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MAPPING FOOD ACCESS

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Abstract

In many of America's inner cities and rural areas, there exist areas known as "food deserts." These are places where there are few or no grocery stores selling fresh, nutrient-dense food. That is: access to healthy, culturally appropriate food is limited. And yet, fast food and convenience stores flourish. There has been a plethora of studies and maps made to try to understand, affect policy on and educate the public about this issue. Gottlieb, et al. (1996) examined food access and distribution. Goldsberry et al. (2010) surveyed and quantified fresh produce in Lansing, Michigan and Alberquerque, New Mexico. Schafft et al. (2009) explore food distribution's effect on childhood obesity. Most maps of food deserts take into account two parameters- distances to food and income level. This approach shows the viewer these two factors, but not the level of food access. Yet, knowing the level of food access is pivotal for assessing critical need and planning initiatives. Despite this inferred simplicity, the issue of food deserts is extremely complex. Because food access is based on location, it is a spatial phenomenon, and maps are useful tools to more easily view and understand it. This thesis sets out to create a map to quantify food access to show the related complexities and uncertainties. It hopes to contribute to a richer understanding of how people access food and to a more localized policy design process.

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Introduction

This thesis is about food deserts. Food deserts are areas, most often in inner cities or rural places, with a severe lack of access to nutritional, culturally appropriate food. Such places are said to be food insecure because they severely lack access to these foods for reasons of mental, financial, and physical barriers. Thus, food security means that no one goes hungry, and everyone is able to find, buy, transport home, cook and eat nutritional, culturally appropriate food. In this thesis, I argue that, of the two necessities for creating food secure communities, food availability and food access, the former has been solved and the latter is what policy efforts and grassroots initiatives must focus on. University and government research efforts focus on identifying food deserts' causes, designing strategies to improve food security, and mapping food deserts to better target policies, programs and initiatives. Most maps use grocery store location and income to map food deserts, but the data used is often inaccurate. To resolve this problem, I designed an index to create a map of food access to moderate data inaccuracies and to show the complex nature of food deserts.

The catalyst for the work presented here is the work I did during an internship I completed with Esri in the summer of 2011. This experience was the biggest sole influence that shaped my thinking of the topics related to this thesis. During this internship, I redesigned the Food Deserts Finder (FDF) online application. Talking with the map's original designer, Jim Herries, gave me insight into the logic behind the creation of the original map and what the redesign needed to take into account. The idea of the redesign was to come up with a way to convey a "food environment" and the complexities of food access.

Building on my experience redesigning the FDF, I decided to gain a stronger understanding of the issues behind food deserts and ways of mapping them for this thesis. The

research for this paper included a theoretical and an empirical part. The theoretical part explores the ways in which scholars conceptualize food security, availability, access, and food deserts. The theoretical aspects raised, such as the relationships between global food supply, food distribution, and local initiatives inform my analysis in terms of the complexity of our food system and the social justice issue at hand. The empirical part of this thesis built on past efforts by researchers to map food desert and focused on techniques to create the index and the map.

To begin the research on the theoretical part of my thesis, I did a broad search of academic articles related to "food deserts" on Google Scholar and the Penn State University Libraries online catalog. I chose these search engines because they have proved helpful in the past. From the search results, I chose and read those articles that seemed most relevant to my project. These sources came from academic journals such as the British Journal of Nutrition, the American Journal of Preventative Medicine, and the Journal of Hunger and Environmental Nutrition. From these papers I distilled the important information and narrowed my subject of search. I looked in these papers' bibliographies to find papers related to the aspects of the papers in which I was most interested. I also performed further searches in the previously named search engines of concepts related to food deserts, including "food security," "food availability," "food access," "history of [each of the preceding terms]," "hunger," "malnutrition and education," and combinations of those terms. I looked for research on these subjects, namely what research has been done and how it was performed. Most articles I read were academic articles published after 1990. I chose these articles because they seemed the most reliable sources to answer my research question.

Once I felt I had a thorough understanding of these subjects and how they related to each other, I read government reports and the work of non-governmental organizations. I examined

those government reports mentioned in the academic papers. The government reports by the United States Department of Agriculture (USDA) and the United Nations World Food Program, mentioned by the academic articles also referred to other government reports, and I read those as well. Many of the academic articles and government reports were directly related to grants and local initiative, so I performed a search on the Google search engine to find the websites of the resulting programs. In addition, I searched for related initiatives not mentioned in the articles or reports to gain an understanding of the larger picture of work directly related to increasing food access. I chose these articles because many academics and initiatives hope to directly influence government policy, and it is therefore related to the subject at hand. By the same token, academics and government policy hope to influence the work of initiatives, so they are related.

I followed similar techniques to research the empirical part of my thesis. I referenced maps mentioned in papers found during my theoretical research. Also, I searched for "maps of food deserts" on the Google search engine and was able to follow those maps to their origins, usually government or academic. I then read the associated articles and reports. Again, I drew on the sources listed in the bibliographies of the papers. I also looked for techniques related to the design of econometric analyses and indexes. I examined the maps that used these techniques and the articles describing their creation. I performed several iterations of this to examine a wide variety of maps. These articles were sourced from academic journals such as Applied Geography, Geocarto International and the International Cartographic Association and from government reports by the USDA.

Based on a review of the literature and the empirical data, this paper will examine food deserts, focusing on food access and how it has been mapped. The research involved the exploration of prior theoretical and empirical research through several iterations of research

techniques including queries of search engines, library catalogs, and searches of related articles in bibliographies. It was found that food security and access are at the root of the food desert problem. This paper will examine the myriad of causes behind food deserts and create an index to resolve limitations of prior maps of food deserts.

Food Security and Access

Hunger

According to the United Nations' World Food Programme, hunger kills more people every year than AIDS, malaria and tuberculosis combined. There are more hungry people in the world than collectively live in the United State, Canada, and the European Union (World Food Programe, 2012). A technical term for "hunger" is food insecurity. The United States Department of Agriculture (USDA) estimated that 48.8 million Americans lived in food insecure households across the nation in 2010. Individuals are unable to afford to feed themselves and must choose, monthly, between eating, paying utility bills, medical care, rent, and other basic necessities. Just under 60 percent of these households participate in one of the three federally funded food assistance programs, Supplemental Nutrition Assistance Program (SNAP), The National School Lunch Program, and the Special Supplemental Nutrition Program for Women, Infants, and Children (Feeding America, 2010). These programs have not been adequate in decreasing food insecurity, evidenced by the 48.8 million food-insecure Americans. The main issues that have been identified in combating hunger are food availability and food access. Because food availability has been achieved through the invention of artificial nitrogen fixation, this paper will focus on access. Nonetheless, in the next section, I will trace the trajectory of both as they relate to the discussion of food security

Availability versus Access

Two concepts have become prominent in the discussion on how to end world hunger: food availability and food access. Availability has been solved through artificial nitrogen fixation. The problem of access remains. Both issues are important to our understanding of

hunger and food security. Research focused on the causes of low food access has found that people with low incomes supply a low market demand for food.

"Food availability" was first a government term used to refer to the national food supply, and means how much food is available in the country or world, in total. Food availability was addressed with the invention of artificial nitrogen fixation. In the early 20th century, Fritz Haber invented the Haber-Bosch process to artificially fix nitrogen. This provided nutrient-dense fertilizer to increase crop yields of corn, wheat and rice. Today, this process creates enough fuel for the industrial agricultural system to run smoothly and produce the large volume of food grown today. In total, farmers produce slightly more than enough food to feed everyone in the world (U.S. Department of State & Bureau of International Information Programs, 2007). If there is enough food to feed everyone, then hunger should not exist.

