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Assessing the local food supply capacity of Detroit, Michigan

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Abstract
Urban agriculture is touted as a strategy for more locally reliant food systems, yet there is little understanding of its potential food provisioning capacity. Using Detroit, Michigan as an example, we use secondary data to develop a methodology for estimating the acreage required to supply, as far as seasonally possible, the quantity of fresh fruits and vegetables consumed by city residents. We compare these requirements with a catalog of the publicly owned, vacant parcels in Detroit to assess the feasibility of producing significant quantities of the fresh produce consumed within city limits. We demonstrate that if high-yield, biointensive growing methods are used, 31% and 17% of the seasonally available vegetables and fruits, respectively, currently consumed by 900,000 people could be supplied on less than 300 acres without incorporating extraordinary postharvest management or season-extension technology. This indicates that urban agriculture could play an important role in food provisioning in many places.

Keywords
food supply, local food systems, season extension, urban agriculture, urban sustainability

Introduction and Background
Deindustrialized cities with large amounts of vacant land and transitioning economic foundations force us to reconsider patterns of urban land use. Some scholars have proposed developing green infrastructure, including urban agriculture, as a way to "revitalize urban environments, empower community residents, and stabilize dysfunctional markets" within shrinking cities (Schilling & Logan, 2008, p. 451). Research from Germany points to community gardens as a good use of land in deindustrialized areas, not only because of the social and ecological benefits, but also because these uses require minimal up-front investment and do not impede later edificial development (Rosol,

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2005). In numerous U.S. cities that have faced severe economic declines, such as Philadelphia, Detroit, and Milwaukee, urban agriculture (UA) movements have been able to utilize vacated spaces to cultivate food and reinvest in neighborhoods (Gray, 2007; Hair, 2008; McGuire, 2007; McMillan, 2008; Wells, 2008).

As interest in UA grows and as ecological threats increase, the possibility of UA on a larger scale has gained attention as a strategy for moving toward sustainable urbanization. Urban green space, which can include UA, has been shown to generate numerous social and environmental benefits (Kuo & Sullivan, 2001; Taylor, Wiley, Kuo, & Sullivan, 1998; Tzoulas et al., 2007) and has been posited as a key element of urban sustainability (Chiesura, 2004). Advocates of urban agriculture have argued that an increase in local food production would diminish a city's reliance on resource-consumptive imported foods (see for example Deelstra & Girardet, 2000; Garnett, 1999; Rees, 1997). Our research addresses this possibility by exploring the connection between an urban land base and local provision of food. A better understanding of this connection and the methods by which a potential contribution to urban food supply can be estimated will enable city planners and urban developers to understand the food-provisioning capacity of UA.

With Detroit, Michigan, as a test case, our research was driven by two questions. First, what percentage of current and recommended Detroit resident dietary intake of fruits and vegetables could be met through urban food production? Secondly, how much land would be necessary to achieve this level of production, and is the utilization of this quantity of land feasible given the amount and distribution of vacant, publicly owned land? With its large swaths of vacant land and its strong urban agriculture movement, Detroit offers an ideal place to conduct research on the opportunities to significantly affect food supply through scaling up UA.

We begin by summarizing the links between UA and sustainable urbanization. We then present our research methods alongside a discussion of our results. Our discussion summarizes the most significant results and notes the transferability of our methodology. We conclude by discussing future avenues of inquiry and implications for practitioners.

Urban Agriculture and Sustainable Urbanization

Empirical studies of UA document benefits such as improved air quality, preservation of cultivatable land, cooler buildings, improved urban biodiversity, waste and nutrient recycling, and stormwater management (Deelstra & Girardet, 2000; Mendes, Balmer, Kaethler, & Rhoads, 2008). Irvine, Johnson & Peters (1999) argue that community participation in the creation of a garden can be a model for defining the dimensions of urban sustainability in a way that meets the needs of diverse urban residents.

Smit and Nasr (1992) envision UA integrating into the urban environment and improving sustainability through its ability to recycle urban wastes, utilize idle land and bodies of water, and conserve energy by substituting for less sustainable practices associated with importing food. Landscape architect André Viljoen (2005) advocates urban landscapes that are socially, economically and environmentally productive and imagines UA playing a key role in achieving urban sustainability as sites for recreation, for ecological services, and as the foundation for food system relocalization. Yet, absent empirical research on the impacts of UA on a particular city, much in these visions remains speculative.

A small body of work looks at how UA can contribute to the social dimension of sustainability. Ferris, Norman, and Sempik (2001) show that community gardens can play a role in restoring environmental justice to ecologically degraded and marginalized communities. Garden sites can be a model of dynamic and participatory "sustainability in action" through social inclusion, environmental protection, and organic food production (Holland, 2004, p. 304). Howe and Wheeler (1999) argue that UA can support local economies by providing vocational training, producing goods and services, and bridging market gaps in the mainstream food system. The social and ecological impacts of gardens can be particularly pronounced when blighted vacant lots necessitating continual city maintenance expenditures are transformed into places of beauty that foster safe play for children and neighbor interaction (Pottharst, 1995).

While estimates of the contribution of UA to food supply have been made, much is still unknown. A number of researchers have conducted foodshed analyses that look at the ability to supply a local population from current agricultural production within a region. Peters, Bills, Wilkins, and Smith (2002), for example, find New York has the capacity to provide 37.5% of the state's total annual vegetable intake, while maintaining surplus levels of some crops. Researchers looking at the Willamette Valley in Oregon found that in 2008 agriculture production met only 10% of the recommended vegetable servings and 24% of the recommended fruit servings for the valley's population (Giombolini, Chambers, Schlegel, & Dunne, in press). Desjardins, MacRae, and Schumilas (2010) looked at the Waterloo region of Ontario, Canada, and found it would be feasible to supply 10% to 50% of the additional intake needed to meet nutritional guidelines of particular fruit and vegetable crops that grow well in the area. However, there remains a dearth of research relating an *urban* land base to food consumption by urban residents.

