (2008); MaPLUTO © New York City Department of City Planning (2009)

1940's as much as 40% of the nation's produce was grown in such gardens.[13] The program was successful in engaging urban and suburban populations in re-engaging in food production at a time when agriculture was becoming increasingly mechanized. While no such equivalent program exists today, sales of seed and garden equipment have been rapidly increasing in all parts of the nation over the past few years,[14] pointing to a resurgence in gardening. Other innovate approaches to using backyard space for food production include BK Farmyards, a decentralized approach to urban farming wherein property owners can arrange for their land to be cultivated by urban farmers in exchange for a portion of the yield.

Rooftops

Due in part to the density and high land values in NYC, rooftop agriculture has become more established in the city. (See the **Approaches** section of this report for a more in-depth discussion of rooftop farming.) There are approximately 1 million buildings in NYC, with a total of 38,256 total acres of rooftop area. The most prevalent building type is one or two family houses,[15] many of which have sloped roofs, while others may be too tall, too small, or otherwise unsuited for rooftop farming. There are many multi-family residential buildings in the city as well, a majority of which have flat roofs and could support small scale food production. For the purposes of this study, we are focusing on larger commercial and industrial properties that could be suitable for a larger-scale rooftop farm. These are shown in **Map 6: *Potential Rooftop Farming in NYC***. These structures were selected using the following criteria:[16]

1) Located in manufacturing and commercial districts, as industrial buildings are often more structurally robust, and such zones allow for commercial activity;

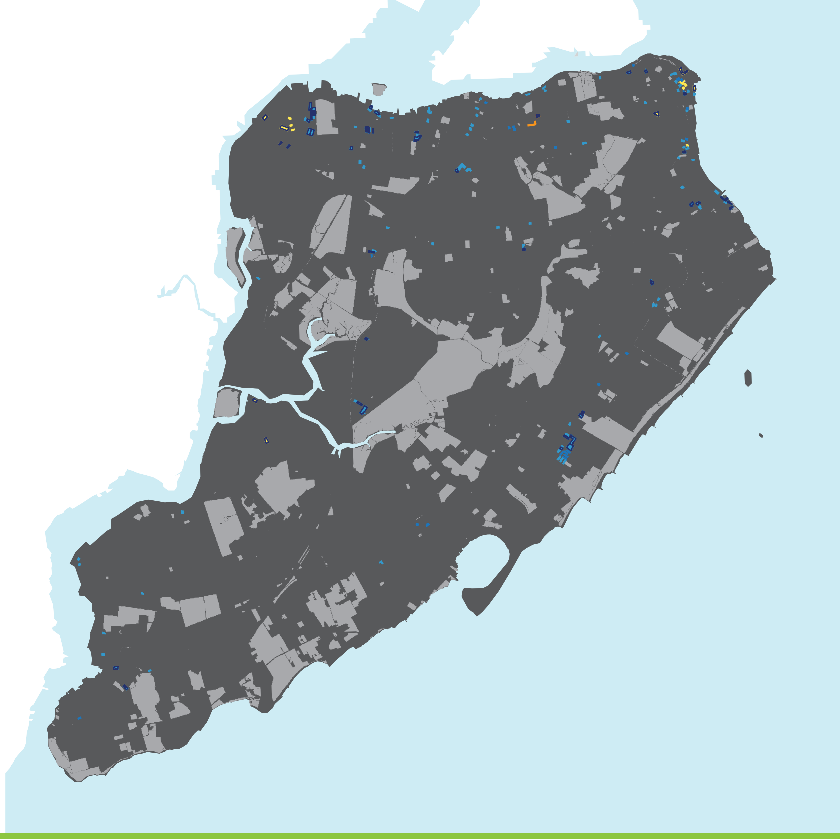
2) Built between 1900 and 1970, when building codes mandated greater roof live load requirements; generally, buildings built before 1970 were built to withstand up to 50 lbs./s.f. of rooftop live load, and live load requirements have been decreasing since then.

3) Have a footprint of over 10,000 square feet – although plant cultivation is possible on roofs of any size, experienced rooftop farmers have noted that economic viability on farming on smaller roofs is uncertain (unless a cluster of adjacent roofs were used for the purpose);

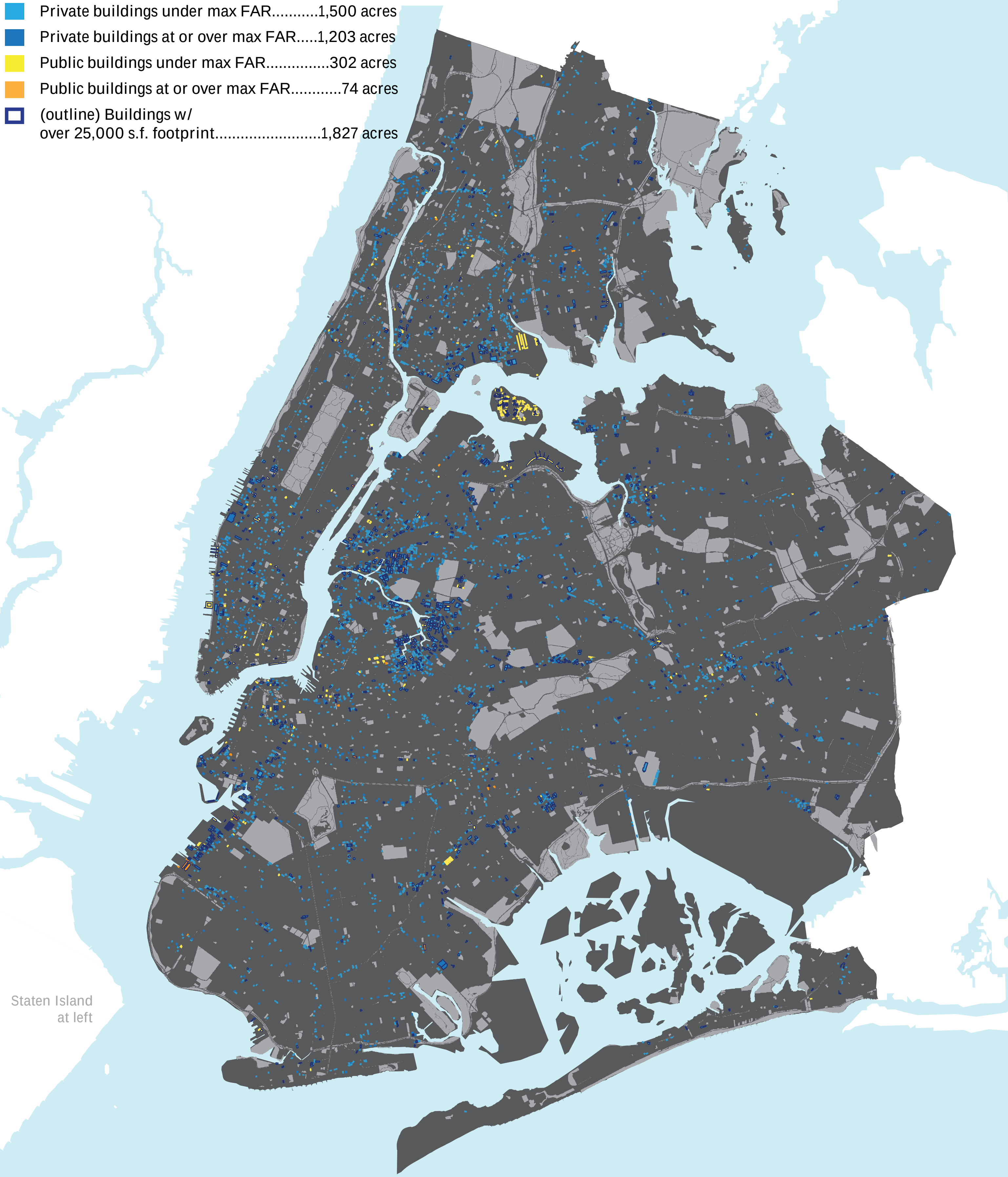
4) 10 stories tall or lower, because above that height climatic conditions are inhospitable for plants and people and it becomes more difficult to transport growing media, materials, and equipment;

5) Not used for heavy industry or noxious purposes, which could compromise the health and safety of both farmers and food grown on such structures.

(See **Appendix 1: Methodology** for more information on how this map was created.) Using these criteria, we identified 5,227 private buildings with a total area of 2,703 acres, and 474 public buildings with a total area of 376 acres. 1,271 of these buildings have a roof area of over 25,000 s.f., which is over half an acre. Other factors which need to be considered in determining whether a roof is suitable for agriculture include sun exposure (the City University of New York's NYC Solar Map shows that 66.4% of the City's buildings are suitable for solar panels,[17] indicating adequate sun exposure, but this includes sloped roofs as well), roof materials and condition, and roof access and egress. **Map 6** reveals clusters of potentially suitable roofs in the Greenpoint, Brooklyn, and the Maspeth and Long Island City neighborhoods of Queens, which is one of the most promising areas in the nation for rooftop agriculture (see the **Case Studies** section of this report for more information on these two areas). Additional areas with potential include Gowa-



Map 6: Potential Rooftop Farming in NYC



Sources: UDL, New York City Department of Information Technology and Telecommunications (2009); New York City Department of City Planning (2010) nus, Sunset Park, and East New York in Brooklyn, and Port Morris and Mott Haven in the Bronx. These estimates of the amount of rooftop space that would be suitable for agriculture are fairly conservative given the restrictive criteria – many roofs that are not included in these figures could potentially be used; the purpose of this analysis is to determine how much rooftop area is most suited for farming. As with other types of sites, accurate evaluation of suitability would have to take place on a case-by-case basis; supermarkets, for example, which would seem to be an ideal place for the location of a rooftop farm or greenhouse, often present a challenge due to the large number of refrigeration vents and other protrusions on the roof.

The construction of a rooftop greenhouse counts towards a building's total floor-area ration (FAR), and although changing the building code to allow for an FAR exclusion for rooftop greenhouses has been suggested, currently no such amendment has been formally introduced in NYC. Map 5 also shows which of the buildings which fulfill the multiple criteria are also under maximum allowable FAR for their zone. Approximately 68% of all buildings with a footprint greater than 10,000 s.f.in commercial and manufacturing districts are under the maximum FAR limit, and therefore could potentially have additional structure in the form of a rooftop greenhouse under current zoning law.

Site distribution

As is clear from the maps of potential ground-based and rooftop sites in NYC, the wide variety of urban fabric typologies in the city calls for a corresponding diversity in approaches to urban agriculture. Certain areas, such as Midtown Manhattan, offer few opportunities for space (other than the POPs). Other neighborhoods, such as the areas in Brooklyn and the South Bronx mentioned in the Vacant Land description, have large concentrations of small vacant lots which could be organized into clusters or networks of farms and gardens sharing resources and equipment. Such networks would allow for food production from these areas to be aggregated for distribution and sale in stores, CSAs, farmers markets, or for donation to food pantries, and would allow for maximization of resources. Other areas, particularly in Staten Island, have large areas of vacant land that could be used for more conventional types of farms, while many parts of eastern and southern Queens, characterized by single family houses, are well suited for backyard food production. Other neighborhoods are particularly suited for rooftop farming.

Notes

1. Brown, E. (2011, March 14). City Construction Remains at Minimum. *The Wall Street Journal*. Retrieved from http://blogs.wsj.com/metropolis/2011/03/14/city-construction-remains-at-minimum/.
2. PlaNYC projects an increase of as much as 1 million residents by 2030. The 2010 census found population growth from 2000 to 2010 in NYC to be lower than the City's estimates; the City is disputing these figures, claiming that they represent a significant undercount. The City of New York. (2011). *PlaNYC Update: A Greener, Greater New York*. The Mayor's Office of Long-Term Planning and Sustainability; and New York City Department of City Planning. (2011). *NYC 2010 Results from the 2010 Census: Population Growth and Race/Hispanic Composition*. Retrieved from http://www.nyc.gov/html/dcp/pdf/census/census2010/pgrhc.pdf
3. Been, V. & Voicu, I. (2007). The Effect of Community Gardens on Neighboring Property Values. *NYU Law and Economics Research Paper* No. 06-09. Retrieved from http://ssrn.com/abstract=889113.
4. Easements give third parties, including public agencies or utilities, the rights to locate infrastructure such as roads or transmission lines on property which does not belong to them.
5. Been, V. & Voicu, I. (2007). The Effect of Community Gardens on Neighboring Property Values. *NYU Law and Economics Research Paper* No. 06-09. Retrieved from http://ssrn.com/abstract=889113.
6. Otterman, S. (2010, October 19). Turning Asphalt Into Edible Education. *The New York Times*. Retrieved from http://cityroom.blogs.nytimes.com/2010/10/19/turning-asphalt-into-edible-education/.
7. The City of New York. (2011). *PlaNYC Update: A Greener, Greater New York*. The Mayor's Office of Long-Term Planning and Sustainability.
8. Ibid.
9. New York City Department of Environmental Protection. (2010). *NYC Green Infrastructure Plan: A Sustainable Strategy for Green Waterways*. NYC Environmental Protection. Retrieved from: http://www.nyc.gov/html/dep/pdf/green_infrastructure/NYCGreenInfrastructurePlan_LowRes.pdf.
10. The City of New York. (2011). *PlaNYC Update: A Greener, Greater New York*. The Mayor's Office of Long-Term Planning and Sustainability.
11. Kayden, J.S., The New York City Department of City Planning, and the Municipal Art Society of New York. (2000). *Privately Owned Public Space: The New York City Experience*, New York: John Wiley & Sons.
12. Solecki, W, et. al. (2008). *Urban Forests In Our Midst: Environmental Benefits of Open Spaces in City Backyards*. New York: The CUNY Institute for Sustainable Cities, Hunter College. Retrieved from http://www.landmarkwest.org/green/LW_FinalReport%5B1%5D.pdf.
13. Bently, A. (1998). *Eating for victory: food rationing and the politics of domesticity*. Chicago: University of Illinois Press.

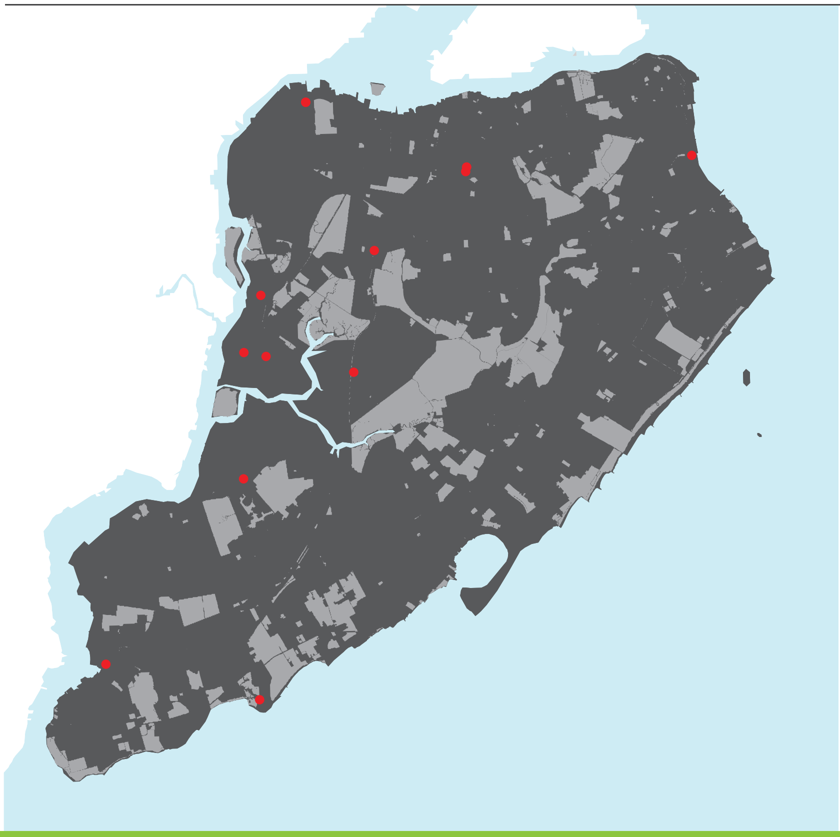
14. Horovitz, B. (2009, February 20). Recession grows interest in seeds, vegetable gardening. *USA Today*. Retrieved from http://www.usatoday.com/money/industries/food/2009-02-19-recession-vegetable-seeds_N.htm.
15. New York City Department of City Planning. (2010). 2010 Primary land Use: Each Borough's Lot Area by Land Use Type. Retrieved from: http://www.nyc.gov/html/dcp/pdf/landusefacts/landuse_tables.pdf
16. This analysis is partially informed by Lauren Mandel's work on rooftop agriculture.
17. NYC Solar Map. (2011). Sustainable CUNY. Available at: http://nycsolarmap.com/

In *Growing Better Cities,* Luc Mougot writes that "unused urban space is a wasted opportunity - an asset denied to a community's well-being and a brake on the city's development."[1] Transforming unused space into productive space through agriculture can be an excellent way of converting a liability into an asset; however, there are often many other potential uses for such areas which must be considered. Whether any particular lot is converted to a farm, a park, condominiums, or a community center depends primarily on sociopolitical factors, such as property ownership and community support, as well as economic factors, including land costs and development pressure, some of which are addressed in other sections of this report. Even when such factors are aligned in favor of urban agriculture, environmental site conditions must be considered. These include adequate sunlight, slope and drainage factors, and soil contamination.

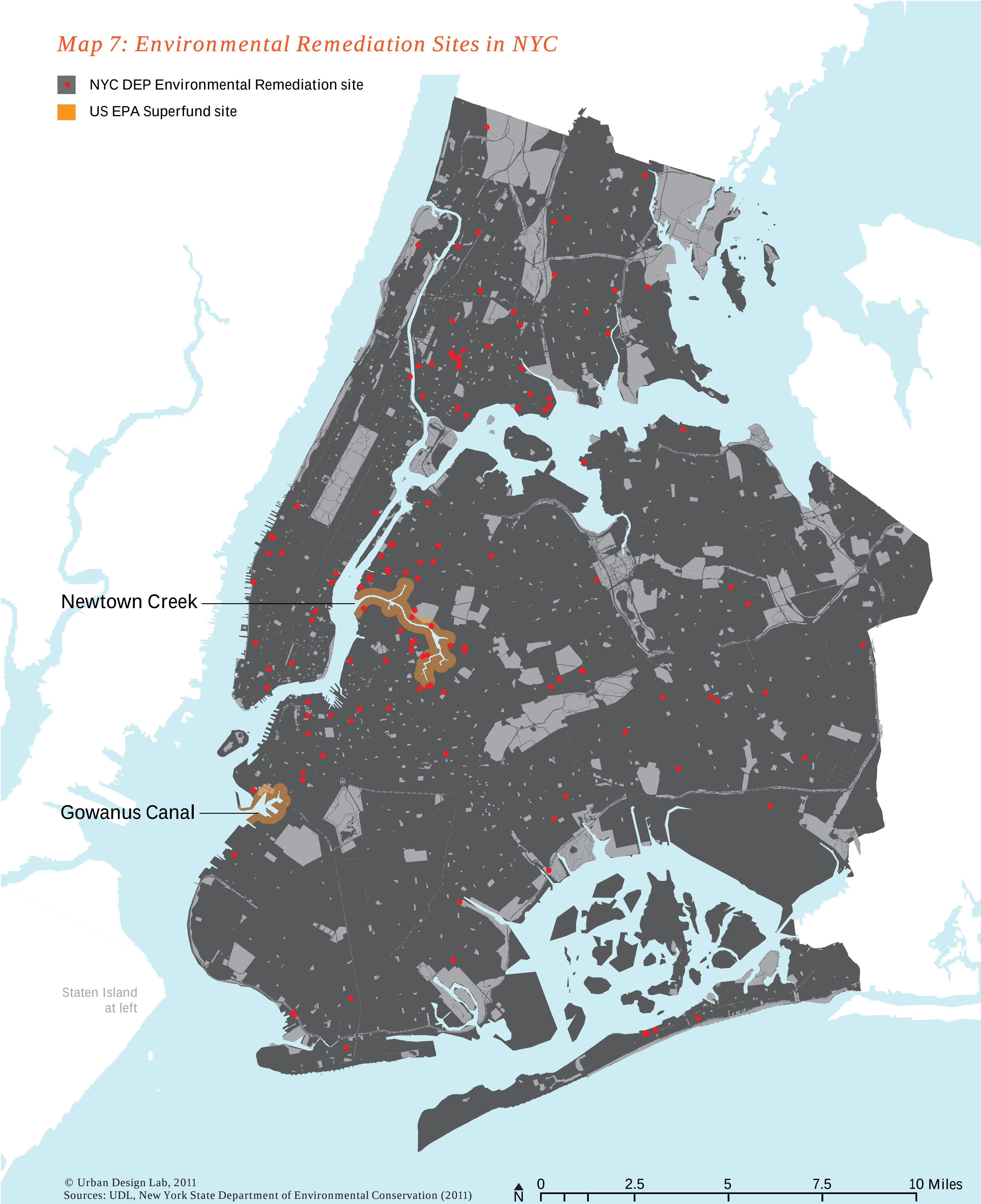
Sunlight can be an issue for small lots in densely developed areas, a common condition in NYC, and a more thorough assessment of site suitability would include an analysis of how many of NYC's vacant lots are wholly or largely overshadowed by tall buildings. Tree shade can also be a challenge, as many otherwise suitable sites are shaded by tree canopy. An analysis of urban tree canopy in NYC found that 44,509 acres, or 24%, of the total land area is covered by urban tree canopy, while 45% of open space and 41% of vacant land is covered by trees.[2] Our vacant land availability analysis excluded many large forested areas, but smaller lots or areas that are only partially wooded are included. Urban trees provide important environmental and health benefits, and the city is actively working to increase urban tree cover with such programs as the MillionTreesNYC program. Building and tree shade are limiting factors on crop types and yields, and on heavily shaded sites farming and gardening would have to be limited to shade-loving plants such as certain varieties of berries. As far as slope is concerned, New York is a relatively flat city, especially compared with many urban areas in the West, and most of the steepest areas lie within the city's parks. While there are sites where slope and consequent soil erosion could be an issue for farming, they are few and far between.