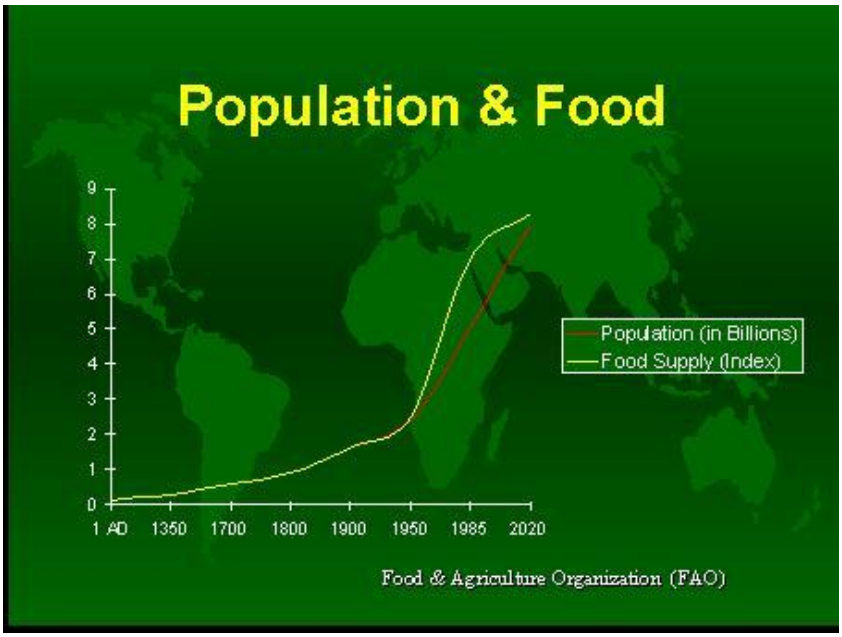

Figure 1: United Nations Food and Agriculture Organization. (2011). *Population & food*. [Web Graphic]. Retrieved from http://thewatchers.adorraeli.com/wp-content/uploads/2011/10/graph1-11.jpg

As exemplified in Figure 1, the food supply is beyond the caloric needs of the current population.

However, food availability only concerns the quantity of food available on a global or

national scale, not its distribution. In his 1970 Nobel Prize acceptance lecture, plant pathologist Norman Borlaug lauded the green revolution, sparked by the Haber-Bosch process, as having conquered food availability, but noted that "adequate food", or food availability, is only one necessity for a good life (U.S. Department of State & Bureau of International Information Programs, 2007)

The term "food access" was first coined in 1983 by the Food and Agriculture Organization of the United Nations (Clay, 2002). Food access means how people obtain food, or where food is located and how people get there. In analyzing who actually gets to eat (an important component of food security), food access becomes the variable of interest. Gottlieb et al. (1996) consider food access as the "crucial yardstick" or most important measure of a community's food security (the opposite of food insecurity). They point out that it is indicative of people's ability to get to and from food sources in their area, and the nature of the food outlets and types.

Gottlieb et al. also find that low-income people are more likely to live in food-insecure areas because the nature of their low-income status means they supply a low market demand. In turn, measuring how easy or hard it is for someone to eat measures their level of food security (Gottlieb et al.). Pothukuchi (2005) recognizes the problems caused by unequal food access and social inefficiencies of providing people with food stamps in low-access areas. Unequal food access forces people to travel farther to obtain food, spend more money on food, go hungry, and in some cases develop poor eating habits (Pothukuchi, 2005).

In the debate between food availability and food access, it is clear that food availability is not a problem. Since food insecurity continues, access must be the aspect that has not yet been solved. Research has found that food access is indicative of an area's food security. Low-

income people supply a low market demand and are more subject to low food access and its resulting problems. The place in which people live profoundly affects their level of food access, which means that food access is spatially dependent.

Access is Spatially Dependant

The kind of food that people have access to is highly dependent on the place where they live. Areas far from full-service grocery stores are rife with convenience stores that charge higher food prices. Consequently, the people living in these areas are forced to spend more money on food or travel farther to food stores than they would if they lived elsewhere. They also go hungry more often than those living close to grocery stores. Finally, areas without grocery stores lack sources of nutritional food and often knowledge about healthy eating habits.

Food insecurity is so profound that low-income areas are less likely to have access to full-service grocery stores because of a lower market demand. In area lacking a full-service grocery store, convenience stores are often the only option. Many inner city areas have up to 30 percent fewer full-service grocery stores than more affluent suburban areas (Gottlieb et al., 1996). In Lansing, Michigan, less than four percent of residents live within a ten-minute walk of a grocery store. Residents outside of this "walk zone" choose to travel farther to spend money on food at grocery stores rather than convenience stores whenever possible (Duvall, et al., 2010). There, fresh food is sparse and expensive, and processed foods are comparatively cheaper. Still, food is generally more expensive because small stores cannot capitalize on the economies of scale that large stores can (Gottleib et al.).

Gottleib et al. (1996) find that certain areas are correlated with lower car ownership and higher food expenditures. Car ownership is a prominent factor of access: residents with cars can

travel farther to reach grocery stores and transport more food home at once. Low car ownership in an area shows that traveling to far away grocery stores is often not possible, so they must spend food dollars at closer, more expensive food stores. Logically, areas with low rates of car ownership are linked with higher food expenditures. Shopping at small inner-city food stores in these areas costs a family of three $285 more per year than buying the same food at a suburban grocery (Gottlieb et al.). Low-income people who spend more money on food are forced to choose between buying food and other basic necessities, and therefore go hungry more often. For instance, in some neighborhoods in Los Angeles, 27% of area residents surveyed reported that they went hungry an average of five days every month (Gottlieb et al.).

The USDA, along with Gottlieb et al. (1996), Schafft et al. (2009), Opfer (2010), and other researchers, have recognized that one's environment heavily influences eating and activity. Food access is part of one's environment, and affects health through the food available, which affects the choices people make about what to eat (USDA, 2009). Schafft et al. (2009) find that residents in rural Pennsylvania with lower food access have a higher prevalence of childhood obesity. Opfer (2010) recognizes that full service grocery stores are "the most likely site to supply the range of foods necessary for a healthy diet" (p. 23).

Food stores are place-based. Where people live in relation to these food stores and the transportation they use affects the type of food access they have. Areas that do not have grocery stores and are home to people who face obstacles to travel have less food access. These same areas are home to low-income residents often have less cars available because residents cannot afford them. More expensive food is less affordable, so low-income people in these areas go hungry more often and are less likely to purchase nutritious food. Food outlets and transportation available affect the food that people buy, and both contribute to eating habits, food

choices and health.

Far-Reaching Effects of Access

Low food access has effects beyond leaving people hungry. Areas with low food access have much higher rates of health problems. One of the most serious of these is the national obesity epidemic; areas with low access are more likely to be low-income and have much higher rates of obesity, and consequently pay more in health costs. In order for youth to learn, build healthy eating habits, and consequently lower the prevalence of obesity, they must have adequate nutrition.

Unhealthy food choices and eating habits have led us to a national epidemic of obesity. In this light, food is a public health issue. Low-income, low-access areas are correlated with a higher prevalence of obesity (Schafft et al., 2009). Health problems linked with obesity are diabetes and high medical costs (nationally, 130 million is spent on costs associated with obesity). It is ironic that people who cannot afford healthy food have to pay more for medical care than those who can afford both (Marty, 2010). Gaps remain in understanding how food access and the food environment and health are connected, but it is sure that they are connected (USDA, 2009). In low-income areas in Baltimore, more than two thirds of adults and nearly half of all high school students are overweight or obese, and the death rate from heart disease is 30 percent higher in food desert areas than the rest of the city (Nuckols, 2010). This trend is unacceptable and must be changed.

If we want a healthy population, we need to feed our people healthy food and teach healthy eating habits. Public school, required until the age of 16, is the primary place that we can educate our population about healthy food and eating habits. Despite this, students may not

practice what they learn. Murphy et al. (1995) found that school programs are effective at teaching students about what healthy eating habits are, but less effective at changing how they eat. Students qualifying for free or low-cost school meals come from low-income households, who often live in areas with low food access. The type of food provided by these meals is key in building healthy eating habits and providing adequate nutrition to facilitate learning (Murphy et al., 1995).