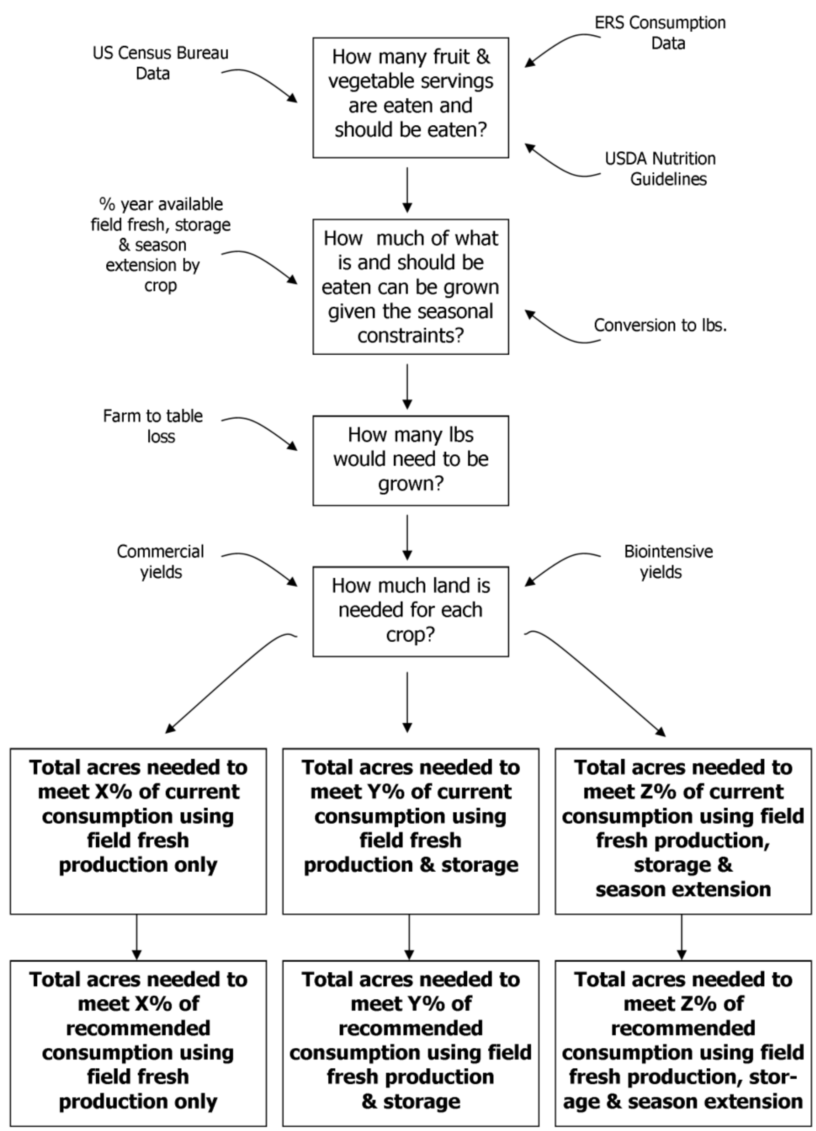
Some estimates suggest there are cities around the world that supply much of their own fruits and vegetables. For example, Shanghai and Beijing are apparently fully self-sufficient in vegetables (Howe, Bohn, & Viljoen, 2005). Several urban centers in Africa, including Brazzaville (Congo), Dar Es Salaam (Tanzania) and Accra (Ghana), produce more than 80% of their leafy vegetable needs (Mougeot, 2005). Some large Latin American cities are able to meet one-third of vegetable demand through urban production (Mougeot, 1993). However, the geographical boundaries used in these estimates are not clear and empirical data is scarce.

Nonetheless, a small but growing number of municipalities have embraced UA as a strategy for sustainable urbanization (Mendes et al., 2008). City government support has often come from the desire to increase green space and capitalize on public concern with environmental issues (Connelly & Ross, 2007). In 2006 the city of Vancouver announced an initiative to create 2,010 new gardens as a legacy for the 2010 Olympics (City of Vancouver, 2006) and as a way of "enhancing the City's food security and reducing the City's ecological footprint by reducing 'distance to fork,'" of "encouraging increased social interaction," and of "supporting and encouraging an environmentally and socially sustainable activity" (Morris & Tapp, 2008, p. 3). Similarly, in 2008 the mayor of London and his appointed Chair of London Food announced a program to support identifying land and providing resources to create 2,012 garden sites by the 2012 Olympics (Capital Growth, 2008). At the national level, an executive order from the Philippines mandates funding for "the setting up of urban vegetable gardens and backyard fisheries" as protection against the global financial crisis (President of the Philippines Executive Order No. 776, 2009). All of these initiatives cite environmental benefits and increased food security from UA as motivating forces.

Yet the question remains, what portion of the food supply could really be achieved through urban cultivation? Despite the interest in UA, we need to understand what level of urban production is feasible and what level is desirable across a city. While numerous advocates have speculated that UA could reduce dependency on imported food, and the associated carbon footprint, little research has explored the conceivable scale of urban food production relative to a city's food needs.

This question becomes even more interesting when we consider that the majority of people in the U.S. eat far fewer fruits and vegetables than recommended by the U.S. Department of Agriculture (USDA) dietary guidelines (U.S. Department of Health and Human Services and U.S. Department of Agriculture, 2005). How might the land base required to supply a city's fruit and vegetable needs change depending on whether or not these dietary guidelines are followed? To better understand the effect of these different consumption levels, the goal of this research is to estimate how much of current and recommended fruit and vegetable consumption could be supplied through cultivation within the city limits of Detroit.

Figure 1. Overview of the Process to Determine Fruit and Vegetable Acreage Requirements



Methods and Results

In order to determine the production potential on vacant land in Detroit relative to residents' present and recommended consumption levels, we draw together secondary data to estimate: (1) fruit and vegetable consumption; (2) seasonal availability by crop; (3) quantity and acreage of Detroit's publicly owned vacant parcels, and (4) acreage required to maximize local food supply based on fruit and vegetable yields. This methodology results in a range of acreages that could conceivably be cultivated to supply a given portion of the local diet and places these in the context of the available land within a municipality. Looking at the land required to produce a given portion of resident diet, rather than the amount of food that could be produced on a particular quantity of land, enables us to compare production space requirements to actual diet composition rather than make a prior determination of crop composition on set acreages. Figure 1 depicts an overview of our research process, where X, Y, and Z represent the greatest percentage of real and hypothetical consumption levels that could be supplied based on the seasonal limitations inherent to each production scenario. We turn now to a discussion of these steps, and the results obtained, in greater detail.

Current and Recommended Consumption

Estimates of current consumption were calculated using a 10-year average (1996–2006) of the USDA Economic Research Service (ERS) average daily per capita servings for fresh fruits and vegetables. We used the ERS Loss-Adjusted Food Availability database, which starts with aggregate food availability data, adjusts for waste, and then calculates national average daily per capita servings (U.S. Department of Agriculture Economic Research Service, 2008). These per capita servings were multiplied by the resident population of Detroit according to the 2006 U.S. Census Bureau (834,557 people).[1]

The number of fruit and vegetable servings that should be eaten according to the USDA Nutrition Guidelines was calculated based on the My Pyramid recommendations for daily consumption of fruits and vegetables according to gender, age range, and activity level (U.S. Department of Agriculture Center for Nutrition Policy and Promotion, 2005). An active lifestyle is defined as one that, in addition to the activity of daily life, involves "physical activity equivalent to walking more than 3 miles per day at 3 to 4 miles per hour" (U.S. Department of Agriculture Center for Nutrition Policy and Promotion, 2005).

Following the assumption made by Conner, Knudson, Hamm, and Peterson (2008) that two-thirds of the population is sedentary and one-third of the population is active, we used the 2006 U.S. Census Bureau data to determine the resident population by gender and age range (U.S. Census Bureau American Fact Finder, 2006), which then allowed us to calculate the yearly number of fruit and vegetable servings that should be eaten by Detroit residents. Since it was beyond the scope of this study to explore the potential for the processing of locally grown fruits or vegetables, only the consumption of fresh, unprocessed fruits and vegetables was considered.

