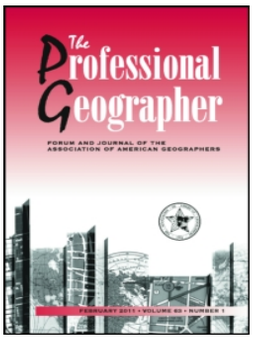

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Strategically Siting Urban Agriculture: A Socioeconomic Analysis of Roanoke, Virginia

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Food insecurity is a major concern in the United States, particularly in high-poverty areas and among households with children. Urban agriculture helps address food insecurity and promote recreation, aesthetics, biodiversity, and other benefits. This article reports a socioeconomic evaluation of ten different variables, including in situ analysis of healthy, nutritious food options, of a small, intensely urbanized city to identify neighborhoods that would benefit from urban agriculture. We produced a hierarchy of locations (using census block groups), from least to greatest socioeconomic need, for new urban agriculture sites. Our results found that one block group qualified in all ten variables and two-thirds demonstrated a need in at least half of the variables. The majority of these block groups were distributed within the middle of the city. **Key Words: food security, GIS Roanoke, Virginia, urban agriculture.**

粮食不安全是美国的一项主要考量，特别是在高度贫穷的地区和养育小孩的家户中。城市农耕协助应对粮食不安全的问题，并提倡休閒、美学、生态多样性及其他益处。本文记述一个具有十个不同变项的社会经济评估， 包含对一个小型且密集城市化的城市中的健康、营养的粮食选项的就地分析，从而指认能够从城市农耕中获益的邻里。我们生产对新的城市农耕地而言，具有从最小到最大的社会经济需求的区位阶层关係 (运用人口统计的街区群体)。我们的研究，发现一个完全符合十个变项的街区群体，而三分之二的街区群体显示出需要至少半数以上的变项。这些街区群体的大部份分佈于城市的中心。 **关键词：粮食安全，地理信息系统，罗阿诺克，维吉尼亚，城市农耕。**

La inseguridad alimentaria reviste gran preocupación para los Estados Unidos, particularmente en áreas de alta pobreza y en hogares con niños. La agricultura urbana ayuda a enfrentar la inseguridad alimentaria a la vez que promueve la recreación, la estética, y la biodiversidad, entre otros beneficios. Este artículo informa sobre una evaluación socioeconómica de diez variables diferentes, incluyendo el análisis *in situ* de opciones alimentarias saludables y nutritivas en una ciudad pequeña, intensamente urbanizada, para identificar los vecindarios que se beneficiarían de la agricultura urbana. Diseñamos una jerarquía de localizaciones (usando grupos de manzanas censales), desde la mínima hasta la más grande necesidad socioeconómica, para nuevos sitios de agricultura urbana. Nuestros resultados hallaron que un grupo de manzanas calificaban en todas las diez variables y dos tercios demostraron una necesidad en por lo menos la mitad de las variables. La mayoría de estos grupos de manzanas estaban distribuidos en la mitad de la ciudad. **Palabras clave: seguridad alimentaria, SIG, Roanoke, Virginia, agricultura urbana.**

In the United States, more than 81 percent of the population live in urban areas (United Nations 2014). Within urban areas, internal variations in built environment, greenways, and socioeconomic settings create disparities in quality of life, health, and well-being for residents (Eisenhauer 2001; Frank, Andresen, and Schmid 2004; Feng et al. 2010). These disparities often appear to be related to differing socioeconomic status (L. V. Moore and Diez Roux 2006; Seaman, Jones, and Ellaway 2010). Impacts from such disparities include uneven access to affordable food and housing, transportation, employment, and locales for social interaction and physical activity (Freedman and Bell 2009; Richardson et al. 2012).

Urban agriculture has recently received wide attention because it offers a spectrum of benefits to urban populations, including opportunities to promote recreation, aesthetics, biodiversity, and other factors. Most researchers agree that a land inventory is the first step in siting urban agriculture (Dongus and Drescher 2006; Dubbeling, van Veenhuizen, and de Zeeuw 2010). Urban agriculture land inventories—the foundation for planning urban agriculture—largely focus on availability and physical evaluation of vacant or underutilized lands as potential urban agriculture sites (e.g., Balmer et al. 2005; Colasanti and Hamm 2010; Meenar and Hoover 2012; McClintock, Cooper, and Khandeshi 2013). Investigators conduct land inventories for a variety of reasons, including research projects (Colasanti and Hamm 2010; Meenar and Hoover 2012), at the request of municipalities (Balmer et al. 2005) or local food and nonprofit organizations (McClintock, Cooper, and Khandeshi 2013), but all are accomplished to support siting new urban agriculture. Furthermore, implementing urban agriculture on vacant or underutilized lands allows for the productive use of otherwise nonproductive spaces.

Although an urban agriculture land inventory provides a groundwork for sustainability efforts of an urban area as a whole, identification of underutilized lands does not necessarily address socioeconomic inequalities faced by lower income residents. An important priority should be identifying those neighborhoods with socioeconomic characteristics that would best benefit from urban agriculture, scaffolded with a land inventory, which has been largely ignored.

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To date, only one land inventory could be identified that included data on low-income neighborhoods within the land inventory analysis (e.g., Meenar and Hoover 2012).

The goal of this study is to evaluate socioeconomic factors, including landscape variables related to these factors, to identify neighborhoods that could benefit from urban agriculture's contributions to improving socioeconomic qualities. The study was conducted within the small, yet completely urbanized and densely populated City of Roanoke, Virginia. The first step was to identify socioeconomic variables important for our analysis. Then, from empirical studies, we outline how urban agriculture can help address disparities in lower income neighborhoods. Next, we outline why our study site is appropriate for such an urban agricultural analysis. We identify data applicable to Roanoke and outline our analytical methods. Finally, we review our results—a hierarchy of locations (identified spatially as census block groups) for strategically siting urban agriculture to help alleviate factors adversely affecting health and well-being of low-income urban residents.

