A SPATIAL ANALYSIS OF HEALTHY FOOD AVAILABILITY IN URBAN NEIGHBORHOODS

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ABSTRACT OF THE DISSERTATION

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Food insecurity and poor access to healthy foods is a global and local issue. In the United States, urban populations demonstrate enormous disparities in quality and access to food resources necessary for a healthy life. This study demonstrates that although healthy foods may be available within a close proximity to some urban neighborhoods, these resources may be in limited supply or inaccessible by segments of local populations. In south and southwest Philadelphia, two neighborhoods demonstrate a high concentration of fresh food and vegetable availability characterized by supermarket service regions of approximately 0.10 square miles. Six additional high density neighborhoods demonstrate much lower availability with supermarket service regions extending to 2.53 square miles. Gaps or underserved areas outside supermarket service areas demonstrate a lower rate of accessibility to fresh fruit and vegetables than the corresponding service areas of supermarkets. Within supermarket service areas the density of grocers stocking fresh fruits and vegetables is 35.3 grocers per square mile. In supermarket gap areas this number drops to 7.1 grocers per square mile. Thus some neighborhoods have access not only to supermarkets, but also benefit from a higher density of smaller grocers stocking fresh fruits and vegetables. Similarly, the mean produce accessibility rate for pedestrian supermarket service areas is 887.3 square feet of fresh fruits and vegetables per 1000 population. The produce accessibility rate drops significantly in pedestrian and public transit gap areas. In spite of statistical relationships between produce accessibility and location in a gap or service area, fruit and vegetable intake does not show a correlation with an accessibility measure to supermarkets. Policy recommendations include aligning transportation and food access for underserved areas and coupling education with improved access to improve healthy food intake. Neighborhoods vulnerable to poor fresh fruit and vegetable access tend to be less dense fringe areas of well established urban neighborhoods.

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Chapter 1: Introduction

A. Food insecurity

Poor neighborhood food environments contribute to food insecurity and health crises such as obesity. Food insecurity describes the inadequate accessibility to food for individuals to lead an active and healthy life. Food insecurity plagues populations in urban and rural geographies throughout the world and the United States (Nord and Andrews 2002; Morton et al. 2005; Garasky, Morton and Greder 2004). Obesity is a health condition related to food insecurity that has escalated among Americans in recent decades and most notably increased among minority populations including African Americans (Kumanyika 2008). Many factors influence each individual's dietary habits, and risk factors for obesity and other chronic conditions are genetic, cultural, socioeconomic and environmental. In 2006, almost 9 million U.S. children were overweight according to a statement in the American Journal of Preventive Medicine (Story and Orleans 2006). Ford and Dzewaltowski (2008) suggest that racial, geographic and socioeconomic disparities in obesity within the United States are not likely to be individual and psychosocial, but more likely to be linked to structural factors in social and physical environments, including the retail food environment.

This dissertation examines the role of residential neighborhoods and food insecurity, as a consequence of neighborhood environmental conditions. The retail food environment is considered in this study. Spatial assessment of the retail food environment in low income inner city neighborhoods has received research attention (Whitman et al. 2004; Wrigley, Warm and Margetts 2003; Smoyer-Tomic, Spence and Amrhein 2006). I attempt to characterize gap areas in supermarket service to neighborhoods. Accessibility to healthy foods such as fresh fruits and vegetables is extremely erratic within small geographic areas such as urban neighborhoods. My research aims to highlight the disparities in accessibility that local residents face when trying to eat nutritionally balanced and healthful diets. I consider the accessibility to fresh fruit and vegetables for residents of urban neighborhoods who are pedestrians and individuals reliant on public transit to shop for groceries. I calculate a produce accessibility rate, the quantity of shelf space designated to fresh fruits and vegetables per 1000 population, in gap areas and supermarket service areas.

The relationship between food insecurity and obesity is a widely pursued research field, as is the relationship between the availability of healthy foods and the impact on diet (Gundersen et al. 2008; Dinour, Bergen and Yeh 2007; Crawford et al. 2007; Martin and Ferris 2007; Morland et al. 2002b). Research extends from medicine and health through sociology, psychology, urban planning and geography. The relationship between food insecurity and obesity has produced mixed and conflicting results and the nature of the relationship is yet to be well understood (Public Health Nutrition 2008; Whitaker and Satin 2007; Holben and Myles 2004).

Research indicates that genetics alone cannot be responsible for the explosion in rates of obesity throughout all population groups within the United States. A second factor is greater caloric consumption, with documented increases in portion size across most food groups. Along with portion size increases, the Obesity Action Coalition (2007) estimates that approximately 40 to 50 percent of every food dollar are spent on food outside the home. Sugared beverages such as soda and juice boxes also contribute to childhood obesity. The consumption of soda by children has increased throughout the last

20 years by 300 percent and the Obesity Action Coalition estimates that 20 percent of overweight children are overweight due to excessive caloric intake from beverages (Obesity Action Coalition 2007). Food retailing has a profound impact on dietary intake and obesity (White 2007).

Environment, a third contributing factor for obesity, can be described in cultural and physical dimensions. Programs and actions that identify environmental determinants of healthy eating and body weight are vital to addressing this national health crisis. Urban environments present many confounding factors for public health. High crime statistics, high population density, high traffic volume and aging public infrastructure create environmental health hazards endemic to many urban neighborhoods. Limited availability of amenities such as extensive areas of green space for physical fitness and easily accessible supermarkets are further limitations of urban environments. Some blocks or neighborhoods within high density urban areas, may display adequate local availability of fresh fruits and vegetables, but many areas are lacking this accessibility. Food insecurity is evident in areas with a scarcity of grocers, but may also be reflected in low consumption or intake of fruits and vegetables among residents.