Of the fruits and vegetables tracked by ERS, only one vegetable, artichokes, cannot be grown in the Detroit region. However, 12 of the 23 fruits cannot be cultivated in this area: oranges, tangerines, grapefruit, lemons, limes, avocados, bananas, kiwifruit, mangoes, pineapple, papayas and cranberries.[2] In this analysis we included artichokes and cranberries in the total number of current and recommended servings, but excluded the aforementioned 11 tropical fruits, which we presume would continue to be imported and consumed in the same relative proportions. In other words, the total numbers of both presently consumed and recommended vegetable servings include all vegetables for which data was available, but the total numbers of fruit servings include only the temperate fruits and do not include any tropical fruits.[3]

Again following Conner et al. (2008), we assumed that if Detroiters increased their daily servings of fruits and vegetables, they would still maintain both the relative proportions of different fruit and vegetable types and the relative proportions of fresh and processed produce in their diets. We therefore multiplied the total number of recommended fruit and vegetable servings by the proportion each fruit or vegetable in its fresh form represents within

[1] The Detroit population differs from the U.S. population as a whole in some significant ways. Most notably the city is 83.2% African-American and 32.5% of individuals are below the poverty line, according to the 2006 U.S. Census, compared to the national average of 12.2% African-American and 13.3% of individuals below the poverty line. This will certainly affect consumption patterns even though our analysis does not account for this. Furthermore many Detroiters suspect that the U.S. Census significantly undercounts the city's population, particularly in the poorest communities. Despite these limitations, we believe the data nonetheless provide the appropriate order of magnitude for estimating fruit and vegetable consumption.

[2] Cranberries are the sole nontropical fruit in this list, and while on the basis of seasonal temperature fluctuations they could be grown in Detroit, their cultivation necessitates distinct production techniques that involve flooding the crop at various stages, the possibility of which was not considered in this analysis.

[3] Of all the fruit and vegetable crops included in this analysis, all but six of the vegetables (asparagus, eggplant, escarole/endive, garlic, kale, and lima beans) and all but three of the fruits (cherries, grapes, and plums) were documented crops in Detroit gardens in the 2005–2006 growing seasons (Alaimo & Miles, 2007).

current fruit and vegetable consumption. This allowed us to compare quantities of current fresh fruit and vegetable consumption with hypothetical quantities of fresh fruit and vegetable consumption that would accord with dietary guidelines even though there is no recommendation for levels of fresh produce consumption.

In this analysis both current and recommended consumption figures assume individuals consume equal portions of all fruit and vegetable crops throughout the year. While this is likely generally true for many crops, some crops, such as strawberries or sweet corn, are probably eaten in greater quantities during the local harvest months. To the extent that this is the case, the proportion of current consumption that could be met through local production will be underestimated in our analysis, as will the amount of land necessary to supply current consumption levels.

According to our calculations, Detroiters eat an annual total of 285 million (285,036,649) fresh vegetable servings and 98.2 million (98,232,531) fresh, temperate fruit servings. If dietary patterns were to follow USDA recommendations, they would eat 854.1 million (854,131,315) fresh vegetable servings and 410.6 million (410,572,711) fresh, temperate fruit servings. This means that recommended consumption levels are more than four (4.2) times higher for fruit and three (3.0) times higher for vegetables than current consumption. In confirmation of this consumption pattern, the 2005–2007 Michigan Behavioral Risk Factor Surveillance System Regional & Local Health Department survey found that 77.2% of Detroit residents consume less than 5 servings of fruits and vegetables per day (Fussman, 2008).

The reasons why not just Detroiters but the majority of people across America tend to underconsume fruits and vegetables are many. Research has drawn attention to the comparatively limited physical access to healthy foods, including fruits and vegetables, for rural, low-income, and minority communities (Larson, Story, & Nelson, 2009; Pothukuchi & Wallace, 2009). While cultural dietary patterns, household food practices, knowledge level, and perhaps even evolutionarily influenced food preferences (see Pollan, 2008) also affect consumption patterns, a literature review notes that research generally shows a correlation between better access to supermarkets and healthier diets (Larson et al., 2009). Furthermore, some research has shown that participation in UA increases fruit and vegetable intake (Alaimo, Packnett, Miles, & Kruger, 2008).

In Detroit, the extent to which research shows fruits and vegetables are not only physically less accessible but also of poorer quality and more expensive than in the suburbs (M. Gallagher, 2007; Pothukuchi, 2003; Treuhaft, Hamm, & Litjens, 2009; Zenk, Schulz, Hollis-Neely et al., 2005; Zenk, Schulz, Israel et al., 2005; Zenk et al., 2006), indicates that the limited sources for fruits and vegetables may have a particularly large influence on underconsumption patterns. Still, our intention in this work is not to argue that growing more fruits and vegetables in Detroit would reverse dietary patterns. We simply wish to call attention to the existence of this consumption gap, in Detroit and elsewhere, and argue that even if a city could grow all of its own fruits and vegetables based on what its residents currently eat, it does not necessarily mean it could meet the quantities needed for optimal diets. We also are not implying that if a city could grow quantities necessary for an optimal diet that residents would necessarily consume them; rather our goal is to explore the boundary conditions of what is feasible from a supply-consumption perspective.

Seasonal Availability

In order to compare consumption data with what could be grown in Detroit, it was necessary to factor in the months of the year during which different fruits and vegetables are available. In addition to considering the season in which each crop is available fresh from the field, we also looked at whether and during what time period any of these crops could be available through the use of storage or season-extension technology via unheated hoop houses. Based on harvest and distribution data from the Michigan State

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University Student Organic Farm,[4] a previously published Michigan Availability Guide (Michigan State University Extension, 2004) and feedback from two staff members of the nonprofit organization Michigan Food and Farming Systems, we determined the months each crop is available (1) fresh from the field, (2) through crop storage, and (3) through season extension. From this, we calculated the percentage of the year, according to half month increments, that each crop would be available in each of these production scenarios.[5,6,7]

We assumed the use of the lowest technology system available; that is, if a crop could be grown with and without season-extension technology in the same time period, we only considered the availability fresh from the field in the percentage calculation. We also only included the crops for which there is a viable early or late season retail market in Michigan,[8] as opposed to what would be possible to cultivate, in the season-extension availability estimates. Furthermore, while this analysis accounted for successive planting of a single crop, we assumed that only one crop would be planted on a given square foot through the length of the growing season, rather than rotating early, middle, and late season crops. In regard to the hoop houses, we assumed they would only be in use during the months when field production is not possible. The resulting data shows three scenarios—field fresh only; field fresh and storage; field fresh, storage and extended season—that meet a progressively larger portion of local consumption but also necessitate progressively more substantial financial investments and infrastructure developments to enable crop storage and hoop-house construction.

GIS Vacant Land Identification and Mapping
Vacant parcels were identified using the November 2008 dataset from the City of Detroit (City of Detroit, 2008). Though this dataset originates with the Assessment Division and the accuracy of their property database has been questioned (Dewar, 2006), after cross-referencing a subset of our catalog of vacant parcels against 2005 aerial imagery (Michigan Geographic Data Library, n.d.), we found only 45 of 1,323 parcels identified as vacant that appeared to have a home or other structure present (3.4% error rate).

