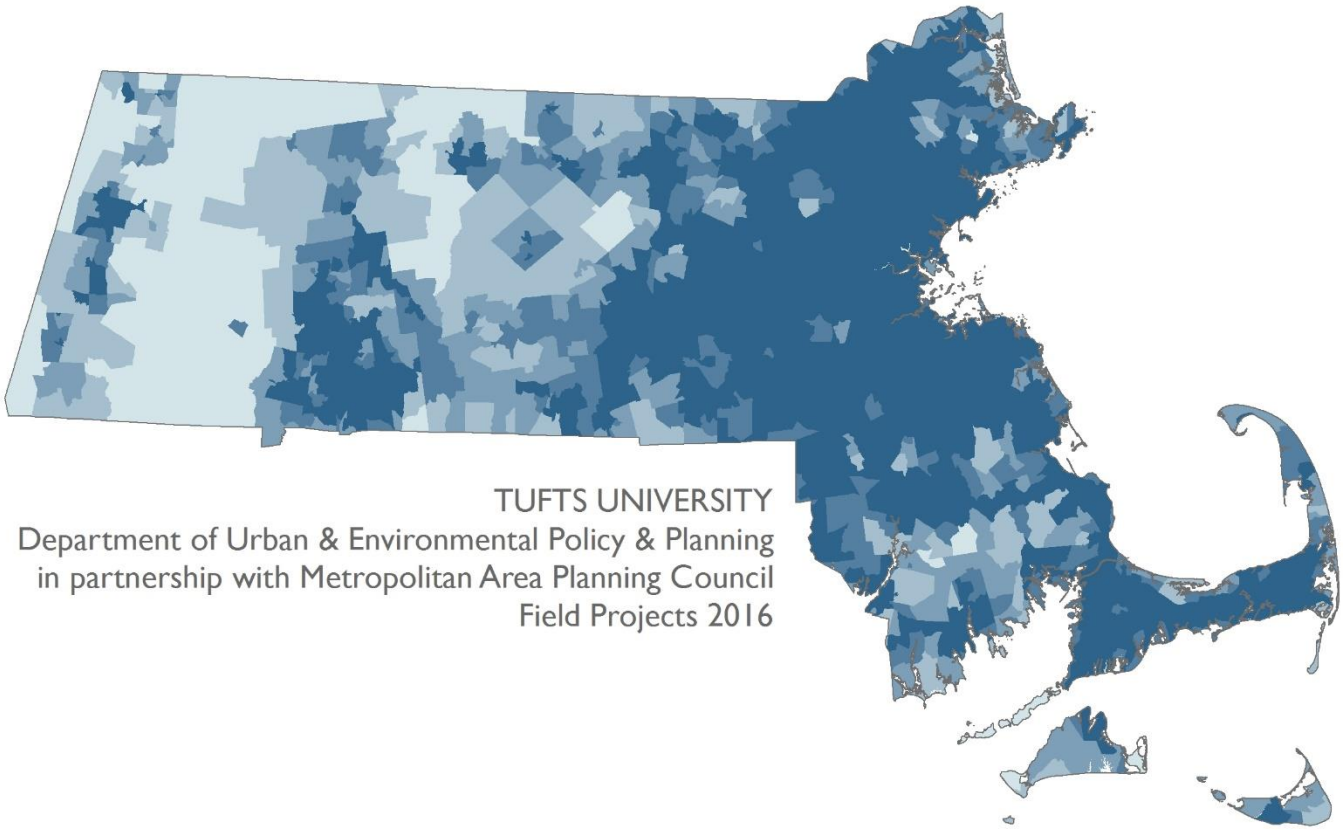
MASSACHUSETTS FOOD ACCESS INDEX

A Pilot Method for Assessing Food Access in the Commonwealth



TUFTS UNIVERSITY
Department of Urban & Environmental Policy & Planning
in partnership with Metropolitan Area Planning Council
Field Projects 2016

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Executive Summary

In recent years, food systems have increasingly fallen within the domain of planning. As the American Planning Association explains, "The time is ripe for the food system to become less of a stranger to the planning field" (American Planning Association, 2016). Embracing this responsibility to plan for community and regional food security, the Metropolitan Area Planning Council (MAPC) has embarked on a statewide food systems planning initiative. MAPC, the regional planning authority serving metropolitan Boston, is a public agency formed in 1963 to coordinate regional collaboration and implement smart growth strategies in regards to housing policy, transportation planning, economic development, and a range of other issues. Over the past two years, MAPC has facilitated the Massachusetts Food System Planning process. This process involved over 1,500 people, including key stakeholders in various fields: farm and business owners, members of government, policy experts, and many others. This process resulted in the publication of the Massachusetts Food System Plan[1] in December 2015. This plan offers policy recommendations for the state food system.

Since the completion of the initial planning process, the Massachusetts Food System Collaborative has formed in order to implement the key policy recommendations. The Collaborative consists of stakeholders involved in the statewide food systems planning process and the Massachusetts Local Food Access Plan. The Collaborative has four distinct goals:

- Increase production, sales & consumption of Massachusetts-grown foods.
- Create jobs & economic opportunity in food, farming and fishing, and improve the wages and skills of food system workers.
- Protect the land and water needed to produce food, maximize environmental benefits from agriculture and fishing, and ensure food safety.
- Reduce hunger and food insecurity, increase the availability of healthy food to all residents, and reduce food waste. (About the Collaborative, n.d.)

[1] The official name of this plan is the Massachusetts Local Food Action Plan, which is the name we will use throughout the rest of the report.

Additionally, MAPC has recently expanded its planning divisions to include public health interests. Issues of food access, nutrition, and hunger all fall under this greater umbrella. As a result of MAPC's involvement in the development of the Massachusetts Local Food Action Plan, and due to this budding interest in public health, the agency has received numerous requests for information regarding food access throughout Massachusetts. Statewide assessment of food access is needed in order to better address food insecurity, a challenge that 11.9% of the population experiences (MAPC et al., 2015, p. 8). MAPC engaged the UEP Field Projects course to fill this gap and conduct a spatial assessment of food access throughout the state. Between January and April of 2016, the MAPC Field Projects team drew on existing literature to define food access, investigated prevailing methods for assessing food access in order to create a framework for spatial assessment at the statewide level, and piloted these methods in a model of Massachusetts food access.

In developing these methods, the field project team asked three foundational questions about food access:

- Access to what?
- By what mode?
- And for whom?

These essential questions address fundamental evaluations of the food retail environment, walkability and drivability to food, as well as socioeconomic and demographic factors that make up community characteristics.

After considering these fundamental questions, the Field Projects team implemented a novel methodology for measuring food access. The methodology starts with the mapping of food retailers in the state by weight. Weights are assigned to food retailers based on the ability to procure healthy food across a full diet. Food retailer data used to assign weights is based on information from National American Inventory Classification Systems (NAICS) codes. Next, models for walking and driving are calculated using MassDOT Roads data. Numerous distances are considered in order to take into account the differences of rural, suburban, and urban food access. Finally, a mean food access index score is calculated for each census block group at each network distance. At this point, it is possible to conduct statistical summaries and analyses based on demographic and socioeconomic characteristics.

In piloting the model, it became clear that there are noticeable disparities in food access in particular community types as well as socioeconomic and demographic categories. Rural communities experience significantly lower food access over set geographic distances in comparison to urban and suburban communities. Additionally, low income households, single parent households, and households with a Hispanic/Latino or Black/African American head of household on average experience significantly lower food access and must travel further distances to reach healthy and diverse food options.

The Field Project team, in creating this model, attempted to go beyond previous methods of assessing food access based mainly on the USDA food desert approach. The final outcome is a model for statewide food access in Massachusetts with greater detail than existing models. Though the model piloted in this project faced a number of limitations, namely, the availability and quality of data, the methods for developing the model can be adapted and applied to individual communities, regions, and even other states. We recommend that MAPC conduct further statistical analyses of the model as it currently exists, with particular attention to socioeconomic and demographic characteristics that were not addressed. Additionally, the model could be strengthened by adding public transportation to the walksheds and drivesheds that the model is based on. In order to develop a more comprehensive model, we recommend that MAPC, communities, and other entities create a strong food retailer data source and engage the community in order to better consider social aspects of food access such as cultural appropriateness and affordability of food. Greater engagement with the public will allow for a better understanding of lived experiences of food access.

This assessment of food access in Massachusetts can serve as a foundation for future policy work, a method for further investigation into the state's food environments, and a tool to improve food access across all community types. The model offers a new methodology for assessing food access, which can be further improved and more widely applied to communities in Massachusetts and beyond.

Section I: Nature of Inquiry

Introduction

Hunger and lack of food access impact a significant portion of the population in the United States. Feeding America, the largest hunger relief organization in the United States, recently reported that 46.5 million people in the United States receive some form of food assistance (Feeding America, 2016). A lack of sufficient access to food poses challenges to health and general wellbeing, as well as many other aspects of life. Studies have shown that limited access to food results in many negative health outcomes, including obesity and diet-related diseases, such as high blood pressure (Ver Ploeg, 2010; Feeding America, 2016). In addition to negative impacts on health, inadequate access to food can be linked to poor school attendance and job performance (MAPC, 2015). Additionally, households that experience challenges accessing adequate food are often forced to choose between purchasing food and paying for medical care, household utilities, or transportation (Feeding America, 2016).

Food access is an issue that impacts all populations in Massachusetts. There are, however, particular populations of people that are at higher risk for lack of sufficient food access, including low-income communities, people of color, seniors, and people with disabilities. The Massachusetts Local Food Action Plan includes eight goals to improve "food access, security, and health," including increasing affordable, healthy, and local food; creating comprehensive healthy eating curricula; and improving transportation infrastructure to improve access to healthy food, among other goals (MAPC, 2015). The Metropolitan Area Planning Council (MAPC), a regional planning agency serving 101 municipalities in Greater Boston, had a primary role in developing the Massachusetts Local Food Action Plan. Since the plan's completion in December of 2015 the Massachusetts Food System collaborative has taken responsibility for implementing the plan.

This project is an effort between the UEP Field Projects team and MAPC to serve the needs and interests of the Collaborative and residents of the Commonwealth at large. As such, this food access index will depict the availability of food access retailers within communities and across the state.

Goals

The goals of the project were to define food access, devise methods to assess food access in Massachusetts, and create a preliminary map of statewide food access that pilots these methods to better understand factors and patterns of food access in various community types.

We began this project by evaluating varying definitions of food access to understand the nuances of different definitions, how they are used, and by whom they are used. This evaluation included both food access definitions based in spatial analysis - the type of definition we employed in creating our index - and those based in more qualitative aspects of food access. Once we had an understanding of the current discourse regarding food access, we set out to determine the definition that we would employ for our project. After defining food access, we assessed methodologies that have been employed to determine food access and utilize features of these methodologies in our own methods and model development.

Section II: Literature Review

Defining "Food Access"

Although "food access" has been the subject of a multitude of journal articles and studies in recent years, the term lacks a universally accepted definition. It is common for the term to go undefined – assuming that it will be understood based on the commonness of its two component words – or to be defined generally or vaguely. Two examples include: "people's ability to find and afford food" (Alexander & Kelley, 2014, p. 60) and "the ability to obtain food items needed from outlets that are available within a neighborhood" (Eckert & Shetty, 2011, p. 1216) For full definitions, see Appendix A. The lack of a clear definition makes evaluating food access challenging.

In the absence of a measurable "food access" definition, researchers have often resorted to defining food access by describing the conditions that constitute lack of access. Spatial analyses have carved out areas of low food access by demarcating spaces that are congruent with the definitions of other related terms – most commonly "food desert." The 2008 Farm Bill defined "food desert" as an "area in the United States with limited access to affordable and nutritious food, particularly such an area composed of predominantly lower income neighborhoods and communities" (The Food, Conservation, and Energy Act of 2008, Title VI, Sec. 7527). The United States Department of Agriculture (USDA) often speaks of food access and food deserts in the same breath, making it difficult to distinguish between the two concepts. A prime example is the USDA report to Congress titled *Access to affordable and nutritious food: measuring and understanding food deserts and their consequences* (Ver Ploeg, 2010). Further evidence of the blurring of lines between these terms is the evolving name of the USDA Food Desert Locator tool (2006-2010), which is now called the Food Access Research Atlas (from 2010 to present). In fact, in the Food Access Research Atlas documentation, the "food access" definition reads:

> Limited access to supermarkets, supercenters, grocery stores, or other sources of healthy and affordable food may make it harder for some Americans to eat a healthy diet. There are many ways to measure food store access for individuals and for neighborhoods, and many ways to define which areas are food deserts—neighborhoods that lack healthy food sources (USDA-ERS, 2015 March 11).

This definition does not actually define either term, but we can interpret that "food desert" is one type of food environment with reference to "food access."

Elsewhere in the Food Access Research Atlas documentation, the food desert criteria are further defined to include census tracts that are both low-income (meeting the New Market Tax Credit low-income neighborhoods definition)[2] and low-access ("a significant number or share of individuals in the tract is far from a supermarket") (USDA-ERS, 2015 March 11). However, there is still debate about thresholds of geographic distance to food retail for urban and rural areas. New terms such as "food swamp" (Behrens & Simons, 2013) and "food hinterland" (Leete, Bania, & Sparks-Ibanga, 2011) have been introduced to describe the nuance of the food desert environments in urban versus rural areas. See Appendix A for full definitions of related food access term.

While the negative space approach (identifying low access areas) has utility in the sense that the overarching goal is to improve access to healthy, affordable food options in communities with limited access, there have been critiques of the utility of the food desert approach to defining food access. This criticism is often aimed at the limited number of variables included in the analysis (essentially two: median household income and distance to supermarkets). Moreover, "food access" is only one term used to approximate the concept of availability, affordability, and accessibility of food.

[2] New Market Tax Credit program defines a low-income census tract as one where "the tract's poverty rate is 20 percent or greater; or the tract's median family income is less than or equal to 80 percent of the State-wide median family income; or the tract is in a metropolitan area and has a median family income less than or equal to 80 percent of the metropolitan area's median family income" (USDA-ERS, 2015 March 11).

Several other terms relating to this concept offer more comprehensive definitions. For example, food access is just one of four main components of "food security" as defined by the Food and Agriculture Organization of the United Nations (FAO):

> A situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life. Based on this definition, four food security dimensions can be identified: food availability, economic and physical access to food, food utilization and stability over time (FAO, 2015, p. 53).

The USDA employs a pared down variant of the FAO definition of food security: "access by all people at all times to enough food for an active, healthy life" (USDA, 2015 Sept 8).

Maxwell (1996) notes that the conversation about "food security" has shifted several times since the 1970s. What was once a term fit for the global scale has since been applied to national, community, and even household scales (Maxwell, 1996). This shift has been concurrent with a shift from an almost exclusively developing world focus to include definitions of "community food security" in the developed world, such as the Hamm and Bellows (2003) definition: "a situation in which all community residents obtain a safe, culturally acceptable, nutritionally adequate diet through a sustainable food system that maximizes community self-reliance and social justice" (p. 37) See Appendix A for additional definitions of "food access. Another shift in the concept of "food security" has been in how it is measured – from empirical indicators to subjective perception (Maxwell, 1996). Two examples of subjective measures are the survey instruments used in the USDA study titled *Household Food Security in the United States in 2014* (Coleman-Jensen et al., 2015) and the Food Research and Action Center's study titled *Food hardship in America 2010* (Food Action Research Center, 2011).

Given the number and variety of terms and definitions that exist to communicate about the availability, affordability, and accessibility of food, each food access study must redefine what it is measuring. Thus, the methodology of and selection of indicators in individual studies give a clearer picture of how researchers define food access.

Previous Food Access Studies

Food access can be measured at numerous scales, with each level highlighting different elements of food security and drawing linkages between related factors including transportation, affordability, and cultural appropriateness. These scales can range from macro-level depictions of food access on a national scale to micro-level analyses of food access within a particular neighborhood or community. As with any choice of scales of evaluation, each level of analysis is associated with particular benefits and tradeoffs.

National Studies

National scale evaluations of food access are broad in scope to best capture a general measurement of food access that can be applied across the entire country. The USDA has put significant efforts into developing a framework to evaluate food access on a national level. These efforts, however, produce limited measurements of food access based primarily on geographic distribution of supermarkets within a particular community. While the USDA's focus on supermarkets as a source of food rather than other retail locations may be somewhat limiting or create an inaccurate depiction of food access, the choice supports the notion that "when consumers shop at convenience stores, prices paid for similar goods are, on average, higher than at supermarkets" (Ver Ploeg, 2010, p. iv). Similarly, other national-scale assessments of food access break down the concept of access into more nuanced categories including affordability, accessibility, and availability. These studies acknowledge the nuances of food access, but because of scale and data availability, these studies are still limited to assessing these different forms of access with respect to the spatial proximity of food retailers (Sharkey, 2009).

The geographic units of analysis within the national framework can vary across different studies. In some studies, such as Feeding America's "Map the Meal Gap," food access is viewed at the levels of counties and congressional districts, while in other assessments, like the USDA's "Food Access Research Atlas", food access is evaluated on the level of census tracts (Gundersen et al., 2015; USDA-ERS, 2015). Since census tracts are based on population, ranging between 1,200 and 8,000 people per tract, the use of census tracts for evaluation purposes can vary dramatically depending on the type of community being assessed. In urban settings, a census tract can portray a neighborhood, while in a rural setting, an entire town could be within a single census tract (U.S. Census Bureau, 2012).

National scale assessments of food access can provide a big picture, making them useful for government agencies or organizations working on a national level. Understanding people's ability to access food, however, can be especially complex and there are many critiques regarding the effectiveness of a national scale of analysis. A recent study by Ver Ploeg et al. challenges this large scale of assessment by stating, "the focus on neighborhoods instead of individuals underestimates the barriers that some individuals face in assessing healthy food, and overestimates the problem in other neighborhoods" (2014, p. 205). The authors further argue that "greater attention be paid to individual measures of food store access," an idea that could lead to a far more comprehensive understanding of food access, but would be both time consuming and challenging to assess nationally (Ver Ploeg et al., 2014, p. 205).

Massachusetts Studies

Statewide assessments of food access are less general in scope than those conducted at the national level because they can focus on geographic, socioeconomic, and demographic characteristics specific to the state. With a smaller region to cover, it is more feasible to include greater depth in evaluating and measuring food access, which may not have been considered

on a larger scale. Statewide studies, however, are still complicated because there is significant variation in community types as well as socioeconomic and demographic characteristics.

In Massachusetts, existing statewide assessments of food access are framed within a number of different contexts such as hunger, food insecurity, and geographic proximity to supermarkets. The assessments that have focused on hunger and food insecurity were conducted by Massachusetts-based, hunger-focused organizations, and mainly measure people's ability to afford food, considering income, cost of living, and access to affordable food (Project Bread, 2013; Greater Boston Food Bank, 2011; Ettinger de Cuba et al., 2013). Though the variables included in these measures are related to issues of transportation, geographic proximity, and other community-wide qualities of food access, they are much more household oriented than studies at the national level.

In contrast, other statewide studies of food access in Massachusetts evaluate the presence of supermarkets in communities throughout the state and make conclusions about people's access based on the presence of appropriate food retail locations. The Food Trust, a national organization dedicated to improving food access, has published two different reports on food access in Massachusetts that focus on grocery stores in the state. Both of these reports highlight that:

> Despite being one of the most affluent states in the nation, Massachusetts has fewer supermarkets per capita than almost any other state. Some cities, including Boston, Springfield and Brockton, have as much as 30 percent fewer per capita supermarkets compared to the national average. (The Food Trust, 2010)

Both of these studies base the food access of a community on the number of supermarkets within a given zip code. These assessments also note the relationship between income and food access. People with higher incomes frequently have access to adequate transportation in order to travel to supermarkets and other food retailers; people with lower incomes, who often have limited food access, are often forced to rely on less healthy food, which can contribute to obesity, high blood pressure, and other diet-related diseases (The Food Trust, 2010; Manon & Tucker, 2012).

The Massachusetts Local Food Action Plan, a comprehensive plan detailing food production, processing, access, and other aspects of the food system, addresses food access by offering an assessment of food access in the state, paired with recommendations to strengthen the food system. This assessment focuses largely on the affordability of food, education about healthy eating, and the accessibility of infrastructure that supports food access, namely transportation (MAPC et al., 2015). See Appendix B for a full list of Massachusetts-wide assessments of food access.

Similar to the challenges discussed regarding national food access assessments, Massachusetts-wide measures of food access are limited in that they must generalize entire neighborhoods or communities. Raja et al. discuss that "existing quantitative studies of neighborhood food environments define neighborhoods as census tracts or zip codes, which owing to their large size – particularly in suburban and rural municipalities – serve as a poor proxy for neighborhoods" (2008, p. 471).

Regional and Community Studies

Food access varies dramatically across geographies as a result of socioeconomic differences, demographics, availability of transportation, and other factors. Given the many variables which can influence food access Raja et al. argue that, "it is important to examine disparities in the food environment at as fine a geographic scale as feasible" (2008, p. 471). Within Massachusetts micro-level studies of food access have been conducted in particular neighborhoods, cities, and regions. This smaller scope allows these studies to reach greater

analytical depth, including comparisons of the price of foods across different food retail locations within a community, interviews with community residents, and consideration of factors like cooking skills and cultural food preferences.

Two regional level studies of food systems and food access in Massachusetts – one focusing on Central Massachusetts and the other on the Pioneer Valley – detail the price of particular foods in different retail settings in the state (Olendzki et al., 2015; Pioneer Valley Planning Commission, 2013). In addition to assessing the affordability of different food items, Olendzki et al. (2015) quantified the presence of healthy food, culturally appropriate food, and canned and frozen foods in grocery stores and supermarkets in Central Massachusetts. Many of the regional and community scale studies of food access in Massachusetts reference measures of food access used on statewide and national scales as well. In particular, studies use the definition of food deserts from the USDA's "Food Access Research Atlas" and show levels of food insecurity and hunger by participation in federal programs including the Supplemental Nutrition Assistance Program (SNAP), Special Supplemental Nutrition Program for Women, Infants, and Children (WIC), and the National School Lunch Program (NSLP) (Alexander & Kelley, 2014; Pioneer Valley Planning Commission, 2013).

Additionally, there have been a number of food access studies on particular communities and regions throughout Massachusetts, including Boston, Lowell, Springfield, Worcester, and Western Massachusetts, conducted by students in various planning and design programs. Since these studies are focused on much smaller geographic areas than national or statewide studies they are heavily rooted in ground truthing and portraying individual and community experiences with food access rather than applying a broad framework across a multitude of communities. Ground truthing is a process of collecting data at specific locations to either confirm or deny prior results. See Appendix B for a full list of published and unpublished regional and community assessments of food access in Massachusetts.

The small scale of regional and community based studies of food access allows for an in-depth analysis of the food environment and various forms of access. For instance, the cultural appropriateness of food available in a community is not a characteristic of food access that is considered on a national or statewide scale, perhaps as a result of feasibility. On a more local scale, however, it is possible to not only assess the presence of food in a community, but also the types of food available. A shortcoming of this scale, though, is the time intensive nature of analysis. Since much of the data used in this sort of analysis includes prices, availability of food, and other data that must be collected, it is difficult to apply this approach to all communities or regions within a state, or the nation as a whole.