Soil contamination: risks and considerations

The health of the soil is one of the primary factors contributing to the success or failure of food production, and many farmers believe that their role as soil stewards is as important if not more important than their role as food producers – while crops can have good and bad years, developing healthy soils is an incremental, long-term process. Soil quality and contamination is therefore a critical issue for all urban farms in NYC as elsewhere. Given the long history of human habitation and activity in most parts of NYC, its soils are generally assumed to be contaminated unless proven otherwise. **Map 7: *Environmental Remediation Sites in NYC*** shows existing NYC DEP Environmental Remediation sites[3] and the two more extensively contaminated US EPA Superfund sites. This is by no means a complete picture of soil contamination in the city; it is likely that there are many more areas that would warrant the brownfield designation with a more comprehensive soil testing program. Brownfields are properties that are deemed contaminated due to previous on-site commercial or industrial activity. Such sites are often abandoned, idle, or under-utilized, although in some cases they remain active. Superfund sites are areas that have



Map 7: Environmental Remediation Sites in NYC



Sources: UDL, New York State Department of Environmental Conservation (2011) been designated as uncontrolled hazardous waste sites by the EPA, which assumes oversight over cleanup. There are a number of approaches to dealing with soil contamination, including raised beds, composting, or various other soil remediation strategies that can make a site suitable for food production, and urban farming is increasingly becoming recognized as a means of reclaiming such areas. In NYC, the city has called for the creation of a pilot community garden on a remediated brownfield site, and will assist in designing protective measures that will be used to reclaim more brownfields as community gardens.[4] On heavily contaminated sites, however, remediation may be a long-term process, and food production may not be suitable for many years. Such areas could benefit from phytoremediation strategies of non-food horticulture, and, given that stormwater runoff is the primary means through which these toxins get into the waterways, the establishment of absorptive green spaces is an ideal strategy.

The primary chemicals of concern in urban gardens are metals like lead and arsenic, as well as polynuclear aromatic hydrocarbons (PAHs/PNAs). Sixteen PAHs are on the EPA priority pollutants list because they are known to be carcinogenic, mutagenic, or teratogenic. Other chemicals of concern include volatile organic compounds (VOCs), polychlorinated biphenyls (PCBs), other metals, herbicides, pesticides, dioxins, and semivolatile organic compounds, and site specific toxic compounds. Urban farmers and gardeners should always test for lead, and should consider what is known of a site's history to determine which other chemicals of concern might be present, as soil contamination is often the result of past land uses. For example, gas stations and mechanics' garages use different fuels and lubricants on-site, which can enter the soil inadvertently as a result of poor storage practices or spillage onto the ground. Other sources of contamination may be more indirect. Examples of these sources of contamination include rain runoff from roofs, roads, and other structures that may introduce heavy metals such as lead or mercury into the soil. Contaminants can also be introduced from adjacent properties through the movement of groundwater and soil water.[5]

The most serious contaminant in NYC is lead, followed by arsenic and cadmium. Because lead contamination is due to lead-based paint from old buildings or from auto emissions, lead levels are often highest at building footprints and near busy streets.[6] In a 2010 study of 116 garden soil samples from 72 homes and 12 community gardens in NYC, mostly in Northern Brooklyn, soils were found to be heavily contaminated with heavy metals at highly variable concentrations, with some levels of contamination 1-2 orders of magnitude higher than New York State's background levels. Based on guideline values developed by the New York State Department of Environmental Conservation for Brownfield redevelopment, only 4% of the gardens were found suitable for unrestricted use.[7]

Understanding the risk inherent in soil contamination is very difficult. The fact is that there has simply not been enough research on the hazards posed by various contaminants and thresholds for safety. There are several factors that complicate the issue: 1) testing can be unreliable, in that there may be compounds present which are not tested for, and levels can vary significantly within each site (there are protocols for number and spacing of soil samples for site testing) 2) there are no agreed upon thresholds beyond which soil is considered unsafe for food production, with the NYS DEC guidelines differing substantially from federal EPA standards (in general, the EPA standards are more permissive), and 3) there is inadequate information as to the bioavailability of various metals or compounds (the degree to which they are absorbed by plants), much less of their effects on the human body (lead is an important exception, with a good deal of resources and information available on its effects). For example, many heavy metals such as lead do not accumulate in the fruiting parts of plants, but there is concern about leafy greens and root crops. There are three ways in which people are exposed to contaminants in soil: ingestion (eating and drinking), dermal exposure (skin contact), and inhalation (breathing).[8] Depending on the contaminant, the main risk is often not the consumption of food grown in such soil but rather dermal exposure or direct ingestion of soil, which is the most serious types of exposure. In a study conducted by the Cornell Waste Management Institute, contaminants did not end up in food from the gardens, but children on the site ingested and inhaled soil particles, which presented health risks.[9] In general, plant cover helps to minimize the airborne particulates from soil, which is another public health benefit from urban agriculture or any other form of urban greenery, but caution must be exercised when handling urban soil, especially for children. On a commercial farm, the standards for soil testing and remediation should be higher than for community gardens and backyards, which may have more limited budgets. Urban farms also must contend with public perception and concerns about soil safety that may or may not be warranted.

Soil contamination: solutions

Precautions can be taken to minimize chemical contaminants in the soil. Most simply, farmers and gardeners can import soil or compost to use in raised beds on top of existing soil (or in some cases, as with Added Value's Red Hook farm, soil can be placed directly onto asphalt). Contamination can also be avoided by pre-screening sites and locating gardens as far from busy streets and older buildings as possible. If a hot-spot (a source or particularly high concentration of a contaminant) is found, this source can be removed before planning continues. Adding organic matter and compost to the soil minimizes contaminants, especially if the gardens are planted in raised beds that are sealed off from the contaminated soil below. Sheltered production methods have been used in urban agriculture to avoid contact with the soil and air by providing alternative production sites in contaminated areas (e.g., greenhouses, indoor production, hydroponic growing mediums, etc.). Choosing crops based on their resistance to taking up contaminants can also reduce the risk of food contamination. Low-cost soil testing programs have enabled low-income gardeners to know their level of risk and seek appropriate solutions. Conservation programs that share the costs with farmers who use techniques that bring environmental benefits have also been piloted.

While growing food in heavily contaminated soil is not recommended, certain garden crops can be safely grown in less than optimal soils. As mentioned above, the greatest hazard may be from soil dust deposited by rain or wind, which is why washing crops directly after harvesting is critical. The results of past research provide some information about the potential for heavy metal transfer into garden crops, which allows for recommendations of garden crops that are most and least suitable for growing directly in contaminated soils. These resources will expand in the future as new research findings become available.

The most suitable crops include vegetables, fruits and seeds like tomatoes, eggplant, peppers, okra (seed pods only), squash (summer and winter), corn, cucumber, melons, peas and beans (shelled), onions (bulb only) and tree fruits like apples and pears. The least suitable crops include green leafy vegetables like lettuce, spinach, Swiss chard, beet leaves, cabbage, kale, collards, other vegetables like broccoli, cauliflower, green beans, snow peas and root crops like carrots, potatoes, and turnips.[10]

Soil remediation

There are several approaches to mitigating polluted soil, including physical and biological remediation techniques.[11] Physical techniques include excavation, capping with geotextiles, soil washing, and soil vapor extraction. Excavation is the process of removing contaminated soil for disposal, usually at a landfill. Its main benefits are convenience and speed. Geotextiles are synthetic fabrics used after excavation to provide a protective barrier that is impermeable to remaining contaminants. Soil washing is the process of removing contaminated soil, treating it offsite to remove contaminants, and then putting the soil back into the ground. Soil vapor extraction involves installing wells and pipes in the soil and extracting soil contaminants through these channels. These techniques can be very effective, but they are costly and have environmental drawbacks, namely the disposal of contaminants and the air pollution from machinery.

Unlike physical remediation techniques, biological techniques are generally performed directly on-site, and at a much lower cost. These include microbial and fungal remediation, composting, and phytoremediation. Microbial remediation uses microbes to degrade contaminants into less toxic compounds. It is low cost and has a short timeframe; however, there is the possibility of increased toxicity of certain metals through interactions with microbes. It is important to be aware of this potential increased toxicity in considering the health risks of consuming edible plants grown in microbially remediated soils. In fungal remediation, certain species of fungus are used to break down contaminants, although this technique is not yet commercially available. Compost remediation is the addition of organic material to the soil, which can either dilute contaminants or, if compost is added on top of existing soil, help to create a new soil layer. This is a commonly used method for building healthy soils that is discussed in greater depth in the Waste section of this report.

Phytoremediation

Phytoremediation is the process of using plants to extract contaminants or to degrade them in the soil. As urban areas across the nation look to revitalize waterfront and former industrial zones and as land values in these areas rise, processes such as phytoremediation will likely become be a critical tool in the arsenal of green infrastructure strategies to bring marginal land back into the fold of urban activity. According to the EPA there are already over 200 contaminated sites in the U.S. where phytoremediation is being used for clean-up. And while phytoremediation usually excludes food crops, its status as a form of functional (as opposed to decorative) urban horticulture warrants inclusion in this report.

The process of phytoremediation can take many forms. *Hydraulic control*, or phytohydraulics is the control or containment of migrating subsurface water as plants take up large volumes of water; *Phytodegradation*, or phytotransformation, is the breakdown of contaminants through a plant's internal metabolic processes or the external effects of compounds (often enzymes) produced by the plant; *Phytoextraction* is the absorption of a contaminant by plant roots and the storage of the contaminant in the aboveground portion of the plants (leaves, stems), which must be removed by harvesting the plants; *Phytostabilization* is when a contaminant is immobilized after being absorbed and accumulated by roots or precipitated in the root zone of plants; *Phytovolatilization* is when a plant takes up and transpires a contaminant, which releases the contaminant or a modified form of the contaminant into the atmosphere; *Rhizodegradation* is the breakdown of a soil contaminant through microbial activity in the root zone of a plant, and *Rhizofiltration* is either a contaminant's adhesion or precipitation onto plant roots or the absorption of contaminants that are in solution in the root zone into the roots.[12]

Advantages to phytoremediation include that it potentially treats a wide variety of contaminants, provides in-situ treatment, is low cost, and can be integrated into the natural environment and landscaping plans. Phytoremediation also has the secondary effects of creating riparian buffers near water bodies to reduce non-point source pollution, preventing erosion, and providing habitat.[13] One major benefit is that phytoremediation has cost savings over conventional contamination treatments, with savings projected at 50% - 90% over other technologies, depending on the contaminant.[14] Phytoremediation has several disadvantages, including limitations on the types and levels of contaminants it is able to remove, soil properties, and acceptable exposure risks. In addition phytoremediation takes a long time (several years or more), since it is limited by plants' growth rates and the length of the growing season. Effectiveness in bringing soil up to agricultural standard varies, as one species of plant is generally used on one type of contaminant, potentially leaving other contaminants behind. Also, the contaminated plants used for extraction must be disposed of properly. Phytoremediation (plants releasing chemicals that break down toxins) is very different from Phytoextraction (plant uptake of toxins). Phytoextraction is a difficult process to control, and there is debate as to whether significant levels of lead can be removed through this process. Metals are relatively insoluble, so phytoremediation may be less viable for metals like lead,[15] although some studies have shown that sunflowers, mustard plants, and spinach can be effective in extracting lead.[16]

In general, bioremediation techniques can be very effective in bringing soil up to agricultural standards. Some uncertainty may remain about soil contamination after bioremediation, because unlike physical remediation techniques, it works selectively on specific compounds and metals. Phytoremediation can take a long time, and the plants must be disposed of after the process is complete. Despite the extended time frame, these techniques are generally inexpensive, easy to implement, do not have adverse effects for the environment. Of the techniques described, microbial remediation may the most suitable for future urban agriculture sites because of its low cost and relatively short timeframe,[17] though the most appropriate techniques will have to be determined on a case-by-case basis.

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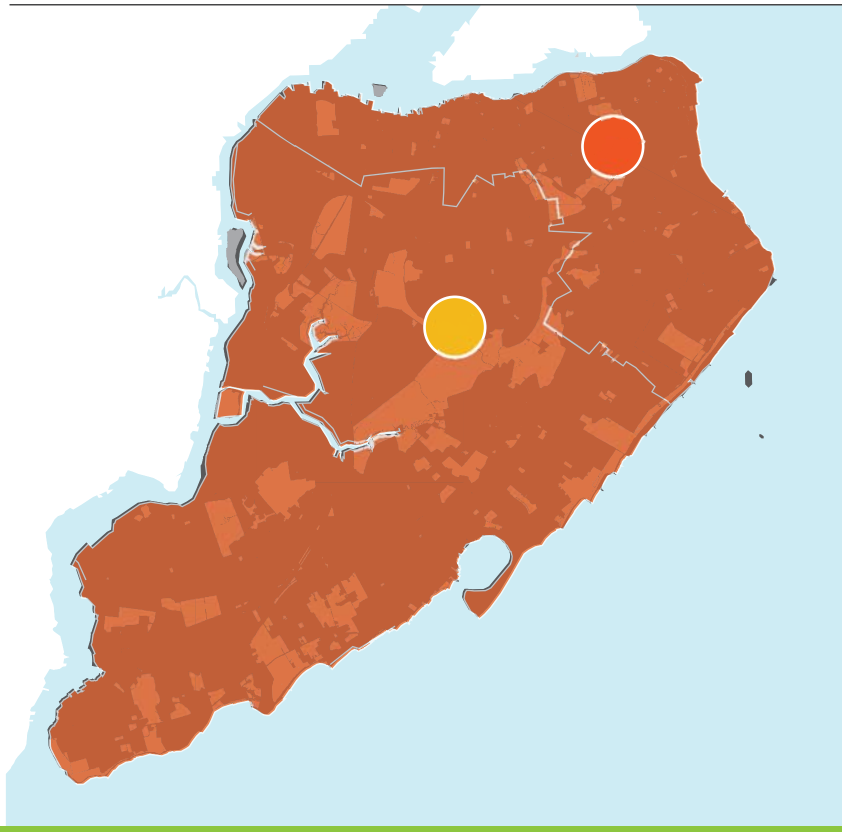
While the potential benefits of urban agriculture are wide-ranging, the primary focus of interest remains the production of food within and for urban communities and the effects on food access and health. The U.S. has experienced a rapid increase in the prevalence of diet-related disease such as obesity and diabetes in the last several decades, with as much as 68% of the population classified as overweight in 2008.[1] In many disadvantaged communities, this problem is compounded by inadequate access to healthy food retail options. These trends, now exacerbated by rising food prices, are contributing to a cultural shift in which consumers are increasingly looking to alternatives to what is perceived as an overly industrialized and globalized food system. Urban agriculture is one of these alternatives, not because it has the capacity to supplant the dominant food supply network for urban populations, but because it represents an opportunity for city dwellers to increase their awareness of the food system, diet, and their effects on health, and also because it can substantially increase the supply of the healthiest foods which are sorely lacking in many inner-city neighborhoods.

Food security in New York City

"Food security" is a term which is often used to signify a number of different factors. On a basic level, a household or community is considered "food secure" if members do not live in hunger, but in the U.S. the term has come to refer to access to and affordability of healthy food as well, as defined by retail locations and food prices. Other factors that are sometimes used to define food security include fruit and vegetable consumption, income, and obesity and diabetes rates. By any measure, many New Yorkers struggle with food security. Hunger is on the rise in the city,[2] with increasing numbers of people forced to rely on food pantries and soup kitchens,[3] and in a recent study the South Bronx (NY Congressional District 16) was characterized as the most food insecure in the nation.[4] NYC obesity and diabetes prevalence, at 22% and 9%, respectively, are higher and increasing more rapidly than national averages,[5,6,7] with corresponding effects on medical expenditures, life expectancy, and quality of life.[8] These diseases are directly related to poor dietary habits caused by lack of availability and affordability of fresh whole foods in many NYC neighborhoods, particularly in the disadvantaged areas where chronic disease prevalence is highest.[9]

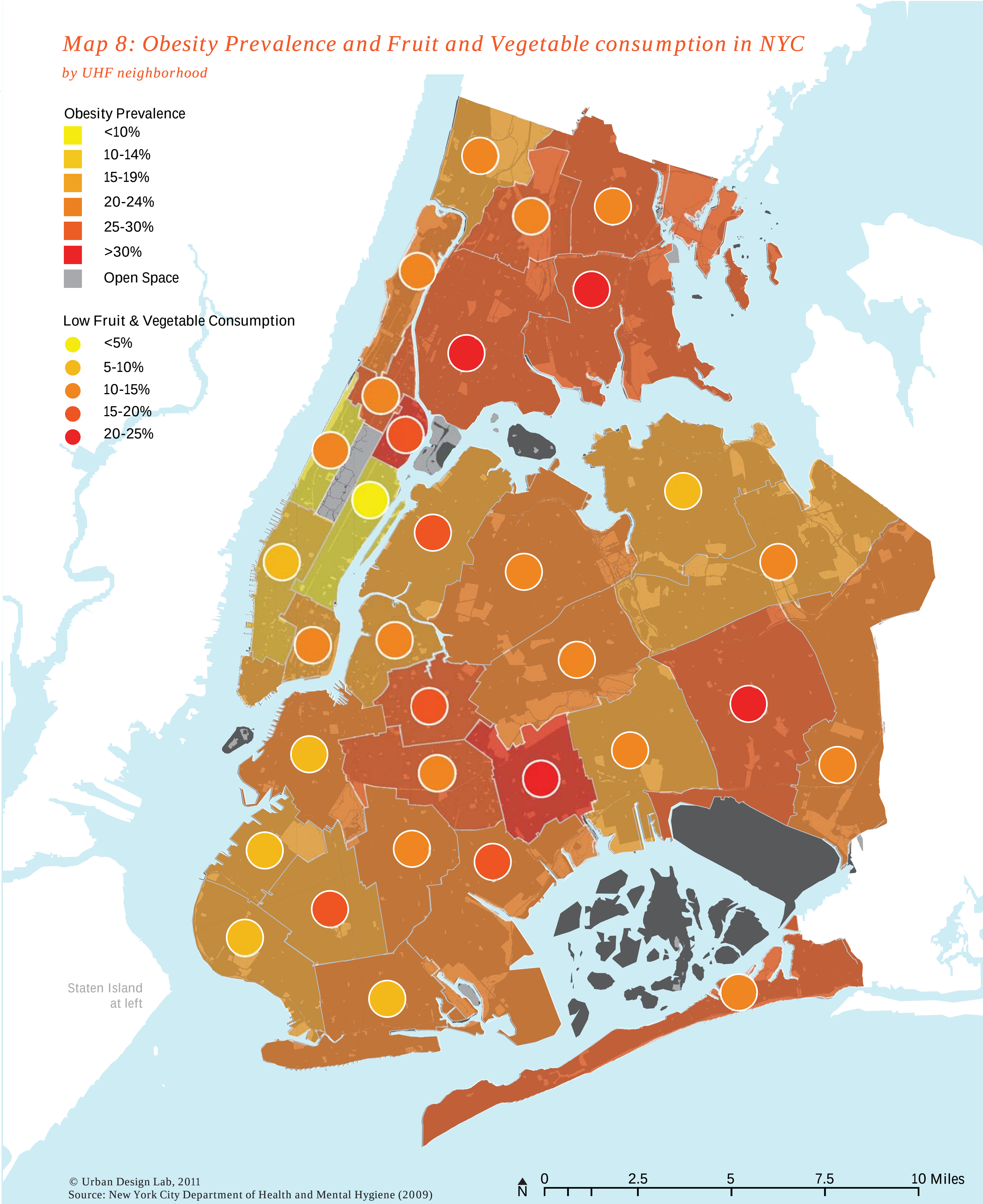
Perhaps the most striking feature of this epidemic is the disparity among neighborhoods within the city, with obesity prevalence ranging from only 9% in the Upper East Side of Manhattan to over 30% in East Harlem and Brownsville.[10] As is evident in ***Map 8: Obesity Prevalence and Fruit and Vegetable Consumption in NYC***, which shows data by United Hospital Fund (UHF) neighborhood, there is a correlation between obesity prevalence and fruit and vegetable consumption. Produce consumption impacts other health outcomes as well - people who eat fruits and vegetables three times or more a day are 42% less likely to die of stroke and 24% less likely to die of heart disease than those who eat them less than once a day.[11]

The neighborhoods in which obesity and diabetes levels are high – Harlem, the Bronx, far eastern Queens and the Rockaways, central Brooklyn, and northern Staten Island - have the lowest consumption of fruits and vegetables. In these places, less than one quarter of food retailers are likely to sell fresh food. A joint study conducted by the Department of Health and Mental Hygiene (DOH), the Department of City Planning (DCP), and the New York City Economic Development Corporation (NYCEDC), found that the city faces a widespread shortage of