Food access enhances nutritional outcomes. Providing balanced nutrition is especially important for young adults and children of school age. Students growing bodies and minds require healthy food, and those who lack this often have trouble concentrating and learning in school. Bellisle (2007) found that nutrition has immediate and long-term affects on learning. For example, glucose intake facilitates mental performance, particularly in demanding or long-duration tasks. A lack of glucose results in a reduced capacity to pay attention. Eating breakfast is one way to increase glucose intake, and significantly improves school performance. Micronutrient deficiency leads to lower school performance (Bellisle, 2007). This condition is most often seen in malnourished populations in developing nations and is caused by too little food or a diet that is not nutritionally balanced. Malnutrition also affects long-term physical growth and development (Bhan, Sommerfelt, & Strand, 2001). Micronutrient deficiency and malnutrition are easily remedied by eating a diet that includes a diversity of fruits, vegetables and animal-source foods (Smitasiri et al., 2000). If we want an educated population with healthy eating habits and better health, students need healthy food.

Food security is a profound problem that affects public health and education, and spreading food access is important for the health and education of our country. Low access areas have higher incidence of obesity. Low income, low access areas are home to many families who

have a hard time affording to feed their children, which affects the children's ability to learn. Adding to the problem, healthy eating habits are hard to form when there are limited nutritional food choices available. Programs to spread access and education need to be aimed at the local level; so far, many of these initiatives have been successful in the small areas they target.

Leadership and Initiatives

Across the country, leadership to spread food access is growing. Programs to combat low food access are most effective at a local level, and local programs have been proliferating. Some are in the form of government "food councils" whose aim is to spread access by planning and implementing initiatives, but these lack sufficient funding. Some allow people without cars to virtually order groceries that are later delivered, or teach communities practices of urban gardening. To reach children, some school districts have been awarded funds to provide more school meals. Other grant programs partner with school districts to fund education programs about fitness and healthy eating choices.

There is a statistical correlation between public health issues, like childhood obesity, and distance to healthy food sources. Research studies exploring this connection have found that each local area has its own set of risk variables; correlating factors are most readily found on a regional level (Rosenshein & Waters, 2009). From this, we can infer that the problem of food access must be addressed on a local basis. A national policy to increase food access in underserved areas would be most effective partnered with local initiatives.

Many cities, including New York, Portland, Knoxville, Boston and Chicago, have food councils who are able to come up with many good ideas of programs to implement. Unfortunately, little is accomplished because of a lack of funding; most councils have no paid

staff and a minimal budget (Harper et al., 2009). Michael Pollan, an author and leader in the local food movement, has called for a national food policy director to be appointed to the President's cabinet (Smith, 2010). Michelle Obama's "Let's Move" campaign is aimed at ending childhood obesity, and has brought further attention to food security.

Although appointing government positions highlights the importance of access to healthy food, governments need to pay the people they appoint and fund programs so they are able to create enforceable policies that encourage access to and knowledge of healthy food. Twenty-eight percent of local food policy councils lack funding, while half of state food policy councils are minimally funded by the state government (Harper et al., 2009).

One city fighting low food access is Baltimore. It is estimated that one fifth of the city's 630,000 residents live with "little or no access to fresh foods." In June of 2010, Mayor Stephanie Rawlings-Blake appointed Holly Freishtat as Baltimore's first "Food Czar." Freishtat's mission is to "address food from a multi-sector perspective, increasing citywide access to healthy, affordable food" and to coordinate the many small organizations already working in the city (Institute for Agriculture and Trade Policy, 2008). The Baltimarket virtual supermarket programs link customers in food deserts with grocery stores. People can order food online, then pick it up or have it delivered through the existing system of libraries and librarians (Kast, 2010). So far, the program is small, but it has increased food security in the areas it serves.

The Philadelphia Urban Gardening project and other urban gardening programs have taken advantage of the many vacant lots in Philadelphia and started community gardens. These gardens have dramatically increased the quality of life local residents by providing people with tastier, more nutritious food, lowering the amount of money and percentage of income that households spend on food, providing an educational and recreational outlet and fostering a sense

of pride in the local community. Urban gardening as production agriculture also helps by bringing in outside income. Detroit, Michigan and Braddock, Pennsylvania (featured in Levi's advertisements) have urban gardening programs that have had comparable results (Blair et al., 1991). These efforts to increase food security are small but usually successful in educating people and increasing food security during the harvest months.

Providing better food access at home might also lift the burden on the already strained public school system. The nonprofit organization Hunger Free Vermont assists schools in Vermont in serving nutritious meals to students and expand free and reduced price meal plans. Its efforts have succeeded in raising the percentage of schools serving breakfast and lunch from 17 percent to 97 percent ("Hunger Free Vermont," 2011). This organization works within the school system, and consequently runs into problems with funding in low-income school districts. Fortunately, they are often able to obtain grants for funding (Drive et al., 2010).

Another effort is the Healthy Kids, Healthy Communities grant, led by the Robert Wood Johnson Foundation. This grant "promotes changes to local policies and the physical environment that foster healthy living and prevent childhood obesity," (p.1) placing a special emphasis on reaching children at the highest risk for obesity based on geographic location. It has been able to link more experienced communities with those less experienced, and make 85 policy changes and 144 environmental changes in 49 communities (Robert Wood Johnson Foundation, 2012). Here, the problem faced may be that dispensing the grant money is complicated: public officials are busy and the grant coordinates 49 communities. Fortunately, the foundation recognizes that changing social norms precedes changing eating habits.

Hunger, globally and nationally, is a problem. The problem of food availability has been remedied, but that of food access, especially for low-income communities, remains. Awareness

of the problem is growing, and leadership and initiatives are springing up. The problem of food access is best addressed on a local basis. Many local initiatives exist, but in order to be effective they require adequate funding. These programs exist to fill the void left by current federally funded programs, which have not done enough to help. Food access is spatially dependent, and the environment in which people live heavily affects the choices they make about what to eat. Low food-access has public health consequences, especially for growing, learning children and the national obesity epidemic. The areas most severely affected by low food access have been dubbed "food deserts."

Food Deserts

Areas known as "food deserts" were first identified in 1990. Since then, they have been targeted in the light of food access inequality as severe problem areas. Contributing factors include zoning changes and retailer consolidation. Also, grocery stores are less likely to locate in areas with high crime. Other factors have to do with individual and household socio-economic status. These include mental, physical and financial barriers that people must overcome to reach a food source, buy food, and transport it home. Recent academic and government research has focused on identifying causes of food deserts and designing strategies to combat them.

Research on food deserts started in the 1990's in the United Kingdom to try to explain the inequalities in food access in some cities and towns. Wrigley (1994) documents the consolidation of supermarket chains and the resultant public unease that contributed to public concern over food inequality. The 1993 survey by the Health Education Authority in the UK documented that those in the lowest income bracket were less likely to have access to a car for food shopping. The term "food desert" was coined by the Low Income Project Team in the UK in 1995 to define the "complex nexus of interlinkages between increasing health inequalities… differential access to food retail… compromised diets, undernutrition and social exclusion" (p. 2032) where nutritious food is "virtual unobtainable" (Wrigley, 2002). In 1998, The Independent Inquiry into Inequalities in Health found that a 'healthy' bundle of food cost more in poor areas than in affluent areas and that they were significantly more difficult to obtain (Rait, 1999).