Spatial Approaches to Studying Food Access

While early food access studies utilized geographic information systems (GIS) to visualize information and create maps, more recent studies have utilized GIS as a tool for spatial analysis instrumental in conducting research on food access. GIS has allowed for relatively quick analysis of road networks in ways previously difficult, making possible complex analyses. GIS studies of food access have mapped distance to supermarkets based on road networks, taking into account the average walking speed for men and women to determine access to food (Donkin et al., 1999). In the same study, GIS analysis was coupled with resident interviews so as to take into consideration the ethnic and cultural components of healthy food to the four major ethnic groups living in the area (Donkin et al., 1999). GIS has now become an essential analytical tool for conducting research on food access.

Among the GIS functions or tools typically utilized to study food access are buffer analysis, network analysis, and measures of density and proximity. GIS allows for the construction of buffers around travel routes, neighborhoods, and individual parcels. Buffers may be used to see food retail availability at different distances from an individual home or any other location. Buffers may also be used in the converse - to delineate an area of access around a food retail location. Network analysis allows for the examination of interconnected points and lines, for example road networks. The ESRI extension Network Analyst is used in food access studies to measure travel distance to food retail outlets, and is an essential and frequently used tool for determining geographic access (Eckert & Shetty, 2011).

In conducting GIS analysis of food access, there are common variables that are typically used. These variables are primarily indicators of barriers to food access and can be used to elucidate the three components of food access identified by McEntee and Agyeman (2010): geographic access, socioeconomic access, and informational access. Geographic access is frequently measured using distance to supermarkets as a proxy for geographic access to healthy food choices. Convenience stores and fast food restaurants, which generally offer fewer healthy food choices, often have lower square footage than full service food retailers, such as grocery stores. Thus, by excluding retail outlets of smaller square footage, the retailers that remain provide a general measure of healthier food choices.

Though the use of supermarkets as a proxy for access to healthy food choices is widespread, there are different ways of measuring this form of geographic access. Some studies measure distance to supermarkets, while others consider travel time to supermarkets (Charreire et al., 2010). In addition to considering distance or travel time to supermarkets, some studies consider the density, or number of supermarkets within a region, in order to understand diversity and variety of choices (Apparicio, 2007). Clustering of supermarkets can also be used as an indicator of spatial access based on a valorization of diversity of choice (Baker et al., 2006). In the significant public health literature, fast food restaurants are also considered in GIS analysis of food access in order to determine access to "unhealthy" choices correlated with obesity or other public health issues (Charreire et al., 2010).

Research on food access from many different approaches has acknowledged the important role of poverty and race in accessing healthy food choices. Socioeconomic access, in addition to geographic access, is necessary to fully understand the reality of food access in any given community. Much of the food access literature relies on the concept of the food desert, and specifically the USDA definition or slight modifications of this definition. The USDA uses census tracts to identify food deserts that meet low-income and low-access thresholds, embracing both geographic and economic understandings of access (USDA-ERS, 2015 March 11). While there is a body of research that calls into question the efficacy and utility of this definition of food desert (Leete and Sparks-Ibanga, 2011; Diao, 2014; Ghosh-Dastida et al., 2014), this definition remains the basis for much of the research on food access, thus showing the preeminence of this paradigm (Behrens, 2013).

Research on socioeconomic access to food has centered on low-income neighborhoods deemed food deserts. In one study of New York City's low-income neighborhoods, GIS was used to map the presence of grocery stores, convenience stores, and fast food restaurants in given census blocks (Gordon et al., 2011). This GIS analysis, in addition to a food desert index comprised of survey data on food availability, was used to devise a food desert index. While this does consider race and income, the study still mainly quantifies food access as geographic accessibility. Attempting to look past the primary paradigm of food deserts and understanding of supermarkets as the best indicator for food access, one study conducted statistical analysis of food retailers within census block groups, comparing neighborhoods that were "predominantly white," "predominantly black," and "racially mixed" in order to map racial disparities at the neighborhood level (Raja et al., 2008).

Informational access, though important to understanding food access, is likely the least studied of the three enumerated components. Informational access acknowledges the role of individual choices in food security. Even if there is geographic access and economic access to food, individuals may lack the knowledge to make healthy decisions when consuming food. Some individuals may not choose healthy choices, despite having economic resources. Educational attainment is one variable that can be studied and correlated to certain patterns of food consumption (Morton & Blanchard, 2007; McEntee & Agyeman, 2010). Cooking skills is another variable that can affect informational access to healthy food, as can nutritional knowledge. Informational access, however, is difficult to represent spatially in comparison to geographic or socioeconomic access, complicating its inclusion in geographic approaches to studying food access.

From this review of existing literature on food access, an inventory of variables can be created to assess food access in Massachusetts. Among these common variables are general demographic and socioeconomic variables including race, ethnicity, age, family structure, income, household type, and employment status. Demographic variables like receipt of different public assistance programs can also be valuable in determining access to food. In determining geographic access, supermarket proximity and density, as previously discussed, is often used as a proxy for access to a variety of healthy food choices. Other variables may include retail locations and farmers markets that accept SNAP/WIC, as well as distance to and density of farmers markets. Transit access, which is measured in a variety ways using GIS, is another common variable for assessing geographic access. As previously discussed, to measure informational access, educational attainment is frequently used as a proxy. Finally, cultural appropriateness of food is an important though understudied factor. Some studies that use interviews devise inventories of culturally appropriate healthy food choices (Donkin et al., 1999), but geographic approaches to studying food access often lack attention to cultural appropriateness in mapping food access.

Rural vs. Urban Food Access Methodologies

In approaching geographic-based studies of food access, attention must be given to the differences between rural, suburban, and urban locations. Most of the previously discussed methodologies, especially those that study geographic access, have only been applicable to urban realms. The common use of 500 meters (.311 miles) as an acceptable distance to travel to food retailers is unrealistic for rural communities (Donkin et al., 1999). Different methodologies are necessary for understanding rural food access. In studying rural food access, distance to supermarkets from residential locations can still be used as a proxy for geographic access, but greater distances must be considered, such as 10-miles, in order to meaningfully interpret food access (Morton & Blanchard, 2007; McEntee & Agyeman, 2010). According to the Rural Sociological Society definition of food deserts in rural contexts, "counties in which at least one-half of the population lives more than 10 miles from these large food stores," are considered low-access counties, of which there are 803 nationally (Morton & Blanchard, 2007). In this study, a different methodology was used than would be appropriate

for studying urban food access. Zip codes with at least one supermarket with 50 employers or more were identified, and only census blocks that fell 10-miles outside of these zip codes were considered food deserts (Morton & Blanchard, 2007). Some studies of rural food security, however, rely more heavily on questionnaires, interviews, focus groups, and quantitative methods rather than geographic approaches (Furey et al., 2001).

These methodological differences between rural and suburban/urban contexts make mapping food access at the statewide level difficult. For this reason, statewide analysis may lack utility and explanatory power. Additionally, political boundaries are not always important when considering consumer habits. Many Massachusetts residents living in rural towns near the Connecticut, New York, Vermont, Rhode Island, or New Hampshire borders may do grocery shopping outside of the state. This means political boundaries are, within some contexts in the state, inconsequential to understanding food access, a limitation noted in other studies of rural New England food access (McEntee & Agyeman, 2010) (USDA-ERS, 2015 March 11).

Other studies find that even the census tract level of analysis is insufficient for understanding experiences of food security. Studies based at the census tract level, or higher, are not able to capture the microclimates of food access in a given neighborhood or illustrate an accurate depiction of the food situation (Raja et al., 2008). Still, census tract is a common level of analysis for studies of food access. Some studies include extensive ground truthing as well as qualitative methods such as focus groups and long interviews in order to understand individual experiences of food access and to test these experiences against findings from geographic-based approaches to studying food access (Coveney, 2009).

Limitations of Spatial Approaches

In conducting geospatial analyses in studies of food access, there are numerous limitations that must be carefully considered. First, there is the challenge of incomplete or inaccessible data. Many studies identify reliability of data as a limitation. For example, data for retail outlets that accept SNAP could be incomplete. Many studies utilize square footage to exclude fast food and convenience stores from measures of grocery stores, based on an industry standard of 2500 square feet, though this could potentially exclude smaller stores offering healthy options (McEntee & Agyeman, 2010). Often times, data is simply unavailable and the collection of data is prohibitively expensive in cost or time.

Second, qualitative data collected from interviews is often difficult to spatially analyze. Some studies have rightly acknowledged that qualitative experiences are equally as important as geographic data about food access, choosing to use long interviews to understand mobility and location of food rather than geospatial data (Coveney, 2009). Though this research is promising and an important complement to spatial analysis, there are still too few studies that have documented individuals' personal experiences of food access and food security. Additionally, there is limited understanding of how these qualitative studies can be integrated with geographic approaches to develop a more nuanced and complex understanding of food access.

Finally, qualitative interview-based studies shed light on another limitation of geographic-based studies of food access. These geographic studies are place-based and often may not accurately reflect the experiences of people who live in the geographic area being studied. Place-based analyses adequately describe the retail environment, but cannot explain individual factors that influence people's food access and purchasing habits. Though often infeasible due to time and cost, ground truthing the results of spatial analysis through direct observation, interviews, and participatory action research, would provide more accurate depictions of food access. This limitation may be particularly true of research using the food desert paradigm. As previously discussed, many studies have acknowledged the weakness of the common USDA definition to accurately capture experiences of food access. One study of food deserts used GIS methods to survey Portland, Oregon. When using different definitions of food deserts, different swathes of the city were identified, none of which satisfied the researchers, showing the inability to use GIS and the food desert paradigm to adequately understand food access (Leete & Sparks-Ibanga, 2011).

Key Learnings

After a thorough review of literature and research methods pertaining to food access, it is apparent that the framework commonly used to assess food access has many limitations. Strategies for defining food access tend to rely more on evaluating why food is unavailable, rather than evaluating what food is available. Furthermore, devising comprehensive approaches to spatial analysis are often dependent on the scale of the focus geographic area and/or the availability and quality of data. This leads us to conclude that assessments of food access at smaller scales allow for more comprehensive data collection and analyses. In order to develop more effective food system policies, food access must be assessed with greater precision and methodological clarity.

Section III: Methods for the Massachusetts Food Access Index

Framework for our Spatial Analysis

We framed our spatial analysis with three guiding questions:

- Access to what? (food retail environment)
- By what mode? (transportation)
- For whom? (demographic and community characteristics)

These questions represent three key components of assessing food access. The following schematic illustrates how these three questions organize our analysis into three parts.

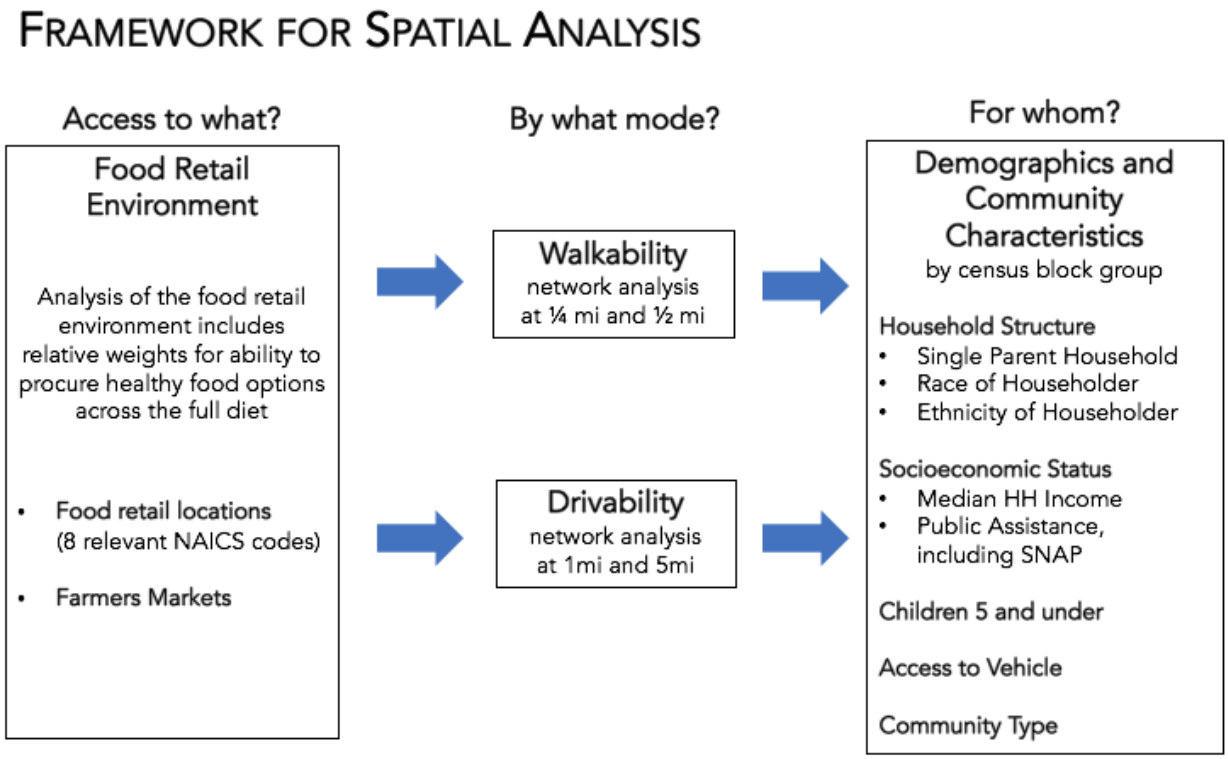


Figure 1. Framework for Spatial Analysis. Source: Caitlin Matthews

Influential Studies

In addition to the methodologies considered in our literature review, several spatial analyses were particularly influential in developing our methods.

We adapted the basic steps for our analysis from "Walking the Network: A Novel Methodology for Measuring Walkability Using Distance to Destinations Along a Network," which was created by Tufts UEP student Gabriel Holbrow (Holbrow, 2010).

Two studies influenced our thinking about how to categorize food retailers based on the food options they offer. The analysis "Social inequalities in neighborhood conditions: spatial relationships between sociodemographic and food environments in Alameda County, California" (Cubbin et al., 2012), adapts the Holbrow method to analyze access to healthy and unhealthy food options. We gleaned similar insights from their methods and paid additional attention to how food procurement options were categorized as healthy or unhealthy. "Neighborhood Food Environment and Walkability Predict Obesity in New York City" (Rundle et al., 2009) provides another model for categorizing food procurement options as healthy, intermediate, and unhealthy. Although we do not use labels such as "healthy" or "unhealthy," our weighted categories reflect similar hierarchy of food procurement options based on NAICS codes, similar to Rundle et al. Our food retailer weight categories (described in detail below) reflect a consumer's ability to procure healthy food options across the full diet at a single retailer. Our first order criterion is primary NAICS code and our second order criterion is square footage.

In piloting a statewide food access index, we faced the challenge of creating an index that could be applied to analyze urban, suburban, and rural settings. As we previously mentioned, McEntee & Agyeman (2010) point out that larger distances must be considered in order to meaningfully interpret food access in rural areas. Therefore, we have included multiple network distances in both the walking and driving models. In doing this, we can interpret food access based on the most relevant travel mode and distance(s) for each community type.

Basic Steps

In broad brushstrokes, the steps for creating the Massachusetts Food Access Index are:

1. Mapping food retail locations by the weighted categorization we compiled based on food availability.
2. Calculating the closed shaped arrangements based on the appropriate travel distance away from food retailers, often termed, network polygons.
3. Converting the network polygons to a raster layer. Whereby a raster layer is a mapping layer which compiles a group of cells that share the same value and represent the same type of geographic feature.
4. Calculating a composite raster layer, which merges the layers to provide a more visually appropriate map.
5. Calculating a mean food access score by census block group.

The following maps illustrate these five steps as we have adapted them for the Massachusetts Food Access Index pilot. In these illustrations, the inset map of Springfield simply provides a more detailed view of the steps. These steps are described in further detail, following the maps.