B. Healthy People 2010

Obesity and nutrition are acknowledged as national health crises by inclusion as a focus area in the set goals for in Healthy People 2010 (US Food and Drug Administration (FDA) and the National Institutes of Health (NIH) 2005). The Office of the Surgeon General initiated Healthy People in 1979 to identify national health issues and create coordination across federal agencies to address two goals: improve the overall health status of Americans and eliminate health disparities among population groups (FDA and

NIH 2007). Healthy People 2010 identify nutrition and obesity as Focus Area 19 for which it has established objectives (FDA and NIH 2007).

Healthy People 2010 clearly indicates failure to facilitate or communicate the importance of healthy food choices to the American population. Whereas educational campaigns are present in many communities and schools, to combat aggressive commercial sector marketing; actual facilitation of healthy choice behavior does not occur for many segments of the population (Stevenson et al. 2007). Strategies to reduce food insecurity among seriously disadvantaged city dwellers should focus on creating access to affordable healthful food for those without kitchen facilities, improving dental health, and reducing addictions (Wicks, Trevena and Quine 2006).

C. Healthy food availability, an environmental health factor

This study examines the spatial distribution of healthy foods, fresh fruits and vegetables across a high-density, racially-mixed section of Philadelphia. My research premise is that healthy food availability is a community resource which can be presented cartographically and correlated statistically with low rates of consumption of healthy foods. A healthy diet, as defined by the 2005 U.S. Department of Agriculture Dietary Guidelines for Americans (U. S. Department of Agriculture 2007), consists of daily consumption of whole grains and a variety of fruits and vegetables. Limited availability of healthy food is an environmental health factor which increases a target population's vulnerability to obesity and ultimately health conditions such as diabetes, cardiovascular disease and hypertension. The first research question in this study is whether aspects of the "healthy quality" of the local grocery environment can be spatially measured and associated with neighborhood healthy food intake. I suggest that shelf space for healthy food products, i.e. fresh fruits and vegetables, is a valid measurement of healthy food availability. Other food choices which indicate healthy food choices may be lean meats, whole wheat products, low fat and low salt products. The second research question explores the relationship between healthy food intake in an urban neighborhood and the local retail food environment. I examine the spatial pattern of traditional retail grocers as one component of the built environment. Are the stores which offer healthy food choices distributed in a discernable pattern? Are healthy food choices distributed somewhat evenly across neighborhoods or are healthy food choices more clustered? Retail grocers are a community resource which provide or fail to provide nearby populations healthy food choices. Other environmental elements such as the distribution of restaurants, fast food outlets, soup kitchens or shelters are not included.

D. Ecological Analyses

This study is an ecological analysis. Ecological analyses target a population group or geographic area as a unit of study rather than individuals as cases (Yassi et al. 2001). Ecological analyses often provide descriptive or contextual summaries, because isolating direct, clear and measurable indicators between local food availability and chronic poor health is intricate. Story et al. (2008) confirms that ecological studies concerning food environments are limited due to lack of validated measures. I offer new indicators to address quality of food environments through identification of gap areas, and determination of produce accessibility rates for local residents.

The strength of ecological analysis is to provide probable conditions which contribute to chronic disease prevalence. My argument is that limited food options and low availability of healthy choices in urban communities are health hazards that may present a health risk to individuals if opportunities for healthy food intake are too few. The conditions which produce an unhealthy environment are poor or non-existent local availability of fresh fruit and vegetables, and limited mobility among residents. Households without private vehicles, restricted to mass transit or walking have fewer shopping choices. Individuals of limited mobility may rely on local food environments, and if healthy choices are absent, the opportunity to eat a nutritionally-balanced diet is absent. Morland et al. (2002a) demonstrates that white populations have greater mobility, compared to black populations of the same neighborhood. Nord (2003a) summarizes the limited mobility of seniors in urban neighborhoods. As indicated in the quote by Hillary Clinton below, some health conditions are beyond our personal control and require social intervention to rectify. “Each of us can help make ourselves healthier by staying away from bad habits and behavior and by making our environment as user-friendly as possible. However, we have to recognize that there are many issues related to health and the environment over which no individual has any control. If there is any area that needs society as a whole to act, it is the intersection of health and the environment” (Clinton 2004: 17).

Two methods of environmental exposure assessment are area sampling and personal sampling (Yassi et al. 2001). This study samples an area to assess low availability of healthy food choices as a potential health hazard within Philadelphia. Resources from Philadelphia’s health community, including data from the Office of Food Protection, Philadelphia Department of Public Health and the Philadelphia Health Management Corporation, are compiled to examine the number of grocery stores across eight neighborhoods in the city.

Linking chronic disease causation to environmental exposure is difficult to trace and environmental health professionals call for further research into complex environmental exposures. Striegel-Moore and Bulik (2007: 183) insist "the state of knowledge concerning risk and causal factors of eating disorders is frustratingly incomplete", as is the demographic diversity of populations included in eating disorder studies. Whereas environmental health indicators are most effective when clear and direct, the long term effects of health behaviors and the epidemic of chronic diseases require that new, less direct indicators be explored.

E. Research Hypotheses

Research assessment of local food environment includes measures of accessibility and availability of healthy foods, such as fresh fruit, fresh vegetables, low fat milk, whole-grain products and other items specified in Dietary Guidelines for Americans designed by the U.S. Department of Agriculture (DOA) and the U.S. Department of Health and Human Services (HHS) (2005). Availability is the presence or absence of food choices for the local community. Are fruits and vegetables stocked and sold locally? Accessibility encompasses availability but also provides means for the local community to acquire available resources. Accessibility is measured through distance from consumers, frequency of available products, cost of products, knowledge of local availability of products (advertisements), sufficient public assistance for healthy eating (WIC, Food Stamps, school lunch programs), and individual and parental concern for a healthy diet (education).