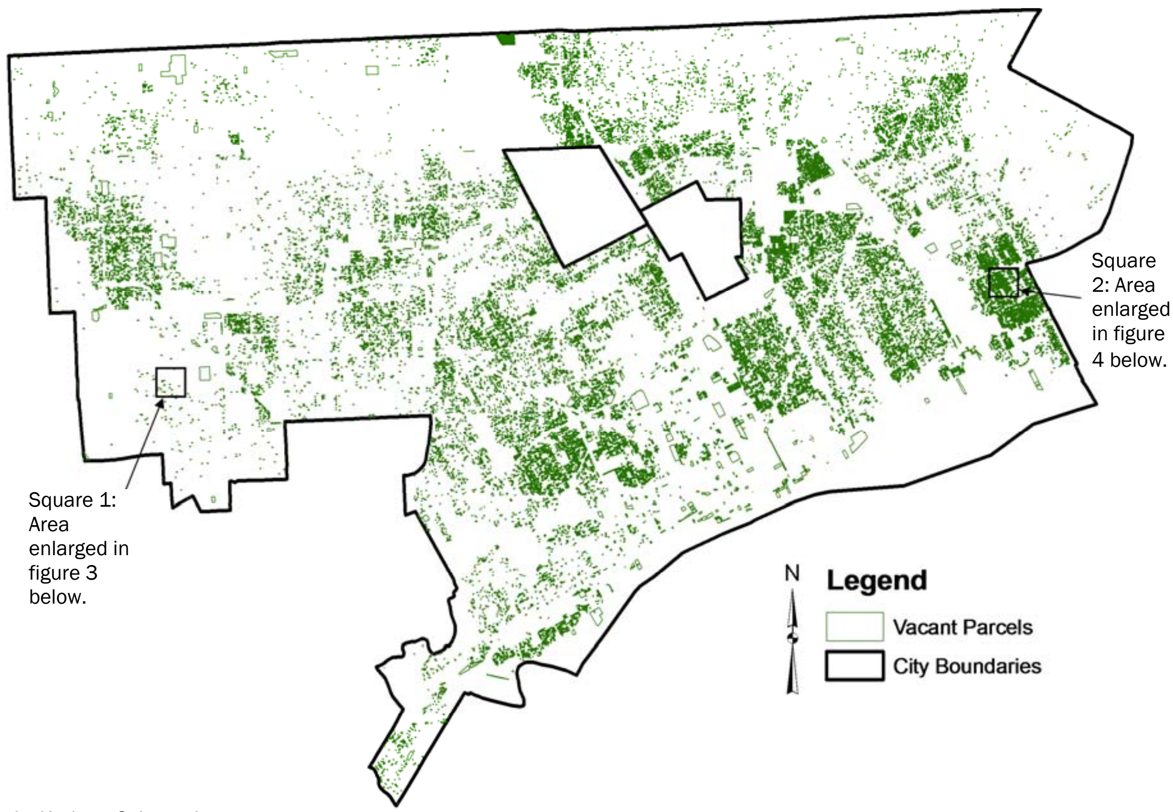
Only fully vacant parcels located within city limits and owned by the city, county, state, county land bank, or state land bank were considered in our tally of vacant property. All parcels owned by the City of Detroit Recreation Department were excluded. The selected parcels were mapped and their area calculated using ESRI ArcInfo® 9.3. The number and area of vacant parcels were totaled by zip code after missing or erroneous zip code data were corrected for over 500 parcels. Road data and city boundary data were obtained from the Michigan Geographic Data Library (n.d.).

Table 1. Number and Acreage of Vacant Parcels by Ownership Category

Ownership	No. of Vacant Parcels	Acres
City of Detroit	31,123	3,589
Wayne County	6,135	563
State of Michigan	401	104
Wayne County Land Bank	551	55
State Land Bank	5,875	537
TOTAL	**44,085**	**4,848**

[4] Unpublished data from the Michigan State University Student Organic Farm 2004-2008 growing seasons. See http://www.msuorganicfarm.com
[5] Due to minimal available harvest data for lima beans, the seasonal availability of snap beans was used as a best estimate. The seasonal availability of okra was based on Conner et al. (2008).
[6] Because the goal was to compare these numbers with consumption data and it was unclear in the ERS data whether "squash" referred to summer or winter squash, the seasonal figures reflect the availability of at least one of these varieties. Accordingly the squash yield figures (discussed later) are an average of winter squash and zucchini given in Jeavons (1995).
[7] The seasonality data for season extension assumes unheated hoop houses.
[8] Based on personal communication with Adam Montri, Hoop House Outreach Specialist, Department of Horticulture, Michigan State University, October 2008.

Figure 2. Distribution of Vacancy Across Detroit. Two areas noted here are enlarged in figures 3 and 4.



Map by Kathryn Colasanti.

The final GIS analysis gave a total of 44,085 vacant parcels comprising 4,848 acres, or 7.6 square miles. Based on this figure, 11% of the 386,584 total parcels in the city are publicly owned, nonpark, vacant land. The majority of these parcels (approximately 70% percent) are owned by the city (see table 1, above).

Our calculation of the number of vacant lots is on the low end of other Detroit estimates, which range from 40,000 (Gopakumar & Hess, 2005; Stohr, 2003), to 65,000 (Lachance, 2004), to 103,000 (Roberts, 2008) parcels. Acreage estimates range from 17,000 acres (Gray, 2007), to 25,600 acres (J. Gallagher, 2008), to nearly 30,000 acres (Altman, 2009; McKee & Ortolani, 2008). Furthermore, our tally of vacant parcels does not include parcels with abandoned buildings, which have been estimated to number more than 80,000 (Riley, 2008). None of these popular press estimates discusses how its figures were obtained, however.[9] In sum, we believe that the figure of 4,848 vacant acres is a conservative estimate of unutilized land in Detroit and thus production potential will be underestimated.

Mapping the nonrecreational, publicly owned vacant parcels across the city provides a way to look at the range in vacancy levels (see figure 2). The belt across the center of the city, and the eastside neighborhoods in particular, has the

[9] It is likely that the discrepancy between our tally of vacant parcels and the estimates in the popular press is largely due to the private ownership of vacant parcels and the typical waiting period before a foreclosed property returns to the city or other government entity.

Figure 3. Example of Vacancy Distribution in a Low-Vacancy Neighborhood.
These neighborhood blocks, which are located within zip code 48228, correspond to Square 1 in Figure 2.

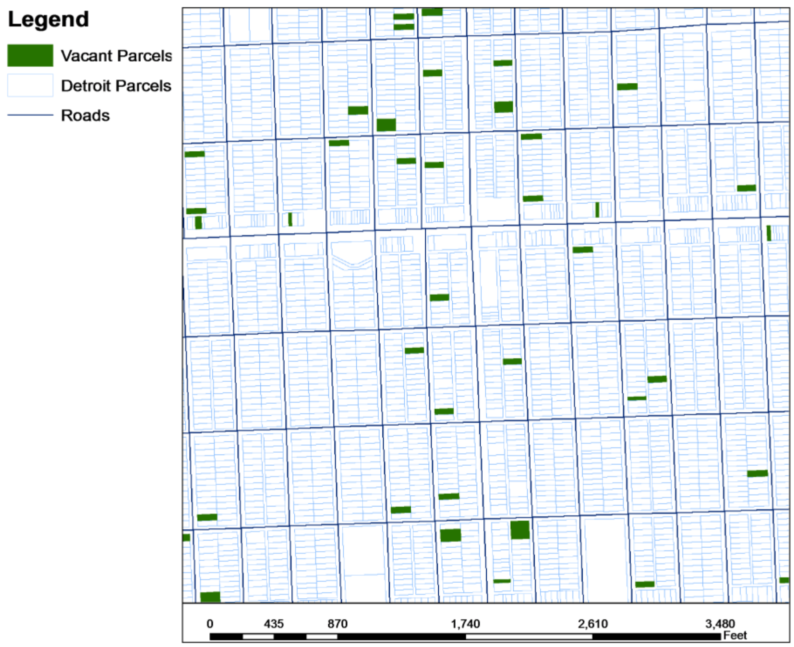


Figure 4. Example of Vacancy Distribution in a High-Vacancy Neighborhood.
These neighborhood blocks, which are located in zip code 48215, correspond to Square 2 in Figure 2. Most of the larger shaded areas comprise multiple parcels.