Food deserts are the result of many historical precedents, mainly zoning and retailer consolidation. Both have provided ample reasons for companies to locate stores according to clear patterns of demand and conspired to make food access geographically unequal. Patterns of

zoning started to form during World War II, when people were encouraged to grow their own food in patriotic "victory gardens." After the war, people continued this endeavor. Later, as industries left cities, more and more people lost jobs and income. Relocation, combined with white flight to the suburbs, left inner cities depopulated and the remaining population living in poverty. Low-density, low income markets could no longer support supermarkets, so the stores left and moved to the suburbs, where people had more money to spend. Zoning for single-family homes on large lots in suburbs prevented low-income people from moving in, and zoning in cities prevented them from keeping animals or gardening (Marty, 2010). Thus, zoning ordinances affected household food security making people more reliant on grocery stores. Furthermore, zoning laws eroded the ability for households to retain gardening knowledge, so growing food all but ceased in cities. Food insecurity due to zoning restrictions and loss of gardening knowledge was compounded by market failure. The market failed to provide a supply for these areas because the demand, and profit to be made, was greater elsewhere.

Another major factor contributing to food deserts is the consolidation of the supermarket industry, wherein large chains buy small stores and eventually close them. Large chains locate their stores in areas where there is a high demand for food, which means in areas where the number and wealth of consumers can support a large supermarket (Pothukuchi, 2005). This has left many rural areas and low-income urban areas without full service grocery stores (Schafft et al., 2009).

Today, the failure of the market to locate grocery stores in low-income, high crime areas and resultant mental, physical, and financial barriers perpetuate the existence of food deserts. People continue to leave lower-income areas because, to most, they are undesirable places to live. Mental barriers include limited knowledge of cooking certain foods and the importance of

healthy eating. They also include lost knowledge of gardening from prior eras. In feeding people, it is important that they have access to food that is not only healthy, but is also culturally appropriate. Culturally appropriate food caters to the knowledge people have of food storage and preparation as well as their tastes. It is also convenient to access (Marty, 2010).

Financial access barriers are the inability to afford healthy food or to afford bus fare or car fees to travel to a place where it is sold or the inability to afford adequate storage and cooking facilities (Marty, 2010). Currently, 81 percent of Americans live in urban areas, with low-income urban dwellers spending more than a third of their income on food (UN Population Division). Furthermore, foods are more expensive at convenience stores than full-service supermarkets, and low-income areas in inner cities often lack supermarkets due to a lower demand for food (different from hunger) and higher crime rates (Schafft et al., 2009). To feed so many people in such high density requires that food be imported from surrounding areas, using exorbitant amounts of time and effort. This makes the cost of living, and therefore food, more expensive in cities than in rural areas.

Physical access is proximity to food, and the ability to transport it home. Barriers to this can include poor car or public transportation access, having to walk along busy roads to travel to food stores, and people's physical disabilities. When people do not have the ability to store and cook food, they will usually not buy it. When people cannot travel to further away groceries, those groceries may close as their demand base shrinks. There are no national policies and few market incentives for grocery stores to locate in food deserts (Marty, 2010). Despite all these barriers, low-income residents of inner cities go to great lengths to buy lower-cost food at grocery stores farther away than neighborhood convenience stores (USDA, 2009).

Research on food deserts has proliferated in academic and government research in recent

years. Shaw (2006) has written papers defining what food deserts are, exploring their causes, and developing a classification scheme. Schafft et al. (2009) focus on the effects of food deserts on the prevalence of childhood obesity in Pennsylvania. Pothukuchi (2005) explores methods for bringing greater food access to inner-city food desert, such as the creation of an agency to aid supermarket chains to open stores in low-access areas by finding appropriate lots and simplifying regulations. Larsen & Gilliland (2008) study the incidence of food deserts in London, Canada from 1961 until 2005. They find that neighborhoods with low socioeconomic status are the most likely to be food deserts.

The 2008 Farm Bill provides a more specific definition of a food desert: "an area in the United States with limited access to affordable and nutritious food, particularly such an area composed of predominantly lower income neighborhood and communities" (Breneman & Ver Ploeg, 2009). The United States federal government recently recognized the public health problem posed by lack of food access by mandating a study of food deserts in the 2008 Farm Bill. The study was a one-year comprehensive study of "areas with limited access to affordable and nutritious food to determine correlated factors, extent of the problem, effects on people and to make policy recommendations" (Opfer, 2010). The study found that increases in obesity and other diet-related diseases are exacerbated because of low access to "affordable and nutritious foods." It found that although the number of households who live more than a mile from a supermarket and who do not have access to a vehicle comprises only 3.2 percent of all households, nearly 6 percent of households in the United States have "access-related problems" to food. It confirmed academic findings that full-service grocery stores have lower prices than convenience stores and that low-income households search for low cost food. It recognizes that market conditions contribute to differences in food access, and that food is a tool for community

development. It recommends taking these findings into account when forming policy (USDA, 2009).

Food deserts stem from a history of policies and market trends that failed to create food secure communities. Today, these market trends, as well as mental, financial and physical barriers perpetuate the existence of low access areas known as food deserts. They have been the focus of academic research since the 1990's, and more recently, government study. Because food access is spatially dependant, some researchers have sought to better understand food deserts by creating maps.

Maps of Food Deserts

Maps allow for the portrayal of information in a way that can affect public opinion or policy. Many methods of mapping food deserts have resulted from recent government and university research. Although there are some differences between these methods, most use geocoding to place grocery store locations on the map before calculating their distance to people served by each food store. Research on the geocoding process has shown it to be inaccurate. Because these maps use inaccurate data, many are insufficient to correctly pinpoint all locations of food deserts. A research effort Goldsberry and Duvall has collected its own data on grocery store location and therefore bypassed this limitation (Goldsberry et al., 2010).

Maps allow people to show and disseminate data about many different kinds of phenomena, so that viewers can visualize and more readily understand spatial patterns. The mapmaker is able to show patterns and paint desired pictures to affect public perception of an issue, as well as affect policy by changing how an issue is framed. Because of this, they have been instrumental in policy making and disseminating research. When made well, they are powerful tools.

The maps identifying food deserts most often use zip codes, population weighed centroids, gridding, and average household distance to map the distance needed to travel to a supermarket. The map made by Schafft et al. (2009) approximates grocery store locations using zip code centroids and highlight school districts without full-service groceries. Opfer (2010) identifies food deserts in two counties along the Oregon coast. She uses several different definitions of "low-income," including "below 200 percent of the poverty line," (p. 34) and "median household income [of a block group] under $34,643" (p. 34). She classifies area densities on a scale ranging from more urban to more rural. She weights the block group

centroids by population and calculates their distance from a full-service grocery store. The final map is made by highlighting those block groups outside a "critical distance" from a store (Opfer, 2010).