Urban Socioeconomic Disparities

Within an urban landscape, the physical distribution of vegetation (i.e., parks, urban forest, and other greenspaces) and the built environment (buildings, roads, and other related infrastructure) varies. Such physical variations are frequently related to socioeconomic factors (e.g., income, assets, education, etc.) because, in most cases, money drives how and where these physical aspects are developed (Wolch, Wilson, and Fehrenbach 2005; Ernstson 2013; Anguelovski 2015). As such, those populations with the greatest need for jobs and for affordable housing, food, transportation, and recreational facilities are those often excluded from the decision-making process (Ernstson 2013; Cohen and Reynolds 2014). These socioeconomic factors even appear to drive construction, maintenance, and enhancement of greenspaces (Wolch, Wilson, and Fehrenbach 2005; Ernstson 2013; Francis and Chadwick 2013).

Urban disparities are highlighted when we examine access to affordable and nutritious food—that is, food security (L. V. Moore and Diez Roux 2006; U.S. Department of Agriculture [USDA] 2009). The USDA defines food security as access to sufficient quantities of healthy and nutritious foods for an active and healthy life (Coleman-Jensen, Gregory, and Singh 2014). Food insecurity is prevalent in the United States. In 2014, 14.3 percent of U.S. households (45.6 million people) were found to be food insecure sometime during the previous twelve months (USDA 2015); this rate increases to one in five when only examining households with children. Food insecurity rates vary across the country and across socioeconomic and demographic characteristics (Coleman-Jensen, Gregory, and Singh 2014; USDA 2015). Higher rates are found in major urban areas (16.7 percent), female single-headed households (34.4 percent), and households with incomes less than the federal poverty level (42.1 percent; Coleman-Jensen, Gregory, and Singh 2014).

In lower income households, a greater portion of income is spent on food and housing and, to afford adequate food, it is necessary to buy less nutritious food (USDA 2009; Walker, Keane, and Burke 2010). Although income constitutes a major factor in food choices (Rose 1999; Hofferth and Curtin 2005), access to healthy and nutritious foods could be complicated by factors such as vehicle ownership, availability of public transportation, local crime rates, and locations of supermarkets or commercial food establishments offering healthy choices (Eisenhauer 2001; Rose and Richards 2004; L. V. Moore and Diez Roux 2006; Galvez et al. 2008; Bader et al. 2010).

Locations without such availability (e.g., establishments offering healthy choices) are considered food deserts—defined as areas where people have limited access to affordable fresh fruits and vegetables and other healthy foods (Bader et al. 2010). Access is more than just the presence of retail food outlets (or lack thereof), however (Caspi et al. 2012); it also encompasses accommodation—for example, operating hours (Caspi et al. 2012; Chen and Clark 2016); availability, or the presence of sufficient quantities of healthy food for all residents (Bader et al. 2010; Caspi et al. 2012); and acceptability, or people's attitudes about the food that is available (Freedman and Bell 2009; Caspi et al. 2012). In recent years, a prolific research effort has investigated specifics of designating exact locations of food deserts and defining what constitutes a true food desert (e.g., Sage, McCracken, and Sage 2013; Cho and Rodriquez 2015; Thibodeaux 2015; Chen and Clark 2016) and ways to overcome lack of supermarket access (by either providing farmers' markets or identifying locations for new retail outlets that offer nutritious alternatives; e.g., Wang, Qiu, and Swallow 2014; Anderson and Burau 2015; Lu and Qiu 2015).

Strong evidence exists that lack of local access to foods can indicate overall dietary quality and food insecurity (L. V. Moore and Diez Roux 2006; Bader et al. 2010). Lack of food security has repercussions beyond insufficient diets (Robert and Reither 2004; Riva et al. 2009; Coleman-Jensen, Gregory, and Singh 2014), including health issues such as higher rates of obesity (Robert and Reither 2004; Riva et al. 2009). For example, full-service restaurants, grocery stores, and direct marketing of local foods are associated, on a per capita basis, with lower rates of obesity, whereas quick-service restaurants and convenience stores are associated with higher obesity rates (Ahern, Brown, and Dukas 2011). Presently, obesity is considered a national epidemic (Wyatt, Winters, and Dubbert 2006), as more than one third of U.S. adults (35.7 percent) are considered obese (Ogden et al. 2012).

Furthermore, many studies have also tied other health issues in urban areas to a lack of greenspaces (De Vries et al. 2003; Mitchell and Popham 2007;

Maas et al. 2009). Urban populations experience greater exposure to heat-related illnesses, deaths, and infectious disease because of the urban heat island effect (Patz et al. 2005), a phenomenon that causes urban areas to be warmer than surrounding rural areas because of reduced vegetative cover and higher amounts of impervious surfaces. Furthermore, lack of vegetation is associated with higher levels of air pollution, which can also increase susceptibility to asthma and other respiratory illnesses, especially for children (Gern 2010; Malik, Kumar, and Frieri 2012). Some studies have further tied higher health risks in lower income neighborhoods to limited greenspace in these neighborhoods (Mitchell and Popham 2008; Seaman, Jones, and Ellaway 2010; Marcus 2012). These effects can be further exacerbated among lower income populations, who can ill afford increased energy costs for air conditioning or have limited access to medical care (Malik, Kumar, and Frieri 2012).

In addition to providing areas for physical activity, urban greenspaces provide both emotional and psychological benefits (Kaplan 2001; van den Berg, Hartig, and Staats 2007) by reducing stress, depression, and anxiety (Mitchell and Popham 2007, 2008; Kuo 2010). People report better health, physically and mentally, when they live in greener environments (Kaplan 2001; Mitchell and Popham 2007, 2008; Maas et al. 2009). Greenspaces also constitute a social resource where people can meet and interact, in addition to participating in physical activity (Kuo 2003; Secco and Zulian 2008; van Leeuwen, Nijkamp, and de Noronha Vaz 2010). Furthermore, decreases in attention deficit disorder, hyperactivity disorder, and propensity to crime have been reported in children after increased exposure to greenspaces (Louv 2005; Kuo 2010; Marcus 2012).