In geographic studies physical distance is the basis of analysis, and distance decay, the inverse relationship between spatial interaction and distance between phenomena, is a recognized function (Haggett 2001). It is well established that as distance increases from a good or service, accessibility and utilization decrease. Distance creates advantageous and disadvantageous locations for populations from various services such as groceries. Regionalization is another geographic concept which can be employed to describe areas of disparity. The Health Resources Services Administration defined medically underserved areas (U.S. Department of Health and Human Services 2006), or in the case of few healthy food choices, nutritionally underserved areas. This study proposes four research hypotheses. The first hypothesis states that, in south and southwest Philadelphia some residential areas fall outside functional regions of large supermarkets.

A functional region is a geographic area which has a core and a surrounding area referred to as a hinterland. The region is defined by the interaction between the core and the surrounding hinterland or periphery. In this case the core is a supermarket of at least 5000 square feet and the hinterland is the surrounding neighborhood which provides a local customer base. The functional regions are created using the Huff Model, a gravity model. The model plots supermarkets with total floor area greater than 5000 square feet as points. Secondly, the model defines polygons of high probability of belonging to a supermarket service area, based on distance to proximate census block groups. After initially calculating shopping regions based on distance, an attractiveness variable is added. Attractiveness is calculated using two separate variables. Attractiveness is calculated using the total floor size of the supermarket, and then by total shelf space or floor space designated for fresh produce in each supermarket. Using simple distance from a census block group to a supermarket and then adding two different attractiveness variables demonstrates the flexibility of demarcating supermarket service areas when considering particular attributes. Many chain supermarkets gained service area when the total floor size is included in the calculation. Local grocers tend to have less floor space. Similarly chain grocers also carry more fresh fruits and vegetables shelf space and gained service area when this factor is included.

Following the creation of high probability shopping regions for each supermarket, I generate a service area of ten minutes travel time for walkers, drivers and for users of public transit around each supermarket. By overlaying the 10 minute service areas for walkers, drivers and users of public transit, I identify gap areas which fall outside the supermarket service area for each mode of transit. I present the proportion of these "gaps", (i.e. residential areas falling outside functional regions of large supermarkets) from sample data, as well as a cartographic representation of their spatial distribution in sample areas from south and southwest Philadelphia.

The second hypothesis states that in south and southwest Philadelphia, residential areas or gaps, have a lower density of grocers than supermarket service areas.

Grocer density is calculated as the number of grocers, carrying fresh fruits and vegetables, per square mile per census block group. To test this hypothesis, gap areas delimited in the first step are geographically indexed with locations of small grocers that operate within each area. High quality food sites are defined as sites with shelf space dedicated to fresh fruits and vegetables. Low quality sites are grocers which do not carry fresh fruits and vegetables but may include canned or frozen produce. The spatial distribution of high and low quality sites within gap areas is presented cartographically. Statistically to accept this hypothesis the 95 percent confidence intervals of the grocer density between the mean of gap areas and the mean of supermarket service areas will not overlap. As presented in Table 5.8 a statistically significant difference is demonstrated in grocer densities between public transit supermarket service areas and gap areas. The mean grocer density for the entire study area is 31.4 grocers stocking fresh fruits and vegetables per square mile. The mean grocer density for pedestrian gap areas (greater than 10 minutes walking to a supermarket) drops to 23.6 per square mile, but this is not a statistically significant difference from pedestrian supermarket service areas. Alternatively when considering public transit service areas around supermarkets (10 minutes by transit to a supermarket) the mean grocer density is 35.3 grocers stocking fresh fruits and vegetables per square mile. Public transit gap areas have a mean grocer density of only 7.1 grocers stocking fresh fruits and vegetables per square mile.

The third hypothesis states that, in south and southwest Philadelphia, the rate of produce accessibility per 1000 residents in gap areas is lower than the produce access rate per 1000 residents in corresponding functional areas of supermarkets. Within the gap areas, I hypothesize that the rate of produce accessibility, defined as square feet of shelf space for fresh fruits and vegetables per 1000 residents, is significantly lower than that calculated from the functional areas of supermarkets. To test this hypothesis primary data was collected in the field in 2006. A field survey has been completed where total floor space and total fresh fruit and vegetable space has been calculated for each store, small grocers and supermarkets throughout the study area. I then calculate the rate of square feet of produce space per 1000 residents in gap areas for comparison with a similar rate from the functional areas of supermarkets. I show that the rate of produce space per 1000 residents for gap areas is less than that of functional areas of supermarkets by showing that the 95 percent confidence intervals for the means of these rates do not overlap. Table 5.17 presents data which demonstrates that the produce accessibility rate is statistically significant for pedestrian gap areas and public transit gap areas. The mean produce accessibility rate for supermarket service areas is 887.3 square feet of fresh fruits and vegetables per 1000 population. The mean produce accessibility rate for pedestrian gap areas is merely 90.1 square feet of fresh fruits and vegetables per 1000 population. Similarly the mean produce accessibility rate for public transit gap areas is 5.4 square feet of fresh fruits and vegetables per 1000 population compared to 540.7 square feet of fresh fruit and vegetable shelf space per 1000 population in public transit supermarket service areas (10 minutes or less to a supermarket by public transit).