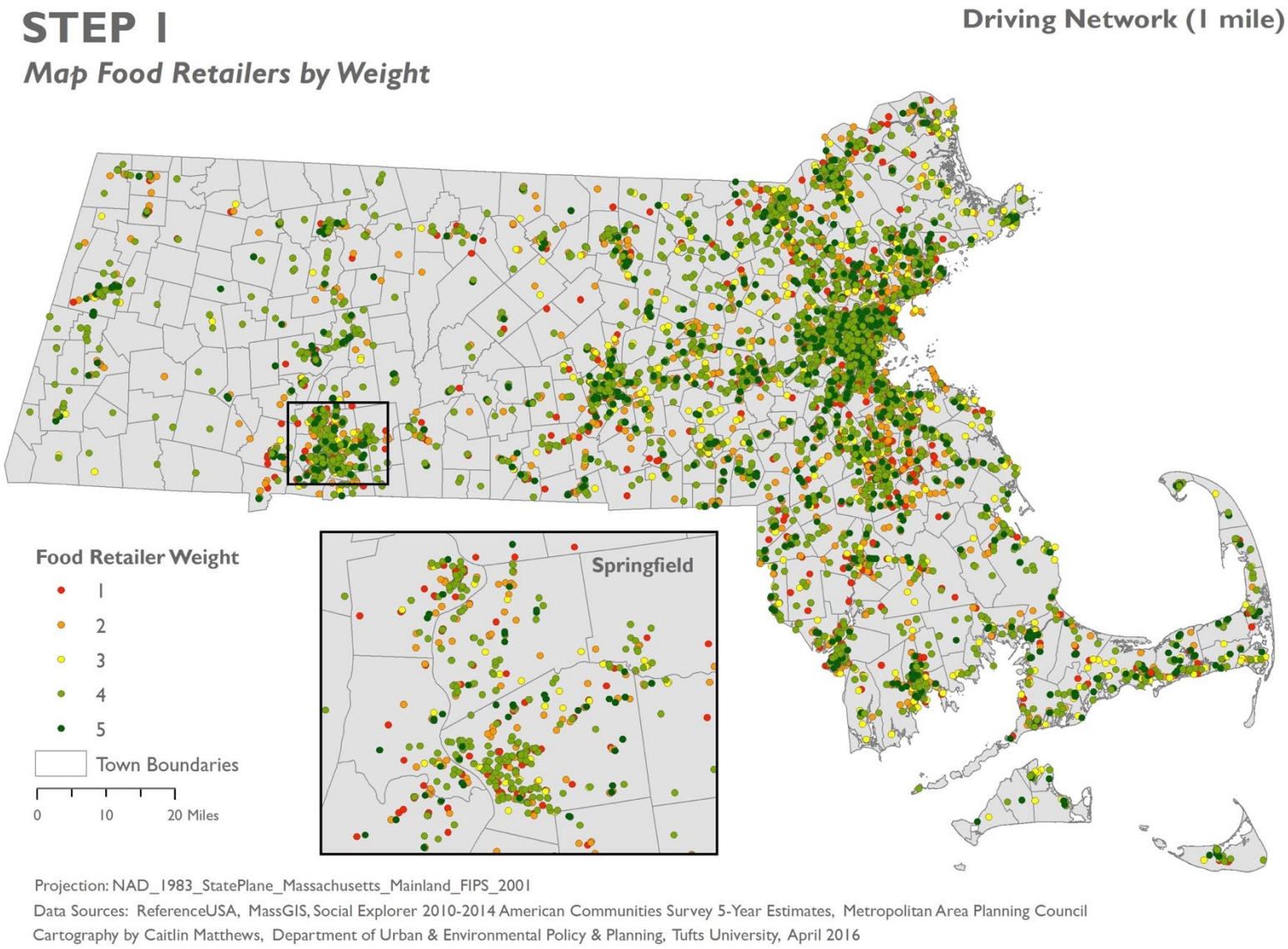


Figure 2. Illustration of Basic Step 1. Source: Caitlin Matthews

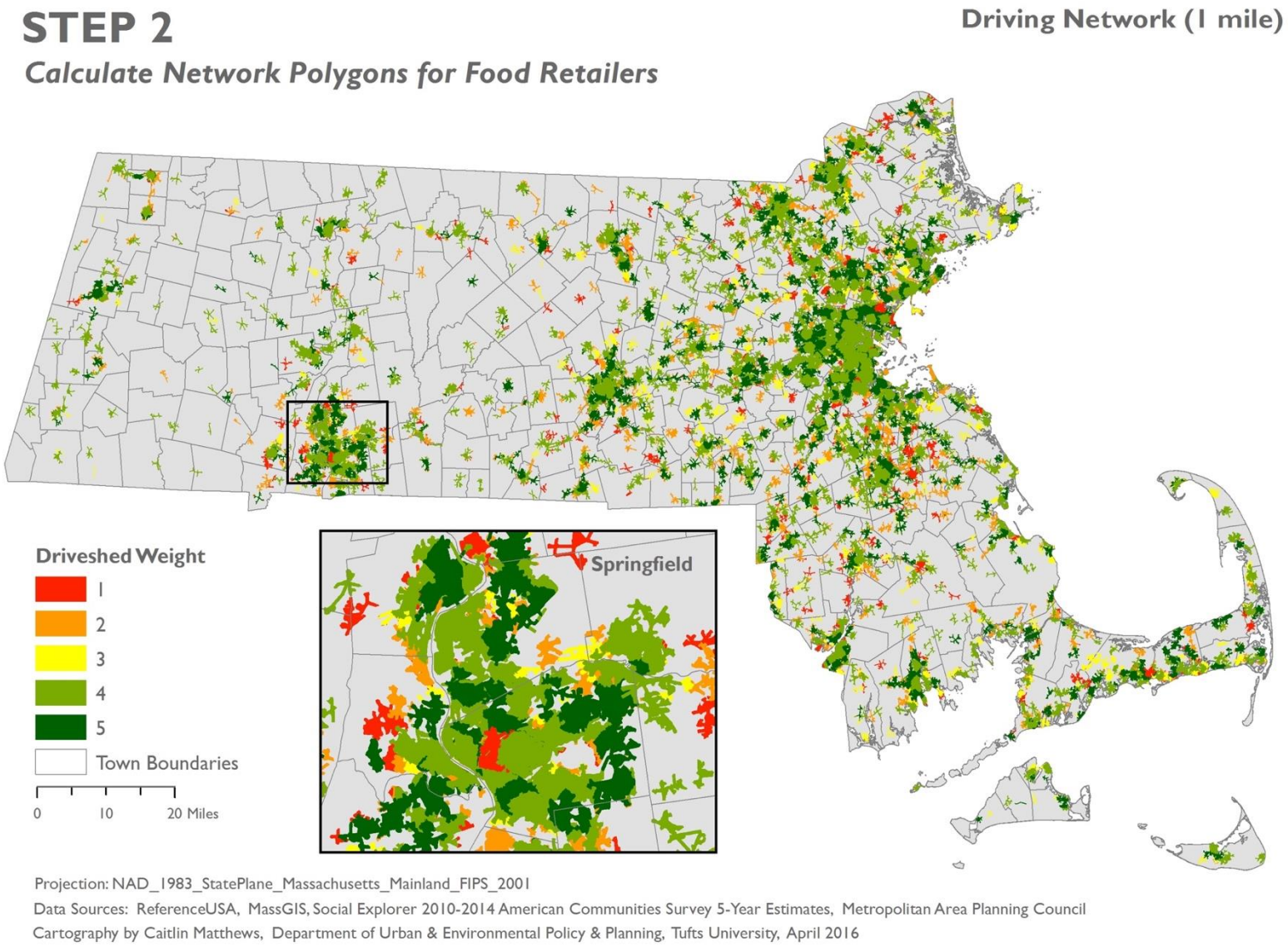


Figure 3. Illustration of Basic Step 2. Source: Caitlin Matthews

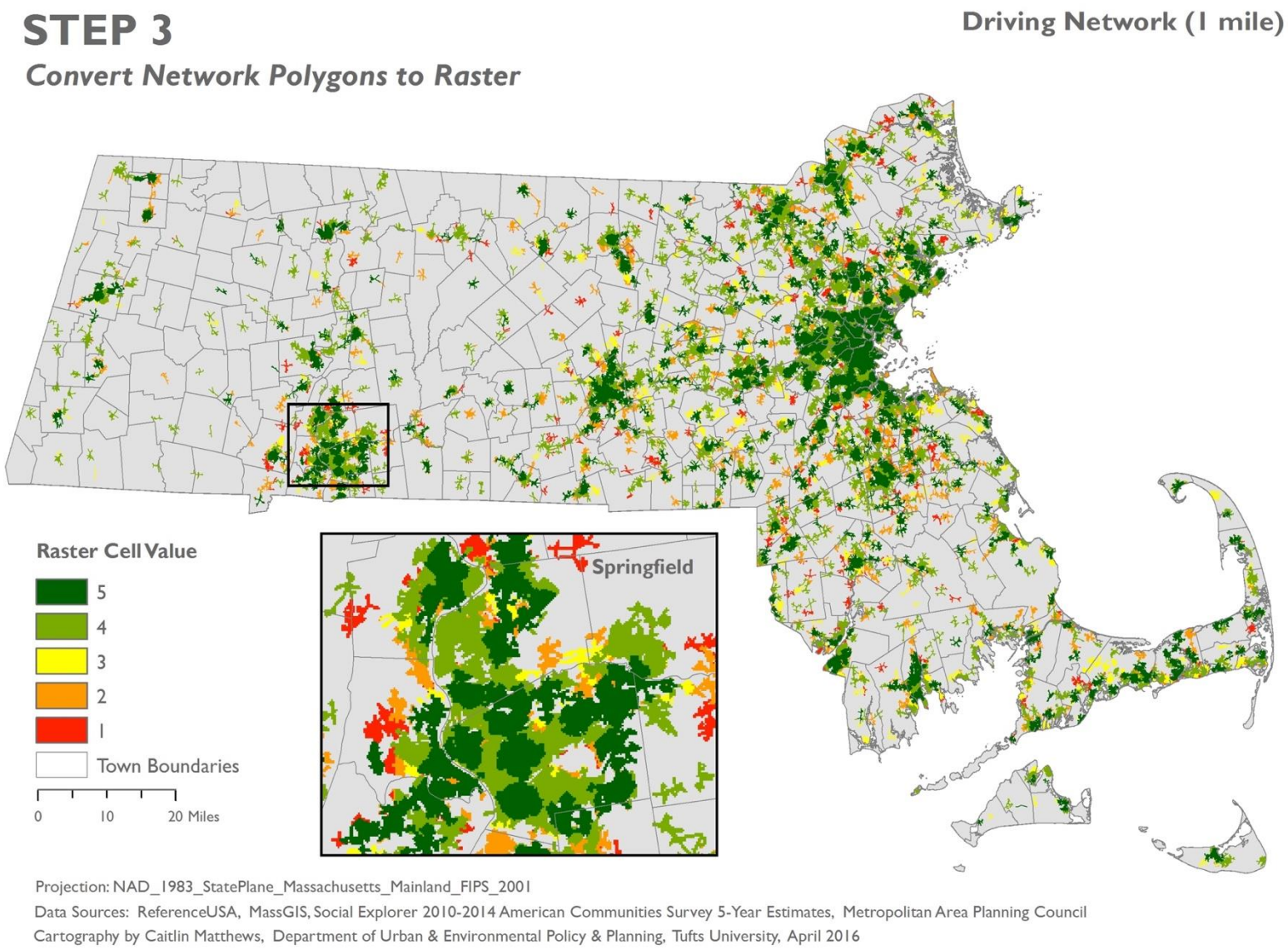


Figure 4. Illustration of Basic Step 3. Source: Caitlin Matthews

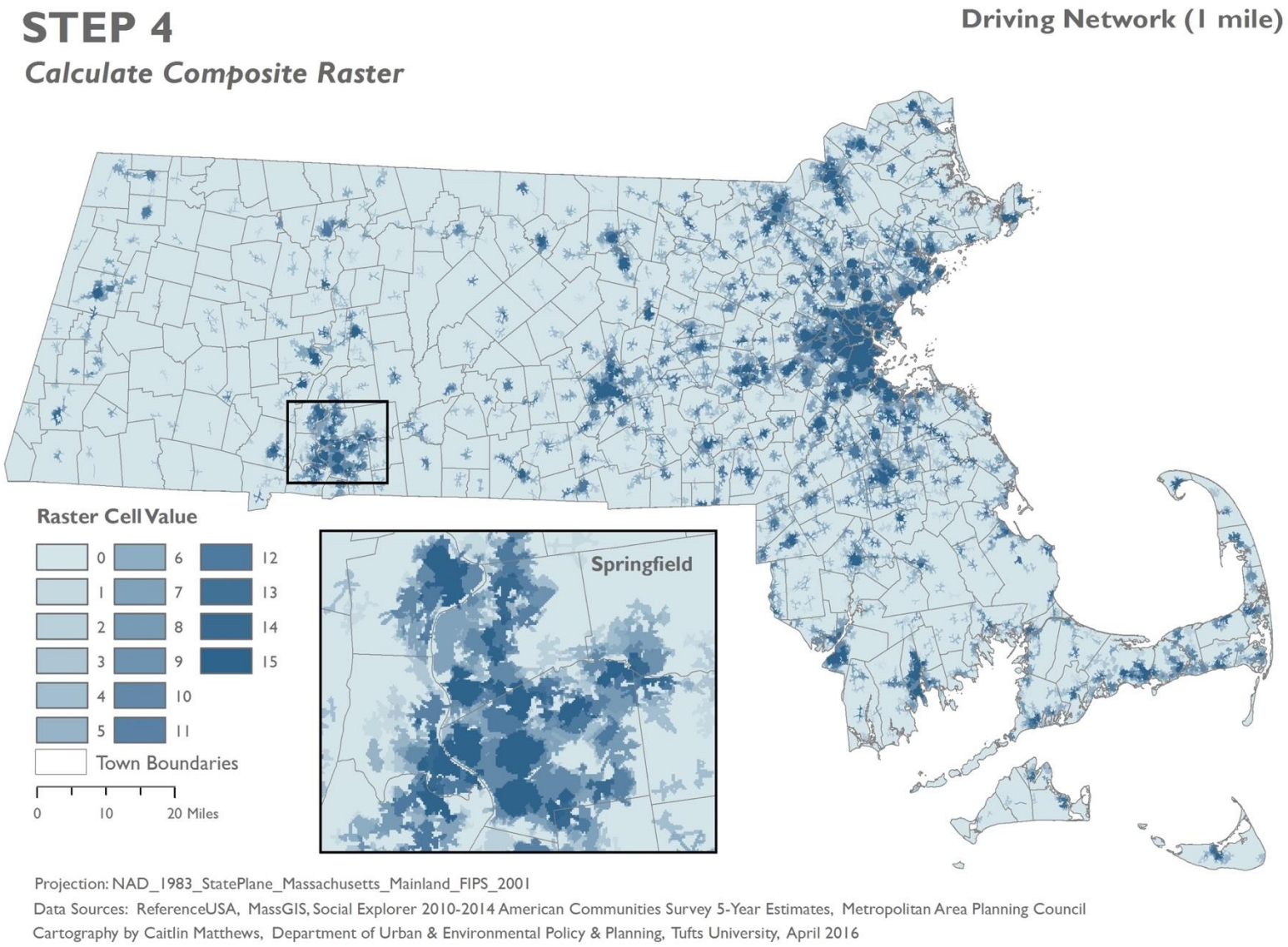


Figure 5. Illustration of Basic Step 4. Source: Caitlin Matthews

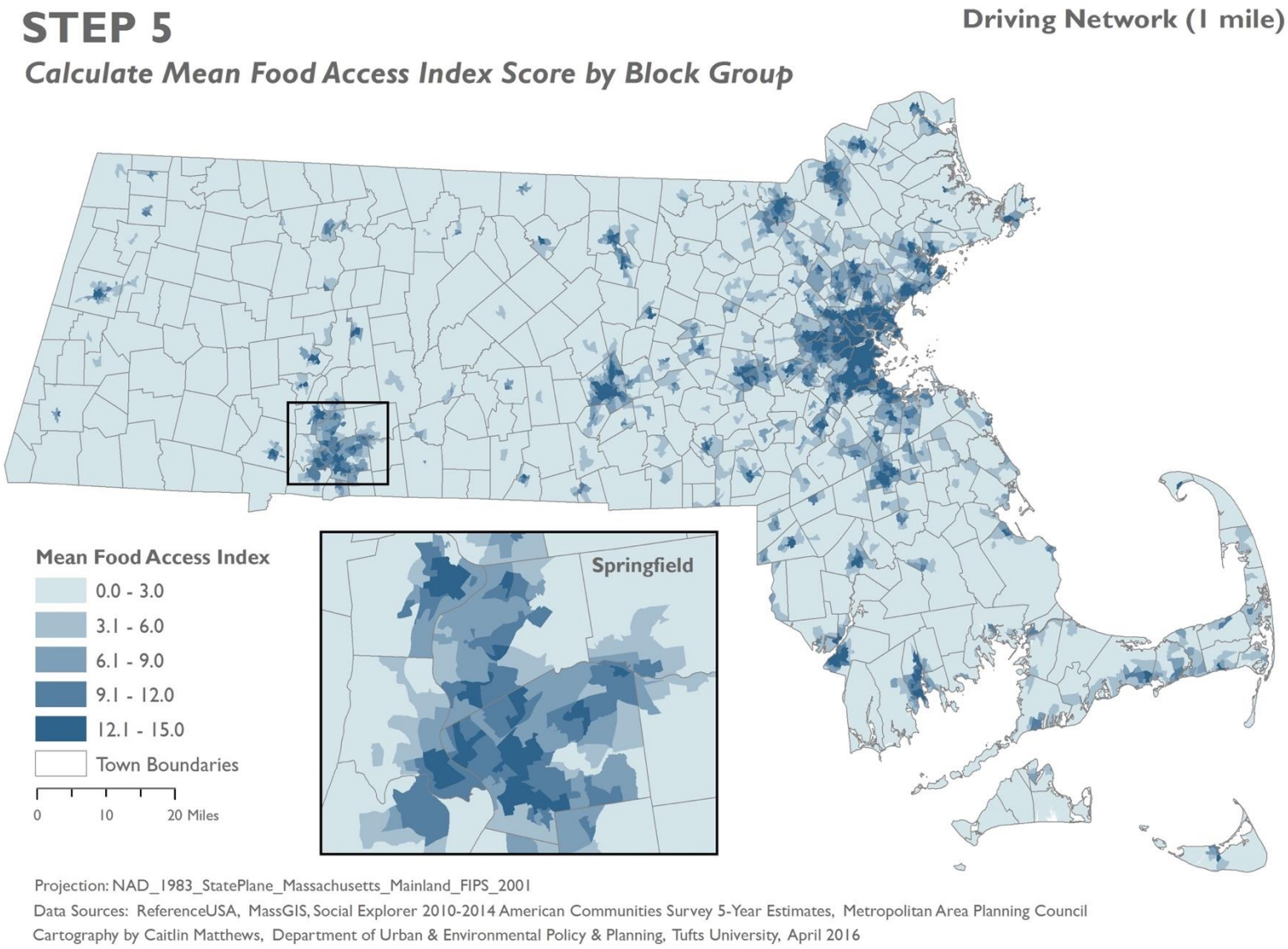


Figure 6. Illustration of Basic Step 5. Source: Caitlin Matthews

PART A: Access to what?

1. Create a dataset of food retailers in Massachusetts to include farmers markets and retailers with the following primary NAICS codes (see prior definition of NAICS codes on page 11 and further description in of use in Appendix C):

Supermarkets and Other Grocery = 445110
Convenience Stores = 445120
Meat Markets = 445210
Fish and Seafood Markets = 445220
Fruit and Vegetable Markets = 445230
Warehouse Clubs and Supercenters = 452910
Drug Stores and Pharmacies = 446110 (only including stores that sell food)
All Other Specialty Food Stores = 445299 (only including stores that sell "ingredients" and food to be consumed at home)

2. Assign relative weight categories to all of the food retailers based on the ability to procure healthy food options across the full diet. The weight categorization designed below relies on prior analysis of types of food retails and the availability of foods across the full diet. For example, supermarkets and large grocery stores commonly have food available to satisfy the full diet while specialty food stores or meat markets commonly do not. Square footage is used as a proxy for diversity of healthy choices; larger supermarkets are assumed to have a more diverse array of healthy choices.

5 - Supermarkets and Other Grocery (except Convenience) [>10,000 sf], Warehouse Clubs and Supercenters
4 - Supermarkets and Other Grocery (except Convenience) [<10,000 sf], Farmers Markets, and Fruit and Vegetable Markets
3 - Specialty Food Stores, Meat Markets, and Fish and Seafood Markets
2 - Convenience stores [>2500 sq ft], Pharmacies and Drug Stores
1 - Convenience stores [<2500 sq ft]

PART B: By what mode?

1. Calculate the geographic area by which a person can travel along road networks, a travelshed polygon, for all food retailers using MassDOT roads as the network data set. The network distances are as follows:
    a. For walkability: ¼-mile and ½-mile walksheds along walkable roads
    b. For drivability: 1-mile and 5-mile drivesheds along all roads

    Polygon travelsheds are clipped at 100 meters from the roadway.
2. Convert the travelshed polygons to raster datasets. Raster data essentially converts the polygons into pixels. This creates a binary layer for each food retailer weight, in which cells within a travelshed polygon equal the food retailer weight (1-5) and cells outside of travelshed polygons equal zero.
3. Add the raster layers together to create a composite food access index score for each travel distance.
4. Calculate a mean food access index score by block group at each network distance.

PART C: For whom?

1. Conduct descriptive statistical summaries and analyses based on the following demographic characteristics with data from the 2010-2014 American Community Survey 5-year estimates:
    a. Single parent households (percent of households in block group)
    b. Black or African American householders (percent of households in block group)
    c. Hispanic or Latino householders (percent of households in block group)
    d. Children under five (percent of block group population)
    e. Public cash assistance including SNAP (percent of households in census tract)
    f. Median Household income (by block group)
    g. Access to one or more vehicles (percent of occupied housing units in block group)
2. Conduct statistical summaries and analyses based on the following four community types adapted from MAPC's community typology:
    a. Inner Core
    b. Regional Urban Centers
    c. Suburban
    d. Rural

For a more detailed description of our methods, see Appendix C.

Working Assumptions

Throughout the course of the project our team has maintained various assumptions based on prior knowledge and literature review. These assumptions address some of the rationale behind the methodology of spatial and data analyses.

Several of these working assumptions address the decisions an individual might make to procure food. Firstly, all Massachusetts residents who live in bordering communities may procure food in other states. Our spatial analysis used only Massachusetts data and therefore may portray an imprecise picture of food access for communities bordering surrounding states. This model was also based on the assumption that people purchase food near where they live. This assumption is due to the fact that census data provides us with demographic and socioeconomic information on communities based on where people live, not where they work or otherwise spend significant amounts of time. Because of this assumption, it is possible that we misinterpreted how people access food and some people regularly acquire food from food retail locations near where they work or spend significant amounts of time. Our team made an additional assumption that full service grocery stores provide a vast amount of food options capable of satisfying an individual's dietary needs while a convenience store may not. Many of the limitations of our model are to be expected of a macro level study, and are not dissimilar from the limitations of previous food access spatial analysis studies. Community level assessments of food access that include elements of ground truthing and verification are able to overcome some of these limitations by using methods that are infeasible at the statewide scale.

Lastly, although the methods for spatial analysis we laid out are specific to Massachusetts, this framework was devised with the potential to be feasibly replicated in other states and communities. This replication is dependent on the availability of datasets and similarity in community types.

Datasets, and Data Sources

To create the statewide food retailer dataset, we collected farmers market data from MassGIS and food business information from ReferenceUSA. Once compiled, this dataset originally included more than 14,000 entries. We worked to clean and categorize the data, eliminating inappropriate or inaccurate data entries. This process of cleaning the data included removing all entries for which the primary NAICS code was not one of the eight that we included in our assessment, removing entries that were mislabeled as food retailers, and removing entries from the Other Specialty Food Stores and Drugstore and Pharmacy categories that do not sell food ingredients. See Appendix C, Part A for a more in depth description of this process.

We gathered other datasets, including road network datasets, from the Massachusetts Office of Geographic Information (MassGIS). Our partner MAPC provided the datasets related to community typology. Demographic information came from the 2010-2014 American Community Survey, downloaded from Social Explorer.

For a list of data sets included in our spatial analysis, see Appendix D.

Section IV: Discussion of the Massachusetts Food Access Index Model

Interpreting Food Access Index Scores

The range of index scores is from 0 through 15. A score of 0 represents lack of access to a food retailer of any weight category at the specified network distance. A score of 15 represents access to at least one food retailer of each weight category at the specified network distance. For many of the index scores, there are multiple combinations of food retailer weights that can lead to the overall score. Please refer to Appendix E for a detailed matrix of possible combinations leading to each index score.

The model is constructed in such a way that food retailers of the same weight category cannot be double counted in one index score. The decision not to double count food retailers of the same weight category allows the index score to reflect the diversity of options rather than allowing a high density of low-weight food retailers, such as convenience stores, to misrepresent access to healthy options across the full diet.

Very high (12-15) index scores indicate guaranteed access to at least one large-scale grocery store or supercenter within the specified network distance. Very low (0-3) index scores indicate guaranteed lack of access to a grocery store of any scale. Low (3-6) index scores indicate likely access to a smaller-scale grocery store, farmers market, or fruit and vegetable market. Moderate (6-9) and high (9-12) index scores indicate increasing likelihood of access to a large scale grocery store or super center.

Statewide Food Access

The following map, Figure 7, provides a reference of the geography, major road networks, and large cities throughout Massachusetts. The highlighted cities are the five cities in Massachusetts with populations greater than 100,000 people – Boston, Cambridge, Lowell, Springfield, and Worcester. This map helps to visually understand food access index scores; dense, urban areas are more likely to have higher sores than other community types, while parts of the state with large amounts of open space are more likely to have lower index scores as a result of low population density.

Following the reference map of Massachusetts, Figures 8 through 11 depict the Massachusetts Food Access Index at the four network distances that we analyzed – ¼ mi, ½ mi, 1 mi, and 5 mi. The first two index maps are based on walksheds, while the following two maps are based on drivesheds and include all road networks.

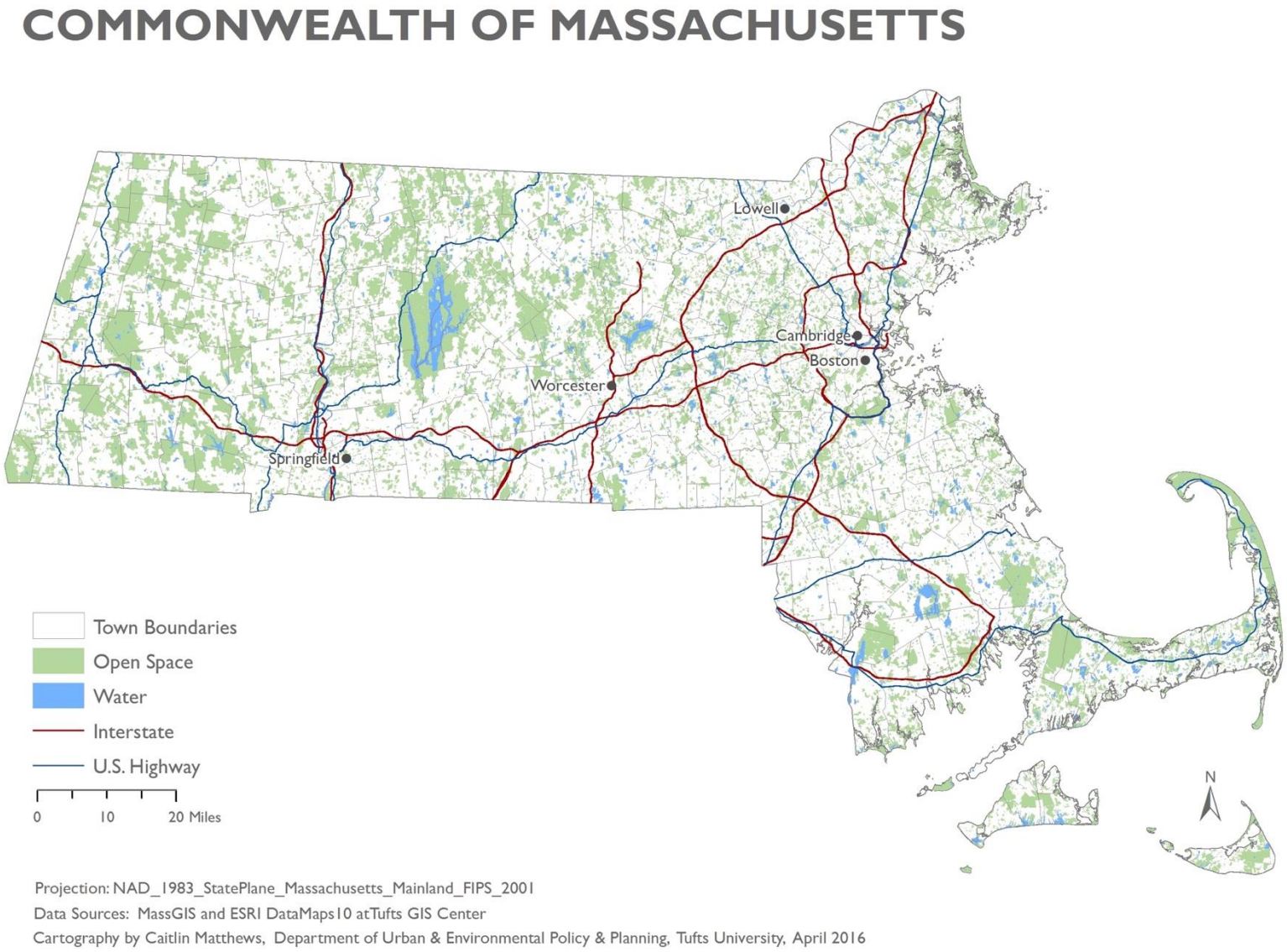


Figure 7. Overview of Massachusetts. Source: Caitlin Matthews

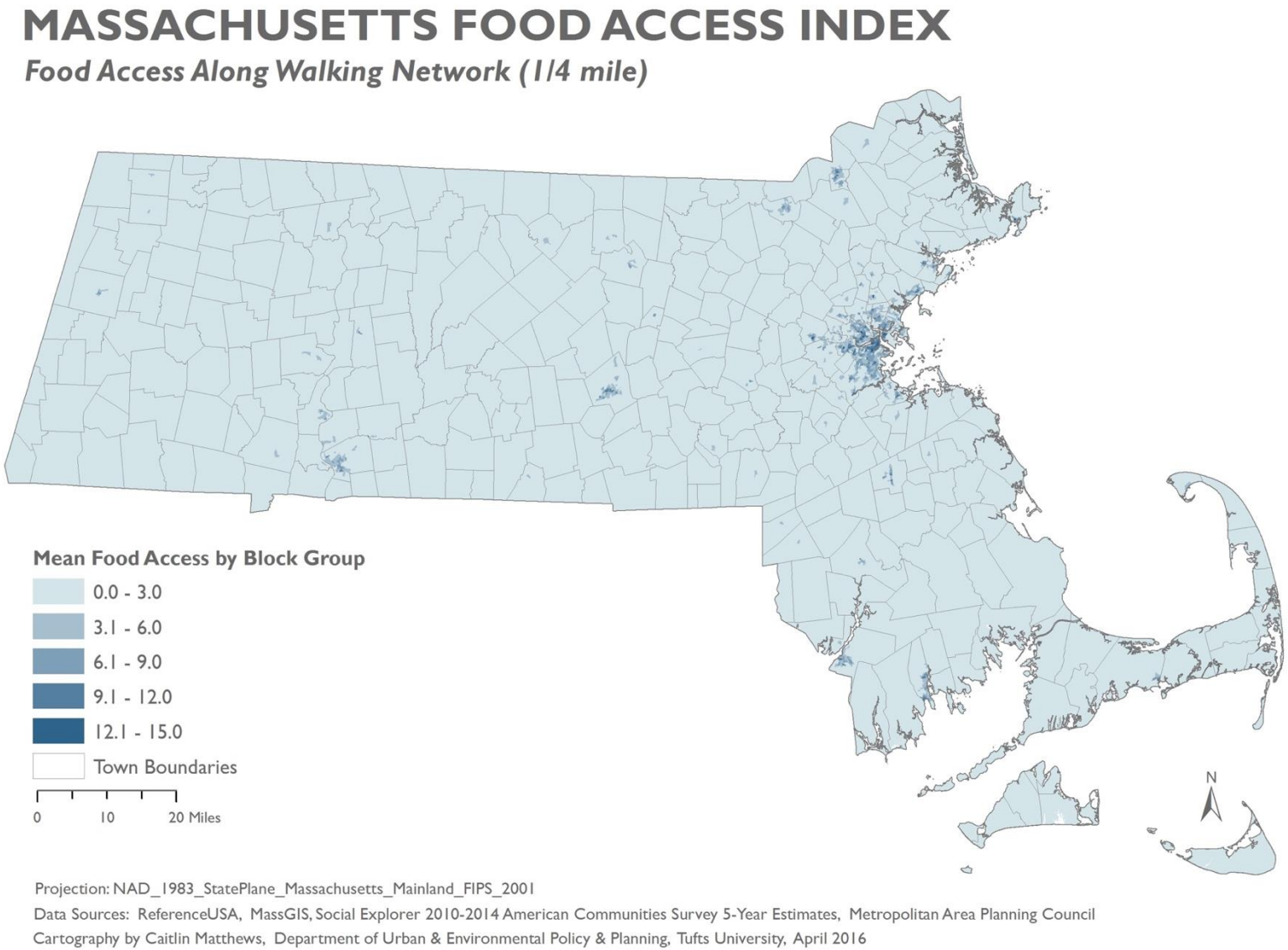


Figure 8. Massachusetts Food Access Index for 1/4 mile Network Distance. Source: Caitlin Matthews