Socioeconomic Benefits of Urban Agriculture

A greenspace is defined as "land that is partly or completely covered with grass, trees, shrubs, or other vegetation" (U.S. Environmental Protection Agency [EPA] 2015). Within an urban area, a greenspace "functions as productive green areas that are able to deliver useful products (wood, fruits, compost, energy, etc.) as a result of urban green maintenance or construction" (van Leeuwen, Nijkamp, and de Noronha Vaz 2010, 20). Urban agriculture is "the growing, processing, and distribution of food and nonfood plant and tree crops and raising of livestock, directly for the urban market, both within and on the fringe of an urban area" (Mougeot 2006, 4). Urban agriculture forms a productive greenspace that encompasses a broad range of scales, from small containers on windowsills and patios, to a commercial urban farm, as large as several hectares, and can be owned and operated by private citizens, business, nongovernmental organizations, or municipalities (Pearson, Pearson, and Pearson 2010).

Research on urban agriculture and its benefits is quite extensive. Urban agriculture provides a wide range of socioeconomic benefits (as reported by a selection of studies found in Table 1). These studies document (either quantitatively or qualitatively) urban agriculture's contribution to food security (e.g., increasing access and consumption of fresh fruits and vegetables,

Table 1 *Benefits of urban agriculture*

Benefits	Author (Year)
Increased access to and consumption of fresh fruits and vegetables	Maxwell, Levin, and Csete (1998); Alaimo et al. (2008); Bleasdale, Crouch, and Harlan (2011); Corrigan (2011); Ottman et al. (2012); White (2014)
Supplementing food supplies	Reynolds (2009); Wills, Chinemana, and Rudolph (2010); Abdulkadir et al. (2012); Ottman et al. (2012); Pourias, Duchemin, and Aubry (2015); Taylor and Lovell (2015)
Reducing food expenses and generating income	Faruqui (2002); Reynolds (2009); Abdulkadir et al. (2012); McCabe (2014); Taylor and Lovell (2015)
More thorough knowledge about healthy food choices	Hatchett et al. (2015)
Knowledge about food systems	Faruqui (2002); Travaline and Hunold (2010); Hatchett et al. (2015)
Health benefits from outdoor exercise	Bleasdale, Crouch, and Harlan (2011); Hale et al. (2011); Ottman et al. (2012); S. A. Moore et al. (2015)
Stress relief	Bleasdale, Crouch, and Harlan (2011); Hale et al. (2011); Ottman et al. (2012)
Community revitalization	Reynolds (2009); Ottman et al. (2012); McCabe (2014)
Crime prevention	Ottman et al. (2012); McCabe (2014)
Increased property values	Voicu and Been (2008); McCabe (2014)
Cultural preservation	Saldivar-Tanaka and Krasny (2004); Hale et al. (2011); Ottman et al. (2012); Li et al. (2013); Taylor and Lovell (2015)
Social interactions and cultivation of relationships	Travaline and Hunold (2010); Wills, Chinemana, and Rudolph (2010); Hale et al. (2011); Ottman et al. (2012); White (2014); Hatchett et al. (2015)
Building a sense of community	Saldivar-Tanaka and Krasny (2004); Travaline and Hunold (2010); Hale et al. (2011); Ottman et al. (2012); Hatchett et al. (2015); S. A. Moore et al. (2015)
Empowerment and social inclusion	Agustina and Beilin (2012); Ottman et al. (2012); White (2014)
Leadership development	Hatchett et al. (2015); S. A. Moore et al. (2015)
Sense of connection to place	Hale et al. (2011); Ottman et al. (2012); White (2014)

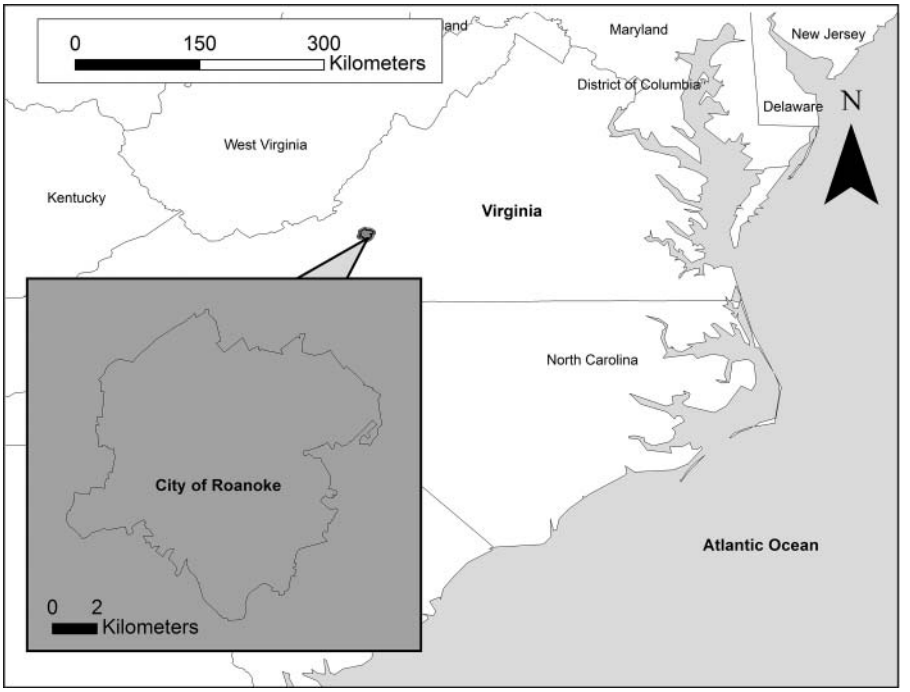

Figure 1 *City of Roanoke, Virginia, reference map.*

supplementing food supplies, and increasing knowledge about healthy food choices), health benefits (e.g., increased activity and stress relief), and community benefits (e.g., community building, social inclusion, and community revitalization), among others.

Study Site

The City of Roanoke is southwest Virginia's largest city (Figure 1), and its demographic characteristics provide the opportunity to explore relationships between socioeconomic variables and optimal locations for urban agriculture. Roanoke's poverty rate and food insecurity rates are higher than those of the surrounding county, state, and national averages (Table 2) and, according to the USDA (2014), residents of a majority of the lower income census tracts within the city live in a food desert (specifically, they live at least one mile from a grocery store). In addition, according to the Virginia Department of Health, Roanoke's rates for poor health conditions exceed state averages (Table 3; Virginia 2015b). A study completed by the University of Wisconsin (2015) ranked (for 2014) the City of Roanoke 127th out of 133 counties and cities in Virginia for poor health factors such as obesity, diabetes, and physical inactivity. Within Roanoke, socioeconomic characteristics vary from neighborhood to neighborhood. Across census block groups, the household poverty rates range from 0 to almost 53 percent, rates of female single-headed households range from 0 to over 67 percent, and unemployment rates range from 0 to almost 29 percent (U.S. Census 2015b). For each public school, rates of student eligibility for a free or reduced-price school lunch program, under the USDA National School Lunch Program, range from 18 percent to almost 98 percent (Virginia 2015a). Roanoke has sixty-two city parks (642.5 ha) and some land associated with National Parks (96.7 ha), but the majority of these greenspaces (72 percent) are highly concentrated around the river (chief site of the railroad) or in the southeastern portion of the city.