The fourth hypothesis states that, within this sample of neighborhoods in south and southwest Philadelphia, high accessibility to large supermarkets is positively correlated with each neighborhood's aggregate intake of fruits and vegetables. Whereas prior steps in this dissertation used census block groups as a geographic unit of analysis, this step utilizes the larger census tract as the geographic unit. Census tracts are then aggregated to form neighborhoods. Previously the distance from each census block group centroid to the closest supermarket is calculated as a measure of accessibility. The mean of these minimum distances to supermarkets is used as the measure of accessibility in this step. The mean of minimum distance to supermarket is correlated with the "Number of Fruit and Vegetable Servings per Day" collected in the 2006 Community Health Database of the Philadelphia Health Management Corporation, and aggregated by census tract. I present the rates of fruit and vegetable intake for all neighborhoods, functional regions of supermarkets and nutritionally underserved gap areas, alongside the accessibility measure. I also present the correlation coefficient with a 95 percent confidence interval, between accessibility and aggregate food intake of the neighborhoods. “Nutritionally underserved areas” are mapped as irregular polygons, derived from gap areas between grocery service areas. I hypothesize that the nutritionally underserved areas will overlap spatially with census tracts exhibiting lower fruit and vegetable intake values and that census tracts with low values for “Fruit and Vegetable Intake” will demonstrate a statistically significant positive correlation coefficient with census tracts containing “nutritionally underserved areas.” The results of this study indicate that nutritionally underserved areas do not exhibit lower levels of fruit and vegetable intake with respect to the functional areas of supermarkets. At the level of geographic analysis within this study the forth hypothesis is rejected.

This study compares healthy food shelf space across neighborhoods as an indicator of healthy food availability. The analysis answers questions including which neighborhoods have a greater local availability of fresh food and produce, what patterns of availability for produce exist across these neighborhoods and what is the role of small grocers as a source for healthy foods. This study integrates components of multiple research fields including geography, public health, and geographical information science. The elements of public health research advocated throughout this analysis are that public health is a field which targets communities not individuals. Secondly, good health indicates complete physical, mental and social well being and not merely absence of disease or illness. People and communities survive with few food choices, but limited food choices are a deprivation and a symbol of crisis, and thus, a threatening condition to good health. Geography advances study of spatial variations in features of natural and cultural environments. Food insecurity results from conditions of both cultural (poverty) and physical (seasonal hardship) environments. Both cultural and natural features have spatial manifestations generating negative or positive health conditions. In public health the triad of operation is the host, the agent and the environment. In this study the hosts are the residents of urban areas suffering from food insecurity and possibly obesity. The environment is depicted as urban neighborhoods which provide better or worse access to the necessary conditions for resident populations to thrive successfully. The agent is far more ambiguous. Without an obvious agent the interaction between host and environment gains significance. This type of ecological analysis attempts to describe the interplay of host characteristics and environmental characteristics which can elicit food insecurity and obesity as a consequence of food insecurity.

Geographical Information Science integrates questions of spatial variation, data capture, integration and dissemination. The combination of public health, geographical variation, spatial data capture and representation form a compelling field of research pioneered in this analysis.

The structure of this dissertation is the presentation of food consumption trends and conditions of the United States in recent years. In Chapter 2, I consider family and household patterns of consumption, larger trends in urban areas moving away from grocery stores to larger multidepartmental supermarkets, set further distances apart and forming larger service areas. Household consumption patterns indicate less time spent eating meals and less time spent preparing meals. In Chapter 3, I review various methodologies of spatial analysis utilizing a GIS and define several terms employed in this study, including a functional region, accessibility, healthy food and nutritionally underserved. In Chapter 4, I specify my research methodology and describe the components of my data. In Chapter 5, I present the results of each hypothesis tested and in Chapter 6 discuss areas of policy and research implications.

The strength of this dissertation lies in its methodological approach to addressing neighborhood conditions and local food environments. Whereas food deserts are recognized, more precise characteristics of a food desert are not defined. This study offers shelf space as measureable indicator of deprivation for neighborhoods suffering from issues and health conditions related to food insecurity. The majority of Americans are reliant on private automobiles for transportation to work and for and activities supporting basic livelihood such as grocery shopping. Large populations which may live within a relatively short distance which do not have the luxury of a private vehicle may be severely disadvantaged to provide themselves with basic healthy food choices. The combined factors of limited mobility and limited healthy food choices form a research field of critical need.

Chapter 2: Food Availability and Intake

A. Coping with Food Insecurity

Food insecurity, poor access to foods which support a healthy and active life, is an issue identified by the Food and Agricultural Organization of the United Nations (FAO) worldwide and the U.S. Department of Agriculture (USDA) in the United States. Food insecurity encompasses undernutrition, obesity, overnutrition accompanied by micronutrient deficiencies, and complexities of diet-related health inequities (Dixon et al. 2007). Household food security is the state that all residents within a household have enough food at all times for an active, healthy lifestyle (Nord and Andrews 2002). In the 1990s food insecurity in the United States was analyzed indirectly using data collected during the 1989-1991 Continuing Survey of Food Intake by Individuals (CFSII) and the 1992 Survey of Income and Program Participation (SIPP). CFSII and SIPP indicated that 2.3 percent and 2.5 percent of the U.S. population were food insecure (Rose, Gunderson and Oliviera 1998). Households reporting that sometimes or often, residents do not have enough to eat are deemed food insufficient. Although poverty is an indicator of food insufficiency, Rose, Gunderson and Oliviera (1998) report that over 40 percent of food-insufficient households were above the poverty line and about 10 percent of households in poverty were food insufficient. The first food security survey conducted in April 1995 by the USDA estimated that 12 percent of U.S. households (11.8 million households) were food insecure (Nord and Andrews 2002). According to USDA, 11.0 percent of U.S. households (12.6 million) were food insecure at some time during 2005 and that 13 million U. S. households (11.1 percent) reported food insecurity at some time in 2007 (USDA 2008).

Food insecurity is addressed in research and practice across the United States. Many diverse initiatives are implemented through food security programs. Kantor (2001) and Molnar et al. (2001) describe community-supported agriculture programs, farmers' markets, pick-your-own farms, farm-to-school initiatives, community gardens, food banks and other private feeding programs. Morland et al. (2002a) argue that in spite of the existence of a range of public assistance programs aimed at eliminating food insecurity many people cannot meet nutritional needs. Convincing individuals to select and consume nutritious foods is one obstacle.