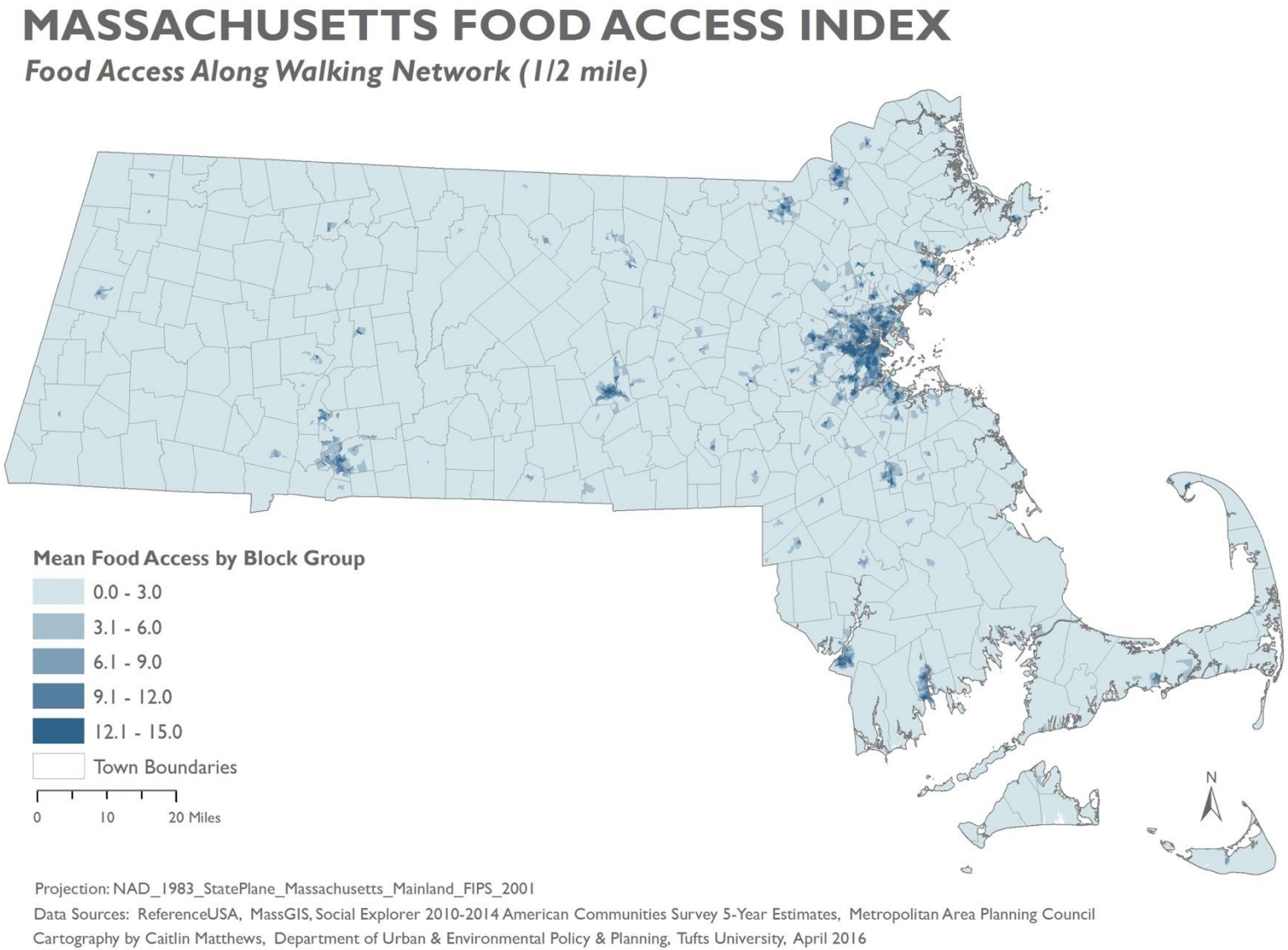


Figure 9. Massachusetts Food Access Index for 1/2 mile Network Distance. Source: Caitlin Matthews

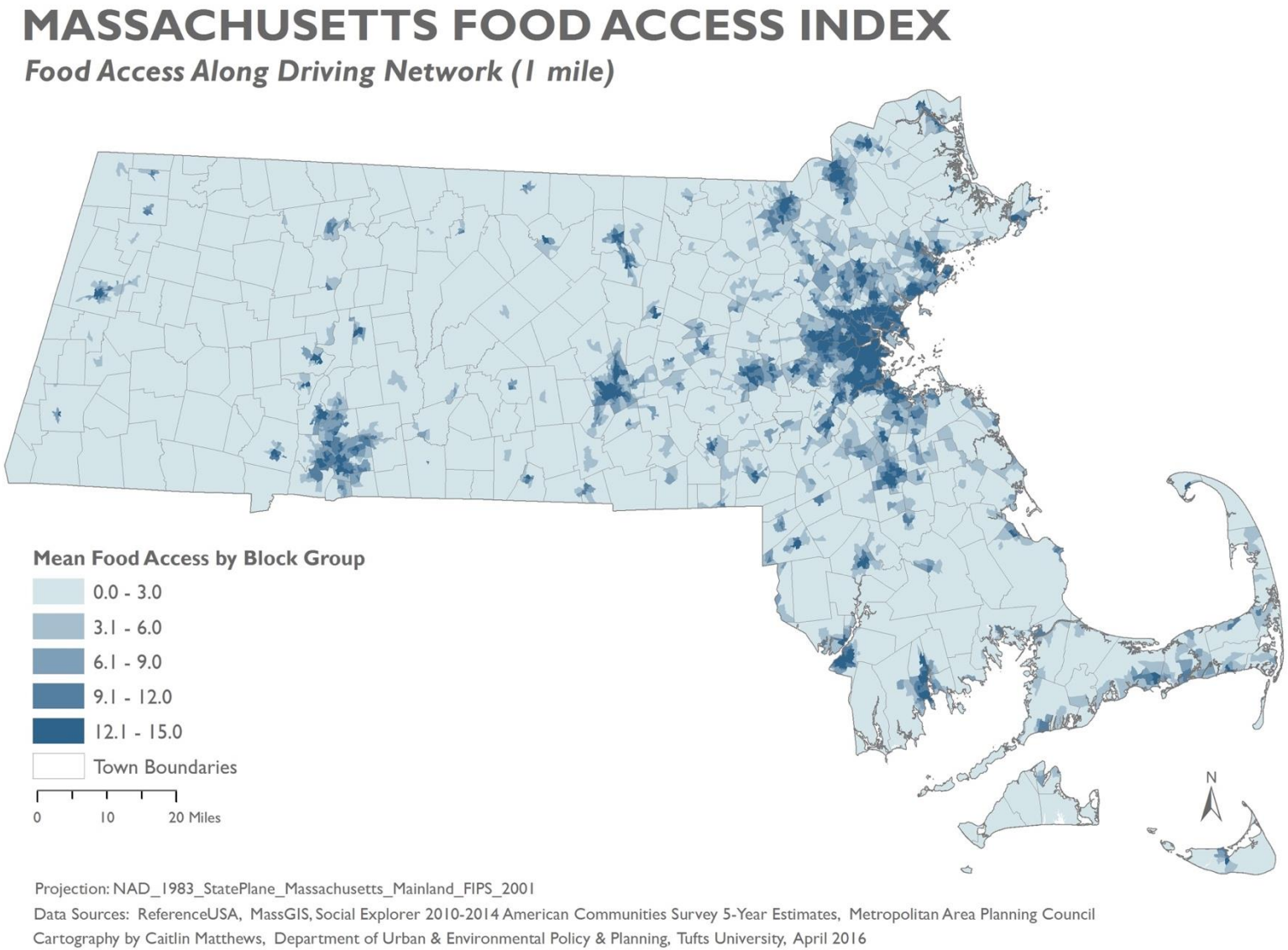


Figure 10. Massachusetts Food Access Index for 1 mile Network Distance. Source: Caitlin Matthews

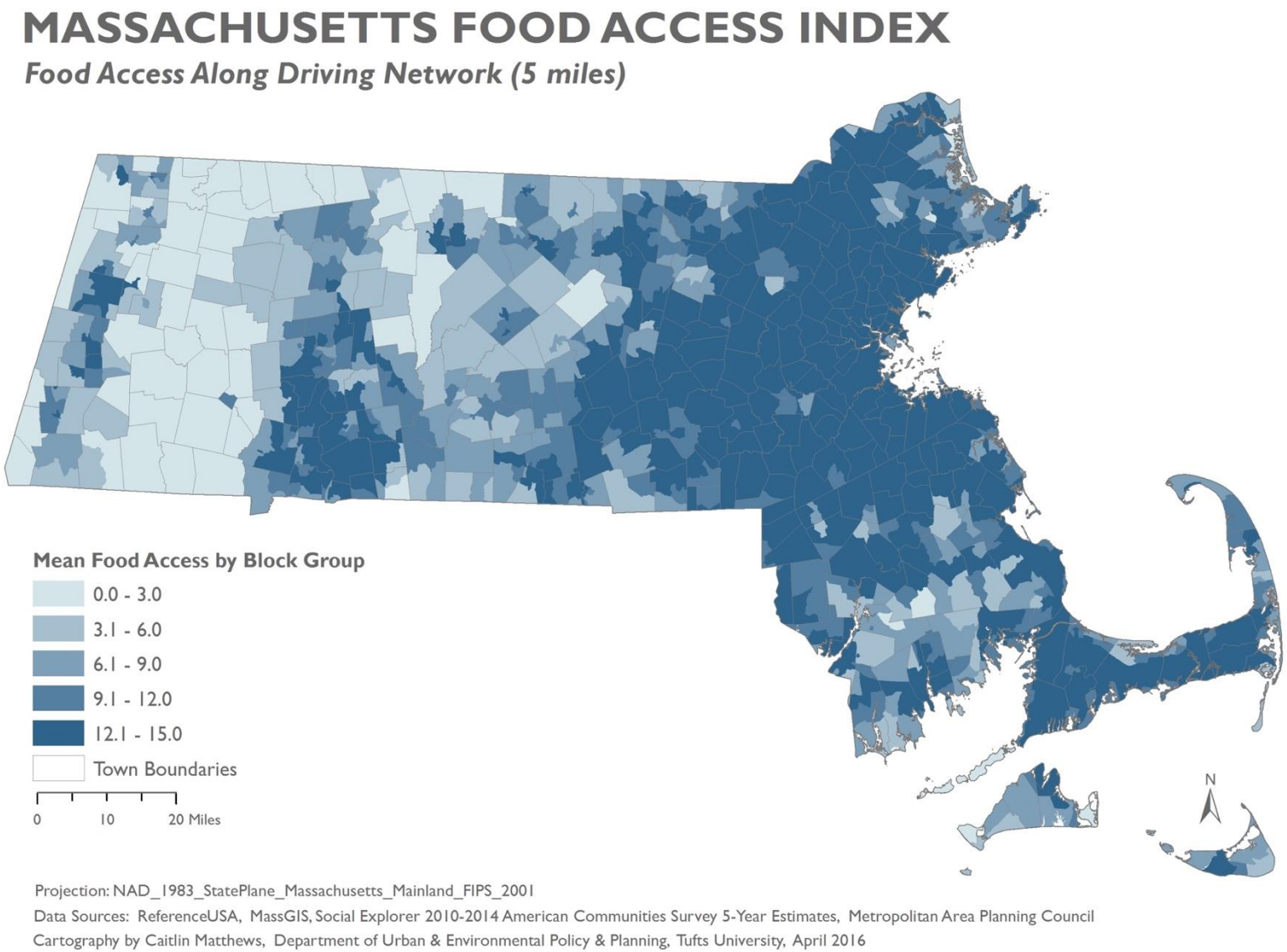


Figure 11. Massachusetts Food Access Index for 5 mile Network Distance. Source: Caitlin Matthews

On a statewide level, **the model of food access in Massachusetts highlights the general dependence people have on cars as a means of assessing food retailers**. Figure 12 illustrates the share of block groups at the various ranges of index score at all four network distances. As seen in Figure 13A, within a ¼ mile walkshed, none of the community types reached an average food access score of over 3.5. In fact, the average of the 4,979 block groups was 1.9 out of 15. At this same network distance, over 50 percent of block groups had food access scores of 0, illustrating that on the statewide level, people generally do not live within ¼ mile of food retailers. Convenience stores are the only type of food retailer associated with food access scores of this level, suggesting that individuals who live ¼ mile from food retailers cannot meet all of their dietary needs within this network distance. Increasing the walkshed to ½ mile increases average food access scores to 4 for the state; however, this score is still very low – under no circumstance would this score allow for access to a large grocery store, and about 33 percent of block groups had food access scores of 0 at this distance.

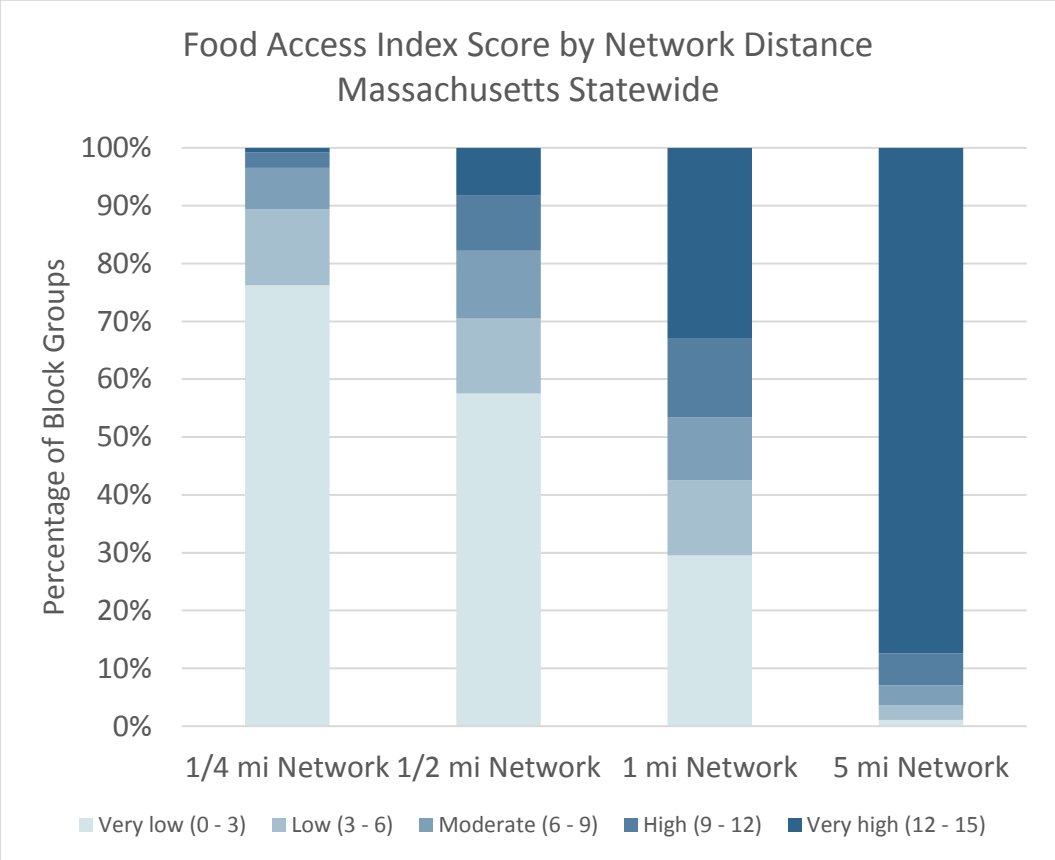
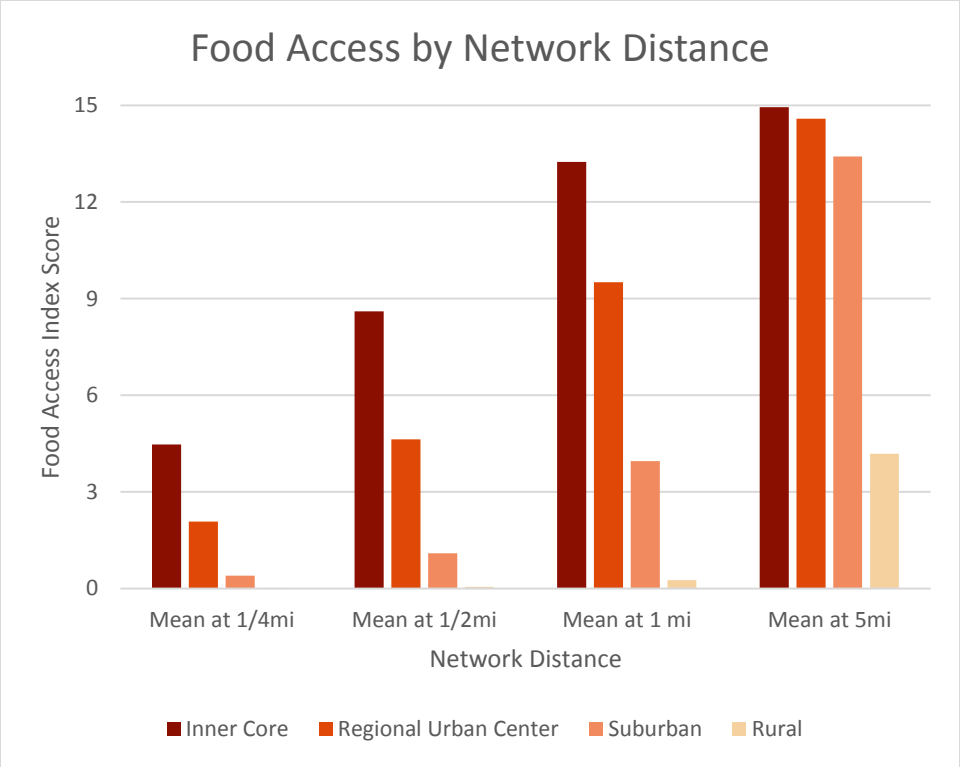


Figure 12. Food Access Index Score by Network Distance. Source: Caitlin Matthews



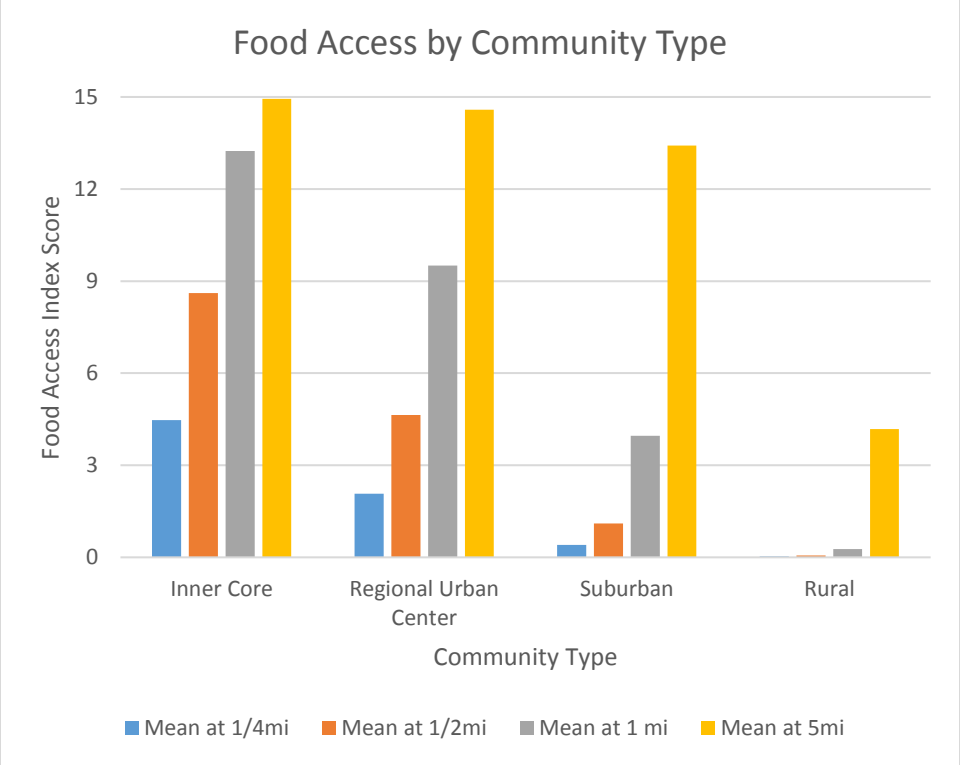


Figure 13. A and B. Food Access by Network Distance and Community Type. Source: Caitlin Matthews

In our assessment, larger travelsheds of one-mile and five miles were associated with accessing food by car, and as a result may include major highways that walksheds would not include. Increasing network distances to these more car dependent distances shows significant gains in food access scores. At a one-mile network there is the greatest distribution of average food access scores for all 4,979 block groups, with more than 10 percent of block groups having average food access scores of 0, while more than 20 percent of block groups having average food access scores of 15 (Figure 13). Overall, the average food access score for block groups throughout the state at a one-mile network distance reached a score of 7.9. Given the weighted categories of food retailers, at this distance the average block group had access to at least three different categories of food retailers (see Appendix E).