Urban agriculture is practiced within the city (17.3 total hectares) in a variety of locations, sizes, and forms (home gardens, community gardens, and two urban farms; Figure 2). One urban farm (Lick Run—yellow

Table 2 *Comparison of City of Roanoke to the surrounding county, the state, and the country*

	City of Roanoke (%)	Roanoke County (%)	Virginia (%)	United States (%)
Households below federal poverty level (U.S. Census 2015a)	22.4	5.1	11.3	15.4
Food insecurity rates (Feeding America 2014)	16.9	8.3	9.6	14.3[a]
Eligibility for National School Lunch Program (Virginia 2015a)	67.9	25.0	39.7	42.9[b]

Note: In Virginia, counties and cities are independent entities.
[a]USDA (2015).
[b]USDA (2013).

Table 3 *Comparison of various health condition rates, City of Roanoke, Virginia*

Health condition	Rate in City of Roanoke	State average
Primary hypertension and renal disease	11.2%	7.6%
Chronic liver disease	24.0%	8.8%
Diabetes mellitus	28.7%	18.5%
Nephritis and nephrosis	27.6%	18.2%
Heart disease	222.1[a]	157.4[a]
Adult obesity[b]	36.0%[c]	27.2%

Note: Data are from Virginia (2015b).
[a]Per 100,000 people.
[b]Virginia (2015c).
[c]Rate was less than 30 percent in 2007.

polygon) is operated by a private citizen. The largest of the two urban farms (Heritage Point Farm—blue polygon, 7.1 ha), located in the northeastern part of the city in an industrial park, is operated by the Roanoke Natural Foods Co-op. The most common urban agriculture form—home gardens (red polygons)—are distributed throughout the city, with notable voids around the airport, the railway complex, the aforementioned industrial park, two very large city parks—Mill Mountain and Yellow Mountain—and in inner-city residential areas. Community gardens (green polygons) are sited in these inner-city residential areas lacking home gardens.

Data

For this analysis, we used geographic information systems (GIS), examining demographic and geospatial data acquired from publicly available sources and from our firsthand, on-site observations as described in the next section. Our spatial unit of analysis is the census block group, subdivisions of census tracts, and a common spatial unit for analyzing socioeconomic data in most areas of the world. Using block groups as the spatial unit for our analysis provides for finer scale examination, comparable with the scale in other studies of urban demographics. A shapefile for block group boundaries was downloaded from the TIGERLine® Web site (see https://www.census.gov/geo/maps-data/data/tiger-line.html).

Income, education, type of household, and employment status are indicators of socioeconomic status, at both fine (e.g., an individual or household) and broad scales (e.g., a city or country; Robert and Reither 2004). The U.S. Census Bureau computes poverty status for households, so instead of income level, we used household poverty status. We feel that household poverty status is a more appropriate income variable than income alone because poverty rate includes the number of household members in its calculation (U.S. Census 2015a). Poverty status records document total number of households within each block group and also

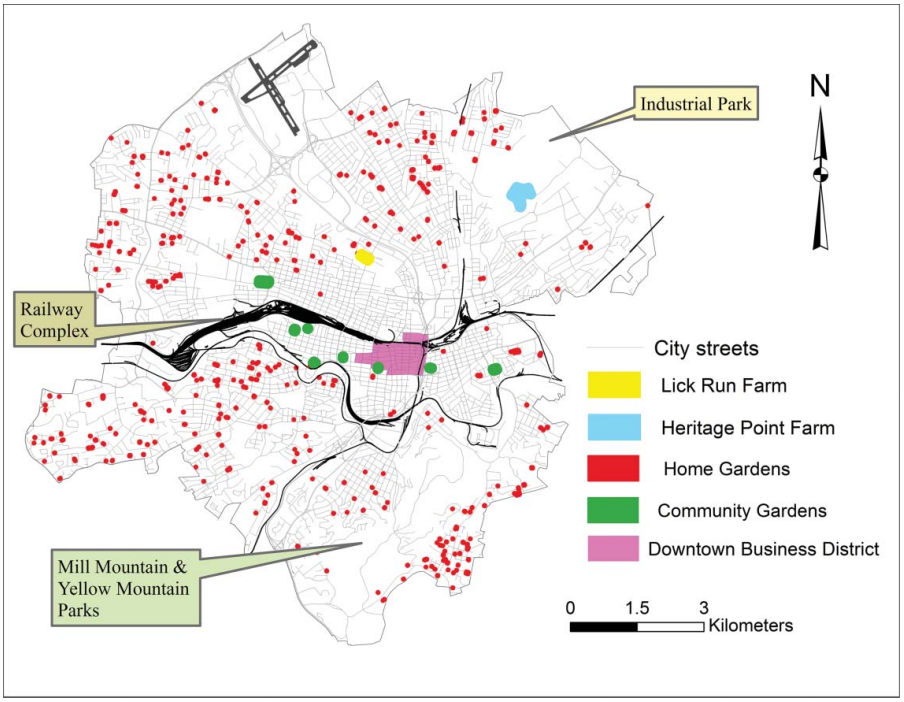

Figure 2 *Locations of existing urban agriculture within the City of Roanoke (polygons are enhanced for visual reference only and do not represent the size of the garden). Shapefile for urban agriculture sites was created by first author. (Color figure available online.)*

divides households into different types (e.g., couples, male-headed only, female-headed only) and notes the number of households within each group that are at or below the federal poverty level. Records of educational level (called *educational attainment* by the U.S. Census Bureau) contain data for total population (age twenty-five and older), along with subdivisions (male and female) and different levels of educational attainment (no high school diploma, high school diploma, bachelor's degree, etc.). Employment status records contain total population over sixteen years, total population in labor force over sixteen years, and total population over sixteen years not employed.