Maps by Kathryn Colasanti.

greatest concentration of vacant property. Figures 3 and 4 show snapshots of two areas with relatively low (figure 3) and relatively high (figure 4) vacancy at a scale in which the individual parcels are distinguishable. Figure 4 is representative of the areas of the city in which vacancy is extremely high and many of the vacant parcels are contiguous. In contrast, figure 3 demonstrates that very few vacant parcels are contiguous in the areas of the city in which vacancy is relatively low. These areas are characterized by small, interspersed lots, the majority of which are roughly one-tenth of an acre.

Acreage Needed to Meet Consumption Levels

In order to determine the amount of land necessary to support as much of the fresh fruit and vegetable consumption as possible through Detroit-based production given seasonal limitations, we first converted the serving totals of each crop, at both current and recommended consumption levels, to pounds based on published figures for servings per pound adapted for adult populations (U.S. Department of Agriculture Food and Nutrition Service, 2008).[10] Next we multiplied this number by the percentage of the year available within each of the three seasonal production scenarios. We then factored in losses in the transmission of produce from the farmgate, the loss due to any inedible portion, the loss at the retailing stage, and the loss in cooking (Kantor, 1998; Peters et al., 2002). This enabled us to determine a total weight in pounds for each of the fresh fruits and vegetables commonly consumed by the approximately 835,000 residents of Detroit.

We were then able to use these figures in conjunction with published high and low productivity biointensive yields that reflect small-scale cultivation (Jeavons, 1995)[11] to determine a range of acreage needed for each crop.[12] For the sake of comparison, we also calculated requisite acreage according to compiled Michigan commercial crop yield figures (National Agricultural Statistics Service Michigan Field Office, 2006; Peters et al., 2002; Peters, Bills, Wilkins, & Smith, 2003; U.S. Department of Agriculture Economic Research Service, 2003; Zandstra & Price, 1988). While the scale and mechanization level of commercial agriculture would be less feasible within much of the urban Detroit setting, these more modest yields can nonetheless provide a cautious upper limit to the quantity of land necessary. For each of the yield levels and for both current and recommended consumption, we used the sum of the fruit and vegetable acreages to show approximately how much land would need to be put into production in order to meet a given percentage of local consumption with various scenarios of seasonality. Table 2 shows the range of acreages needed. The first two rows in each production scenario reflect high and low productivity under biointensive cultivation, while the third row reflects commercial agriculture yields. If a high level of biointensive agricultural productivity is assumed, putting only 263 acres into production could meet the maximum percentage of fruit and vegetable consumption seasonally possible, given our assumption that people would not change their relative consumption of fresh, frozen, canned, or tropical fruits. That is, of the total quantity of fresh vegetables and fresh nontropical fruits consumed annually, 31% of the vegetables and 17% of the fruits could be produced without the use of storage or season extension. If low productivity is assumed, the acreage needed to meet the same level of consumption increases to nearly 900 acres, which is similar to acreage requirements for the recommended consumption

[10] Servings per pound were based on a ¼ cup serving in the USDA report created for child nutrition programs but were adapted to the basis of ½ cup servings for the purposes of this research. Servings per pound figures for all fruits and vegetables discussed in this research were derived from this report except for garlic, for which the estimation of 5.5 servings per pound was estimated.

[11] Jeavons discusses low productivity figures as reasonable for beginning farmers and gardeners and high productivity figures as achievable for experienced farmers and gardeners.

[12] The two exceptions were escarole/endive, for which the yield data for head lettuce was used as a best estimate, and mushrooms, for which the commercial-production NASS figure of 71,874 lbs./acre was used for both low and high productivity (from www.nass.usda.gov).

Table 2. Acreage Needed To Supply Current and Recommended Consumption

Production Scenario		Acreage Needed to Meet Current Consumption	Acreage Needed to Meet Recommended Consumption	% Annual Consumption Possible to Produce
Field Only	High Biointensive	263	916	31% Veg 17% Fruit
	Low Biointensive	894	3,001	
	Commercial Yields	1,660	5,549	
Field + Storage	High Biointensive	511	1,831	65% Veg 39% Fruit
	Low Biointensive	1,839	6,174	
	Commercial Yields	3,063	10,210	
Field + Storage + Extension	High Biointensive	568	2,014	76% Veg 42% Fruit
	Low Biointensive	2,086	6,976	
	Commercial Yields	3,602	12,067	

levels of fruits and vegetables at high productivity. (See appendix A for sample calculations.)

If both postharvest management and season-extension techniques are used, the percentage of consumption that could technically be achieved escalates to three-quarters of vegetable and nearly half of fruit consumption. The acreage requirements, however, are roughly double those of the requirements under field harvest at each of the three yield levels. Still, in regard to present consumption, these percentages could be achieved with 568 acres and high productivity biointensive yield levels according to this analysis. Utilizing less than half of the catalogued publicly owned vacant acreage could achieve these percentages for present consumption levels at low productivity biointensive yields or for recommended consumption levels at high productivity biointensive yields.

Discussion

This research sought to understand the food supply capacity of urban agricultural production, looking within the city limits of Detroit as our test case. Our estimate of roughly 4,800 vacant, nonrecreational, publicly owned acres in Detroit does not include land in and around parks, golf courses, cemeteries, schools, churches, hospitals, jails, utilities or right-of-way areas, nor does it include household cultivation. These constraints ensure that our estimate is conservative. Though we do not assert that all vacant land should be converted into farms and gardens, transitioning a portion of the available land into productive spaces appears very appropriate and could have significant impact. Based on our analysis of consumption, seasonal availability, and yield potential, an investment in infrastructure for postharvest management paired with less than half of the available land (roughly 1,800 acres) could provide two-thirds of fresh vegetables consumed and 40% of fresh nontropical fruit consumed at low productivity levels, or the same percentages of recommended consumption levels at high productivity levels. Significant investments in the construction of hoop houses and larger quantities of land could supply even greater proportions.

In addition to only cataloging publicly owned, nonrecreational land, this analysis includes a number of assumptions (previously stated) that overestimate the amount of land required to produce a given amount of food: namely, that only one crop would be grown on a given square foot of land; that hoop houses would be used only for crops for which there is a reliable early- or late-season retail market; and that hoop houses require additional acreage rather than increasing the productivity of existing acreage. For example, salad greens in hoop houses could likely produce several additional crops beyond the very early and very late season crops, thus greatly increasing the space efficiency. On the other hand, assuming that all fruit and vegetable crops are consumed at the same level throughout the year underestimates the amount of land necessary to supply current consumption. Furthermore, because we only considered fresh fruit and vegetable consumption, if *all* fruit and vegetable consumption were included, the land base required would approximately double. Finally, the significant increase in land necessary under commercial yields indicates that the biointensive yields may be overly optimistic for a large percentage of the production.

In the end, meeting a substantial portion of current Detroit fruit and vegetable consumption seems feasible given the amount of vacant land we have catalogued and the assumptions we have made, even if yields on par with the commercial level of productivity are assumed. Supplying the recommended levels of fruits and vegetables may not be feasible unless yield levels akin to high-productivity biointensive production are achieved.

Yet feasibility goes beyond the quantity of land present and includes the extent to which vacant land can be effectively utilized. In this regard, the challenges are not insignificant. If the city takes seriously the possibility of scaling up urban food production, more accurate mapping of the vacant parcels will be needed. A way to communicate this information and make parcels accessible to those interested in farming will also be critical. Competing interests among both UA models and alternative land uses, however, have already arisen and will likely continue. At the neighborhood scale, citizens should be engaged to help determine how vacant land is repurposed. At the broader scale, the full diversity of citizens and stakeholder groups should be engaged in comprehensively planning for UA in Detroit within the context of broadly rethinking future land-use patterns.