Given that some scores have multiple possible combinations – for instance, a score of 4 in a given network distance could mean that the block group has access to a small convenience store and a meat market or that it has access to a small grocery store – the score alone does not reveal which categories of food retailers people have access to. The food retailers included in the index vary significantly in the variety and quality of products that they sell. However, food access at a five-mile network distance resulted in a frequency distribution opposite of that for the ¼ mile walkshed. At five miles, over 70 percent of block groups had average food access scores of 15 and the overall average score was nearly 14. At this distance, block groups would have access to an average of four different categories of food retailers, suggesting high levels of food access.

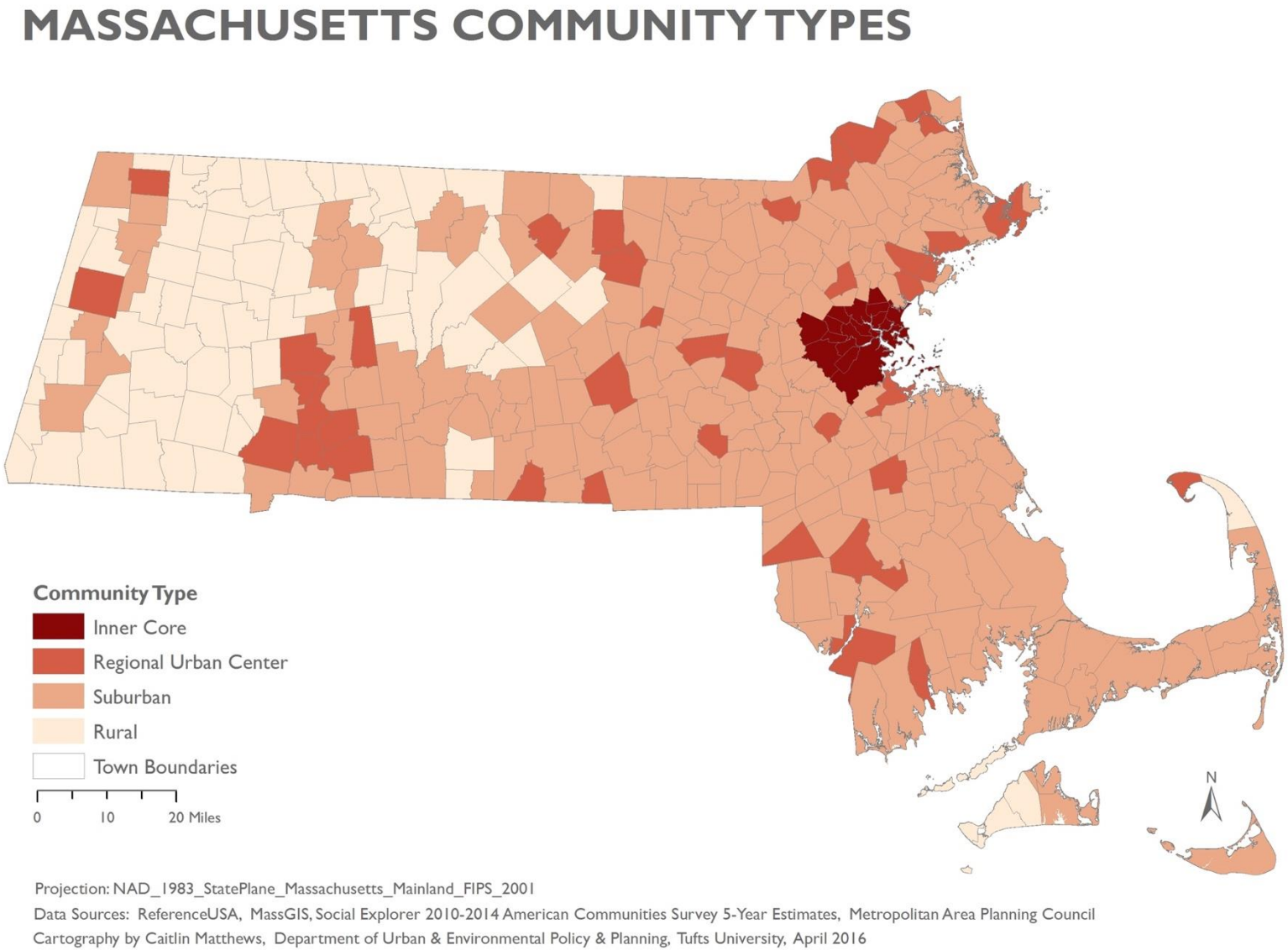


Figure 14. Massachusetts Community Types. Source: Caitlin Matthews

Community Types

Inner Core

Our analysis of food access in inner core communities illustrates that **accessing food by foot is a feasible option of acquiring food**, especially in comparison to other community types (Figure 3B). Within a walking distance of ½ mile, people living in inner core communities in Massachusetts have an average food access score of 8.6 out of 15, and within a smaller ¼ mile walkshed, people have an average food access score of 4.5.

The driveshed networks of one and five miles provide significantly more food access than networks associated with accessing food by foot. Within a one-mile driveshed people living in inner core communities had an average food access score of 13.2, while a five-mile driveshed resulted in an average score of 14.9, a nearly perfect score in our index. **Although the analysis of food access by car illustrates significant food access in inner core communities, these travel distances, especially a distance of five miles, are not very valuable to inner core communities**. Five miles generally extends far beyond neighborhood boundaries, and in some instances even city limits, distances that are typically not traveled to acquire food.[3]

Regional Urban Centers

Our assessment of food access in regional urban centers illustrated that while people living in these communities are not able to access food by foot as readily as those living in inner core communities, there is still some food access within ¼ and ½ mile walksheds – average scores of 2.1 and 4.6 out of 15, respectively (Figure 12B). Within a ½ mile walkshed regional urban centers have scores that are nearly half of what they are in inner core communities, including on average no access to a large supermarket.

Accessing food by car allows for much greater access. Within a one-mile travelshed there is an average food access score of 9.5 and within a five-mile travelshed there is an average score of 14.6. The large increase in food access scores between walksheds and drivesheds illustrates that **though people generally have the ability to access food retailers within walking distance of where they live, having access to a car significantly promotes greater food access**, especially access to the range of foods necessary to meet a full diet.

Suburban

As seen in Figure 12B, the accessibility of food for those living in suburban community types is very limited for ¼, ½, and even one-mile travelsheds. The highest level of access is seen at the five-mile travelshed where the average score reaches 13.4 out of 15. Thus, **most individuals**

[3] Our assessment does not take people's preferences of food into consideration. While it is possible that a person may travel five miles to access a particular food retailer that they prefer because of variety, price, or other factors, it is generally assumed that people will have access to closer food retailers.

with access to a car are more likely to have access to a range of food retailers to meet basic dietary needs.

Rural

From our assessment of community types, it becomes clear that rural communities have the lowest levels of food access. All four travelsheds – quarter-, half-, one- and five-mile – have scores lower than 5, with the highest being 4.1 out of 15 at five miles. The average of the four travelsheds only reaches 1 out of 15, which shows that **rural regions of Massachusetts are largely car dependent** in order to access food. In comparison with other community types, the rural community has the lowest average food access score at each travelshed.

Demographic Characteristics

The following sections include analyses of the relationship between food access index scores and various demographic characteristics. Each characteristic has corresponding statewide maps and figures highlighting the prevalence of characteristics throughout the state and their relationship to food access scores across the different network distances.

Householder Demographics

We analyzed a number of different characteristics relating to the demographics of householders to see how characteristics such as race, ethnicity, and single parenthood relate to food access index scores. In our analysis we focused on minority racial and ethnic groups, specifically Black or African American householders (Figure 15) and Hispanic or Latino householders (Figure 16), as these two groups are generally perceived to have poorer access to food than people of other backgrounds. We also focused on single parent households (Figure 17). In the analysis, particularly for householders, race, and ethnicity, we were especially interested in the shorter network distances, ¼ mi and ½ mi, because in Massachusetts there are generally larger populations of minority groups in urban areas than in suburban or rural areas.

Our analysis of the relationship between various demographic characteristics - single parent households, Black or African American householders, and Hispanic or Latino householders - illustrated similar trends (Figures 18-20). For each of these characteristics in the walkshed networks, block groups experienced convex trends, initially increasing as food access scores increase, peaking, and then declining as food access scores neared 15. The shape of these curves illustrates the greater social impacts of living in urban areas that have either very high or very low food access index scores. Both walkable and car dependent urban communities are often associated with higher costs of living, as a result of increased rent or vehicle dependence, which are often related to demographic characteristics.

In contrast, the driveshed network distances of one and five miles show that as food access index scores increase the percentage of community members in each of the demographic categories also increases. This contrast between the walkshed and driveshed networks can be attributed to factors of both population density and the unequal distribution of single parent and minority households across urban and suburban and rural communities. See the maps of single parent households, Black or African American householders, Hispanic or Latino householders on the preceding pages for the geographic patterns of these demographic characteristics. Car dependent communities with high food access index scores show higher percentages of single parent, Hispanic or Latino, and Black or African American households than car dependent communities with lower food access index scores. Though these communities are car dependent to access food, they may lie within or just outside of the periphery of urban areas, making them less desirable but more affordable than walkable urban centers. This may depict the effects of gentrification on minority communities in urban areas.

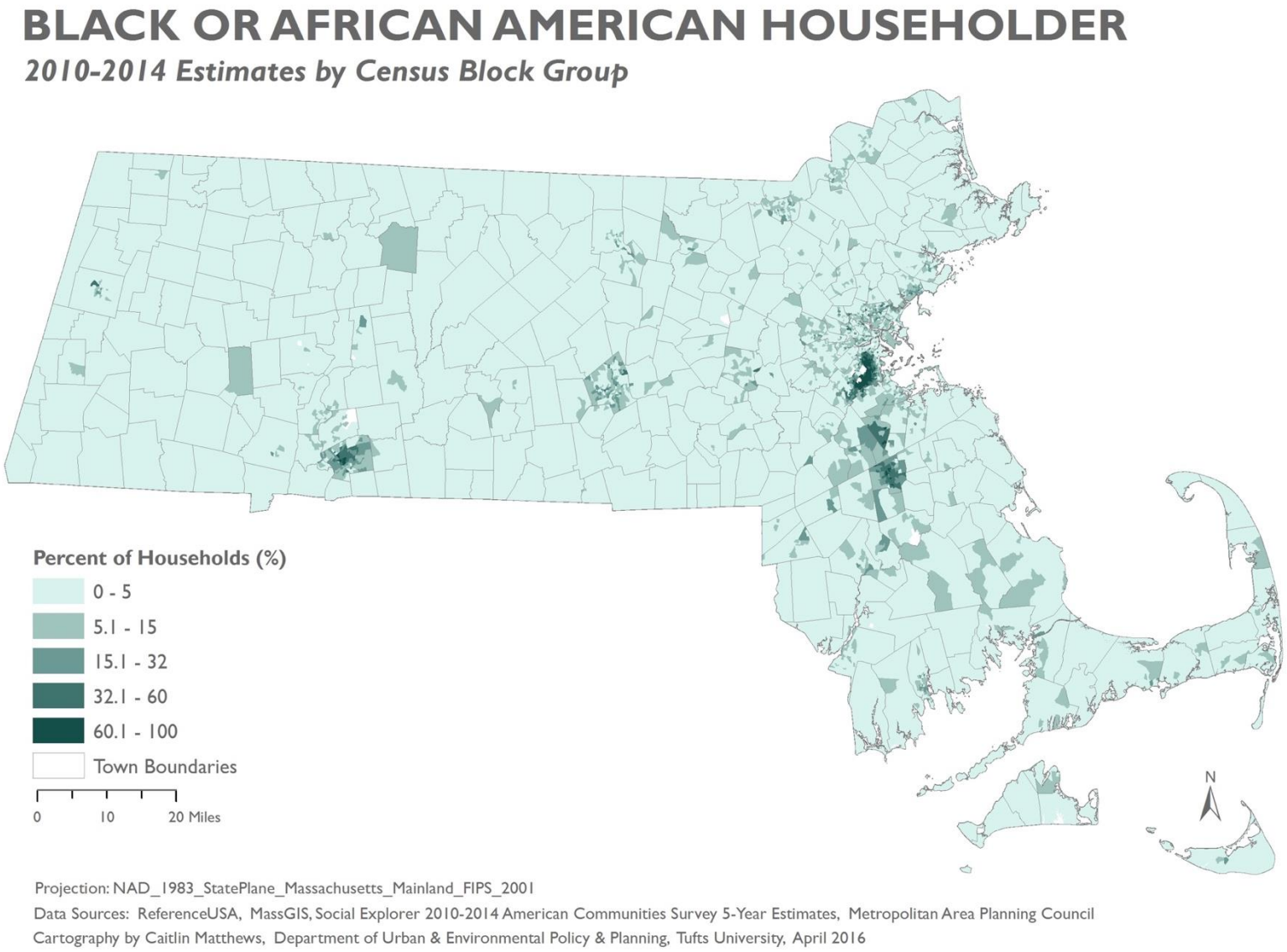


Figure 15. Black or African American Householders as Percentage of Total Block Group Householders. Source: Caitlin Matthews

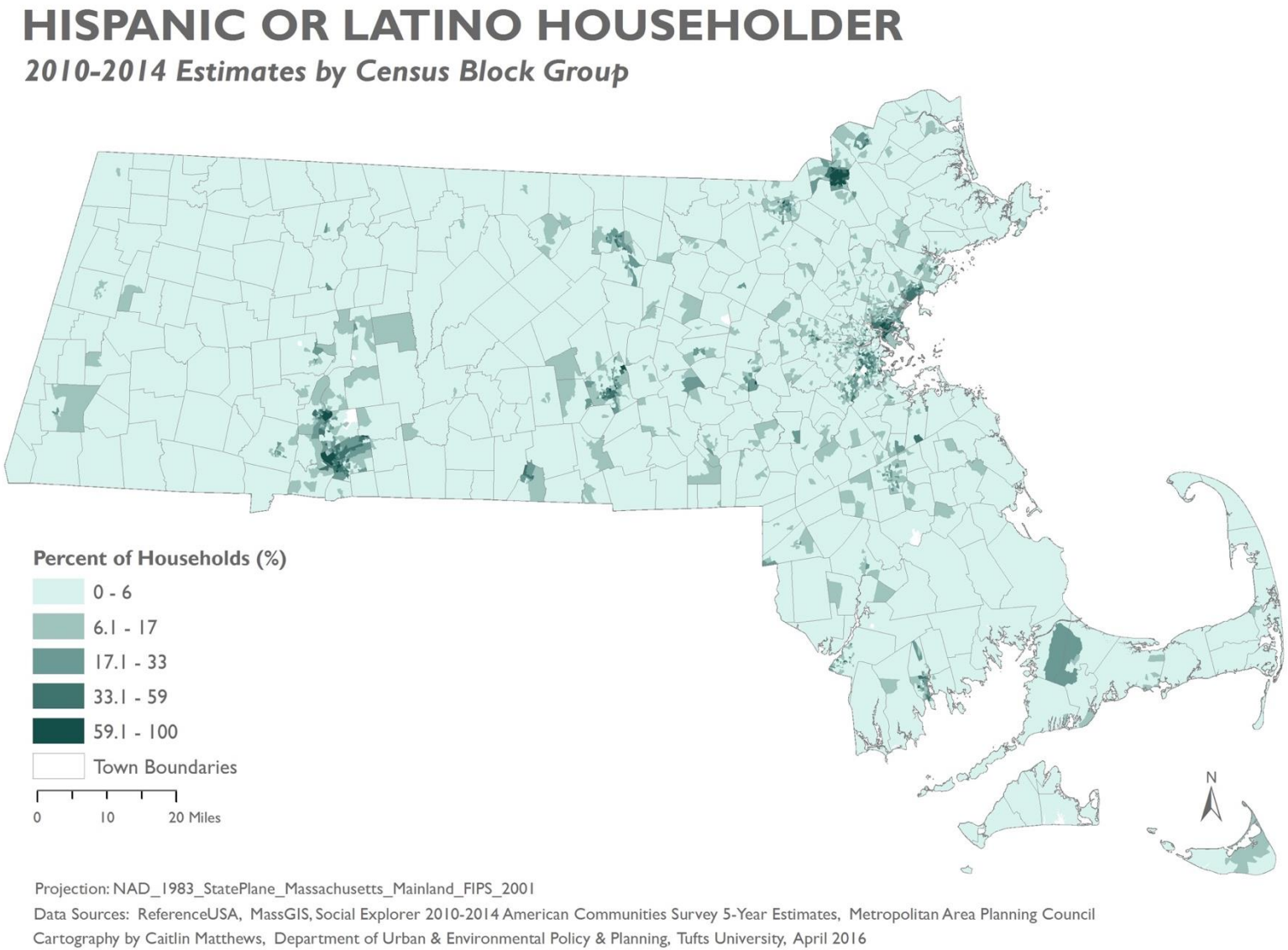


Figure 16. Hispanic or Latino Householders as Percentage of Total Block Group Householders. Source: Caitlin Matthews

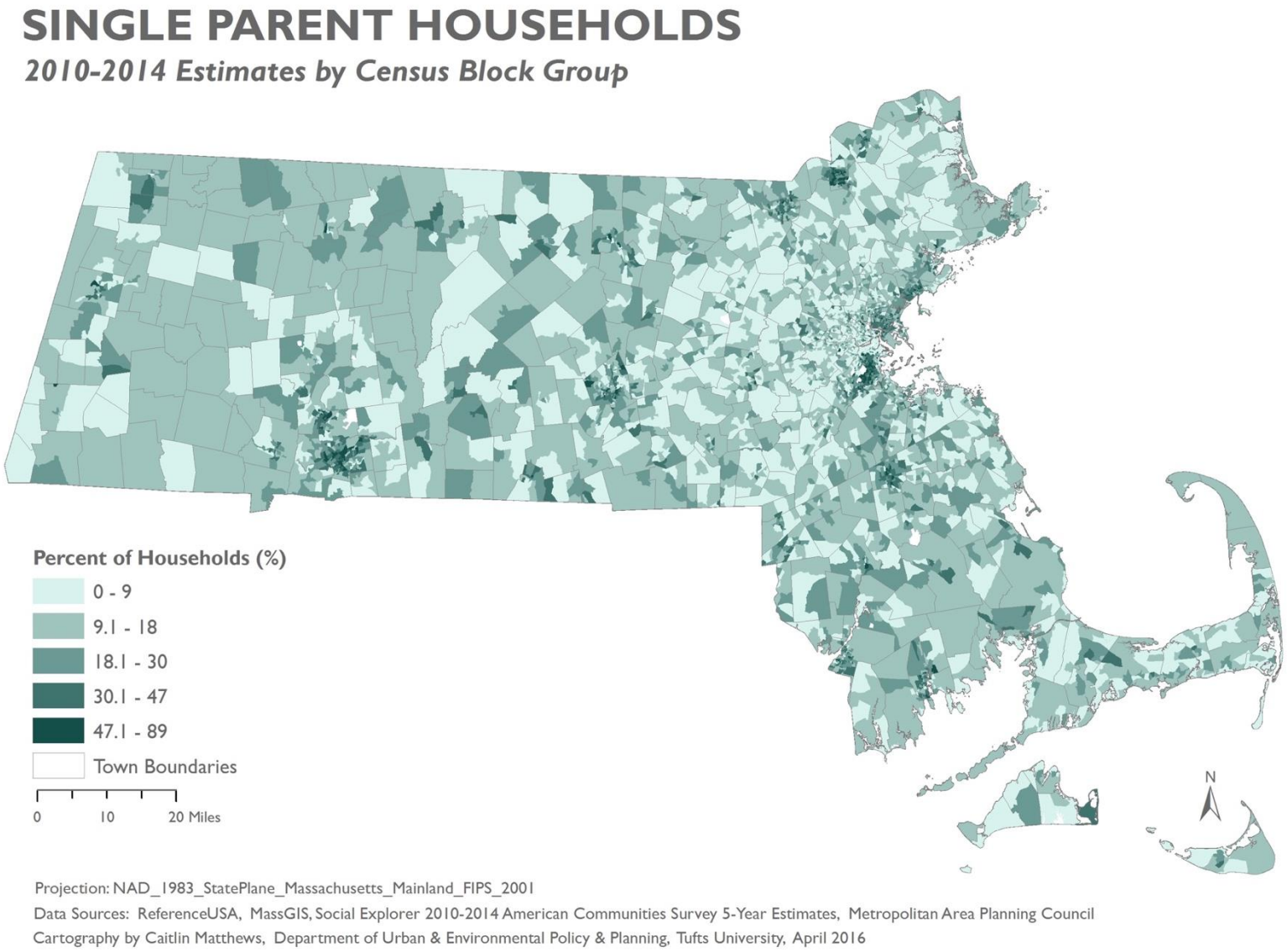


Figure 17. Single Parent Households as Percentage of Total Block Group Households. Source: Caitlin Matthews

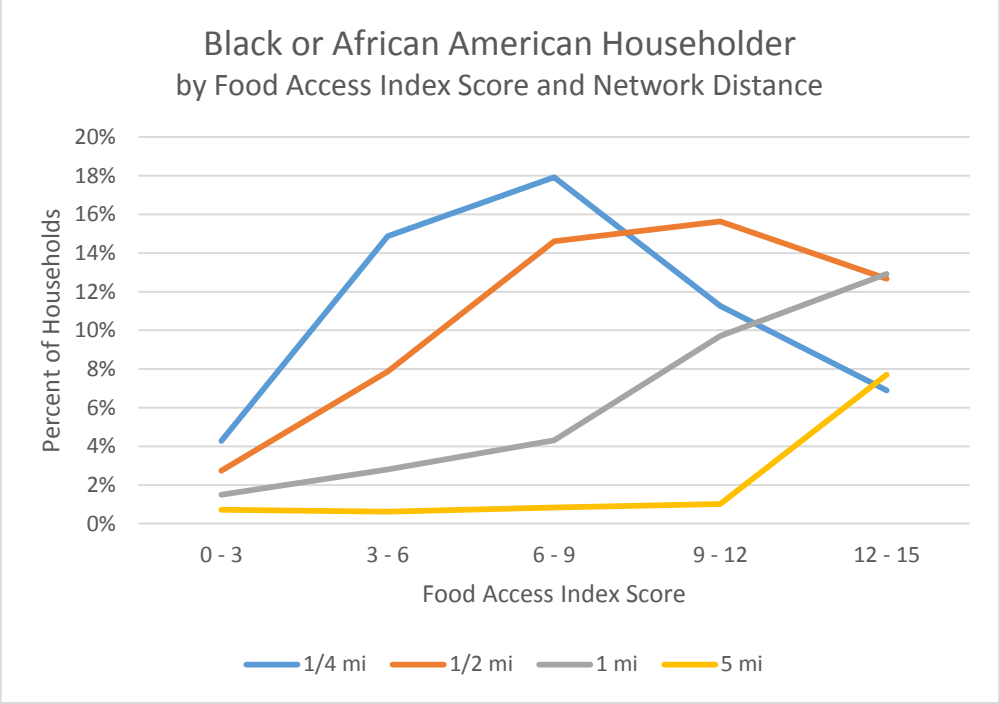


Figure 18. Black or African American Householder by Food Access Index Score and Network Distance. Source: Caitlin Matthews