In addition to these data, we obtained population data, subdivided to represent male and female population by age group and by means of transportation to work. The last decadal census was completed in 2010, but the U.S. Census Bureau has updated their summary profiles for the five-year period from 2009 to 2013 (U.S. Census 2015c), which we used for this analysis. Data for all variables previously listed above were obtained from the American Fact Finder Web site as a spreadsheet file (see http://factfinder.census.gov/faces/nav/jsf/pages/index.xhtml).

Health condition information is not available at a scale finer than the city level, but the rate of student eligibility by school for the USDA's National School Lunch Program can represent a proxy for food insecurity and health conditions related to inadequate nutrition (The Brookings Institute, as cited by Smit, Nasr, and Ratta 2001; Houston et al. 2013). This report details the percentage of students within each school who qualify for a free or reduced-price school lunch. These data are available as a spreadsheet file, per school district and by individual school zone, from the Virginia Department of Education Web site (http://doe.virginia.gov/support/nutrition/statistics/index.shtml). The shapefile for school zones was downloaded from the City of Roanoke FTP Web site (ftp://ftp.roanokeva.gov/GIS/). Shapefiles for parks were downloaded from the Virginia Department of Conservation and Recreation (http://www.dcr.virginia.gov/natural_heritage/cldownload.shtml) and City of Roanoke FTP site. Community gardens and urban farms were identified and assessed through personal visits. Retail food outlet locations were defined and evaluated with information from the Internet (e.g., addresses of grocery stores, neighborhood convenience stores, fast food stores, etc.), from the city's parcel shapefile, and from our on-site observations (more details are found in the next section).

Methods

For each census block group ($n = 76$), within GIS, we joined all variables from the spreadsheets downloaded from American Fact Finder. Then for each block group, we calculated the following rates:

- Poverty rate (total households with income in the past twelve months below poverty level divided by total households).
- Rate of female single-headed households (total female single-headed households divided by total households).
- Unemployment rate (total unemployed divided by total population in the labor force).
- Percentage population age twenty-five or older with no high school diploma (total of all men and women, age twenty-five or older, with completed education less than high school diploma divided by total population age twenty-five or older).
- Percentage of women without a high school diploma (sum of all women with completed education less than high school divided by total population).
- Percentage population in the workforce using public transportation to and from work (population using public transportation divided by population in workforce).
- Percentage population under the age of eighteen years (sum of all male and female under eighteen years divided by total population).

Student eligibility rates by school for the National School Lunch Program were joined to the school zone shapefile (elementary schools, $n = 17$; middle schools, $n = 5$; and high schools, $n = 2$). We chose the elementary school zones because they are more numerous and student population numbers are less than middle school and high school zones (i.e., are at a finer scale). Elementary schools were selected and exported into a separate shapefile.

We intersected the parks, community gardens, and urban farms areas separately with the block group shapefile to determine whether any block groups lacked either or both of these greenspaces. We did not include home gardens in this analysis because the food produced might not be available for consumption outside the specific residence.

For our food evaluation, we first identified retail food locations from the Internet, creating three separate shapefiles: retail food stores (farmer's markets, grocery stores, and convenience stores), large food retailers (supermarkets, superstores), and restaurants (fast-food, sit-down, and delis). We either verified these locations from the city's parcels shapefile using GoogleEarth or geocodes the addresses.

We then visited retail food stores and restaurants to evaluate the type of food (and price) available for sale. Instead of a random sample, we chose a specific area of the city as advised by a city official that Roanoke's "food desert" existed along Melrose Avenue (Chris Chittum, Director, City of Roanoke Planning, Building and Development, personal communication 28

February 2013). We chose the center point of this area and created a half-mile (1.6 km) buffer to identify specific locations within which to evaluate local access to affordable and nutritious food.

Our first visit to this area was to verify the locations identified as noted previously. In subsequent visits over a twelve-month period, an observational checklist, adapted from the Nutrition Environment Measures Study in Restaurants (NEMS–R; Saelens et al. 2007) and Nutrition Environment Measures Surveys in Stores (NEMS–S; Glanz et al. 2007), was completed to record data on availability of foods and beverages within each location. The checklist included the following food groups, including brand name, size range, price range, and comments: fruit; vegetables; frozen desserts; sugar-sweetened beverages; water; alcohol; grains and baked goods; grain-based desserts; snacks; protein, meats, beans, and alternatives; and prepackaged foods. We noted on this checklist those foods available for sale and in what form (i.e., fresh, frozen, canned, etc.). The goal of the checklist was to assess availability of nutritious foods and beverages, based on the Dietary Guidelines for Americans (USDA 2010) and the U.S. food guidance system, including whole grains; fruits; vegetables; low-fat milk; lean meats, beans, and alternatives; and water; and nutrients of concern, such as saturated or solid fats, added sugars, and calories from alcohol. The assessment has been widely used to provide insight and illustrate the quality of food available and accessible to individuals within a targeted geographic area. It has also been shown to help predict dietary quality of community residents. Graduate nutrition students were recruited and trained as observers in direct observation; said training was conducted by the second author. The checklist was tested at restaurants and convenience stores within a different neighborhood and modified accordingly. We then compared our results to the main food groups of the U.S. food guidance system (USDA 2010), identifying stores and restaurants that include healthy foods for sale (e.g., fresh fruits and vegetables, whole-grain breads, low-fat milks and cheeses).

Our final step was to rank each block group to identify locations that would gain the greatest benefits from new urban agriculture sites. For each of the following parameters, we added a field to the block group shapefile's attribute table. Then, we used a query within GIS to answer the questions that follow, adding the appropriate value to the field for that specific block group. We used a binary method (yes–no) to rate each parameter. For our first six variables, *yes* equates to any parameter that exceeds the national rate (in parentheses for the following variables) and was assigned a 1; *no* equates to any parameter equal to or less than the national rate as follows, and was assigned a 0: (1) student eligibility rate by school for National School Lunch Program (a proxy for food insecurity and health-related conditions; national rate, 42.9 percent); if any block group contained more than one elementary school zone, we used the school zone representing majority of the land area; (2) poverty rate (15.4 percent); (3) unemployment rate (5.4 percent); (4) percentage of population with less than a high school diploma (14.0 percent); (5) percentage of female-headed households (19.0 percent); and (6) percentage of children (23.3 percent).