Inventories of these parcels that assess the soil quality and other physical conditions of the property will be crucial as well. Most if not all organized groups currently cultivating food crops on Detroit land test soil for lead content prior to breaking ground. However, increasing the scale of UA may push cultivation toward more marginal property with higher risk of contamination. Furthermore, even if all cultivation does occur on soil tested as safe, to sell the produce effectively it will be necessary to assure customers of safety of the soil in which it was grown. And again, simply growing greater quantities of fruits and vegetables does not guarantee residents will consume additional quantities. As the scale of urban cultivation increases, marketing in ways that include consumer education while building demand will be necessary.

Through the course of this research we sought to develop a method that would generate reasonable estimates of the acreage needed to supply as much of the fruits and vegetables consumed locally as possible given seasonality constraints. The most significant limitation of this analysis is that our catalog of vacant properties hinges on the accuracy and continual maintenance of an enormous database of city parcels that is constantly changing. We can only hope that this research presents a reasonable picture of the scale and distribution of publicly owned vacant properties. Our cross-reference with aerial imagery does at least affirm vacancy. The second major limitation is that the yield data we have relied upon, first, are not specific to the Detroit area and, secondly, assume either biointensive growing methods or commercial growing methods, which may not reflect local production practices. Nonetheless, in presenting a range of production levels we hope to illuminate the relationship between land area devoted to urban production and food supply.

While the data sources for resident population, fruit and vegetable consumption, and yields are particular to the United States and those for seasonal availability are particular to Michigan, the basic analytical process should be applicable in other locales, assuming the availability of comparable data sources. We argue that this basic food supply analysis, regardless of the extent of vacant property, would be useful to any city attempting to systematically plan for urban agriculture in the context of resident food security or agrifood market opportunities. Inventorying the quantity of vacant land within a municipality requires an existing database or extensive mapping and surveying. In a general sense, given that Detroit falls near the 42nd parallel, we can presume that in many parts of America and the globe it would be feasible to supply locally even more substantial portions of the fruits and vegetables consumed.

Conclusion

This research indicates that urban farms and gardens can contribute significantly to the supply of fresh fruits and vegetables in cities like Detroit with large amounts of vacant land. If residential yards and spaces around other buildings, as well as nontraditional cultivation sites like rooftops and balconies, were considered, this level of production may well be achievable in other urban areas as well. In any case, this research sets out a method that any locality could use to estimate how much of its fruits and vegetables could be grown within its boundary.

On a conceptual level there remains a need to critically consider not only how scaling up UA could integrate into the urban landscape, but also how expanded scales of UA in a city core would affect suburban and rural development, potentially on prime farmland. Expanding urban food production will transform the design of everything from buildings to neighborhoods to cities themselves. On the leading edge of this new research frontier, Mullinix et al. (2008, p. 4) coined the term "agricultural urbanism" to describe "a comprehensive social, environmental and economic integration of an agrifood system, in all of its dimensions and manifestations, within the planning, governance and function of the city" and a handful of scholars have begun to explore the shape of such integration (see for example Barr et al., 2008; Gorgolewski, Komisar, & Nasr, 2009; Viljoen, 2005). In Detroit, given the low population density relative to other major cities and the high concentration of vacancy in particular areas of the city, along with interviews and focus groups with Detroit residents that suggest many people are supportive of expanding food production in the city but not entirely comfortable abandoning the traditional cityscape (Colasanti, Litjens, & Hamm, 2010), it may be most feasible to move toward developing distinct agrifood districts as a way to expand urban agriculture to the farm scale.

The research presented here suggests many possible avenues for future inquiry in relation to increasing a municipal commitment to supporting urban food production. How will farm and garden spaces integrate into the cityscape? How can planners and local officials support UA and also maintain distinctly urban settings? What tools are available for the remediation of soils contaminated to varying degrees? If urban production is increased, how will the food be marketed and distributed? What would tenure on these land parcels looks like? How could scaling up also catalyze local resident ownership? How can urban agriculture further sustainable urbanization? As researchers continue to investigate the social and ecological services of urban agriculture, and as metropolises are increasingly faced with concerns of sustainability and food security, we predict that in many urban centers these questions will rise to the fore.

For practitioners, this research provides a context for gauging the significance of scaling and helps guide considerations of expanding urban agriculture as a means of food provisioning by clarifying the relationship between land base and fruit and vegetable supply related to average consumption. The increasing interest in urban agriculture and the possibility that a major portion of a city's food supply could be produced within its own boundaries points to the need for practitioners to consider the nature of an urban agricultural infrastructure that could both enable such production to occur and facilitate the integration of cultivation with retailing and distribution activities.

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References

Alaimo, K., & Miles, R. (2007). The Detroit garden resource program collaborative research study report. Department of Food Science and Human Nutrition Michigan State University, East Lansing, MI. Contact: alaimo@msu.edu

Alaimo, K., Packnett, E., Miles, R. A., & Kruger, D. J. (2008). Fruit and vegetable intake among urban community gardeners. *Journal of Nutrition Education and Behavior, 40*(2), 94–101. doi:10.1016/j.jneb.2006.12.003

Altman, A. (2009, April 6). Road to renewal. *Time Magazine,* 40–45.

Barr, J., Bolen, D., Boyd, K., Conroy, P., Dodwell, V., Dupuis, F. et al. (2008). Southlands: A vision for agricultural urbanism. Retrieved from http://www.box.net/shared/srol1caobn

Capital Growth. (2008). Mayor launches capital growth to boost locally grown food in London. Retrieved from http://www.capitalgrowth.org/press/press_releases

Chiesura, A. (2004). The role of urban parks for the sustainable city. *Landscape and Urban Planning, 68*(1), 129–138. doi:10.1016/j.landurbplan.2003.08.003

City of Detroit. (2008). GIS maps homepage. Retrieved from http://www.detroitmi.gov/DepartmentsandAgencies/InformationTechnologyServices/GISMaps.aspx

City of Vancouver. (2006). 2,010 garden plots by 2010. Retrieved from http://vancouver.ca/ctyclerk/cclerk/20060530/documents/motionb2.pdf

Colasanti, K., Litjens, C., & Hamm, M. (2010). Growing food in the city: The production potential of Detroit's vacant land. C.S. Mott Group for Sustainable Food Systems at Michigan State University. Available at http://www.mottgroup.msu.edu/uploads/files/59/Growing%20Food%20in%20the%20City%20-%20Colasanti%20Litjens%20Hamm.pdf

Connelly, P., & Ross, C. (2007). Farming the concrete jungle. *In These Times, 31*(9), 20–24.

Conner, D. S., Knudson, W. A., Hamm, M. W., & Peterson, H. C. (2008). The food system as an economic driver: Strategies and applications for Michigan. *Journal of Hunger and Environmental Nutrition, 3*(4), 371–383. doi:10.1080/19320240802528849

Deelstra, T., & Girardet, H. (2000). Urban agriculture and sustainable cities. In N. D. Bakker, M.; Guendel, S.; Sabel-Koschella, U.; deZeeuw, H. (Ed.), *Growing cities, growing food: Urban agriculture on the policy agenda* (pp. 43–65). Feldafing, Germany: German Foundation for International Development.