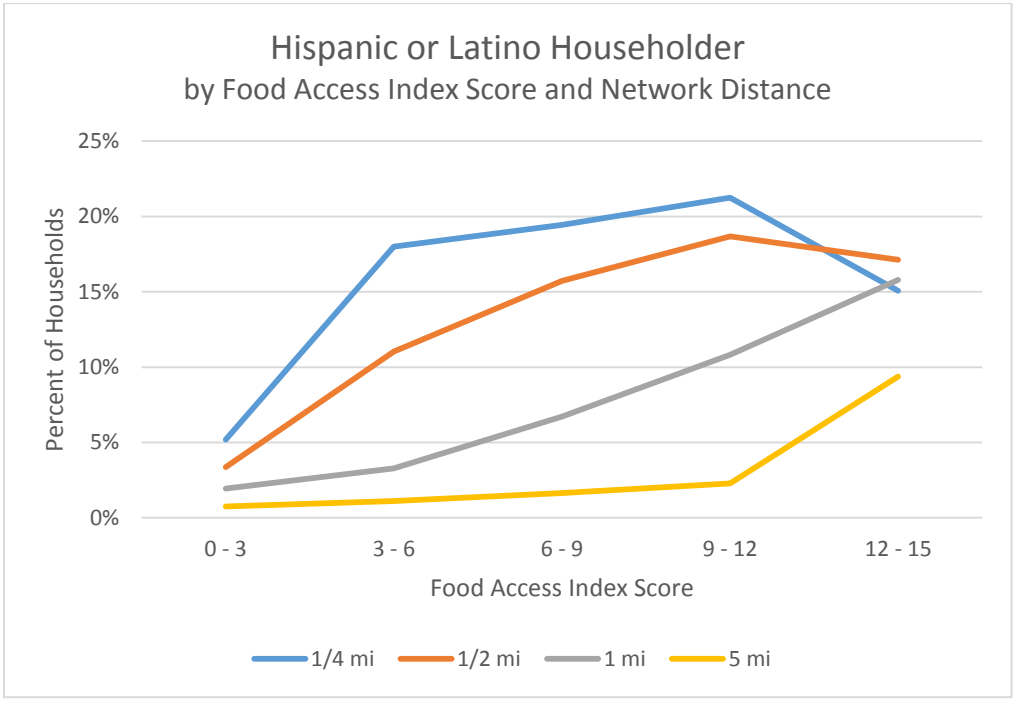


Figure 19. Hispanic or Latino Householder by Food Access Index Score and Network Distance. Source: Caitlin Matthews

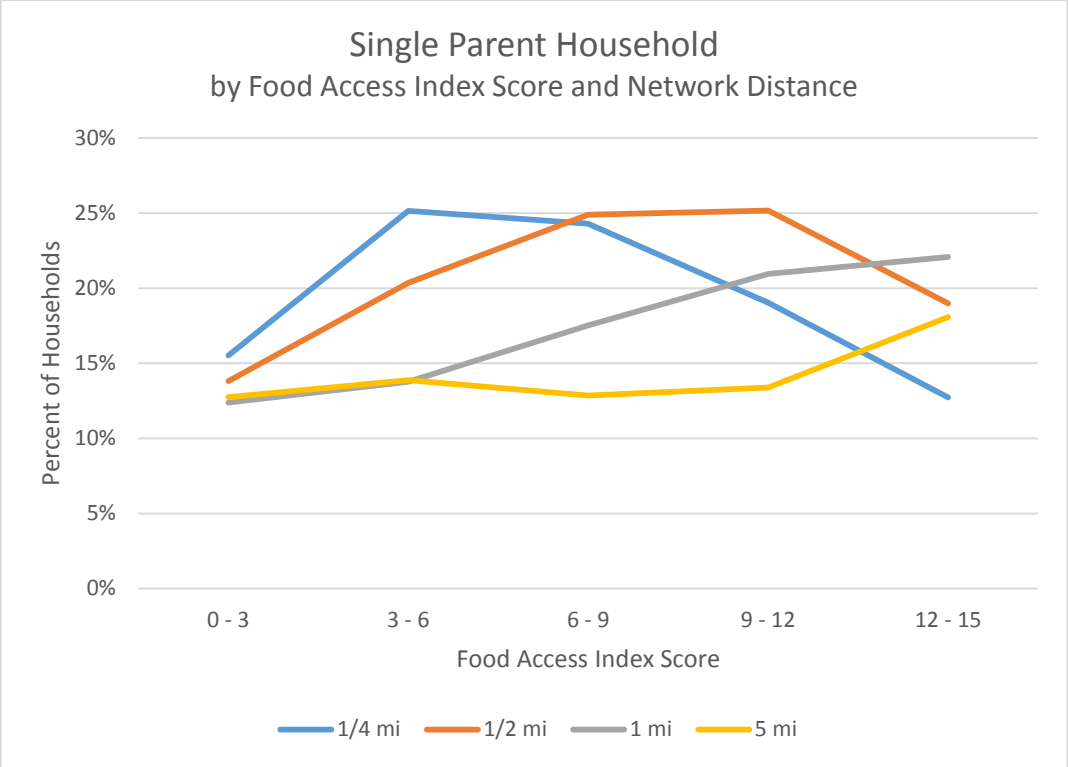


Figure 20. Single Parent Households by Food Access Index Score and Network Distance. Source: Caitlin Matthews

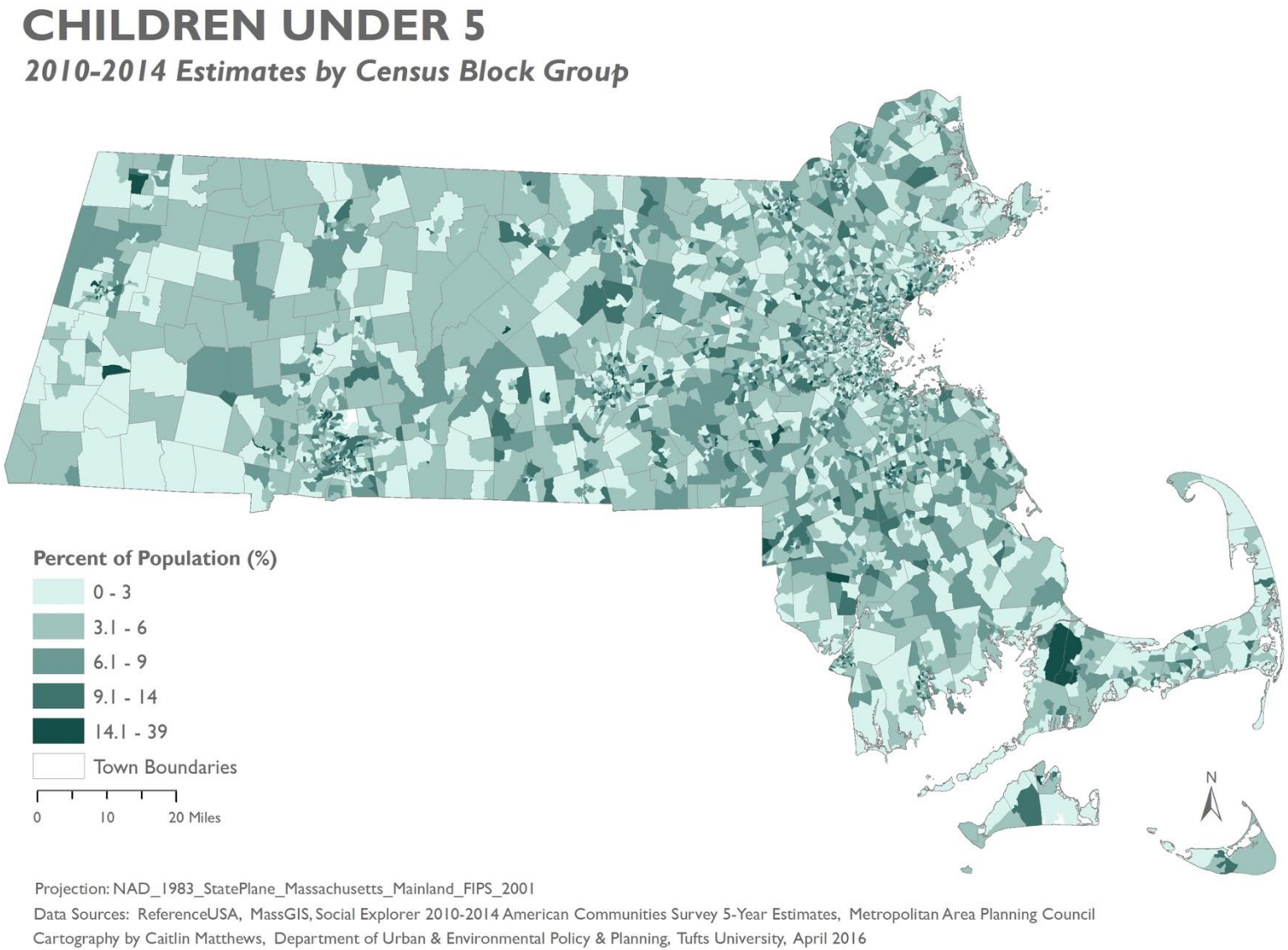


Figure 21. Children Under 5 as a Percentage of Total Block Group Population. Source: Caitlin Matthews

Children Under 5

We included analysis of the relationship between the percent of children under the age of five and block groups' food access index scores because children under the age of five are considered to be a vulnerable population in regards to food insecurity, as they are not yet enrolled in school and are unable to receive free breakfast and/or lunch. The relationship between food access and the percent of a block group's population that is comprised of children under five years of age mirrors similar trends to race, ethnicity, and single parent households (Figure 22). These trends can be related to variations in population density across urban and suburban or rural communities. It must be noted, however, that of the four demographic characteristics that were analyzed, the population of children under five showed the least variation across network distances - at its greatest the range was 2.17 percent of total population.

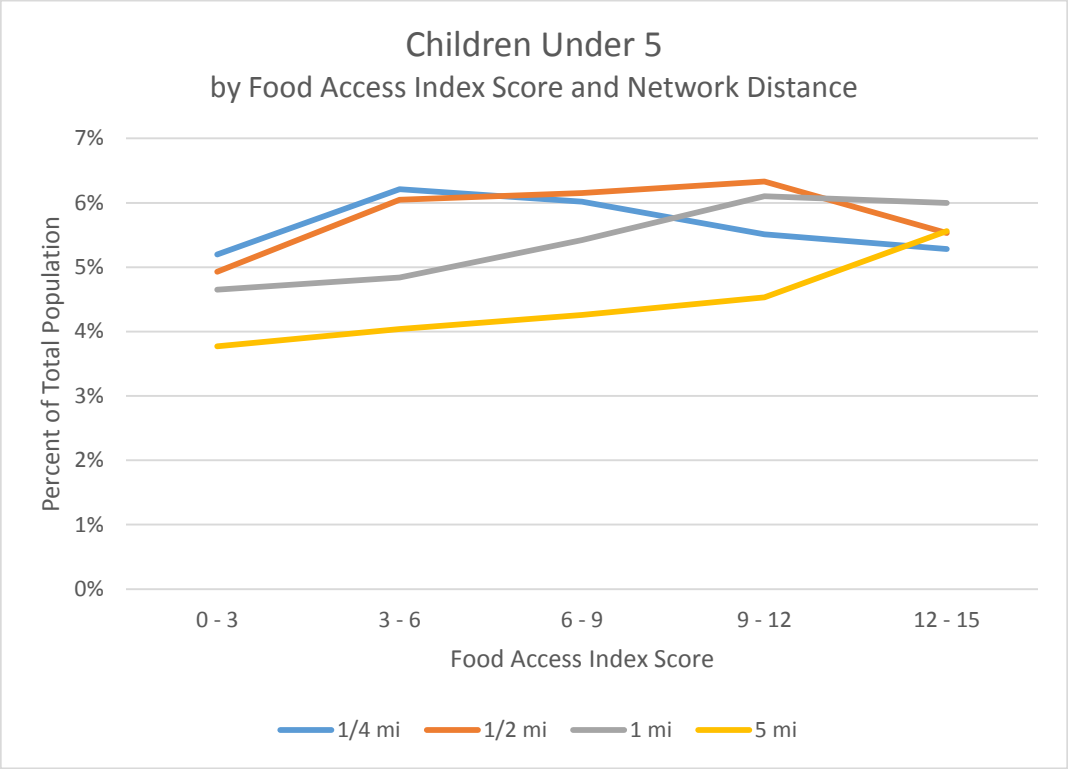


Figure 22. Children Under 5 by Food Access Index Score and Network Distance. Source: Caitlin Matthews

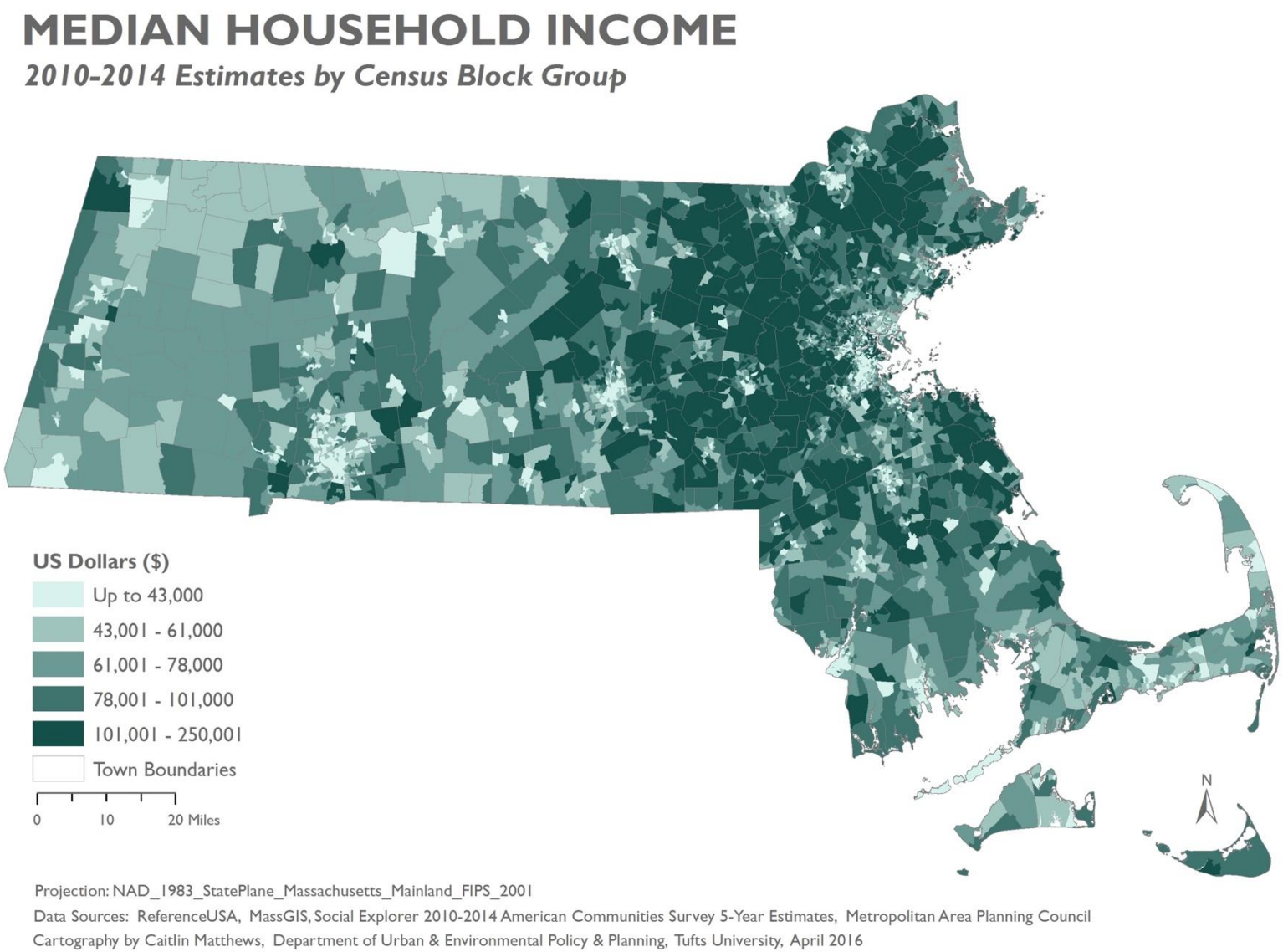


Figure 23. Median Household Income by Block Group. Source: Caitlin Matthews

Socioeconomic Status

Median Household Income

Generally speaking, low-income households have lower food access than higher income households. This is likely attributable to the prohibitively high cost of living in areas with high food access, especially within walking distance. The relationship between median household income and network distances varies significantly across food access index scores (Figure 24). For the walkshed networks (¼ and ½ mile networks), median household income is highest for the extreme low and high scores of the index. This speaks to the relative expense of living very close to or rather far from food retailers. For the low range of food access, higher median household income may reflect the access to and dependence on a vehicle. For the high range of food access, higher median household income likely reflects the higher cost of living in walkable neighborhoods.

The one-mile driveshed suggests a linear relationship between median household income and food access index scores where income declines as food access index scores increase. This trend could be explained by the transition from car dependent middle- or upper-class suburban communities to lower income urban communities. The five-mile driveshed illustrates a trend unlike those seen in the other network distances. At this distance, there is a slight convex trend between median household income and food access index scores, though the overall variation of median household income is the lowest at this level than all other levels.

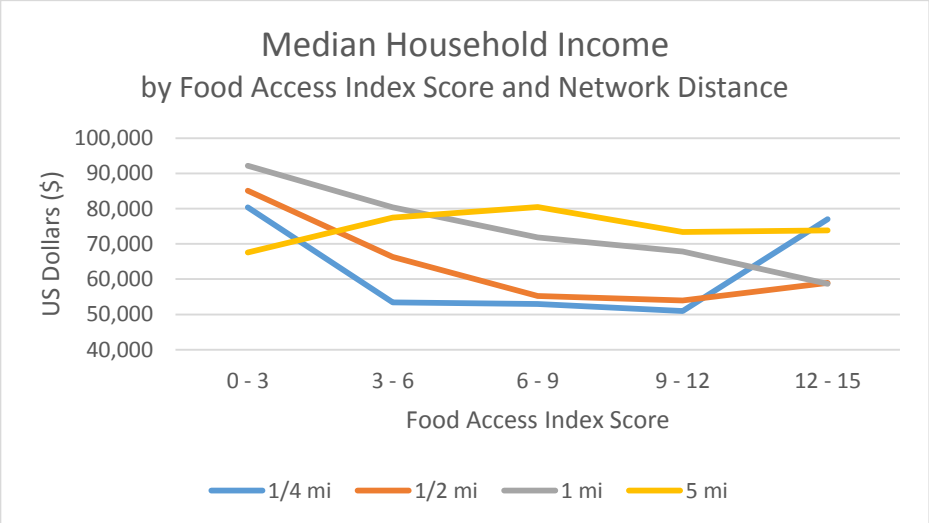


Figure 24. Median Household Income by Food Access Index Score and Network Distance. Source: Caitlin Matthews

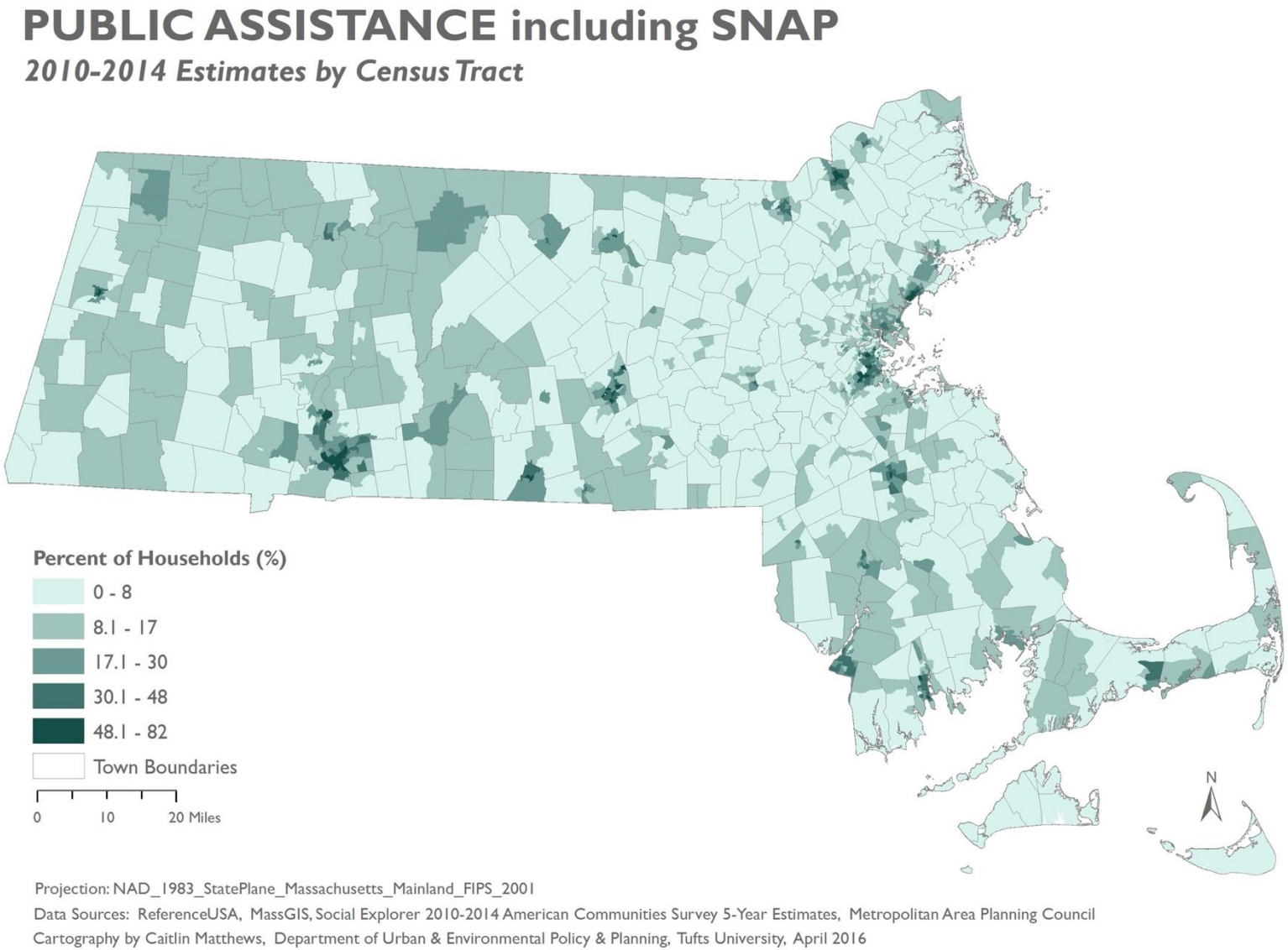


Figure 25. Percentage of Block Group Households Receiving Public Assistance. Source: Caitlin Matthews

Public Assistance including SNAP

Households that receive public assistance, including participation in the Supplemental Nutrition Assistance Program (SNAP) have low household incomes. As previously discussed, low income levels are related to poor food access, suggesting that communities with high percentages of households receiving public assistance would have low food access index scores. Similar to the demographic characteristics of single parent households and the race and ethnicity of householders, the relationship between the percentage of the population receiving public assistance and food access index scores is convex for the walkshed networks and linear for the driveshed networks (Figure 26). These trends can be correlated to the median household income of communities and can also be related to population density in urban communities compared to suburban or rural communities, as well as the cost of living in particular types of communities.