For each of the following additional parameters, presence within the block group equates to less need for urban agriculture, so presence = 0 and no presence = 1: (7) presence of a park, (8) community garden or urban farm present, and (9) supermarket or superstore present. For the final variable (10), we determined whether the block group is contained within the food desert identified by the city official (yes = 1, no = 0).

We added another field to the shapefile attribute table—total score. We then populated this field by adding the binary values (1 or 0) for all variables to produce a ranking of between zero (no need for urban agriculture's socioeconomic benefits) and ten (the block group demonstrating need across all ten variables). We used the final two parameters—percentage of women with less than a high school diploma and rates of public transportation use (both rated individually—1 if it exceeded the national rate, 0 if it was equal to or less than the national rate) to evaluate any questionable rankings, adding these two scores in separate fields of the attribute table.

Results and Discussion

We start with our results for the retail outlet food evaluation. Figure 3 displays the results of our Internet search; we identified 192 restaurants (dark gray circles), 144 retail food stores (light gray circles), and sixteen supermarkets or superstores (one each—Walmart, Target, Fresh Market, Piggly Wiggly, Whole Foods; five Food Lions; two Kmarts; and four Krogers) in the entire city. Within the food desert identified by the city official (large circle with bold black border), we located and evaluated seventeen retail stores (including one grocery store, one discount bakery, and the rest convenience stores) and eight restaurants; none of the twenty supermarkets and superstores was contained within the food desert evaluation area. After our food quality evaluation was completed, four additional stores were opened (three Walmart Neighborhood Markets and an additional Whole Foods location), for a total of twenty larger food stores (black triangles).

Our evaluation from the modified NEMS–S and NEMS–R, as compared to the Dietary Guidelines for Americans (USDA 2010), verified the lack of sufficient and affordable healthy options, thus confirming the location of the food desert. More specifically, for the eight restaurants, only one had a salad bar, three had supersize options, and four noted healthy options, but these were identified as water, nonfried vegetables,

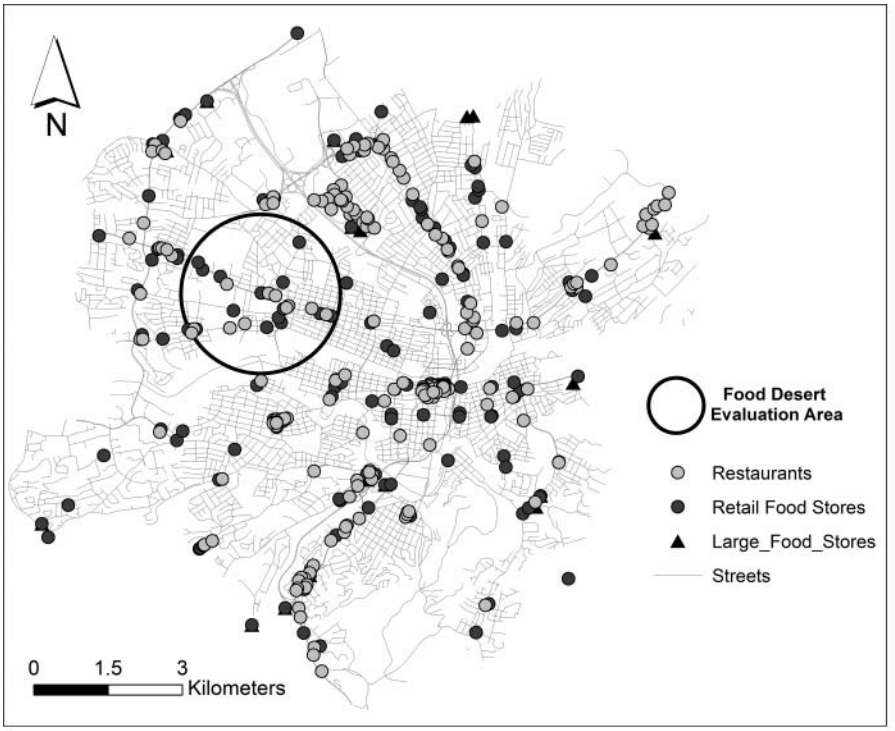

Figure 3 *Locations of all food stores and restaurants in Roanoke, Virginia, and the site of our food desert evaluation (black circle). Shapefiles for food retail locations and food desert evaluation area were created by first author.*

low-fat or fat-free salad dressings, diet soda, and low-fat or skim milk. Of the seventeen retail stores, very few offered fresh fruits and vegetables (and the selections were limited), and few provided healthy drink alternatives. Table 4 summarizes the selection of more healthy options and Table 5 summarizes the selection of less healthy options, as tallied from the NEMS–S for the seventeen stores. Within our evaluation area, only a small percentage of retail outlets offers healthy options, and the majority offer unhealthy options. We have not included all survey items in this summary but based it on a similar summary found in Freedman and Bell (2009). Although we evaluated only a specific buffer zone around the center point of the food desert identified by the city official, the retail stores and restaurants in a larger radius, or in another area of the city (in the eastern part), the food access for Roanoke appears very closely related to that identified by the USDA, and

Table 4 *Summary of Nutrition Environment Measures Surveys in Stores results for healthy food and beverage options*

Food group from MyPlate[a]	Specific food or beverage	Food stores offering item (%)	
Grains		Whole-grain breads	35.3
Fruit	To be encouraged	Apples (fresh)	11.8
		Bananas (fresh)	5.9
		Oranges (fresh)	11.8
	To be limited	Fruit canned in sugar syrup	88.2
Vegetables		Leafy greens (fresh)	11.8
		Onions (fresh)	17.6
		Peppers (fresh)	11.8
		Tomatoes (fresh)	17.6
Protein foods		Hot dogs	35.3
		Lowfat hot dogs	11.8
		Turkey dogs	5.9
		Eggs	64.7
		Beans	70.6
		Tuna (canned)	64.7
Milk	To be encouraged	2% or low-fat milk	29.4
	To be limited	Whole milk	88.2
100% fruit juice		Orange juice only	88.2

[a]Based on ChooseMyPlate.gov food categories.