B. Fruit and Vegetable Consumption

Increasing consumption of fruits, vegetables, and whole grains in the United States presents a range of challenges. Consumers represent a challenge because they weigh attributes such as taste, convenience, availability, price, and perceived health benefits. Price and convenience frequently outweigh other factors. The 2005 Dietary Guidelines for Americans provides a basis for renewed efforts to promote daily consumption of whole grains and of a variety of fruits and vegetables. One framework is the, *5 A Day for Better Health Program*, a large-scale partnership between the fruit and vegetable industry and the Federal Government to identify and implement strategies to increase fruit and vegetable consumption (US FDA and NIH 2005). According to the Healthy People 2010 midcourse review, three objectives on weight status of adults and children have moved away from their targets as demonstrated in Table 2.1 (FDA and NIH 2005).

Table 2.1 Healthy People 2010 objectives related to weight status

Objective and Description		Age-Adjusted Proportion of Population		Target 2010
		1988-1994	1999-2002	
19-1	Adults at a healthy weight	42	33	60%
19-2	Adults Obese	23	30	15%
19-3c	Children and adolescents, aged 6-19, overweight and obese	11	16	5%

Although formal progress towards targets were not assessed for Objective 19-5 consumption of fruits, Objective 19-6 consumption of vegetables, or Objective 19-7 consumption of grains, no apparent progress is evident. The Healthy People 2010 Midcourse Review states that, ‘the average intake [for fruit] by persons 2 years and older remained the same from 1994-1996 to 1999-2002 (1.6 servings).” In addition the Healthy People 2010 Midcourse Review reported that during the same time frame, daily consumption of vegetables has declined from 3.4 to 3.2 servings per day, and that daily consumption of whole grains has declined from 1.0 to 0.8 servings per day (US Food and Drug Administration and the National Institutes of Health 2005). Table 2.2 presents these findings.

Table 2.2 Healthy People 2010 objectives for population aged 2 and older relating to fruit, vegetable and grain intake

Objective and Description		Average intake in servings per day		Target 2010
		1994-1996	1999-2002	
19-5	Fruit intake	1.6	1.6	2+
19-6	Vegetable intake	3.4	3.2	3+
	Dark green or orange vegetables	.3	.3	1/3 of vegetable consumption
19-7	Total grain intake	6.8	6.8	6+
	Whole grain intake	1.0	.8	3+

C. Measuring Food Insecurity

Food security research involves defining the dimensions of food insecurity and identifying measurable constructs of food insecurity studies of individual and household food insecurity. Food security research also assesses effectiveness of assistance programs such as Food Stamps in alleviating food insecurity and associations between food insecurity and obesity. The relationship between household food insecurity (HFI) and child food insecurity is explored by Cook et al. (2006), who finds that children with household food insecurity had significantly greater adjusted odds of fair/poor health rather than good health, and of being hospitalized since birth. Households demonstrating both HFI and child food insecurity had even more adverse effects. Cook et al. (2006) also find that participation in the Food Stamp Programs modifies negative health effects. Dinour, Berge and Yeh (2007) propose several hypotheses to explain a correlation between food insecurity and obesity in adults and also propose a conceptual framework linking the Food Stamp Program and other coping strategies. Webb et al. (2008) find that food stamp program participation, but not food insecurity, is found to be associated with higher adult BMI. Whitaker and Satin (2007) did not find a relationship between obesity and changes in food security status over a two year period.

Maxwell (1996) researches food insecurity measurement and identifies several constructs including accessibility, sufficiency, security rather than vulnerability, and sustainability. Research also includes coping strategies among food insecure populations. Wicks, Trevena and Quine (2006) list missing meals and restricting quantities, Maxwell (1996) adds skipping eating for whole days, maternal buffering of children against hunger, limiting portion size, and borrowing money to buy food as coping strategies.

Feinberg et al. (2008) found that household food insecurity is associated with maternal compensatory feeding, and they suggest this may alter food environments.

In Wicks, Trevena and Quine (2006), participants demonstrated adequate knowledge and a desire to eat healthful food, but barriers for nutritional intake included poor dental care, and a lack of food storage or cooking facilities. A social dimension which Wicks, Trevena and Quine (2006) identify as an opportunity for food banks and community programs, is to develop social interaction and trust between participants and soup kitchen staff which motivated attendance. Holben and Myles (2004) revealed that 30 percent of emergency food clients were faced with the choice of either paying for food or medicine or medical care. In addition, 45 percent of emergency food clients were faced with choosing to pay for food or for utilities or heating fuel, and 36 percent had to choose between paying for food or rent or mortgage payments. Miller et al. (2008) recommend opportunities for families to report hunger as a means of intervention. Better screening is recommended to identify families suffering food insecurity with hunger (Chavez, Telleen and Young 2007). Holben and Myles (2004) agree that physicians require knowledge of personal history and community culture to obtain information about food insecurity. Physicians need insight to provide guidance during office visits and make necessary referrals to assist patients in securing adequate food (Holben and Myles 2004).

The link between individual health, weight and food insecurity is widely researched. Body mass index (BMI) is a regularly employed indicator of individual health and an indicator of household food security. Bhargava, Joliffe and Howard (2008) modeled body weight and food insecurity among children. Bhargava, Joliffe and Howard (2008) found that households' food insecurity score was not a significant predictor of children's body weights. They did identify that higher parental education was significantly associated with lower child body weight, the number of siblings is significantly related to lower body weight and that models for households' food insecurity scores showed that poverty and respondents' poor emotional and physical health significantly increased food insecurity. Lyons, Park and Nelson (2008) found that associations between obesity and food insecurity are more pronounced when self-reported data on height and weight are used than when measured height and weight data are used. Crawford et al. (2007) suggest that current and past maternal food insecurity is an indicator of obesity in immigrant children of low-income Mexican families. Richards and Smith (2007) found that 45 percent of homeless children interviewed about food access were overweight. The children referred to parental, environmental and personal conditions as determining factors in food access and intake. Specifically children cited shelter rules, lack of storage space or cooking facilities and few food stores near shelters as critical factors.