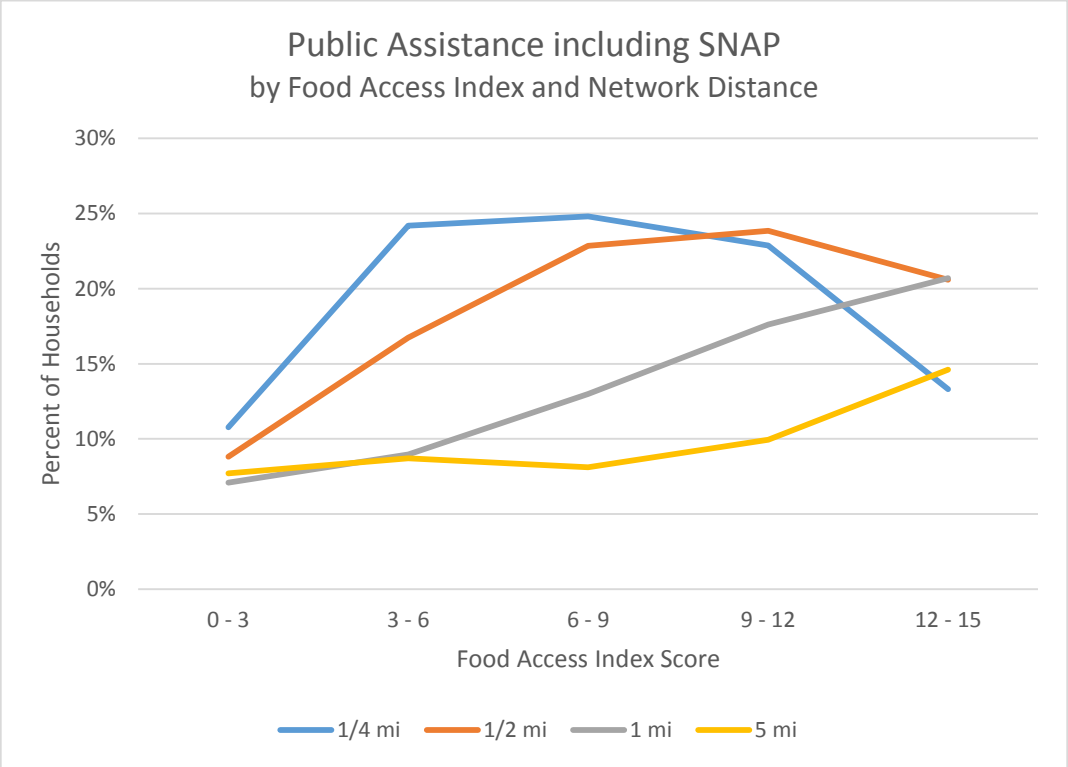


Figure 26. Public Assistance including SNAP by Food Access Index Score and Network Distance. Source: Caitlin Matthews

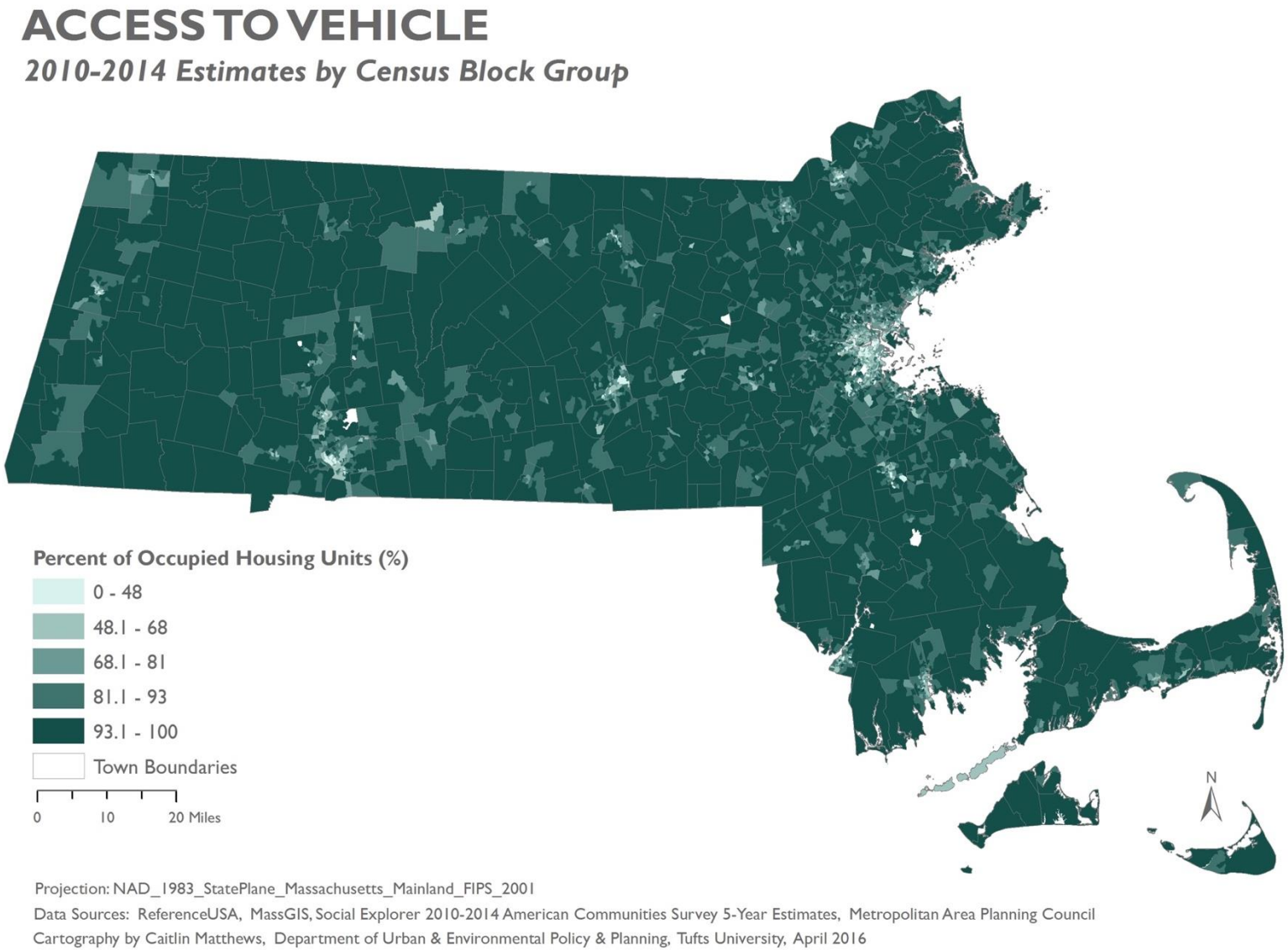


Figure 27. Percentage of Occupied Housing Units with Access to a Vehicle. Source: Caitlin Matthews

Access to Vehicle

Though it depends on the type of community that people live in – urban, suburban, or rural – people are largely dependent on cars to access food. A household's ability to access a vehicle can thus have significant impacts on its food access index score. Likewise, a household's food access index score can influence a person's dependence on a vehicle. Regardless of network distance, average vehicle access across block groups declines as food access index scores increase (Figure 28). This decline is most notable in the walkshed networks. In a ¼ mile walkshed, vehicle access by household declines from over 90 percent to under 60 percent as food access index scores increase from 0 to 15. In communities with the lowest food access index scores, nearly all households across network distances have access to a vehicle. In communities with food access index scores in the range of 12 to 15, vehicle access ranges from 54 percent to 86 percent depending on the network type and distance. This significant variation can be attributed to differences in community types. People who live within walking distance to five different categories of food retailers are less reliant on a vehicle, while people who live in communities with high food access scores at one and five miles are still generally reliant on a vehicle to travel that distance.

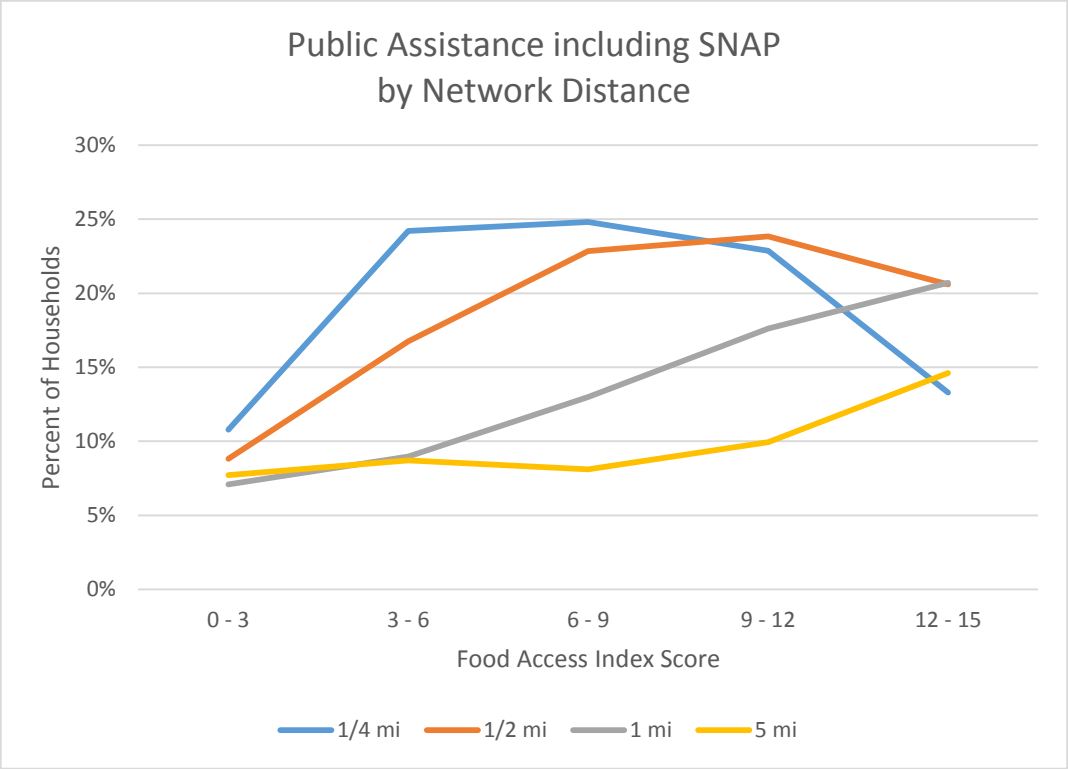


Figure 28. Access to Vehicle by Food Access Index Score and Network Distance. Source: Caitlin Matthews

Limitations of Model

In our literature review of previous food access studies, we were critical of studies that depicted food access solely with regard to a household's proximity to food retailers. As we discussed in our literature review, these analyses are limited in that they do not include many economic, cultural, and social factors that influence what people eat and where they purchase their food. Therefore, we have worked to incorporate levels of access to target: Access to what? By what mode? and For whom? This includes analyzing walkability and vehicle access; a comprehensive analysis of community demographics; and a detailed weighting scale of food retailers. Rather than simply measuring proximity to available food, we assessed proximity to food of a level of quality.

Data Accuracy and Completeness

One of the main limitations of our model is that it relies on generalizations about food retail locations. We made an assessment at the statewide level and could not look at each grocery store or food retail location on an individual level to determine the variety of food available, the general affordability of food, or other characteristics. In some cases, especially with independent food retail locations, our generalizations may not prove to be accurate. For example, the framework of our model relies on informed research that describes how the square footage of many food retail locations can expose the availability of all food groups, thus many retail locations with additional square footage have been deemed to provide greater food access.

Data limitations play a significant role in our model. Forsyth, Lytle & Van Riper (2010) highlight the challenges of creating high quality food retail datasets – whether through fieldwork, land use and parcel data, health and agriculture department licensing data, online photos (e.g. Google street view), industry codes, or others. These datasets are often incomplete, labor-intensive to gather and/or verify, and only partially indicative of the ever-changing food retail environment (Forsyth, Lytle, & Van Riper, 2010).

The food retail locations that we have included in our analysis are retailers for which the primary NAICS code is one of the eight NAICS codes listed in our methods. One of the limitations to this data is that some food retail locations may be wrongly identified as having a primary NAICS code other than one of the eight that we consider, excluding these locations from the proper category. Similarly, non-food retail locations may have been wrongly assigned a primary NAICS code associated with food retail. Prior to analyzing the data, we cleaned the dataset by removing all entries for businesses that were part of the original dataset downloaded from ReferenceUSA for which the listed primary NAICS code was not one of the eight relevant codes. We also removed entries for businesses that were incorrectly listed with one of the eight relevant primary NAICS codes.[4] It is probable that we missed some businesses

[4] Businesses that were incorrectly listed with a food retail NAICS code included law firms, public works departments, non-food retail stores, and many other types of businesses.

when cleaning the thousands of locations initially included in the dataset; in the process of cleaning the data for mis-categorized retailers we reduced the size of the dataset from more than 14,000 entries to approximately 9,500. Another limitation to the food retail data that we use in our analysis is that for some retailers it may not be updated may be out of date. Though ReferenceUSA updates its datasets daily – the dataset we used was from March of 2016 – its updates rely on businesses informing ReferenceUSA of changes to their location, status, etc. As a result, we may have included businesses that are no longer in operation and excluded newer food retail locations.

Modes of Transportation

Our model does not include all modes of transportation. Most notably, our model does not include analysis of food access by public transportation. We contemplated analyzing the presence of rapid transit and bus stops and lines within particular distances of food retail locations; however, we were not able to include this analysis in the food access index model due to time limitations. In the following section, we present suggestions on how this component could be added to the model. Our analysis also excludes people who travel to food retail locations by bicycle. While the number of those who travel to food retail locations by bicycle is small in comparison to travel by other modes of transportation, it is possible that our analysis excludes a demographic of people, especially in urban areas, who may not have access to a car but may travel more than a half mile to a grocery store or other food retail location.

Comparison Across Community Types

As we acknowledged in our literature review, food access studies with larger geographic scope present unique challenges. In the case of our statewide model, we were limited to analyzing variables for which a statewide dataset of consistent and acceptable quality exists, with one notable exception being a food retailer dataset created from two sources (see Appendix D for a list of datasets used). Even when data is available for the entire geographic focus area, however, it is challenging to create an analytical model that applies across diverse community types. In the case of our analysis, direct comparison of the mean food access index score may not be comparable between urban (inner core and regional urban centers), suburban, and rural communities. To elucidate further, when using network analysis along a road network it is necessary to decide the distance from the road network at which the polygons will be clipped to include in the travelshed. In our case, we clipped the network polygons at 100 meters from the road. In an urban area where road density is high, almost every square foot of a census block group (with the exception of large parks) is within 100 meters of a road. Therefore, nearly all of the area of an urban block group could potentially be within a food retailer network polygon. In contrast, in a rural area where road density is much lower, a significant area of the block group is more than 100 meters from a road and therefore could never be part of a network polygon. Even though most housing units are within one hundred meters of a road in all community types and could therefore potentially be included in a network polygon, the vast amount of rural land area that is farther than 100 meters from a road would still factor into the mean food access score and potentially lower that score. Adding even greater complexity to

the analysis, road density ranges broadly within suburban block groups. This phenomenon could make it difficult to compare the mean food access scores of urban, suburban, and rural block groups. One way to address this issue would be to normalize the mean food access index score for a block group by the mean road density for a block group. This could make for more robust comparisons between community types.

Influence of Limitations

Although there are limitations to the fundamental dataset we used in this analysis, our method creates a framework for a robust model for assessing food access. This pilot analysis would be significantly improved by investing the time and resources in building a food retailer dataset that is more accurate of the current food environment. Additionally, this model provides an assessment of food access in Massachusetts that was not previously available, serving as a foundation for future study.

Further Development of the Model

While the model that we developed includes a diverse array of data sets and analyzes a variety of demographic characteristics as well as community types, the analysis could be more complex and more nuanced with the addition of other demographic and community characteristics. The following additions are priorities in order to enhance the model and subsequent analyses:

SNAP and WIC Acceptance

At present, the food retailer information does not capture SNAP and WIC acceptance at individual retailers. We were unable to include this descriptor in our food retailer data set because it was not available through the ReferenceUSA database. It was available in the MassGIS farmers market dataset, but farmers markets represent a small portion of all food retailers. If SNAP and/or WIC acceptance information was available for each food retailer, then a SNAP/WIC acceptance multiplier could be used along with the weighted food retailer category in order to better include affordability as a component of food access.

Public Transit

Public transit is an important mode of transportation for food procurement. Analyzing accessibility by public transit (buses and/or rapid transit) presents new challenges and necessitates a new framework for analysis. If public transit access were analyzed using the same network polygons around food retail locations, then we would be able to learn which food retailers are most accessible by public transit routes and/or which food retailers are located near the most public transit stops. However, such an analysis would not speak to where the consumers are coming from or going to when accessing a food retailer by public transit. While this analysis would still be informative, new methods would need to be developed to analyze the origins and/or destinations of consumers in order to comment on the demographics of those who access specific food retailers via public transit.

Services to Increase Food Access

Similar to the way that community types were overlaid on the map of Massachusetts Food Access Index to look for patterns of food access across community types, overlays could be employed to assess whether services to increase access to healthy food are located in low food access areas. Two such overlays could be emergency food locations and redemption of SNAP benefits at individual retailers - for which there are available corresponding datasets. Project Bread, an organization focused on ending hunger in Massachusetts, maintains and annually updates a dataset of food pantries across Massachusetts. Additionally, MAPC has access to a dataset that details SNAP benefits redemption by individual food retailer for five consecutive fiscal years. This dataset, which is available due to a Freedom of Information Act request, could be used to visualize where SNAP benefits are being redeemed in relation to the food access index.

Applications of Model – Local and Statewide

Our model and analysis can be applied to local, regional, and statewide interests in food access, both generally and with regard to specific demographic and socioeconomic categories. We anticipate this model will serve as a key component for improving food access. Specifically, we expect interest groups and policy makers to use this model as a method of identifying communities with both limited and high access to food. By identifying communities with limited access to food, interest groups and policymakers can develop action plans to improve such communities. Furthermore, by identifying communities with high access to food, planners can potentially identify successful strategies for achieving high food access and apply them to communities in need of improvement.

To apply the methods used in this model to a smaller geographic focus area (such as a city, town, or neighborhood), there are several possible adjustments for scale. First, adjusting raster cell size would allow for a finer level of detail. We conducted our analysis using 100m x 100m raster cells because all of our network distances (400m, 800m, 1600m, and 8000m) were easily divisible by 100 meters. An alternative would be a 50m x 50m raster cell size in order to have a more granular level of detail and more precise means by block group, block, or other unit of analysis. The second adjustment would be to calculate a food access index means by census block rather than block group. While this adjustment would offer a more refined food access index, it could make the analysis of demographics problematic, as American Community Survey 5-year estimates are not available at the block level.

Section V: Next Steps and Recommendations

Next Steps for MAPC

We suggest that MAPC use the methods that we have developed to study communities of interest in Massachusetts, while also improving the model by conducting further statistical analysis and adding public transportation to the model. The application of the model to communities of interest can be a part of a verification process to discern whether the findings hold true on the community level. Additionally, we advise that MAPC conduct further statistical analyses of the model that we have piloted to assess the relationship between different socioeconomic and demographic factors and people's access to food. While our pilot study has considered numerous important demographic and socioeconomic factors, many others could be studied, including: additional ethnicity/race categories, disability status, educational attainment, etc. Furthermore, our project was limited to assessing food access by means of walkability and drivability. We are aware that public transportation plays a significant role in how people, especially in urban areas, acquire food, and suggest adding accessibility to food retailers via public transportation to future updates to the model. Eventually, it is our hope that this research could lead to policy and infrastructure changes, as well as further refinement and implementation of the pilot model.

Recommendations for Future Studies

Now that we have piloted these methods, which could be applied to communities and states beyond Massachusetts, there are other elements of food access that need to be studied. These other components go beyond the data available and scope of spatial analysis; they require further study and address micro level and community scale food access. Future studies could verify our pilot method through community-level food access assessments, while adding to knowledge on statewide food access by using methods complementary to spatial analysis to better evaluate the lived experiences of community members.

Verification of Methods

The statewide scope and semester-long timeline of this project made it infeasible to travel to communities throughout the state and make assessments using observation or interaction with community members. A process of community-level verification of the findings of this assessment would be valuable for all community types. It could also confirm whether or not communities that appear to have both poor food access and high food access actually experience such realities. In addition, our broad scope of analysis was dependent on previously existing spatial data. This required us to reframe our project to assess food availability, accessibility, and affordability at the expense of assessing cultural appropriateness and other social factors. This assessment has categorized communities throughout Massachusetts based on a condensed version of MAPC's community typology – including inner core, regional urban centers, suburban, and rural communities. The methods of verification and further assessment should be similar across community types, focusing on the types of food that people have access to and other factors that influence people's purchasing decisions.

The recommended approach to verifying this method is best exhibited through local studies that provide detailed analyses of communities. The report regarding food access in the City of Lowell used a variety of data inputs beyond GIS. A variety of information was collected through government data, stakeholder meetings, interviews, and surveys (Nyman et al., 2013). Similar assessments of food access in the cities of Worcester and Springfield relied heavily on conducting surveys and assessments of particular food retail locations. These assessments included the availability of healthy, culturally appropriate, and affordable food through the creation of various indexes and guidelines. These assessments also focused on the physical environment of food retail locations and people's perceptions of the stores and the food available within them (Allen et al., 2012; Creeley et al., 2008).

In addition to assessing the cultural appropriateness, affordability, and health of food, verification methods should include ground truthing of the food retailers that were included in the food retail dataset to confirm that retailers are in business, sell the types of food products that had been reported, and fall within the reported square footage range. This ground truthing process can also establish holes in the dataset where applicable food retailers may have been accidentally excluded from the dataset because of reporting errors.

Community Level Food Access Assessments

This analysis does not address cultural and social aspects of food access. In order to enhance this statewide analysis, we recommend that interest groups looking to improve food access in communities throughout the state take the initiative to ground truth and extend our assessments. This process should include interacting with those who live in the community through interviews, surveys, focus groups, or a combination of the three. These methods can be used to inquire about people's lived experiences of food access. Aside from people's proximity to food retail, and other food procurement locations, data collection should include the following categories:

- Culturally-appropriate food – Which cultures are represented? Is the available culturally appropriate food affordable? Where is it available (specialty stores, major grocery stores, etc.)?