Table 5 *Summary of Nutrition Environment Measures Surveys in Stores results for less healthy food and beverage options*

Specific food or beverage	Food stores offering item (%)
Beer	88.2
Other alcohol (i.e., wine or mixed drinks)	88.2
Soft drinks	100
Potato chips	100
Canned pastas	82.4
Packaged sausage and bacon	76.5
Candy	100
Prepackaged deserts (cakes, pastries)	88.2

most poverty census tracts within Roanoke have limited access to retail outlets selling fresh and nutritious foods.

In addition, most of the elementary schools' student eligibility rates for the National School Lunch Program exceeded the national rate; indeed, only two schools were less than the national rate (Figure 4). Moreover, in eleven of seventeen elementary schools, greater than 75 percent of students qualify for the program.

For our individual block group analysis (as a reminder, Roanoke has seventy-six census block groups):

- Sixty-four exceed the National School Lunch Program national rate of 42.9 percent.
- Forty exceed the national poverty rate of 15.4 percent, and some have extremely high rates over 35 percent (Figure 5).
- Thirty-two exceed the national rate of female headed-households of 19.0 percent.
- Forty-six exceed the national unemployment rate of 5.4 percent.
- Forty-six exceed the national rate of people age twenty-five or older with less than a high school diploma of 14.0 percent.
- In twenty-five, the percentage of the population that are children less than eighteen years exceeds the national average of 23.3 percent.
- Forty have no park.
- Seventy-three do not have an urban farm or a community garden.
- Sixty-five do not have a supermarket or superstore within their boundaries.
- Fourteen block groups were found within the area identified by the city official as a food desert and where we confirmed a lack of healthy and nutritious options from our field data collection using the NEMS–S and NEMS–R.

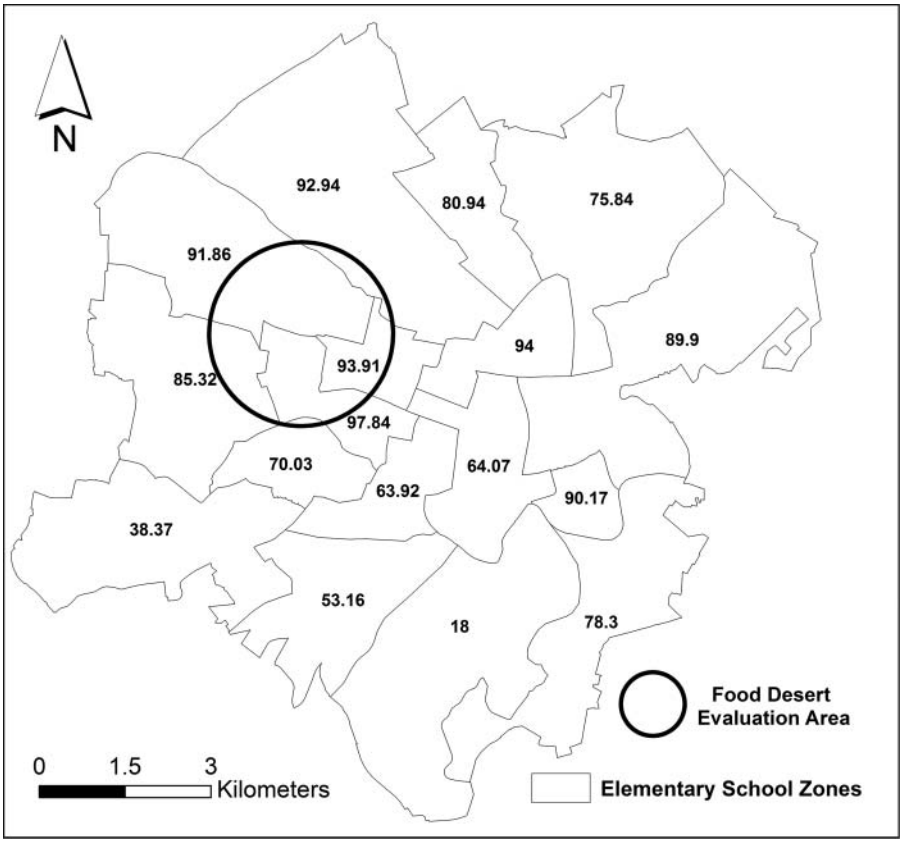

Figure 4 *Elementary school zones. Number represents the percentage of students in the school who qualify for the National School Lunch Program.*

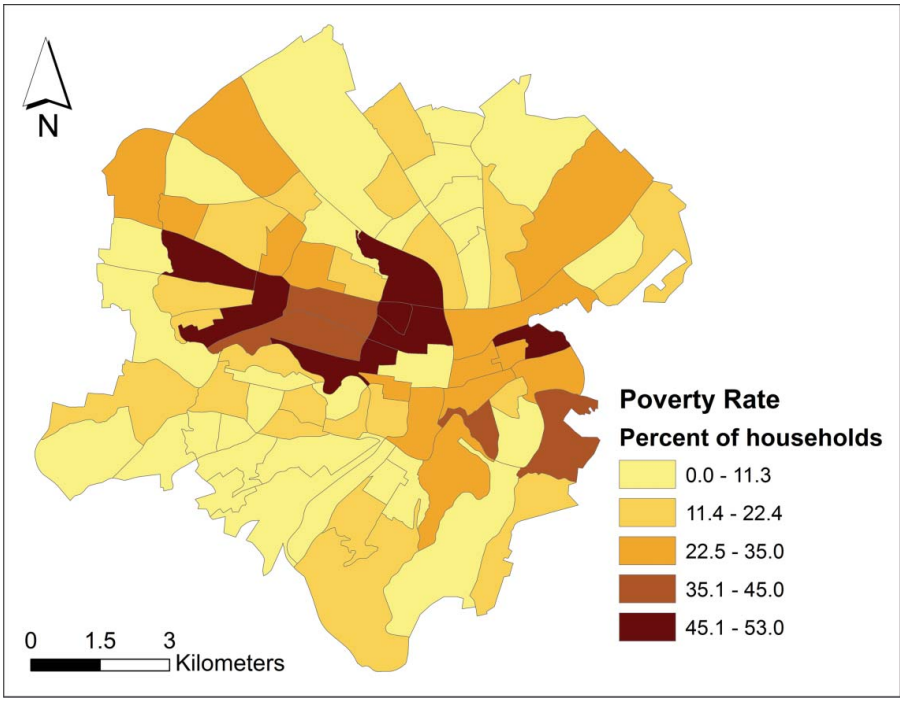

Figure 5 *Percentage of households, by block group, falling below the federal poverty rate. (Color figure available online.)*

After adding all binary values, only one block group demonstrated a need in all ten categories; five demonstrated a need in nine categories; nine in eight categories; eleven in both seven and six categories; fifteen in five categories; twelve in four; ten in three; two in two categories; and no block groups had only one or zero qualifications. Figure 6 shows the distribution, from least to greatest need, within the city.