In summary food insecurity is an issue of national scale which effects not only low-income groups but additional populations including children across the United States. The mechanisms of household food insecurity are being uncovered. Food insecurity presents a health risk with ties to obesity and malnutrition. A mixture of food supply strategies are striving to define and address this issue at the community, household and individual levels.

D. Food insecurity and urban populations

Dixon et al. (2007:i121) categorize health impacts in urban areas of developing, industrial and post-industrial cities, and note referring to health consequences, "urban areas contain marked disparities which can be greater than rural differentials." Within the United States populations suffering from food insecurity include the elderly, immigrants, Latinos, African Americans, individuals suffering from mental illness or physical disabilities, and disadvantaged populations. Of the 13 million households reported to be food insecure in 2007, the Department of Agriculture Economic Research Service reported that, notable household types suffering from food insecurity include low income households (37.3 percent), households with children headed by single women (30.2 percent), black households (22.2 percent) and Hispanic households (20.1 percent) (Nord, Andrews and Carlson 2008; 4, 10). The number of households identified as food insecure was higher (13.5 percent) in principal cities of metropolitan areas compared to surrounding urban and suburban areas. Among vulnerable urban populations are low income (Nutrition Research Newsletter 2006) and county hospital populations (Nelson, Brown and Lurie 1998). Chavez, Telleen and Young (2007) identify food insecurity as a problem among urban Latino populations. In urban Iowa, Garasky, Morton and Greder (2004) report that households with children suffer higher levels of food insecurity, and the average household size for individuals using food pantries is 2.9 people. Garasky, Morton and Greder (2004) found that 54 percent of urban respondents within their study reported food insecurity with hunger.

Among children, food insecurity is precluded by issues of physical health, mental health and poverty. In a survey of 245 participants, with the majority of respondents being single, female and African-American, 66 percent of households experienced some food insecurity (Oberholser and Tuttle 2004). Bronte-Tinkew et al. (2007) examine how food insecurity influences parenting, how parental depression is a stressor on parenting behavior and the importance of continuing and strengthening policy initiatives to ensure that families with infants and toddlers have sufficient food supply. Kersey, Geppert and Cutts (2007) and Kaspar et al. (2000) examine food insecurity with hunger among children and immigrant populations and find that Latino children in immigrant families are more likely to experience food insecurity than non-Latino, non-immigrant families. Cook et al. (2006) find that household food insecurity is related to child health and welfare and that household food insecurity is positively associated with fair/poor health (rather than good health), and hospitalizations in young children. Parish et al. (2008) study measures of hardship including food insecurity, health care access and housing instability. Their research indicates that families of children with disabilities experienced significantly greater hardship than did other families. Among families of children with disabilities, single-mother and cohabitating-partner families particularly were at risk for experiencing severe hardship.

Other exceedingly vulnerable groups are elderly residents of urban neighborhoods. Elderly individuals frequently experience physical deterioration through aging and have mobility curtailed by fragile health or physical handicaps. Limited mobility in seniors or impaired individuals may progress to food insecurity, though physical distances may be readily manageable for individuals in full health. Nord (2003a) specifies that some elderly face food-access problems, such as difficulty in traveling to a food store, rather than shortages of funds or insufficient resources to buy food. Wolfe, Frongillo, Valois (2003) examine elderly food insecurity, and argue that anxiety related to the inability to obtain the right foods for health is an element specific to elders. Wylie (2000) examines nutritional intake of elderly people with restricted mobility and finds. Poor mental or emotional health may also play a role in progression of food insecurity among seniors. Health and social factors which affect the food choices and nutritional intake in this group of the elderly population were identified as being inadequate money, inadequate food storage facilities, physical disabilities affecting food preparation, poor access to shops, difficulties in shopping, type of cooking facilities, loneliness and bereavements (Wylie 2000).

Ethnic and racial minorities in the United States have a greater prevalence of obesity, as compared to white populations (Ford and Dzewaltowski 2008; Horowitz et al. 2004). Within neighborhoods with community structure supportive of healthy eating, Sekhobo and Berney (2008) found obesity prevalence was much higher among blacks (19.5 percent) and Hispanics (21.6 percent) compared to whites (9.7 percent). Frenn et al. (2005) and Ayala et al. (2005) study family influences on diet among urban Hispanic populations. Ayala et al. (2005) suggests that longer tenure for Latin women in the United States creates more comfort with shopping options and greater likelihood of shopping in supermarkets rather than local markets, but also a greater preference for fast food. Similarly, Frenn et al. (2005) discusses the protective influence of traditional diets among low income Hispanic populations in the United States. They find that as Hispanics assimilate to American society, younger individuals tend to adopt high fat American diets, and lose the health benefits of traditional foods. Among Mexican migrant populations, greater length of time in the United States was associated with worse overall health (Public Health Nutrition 2008).

Among African Americans families, Airhihenbuwa et al. (1996) studied cultural dietary effects to determine if consumption of “soul food” and “favorable food habits” were perpetuated for health benefits. Positive benefits among African American eating habits include families sitting and eating together, and consumption of low fat and nutritional foods including boiled or steamed vegetables, salad greens, baked chicken, beef and one-pot meals. Among negative factors are foods with high fat, salt and cholesterol (Airhihenbuwa et al.1996). Ahye, Devine and Odoms-Young (2006) continue this theme and study the intergenerational role of African-American women on diet and food intake.