- Cooking skills – Do people in the community consume more processed/prepared foods or meals made from scratch? Our model did not include restaurants and other fast food retailers, which in some communities play a significant role in people's food consumption. Is the type of food that people consume a result of factors such as lack of cooking skills or knowledge, lack of time, the age of the meal preparer or consumer, etc.?

- Kitchen facilities and cooking equipment – Do community members have access to kitchens and kitchen equipment to prepare meals (stoves, ovens, microwaves, pots/pans, etc.)? Is there a discrepancy between renters and homeowners? Is there a discrepancy between people of different socioeconomic statuses?

- Community gardens, CSAs, farm stands – Do these "alternative" food outlets play a significant role in a community's access to food?

- Consideration of workplace and other locations – Do people shop in their community or do they shop elsewhere (e.g. someone who commutes a distance to work and shops near where they work because of convenience, price, availability, etc.)?

Many of these elements have been incorporated into the small-scale studies we reviewed of Lowell and Springfield. The Lowell study attempted to measure and incorporate access to community food retailers and cultural components of food access. Because Lowell has a wide array of cultures, the report incorporated availability of culturally appropriate foods by interviewing residents and locating food retailers in the city.

A similar study in the North End of Springfield, Massachusetts included very localized components using quantitative and qualitative data collection to identify specific food retailers and to conduct surveys on food availability.

Studies such as these, as found in Appendix B, could provide a quality framework for ground truthing methods and more localized food access assessments.

Generating a Food Retailer Dataset

In addition to verifying the methods that we developed in this project, communities could develop more reliable datasets to use in the model and evaluate food access on a smaller scale. As we have previously mentioned, the datasets that we have relied heavily on are flawed and could not be cleaned with certainty of their accuracy given the scope of this project. A deeper evaluation of the dataset, including the assessment of whether or not food retailers are still in business and if independent retailers, namely pharmacies, offer food, would greatly benefit the model. Developing datasets from scratch would necessitate that communities determine the categories of food retailers that are of interest - supermarkets, farmers' markets, convenience stores, etc. - and generate a comprehensive list of all retailers.

It is important to note, however, that developing a dataset from scratch would not necessarily have complete accuracy. It may not be feasible to account for all food retailers in a community. Additionally, data can quickly become outdated, and the data collection and reporting process can have errors. While it is not likely that a dataset of food retailers would have complete accuracy, community-focused datasets can be more accurate and could be updated more feasibly. Communities can then use this dataset in the model that we created to examine the most up-to-date food environment. Communities using our model with a new dataset would still be limited to the framework of our model, which does not address the social and cultural aspects of food access, and thus should also engage in community-level verification of the findings and further assessments.

Conclusion

In the interest of improving public health and food access, this report provides not only an assessment of how food access is defined but also a method of how to assess a community's level of access. This method for assessing food access provides a unique and practical framework which can be further investigated and replicated either in communities in Massachusetts or elsewhere.

This assessment of food access in the state of Massachusetts serves as a pilot to display the assessment capabilities of the method and provide maps of food access across the state. Although this pilot was created with data limitations, it provides the most detailed existing depiction of the levels of food access specific to community types throughout Massachusetts. The pilot displays how within a spatial framework, rural and suburban areas have limited access to food while more urban areas have greater access. Furthermore, layering specific demographic data illustrates how low-income, Hispanic or Latino, Black or African American, and single parent households all have low food access and need to travel five miles or more to reach full service food retailers that offer food options across the full diet. These findings illustrate the need for food access improvements in the state of Massachusetts either by interest groups or policymakers to best serve the Massachusetts community.

Section VI: Appendices

Appendix A: Glossary of Terms

FOOD ACCESS (1)
"The term 'food access' generally refers to people's ability to find and afford food." (Alexander and Kelley, 2014, p. 60)

FOOD ACCESS (2)
"The ability to obtain food items needed from outlets that are available within a neighborhood." (Eckert and Shetty, 2011, p. 1216)

FOOD ACCESS (3)
"Limited access to supermarkets, supercenters, grocery stores, or other sources of healthy and affordable food may make it harder for some Americans to eat a healthy diet. There are many ways to measure food store access for individuals and for neighborhoods, and many ways to define which areas are food deserts—neighborhoods that lack healthy food sources. Most measures and definitions take into account at least some of the following indicators of access:

- Accessibility to sources of healthy food, as measured by distance to a store or by the number of stores in an area.
- Individual-level resources that may affect accessibility, such as family income or vehicle availability.
- Neighborhood-level indicators of resources, such as the average income of the neighborhood and the availability of public transportation."
  (USDA-ERS, 2015 March 11)

FOOD DESERT
"Area in the United States with limited access to affordable and nutritious food, particularly such an area composed of predominantly lower income neighborhoods and communities." (The Food, Conservation, and Energy Act of 2008, Title VI, Sec. 7527)

FOOD SWAMP
"A food swamp is a place where unhealthy foods are more readily available than healthy foods[…]Food swamps typically exist in food deserts, where there are limited options for purchasing healthy foods[…]A food swamp might be an area where there is predominance of small corner stores and carry-outs, but no healthy food sources, such as supermarkets or farmers markets." (Behrens and Simons, 2013)

FOOD HINTERLAND
"Low-food-access areas typically away from more centrally located food deserts. These are often less dense, dispersed suburban areas. They lack the concentrated poverty and the empty shells of defunct grocery stores that are visible reminders of food access issues in food deserts." (Leete, Bania, and Sparks-Ibanga, 2011)

FOOD SECURITY AND INSECURITY (1)

Food Security: "A situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life. Based on this definition, four food security dimensions can be identified: food availability, economic and physical access to food, food utilization and stability over time." (FAO, 2015, p. 53)

Food Insecurity: "A situation that exists when people lack secure access to sufficient amounts of safe and nutritious food for normal growth and development and an active and healthy life. It may be caused by the unavailability of food, insufficient purchasing power, inappropriate distribution or inadequate use of food at the household level. Food insecurity, poor conditions of health and sanitation and inappropriate care and feeding practices are the major causes of poor nutritional status. Food insecurity may be chronic, seasonal or transitory." (FAO, 2015, p. 53)

FOOD SECURITY AND INSECURITY (2)

"Food security means access by all people at all times to enough food for an active, healthy life." (USDA, 2015 Sept 8a)

The USDA defines four levels of food security:

"**Food Security**

- High food security: no reported indications of food-access problems or limitations.
- Marginal food security: one or two reported indications—typically of anxiety over food sufficiency or shortage of food in the house. Little or no indication of changes in diets or food intake.

Food Insecurity

- Low food security: reports of reduced quality, variety, or desirability of diet. Little or no indication of reduced food intake.
- Very low food security: Reports of multiple indications of disrupted eating patterns and reduced food intake." (Coleman-Jensen et al., 2015)

COMMUNITY FOOD SECURITY (1)

"Community food security has roots in disciplines such as community nutrition, nutrition education, public health, sustainable agriculture, and anti-hunger and community development. There is no universally accepted definition of community food security. In the broadest terms, community food security can be described as a prevention-oriented concept that supports the development and enhancement of sustainable, community-based strategies:

- To improve access of low-income households to healthful nutritious food supplies.
- To increase the self-reliance of communities in providing for their own food needs.
- To promote comprehensive responses to local food, farm, and nutrition issues.

Policies and programs implemented under the label of community food security address a diverse range of issues, including:

- Food availability and affordability.
- Direct food marketing.
- Diet-related health problems.
- Participation in and access to Federal nutrition assistance programs.
- Ecologically sustainable agricultural production.
- Farmland preservation.
- Economic viability of rural communities.
- Economic opportunity and job security.
- Community development and social cohesion." (USDA-ERS, 2015 Sept 8b)

COMMUNITY FOOD SECURITY (2)
"A situation in which all community residents obtain a safe, culturally acceptable, nutritionally adequate diet through a sustainable food system that maximizes community self-reliance and social justice." (Hamm and Bellows, 2003, p. 37)

Appendix B: Summary of Massachusetts-Based Food Access/Food Security Studies

Study Name	Conducted By	Year	Study Area	Assessment/Findings
STATEWIDE ASSESSMENTS				
Massachusetts Food Insecurity: Landscape and Innovation	Foster West et al. Tufts University on behalf of the MA Food Policy Council	2014	MA	- Measured food insecurity by county (Map the Meal Data). - In 2012, 259,000 people in Massachusetts were food insecure but did not meet the income guidelines for Supplemental Nutrition Assistance Program (SNAP). - In 2012, the food insecurity rate was 11.9 percent and the child food insecurity rate reached 16.6 percent. - Found that veteran status, disability status, and SNAP participation are also associated with food insecurity.
Status Report on Hunger in Massachusetts	Project Bread	2013	MA	- In 2013, 375,695 food insecure households in Massachusetts. - In 2013, 11.4% of MA households were hungry (40% higher than prior to the Great Recession). - MA food insecurity has increased 71% in the past 10 years. - Direct linkages between income and cost of living with food insecurity.
Stimulating Grocery Development in Massachusetts: A Report of the Massachusetts Grocery Access Task Force	Manon & Tucker	2012	MA	- Reports that the scarcity of supermarkets in Massachusetts is a key cause of food insecurity and blocks realistic access to food.

Food for every child: The need for more supermarkets in Massachusetts.	The Food Trust	2010	MA	- Assesses the availability of grocery stores in Massachusetts based on the per capita number of grocery stores in a given zip code. - The report makes linkages between food access and the geographic access to food outlets.
REGIONAL ASSESSMENTS				
Disparities in Access to Healthy and Unhealthy Foods in Central Massachusetts: Implications for Public Health Policy	Olendzki et al. Journal of the American College of Nutrition	2015	Regional, Central MA	- Conducted a survey study measuring food stores in a region of Central Massachusetts with additional analysis on the geographic and temporal variations in communities and store level health food availability. - This research study determined that over half of Central Massachusetts communities (mostly rural and low populations) had no store or a just a few stores with a limited availability of healthy foods.
The Southeastern Massachusetts Food System Assessment.	Alexander & Kelley, The Southeastern Massachusetts Food Security Network, and the Island Foundation	2014	Regional, Southeastern MA	- Assessed local food security by measuring local food production, food processing and distribution, and food access and consumption. - Findings include: increase in direct Community Supported Agricultural Sales by 64% between 2007 and 2012, only 2 percent of the local food production is for processing (making the assumption that on and off farm processing capacity could increase year-round food security).
The Pioneer Valley Food Security Plan	Pioneer Valley Planning	2013	The Pioneer Valley, MA	- Evaluates food security with an emphasis and interest in local food (having food produced in the region).

	Commission			- 1 in 8 people in Western Massachusetts are food insecure.
MUNICIPAL OR COMMUNITY-LEVEL ASSESSMENTS				
Food Retail Opportunities in Boston's Underserved Neighborhoods.	H. Stucker	2013	City of Boston, MA	- Measures food access and negative health outcomes by way of proximity to supermarkets. - Investigates the opportunities and locations that are in need of food markets. - Determined these locations by measuring food purchasing power and grocery demand in specific underserved areas of Boston.
Setting the Table Towards Greater Food Security in Lowell, MA	Nyman, McCarthy, et al. The Conway School	2013	City of Lowell, MA	- Evaluated the barriers Lowell residents face in obtaining food. - This study measures food access by way of affordability (household income), proximity (mileage to a food market), choice (availability of culturally appropriate foods), and preparation (knowledge and physical ability to prepare food.
Analyzing Food Security in Worcester	Allen et al. Worcester Polytechnic Institute	2012	City of Worcester, MA	- Examined Worcester's food retail outlets (location, price, and food quality), against race, income and ethnicity census data. - Argues that food insecurity is directly connected to a state's economy. - Between 2001 and 2005 there was a 40% increase in the number of people served by food pantries and soup kitchens. - Developed a healthy food index to score the food markets specifically giving food markets a healthy score, and a availability score. - Found neighborhoods that are predominantly white are more likely to have access to food retail outlets that sell high quality and nutritious food. - Low-income and high ethnically diverse communities are likely to have ethnic grocery or corner stores - but they are expensive.

Socio-spatial Constructs of the Local Retail Food Environment: A Case Study of Holyoke, Massachusetts	Ramsey, W.F. UMass Thesis	2010	Holyoke, MA	- Food insecurity varies from 14.3% in Hampden County to 10.2% in Hampshire County. - Collecting local farm sales and farm accessibility is a method used measure food availability. Community Supported Agriculture (CSA) sales can be used to estimate support of local food systems, specific to healthier and more specific to produce consumption.
An Assessment of the North End Food Environment	Creeley et al., Massachusetts Institute of Technology	2008	North End, Springfield, MA	- Ranked the availability of healthy food options in the North End, scoring the community a 13 out of a maximum 50 points. - Used census of food stores, a validated survey tool (NEMS-S) and qualitative data to score the food environment.

Appendix C: Detailed Spatial Analysis Methods

PART A: Access to what?

1. Download information from ReferenceUSA for the following NAICS codes:

Supermarkets and Other Grocery = 445110
Convenience Stores = 445120
Meat Markets = 445210
Fish and Seafood Markets = 445220
Fruit and Vegetable Markets = 445230
Warehouse Clubs and Supercenters = 452910
Drug Stores and Pharmacies = 446110 (only including stores that sell food)
All Other Specialty Food Stores = 445299 (only including stores that sell "ingredients" and food to be consumed at home)

For each business, download the default fields, as well as the latitude, longitude, primary NAICS, primary NAICS description, and square footage.

2. In Excel, clean the ReferenceUSA data and create food retailer data set.
    a. Remove all entries for which the primary NAICS code is not one of the 8 considered.
    b. Remove all entries for which primary NAICS code is obviously misreported (to the extent that this can be identified by looking at the name of the business and/or through a Google search).
    c. Remove entries for pharmacies that are located within grocery stores, in order not to double count the grocery stores.
    d. For pharmacies and drug stores, keep only the chain pharmacies that we know sell food items (CVS, Rite Aid, Walgreens, and Brooks).
    e. For specialty food stores, eliminate ice cream and frozen yogurt shops, and tea and coffee shops.
3. In Excel, assign relative weight categories to all of the food retailers, based on the ability to procure healthy food options across the full diet.

5 - Supermarkets and Other Grocery (except Convenience) [>10,000 sf], Warehouse Clubs and Supercenters
4 - Supermarkets and Other Grocery (except Convenience) [<10,000 sf], Farmers Markets, and Fruit and Vegetable Markets
3 - Specialty Food Stores, Meat Markets, and Fish and Seafood Markets
2 - Convenience stores [>2500 sq ft], Pharmacies and Drug Stores
1 - Convenience stores [<2500 sq ft]

For Farmers Markets, add a field to the attribute table of the shapefile and assign weight 4 to all Farmers Markets.

4. In ArcMap, map food retail locations using "display XY data."
5. Export a shapefile of the food retailers.

6. In ArcMap, use the merge tool to make a new composite data layer of the food retailers and the farmers markets.
    a. Before merging, add a field to each attribute table for "source" as ReferenceUSA or MassGIS.
    b. Make sure that the merge keeps the name, latitude, longitude, weight, and source (at the least).

PART B: By what mode? (walkability and drivability models)

7. In ArcMap, create a travelshed polygon layer for each weight category of food retailer at each network distance (for a total of 20 polygon layers = 5 food retail weight categories x 4 network distances).
    a. In the composite food retail layer, select by attribute for all entries of the appropriate weight category.
    b. Use Network Analyst to create travelsheds using MassDOT roads layer as the network dataset.
        i. For walkability: ¼-mile (we used 400 meters as a substitute) and ½-mile (we used 400 meters as a substitute) travelsheds along walkable roads (class 4-6 in MassDOT roads) from food retailers.
        ii. For drivability: 1-mile (we used 400 meters as a substitute) and 5-mile (we used 400 meters as a substitute) travelsheds along all classes of MassDOT roads from food retailers.
8. Rasterize each of the travelshed polygon layers. Use "weight" as the value of the raster.
9. Reclassify each travelshed raster to create a binary raster layer in which cells within a travelshed polygon equal the food retailer weight (1-5) and cells outside of travelshed polygons equal zero.
10. Use the raster calculator to calculate a composite food access index score for each travel distance.
    a. For example: Food Access Index at ¼ mile = binary raster for weight category 5 + binary raster for weight category 4 + binary raster for weight category 3 + binary raster for weight category 2 + binary raster for weight category 1
    b. The range of the Food Access Index will be 0-15.
11. Use Zonal Statistics as a Table to calculate a mean score for the food access index by block group at each network distance.

PART C: For whom?

12. In ArcMap, using the resulting tables from the Zonal Statistics as Table, use Join Field in Data Management Tools to add a field for each of the mean food access index scores to the attribute table for the census block group geography data layer (based on block group ID).
13. Use Join Field to join data (based on block group ID) from the 2010-2014 American Communities Survey 5-year estimates to the census block group geography data layer for each of the following demographic characteristics (at block group level unless otherwise specified):
    a. Total population

    b. Total households
    c. Number of single parent households
    d. Number of African American householders
    e. Number of Hispanic householders
    f. Number of children under five
    g. Number of households with public cash assistance (including SNAP) [This is only available at census tract level, so the tract percentage is used at the block group level]
    h. Median HH income for the block group
    i. Number of households with access to one or more vehicles
14. Use Join Field to add the municipal name for each block group, and then use Join Field again to add the community type, based on a simplified version of the MAPC community typology and including:
    a. Inner Core
    b. Regional Urban Centers
    c. Suburban
    d. Rural
15. In the attribute table, use Summarize for the Community Type attribute to look at patterns of food access across community types.
16. Use Summarize to compare and describe census block group demographic data with mean scores for the food access index. Look for and describe demographic patterns across the range of food access index scores.
    a. In order to use the Summarize option more easily, add a field in which to divide the mean food access index scores for the block groups into five food index score categories (0-3, 3-6, 6-9, 9-12, 12-15). Repeat this step for all four network distances.
    b. Then use Summarize to look at the means of the demographic characteristics by food index score categories

Appendix D: Data Sets and Sources

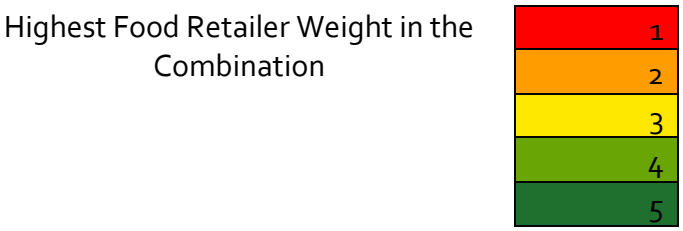
Name of Data Set	Description	Data Source (hyperlink, if available)	Key Attributes
Part 1: Access to what? (food retailers)			
Massachusetts Food Retailers	This is a data set we compiled, cleaned, and categorized for food retailers with one of the eight relevant primary NAICS codes. This data was downloaded from ReferenceUSA.	Prepared by the UEP Field Projects Team	Latitude, Longitude, Primary NAICS, Primary NAICS Description, Square Footage
Massachusetts Farmers Markets	Includes locations; participation in SNAP, and Senior and WIC FMNP; seasonal vs. winter market; days and hours of operation; date range market is open	MassGIS	Latitude, Longitude, SNAP participation
Part 2: By what mode? (walking and driving)			
MassDOT Roads	Includes roads of all classes for the state of Massachusetts. This data set is superior to the Census TIGER roads because there is better positional accuracy.	MassGIS	Class 1-6, Sidewalks
Part 3: For whom?			
2010 Census Block Groups	Data layer for census block group geography	MassGIS	GEOID10
2010-2014 American Communities Survey 5-Year Estimates	Demographic data by census block group	Social Explorer	GEOID10, Total block group population, Total block group households, Number of Single parent households, Number of African American householders, Number of Hispanic householders, Number of children age 5 and under, Number of households receiving public assistance (including SNAP), Median HH income, Number of households with access to one or more vehicles

Massachusetts Community Types	This is an Excel file that categorizes municipalities by MAPC's community typology and also links block groups to municipalities. This file enables a two-step tabular join to associate block groups with community types.	MAPC	Municipality, Community Type, Census Block Group
Future Development (Data sets considered but not included in this analysis)			
SNAP Redemption by Location, FY2006-FY2010	This Excel file includes addresses that will need to be geocoded.	MAPC	Retail Name, Address, City, State, Annual SNAP purchases FY06-FY10
Emergency Food Locations (Pantries)	This is last year's food pantry layer from Project Bread. This year's updated layer won't be available until the summer or later.	Project Bread (via MAPC)	Name and location; No attribute information about address or lat/long, but point data displays in ArcMap)
RTA Stops	Includes stops for all RTA systems in Massachusetts, except MBTA	MAPC	Location of stop
RTA Routes	Includes routes for all RTA systems in Massachusetts, except MBTA	MAPC	Location of route, RTA
MBTA Bus Routes and Stops	Includes bus stops and routes for the MBTA region	MassGIS	Location of stop or route
MBTA Rapid Transit	Includes rapid transit stops and routes for the MBTA region	MassGIS	Location of stop or route

Appendix E: Interpreting Massachusetts Food Access Index Scores

The following table lists all possible combinations of food retailers for each score (0-15) in the Massachusetts Food Access Index. It is essential to understand that for any single raster cell, each retail weight can only be counted once. For example, being within the one-mile driveshed for two convenience stores of weight category 1 will not result in a food access index score of 2. In this way, higher index scores indicate a broader range of food retail options within a certain network distance.

Interpreting Massachusetts Food Access Index Scores			
Index Score	*Possible Combinations of Food Retailers*		
0	0		
1	1		
2	2		
3	3	2+1	
4	4	3+1	
5	5	4+1	3+2
6	5+1	4+2	3+2+1
7	5+2	4+3	4+2+1
8	5+3	5+2+1	4+3+1
9	5+4	5+3+1	4+3+2
10	5+4+1	5+3+2	4+3+2+1
11	5+4+2	5+3+2+1	
12	5+4+3	5+4+2+1	
13	5+4+3+1		
14	5+4+3+2		
15	5+4+3+2+1		



An additional way to visualize and categorize these food retail index scores focuses on how each score reflects the likelihood of having access to a large (>10,000 ft²) grocery store, supermarket, warehouse club, or supercenter (weight 5 retailer). Future analyses could use the four categories of 0-5, 5-8, 8-11, and 11-15, rather than the equal interval categories of 0-3, 3-6, 6-9, 9-12, 12-15.

Interpreting Massachusetts Food Access Index Scores					
Index Score	*Possible Combinations of Food Retailers*			*Average highest food retailer weight at index score*	*Access to Large Scale Grocery Store or Supercenter?*
0	0			0	No
1	1			1	
2	2			2	
3	3	2+1		2.5	
4	4	3+1		3.5	
5	5	4+1	3+2	4	Unlikely
6	5+1	4+2	3+2+1	4	
7	5+2	4+3	4+2+1	4.33	
8	5+3	5+2+1	4+3+1	4.67	Likely
9	5+4	5+3+1	4+3+2	4.67	
10	5+4+1	5+3+2	4+3+2+1	4.67	
11	5+4+2	5+3+2+1		5	Yes
12	5+4+3	5+4+2+1		5	
13	5+4+3+1			5	
14	5+4+3+2			5	
15	5+4+3+2+1			5	

Highest Food Retailer Weight in the Combination
1
2
3
4
5

Appendix F: Bibliography

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