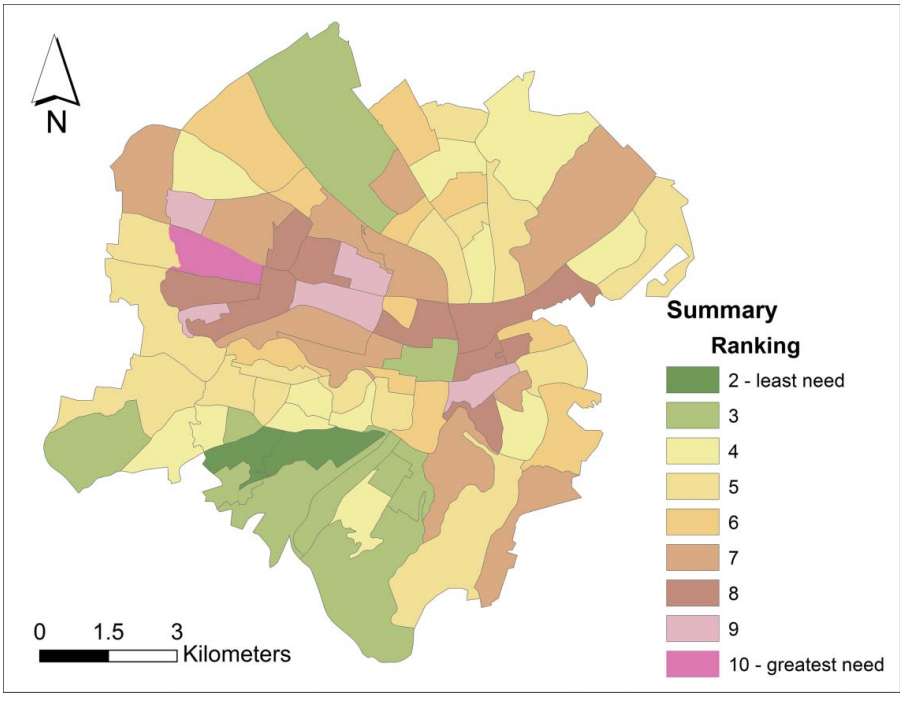

Figure 6 *Ranking of each block group (from 2 [least need] to 10 [greatest need]) for siting new urban agriculture locations. (Color figure available online.)*

When we added the additional two parameters—percentage of women without a high school diploma and percentage of workforce using public transportation—neither variable changed our final results; that is, the order of the block groups did not change. We also looked closely at which variables were highly correlated; less than one third of the block groups had high poverty rates and high employment rates, whereas over one third of block groups with high poverty rates did not have a community garden, an urban farm, or a park within their boundaries.

We do note that the divergent time frames of our different parameters might have affected some of our results: Census data were averaged for a five-year period ending 2013, food evaluation was accomplished over a one-year period ending in 2014, and our urban agriculture sites are current through 2015. Differences in dates do not concern us, but when we compare our more recent data to older data, many variables for Roanoke have remained the same or worsened—for example, the average rate of student eligibility by school for free or reduced-price lunch under the National School Lunch Program remained the same, and rates of obesity increased (see Table 3). Furthermore, one variable not addressed within this analysis—the number of homeless public school students within the city—rose substantially from approximately 386 in 2012 to more than 600 in 2014 (Jackson 2014).

Conclusions

Many researchers and scholars question urban agriculture's ability to address socioeconomic problems (Pollans and Roberts 2014). Not only is urban agriculture practiced across the world, research has documented its contribution to provisioning fresh fruits and vegetables, and many municipalities are including urban agriculture in their development and sustainability plans. Municipalities and researchers are preparing and have completed land inventories to identify vacant and underutilized lands for new urban agriculture greenspaces.

Referring back to our Introduction, though, these land inventories should start with identifying locations within socioeconomically disadvantaged areas and prioritize these locations for urban agriculture projects. Once these areas are identified, vacant or underutilized lands within these neighborhoods can be found. After these two steps are accomplished, the job is not done—physical characteristics must be evaluated, such as soil farming quality, soil contamination, slope steepness, access to water, and so on. Once appropriate sites are identified, the next steps involve local residents in the decision-making process, which would include assessing their desires for a new greenspace; locating, establishing, and maintaining the community garden, farm, or orchard; and assessing their abilities to produce and process food. Furthermore, support through the local extension services will be needed to provide continuity and promote investment of local residents in ownership of the process.

Siting urban agriculture on vacant or underutilized lands is necessary to make productive use of these nonproductive areas. Placing urban agriculture on these lands does not address whether or not lower income residents will have access to these new greenspaces, however. Our GIS analysis, using publicly available data, has explored, quite successfully, a socioeconomic assessment as the first step in a land inventory. This social and economic analysis identified locales within the City of Roanoke, Virginia, as a hierarchy of sites that will best contribute economic, social, and health benefits for underserved populations. These benefits include assisting in alleviation of food insecurity, supplementing healthy food for low-income populations, increasing urban greenspace, providing opportunities for physical activity, and facilitating educational opportunities for citizens. Once urban agriculture has been implemented in such neighborhoods, it offers an opportunity for assessing its contribution to alleviating disparities and its contribution to the health and well-being of urban populations in the context of social and physical infrastructures. Our analysis, as outlined here, can be applied in any urban area. ■

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