Map 8: Obesity Prevalence and Fruit and Vegetable consumption in NYC

by UHF neighborhood

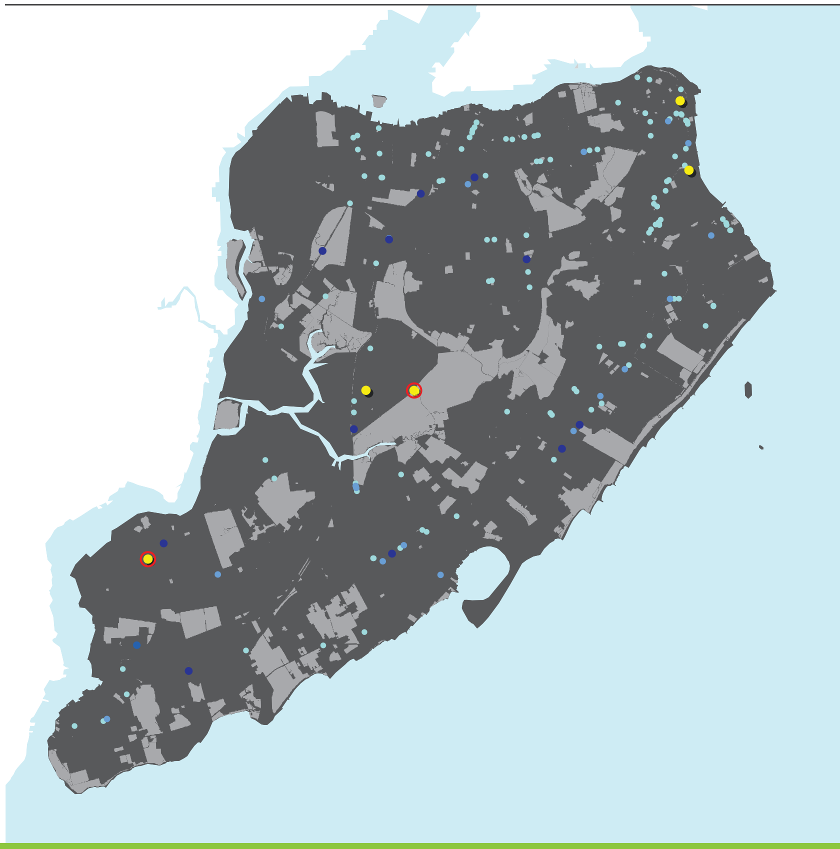


Source: New York City Department of Health and Mental Hygiene (2009) neighborhood grocery stores and supermarkets.[12] The study found that approximately three million New Yorkers face high need for fresh produce, especially in low-income neighborhoods. Many New Yorkers live in areas where bodegas, pharmacies, convenience stores, and discount stores are the major food retailers, and such establishments are often unable or unwilling to provide fresh produce due to the additional costs of storage. Challenges to food retail in NYC include the fact that it is difficult to develop stores larger than 30,000 s.f. in the city's dense commercial corridors, and unlike other parts of the nation, most people do not have access to a car for grocery shopping, making national standards for supermarket zoning inadequate for New York residents. In response to this problem, the City Council passed the Food Retail Expansion to Support Health (FRESH) program in 2008.[13] The goal of the program is to facilitate new grocery store development by offering zoning and tax incentives in underserved neighborhoods (see **Map 9: *Food Retail in NYC*** for location of these areas). These grocery stores must follow strict guidelines for shelf space devoted to fresh produce, interaction with the outside community, and community leadership in order to tackle the food security issues these neighborhoods face. The 2011 PlaNYC update called for using the program to facilitate the creation of 300 additional healthy food retail options in the targeted neighborhoods.[14]

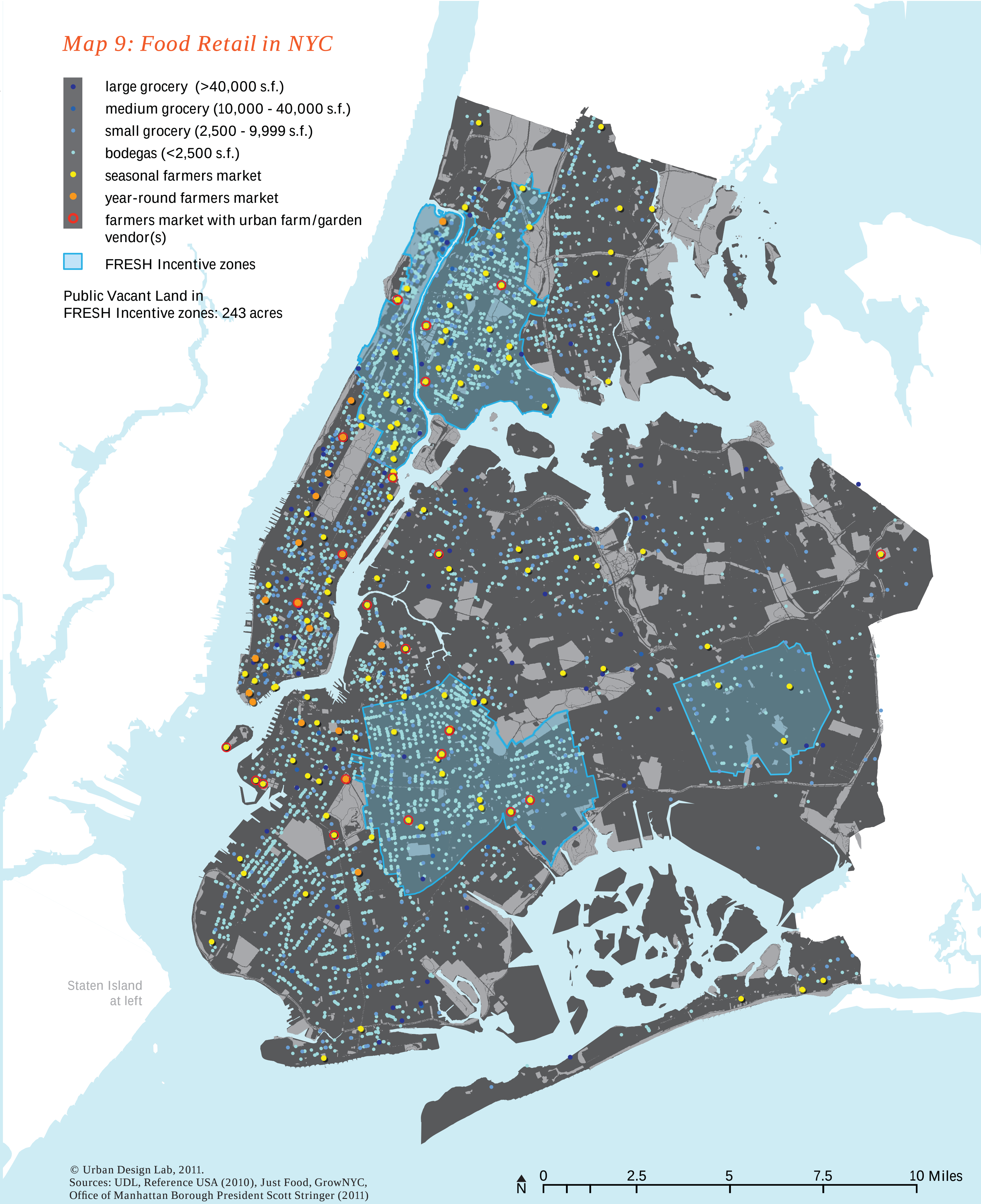
Small grocery stores or bodegas remain a primary source of food for people in many neighborhoods. Such stores rarely offer a selection of fresh, healthy foods, due to cost of refrigeration infrastructure, concerns about adequate demand, and unwillingness to replacing valuable shelf space with perishable items. The DOH Healthy Bodegas initiative was created in 2005 to address some of these issues, and has worked with more than 1,000 bodegas to promote the sale of fresh produce and low-fat dairy products. The initiative also encourages bodega owners to apply for stoop permits to allow the display of vegetables and fruits on the street. Fresh Bodegas, a newer partnership between GrowNYC and Red Jacket Orchards, while much smaller in scope (currently the project focuses on the Bedford-Stuyvesant neighborhood in Brooklyn), is actually helping to provide the refrigeration infrastructure necessary for bodega owners to stock fresh produce sourced from regional producers.[15] The Green Carts program has also expanded, issuing almost 500 new permits to street vendors selling fresh fruit and vegetables in qualified neighborhoods. Community Supported Agriculture (CSA) and farmers markets are also growing entities in the city. Such programs offer famers direct access to consumers, which increases profits for the farmers, increase fresh food retail options for residents, and encourage greater food system awareness by providing opportunities for direct connection between producers and consumers. Just Food operates a neighborhood-based CSA network in over 80 locations. GrowNYC's Greenmarkets program runs 54 farmers markets in the city, and an additional 58 community farmers markets are independently operated. Many of these locations accept EBT cards, and the DOH is supplementing the federal food stamp program (SNAP) with "Health Bucks," which provide SNAP recipients with $2 in coupons for every $5 in SNAP spent at farmers markets.

Urban agriculture and food security

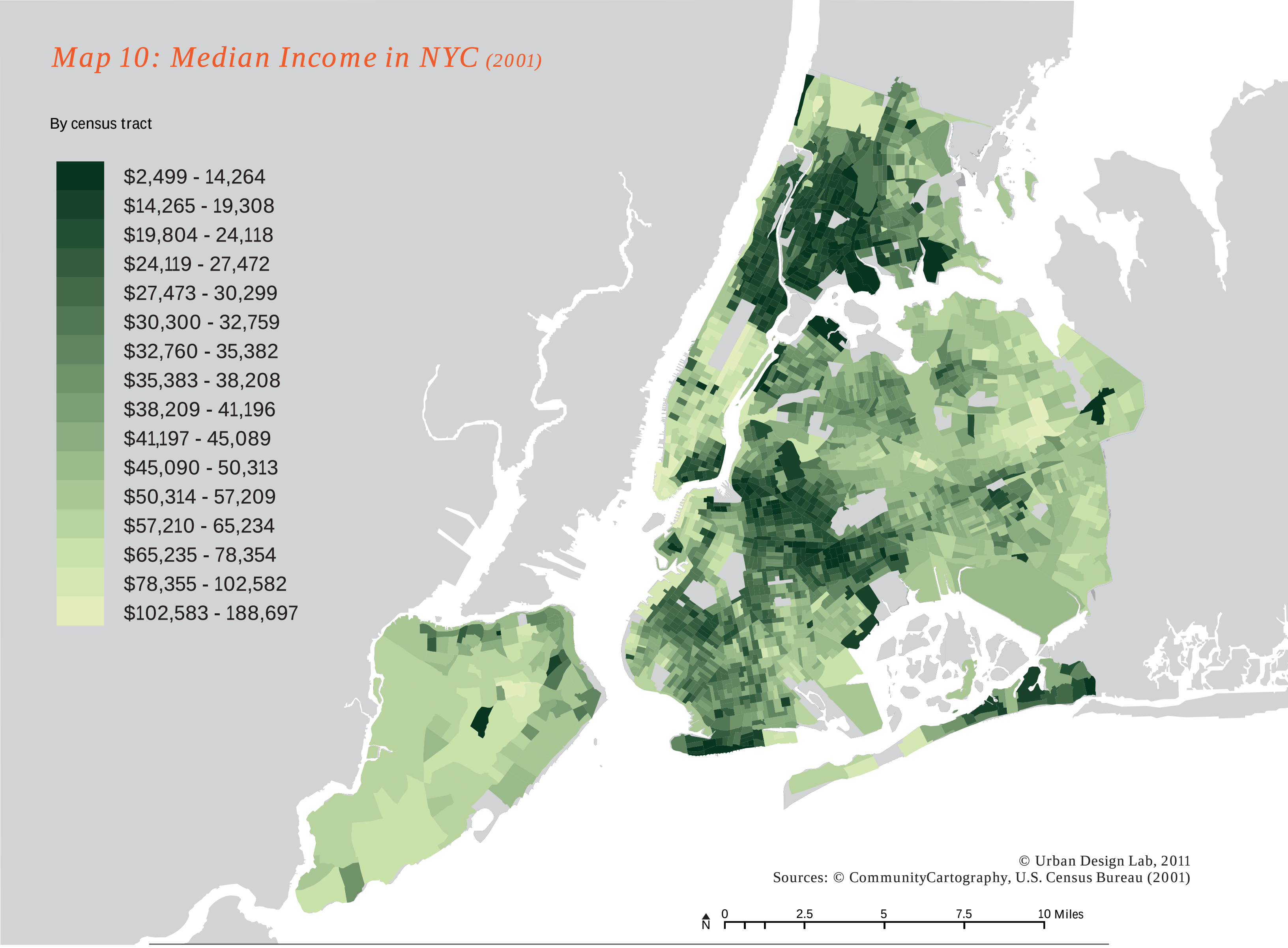
Urban agriculture is already contributing to improved food security in NYC, and clearly has the potential to significantly contribute to increased access to fresh, healthy foods. Community gardens across the city are providing food to members and supplying local



Map 9: Food Retail in NYC



Sources: UDL, Reference USA (2010), Just Food, GrowNYC, Office of Manhattan Borough President Scott Stringer (2011)



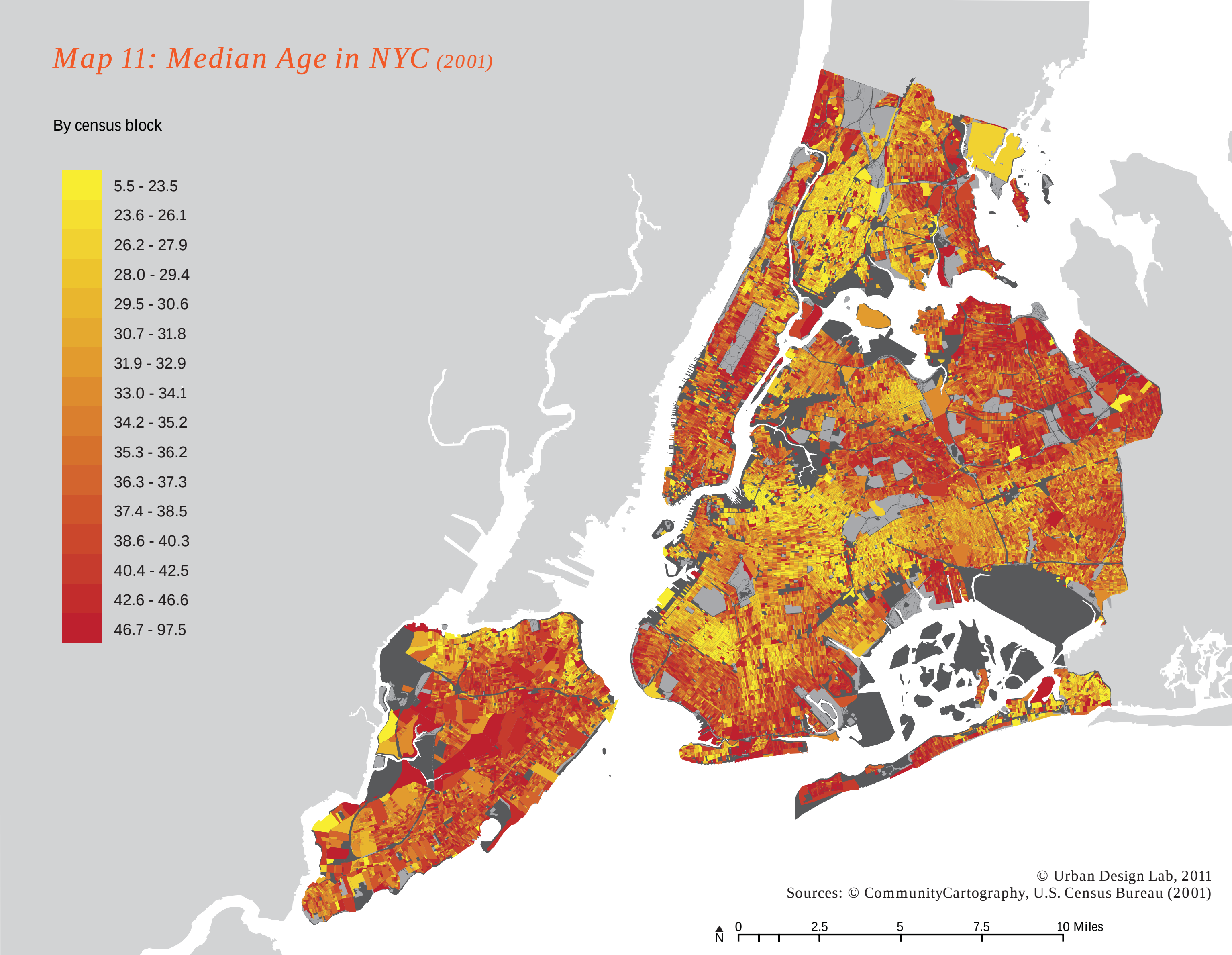
food banks with their produce. The Farming Concrete project measured that 87,690 lbs. of vegetables were grown on just 67 gardens of the city's hundreds of community gardens in 2010.[16] Urban farms such as Added Value Red Hook and East New York Farms have CSA programs offering produce from their farms, while Eagle Street Rooftop Farm has a CSA which is supplemented with produce from a farmer in the Hudson Valley (this may be the first CSA in the nation to be at least partially supplied by a rooftop farm). Farms and community gardens are also selling their produce at farmers markets, in some cases onsite (such as with Added Value Red Hook, East New York Farms, La Finca Del Sur, Hattie Carthan Community Garden, and others), and the City is partnering with Just Food to establish five more farmers markets at community gardens. Many of these farmers markets also host regional producers from outside the city. These examples provide ample evidence of how urban agriculture is already acting as a catalyst for larger food system change by providing facilities and logistical support for regional producers to gain access to urban consumers. Many of these community farmers markets are in areas where conventional grocery stores are reluctant to locate due to concerns about neighborhood income levels and demand, and the success of these markets is a powerful testament to the fact that people of all income levels have an interest in buying and consuming fresh, healthy food. The role of urban agriculture in urban CSA programs and farmers market distribution models demonstrates that urban agriculture is not merely a novel approach to food production but increasingly part of a viable, comprehensive, alternative food system that has the capacity to provide access to fresh food for populations for whom that access is otherwise denied.

Fig. 6: Vacant Land by Median Income Quintiles (in The Bronx, Brooklyn, Manhattan, and Queens)

Median Income: Census block quintiles	Area (acres)	Number of Vacant Lots	Area of Vacant Lots (acres)	% Vacant	Vacant Lots per Acre
$2,499 - 25,229	22,328	6,003	706	3.16%	0.268
$25,230 - 34,234	19,966	4,555	468	2.34%	0.228
$34,235 - 42,908	23,613	3,883	430	1.82%	0.164
$42,909 - 55,114	30,424	4,917	658	2.16%	0.161
$55,115 - 188,679	32,166	3,710	531	1.65%	0.115

© Urban Design Lab, 2011. Sources: © CommunityCartography, U.S. Census Bureau (2001)

If existing urban food production is already impacting food access in NYC, the potential for urban agriculture to contribute to food security is much greater. As discussed in the **Crop Yields** section of this report, it is unlikely that, using current growing methods, NYC would be able to grow a large percentage of its overall fruit and vegetable needs; however, if we consider the needs and resources of particular communities within the city a much different picture arises. The scale at which we evaluate urban agricultural capacity is critical. For a number of reasons, including the fact that many urban farms and gardens are community-run enterprises, the neighborhood scale may be the most appropriate unit of analysis. There are a number of neighborhoods where a confluence of factors makes urban agriculture a particularly attractive and effective means of addressing multiple challenges. These include low access to healthy food retail, high prevalence of obesity and diabetes, low median income, and comparatively high availability of vacant and other available land (see **Map 10: *Median Income in NYC***). Not coincidentally, these factors are all correlated, and it is in these areas where urban agriculture could have the greatest impact on food security. **Fig. 6: *Vacant Land by Median Income Quintiles*** shows the relationship between median income and vacant land in census block quintiles in the Bronx, Brooklyn, Manhattan, and Queens. (Staten Island, which has relatively high income neighborhoods and a great deal of vacant land, was excluded from this analysis because its density, development patterns and demography are more similar to surrounding suburban areas than to the other four boroughs.) The chart demonstrates that areas with lower median income levels have more vacant land, with almost twice the per-



Map 11: Median Age in NYC (2001)

centage of vacant land (3.16%) and well over twice the number of vacant lots per acre (0.27) in the lowest income quintile as compared the highest quintile (1.65% and 0.12 lots per acre, respectively). Another interesting apparent correlation exists between income and age, with lower income areas generally populated by younger populations (see ***map 11: Median Age in NYC***). This is relevant for a number of reasons. Not only is youth empowerment and education a major priority for urban farmers in many communities, but young people are often the driving force for the creation of urban farms and gardens.

Neighborhoods which fit the pattern of inadequate healthy food access, high incidence of diet-related disease, greater percentage of vacant land, etc., include East New York, Brownsville, Crown Heights, Bedford-Stuyvesant, and Bushwick in Brooklyn, the Lower East Side and East and Central Harlem in Manhattan, and Morrisania, Claremont Village, East Tremont, and Belmont in the Bronx, among others. These are also neighborhoods where the presence of many community gardens signifies community interest in and engagement with food production. In these neighborhoods, urban agriculture could significantly improve fresh food availability. For example, Brooklyn Community district 16 (Brownsville) has 58 acres of vacant land, which, if converted entirely to vegetable production, could produce as much as 45% of the district's 85,000 residents' annual supply of dark green vegetables (broccoli, collard greens, escarole, kale, lettuce leaf, mustard greens, spinach, and turnip greens; this estimate assumes an average lot coverage of 70% for growing area). This district also has an estimated 23 acres of green space on NYCHA property, as well 14 acres of surface parking – converting some of this area to farming or gardening could increase the availability of fresh produce even more. While it is unlikely that all or even a majority of this land will be farmed, even a small increase in fresh food availability is these chronically underserved neighborhoods will have an impact on food security. (See the **Case Studies** section of this report for more information on Brownsville.)