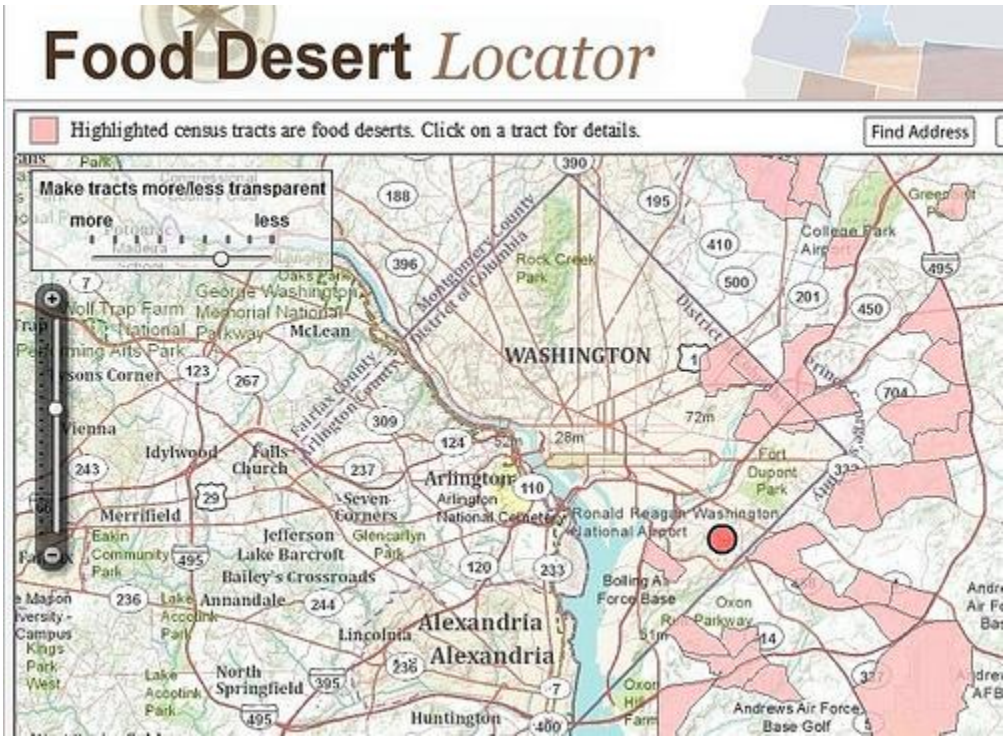

Figure 2: Breneman, V. (Producer). (2011). *Food desert locator*. [Web Map]. Retrieved from http://urbanplacesandspaces.blogspot.com/2011/05/um-where-are-dcs-food-deserts.htm1l

Analysts creating the USDA food deserts locator map divided up the continental United States into a grid of 1x1 kilometer squares and highlighted those census tracts containing squares that qualified as both "low access" and "low income" (Breneman & Ver Ploeg, 2009). The USDA also created an online map application based on this study called the Food Deserts Locator (Figure 2). Eckert & Shetty (2011) use GIS to identify inner-city areas at risk for low food-access and plan for food retail accordingly. They calculate the distance from each household to the nearest chain-store supermarket and average them by block group (Eckert & Shetty, 2011).

Most of these efforts at defining and mapping food deserts divide food retailers into classifications of "convenience stores" (which includes small neighborhood grocers) and "full-service supermarkets", and consider only the supermarkets category in their analyses. These maps often map food density within a certain distance (driving or walking). They also rely heavily on geocoding supermarket addresses. While this is helpful in mapping food deserts at a small scale, the problem with this is that data on grocery store location has large errors and is inaccurate when used to create large-scale maps of food deserts. Research suggests that geocoding is very inaccurate (Zandbergen & Green, 2007) and therefore insufficient for pinpointing the geographic locations of addresses on large-scale (fine detail) maps. Other problems are that store location data becomes quickly outdated when stores open, close, or move, and that some are misclassified by Standard Industrial Codes (Goldsberry, 2009).

With original data collected on produce and grocery store location, Goldsberry et al. (2010) explore where produce is located in Lansing and Albuquerque. They use direct observation and GPS technology to map where food retailers are located and the types of produce sold (Figure 3). They have created maps showing pedestrian access to individual foods and heat maps of pedestrian access to the number of kinds of fresh foods. Their maps have been successful because they accurately show food access in the two cities (Duvall et al., 2010; Goldsberry, 2009). Unfortunately, many efforts studying food deserts do not have adequate funding to survey food in the entire study area.

Figure 3: Goldsberry, K. (Designer). (2012). *Absolute pedestrian access*. [Web Graphic]. Retrieved from http://www.geog.ucsb.edu/events/department-news/906/kirk-goldsberry-maps-food-deserts/

Maps of food deserts use various methods to calculate distance from a population area to a grocery store. By overlaying these areas with low-income areas (variously defined), they are able to highlight areas to be considered food deserts. These efforts are undermined by poor data quality, meaning data with a high level of inaccuracy, and expensive data collection. Goldsberry et al. (2010) have successfully mapped food access, but their process may be too expensive to perform on a nationwide level. A method of mapping patterns of food access to discover food deserts must take into account these limitations as well as the complicated nature of food deserts. The approach of creating an index has not yet been applied to food access and could resolve these limitations by relying less heavily on inaccurate grocery store location data.

Mapping Food Access

Rationale for an index

The USDA states in its report to Congress that "the current state of research is insufficient to conclusively determine whether some areas with limited access have inadequate access" (USDA, 2009). Because of the complex nature of food deserts and the clear inadequacy of other maps stemming from data problems and oversimplification, I propose to create a map that takes into account the multifaceted nature of food deserts and a methodology that could be changed to suit different data sets. On a more practical level, I wanted a map that not only addresses the academic discussion of food access, but one that can be used as a policy tool to identify areas to target programs to increase food security. I also wanted to create a map to educate people in the general public interested in the subject. This map will increase understanding and awareness of food access by allowing the viewer to see and compare levels of food access across a given area. The ability to view access across a given areas shows which areas are more and less likely to be food deserts, and which areas are most lacking in leadership and initiatives.

To this end, I start by creating an index of food access. An index allows for the combination of many contributing variables into an overall ranking. This ranking, when mapped, allows the user to compare areas of higher and lower food access by creating a visual representation of the differences in food access across a surface. Although there are some limitations to the use of indices, namely the generalization involved, I chose this technique because showing the differences in food access demonstrates the complex nature of food deserts and identifies areas that are more likely to be food deserts. To do this, I reclassify each data layer into three levels: the lowest level definitely contributes to the area being a food desert, the

highest level definitely does not contribute, and the middle level is an uncertainty zone in between. Then I add the layers with the raster calculator tools in ArcMap10 to create a final index score. I also referenced two earlier maps, the ITUM (Integrated Terrain Unit Map) and Roger Sayre's ecosystems map. By using interpolation and creating classes of data, these maps create continuous surfaces showing detailed planning areas and summarize a situation that is not easily captured by survey data. For example, small errors in data are less serious when interpolated from vector (discrete) to raster (continuous).

Scale and Study Area

Philadelphia and the greater area were chosen as a study area. It shows urban, suburban and rural populations and thus will be comparable to other areas. It is a city that has areas with very affluent and very poor areas, and places with high and low food access. Also, I have familiarity with the city and these areas and was better able to judge the validity of the processing results when designing the methodology. The limitation of using Philadelphia as a study area is that because it mainly shows urban and suburban communities, it does not capture the results of the geoprocessing on rural areas and provide a clear picture of access there. Also, university campuses, such as Temple University and LaSalle university, do not provide data on the meals they serve on campus and therefore will have artificially low index scores.

I decided to analyze the data at the level to which most people relate that is, on a block-by-block basis, rather than as a larger unit, such as a state, census tract, township, county or state. At this level, maps are easier for people to understand as this is how they relate on a daily basis to their environment. The maps are more useful at this scale for local initiative planning. All real-estate listing sites are based at this scale: housing price changes block-by-block are more

important information to the reader than how they change on a state-by-state basis. Food access operates and is valued similarly. There are many maps at a county, state and national level showing food deserts, such as the USDA's Food Locator Map (Figure 2) and the Good Lifestyles Food Deserts Interactive Map (Figure 4), but few that show someone's neighborhood, like the map of nutritional terrain from Goldsberry et al (2010) (Figure 3).

Figure 4: United States Department of Agriculture. (n.d.). *No car and no supermarket store within a mile*. [Print Photo]. Retrieved from http://pre.cloudfront.goodinc.com/posts/full_1294067955Picture2.png

The disadvantages of this approach is that data are often not available at this scale, data at this large scale is costly to collect, and the dataset (and therefore the map) is more susceptible to errors or changes in the real world that are not captured by the dataset. The interpolation that will be performed on the dataset may make up for the majority of errors on the map.

Quantifying Access

To map magnitude differences, one must use quantifiable data, and numbers ranking food quality are not readily available. Because this map ranks the quality of food access, one must use value-based judgments to assign numbers, quantities, or weights to the importance of each

quality. I compiled the relevant numbers in the literature to create my own ranking scheme of food access quality. The "relevant numbers" I refer to are all factors that could possibly explain differences in food access and diet, or explain why food deserts exist in some areas. In the literature, there are many contributing factors to food access inequalities. Pothukuchi (2005) considers supermarket location and factors contributing to differences in demand, such as age and income, most important. The USDA (2009) considers income and distance from supermarkets most important. Roux (2009) found that walking distance for people without a car in low-income areas was the most important factor in judging food access. Blair et al. (1991) found that community gardens improve access and increase vegetable consumption.