Obesity is most prevalent among rural women, followed by urban and then suburban women (Ramsey and Glenn 2002). Striegel-Moore and Bulik (2007) argue that binge-eating is a significant problem among both white and black women. Environmental shifts are related to eating disorders and obesity, but the gene-environmental interplay remains unstudied. Striegel-Moore and Bulik (2007:192) declare that historical changes in traits such as eating disorders, fertility and obesity reflect environmental changes, and recognize that individuals are differentially and genetically susceptible to environmental shifts. Jansen et al. (2008) agrees in his study of individual vulnerability and consumption reactions following exposure to negative environmental stressors.

Environmental conditions other than retail food environment also influence food intake and weight. Two factors not included in this study are safety considerations such as a limitation to outdoor activity and opportunities for physical exercise. Comfortable and safe recreation and leisure environments are vital to encourage higher levels of physical activity and weight loss. In Adkins et al. (2004) researchers also found that neighborhood safety was not linked with activity levels and participants felt that parks were available, and neighborhoods were safe. Alternatively many studies identified safety as a limitation on physical activity (Dwyer et al. 2006). Safety as a deterrent to physical activity can be described in terms of traffic, fear of physical assault or concern that no person would be of assistance in case of an accident. Adkins et al. (2004) find that level of physical activity among African American girls was not associated with perceived access or safety to facilities nor with family environment. Ross (2000) found that although residents of socially disadvantaged neighborhoods decrease walking because of possible victimization, they still walked more than residents of higher social-economic neighborhoods. Walking is linked to personal mobility and the use of public transportation. Talen (2003) studies walkability of neighborhoods and considers neighborhoods as service providers, using walkability as a measure of quality of life.

E. Household food consumption and grocery shopping trends

The U.S. Department of Labor initiated the American Time Use Survey (ATUS) in 2003 and has calculated average time spent in common daily activities of Americans. Table 2.3 presents average times spent in activities related to eating, meal preparation and grocery shopping from ATUS 2003 and 2007 and two additional surveys. Prior to ATUS, various surveys such as the National Science Foundation Family Time Use Study: 1998-1999 Time Diaries and U. S. Environmental Protection Agency Time Use Survey for September 1992-1994, recorded time spent on daily activities. Although the data presented in Table 2.3 is provided from separate distinct tools, average times across the population have remained consistent since 1992. Devine et al. (2006) reports that between 1965 and 1995 in the US, the overall daily time spent on meal preparation decreased by 39 percent as well as decreases in fruit and vegetable consumption. Table

2.3 presents averages for all respondents including those individuals who do not participate in meal preparation, cleanup or grocery shopping. Average times for particular activities among individuals who participate in each activity are provided rather than averages for the total population of survey respondents. Whereas only 12.9 percent of the population surveyed actually engaged in grocery shopping, of this group, shoppers spent .74 hours (44.4 minutes) on average shopping in 2007, up from .71 hours per day (42.6 minutes) in 2003 (U.S. Department of Labor 2007). ATUS also reports that many more women (64 percent) use time for meal preparation and cleanup on an average day, compared to only 37 percent of men in 2007.

Table 2.3: Time Spent Eating, Preparing Meals and Shopping for Groceries Per Day

Survey and time frame	Eating & Drinking (Min)	Meal preparation (Min)	Meal cleanup (Min)	Grocery Shopping (Min)	Travel related to purchasing goods and services (Min)
American Time Use Survey 2007	66.6	31.2*	--------	6.0	16.8
American Time Use Survey 2003	64.8	31.8*	--------	6.0	17.4
NSF Family Time Use Study 1998-1999	69.0 ± 6.7	32.5 ±50.9	5.9± 17.9	7.8 ± 21.9	18.3 ± 36.6
EPA National Time Use Survey 1992-1994	68.8 ± 6.4	23.9 ± 44.2	4.0 ± 17.7	6.1 ± 21.7	16.0 ± 37.7

* Indicates that meal preparation and meal cleanup data are a combined statistic for this data.

Foster and Lunn (2007) provide an overview of forty years of changing patterns of food production, consumption, shopping and accessibility in the U.K. Notably among changes are that milk consumption has declined, meat consumption remained stable and increased slightly, and although vegetable consumption has declined, fruit consumption has increased. Low-income households consume less fruit, vegetables, and the prevalence rates of diseases related to poor diets often display a marked socio-economic gradient. In the U.K. in 1980, the average time taken to prepare the evening meal was 90 minutes, which fell to 30 minutes in the 1990s. Similar to meal times recorded in Table 3 among American surveys. Another trend which compliments individual meal planning rather than family meals is the increased use of ready-meals and take-out.

Home, family and individual factors influence food intake. Arguments ensue over the significance of home environment, role models, personal likes and dislikes in shopping and consumption patterns among various populations. Kime (2008) stresses the importance of how family environment influences eating habits and obesity. Miller et al. (2008) find that among low income populations, families with hunger are more likely to be obese and more likely to be suffering from mental health and physical health problems.

Devine et al. (2006) argues that dietary changes are largely related to work spillover into family time, such as increased alcohol use, fewer meals eaten together and dissatisfaction with food choices. Negative spillover is when work strain leads to poor nutrition or eating habits. Negative spillover effects include low income, limited time for meal preparation and little support for healthy food choices. Meal strategies include skipping meals, reciprocal food preparation or shopping among multiple households and preparing large quantities for consumption at several meals (Devine et al. 2003).