Increasing food security is more than just a matter of increasing local food production, however. Storage, processing, distribution, and retail are all critical components of ensuring fresh food access, and these components of the supply chain can pose a challenge to urban farmers. Very few urban farms have the capital necessary to build refrigeration space, and processing equipment capable of handling commercial volumes is expensive as well. These factors limit production capacity, as urban farmers without adequate storage capacity must not only concern themselves with growing the food but also with ensuring that they will have a customer or market for produce available upon harvest. Demand at restaurants and markets is uneven (and tends to be highest on the weekend), and without storage capacity it is difficult to meet that demand. Some farms, such as Added Value Red Hook, are looking to build onsite refrigeration so as to be able to provide a greater variety of products to the community and to have a greater retail presence. Others are beginning to establish arrangements with churches or schools to be able to use their institutional kitchens for processing on days when they are not otherwise in use, which can be a very efficient use of existing resources. **Map 12: *Institutional Kitchens in NYC*** (following pages) shows that such facilities are widespread throughout the city, and could be an important resource for farmers. Another advantage of using these existing facilities is that they presumably already have the necessary food processing licenses and fees, which can be prohibitively expensive and difficult for small farmers to obtain. NYC also has huge potential for increasing commercial processing facilities, many of which could process produce grown in the city. This is an issue which is addressed in the City Council's *FoodWorks* report, which calls for the development of new industrial space for food manufacturing businesses, among other recommendations.[17] Increasing storage and processing capacity would also allow for the food grown in urban farms to be available throughout the season and would provide opportunities for farmers to increase profitability through value-added products. Distribution of food is another challenge for farmers – for example, farmers can often get high prices for their produce at restaurants, but sales volume is usually lower than at a typical farmers market, and distributing to multiple restaurants can be costly and time-consuming. Increasing storage and processing infrastructure would provide promising opportunities for establishing aggregation sites that would make the distribution process more efficient for both producers and buyers.

Finally, while there are multiple retail avenues available for urban producers, there is potential for expanding existing opportunities and establishing new retail models. As mentioned above, urban farmers are already forming CSAs, selling at farmers markets, and selling to restaurants. Thus far, the scale of urban farming in NYC has made it difficult to supply conventional produce retailers such as large grocery stores or supermarkets, which need consistent large volumes of produce and generally offer low prices to farmers. While initiatives such as FRESH, which incentivize the production of mid- to large-scale supermarkets, are a critical part of the solution to inadequate food access, it is clear from **map 8** that in many underserved neighborhoods, bodegas will likely remain a dominant form of food retail. These stores form a widespread, accessible, existing retail infrastructure, and there may be opportunities to develop networks of such stores that would be supplied by agriculture taking place within these communities. In fact, the scale and distribution of bodegas could make them highly suitable for linking to small-scale, dispersed urban agricultural activities. Procuring necessary storage and refrigeration equipment remains a challenge, and would likely require additional tax incentives or a subsidized loan or grant program for store owners. The advantages, however, would be considerable, in that it would decrease the need for refrigeration and storage on neighborhood farms or gardens by providing small-scale infrastructure within the community, would enable the proprietor to offer a greater selection of fresh options, and would provide consumers with more choices. The capital necessary for such a small-scale distributed network may well be considerably less than that needed for the construction of a new grocery store. Such an approach may be not be suitable for all neighborhoods, but could offer a lower-cost alternative to larger-scale, capital intensive projects.

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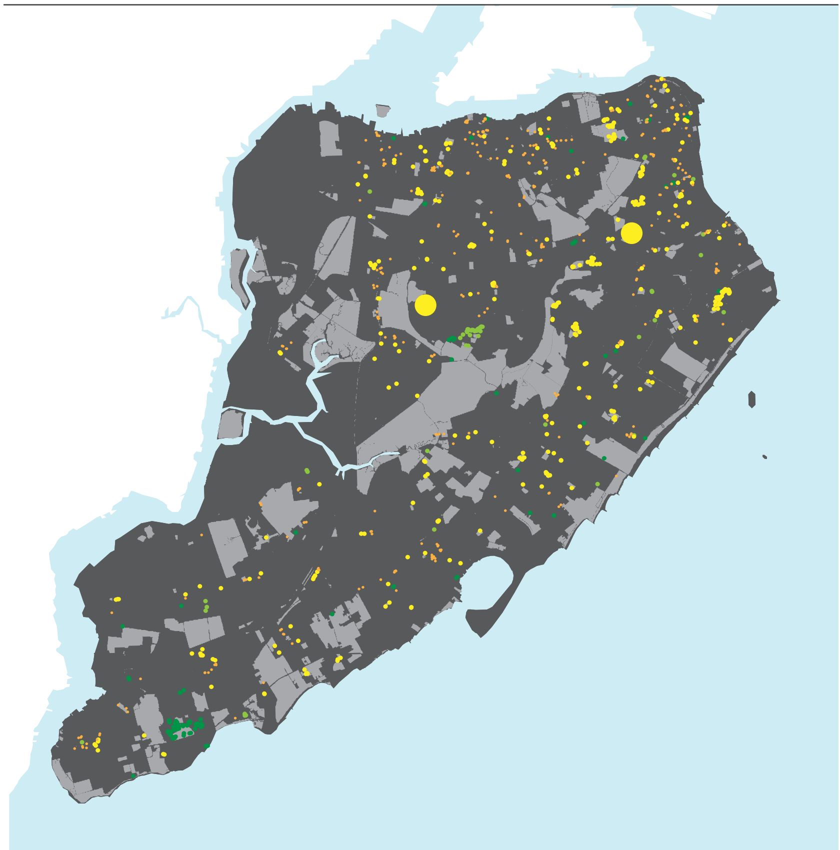
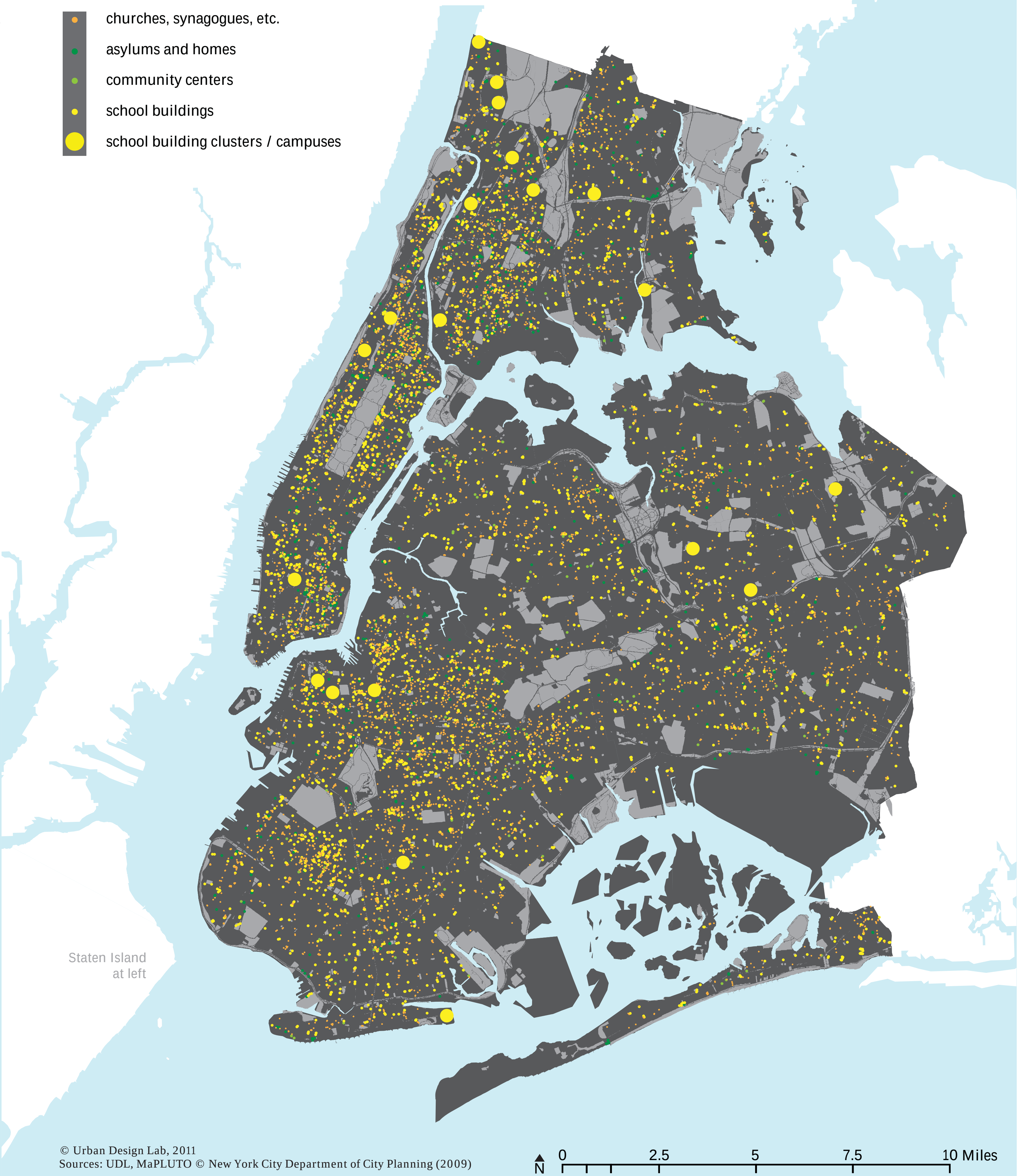


Map 12: Institutional Kitchens in NYC



Sources: UDL, MaPLUTO © New York City Department of City Planning (2009)

VII. Water

Water use

New York City's water infrastructure is comprised of two systems: the water supply system, which ensures safe, reliable delivery of fresh drinking water from the Catskill/Delaware and Croton watersheds in upstate New York, and the sewage system, which disposes of used wastewater. Each of these systems faces unique challenges.

Unlike many parts of the country, the NYC region does not face regular drought conditions, and water scarcity is rarely an issue (certain climate change projections indicate that the region may expect increasing precipitation in the coming decades[1]). However, the water supply system cannot be taken for granted, and requires continual active protection from pollution from agricultural and industrial activity (with regional natural gas-related hydraulic fracturing, or "fracking," being a more recent concern). The supply system's aging infrastructure is continually being upgraded, and the energy and environmental costs of getting fresh water to the city mandate efforts to conserve water. For this reason, urban agriculture must be considered within the context of increasing fresh water use and the ensuing strain on the city's fresh water supply system. Many community gardens currently use water from nearby hydrants for irrigation, while others are transitioning to rainwater collection systems, which are more sustainable solution. Recirculating hydroponic systems have the potential to dramatically decrease water use for agriculture, although their high start-up costs can be a barrier to widespread implementation. In general, the type of intensive growing that is often practiced in urban settings is generally more water-efficient than conventional agriculture, in that more targeted irrigation systems are used.

It is very difficult to estimate the increase in water use that would result from an increase in urban farming in NYC. Different crops and soils absorb varying amounts of water, and the differences are even greater when comparing ground-based gardening to rooftop or hydroponic systems. NYC has a relatively wet climate, with mean annual precipitation of almost 50 inches (making it wetter than Seattle); however, additional irrigation is often needed during especially dry or hot periods and during critical growth phases for plants (fruits and vegetables, the most common and suitable crops for urban areas, consist of 80-90% water by weight). Approximately 0.75 to 1.5 inches of water per week is needed during the summer months to keep most vegetable crops healthy (depending on the crop).[2] This translates to about 470 to 930 gallons of water per 1,000 s.f. of growing area, which at current (2011) NYC Water Board rates would cost between $1.85 and $3.67.[3] While this may not seem like a large amount, this could be an issue for public agencies such as NYCHA which have many community gardens on their property and are looking to increase the amount of land available to farmers and gardeners. Water use can be decreased by installing water efficient irrigation systems such as drip irrigation, which provides water directly to the plant roots, minimizing evaporation and waste. This type of system can be very effective for small-scale ground-based and rooftop farms, but may be beyond the ability of many community gardens to afford and maintain. Rain barrels and other rainwater collection systems offer another solution; see below for a detailed discussion of rainwater collection and blue roofs.

Stormwater management

While the issue of fresh water use in urban agriculture is an important one, a more pressing concern is the problem of stormwater runoff and combined sewer overflow (CSO) into the city's waterways, which is one of NYC's most intractable environmental problems. Given the prohibitive expense of establishing increased treatment capacity through "gray infrastructure," or large-scale, centralized approaches, the DEP is proposing the complementary, decentralized "green infrastructure" approaches of rainwater capture and increasing permeable surface area. Urban agriculture could provide both of these services: through rooftop rainwater harvesting, which is already being practiced at many community gardens, and by increasing urban green space and thus water detention and retention. These approaches are outlined in the PlaNYC Sustainable Stormwater Management Plan from 2008,[4] and more recently in the NYC Green Infrastructure Plan released in 2010, which is to be supported by $1.5 billion in investments over the next 20 years.[5] As noted in these documents, however, green infrastructure solutions are not only cost effective in comparison to grey infrastructure approaches, and have added benefits in the form of reducing energy use, increasing property values, and cleaning the air. If urban agriculture were to be considered as a form of green infrastructure, one could add food security and health outcomes resulting from the potential adoption of healthier diets to those additional benefits, not to mention the creation of economic opportunities that other forms of green infrastructure do not provide – once a sidewalk swale, for example, has been constructed, it's employment potential is limited to periodic maintenance, whereas an urban farm could provide jobs for as long as it is in existence. For these reasons, the green infrastructure potential of urban agriculture is gaining increased attention.

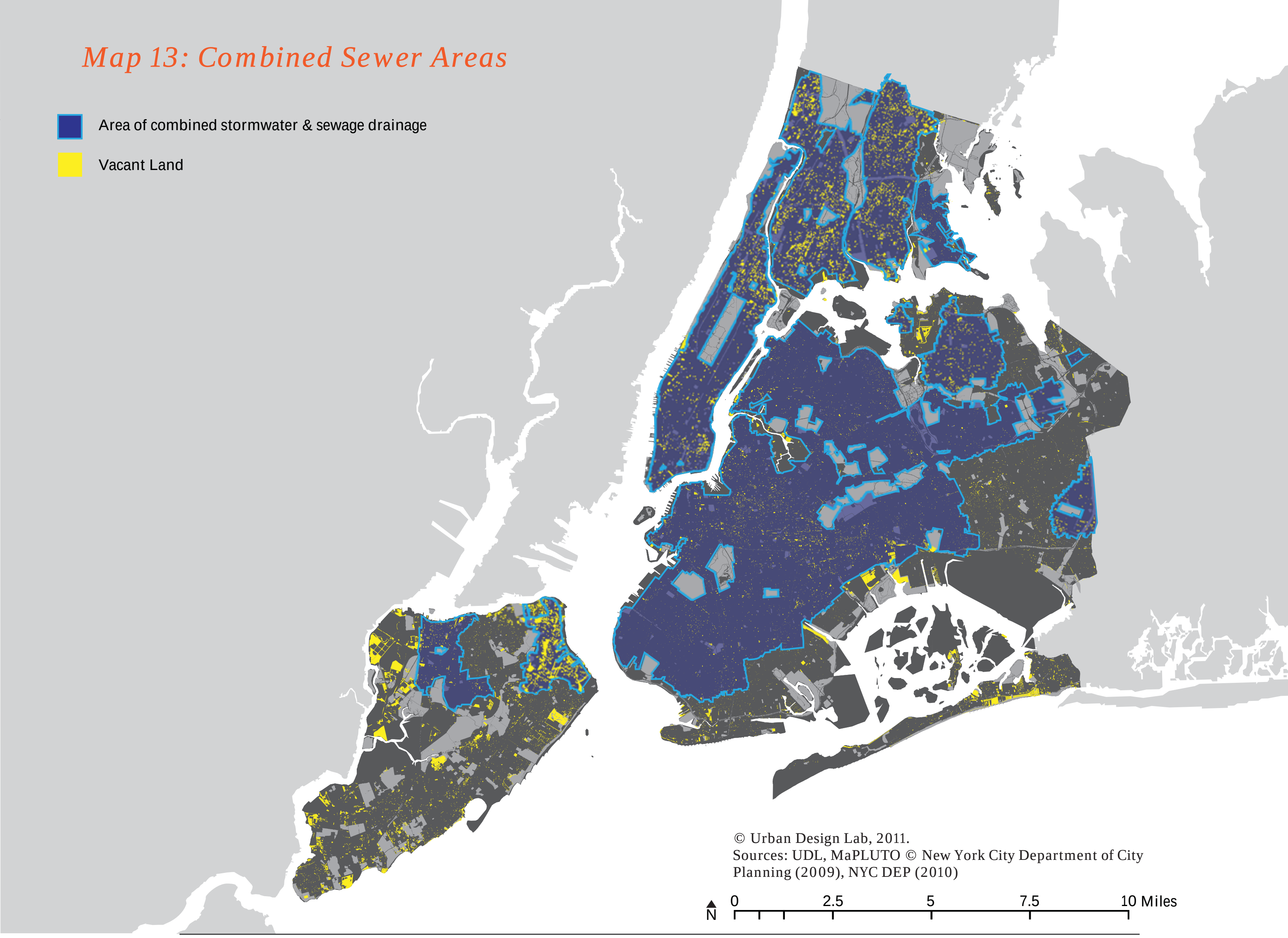
Implications for urban agriculture

The Green Infrastructure Plan calls for a reduction in CSO volumes by an additional 3.8 billion gallons per year, which is to be achieved primarily through green infrastructure approaches, including capturing rainfall from 10% of the impervious surfaces in the Combined Sewage Watersheds (CSWs). See ***Map 13: Combined Sewer Areas*** to see which parts of the city have combined sewer and stormwater systems. This would be achieved by in part by adding anywhere from 993 acres (assuming 25% of acreage required for the 10% capture goal would consist of planted areas) to 2,978 acres (75% of acreage would consist of planted areas) of fully vegetated area to the CSWs.[6] According to our calculations using our methodology (see **Site Availability** above), there are 477 acres of public vacant land and 1,472 acres of private vacant land in the CSWs. The DEP estimates that 78% of the city's land consists of impervious surfaces;[7] within the CSWs, which exclude much of Staten Island (which has the highest ratio of green space of any borough), that figure is likely to be higher. Vacant land consists of, on average, 60% impervious area; converting all of this vacant land in the CSWs to urban farms or other fully vegetated area would increase total permeable area by 1,169 acres. Capturing rainwater from 3,700 acres of rooftop area in the CSWs would add an additional 5% to meet the city's goal.

The impacts of agricultural green roofs on stormwater runoff mitigation can vary. There are two ways in which green roofs can reduce CSO events. Detention occurs as rainwater is absorbed by the soil and eventually released once a saturation point has been reached; the delay between a period of heavy rainfall and the eventual release of the water into the sewer system has the benefit of decreasing the overload on the treatment systems which result in CSOs. Retention occurs as rainwater is absorbed by the soil and eventually evaporates directly from the soil or through the process of evapotranspiration in plants. Retained water never makes its way into the sewage system. As far as detention is concerned, rooftop farms could have an advantage over conventional green roofs in that deeper growing medium is required: at least 6 inches, and often up to 10 inches of soil or other medium, as opposed to 2 – 4 inches for sedum plantings. Deeper soils generally detain more water; however, this benefit could be partially offset by the fact that food crops generally need to be irrigated, and soil that is partially saturated is less effective at absorbing additional stormwater. Detention rates vary widely depending on the type of growing medium used, although there are indications that soils which are replenished through composting have increased hydraulic conductivity.[8] Another factor is the degree of pre-saturation, which is determined by time between rainfall events and how much irrigation is being used for the crops. Farmers (at least of the outdoor variety) are by necessity well attuned to the weather forecast and will make decisions on when to irrigate accordingly; however, it is difficult to account for the vagaries of behavior and varying crop needs when estimating the stormwater mitigation potential of agricultural green roofs. As for retention, the differences between agricultural and conventional green roofs are equally complex. Again, deeper soil is generally assumed to have greater retention capacity. There is some indication in the research that there is an optimal depth beyond which retention decreases,[9] possibly due to the fact that solar energy penetration decreases with depth and deeper soils dry more slowly than shallow ones, though this research was performed on roofs planted with shallow-root sedum, whereas deeper root food crops could offset this factor with increased water transpiration from the bottom of the soil layer. The greater surface area of food crops as compared to sedums could also increase evapotranspiration rates, at least during the growing season, while during the winter months conventional green roofs would likely perform better.

The NYS Green Roof Tax Abatement offers a one-time property tax credit of $4.50/s.f. for up to $100,000 for the construction of green roofs on 50% or more of a building's roof area. Few building owners or developers have taken advantage of this abatement, due in part to the substantial cost of installing a green

Map 13: Combined Sewer Areas



roof, which is only partially defrayed by the credit, and the time-consuming and onerous nature of the application process. Furthermore, as it is currently written, the credit does not apply to rooftop farming - the credit requires that 80% of the green roof area be planted with drought resistant or hardy plants, which effectively excludes food crops. The credit was designed for the purposes of limiting stormwater runoff, hence the requirement for drought-resistant plants. (The Brooklyn Grange rooftop farm may succeed in receiving the credit by arguing that they are cultivating more drought resistant varieties of vegetables – the definition of "drought resistant" is left open to interpretation in the language of the bill.) A resolution before the New York City Council, to be voted on in 2011 seeks to amend the tax credit to make it easier for farms to claim the credit by eliminating the drought resistant requirement and substitute language to allow for food crop irrigation. Given that this credit was developed specifically with stormwater runoff reduction in mind, and that rooftop farming has other additional benefits, it may be more effective to create a separate piece of legislation specific to rooftop farming. Either way, developing a tax credit or other form of financial incentive that is deliberately inclusive of agricultural green roofs would incentivize their creation, giving farmers a critical tool for negotiating favorable terms with building owners. Unlike conventional green roofs, in which installation costs are be borne by the owner, agricultural green roof costs are often borne at least partially by the farmer in return for free or reduced rent.