Desjardins, E., MacRae, R., & Schumilas, T. (2010). Linking future population food requirements for health with local production in Waterloo region, Canada. *Agriculture and Human Values, 27*(2), 129–140. doi:10.1007/s10460-009-9204-y

Dewar, M. (2006). Selling tax-reverted land. *Journal of the American Planning Association, 72*(2), 167–180. doi:10.1080/01944360608976737

Ferris, J., Norman, C., & Sempik, J. (2001). People, land and sustainability: Community gardens and the social dimension of sustainable development. *Social Policy & Administration, 35*(5), 559–568. doi:10.1111/1467-9515.t01-1-00253

Fussman, C. (2008). Health indicators and risk estimates by community health assessment regions & local health departments; Michigan Behavioral Risk Factor Survey 2005–2007 combined. Retrieved from http://www.michigan.gov/documents/mdch/2005-2007_MiBRFS_RegLHD_Tables_9_17_08_249915_7.pdf

Gallagher, J. (2008, December 15). Acres of barren blocks offer chance to reinvent Detroit. Detroit Free Press. Retrieved from http://www.cityfarmer.info/acres-of-barren-blocks-offer-chance-to-reinvent-detroit

Gallagher, M. (2007). Examining the impact of food deserts on public health in Detroit. Chicago, IL: Mari Gallagher Research & Consulting Group.

Garnett, T. (1999). *City harvest: The feasibility of growing more food in London.* London: Sustain.

Giombolini, K., Chambers, K., Schlegel, S., & Dunne, J. (in press). Testing the local reality: does the Willamette Valley growing region produce enough to meet the needs of the local population? A comparison of agriculture production and recommended dietary requirements. *Agriculture and Human Values.* Advance online publication.

Gopakumar, G., & Hess, D. (2005). Case study of community gardens, Detroit, MI. Retrieved from http://www.davidjhess.org/DetroitCG.pdf

Gorgolewski, M., Komisar, J., & Nasr, J. (2009). Carrot city: Designing for urban agriculture (Exhibition). Toronto, Ontario: Exhibition at Design Exchange in partnership with Ryerson University.

Gray, K. (2007, December 24). Urban farmers take root: Foreclosed lots are being turned into vegetable plots. *Detroit Free Press.* Retrieved from http://www.freep.com

Hair, M. (2008, August 1). Cash for carrots: Detroit youngsters are earning money and learning to grow fruits and vegetables at the city's community gardens. *Detroit Free Press.* Retrieved from http://www.freep.com

Holland, L. (2004). Diversity and connections in community gardens: A contribution to local sustainability. *Local Environment, 9*(3), 285–305. doi:10.1080/1354983042000219388

Howe, J., Bohn, K., & Viljoen, A. (2005). Food in Time: The history of English open urban space as a European example. In A. Viljoen (Ed.), *Continuous Productive Urban Landscapes: Designing Urban Agriculture for Sustainable Cities* (pp. 95–107). Amsterdam: Architectural Press.

Howe, J., & Wheeler, P. (1999). Urban food growing: The experience of two UK cities. *Sustainable Development, 7*(1), 13–24. doi:10.1002/(SICI)1099-1719(199902)7:1%3C13::AIDSD100%3E3.0.CO;2-B

Irvine, S., Johnson, L., & Peters, K. (1999). Community gardens and sustainable land use planning: A case-study of the Alex Wilson community garden. *Local Environment, 4*(1), 33–46. doi:10.1080/13549839908725579

Jeavons, J. (1995). *How to grow more vegetables: Fruits, nuts, berries, grains and other crops* (5th ed.). Berkeley, CA: Ten Speed Press.

Kantor, L. S. (1998). A dietary assessment of the U.S. food supply: Comparing per capita food consumption with food guide pyramid serving recommendations (No. 772 Agricultural Economic Report). Washington, DC: Food and Rural Economics Division, Economic Research Service, USDA.

Kuo, F. E., & Sullivan, W. C. (2001). Environment and crime in the inner city: Does vegetation reduce crime? *Environment and Behavior, 33*(3), 343–367.

Lachance, J. D. (2004). Supporting urban agriculture: A proposed supplement to the city of Detroit master plan of policies. Unpublished Master of Urban Planning Thesis, University of Michigan, Ann Arbor, MI.

Larson, N. I., Story, M. T., & Nelson, M. C. (2009). Neighborhood environments: Disparities in access to healthy foods in the U.S. *American Journal of Preventive Medicine, 36*(1), 74–81. doi:10.1016/j.amepre.2008.09.025

McGuire, V. C. (2007, September 2). Replacing neglect with peach trees. *The New York Times.* Retrieved from http://www.nytimes.com/2007/09/02/realestate/02nati.html?scp=3&sq=philadelphia%20urban%20garden&st=cse

McKee, M., & Ortolani, A. (2008, December 8). GM's bust turns Detroit into urban prairie of vacant-lot farms. *Bloomberg News.* Retrieved from http://www.bloomberg.com/apps/news?pid=20601109&sid=aMV8_J49diKs&refer=home

McMillan, T. (2008, May 7). Urban farmers' crops go from vacant lot to market. *The New York Times.* Retrieved from http://www.nytimes.com/2008/05/07/dining/07urban.html?_r=1&scp=2&sq=urban%20farmers&st=cse

Mendes, W., Balmer, K., Kaethler, T. M., & Rhoads, A. (2008). Using land inventories to plan for urban agriculture experiences from Portland and Vancouver. *Journal of the American Planning Association, 74*(4), 435–449. doi:10.1080/01944360802354923

Michigan Geographic Data Library. (n.d.). Center for geographic information, Michigan Department of Information Technology. Retrieved from http://www.michigan.gov/cgi

Michigan State University Extension. (2004). Michigan availability guide. Retrieved from http://www.projectfresh.msu.edu/Portals/Projectfresh/MI_Availability_Guide.pdf

Morris, V., & Tapp, C. (2008). Urban agriculture design guidelines for the private realm. Vancouver, Canada: City of Vancouver Policy Report P2.

Mougeot, L. J. A. (1993). Overview—urban food self-reliance: Significance and prospects. International Development Research Centre Reports, 21(3).

Mougeot, L. J. A. (Ed.). (2005). *Agropolis: The social, political and environmental dimensions of urban agriculture.* Ottawa, ON: International Development Research Centre.

Mullinix, K., Henderson, D., Holland, M., de la Salle, J., Porter, E., & Fleming, P. (2008, September 18). Agricultural urbanism and municipal supported agriculture: A new food system path for sustainable cities. Paper presented at the Surrey Regional Economic Summit, Surrey, British Columbia.

National Agricultural Statistics Service Michigan Field Office. (2006). Michigan agricultural statistics 2005–2006. Retrieved from http://www.nass.usda.gov/Statistics_by_State/Michigan/Publications/Annual_Statistical_Bulletin/stats06/agstat06all.pdf

Peters, C. J., Bills, N., Wilkins, J., & Smith, R. D. (2002). Vegetable consumption, dietary guidelines and agricultural production in New York State — Implications for local food economies. Ithaca, NY: Cornell University.

Peters, C. J., Bills, N., Wilkins, J., & Smith, R. D. (2003). Fruit consumption, dietary guidelines, and agricultural production in New York State — Implications for local food economies. Ithaca, NY: Cornell University.

Pollan, M. (2008). *In defense of food: An eater's manifesto.* New York, NY: Penguin Group.