Overall, important factors include socioeconomic status, access to a car, population density (rural versus urban) and age. I used two main categories of factors in my model: socioeconomic context and food location. Socioeconomic context includes income, access to a car, age, and other socioeconomic markers. Food location simply means where food is located, that is the geographic locations of supermarkets, convenience stores and other food sources in relation to residences. Other variables, such as indexes of unmet demand and the presence of local initiatives, are indicative of an area's food environment, but data on them was not readily available.

I also looked for critical breaks in ranges for each factor, levels above which an area was not considered a food desert, and below which it is considered a contributing factor. For example, 33% poverty or higher is a contributing factor to food deserts in the USDA definition of a food desert (USDA, 2009). By this definition, an area with less than 33% poverty is not considered a food desert. The numbers defining levels of contributing factor will contribute to

making the index. To perform this kind of search and compilation is an econometric analysis.[1] A drawback to this is that the resulting analysis is not entirely objective, as my subjective judgments are involved in assigning weights. In applying this analysis to other places, analysts can be flexible in assigning weights they deem more appropriate.

After exploring the factors involved in the phenomenon of food deserts, I had to decide how important each factor was in relation to the others. In some cases, it was simple. Some studies stated some factors as being more important than others, such as the USDA's (2009) assertion that car ownership is a more significant contributor to food access in rural areas than in urban areas, while percent poverty is more significant in urban areas than rural. In other cases, such as that of walking distance to supermarket, I looked for frequency of inclusion across studies.

[1] Samuelson et al. (1954) write this description and definition of econometrics:

> " [One] form [of intellectual activity] consists in devising suitable methods which will permit the theories and observations to be related, statements to be made as to the extent to which observations support a belief in the theories and the estimation of the strength of the influence of one variable on another… In these terms econometrics may be defined as the quantitative analysis of actual economic phenomena based on the concurrent development of theory and observation, related by appropriate methods of inference."

Data

Although there are many factors contributing to the location of food deserts, not all of it can be easily found in map-able data on a nationwide scale. Contributing factors include food location, socioeconomic context, and initiatives present. Despite this, I could only I found data on two categories: food location and socioeconomic context, and included these in the final map.

Food location includes all places where food is sold. Data is most readily available on supermarket, restaurant, convenience store, and farmers' market location. Walking distance to supermarkets stands out as the best way to judge food access in all studies I found (Duvall et al., 2010; Goldsberry, 2009; Opfer, 2010; Pothukuchi, 2005; USDA, 2009). Large stores are better, but small stores may have higher turnover rates of stock and sell comparable amounts of food at similar prices. It is hard to tell this, as most data on stores either assigns the store to a class or only has an attribute telling us size (Cliff et al., 2004). There are more closings of supermarkets in lower demand areas (inner city poor and rural) but similar rates of openings of supermarkets across all areas regardless of income; more supermarkets close than open in lower demand areas and the number of supermarkets is declining (Cliff et al., 2004). Roux (2009, pg 41) also found that walking distance is the best indicator of food access. Restaurants are a good indicator of high food access if clustered in suburban areas, but not if clustered in inner city areas. This happens because restaurant clustering is indicative of market demand, and fast food restaurants are more likely to locate in lower food access areas (Roux 2009). Farmers' markets are a positive indicator of food access if located in inner-city areas and are used in many initiatives. I have data on all three from Esri 2009 and the Department of Agriculture 2010 (Data.gov Program Management Office, 2010) but decided to only include walking and driving distance to supermarkets to simplify the model, and because they were most widely mentioned in the

literature. The block group data from Esri is accurate at scales less than 250,000:1 (AtlasPublisher, 2012).

Socioeconomic context includes car ownership, income, crime rates, vacant housing units, and age. The variable of not having a car is more important in rural areas but still important in urban areas (USDA, 2009). It is also found to be less important than walking distance to supermarkets (Roux 2009). Income, that is low income leading to low market demand for food, is more important in urban areas but still a factor in rural areas (USDA, 2009). Crime is weakly related to food access because food retailers are loath to located in high-crime areas (Pothukuchi, 2005). A high percentage of vacant housing units is correlated with lower food access (Roux 2009). A high percentage of elderly population is also more vulnerable to lower food access (USDA, 2009; Roux 2009). I have data on car ownership, income and crime rates from Census 2010, Applied Geographic Solutions and Esri 2009, and they are included in my model.

Many of these socioeconomic factors lead to a low market demand for food, but high levels of hunger remain. These communities are characterized by higher rates of public assistance and lower square footage of grocery store space. They are most often inner city areas that have higher costs of living. They are rarely suburban areas that have higher buying power and more stores. I did not have data on levels of unmet demand, although some indexes exist to judge this factor. Some of these low market demand communities are home to initiatives. Local initiatives have been shown to lead to higher food access, whether public, private or nonprofit. This is difficult to map on a national scale. I did not have data on the extent of local initiatives in the Philadelphia area so it was not included in the model.

Methodology

Based on the previous research, the factors I included were walking distance to supermarkets, driving distance to supermarkets, a crime index, the percentage of population without a car, and the percentage of the population in poverty. Walking distance and driving distance to supermarkets were the most widely used indicators of food access, and walking distance was correlated with the best food access. The percentage of the population without a car and percentage of the population in poverty were also considered very important, but less so than walking distance to supermarkets. These two variables also act differently in rural and urban areas, so I weighted them accordingly. The USDA report to congress on Affordable and Nutritious Food found that in urban areas, income equality is the main barrier, while in rural areas, transportation is the biggest barrier (USDA, 2009). The crime rate is weakly correlated with low food access, but still is useful, so I included it as the factor with the least weight in the model. If you have limited resources, walking distance to supermarkets, percentage of the population in poverty and percentage of the population without access to a car are the best indicators to use, as they are most widely mentioned in the literature.

Table 1- weights on factors included

Data layer	weight
% Poverty, urban	2
% Poverty, rural	1.5
% no car, urban	1.5
% no car, rural	2
Supermarket walk score	3
Supermarket drive score	2
Crime index	0.5

Data was obtained from Esri 2009, Applied Geographic Solutions, and the 2010 Census (Applied Geographic Solutions, 2012; Esri, 2010; Esri, n.d.). The crime index was developed

using statistics about "major categories of personal and property crime," including murder, rape, robbery, assault, burglary and motor vehicle theft (Esri, 2010). The walking and driving scores to supermarkets were calculated using the rank_score calculator developed by Jim Herries at Esri. This tool calculates how many specified points (in this case, supermarkets) are within a one-mile and ten-mile Manhattan distance (over the road network) of any given block and enters the value into a new field. These data were used because they were freely obtained during an internship at Esri in the summer of 2011.

I defined three groups in each factor: level 0 is definitely a contributing factor, level 2 is definitely not a contributing factor, and level 1 is a buffer zone of uncertainty in between. For each 25 x 25 meter cell on the map, I calculated a score of 0, 1, or 2 for each of the eleven factors. I then weighted each factor accordingly and added the values for each cell together.