Whether and the degree to which incentives will be created to encourage rooftop agriculture depend at least partially on the whether the relevant city agencies believe that the decrease in tax revenue would be adequately offset through the provision of these ecosystem services. Given that the "existing development" land use category is by far the largest in the

CSWs, it seems that focusing interventions on existing buildings would represent the greatest potential for mitigating stormwater runoff in these areas. The NYC Green Infrastructure Plan prioritizes the creation of green roofs primarily for new development and multi-family residential complexes, while concluding that they are not cost effective as compared to other approaches to mitigating runoff for most other existing development. This finding has been challenged by researchers who claim out that the maintenance cost estimates used in the city's evaluations are inaccurate and the savings incurred from the greater longevity of green roofs were not factored into the analysis. Recently released findings from a group of researchers at Columbia University have measured a retention rate 22 times higher than that assumed in the PlaNYC analysis, which would change the cost-effectiveness ranking of green roofs from the least cost-effective to the most cost-effective of considered measures for stormwater retention.[10] Furthermore, areas with the highest concentration of buildings that could be suitable for rooftop agriculture, such as around the Newtown Creek, Gowanus Canal, and in the Hunts Point neighborhood in the Bronx, are also areas which have high rates of surface runoff, for the same reasons (namely, large rooftop areas and few green spaces).

Another point to consider is that decreasing stormwater runoff from rooftops has benefits beyond reducing CSO incidence; contaminants from roofscapes and streetscapes can make their way into the city's waterways independent of CSO events, either because sewage treatment plants are not designed to treat such pollutants or because of direct runoff into waterways. There are indications that conventional green roofs can reduce pollutant runoff in water through filtration and biological uptake of nutrients;[11] however, green roofs have the potential to leach contaminants into runoff as well. Intensive composting operations, whether on rooftops or at ground level, have the potential to leach nitrogen into waterways if runoff is not well managed. For this reason it is important that more research take place on the composition and potential contaminants from various rooftop growing media, and that growing methods in urban areas conform to organic or more stringent standards. Much of area around the Newtown Creek, for example, where there is a high concentration of buildings that could support rooftop agriculture (see **Map 6: *Potential Rooftop Farming in NYC***), is not in a CSO watershed; rather, much of the stormwater from this area is discharged directly into the Creek, which was designated an EPA Superfund site in 2010. It is important to note that green roofs alone will not solve the CSO issue – a study focusing on the Gowanus Canal Watershed estimated that covering 100% of suitable buildings in that area with green roofs would result in a 26% reduction in CSO volume[12] – but rather part of a larger set of strategies. Clearly, much more research is needed to understand the degree to which agricultural green roofs can reduce runoff, as research date has focused on conventional green roofs. An effort is currently underway to measure the environmental performance of rooftop and gound-based farms in NYC,[13] and while quantifying stormwater mitigation performance is difficult, it is clear that rooftop farms are an important component of will necessarily be a diversified approach to this problem.

Other policy approaches that have been discussed include having the DEP assess stormwater mitigation fees from property owners for direct runoff from their properties, offering exemptions for on-site mitigation strategies. This is an approach advocated by the City Council in their *FoodWorks* report (see the **Reccomendations** section of this document), which calls on the Water Board to change its wastewater billing structure to include a charge on stormwater based on a property's impermeable surface area. This would be an effective way to promote green roofs of all types, including agricultural green roofs, and if rainwater collection was included as an exemption, would further incentivize water-efficient urban agriculture.

Other than increasing the amount of permeable surface area in NYC, urban agriculture can contribute to stormwater mitigation with direct source-controls, such as rooftop rainwater harvesting or "blue roofs," which also decrease water use if used for irrigation. Such systems are potentially more cost effective than green roofs from the perspective of mitigating runoff (according to the DEP, installing a 55 gallon tank results in an annual cost of $0.18 per gallon captured while a green roof has an annual cost of $3.33 per gallon captured;[14] this analysis does not include additional green roofs benefits). Harvesting rainwater from rooftops involves connecting rooftop downspouts to catchment systems comprised of a first flush chamber, or roof washer, in which the initial runoff from a rainstorm (which has the highest level of contaminants, especially if it has not rained in a while) gets diverted into a separate tank, and subsequent runoff gets collected in the main cistern. Water from this cistern is then used to irrigate crops. Testing on captured rooftop runoff has shown low levels of lead, and bacteria can also be present in the rainwater, which is not considered potable (and must be labeled as such). There is no consensus on acceptable levels for contaminants such as lead in irrigation water, but levels of post-fist-flush runoff are generally considered safe for farming and gardening. NYC has favorable conditions for rooftop stormwater harvesting because of its density (most available lots for farming are surrounded by existing structures) and because of its relatively wet climate. In this climate farmers and gardeners can generally plan for 5-6 gallons of storage capacity per square foot of roof area. Rainwater catchment systems tend to be low-tech and low-maintenance, as they do not involve pumps or other motorized hardware. They must be drained in winter, and the first flush filter and roof gutters need to be regularly cleaned. One of the challenges to installing such systems is obtaining the consent of the owners of the buildings adjacent to farms or gardens, although in some cases there are clear benefits to the building, in that catchment systems can divert water away from building foundations and mitigate basement flooding and mold and mildew in basements and walls. As with green roofs, the creation of a viable system combining financial penalties levied on certain property owners with tax incentives or direct subsidies for the installation of source controls or other green infrastructure solutions could go a long way toward encouraging the installation of such systems.

There are already a number of rainwater collection systems operating in farms and community gardens in NYC, with 62 installed by GreenThumb since 2002. Gardeners have found that during most summers the systems can supply most or all of the water necessary to irrigate the garden, though unusually hot & dry summers (such as the summer of 2010) additional water sources are needed. GreenThumb has estimated that each year, these 62 systems divert an average of 772,156 gallons of rainwater from the city's sewer systems, with a total cistern capacity of 39,849 gallons collected from a catchment area of 45,468 sq.ft.[15] The program is expected to expand starting in 2011 with a project funded by fines levied against polluters in the Bronx River watershed to construct additional garden rainwater catchment systems in this area.

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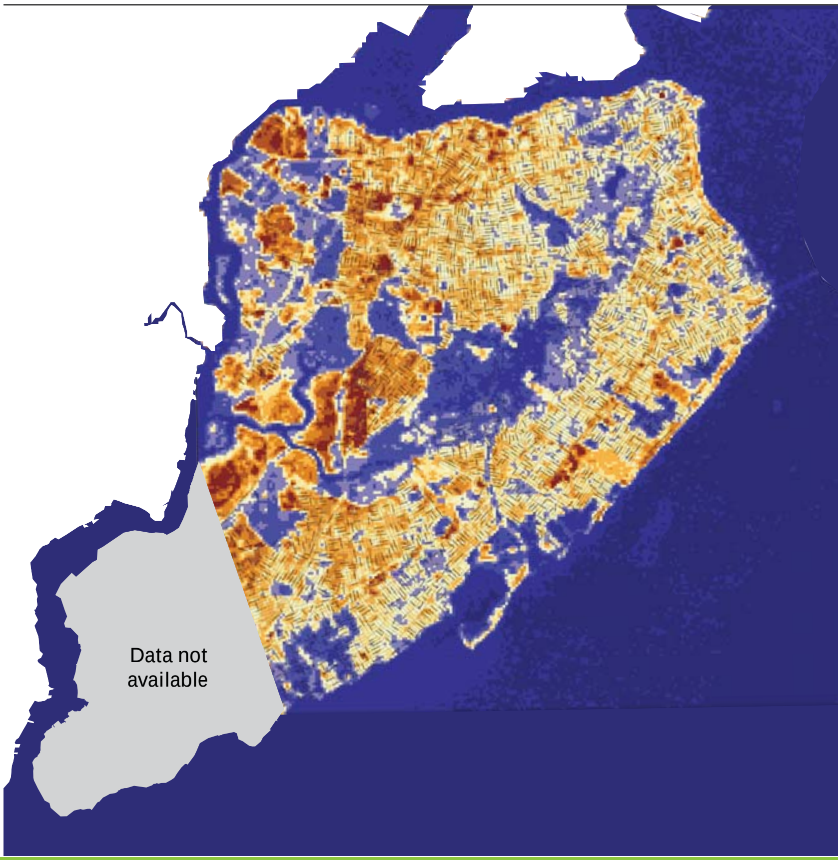
The increasing global demand for energy is one of the most serious environmental challenges of our time. A majority of the world's energy is derived from non-renewable fossil fuel resources, whose extraction causes ecological destruction and contributes to instability and even armed conflict in many resource-rich nations. The burning of fossil fuels causes air pollution and is the primary contributor to global climate change, which has the potential to drastically alter the earth's environment and cause widespread social upheaval. There are no easy solutions to this complex, systemic challenge. What is certain is that a far-reaching combination of strategies is needed to forestall the potentially catastrophic effects of fossil-fuel depletion and climate instability, including investment in new technologies and other economic incentives to encourage increased reliance on renewable resources, and decreases in energy consumption through conservation and efficiency measures. The United States, with under 5% of the world's population, accounts for approximately 25% of global energy consumption,[1] and thus bears special responsibility for addressing this crisis. While average greenhouses gas emissions for NYC residents represents just 29% of the U.S. average,[2] due primarily to the efficiencies inherent in living in a highly dense metropolis, New Yorkers still have a carbon footprint which is almost twice the size of the global average.[3] The City, faced with increasing pressure on its aging energy infrastructure, public health issues from energy-use-related air pollution, and threats from rising sea levels, has committed to decreasing its total energy consumption and CO_2 emissions,[4] a highly ambitious goal in an era when no large metropolitan area has managed to do so.

Decreasing energy use in NYC will require a large variety of approaches, and urban agriculture could have a small albeit important role to play. There are several ways in which urban agriculture could contribute to this goal: a) helping to alleviate the urban heat island effect, b) decreasing building energy use through rooftop agriculture, and c) decreasing energy use associated with food transportation and storage.

Urban Heat Island effect

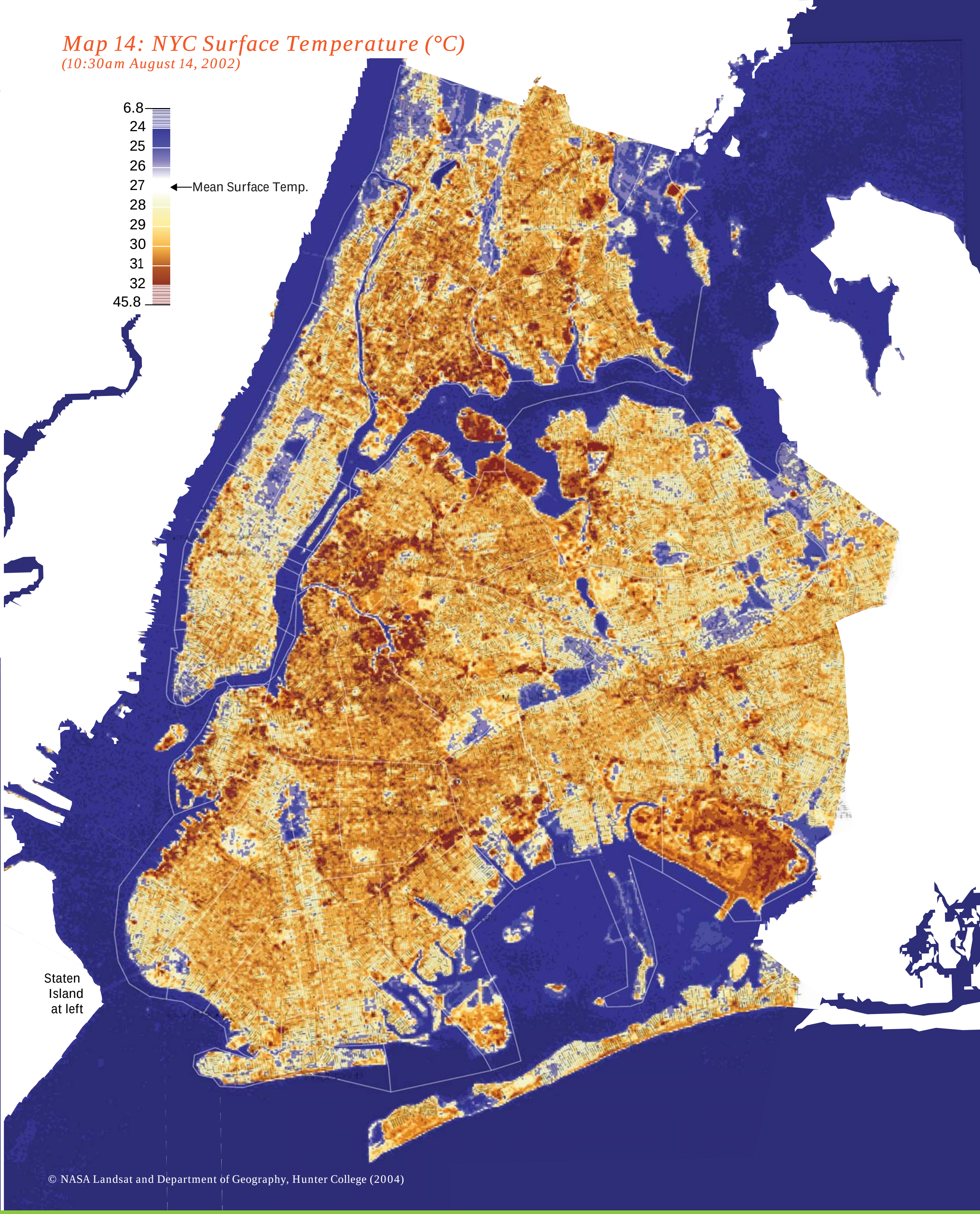
NYC continues to experience increasing summer temperatures associated with global climate change, which are exacerbated by the "urban heat-island" effect (UHI), or elevated temperatures due to heat absorption by materials such as concrete that are prevalent in urban environments. A heat island forms when naturally vegetated surfaces are replaced with non-reflective, impervious surfaces that absorb a high percentage of incoming solar radiation.[5] The intensity of the urban heat island depends on energy balance variables. The rate at which incoming solar radiation is absorbed and reradiated depends on the physical properties of surface types (e.g. albedo, heat capacity) as well as on their configuration within the urban landscape (heights of buildings, road network, etc.) regional meteorology, and local microclimate. This problem leads to increased energy use in the form of air conditioning, which currently accounts for 1/6 of all electrical energy used in the United States.[6] The heat island effect also leads to elevated incidence of asthma and heat-stroke, with higher temperatures accelerating the formulation of harmful smog, which has been shown to increase acute mortality rates as well as increase hospital admissions.[7]

The UHI effect increases NYC's temperature by an average of between 2-4 degrees C (3.6-7.2 degrees F) throughout the year as compared with surrounding suburban and rural areas.[8] **Map 14: *NYC Surface Temperature***, created by NASA Landsat during a heat wave at 10:30 am Aug 14 2002,[9] shows that dense



Map 14: NYC Surface Temperature (°C)

(10:30am August 14, 2002)



industrial and heavily asphalted areas such as around Newtown Creek and Gowanus Canal, JFK International Airport, Hunts Point, and northern Canarsie are hotter than surrounding areas with more green space. These areas closely match the neighborhoods in **map 6** that show concentrations of roofs that could be suitable for rooftop agriculture, and for much the same reasons: large expanses of tar roofs and lack of green spaces that characterize urban industrial neighborhoods. During heat waves, the heat island impact is further amplified, especially in these locations.

One way of addressing UHI is through the creation of more green spaces at ground level or on roofs; clearly, urban agriculture can fulfill this function in addition to its other benefits, as increased vegetation has been shown to cool surfaces more cost-effectively than increases in albedo such as light roofs.[10] Comprehensive green infrastructure solutions (combined urban forestry, open space grass, curbside planting, and green roofs) have the potential to reduce the current urban heat island effect by 22-44%, with widespread on-the-ground planting accounting for 13-25% of that potential reduction.[11] Simulations have also shown that greening 50% of flat roofs in NYC could reduce average temperatures by 1.4 degrees F.[12] Ground level planting can have a greater cooling effect than green roofs,[13] and, in the case of trees, can reduce temperatures further by shading the sides of buildings and people. The effect on UHI of ground level food crops as opposed to other more conventional forms of ground cover, such as grasses, has not been studied, and would be contingent upon the crops – many food crops have wider leaves and provide denser cover than grasses, although the total density of a farmed lot, including paths between planted rows, would have to be considered. Fruit trees would likely provide many of the same effects as other street trees (although frequent pruning could decrease their shade potential). In any case, urban agriculture is likely to be one of several green infrastructure solutions that can help mitigate UHI, and the differences between food crops and non-food plantings are small compared to vegetated versus paved surfaces.

Energy benefits of rooftop agriculture

The basic types of rooftop agriculture, green roofs and rooftop greenhouses, can both decrease the energy necessary to heat and cool buildings. Conventional roofs, in most cases, are designed as low mass systems to minimize structural load and, as such, cannot store much heat. They quickly reach a "quasi-equilibrium" temperature, quickly radiating heat to the interior and exterior of the building and conducting heat downward into the interior. On a green roof, soil media, water absorbed by the soil, and vegetation add significant mass and heat capacity to the roof, resulting in greater heat retention and reducing the need for space heating and cooling. Vegetation can play a large role in lowering temperatures because it combines increased albedo (reflectivity), shading, and transpiration effects.[14] Because of this, green roofs reduce energy usage, fossil fuel consumption, and greenhouse gas emissions. In NYC's climate, green roofs reduce temperatures inside a building by an average of 2 degrees C (4 degrees F) during the day and raise them by an average of .3 degrees C (.5 degrees F) at night.[15]

The degree to which green roofs can decrease energy use in buildings depends on the type and depth of growing medium and type of vegetation planted. There are two basic types of green roofs: "extensive" roofs, which are low cost, low maintenance, performance oriented systems with shallow soils planted with sedum, are generally for roofs with limited public access; and "intensive" roofs, which have deeper soils in which a greater diversity of plants can be grown and are designed to be more accessible. Rooftop farms are examples of intensive green roofs. While more research is needed on the relative cooling effects of intensive versus extensive roofs, studies have shown that intensive roofs and taller plant communities cast more shade, and so would have a greater cooling effect than extensive roofs.[16] The deeper soil medium required for intensive green roofs also adds to the heat capacity of the roof, even in the winter, when plants may be dormant or absent. Food crops could therefore have larger energy saving benefits than typical green roof plant choices such as sedum due to increased shading and soil depth. Unlike food crops, sedums are CAM (crassulacean acid metabolism) plants, which have adapted to harsh environments by opening their stomata only at night to limit water loss through evapotranspiration, which also limits their cooling effect during the daytime. Food crops also must be more intensively watered, which would further increase the cooling capacity of a green roof. In sum, it is likely that rooftop agriculture would be much more effective at cooling a building than a standard extensive roof, and may perform better than many other types of intensive roofs.

Rooftop greenhouses can also contribute to building energy savings. Not only do they provide additional passive insulating benefits to a building, their climate controls can be directly integrated into the HVAC system of the building below. During the summer months, a rooftop greenhouse using passive and low energy cooling methods such as ventilation and evaporative cooling, can yield net energy savings when compared to conventional air conditioning. Side vents and roof vents are the simplest passive method of ventilation to control temperature, and these can be combined with shading systems to control temperature. In NYC's hot summer months, however, simple ventilation may be inadequate to maintain optimal growing conditions, in which case evaporative cooling systems, such as the one used in the greenhouse on the Manhattan School for Children, may be necessary.

In a typical evaporative cooling operation for summer, high temperature, low humidity air enters the evaporative pad wall from outside. Introducing water into ventilation air increases relative humidity while lowering the air temperature, so once it passes through the pad wall, the air becomes cool and saturated with water. As the air moves through the greenhouse, the sun raises air temperature and lowers the relative humidity to acceptable indoor levels. If the greenhouse is integrated into the host building's HVAC system, this cooler air is then pushed by natural circulation patterns and pulled by fans into the rest of the building. The challenge in NYC's climate is the combination of high temperature and high humidity, which makes such systems less effective than in places such as the Southwest. In these conditions, evaporative cooling may have to be supplemented with conventional air conditioning systems on the hottest days, although a well-designed evaporative cooling system can still contribute substantially to energy savings.

In the winter, a rooftop greenhouse decreases heating energy needs through the reduction in thermal losses through the building roof. Rooftop greenhouses also use excess heat from solar gains on cold but sunny days to heat the building below, effectively insulating the building (unlike an agricultural green roof, whose insulating capacity decreases during the winter as plants become dormant).[17] In the winter, the waste heat from the building below can be used to heat the greenhouse, thereby reducing the total combined heating requirements. Without contributions from waste heat, heating a mid- to large-size greenhouse through the winter months can be prohibitively expensive. For this reason, the optimal locations for rooftop greenhouses are on buildings housing bakeries, commercial or institutional kitchens, or industrial activities which generate excess heat.

HVAC systems that incorporate hydroponic or passive greenhouse systems offer energy savings that can exceed those achieved by traditional green roofs. Input costs of water and power for fans are lower than the energy cost to cool the building through conventional air conditioning,[18] representing savings of 13-41% of the original energy load year round.[19] The primary limitation to constructing rooftop greenhouses in that it is very capital intensive compared to other types of urban agriculture. Structural requirements for the building are more stringent that those for green roofs, and equipment and material costs can be substantial, particularly if upgrades or modifications to the building's HVAC system are necessary to integrate it with the greenhouse. CEA/hydroponic greenhouses require continual maintenance and supervision to ensure that their complex interrelated systems are functioning properly.

There are many other potential energy benefits from growing food in cities. A thorough life-cycle analysis of the various approaches to urban agriculture would be necessary to begin to quantify these benefits. The most obvious is the fact that growing food close to or within population centers can dramatically reduce transportation costs and energy use. While transportation accounts for less than 5% of the total energy use in the food system, this percentage is higher for fruits and vegetables.[20] An oft-cited statistic is that food travels an average of 1,500 miles from farm to fork; in fact, this figure was specific to fruits and vegetables traveling to Chicago Terminal Market in 1998.[21] With increased globalization of the food industry and greater distance from the nation's primary produce growing regions in the West, it is likely that the produce in New York's Hunts Point Market has traveled a greater average distance. While it is true that shipping produce across the country by rail can be more energy efficient that an equivalent amount transported regionally in small trucks, the very small distances between farm and market which can be achieved with urban agriculture would almost certainly result in decreased energy use not only for transportation but for storage and refrigeration costs as well.