Pothukuchi, K. (2003). *The Detroit food system: A handbook for community planners.* Detroit: Wayne State University.

Pothukuchi, K., & Wallace, R. (2009). Sustainable food systems: Perspectives on transportation policy. In S. Malekafzali (Ed.), *Healthy, Equitable Transportation Policy: Recommendations and Research* (pp. 113–129). Oakland, CA: PolicyLink; Prevention Institute; Convergence Partnership.

Pottharst, K. (1995). Urban dwellers and vacant lots: Partners in pride. *Parks & Recreation, 30*(9), 94.

President of the Philippines Executive Order No. 776. (2009). Rolling out the backyard food production programs in the urban areas. Retrieved from http://www.lawphil.net/executive/execord/eo2009/eo_776_2009.html

Rees, W. E. (1997). Why urban agriculture? Notes for the IDRC Development Forum on Cities Feeding People: A growth industry. Retrieved from http://www.cityfarmer.org/rees.html#rees

Riley, R. (2008, December 25). Detroit must tear down to build up. *Detroit Free Press.* Retrieved from http://www.freep.com

Roberts, W. (2008, November 26). Looking beyond the auto. NOW Toronto. Retrieved from http://www.nowtoronto.com/news/story.cfm?content=166191

Rosol, M. (2005). Community gardens — A potential for stagnating and shrinking cities? Examples from Berlin. *Die Erde, 136*(2), 165–178.

Schilling, J., & Logan, J. (2008). Greening the Rust Belt: A green infrastructure model for right sizing America's shrinking cities. *Journal of the American Planning Association, 74*(4), 451–466. doi:10.1080/01944360802354956

Smit, J., & Nasr, J. (1992). Urban agriculture for sustainable cities: Using wastes and idle land and water bodies as resources. *Environment and Urbanization, 4*(2), 141–152. doi:10.1177/095624789200400214

Stohr, K. (2003). In the capital of the car, nature stakes a claim. *The New York Times.* Retrieved from http://query.nytimes.com/gst/fullpage.html?res=9405E6DA163DF937A35751C1A9659C8B63&sec=&spon=&pagewanted=1

Taylor, A. F., Wiley, A., Kuo, F. E., & Sullivan, W. C. (1998). Growing up in the inner city — Green spaces as places to grow. *Environment and Behavior, 30*(1), 3–27. doi:10.1177/0013916598301001

Treuhaft, S., Hamm, M. W., & Litjens, C. (2009, August). Healthy food for all: Building equitable and sustainable food systems in Detroit and Oakland. Oakland, CA, Ann Arbor, MI and East Lansing, MI: PolicyLink, Fair Food Network, and the C.S. Mott Network.

Tzoulas, K., Korpela, K., Venn, S., Yli-Pelkonen, V., Kazmierczak, A., Niemela, J. et al. (2007). Promoting ecosystem and human health in urban areas using green infrastructure: A literature review. *Landscape and Urban Planning, 81*(3), 167–178. doi:10.1016/j.landurbplan.2007.02.001

U.S. Census Bureau American Fact Finder. (2006). 2006 American Community Survey; Detroit city, Michigan; age and sex. Retrieved from http://factfinder.census.gov/servlet/ADPTable?_bm=y&-geo_id=16000US2622000&-qr_name=ACS_2008_3YR_G00_DP3YR5&-ds_name=ACS_2008_3YR_G00_&-_lang=en&-_sse=on

U.S. Department of Agriculture Center for Nutrition Policy and Promotion. (2005). My pyramid food intake patterns. Retrieved from http://www.mypyramid.gov/downloads/MyPyramid_Food_Intake_Patterns.pdf

U.S. Department of Agriculture Economic Research Service. (2003). Fruit and tree nut yearbook data archive. Retrieved from http://usda.mannlib.cornell.edu/MannUsda/viewStaticPage.do?url=http://usda.mannlib.cornell.edu/usda/ers/./89022/2004/index.html

U.S. Department of Agriculture Economic Research Service. (2008). Loss-adjusted food availability. Retrieved from http://www.ers.usda.gov/Data/FoodConsumption/FoodGuideIndex.htm

U.S. Department of Agriculture Food and Nutrition Service. (2008). Food buying guide for child nutrition programs. Retrieved from http://www.fns.usda.gov/TN/Resources/foodbuyingguide.html

U.S. Department of Health and Human Services and U.S. Department of Agriculture. (January 2005). Dietary guidelines for Americans, 2005. Washington, DC: U.S. Government Printing Office.

Viljoen, A. (Ed.). (2005). *Continuous productive urban landscapes: Designing urban agriculture for sustainable cities.* Amsterdam: Architectural Press.

Wells, M. (2008, July 10). Urban farming takes root in Detroit. *BBC News.* Retrieved from http://news.bbc.co.uk/go/pr/fr/-/1/hi/world/americas/7495717.stm

Zandstra, B., & Price, H. (1988). *Yields of Michigan vegetable crops.* East Lansing, MI: Michigan State University.

Zenk, S. N., Schulz, A. J., Hollis-Neely, T., Campbell, R. T., Holmes, N., Watkins, G. et al. (2005). Fruit and vegetable intake in African Americans — Income and store characteristics. *American Journal of Preventive Medicine, 29*(1), 1–9. doi:10.1016/j.amepre.2005.03.002

Zenk, S. N., Schulz, A. J., Israel, B. A., James, S. A., Bao, S. M., & Wilson, M. L. (2005). Neighborhood racial composition, neighborhood poverty, and the spatial accessibility of supermarkets in metropolitan Detroit. *American Journal of Public Health, 95*(4), 660–667. doi:10.2105/AJPH.2004.042150

Zenk, S. N., Schulz, A. J., Israel, B. A., James, S. A., Bao, S. M., & Wilson, M. L. (2006). Fruit and vegetable access differs by community racial composition and socioeconomic position in Detroit, Michigan. *Ethnicity & Disease, 16*(1), 275–280.

Appendix A

Sample calculations used to determine total acreage needed to meet current consumption and percent of annual consumption supplied using tomatoes.

Part 1: Calculating total pounds that could be grown locally by crop

Total servings eaten fresh per year	x Servings per pound	= Total pounds eaten	x % year available	= Pounds that could be grown locally	= Total pounds that could be grown locally
21,343,052 servings of tomatoes	4.5 servings/lb.	4,742,900 lbs.	20.8% field fresh	987,800 lbs.	1,975,600 lbs.
			0% storage	0 lbs.	
			20.8% season extension	987,800 lbs.	

Part 2: Calculating acres needed by crop

Total pounds that could be grown locally	x (1 + % cooking loss) x (1 + % retail loss) x (1 + % inedible share loss) x (1 + % farmgate-to-consumer loss)	= Total pounds that would need to be grown	x Yield rates	= Acres needed by crop
1,975,600 lbs.	0% cooking loss; 2% retail loss; 9% inedible share loss; 15% farmgate-to-consumer loss	2,015,112 lbs.	418 lbs./100 sq. ft. High-productivity biointensive	13.87 acres
			100 lbs./100 sq. ft. Low-productivity biointensive	57.99 acres
			22,000 lbs./acre Commercial	114.82 acres

Part 3: Aggregating acreage needed

Sum of all acres needed by crop = Acreage needed

Part 4: Aggregating percent of annual consumption supplied

$$\frac{\text{Sum of total pounds that could be grown locally for all vegetable crops}}{\text{Total pounds vegetables eaten}} = \text{\% annual consumption supplied for vegetables}$$