Table 2- Classes of food access

No.	*Data layer*	*2 (higher)*	*1*	*0 (lower)*
1	**% Poverty**	<10	<25 and >10	>25
2	**% no car (no vehicle)**	<10	<25 and >10	>25
3	**Supermarket walk score (walkscore_1)** Note: because of interpolation, software recognizes the discrete values as continuous ones. Buckets for reclassification are from 0 to 0.49, 0.49 to 1.49, and greater than 1.49	>2 supermarkets	1 supermarket	0
6	**Supermarket drive score**	>2 supermarkets	1 supermarket	0
11	**Crime index**	<35	>35 and <235	>235

In the USDA definition of a food desert, it specifies that a "low-income community…must have either: 1) a poverty rate of 20 percent or higher, OR 2) a median family income at or below 80 percent of the area's median family income." The data available allowed me to map areas with a rate of 20 percent poverty or higher as a contributing factor to food

deserts. By this definition, an area with less than 20 percent poverty is not considered a food desert. The same number applies to the percent of the population without a car (USDA, 2009). Most studies found that the difference between being within walking distance to one supermarket or no supermarkets improved food access much more than the difference between being within walking distance of one supermarket, or two or more supermarkets (Duvall et al., 2010; Roux, 2009). To allow for changes in the real world not captured in the dataset, such as grocery store openings and closings, or mistakes in the geocoding process, I set two grocery stores as the requirement for higher food access. I used this same reasoning for driving access to supermarkets. The Herries walk/drive score set walking at one mile and driving at ten miles, as per the USDA's definition that people residing "more than one mile from a supermarket or large grocery store (for rural census tracts, the distance is more than 10 miles)" are in a food desert. For the crime index, I set the buffer around the national crime index average score of 100 (AtlasPublisher, 2012).

Data Processing

I first joined all the data together into a common file. I then used the Natural Neighbor interpolation tool to interpolate a continuous surface for each layer. I used Natural Neighbor instead of another interpolation tool because it is the best for demographic data. I reclassified the layers using the Reclassify tool according to the values in Table 2. Finally, I used the Raster Calculator tool to aggregate the layers using the following expression:

(3 * "supermarketwalkRECLASS") + (2 * "supermarketdriveRECLASS") + (0.5 * "crimetotcRECLASS") + ((("percentnocarRECLASS" * 2) + ("percentpovertyRECLASS" * 1.5)) * "ruralfilter") + ((("percentnocarRECLASS" * 1.5) + ("percentpovertyRECLASS" * 2)) * "urbanfilter")