There are other ways in which urban agriculture could decrease energy use in the food system. The intensive production methods used in urban agriculture often amount to a substitution of mechanized labor with human labor, meaning that less fossil fuel is consumed for machinery, and if organic methods are used, the energy required for extracting, processing, and transporting fossil-fuel based fertilizer is also decreased.[22] If compost is used, it can decrease the energy used to transport organic waste to landfills. Finally, if urban agriculture can function as a catalyst to increase overall awareness of the food system and change dietary choices towards more healthful foods, this could have a positive effect on energy use in the food system, as total per capita energy required to produce and process meats, oils, and highly processed foods is greater than for fruits and vegetables.[23]

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As with all metropolitan areas, New York City continues to grapple with how best to dispose of the large amount of waste produced by its residents. Inherent in the term "waste" is the concept that our attitudes toward disposability represent a grossly inefficient use of resources. Much of what ends up in our waste stream consists of potentially valuable materials or items that took considerable human and natural capital to produce. Food waste is an unfortunate example of this; over 40% of food produced on farms in the U.S. is not consumed.[1] This represents a colossal and irreversible transfer of resources and nutrients from productive farmland to landfills, and is particularly unfortunate in an age of increasing food insecurity. Over half of the NYC's waste ends up in landfills located hundreds of miles away, leading to landscape degradation, air pollution and greenhouse gas (GHG) emissions associated with transporting waste such great distances. Landfill space is a limited commodity and the cost of disposal and fuel will continue to increase as the Department of Sanitation pays higher and higher outsourcing premiums. The anaerobic breakdown of organic matter in landfills produces methane, a potent GHG. A much greater percentage of the waste that contributes to these problems could be recycled or composted; this, however, would require systematic and structural changes to our waste system.

Despite the fact that New Yorkers produce less waste (approximately 2.4 lbs/person/day)[2] than average Americans (4.3 lbs/person/day),[3] the cost of disposing both municipal and commercial waste is increasing and has significant budgetary implications. The NYC Department of Sanitation's (DSNY) total expenditures increased from $600 million in 1995 to $1.3 billion in 2010;[4] while direct spending on solid waste export was over $328 million.[5] In addition to the fiscal challenge of exporting waste, the location of the city's waste transfer stations poses serious environmental justice questions; the stations are overwhelmingly situated in low-income neighborhoods which suffer from associated truck traffic, pollution, odor, and noise. For all of these reasons, decreasing the amount of solid waste exported from the city is an important goal. Composting operations connected to urban agriculture could provide opportunities to reduce the amount of organic waste transported to landfills while producing a marketable resource.

Composting overview

Composting involves the biological decomposition of organic matter that can be used to improve soil. Mature compost is stable and is made up of called humus, or loose, dark brown or black, nutrient rich soil with an earthy smell. It is created by combining organic wastes (such as yard trimmings, food waste, or manure) in a set ratio into piles, rows, or vessels, then adding bulking agents (e.g. woodchips) as necessary to accelerate the breakdown of organic materials. Composting is an aerobic (oxygenated) process, which does not create a distinctive smell, an important factor in urban areas. Anaerobic putrefaction as is present in landfills produces foul smelling compounds such as methane and hydrogen sulfide (for this reason compost piles must be regularly turned). As mentioned above, the methane which is a by-product of anaerobic decomposition is a much more potent greenhouse gas than the carbon dioxide produced by aerobic digestion. In addition to reducing the waste stream, compost used for agriculture can suppress plant diseases and pests, reduce or eliminate the need for chemical fertilizers, and promote higher yields. Compost can also facilitate reforestation, wetlands restoration, and habitat revitalization efforts by amending contaminated, compacted, and marginal soils, and cost-effectively remediate contaminated soils.[6]

For composting to be a viable activity, there needs to be consistent demand. Currently, compost processed by commercial waste haulers is used on farms outside the city, but urban farming provides an excellent opportunity to use this resource where it is being produced. By incorporating composting, urban agriculture can help create an ideal small-scale closed-loop system wherein nutrients from food waste are recycled back into the soil. Composting is especially well-suited for urban agriculture because of the utility of compost for enhancing and maintaining what are often otherwise nutrient-poor urban soils and even for remediating contaminated soil. The advantage of using compost for urban agriculture is that it reduces the amount of waste that must be transported to landfills without adding to the transport and infrastructure costs that would be necessary to implement a large-scale composting program involving sites outside the city. (This is not to diminish the potential benefits of such a centralized program;

rather, incorporating urban agriculture uses for compost could offset the costs of transporting organic waste to processing sites and farms far from the city.)

There are many different approaches to composting, which range from small-scale individual backyard bins to centralized city-wide programs. Distributed approaches involve in-vessel composting, in which organic waste from a single household, an apartment building, or even a neighborhood is collected and composted in bins outside a building or in a neighborhood garden. Centralized approaches include source separated composting, in which residents would separate compostable waste into designated bins (as with recycling) to be collected, and mixed material composting (in which organic waste would be separated out by the Sanitation Department). The waste would be carted to a location, likely located outside the city, to be composted en-masse and distributed to farms. This is the approach currently used by some commercial haulers in NYC.

Composting in New York City

Fig. 7: *NYC Annual Waste Stream, 2002 (following pages)* is a visual representation of New York City's waste stream. The volumes change from year to year, and the latest year for which adequate data was available across different segments of the stream for comparative purposes was 2002, making the information somewhat out of date; as a qualitative representation of this complex system, however, it may be informative. NYC's waste system has two principal components: municipal Waste, handled by the DSNY, and commercial waste, managed by private haulers. Approximately 30% of residential waste and 18% of commercial waste is compostable,[7] with an additional 12% of municipal waste consisting of wood and miscellaneous organic materials suitable for composting at an industrial scale.[8] Currently, only a very small fraction of this waste is composted. Composting will be a necessary component of the city's efforts to reach a 75% diversion rate from landfills by 2030.[9] In addition to the environmental benefits of diverting organic waste from landfills, compost is a marketable resource, whose value could help defray the costs of establishing the infrastructure necessary to implement citywide composting programs.

The idea of composting NYC's organic waste has been on the table for decades. Since 1993, with the inauguration of the city's Compost Project, DSNY has funded pilot projects for a variety of composting approaches, including source separated and mixed material composting, and small scale in-vessel and larger scale centralized composting. For a number of reasons, DSNY has not pursued large-scale projects beyond the pilot phase. For source separated composting, challenges included lack of public participation and failure to correctly separate trash items from organic food waste, while capital and operations have been identified as the main obstacle to implementing small to medium scale in-vessel composting options currently on the market. Ultimately, in its last comprehensive study from 2001, the DSNY determined that in a city as dense as NYC, the extra costs for transport and operations did not justify the effort of large-scale municipal composting.[10]

In NYC, some of the pilot programs have also been successful; particularly the Rikers Island's on-site composting system. The Rikers Island approach yields valuable insights on what it takes to maintain a large scale composting program, and suggests that on-site options may be most cost-effective. Success requires a large amount of food waste generated in a compact area, ensuring efficient collection and cost savings, personnel within the program who take on the project as their own, a labor supply for on-site tasks, a supply of bulking agents, space for the facility, dumpsters, and outdoor curing, and facility operators who are knowledgeable about the composting process as well as equipped with adequate resources.

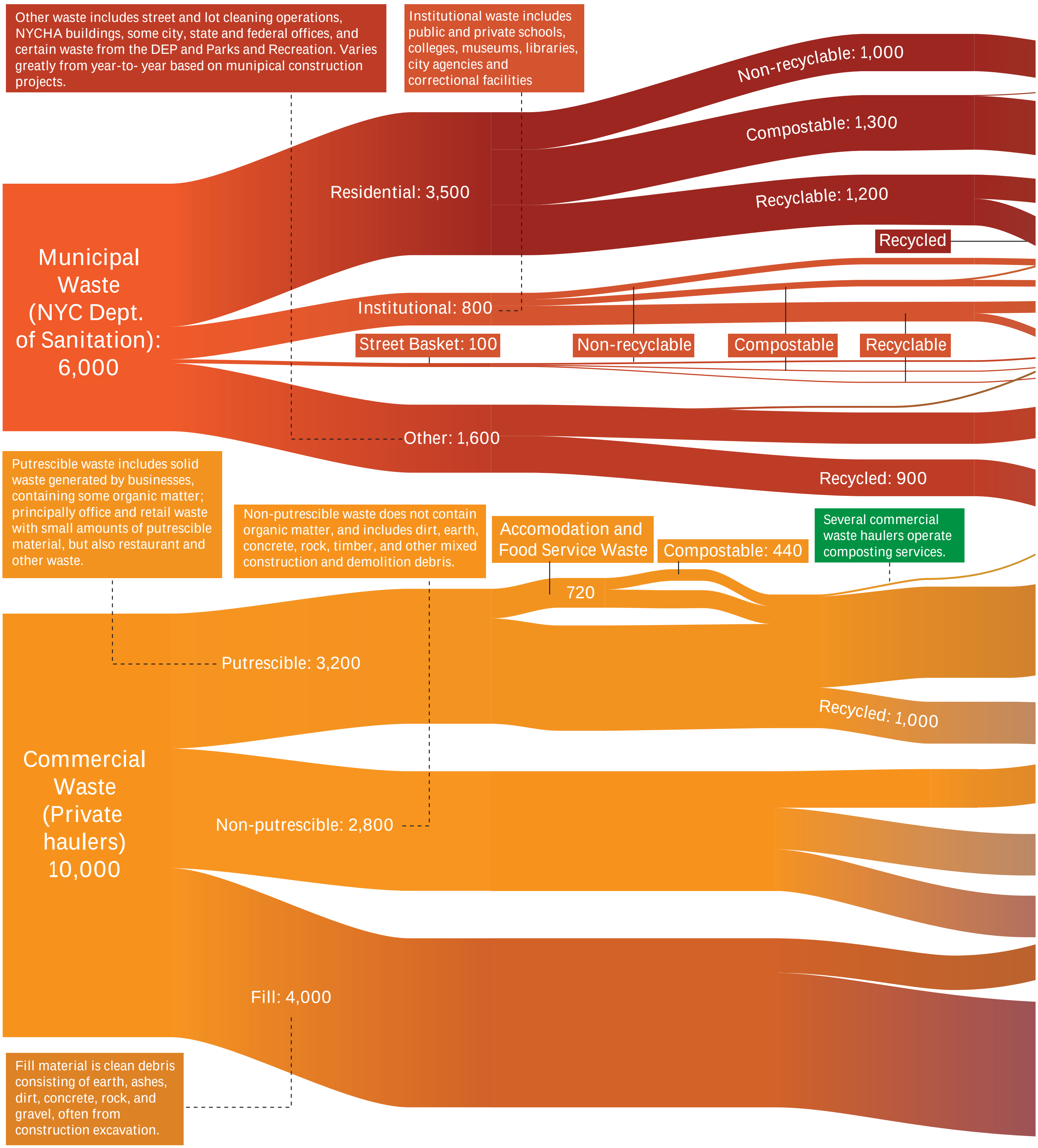
There are indications that with renewed attention to the economic and environmental costs of the existing system in the updated PlaNYC,[11] there may be opportunities to revisit the issue of municipal composting. There is much to be learned from precedents in other urban areas in the U.S., particularly San Francisco, which has succeeded in implementing a large scale, cost-effective, centralized compost collection and processing system.[12] While DSNY has cited logistical and density differences between the two cities, the major factor in San Francisco's success may have been the degree of education and outreach before implementation of the program, which had high voluntary participation prior to legal enforcement. The tide may slowly be changing in New York as well, with the City Council passing 11 Local Laws in 2010 to update and expand the NYC Recycling Laws, including an update of the Yard Waste Composting Law which requires DSNY to reinstate the leaf and yard-waste composting collection program (which was been suspended since 2008 due to budget cuts) in 2012 with the eventual goal of establishing at least one facility per borough. While nothing at the scale of the San Francisco program is currently being considered, DSNY will also be required to provide leaf and yard waste collection at NYC Housing Authority residential buildings and to compost source-separated yard waste through city agencies. Currently, DSNY operates two leaf composting sites (Fresh Kills in Staten Island and Soundview in the Bronx) where it processes leaves and brown matter from the Parks Department and registered landscapers. The compost and mulch created at these sites goes to various parks and community gardens across NYC.

The NYC Compost Project has throughout the years provided technical assistance to hundreds of residents and community-based organizations in all 5 boroughs, including community gardens, schools K-12, parks, residences, institutions, and businesses. This smaller-scale, distributed approach is also being supported by a number of non-profits working in tandem with GrowNYC to provide composting drop-off sites at greenmarkets. Currently these community groups include the Lower East Side Ecology Center, which provides technical support and operates composting programs at their community garden on East 7th Street and at the Union Square Greenmarket, and the Western Queens Compost Initiative and the Fort Greene Compost Project. Six new collection locations have recently been added to this program, which, if successful, will be expanded even further. Composting is increasingly prevalent in community gardens and farms throughout the city, with 65% of surveyed gardens participating.[13] Added Value's farm in Red Hook, Brooklyn, composts approximately 80 tons of organic material a year, making it one of the largest independent composting operations in the city.

In addition to the municipal waste stream, the City has a large commercial waste sector, of which composting is very small but growing component. With approximately 18% of non-construction waste consisting of organic material,[14] the opportunities for expansion in the sector are enormous. 600,000 tons of annual food waste is generated by businesses and institutions in the city, with an additional 20,000 tons of organic waste produced by the Hunts Point Terminal Market alone (which, as the PlaNYC update points out, would be an ideal location for an on-site recovery operation).[15] Despite the fact that businesses must pay for carting fees and that the byproduct fetches prices as high as $26 per ton for landscape mulch to more than $100 per ton for high-grade compost,[16] large-scale commercial composting in NYC has yet to become well established. Logistical and transportation costs are challenges to the profitability of commercial composting. The City's largest private organic waste hauler is Action Carting, which has been composting organic waste from restaurants, food service, medical facilities, building contractors, and other types of businesses in the city since 1999. Composting is not a profitable service for the company, but they offer it as an enticement for businesses to use their primary waste hauling service, as some businesses are requesting the option. As part of a pilot program to determine feasibility, Action is also being paid by the DEP to haul from the Union Square farmers market composting collection site. Due to renewed interest in composting, a number of small-scale start-up companies are emerging with alternative business models, including the New York Compost Company, which aims to use modified bicycles pick up organic waste from restaurants and compost it on urban and local farms.

Fig. 7: NYC Annual Waste Stream, 2002

Rough estimates based on a variety of sources.
Volumes can change substantially from year to year.



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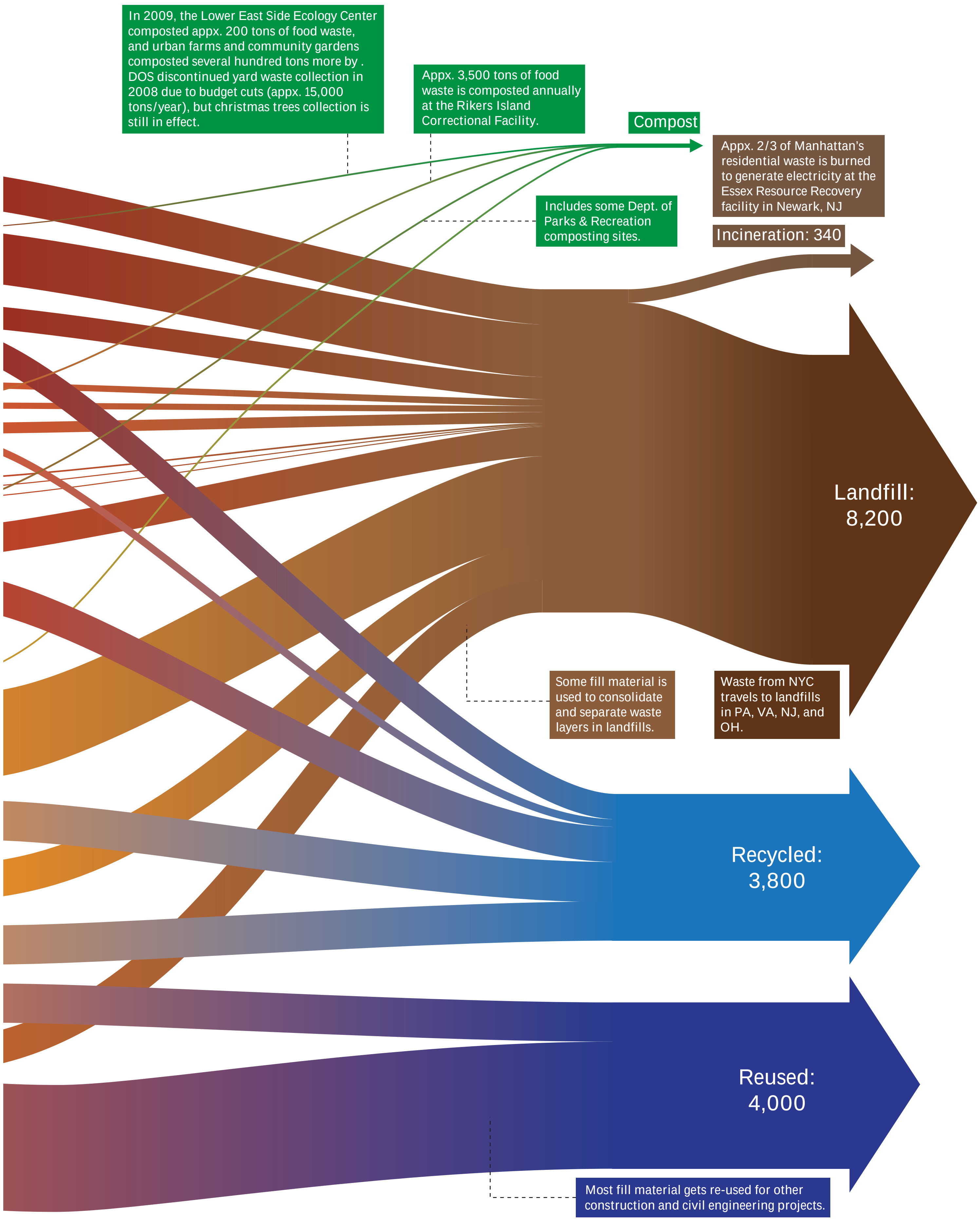
In 2009, the Lower East Side Ecology Center composted appx. 200 tons of food waste, and urban farms and community gardens composted several hundred tons more by . DOS discontinued yard waste collection in 2008 due to budget cuts (appx. 15,000 tons/year), but christmas trees collection is still in effect.
Appx. 3,500 tons of food waste is composted annually at the Rikers Island Correctional Facility.
Compost
Appx. 2/3 of Manhattan's residential waste is burned to generate electricity at the Essex Resource Recovery facility in Newark, NJ
Includes some Dept. of Parks & Recreation composting sites.
Incineration: 340
Landfill: 8,200
Some fill material is used to consolidate and separate waste layers in landfills.
Waste from NYC travels to landfills in PA, VA, NJ, and OH.
Recycled: 3,800
Reused: 4,000
Most fill material gets re-used for other construction and civil engineering projects.

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New York City has a wide variety of urban fabric types, including the iconic Manhattan high-rise commercial districts, vast stretches of townhouse and brownstone neighborhoods in Brooklyn, detached single-family homes in eastern Queens, low-density suburban-style development in Staten Island, and public housing projects in all five boroughs. Given the diversity of both the built environment and the population in NYC, a wide range of techniques and strategies for urban agriculture must be considered. In a series of neighborhood case-studies, we are focusing on three very different areas where it is clear that a set of unique conditions are in place that indicate great potential for specific approaches urban agriculture. These areas are defined by community district boundaries because demographic and land-use data is easily available at this scale, but the characteristics of each neighborhood are of course more fluid and not strictly bound by these boundaries.

Brooklyn District 16 (Brownsville, Ocean Hill)

Map 15

Brooklyn District 16 is characterized by two to three story row houses, low-rise section-8 housing, and high-rise public housing projects. Brownsville has the highest concentration of low-income housing of any neighborhood in the U.S. As of 2009, the district had an estimated population of 85,235,[1] 36% of whom were below the poverty level. [2] 2000 census figures show that the district is 78% black/African American and 18% Hispanic.[3] This area is part of the Bedford Stuyvesant / Crown Heights Community Health neighborhood, as defined by the NYC DOH, which has an obesity prevalence of 26.9% and a diabetes prevalence of 10.6%, both of which are higher than for Brooklyn or NYC as a whole.[4] In a survey, 16.5% of residents in this broader area reported "no fruit or vegetable consumption yesterday."[5] The neighborhood is within the FRESH incentive zone, and according to DCP achieves a supermarket to population ratio above the city average but below the City Planning Standard Ratio.[6] All of the district's zip codes are below the city average for fresh food retail.[7] This district has 12 grocery stores, including an Associated and a Pioneer Supermarket, but most of the existing stores are under 10,000 s.f. There are many bodegas in the neighborhood, and GrowNYC recently established a program to develop a "local food" section in bodegas and supermarkets in Brownsville to be stocked with produce from the Hunts Point Wholesale Farmers Market. This initiative will include the provision of refrigeration equipment to some stores, and once in place could act as a framework for providing retail access to food grown within the city or even within the community itself. There are also two seasonal farmers markets, the Brownsville Community Farmers Market and the Brownsville Youth market, and in response to community demand, the housing and social services group Common Ground has partnered with GrowNYC to increase the number of days that these markets operate during the growing season. There are also over 22 community gardens in this district (not including gardens on NYCHA property), indicating a high degree of interest in urban gardening. The entire district is in the CSO area, and northeastern corner near the East New York Rail Yard has a high urban heat-island index.

District 16 has 606 vacant lots covering 58 acres of land, which represents the greatest potential for expanding urban agriculture in this area. This amount is a huge decrease from the early 1990s, when there were hundreds of acres of vacant land in the neighborhood. These lots are for the most part small individual sites distributed throughout the neighborhood, although there are at least 14 large lots or clusters of adjacent vacant lots, many of which are located within a few blocks of East New York Ave. These include a 1.3 acre vacant area between Rockaway Ave. and Chester St. just south of East New York Ave. owned by the NYC Dept. of Citywide Administrative Services and the Dept. of Housing Preservation and Development (HPD); two adjacent vacant lots totaling 2.6 acres owned by HPD and NYCHA on Sterling Place between Saratoga and Howard Aves.; and a 1 acre paved lot owned by the Dept. of Education on Thomas S. Boyland St. between Bergen and Dean Streets. Many of these sites would be well suited for urban farming, and the large number of distributed small-scale lots would allow for an increase in community gardens. There are also approximately 23 acres of green space on NYCHA property, including large lawns in the Howard Houses development.

Map 15: Brooklyn District 16

Map 15: © Urban Design Lab, 2011. Sources: MaPLUTO © New York City Department of City Planning (2009), New York City Department of Information Technology and Telecommunications (2007)

Given the concentration of vacant land in this district, a network of urban agriculture sites with shared resources and equipment would go a long way toward enabling food production to take place in this area. Such a system could also extend to processing and storage infrastructure. The two existing farmers markets and the local food initiative are obvious resources that could be capitalized upon by urban farmers, offering opportunities for distribution and retail. As mentioned in the **Food Security** section, provided that the problem of refrigeration can be adequately addressed, such stores may be a very good option for making the food grown in the area available to the public.

Bronx District 3 (Claremont, Crotona Park East, Morrisania)

Map 16

Bronx District 3 encompasses Crotona Park, with its many recreational facilities, and has an eclectic mix of urban fabric types. The western part of the district has several large NYCHA developments and includes a manufacturing zone, while the southern area has smaller NYCHA developments and section 8 housing. The eastern part of the district is characterized by three- to six-story residential townhouses and developments. The district had a population of 77,572 in 2009,[8] of which 53% were Hispanic and 44% black/African American.[9] 43% of residents of districts 3 and 6 were below the poverty level in 2008; both community districts are part of NY congressional district 16, the nation's poorest. This area is part of the Highbridge and Morrisania Community Health neighborhood, which has an obesity prevalence of 27% and a diabetes prevalence of 16%, both of which are higher than for Bronx or NYC as a whole.[10] 24.5% of residents in the South Bronx, which includes district 3, reported "no fruit or vegetable consumption yesterday,"[11] which is the highest figure of any NYC neighborhood. The area is within the FRESH incentive zone; according to DCP achieves a supermarket to population ratio below the city average,[12] and all of the district's zip codes are below the city average for fresh food retail.[13] There are a number of grocery stores and bodegas in the central and northeastern part of the district, and there is a seasonal Youthmarket farmers market in McKinley Square, where students sell produce grown in nearby community gardens. There are 18 GreenThumb or Trust for Public Land (TPL) community gardens in this district, including the Crotona Park Victory Garden, and many more public and private community gardens.

Excluding Corona Park, the district is in the CSO area, and northwestern manufacturing zone has a high urban heat-island index. The eastern part of the district is adjacent to the Bronx River, which has been affected by decades of industrial pollution and CSO contamination. The Bronx River Watershed Initiative is a State-level initiative dedicated to funding green infrastructure projects along the River, including a GrowNYC program to install rainwater collection systems in community gardens in the Bronx. Neighborhood residents also suffer disproportionately from asthma, which is exacerbated by the proximity to the heavily used Cross Bronx and Sheridan Expressways and the fact that, not including Corona Park, there are only .24 acres of parkland per 1,000 residents, which is less than 1/10 the accepted standard established by the TPL.[14]

District 3 has 380 vacant lots encompassing 32 acres of land, which would allow for increased urban agriculture in this area. These lots are for the most part small and medium-sized sites in the westerns part of the neighborhood, in and around the manufacturing zone. These include a 1734 Bathgate Ave., a 2.5 acre vacant lot just south of the Cross Bronx Expressway owned by the City, and a 1 acre site on the corner of 159th St. and Melrose Ave. owned by HPD. There are also about 16 acres of green space on NYCHA property, including lawns in the Forest Houses and a large underutilized area on East 173rd and Vyse Ave. The 19 city-owned parks and playgrounds in the area do not provide much in the way of green space, with twelve being having pavement or rubber surface over 90% or more of their area.[15] This neighborhood also has a disproportionate amount of surface parking lots (23 acres), many of which are located in the manufacturing area, and many of which are used for equipment or materials storage. Together, all of these land resources represent a significant opportunity to transform the landscape of healthy food availability in the chronically underserved area.

Map 16: Bronx District 3

Map 16: © Urban Design Lab, 2011. Sources: MaPLUTO © New York City Department of City Planning (2009), New York City Department of Information Technology and Telecommunications (2007)

Brooklyn District 1 (Greenpoint, Williamsburg) and Queens District 2 (Long Island City, Blissville, Hunters Point, Sunnyside, Woodside)

Maps 17 and 18

Brooklyn District 1and Queens District 2 are adjacent neighborhoods on either side of the Newtown Creek. Both districts have large industrial zones along the East River waterfront and the Creek, and the area has been a center for manufacturing since the beginning of the 20th century. Greenpoint is a historically Polish residential neighborhood, and Williamsburg has recently undergone a rapid process of gentrification that has led to the rezoning of the East River waterfront of this district, with the recent addition of many condominium towers. As of 2009, Brooklyn district 1 had an estimated population of 180,666,[16] 30% of whom were below the poverty level.[17] 2000 census figures show that the district is 48% white Nonhispanic and 38% Hispanic.[18] Most of this area is part of the Greenpoint Community Health neighborhood, as defined by the NYC DOH, which has an obesity prevalence of 20% and a diabetes prevalence of 8%.[19] The ratio of supermarkets to population is below the city average,[20] with the lower income southern parts of the district especially affected. There are three farmers markets in the area.

Queens District 2 has very large industrial zones encompassing the western half of the district, including Hunters Point, which is designated for rezoning by the DCP. The eastern half is occupied by the residential neighborhoods of Sunnyside and Woodside, three large cemeteries, and a manufacturing area along the Creek, while the large Sunnyside rail yards dominate the northern edge. The district had a population of 119,397 in 2009,[21] of which 36% were Hispanic, 31% white Nonhispanic and 27% Asian or Pacific Islander.[22] 14% of residents of Queens district 2 were below the poverty level in 2008. There is one farmers market in the district, which has a supermarket to population ratio below the city average.[23]

One of the largest oil spills in U.S. history occurred on the eastern shore of the Creek in Greenpoint over the course of decades in the middle of the last century, with between 17 and 30 million gallons of petroleum seeping into the soil from refinery storage terminals that were located here at the time.[24] Because of this, the area of the spill was designated an EPA Superfund site in 2010. Cleanup will be focused on the waters of the Creek, which continue to be affected by contamination through polluted groundwater seepage, CSO events, and surface water runoff.[25] The areas directly adjacent to the Creek are not within any CSO watershed (see **Map 13: *Combined Sewer Areas***), indicating that stormwater runoff is discharged directly into the Creek from most of the area in the manufacturing districts. This is an issue which will have to be addressed at least partially through the development of more green space and permeable surfaces in the area, as called for in the NYC Green Infrastructure Plan.[26] Additionally, the areas around the southeastern terminus of the Creek have the highest urban heat island index in the City (see **Map 14: *NYC Surface Temperature***), due to the proliferation of large, heat absorbing roofs, extensive paved area ,and lack of green space (the neighborhoods of Hunters Point, Sunnyside, and West Maspeth have an urban tree canopy area of 8%, while East Williamsburg and Greenpoint have an urban tree canopy area of 6%, far below the City average of 24%.[27])

These conditions make the industrial zones of these two districts very well-suited for rooftop agriculture. The three largest rooftop farms in NYC are all in the area (the largest, Brooklyn Grange, is just outside the boundary of Queens district 2), and there are hundreds of other potentially suitable rooftops in the neighborhood. Using the criteria described in the **Site Availability** section, we identify 548 roofs in district 2 and 491 roofs in district 1 that could be suitable, with total areas of 375 and 261 acres, respectively. Of these, 44 buildings are city-owned properties, including several managed by the New York City Industrial Development Agency (NYCIDA), such as 1 Kent Avenue in Greenpoint (70,000 s.f. roof). Other potentially suitable public properties include the DOE's Pupil Transportation Bureau on Vernon Boulevard (90,000 s.f. roof) and NYCHA's central shop on Ash St. in Greenpoint (33,000 s.f.). Additionally, there are 85 acres of private vacant land and 33 acres of public vacant land in Queens district 2 and 64 acres of private vacant and 33 acres of public vacant land in Brooklyn district 1.

Map 17: Brooklyn District 1

Map 17: © Urban Design Lab, 2011. Sources: MaPLUTO © New York City Department of City Planning (2009), New York City Department of Information Technology and Telecommunications (2007)

The concentration of unused rooftop in these neighborhoods represents a huge opportunity for food production in NYC, along with contributing to the goals of the Superfund cleanup and the NYC Green Infrastructure Plan, and helping to mitigate the elevated summer temperatures in the area. Other factors that make this area ideal for urban agriculture include the year-round farmers market in McCarren Park and the ongoing revitalization of local food processing businesses, which represent a new trend of small-scale, "artisanal" food manufacturers focused on quality and local ingredients. There is also a burgeoning restaurant scene which largely caters to a young, engaged demographic that is interested in supporting local and sustainable food.

Notes

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Map 18: Queens District 2
Vernon Blvd
21st Street
31st Street
Queensboro Bridge
Northern Blvd
Murray Playground
Gantry Plaza State Park
Greenpoint Ave
Calvary Cemetery
public roof.....................28.0 acres
private roof...................347.5 acres
public vacant land.........33.0 acres
private vacant land........85.0 acres
NYCHA green space...........0 acres
parking lots....................59.0 acres
community gardens.........0.2 acres
unused open space..........1.5 acres
green streets
farmers markets..........................2
N
0
0.25
0.5
1 Miles


Steinway Street
Newtown Rd
BQE
Northern Blvd
Broadway
Roosevelt Ave
Lawrence Virgilio Playground
Big Bush Park
Queens Blvd
51st Ave
BQE
New Calvary Cemetery
Calamus Ave
Mount Zion Cemetery
Maurice Ave
Long Island Expy

XI. Recommendations

Urban agriculture is a part of a movement which will continue to grow and flourish. Awareness of the links between how and where food is grown and impacts on our environment and health is only increasing, along with a desire to participate directly in smaller-scale alternatives to what many feel has become an overly industrialized food system. All indications are that people will continue to grow food in NYC, regardless of the political and economic climate. However, decision makers in the public, private, and non-profit sectors have important roles to play insofar as their actions can support or hinder these efforts. These recommendations represent a range of (mostly policy) options that we believe could substantially impact the degree to which existing and aspiring urban farmers are able to operate effectively in the city.

Many of the most effective recommendations for supporting urban agriculture have already been outlined in existing policy documents such as the Manhattan Borough President's 2009 report *Food in the Public Interest: How New York City's Food Policy Holds the Key to Hunger, Health, Job and the Environment*,[1] the City Council's *FoodWorks: A Vision to Improve NYC's Food System*,[2] from 2010, and the *PlaNYC 2030* update of 2011.[3] We believe that this report reinforces many of the recommendations included in those documents, including the following:

Recommendations

- Identify land in the five boroughs that could be used for urban agriculture (*Food in the Public Interest*) and compile such information in an accessible database to be searchable by the public (*FoodWorks*). An accurate database may require municipal agencies to conduct an inventory of properties under their jurisdiction (*PlaNYC*) including vacant and underutilized space, as the existing accessible sources of data are inaccurate and incomplete. A proposed initiative before the City Council aims to ament the city charter to require municipal agencies to collect and make public through a searchable database a wide range of information on city-owned properties, including "whether the property is suitable for urban agriculture."[4] To the extent possible, state and federal agencies (such as the National Park Service) with jurisdiction over large areas of land in the city should be encouraged to provide such information as well.

- Promote local agriculture in neighborhoods with limited access to fresh foods (Food in the Public Interest). This could be encouraged through the establishment of "urban agriculture incentive zones" in targeted areas of the city which, in addition to having low access to healthy food retail, are characterized by high prevalence of obesity and diabetes, low median income, and comparatively high availability of vacant and other available land. Provide additional funds to GreenThumb or Dept. of Parks and Recreation to help community groups in these areas identify suitable sites, and offer tax incentives or streamlined small business development loans through EDC for urban farmers.

- Protect community gardens (*FoodWorks*) and increase the number of registered GreenThumb volunteers (*PlaNYC*). In order for this to happen, city agencies and the public will need to advocate for continued funding of the GreenThumb program, which currently is the primary agency providing logistical support for urban farms and gardens. This is critical because no other municipal agency currently has the capacity to fill this role.

- Encourage new development projects to include gardening in neighborhood development plans; create incentives for urban farming and gardening in new large-scale residential and mixed use development projects (*Food in the Public Interest*). This could take the form of increases in allowable FAR if space is set aside for such activities in new developments or could consist of tax incentives to encourage such activity.

- Institute additional property taxes on lots that are deemed vacant or blighted for a prolonged period of time, to be offset by an exemption or credit for owners of such properties who allow for farming or gardening on a certain percentage of the site. Incentivize the transfer of such private land to land trusts dedicated to community gardening or farming.

- Change water rates to include a charge on stormwater based on a lot's impermeable surface (*FoodWorks*). This charge, especially if applied to owners of large properties, would incentivize the creation of green roofs or planted areas on impermeable surfaces. It could also facilitate the conversion of underutilized parking areas to green space, gardens, or farms. Such a change could be coupled with increased education and logistical support for the installation of rooftop rainwater catchment systems for urban agriculture, such that property owners adjacent to such farms and gardens could use such systems to avoid increases in water rates.

- Track and encourage regional food procurement (*FoodWorks*) and assess the barriers and potential interventions to facilitate the distribution and consumption of regional food products (*PlaNYC*). These initiatives would benefit the entire regional food system, of which urban farmers are an integral part. The city's municipal agencies, including the Department of Education, procure huge volumes of food daily, and it is in the city's and state's interest for the economic benefits of such centralized buying power to remain within the region to the degree that it is possible. A more thorough analysis of the economic impacts and multiplier effect of the regional food production on the city and region would go a long way towards supporting such legislation.

- Facilitate the creation of more healthy food retail options in targeted underserved neighborhoods (*PlaNYC*) and improve bodega infrastructure (*FoodWorks*) to allow for the sale of fresh, healthy foods. The City's FRESH program is designed to encourage more access to healthy food, and as such is an important initiative; however, the scale of the existing network of bodegas makes such stores perhaps better suited to support urban agriculture. As mentioned above, the NYC DOH and GrowNYC have programs to facilitate the sale of healthy food in bodegas, and such programs could be bolstered by a direct link to food production within the communities in which the stores are located.

- Identify opportunities to expand food processing facilities to ensure that crops harvested locally and destined for New York City are also processed locally (*Food in the Public Interest*) and create food retail and production opportunities by maximizing the use of City-owned land (*PlaNYC*). Given that the cost of establishing new storage, processing, and distribution infrastructure continues to be a barrier to the expansion of urban agriculture, maximizing the use of existing public facilities, including institutional kitchens, to support urban agriculture would be a highly efficient use of resources. The economic impact of new processing and retail facilities that are the target of economic development incentives could be maximized by ensuring that they are located and equipped so as to be able to take advantage of the interest in local and regional products, which would also support food production within the five boroughs.

- Amend the state green roofs tax credit to encourage food-producing green roofs (*FoodWorks*) by broadening this legislation to include agricultural plants (*PlaNYC*); or, create a separate incentive specific to agricultural green roofs. While more research is needed on the stormwater implications of rooftop farms, these benefits may equal or exceed conventional green roofs, and the additional impact of rooftop farming on economic development, food security, and energy use more than justify the expansion of the credit.

- Streamline the green roof permit application process (*FoodWorks*); given the relative novelty of agricultural green roofs in the city, the permitting process for occupiable green roofs can be cumbersome. Existing rooftop farmers are establishing precedents for expedited "alteration Type I" permits, which is encouraging, and other means of making the permitting process more efficient should be considered.

- Waive the FAR requirements and height restrictions for rooftop greenhouses (*FoodWorks*), provided they are dedicated to food or horticultural production. This would eliminate a significant policy barrier preventing more greenhouses from being constructed on rooftops that are otherwise suitable.

- Develop an initiative modeled on the WWII Victory Garden program to encourage and incentivize gardening and food production in private backyards. This could consist of a publicity and education campaign on such issues as soil testing and remediation, the use of SNAP benefits for the purchase of fruit and vegetable seeds and plants, opportunities for knowledge and equipment sharing, and general information on growing food in urban environments.

- Establish a voluntary household composting program and explore citywide composting of food waste (*FoodWorks*);work with community and government partners to increase the number of available drop-off locations for food waste and launch a grant program for small-scale composting to encourage diversion of food waste (*PlaNYC*). While the logistics and costs of residential curbside composting are challenges that have yet to be worked out in NYC, increasing costs for waste transportation and disposal combined with the opportunity for the creation of a valuable resource for urban and regional farms could tip the balance in favor of such a system. These provisional recommendations are important steps toward are more comprehensive municipal composting program.

- Establish a composting facility to dispose of commercial food scraps (*Food in the Public Interest*). Given the slow growth in the commercial composting sector, some form of public/private partnership for the development of necessary infrastructure may be necessary to encourage more of the city's food service and retail establishments to participate. Such an initiative could contribute to the city's greenhouse gas emissions reduction goals as well as supporting urban agriculture.

- Help create greener, greater communities by integrating sustainability into neighborhood planning (*PlaNYC*). Urban agriculture can be an integral part of urban sustainability plans and incorporated into the planning process as a form of green infrastructure. Interventions aimed at addressing problems related to water, energy, air quality, climate, and public health are often considered and evaluated in isolation, and the system boundaries used for the cost/benefit analyses that drive much policymaking are overly narrow. While many questions still remain as to the actual impacts of urban agriculture on the problems outlined above, its capacity to provide cross-cutting environmental and health benefits, not to mention the more intangible impacts on community-building and education, make for a compelling case for increased public-sector support.

Fig.8 : Land Designation and Potential Urban Agriculture Policy Incentives

Site Category	Potential policy actions to Incentivize urban agriculture
Private vacant land	• Institution of taxes or penalties for owners of vacant or blighted land combined with credits or other tax incentives for allowing farming on such land
	• Imposition of fees for stormwater runoff from large commercial or industrial properties combined with credits or other incentives for onsite mitigation
Public vacant land	• Citywide assessment of land availability and suitability for urban agriculture • Continued funding and support for GreenThumb (or an equivalent agency) to take on management and oversight responsibilities for public land in farms or gardens
Community gardens	• Continued protection of existing community gardens from development • Tax incentives for transfer of private land to land trusts or other forms of community garden protection
NYCHA green space	• NYCHA resident outreach to assess areas where there is greatest interest in gardening or farming • Establishment of pilot programs at several sites to be expanded if successful
Underutilized open space	• Identification of underutilized open space (mostly Parks and Recreation land) most suitable for urban farming
Surface parking lots	• Imposition of fees for stormwater runoff from large commercial or industrial properties combined with credits or other incentives for onsite mitigation
Greenstreets	• Identify streets most suitable for potential fruit tree / food crop planting • Addition of fruit trees to list of allowable plantings for Greenstreets (for appropriate areas only)
Private rooftops	• Amendment of the NYC green roof tax credit to apply to rooftop food production • Streamlining of green roof permitting process; establishment of permitting protocols specific to rooftop agriculture • Imposition of fees for stormwater runoff from large commercial or industrial properties combined with credits or other incentives for onsite mitigation • Creation of incentives (such as increase in allowable FAR) to encourage inclusion of dedicated space for farming or gardening in new residential or commercial developments
Public rooftops	• Citywide building inventory of rooftop availability and suitability for agriculture • Establishment of an entity within an existing city agency or a separate public entity that would have management and oversight responsibilities for public roofs used as farms or gardens
Privately owned public space	• Allow for additional FAR increase if planted space is used for food production
Private backyards	• Establishment of an initiative modeled on the Victory Garden program to encourage and incentivize gardening and food production in private backyards.

Figure 8: *Land Designation and Potential Urban Agriculture Policy Incentives* summarizes the land availability findings and notes which of these policy initiatives that could encourage farming and gardening on such land.

Notes

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XII. Opportunities for Future Research

For all of the information and speculation presented in this research report, it is clear that much more about the future and the potential for urban agriculture remains unknown. The surging interest in issues related to food systems and sustainability indicate that a deeper understanding of the actual implications of increasing the presence of agriculture in our metropolitan areas is critical. Possible directions for future projects include:

- Assisting municipal agencies in conducting internal land-use analyses to determine how much land under their jurisdiction could be suitable for urban agriculture and helping to develop an action and management plan; linking agriculture production on city-owned land to municipal food procurement and support programs;
- Establishment of a network linking urban and regional farmers to assist with marketing and consumer outreach; assisting farmers markets and other programs which bring together urban and rural producers with urban consumers;
- Research and advocacy to articulate the links between urban and rural land use and land access issue for farmers, including the economic and environmental benefits of farmland / community garden protection and support;
- Working with community groups to conduct community-based food access and land assessments to develop an action plan for urban farming and gardening that would directly address access and environmental justice issues at a local level;
- Research into the potential for urban agriculture to contribute to job creation and an economic multiplier effect analysis, including potential for expanding processing and retail facilities;
- Analysis of the degree to which involvement in or exposure to urban agriculture and school gardening changes consumption habits and potential long-term impacts on health;
- Conducting more in-depth research on agricultural yields in urban settings and which crops are most suited to different urban environments;
- Conducting a quantitative cost/benefit analysis of various approaches to urban agriculture in NYC, including crop types, site conditions, and growing methods;
- Measuring actual stormwater runoff and building energy use for agricultural rooftops (the NYC-based project *Seeing Green: The Value of Urban Farms* is focusing on this issue);
- Developing a greater understanding of the energy implications of controlled-environment agriculture on rooftops and in urban settings (this project is currently underway at the UDL with support from NYSERDA);
- Development of a community-based composting program linked to urban farming and gardening sites; analyzing the impact on neighborhood waste stream;
- Analysis of small-scale distribution strategies for urban agriculture, including cooperatives, retail networks, CSAs, and other models, and assess potential for new approaches;

- Detailed research on the cultivation of non-food crops in urban areas and the potential for economic and ecological benefits, as well as impact on community self-sufficiency;
- Assessing the role of urban agriculture in a global context, with an analysis of the potential benefits and drawbacks of establishing urban food production in the face of volatile commodity prices, rising fuel costs, and global climate change.