The Map

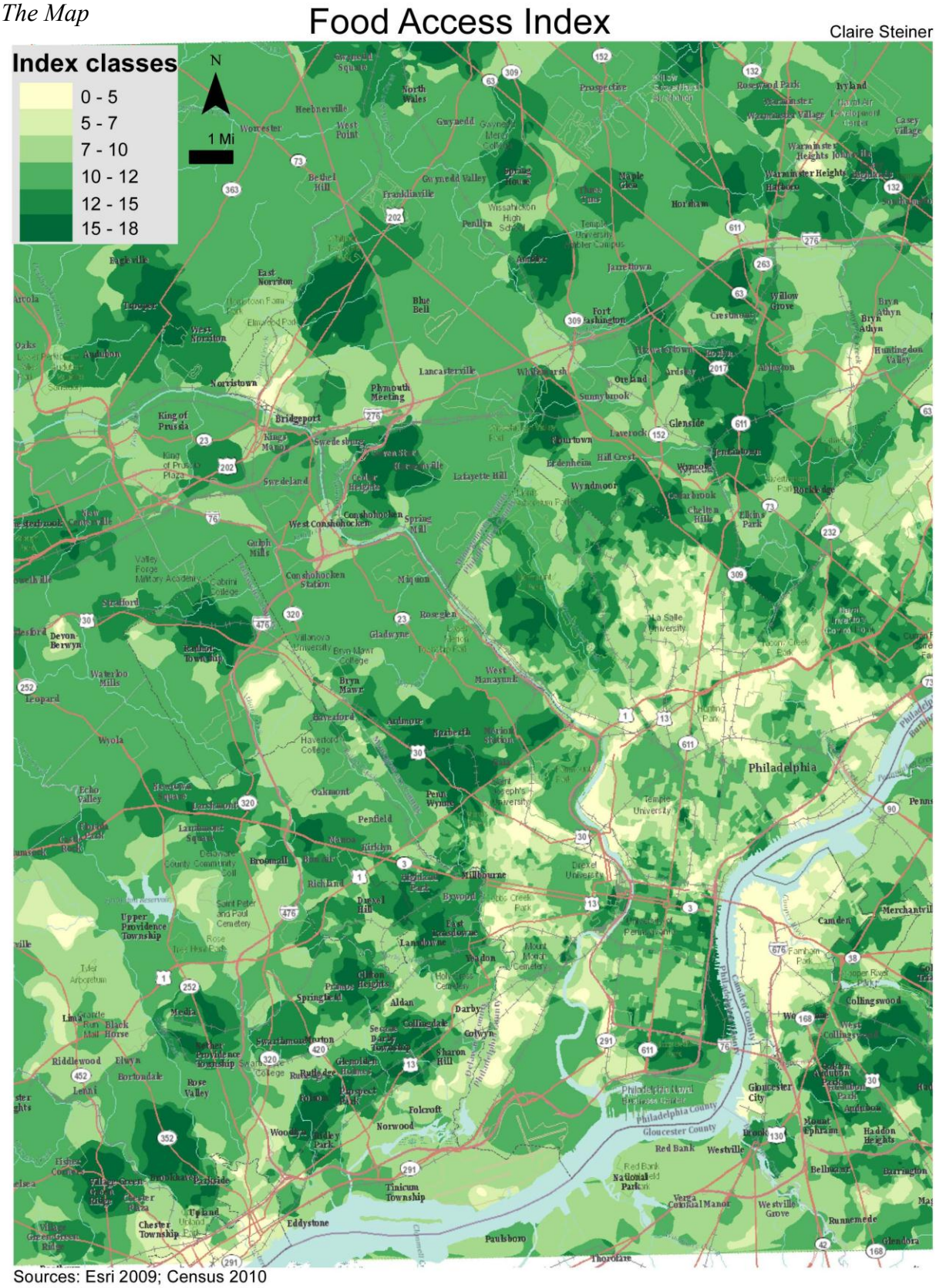

Figure 5

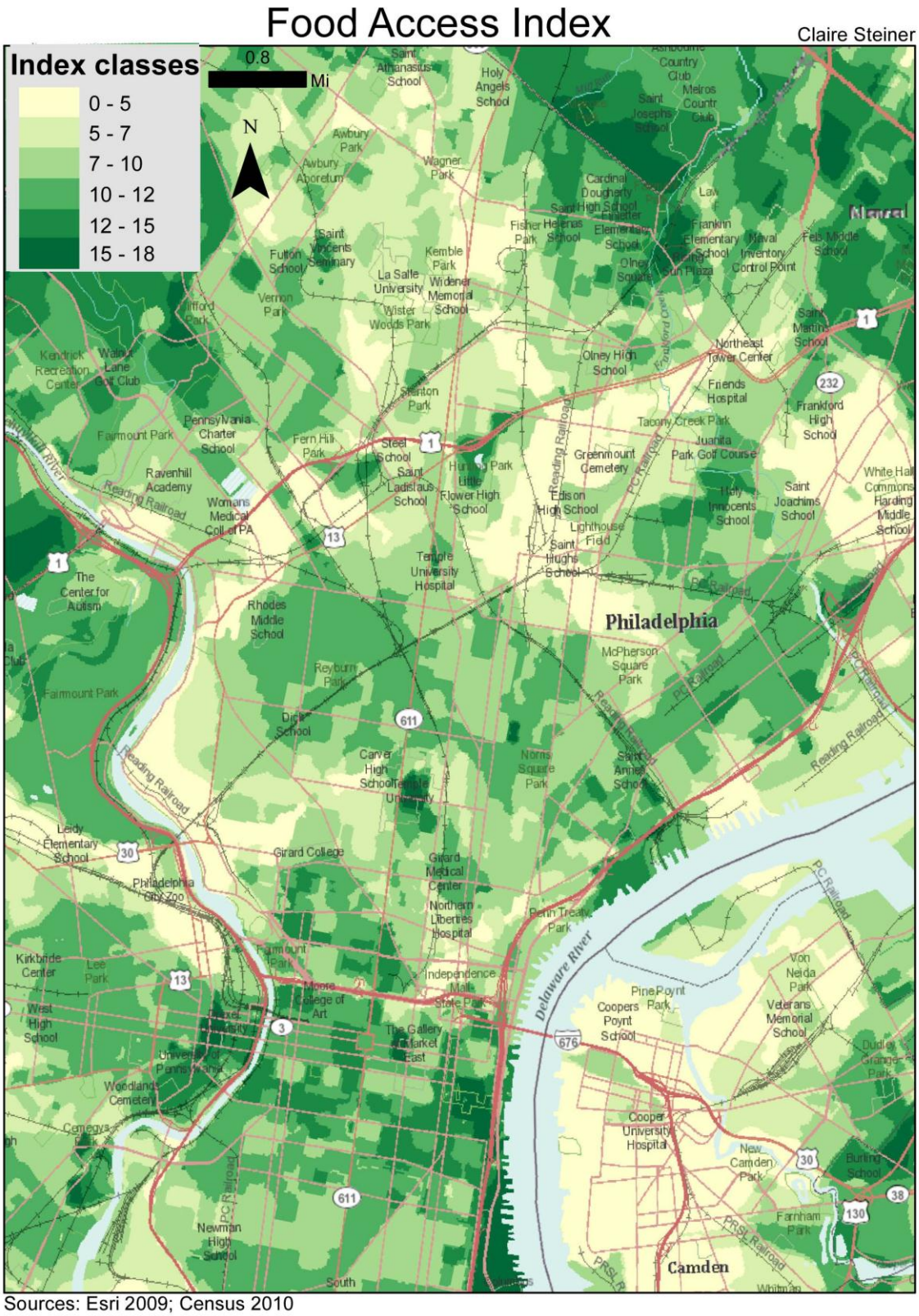
Food Access Index
Claire Steiner
Index classes
0 - 5
5 - 7
7 - 10
10 - 12
12 - 15
15 - 18
0.8
Mi
N
Philadelphia
Camden
Delaware River
Sources: Esri 2009; Census 2010

Figure 6

Discussion

This map presents a simple model to help judge the food environment of an area. The index does not offer an absolute judge of whether an area is a food desert or not, only a measurement of the likelihood it is a food desert. The map shows relative food access and can help pinpoint better areas to target for the implementation of food initiatives.

Figure 5 shows the entire study area, and the Figure 6 shows a detail area. The lightly colored areas on the map are those with corresponding low food access. The greater the index score calculated, the darker the color green. The darkest green colored areas on the map have the highest food access. The viewer can see the how likely it is that an area is a food desert. For example, in Figure 5, there is higher food access along the highways leading to the city, as many commuters live in these communities, and they are often more affluent. In Figure 6, the difference between food access in Camden, New Jersey and the center city of Philadelphia is shown; food access in Camden is much lower.

I tried various classification strategies to discover patterns in the data. When I shifted the classes of food access (seen in table 2) to the lower end of the scale and when I made the middle class wider (table 2), the map pattern reinforced the food insecurity of the inner city. It also showed that areas along roads had higher food access. In this same exploration, I tried different combinations of weights assigned to the factors included in the index. Similar patterns resulted from these changes as is seen in Figures 5 and 6. This map pattern has added validity because it seen regardless of the classification I prepared based on the theoretical research.

The classification scheme I used broke the index values into six classes, using standard deviations from the mean value of 11.29. The standard deviation is 2.64. I used this because I believe that these show the data most accurately. As can be seen in figures 7 to 10, similar patterns resulted from different classification schemes of the final index. Different symbolizations showed more contrast or more smooth transitions between index values, but maintained a similar spatial pattern, showing the robust nature of the index-based surface representation. In the end, I kept the map symbolized by standard deviations from the mean to maintain a statistical basis for the class breaks.

Because the USDA stated that low food access was not necessarily synonymous with insufficient access, I used a sequential color scheme. I did not use a diverging color scheme that emphasizes a critical midpoint in the data set to avoid misleading the reader to think that one color sequence above the critical value was high access and the other was low access.

Figure 7: Standard deviations using 6 classes, final classification scheme; breaks at 5, 7, 10, 12, and 15

Figure 8: Standard Deviations using 7 classes; breaks at 4.7, 7.3, 9.89, 12.6, 15.25, and 17.8

Figure 9: Quantile classification using 6 classes; breaks at 9.5, 11, 11.5, 11.9, and 14.5

Figure 10: Equal Interval classification using 7 classes; breaks at 3, 5.5, 8, 10, 13, and 15.5

Limitations

There were some problems with my model. The universities, such as LaSalle and Temple Universities in Philadelphia, have artificially low scores. This happens because, although these university campuses have dining halls, they do not have grocery stores, and therefore receive a lower score when calculating walking distance to the nearest grocery store. Also, the map can only be used down to a scale of 1:15,000. Another problem is that there is not enough data on meal location, like school meals and food pantries. Researchers at the College of William and Mary are working on school meals data, but the data are not nationwide and have many errors (Saporito, 2010). Abundantharvest.org has the largest database of food pantries that I was able to find, but the owners of the data were unwilling to share permissions for me to use it. There is also not enough information on classification breaks. Some of the classification breaks I inferred from research into subjects unrelated to food deserts. The implications of this are that my analysis is not entirely objective, and that my subjective judgments were used in deciding on the final methodology. I believe that my depth of knowledge about the subject is great enough to compensate for these shortcomings.

Conclusion

Hunger is a worldwide problem, one that humans have tried to conquer for generations. The concept of food security has come to light in discussions on ending hunger; two related concepts are food availability and food access. Recently, the challenge of food availability was solved through the invention of the Haber-Bosch process, ensuring that there is enough food grown for everyone in the world to eat a nutritionally and calorically sufficient diet. Despite this, inequalities in accessing food still exist, and severe problem areas are deemed "food deserts."

Research on food deserts began in the 1990's and continues today. Early theoretical research focused on the effects of food deserts, while research today focuses on identifying, mapping, and designing strategies to remedy these problem areas. Empirical research has used various methods to map distance to grocery stores and identified factors associated with low food access. Unfortunately, many of these maps are limited in scope or of a scale that is too small to be relatable to the general public. Other problems include problems with data accuracy when mapping grocery store location.

To resolve these limitations, and take into account the complex nature of food access, I have created an index of food access using factors correlated with low access in the literature. The inclusion of other correlated factors and the interpolation techniques in the map make up for the lack of accuracy in data on grocery store location. This map and the techniques used in creating it can be used as an educational tool and a policy tool to raise awareness of the issue and help with the planning of local and national initiatives. The limitations of my project are the limited scope of the study area and the educated guesses I had to make to turn a qualitative into a quantitative subject.

Future research could focus on further refining the classification scheme and the weights

used on the factors included in the map, include more correlating factors, or perform the analysis over a wider area.

This map shows that although local initiatives target specific areas, there are places on the fringes of food deserts that would benefit from initiatives. It also shows that there are areas on the fringes of areas with high access that have similar food access to areas on the fringes of food deserts; these areas would also benefit from action to raise their food security. The map shows that the most effective measure that can be taken to raise food access is to open a full service grocery store in a food desert. The policy implications of this are that initiatives need to be more widespread and targeted at a wider range of communities.

From the research I have done I can make several policy recommendations. The first is for governments to adequately fund and staff food councils. Secondly, money is needed to perpetuate the existence of successful initiatives, so more grants could be provided that could be obtained with less paperwork and lower administrative costs. These grants need to be targeted at increasing urban agriculture, increasing the amount of school meals served. These grants also need to incentivize grocery stores not only to locate in areas that clearly have low food access, but also in areas in which the level of food access is less clear.

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