As is apparent from this research, urban agriculture in NYC is an integral component of larger environmental and social systems that will warrant more in-depth analysis. Clear opportunities are emerging from this project and work of others on this topic. The issue of how productive green spaces contribute to the city's social, economic, and environmental well-being by providing food, opportunities for community engagement, and critical environmental services is one that the UDL is committed to exploring beyond the scope of this project. As interest in urban agriculture continues to flourish, it is clear that different site conditions will require a wide variety of approaches to ensure that potential interventions adequately address the immediate needs of the communities within which they are located as well as broader goals for the city and region. The Urban Design Lab looks forward to continuing to contribute to this critical issue in the future.

Maps

Map 1: New York City Regional Foodshed was created using the U.S. Department of the Interior and the U.S. Geological Survey 2006 National Land Cover Database.[1]

Map 2: Existing Farms in NYC was created using information gathered from a variety of sources, including from Mara Gittleman of Farming Concrete who supplied data on community gardens, from Tyler Caruso of the Thread Collective who compiled information on urban farms, and through online and on-the-ground research. As mentioned in the text, the distinction between a farm and a garden is not clear-cut. Criteria for being labeled on the map include over 2,000 s.f. of growing area and a focus on growing food for consumption by people other than the farmers/gardeners, whether through retail or donation. This is not intended to be a definitive list, but rather a general overview of the state of urban agriculture in NYC in 2011.

Map 3: Vacant Land and Community Gardens in NYC was created using three spatial data sets. The first is a polygon shapefile of the tax parcels in NYC with attribute values from the Department of City Planning's PLUTO database, dated June 2009. The second set is a polygon shapefile of the wetlands in New York State made available through the US Fish and Wildlife Service's National Wetlands Inventory website, dated October 2010. The third is a community garden shapefile obtained from researchers at the Farming Concrete project in January 2011.

Vacant parcels were determined through the PLUTO data attributes for the tax parcel features. Specifically, those features with '11' as a value for the 'LandUse' field were determined to be vacant. Public or private ownership was determined by a review of the values for the 'OwnerName' field. The public and private vacant land groups were then intersected with the wetlands shapefile using the 'Erase' function of the 'Analysis' tools in ArcMap to determine the total areas of each which reside within and outside of wetlands. Manual verification of the largest vacant parcels as well as a random analysis of over a hundred lots in all five boroughs listed as vacant were then conducted using Google Earth satellite imagery and Bing Maps aerial imagery. Based on this analysis it was determined that many of the parcels characterized as "vacant" are in fact developed or appear to be in active use (e.g. as a sports or recreation area). Such parcels comprise approximately 12% of the total vacant area. Further assessment of vacant land based on satellite imagery reveals that over 1,000 acres, primarily in Staten Island, are heavily forested, with several hundred additional "vacant" acres being located within on or around the Fresh Kills landfill (future site of the Freshkills Park). These areas were subtracted from the total vacant land. This data was then tabulated by borough. The community garden shapefile was also modified and some areas subtracted based on verification using satellite imagery.

Map 4: Public Vacant Land in NYC was created using the same methodology as above, only isolating those properties where 'OwnerName' is a City agency. Parcels were then divided into categories by area, and converted into point files.

Map 5: Other Potential Sites for Urban Agriculture in NYC was created using a variety of sources. The unused open spaces represented on this map were determined using one spatial data set. This data set is a polygon shapefile of all the open spaces in NYC as of November 2007 and is made available through the City's Department of Information Technology and Telecommunications website. Open spaces were determined to be unused if they had one of the following values for the 'LANDUSE' field: 'EMPTY LOT,' 'TRIANGLE,' or 'Undeveloped'. The majority of these open spaces fall within public rights-of-way, meaning they are not on a tax lot. However, a minority of these spaces do exist on tax lots; these are exclusively owned by the City and under the jurisdiction of the Department of Parks and Recreation. NYCHA green space was mapped using data from the Department of City Planning's PLUTO database, dated June 2009. Properties with values for the 'OwnerName' corresponding to some variation of NYCHA ("New York City Housing," "Housing Authority," etc.) were selected. Vacant lots and administrative buildings were then deleted from the selection, as were building footprints. Based on detailed assessments of plans and aerial imagery of 10 housing clusters throughout the city, we estimated that approximately 50% of developed NYCHA property, not including building footprints, consists of green space, amounting to a total of about 978 acres (this figure does not include parking, walkways, or recreation areas on NYCHA property; nor does it include vacant NYCHA property, which is part of the vacant land inventory). The housing developments assessed were: Jackson/Melrose, Edenwald/Baychester, Jacob Riis, Polo Grounds Towers, Kings Towers, Sheepshead Bay/Nostrand, Brownsville/Tilden/Hughes/Van Dyke I, Red Hook, Queensbridge, and Mariner's Towers. Greenstreets and surface parking are both polygon shapefiles from the PLUTO database. Information on Privately Owned Public Spaces was taken from the publication *Privately Owned Public Space: The New York City Experience*,[2] and affiliated website.[3] The figure for private backyards is from the report *Urban Forests In Our Midst: Environmental Benefits of Open Spaces in City Backyards*, prepared by the CUNY Institute for Sustainable Cities.[4]

Map 6: Potential Rooftop Farming in NYC was created using two spatial data sets. The first is a polygon shapefile of current NYC zoning, effective November 2010 and made available through the Department of City Planning website. The second set is a polygon shapefile of building footprints in NYC prepared by the NYC Department of Information Technology and Telecommunications, dated March 2009. The data set includes additional attributes from an undisclosed entity but most likely the Department of City Planning. Buildings were originally selected to meet four criteria: 1) a footprint greater than or equal to 10,000ft2, 2) a 'YearBuilt' value between 1900 and 1970, 3) inclusion in manufacturing, commercial, or commercial overlay, and 4) 10 stories or lower. These results were divided into two categories by the assumed area of the roof (attribute: 'Shape_Area'); 1) 10,000ft2 – 25,000ft2 and > 25,000ft2. Additional criteria were then applied to further filter these results using the attributes for the building footprint features. These are; 'BuiltFAR', 'MaxAllwFAR', and 'BldgClass'. Excluded buildings were those characterized as heavy manufacturing, garage and gas station, utilities, and categories deemed otherwise unsuitable for farming (including Bridges, Tunnels, Highways, Electric Utilities, Gas, Ceiling Railroad, Telephone Utilities, Communications Facilities, and Revocable Consents).

Map 7: Environmental Remediation Sites in NYC was created using the Environmental Site Remediation Database Search on the NYS Department of Environmental Conservation website.[5] Sites in Bronx, Kings, New York, Queens, and Richmond counties were selected and mapped. General locations of the two US EPA Superfund sites were also mapped – the focus of cleanup efforts in both cases are the water bodies of the Newtown Creek and Gowanus Canal.

Map 8: Obesity Prevalence and Fruit and Vegetable consumption in NYC was created using age-adjusted data from 2009 available from the NYC Department of Health and Mental Hygiene's Community Health Survey website.[6] Obesity was determined based on respondents' self-reported weight and height; a Body Mass Index (BMI) of 30 or greater is classified as obese. Fruit and Vegetable consumption was determined based on response to the following survey question: "How many total servings of fruit and/or vegetables did you eat yesterday? A serving would equal one medium apple, a handful of broccoli, or a cup of carrots."

Map 9: Food Retail in NYC was created using a point shapefile of businesses in NYC made available through ReferenceUSA. The grocery retail locations were determined using the NAICS codes in the 'NAICS_EXT' field. Point codes beginning with '445110,' '445120,' '4452,' were included, corresponding to 'supermarket or grocery store,' 'convenience store,' and 'specialty food market.' However, instead of using these designations, we found that, based on a number of on-the-ground verifications, using store size from the same data set was a much better predictor of the selection of food items actually available at the store (e.g. availability of fruits and vegetables). Stores were therefore categorized by floor area. Farmers Markets were mapped using information on Greenmarkets available from GrowNYC[7] and information on community farmers markets from Just Food[8] and the Office of Manhattan Borough President Scott Stringer.[9]

Map 10: Median Income in NYC was created using income related fields from the 2000 US Census for NYC collected by CommunityCartography with a census tract shapefile from ESRI (2010 U.S. Census tract-level figures were not available at time of publication).

Map 11: Median Age in NYC was created using age related fields from the 2000 US Census for NYC collected by CommunityCartography with a census tract shapefile from ESRI (2010 U.S. Census tract-block figures were not available at time of publication).

Map 12: Institutional Kitchens in NYC was created using data from the Department of City Planning's PLUTO database, dated June 2009. Buildings with property class codes M1 (Church, Synagogue, Chapel), N1-N9 (Asylums and Homes), P5 (Community center), and W1-W9 (Educational structures) were selected and building footprints were converted to point files. Clusters of educational buildings in the W3 (Schools and Academies) W5 (City Colleges) and W6 (Other Colleges and Universities) categories were classified as school clusters/campuses.

Map 13: Combined Sewer Areas was created using information on CSO areas from the NYC Department of Environmental Protection (available in the NYC Green Infrastructure Plan[10]) and vacant land from the Department of City Planning's PLUTO database (see methodology for map 3).

Map 14: NYC Surface Temperature was taken by NASA Landsat during a heat wave at 10:30 am on August 14, 2002 and has a resolution of 60 meters. The street overlay was created by the Hunter College Department of Geography. Image provided courtesy of Stuart Gaffin, Goddard Institute for Space Studies at the Earth Institute, Columbia University.

Figures

Fig. 1: Food Crop Average Yields and Estimated Acreage for NYC Retail was made using a variety of data sources. Fruits and vegetables were divided into different groups based on the USDA consumption recommendations to consolidate information. USDA / Conventional Average Yields were derived primarily from the USDA NASS *Vegetables 2009 Summary*[11] and the *Noncitrus Fruits and Nuts 2009 Summary*.[12] Other sources include: Sweet potatoes: USDA NASS *Crop Production 2009 Summary*;[13] Dry Edible Beans and Dry Peas and Lentils: USDA AMS *Bean Market News 2010 Summary*;[14] Potatoes: USDA NASS *Potatoes 2008 Summary*[15] (NYS average 2006-2008 was used); Eggplant: USDA ERS *Eggplant: An Economic Assessment of the Feasibility of Providing Multiple-Peril Crop Insurance*;[16] and Collards: Oregon State University Commercial Vegetable Production guides.[17] Yields per acre were averaged for each commodity from 2007-2009 using New York State statistics when available; otherwise NJ, PA or national statistics were used. Figures were then averaged for each fruit and vegetable group and divided by 43,560 to determine yields per square foot.

"Bio-intensive Low" Average Yields were derived from the lowest numbers in the "Possible GROW BIOINTENSIVE Yield in Pounds per 100-square foot planting" column in the charts on pages 86-126 in Jeavons' book *How to Grow More Vegetables: Than You Ever Thought Possible on Less Land Than You Can Imagine*.[18] All of this data is from one site, and the figures therefore do not necessarily reflect expected yields for urban agriculture in NYC; however, the limited information available on yields in Northeastern cities indicates that this lower range of the biointensive yields is within the range of what can be expected using intensive growing methods in this area (see the **Crops and Capacity** section for a more in-depth discussion). Figures were averaged for each fruit and vegetable group and divided by 100 to determine yields per square foot.

The "Estimated NYC annual retail" column includes estimates rounded to the nearest 1,000,000 pounds of the amount of each fruit and vegetable type needed to supply NYC's retailers annually. Figures are from the U.S. Food Market Estimator tool developed by the Leopold Center for Sustainable Agriculture,[19] which uses the USDA-ERS Food Availability Data System, an annual estimate of the amounts of hundreds of food items available at a per capita rate for human consumption in the United States. The figures are therefore extrapolated from national consumption figures and do not reflect actual consumption in NYC; they are, however, the best estimates available across a wide variety of food types. While there would certainly be large variations in consumption at a neighborhood level, per capita consumption figures for the entire city are unlikely to be radically different from those for national consumption. The volume estimates indicate the amount of each food type delivered to NYC retailers to supply the population of the city, and accounts for food spoilage in stores and in the home; it does not take into account food spoilage on farms and en route to retail, as it is likely food produced on urban farms sold locally would have a lower spoilage rate than food transported from great distances.

The figures in the "Estimated land area needed for cultivation" columns were derived by multiplying the average yields (conventional or biointensive) by the estimated retail volume (lbs.) separately for each product in each vegetable and fruit group and then adding the results together for each group. The acreage figures are therefore different (and more accurate) than the result of multiplying average yields per food group by total estimated retail volume by food group. In a few cases, yields data for a specific crop was unavailable, and average yields for the fruit or vegetable group to which the crop belongs was used to determine acreage needed for that crop.

Fig. 2: Potential Annual Crop Value – 1000 s.f. bed was created using the yields data from the USDA sources cited above for conventional yields and Jeavons for biointensive yields (see description of methodology for fig. 1). These were then multiplied by average organic retail prices, which were derived using a combination of average fruit and vegetable prices from the USDA ERS Fruit and Vegetable prices website,[20] the USDA ERS *How Much do Fruits and Vegetables Cost* reports,[21] and the USDA ERS *Emerging Issues in the U.S. Organic Industry* report,[22] which includes data on organic premiums for select products. Organic price estimates were used with the assumption that most crops grown in urban areas will be marketed at a price range that is closer to organic than conventional prices, due primarily to the price premium often associated with small-scale, sustainable production methods. The figures reflect average U.S. prices; there is evidence to suggest that food prices in NYC are equivalent to or in many cases lower than in other parts of the country.[23]

Fig. 3: Estimated NYC Fruit and Vegetable Demand features estimates in pounds of the amount fruits and vegetables needed to supply NYC's retailers annually. Figures are derived from the U.S. Food Market Estimator tool developed by the Leopold Center for Sustainable Agriculture,[24] which uses the USDA-ERS Food Availability Data System, an annual estimate of the amounts of hundreds of food items available at a per capita rate for human consumption in the United States. The volume estimates indicate the amount of each food type delivered to NYC retailers to supply the population of the city, and accounts for food spoilage in stores and in the home; it does not take into account food spoilage on farms and en route to retail, as it is likely food produced on urban farms sold locally would have a lower spoilage rate than food transported from great distances. The percentage of each food type sold fresh versus processed or frozen is from the same source, with figures from "fresh" category of the "Sub-product" field for the volume of fresh product sold, and all other categories within that field for the volume of processed or frozen product sold. The percent by which each fruit and vegetable type falls short of or exceeds USDA consumption recommendations was determined by comparing existing consumption figures with those outlined by in the USDA ERS report *Possible Implications for U.S. Agriculture From Adoption of Select Dietary Guidelines*[25].

Fig. 4: Potential Available Land in the Five Boroughs was created using the areas for potentially suitable vacant land and community gardens (as described in the methodology for map 3); potentially suitable rooftops (as described in the methodology for map 6); and NYCHA green space, underutilized open space, and Greenstreets (as described in the methodology for map 5). These figures were then tabulated by borough.

Fig 5: Vacant Land by City Agency was determined after the analysis for the 'Vacant Land after Wetlands' chart was completed and after the forested areas were subtracted. This chart uses no further spatial data sets. Once the public vacant land had been determined and the data set was intersected with the wetlands shapefile, the remaining features were arranged by city agency which was determined by a review of the values for the 'OwnerName' field. The total land area was added up for each agency and they were then listed in descending order.

Fig 6: Vacant Land by Median Income Quintiles was created using NYC median income by census block data from the 2000 U.S. Census (geocoded 2010 Census income data was not available at the time of publication). Staten Island, which has relatively high income neighborhoods and a great deal of vacant land, was excluded from this analysis because its density, development patterns and demography are more similar to surrounding suburban areas than to the other four boroughs. Census blocks for the other four boroughs were divided into quintiles of 409 census blocks each, each of which was then analyzed to determine the vacant land area and number of lots.

Fig. 7: NYC Annual Waste Stream, 2002 was created using a variety of sources. The year 2002 was selected because data or information from a variety of different sources was available for that year; information on the City's waste stream for subsequent years is more fragmented. Multiple reports from the NYC Department of Sanitation[26] and background papers from the NYC Independent Budget Office[27] were used for information on residential, street basket, and institutional waste, municipal recycling, and composting; the primary source for commercial waste data was Commercial Waste Management Study Volume II: Commercial Waste Generation and Projections report by Henningson, Durham, & Richardson Architecture and Engineering, P.C.,[28] and the figure for incineration is from The Works: Anatomy of A City.[29]

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Appendix II: Abbreviations

AMS: United States Department of Agriculture Agricultural Marketing Service

CAM: crassulacean acid metabolism

CEA: Controlled Environment Agriculture

CSA: Community Supported Agriculture

CSO: Combined Sewer Overflow

CSW: Combined Sewage Watershed

DCP: New York City Department of City Planning

DEC: New York State Department of Environmental Conservation

DEP: New York City Department of Environmental Protection

DOB: New York City Department of Buildings

DOH: New York City Department of Health and Mental Hygiene

DOITT: New York City Department of Information Technology and Telecommunications

DOT: New York City Department of Transportation

DSNY: New York City Department of Sanitation

EBT: Electronic Benefits Transfer

EPA: United States Environmental Protection Agency

ERS: United States Department of Agriculture Economic Research Service

FAR: floor-to-area ratio

FRESH: Food Retail Expansion to Support Health

GHG: greenhouse gas

GIS: Geographic Information Systems

HPD: New York City Department of Housing, Preservation and Development

HVAC: heating, ventilation and air conditioning

MASNY: Municipal Arts Society of New York

MBPO: Office of Manhattan Borough President Scott Stringer

NAICS: North American Industry Classification System

NASS: United States Department of Agriculture National Agricultural Statistics Service

NYC: New York City

NYBDC: New York Business Development Corporation

NYCEDC: New York City Economic Development Corporation

NYCHA: New York City Housing Authority

NYCIDA: New York City Industrial Development Agency

NYS: New York State

NYSERDA: New York State Energy Research and Development Authority

OASIS: Open Accessible Space Information Systems

PAHs/PNAs: polynuclear aromatic hydrocarbons

PCBs: polychlorinated biphenyls

POP: Privately Owned Public Space

SNAP: Supplemental Nutrition Assistance Program

TPL: Trust for Public Land

UDL: Urban Design Lab

UHF: United Hospital Fund

UHI: urban heat island

USDA: United States Department of Agriculture

VOCs: volatile organic compounds

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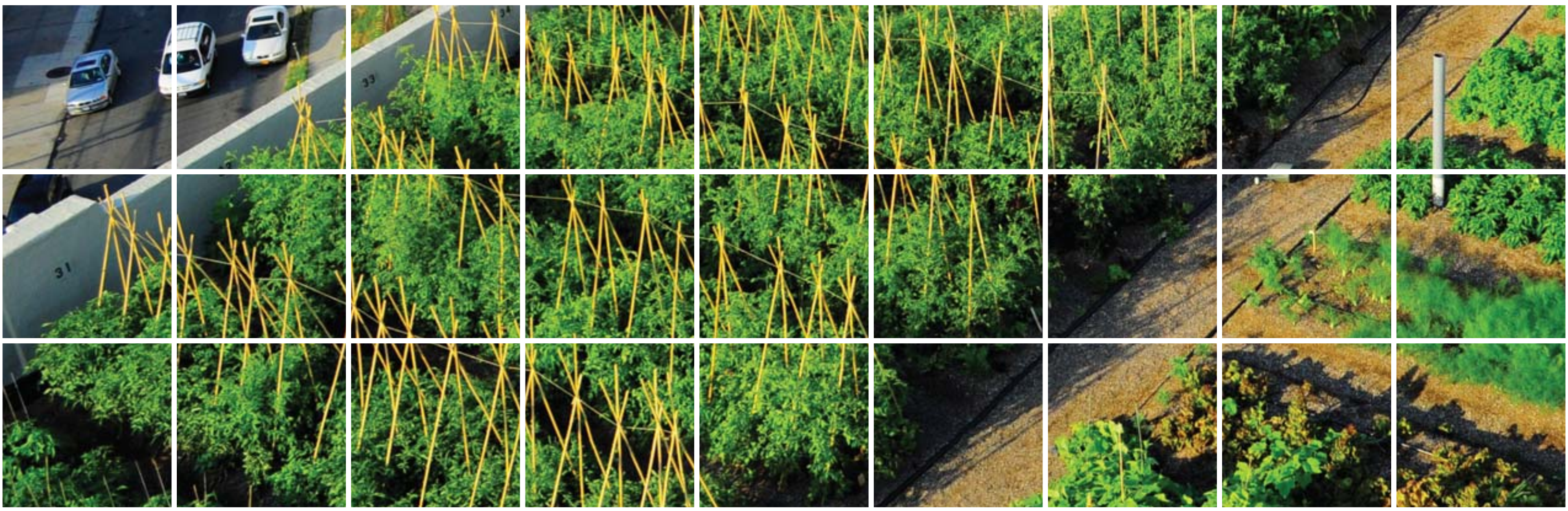
Index



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