Food preferences and food intake research among adolescents is undertaken by Stevenson et al. (2007), Befort et al. (2006) and Lewis-Moss et al. (2008). Among adolescents, central motivations for food choice are physical factors of food, and individual psychological factors (Stevenson 2007). Food aesthetics, in terms of taste, texture, appearance and smell, were reported as powerful traits of food choice. Stevenson

(2007) also found that healthy eating is dependent on parental food preparation skills, such that without parental direction, adolescents did not feel they could maintain a healthy diet. Lewis-Moss et al. (2008) find that among African American adolescents, females are more likely to eat a balanced diet but males are more likely to engage in physical activity. Befort et al. (2006) report that home availability of fruits and vegetables, is not significantly associated with fruit, vegetable, or fat intake. Use of non-fast food restaurants was the strongest positive predictor of vegetable intake. For black and white adolescents, fast-food and buffet restaurant use and eating while watching television were the strongest predictors of fat intake.

Wansink (2004) specifies that environment influences consumption intake and volume, and then distinguishes between the eating environment and the food environment. The eating environment refers to the ambient factors associated with the eating of food, but which are independent of food, such as atmosphere, the effort of obtaining food, the social interactions that occur while eating, and distractions while eating (Wansink 2004). The food environment is determined by the food and its presentation. He argues that weight gain results from a combination of factors in both food and eating environments. If the eating environment requires increased effort to access food this decreases consumption. Benforado, Yosifon and Hanson (2004: 1687) emphasize that each individual's "internal situation or disposition" regulates food intake and interacts with the "exterior situation" or availability of food, to shape or determine food choices." Story et al. (2008) lists homes, schools, worksites, child care as well as retail food environments as environments which play a role in framing an individual's eating environment.

Benforado, Yosifon and Hanson (2004) agrees with Wansink (2004) and claims that other people influence not only what is eaten, but can also increase how much is eaten. Eating meals with familiar people can increase consumption whereas eating with less well known individuals or in an uncomfortable situation can curb consumption. Wansink (2004) associates food overconsumption with distractions such as television, or habitual consumption of certain foods. Jansen et al. (2008) studied negative mood induction and found that food exposure elicited overeating in a group of overweight/obese individuals without eating disorders.

F. Food access in neighborhood environments

Urban neighborhoods are quite diverse in cultural, economic and spatial characteristics. Spatial characteristics include site and situation. Site characteristics are the physical characteristics of a location, including terrain, elevation, climate and natural vegetation. The “situation” is the relative location of a place, in comparison to other places. For example, some neighborhoods have a supermarket located within their boundaries, but other neighborhoods rely on the supermarket in an adjacent neighborhood and transportation to access that supermarket. The first neighborhood has a better situation or relative location for groceries, because of the local access to the supermarket. Thus places may have positive or negative spatial or geographic characteristics for services such as groceries, fast food, medical care, daycare, elementary schools, drug stores, night clubs, bars or liquor stores. Local environment conditions including poor relative location or limited resources create restrictive conditions for healthy diets, whereas ease of food access may influence food purchases, and possibly food intake and body weight (Faith et al. 2007). The significance of a positive situation or relative location of a supermarket to a neighborhood are demonstrated in research studies performed by Inagami et al. (2006), Horowitz et al. (2004) and Alwitt and Donley (1997). Inagami et al. (2006) applied multilevel linear regressions to estimate associations between individual's BMI and socioeconomic characteristics of residential neighborhoods in Los Angeles and determined that higher BMI is associated with residence in a disadvantaged area. They suggest that exposure to a grocery store mediates and suppresses the association of residential neighborhood and BMI. Alternatively, Pearson et al. (2005) applied generalized linear regression models to ascertain predictors of fruit and vegetable intake. Their findings indicate that presence or absence of food deserts and distance to nearest supermarket and potential difficulties with grocery shopping were not significantly associated with either fruit or vegetable consumption.

Low income neighborhoods with poor accessibility to healthy foods are termed "food deserts" by some researchers (Smoyer-Tomic, Spence and Amrhein 2006, Block 2006). Food deserts demonstrating places of food concentration and food scarcity are both urban and rural (Morton et al. 2005), although Nord and Andrews (2002) specify that geographically hunger is more common in central city locations. Poor areas are less likely to be served by chain stores and large retail outlets. In Edmonton, Smoyer-Tomic, Spence and Amrhein (2006) realize that the majority of the population has good accessibility to supermarkets, and a minority subset have limited access, limited mobility and few financial resources. Residents of Edmonton's poor neighborhoods with food deserts had to travel just over two kilometers to supermarkets compared to 1.4 kilometers for most neighborhoods. Alwitt and Donley (1997) found that poor zip code areas in Chicago have fewer and smaller retail outlets overall than non-poor areas, including fewer supermarkets, banks, and large drug stores. Residents of these poor Chicago neighborhoods must travel more than two miles to have access to the same numbers of supermarkets, large drug stores, banks, and other types of stores as compared to residents of non-poor areas. Further study of food deserts in Detroit by Mari Gallagher Research and Consulting Group (2007) identifies food retailers or “fringe” retailers as sources of unhealthy foods readily available throughout the urban area. “Fringe” retailers specialize in more lucrative products such as alcohol, tobacco and lottery tickets and place less emphasis on canned and pre-packaged grocery staples. Whereas “fringe” retailers promote a range of products they are also a large portion of food stamp retailers in Detroit (Mari Gallagher Research and Consulting Group 2007).

Foster and Lunn (2007) describe food deserts as areas of retail and service disinvestment which resulted as trends moved shoppers from small grocers to supermarkets in the 1980s. Public policy emphasis on location planning and commercial redevelopment for supermarkets drew business from small stores leading to closures and perpetuation of food deserts (Smoyer-Tomic, Spence and Amrhein 2006).

Sebhoko and Berney (2008) found obesity prevalence was inversely associated with community occupational structure (COS). High-COS neighborhoods had the highest densities of community resources known to facilitate healthful eating and routine physical activity, including supermarkets, fruit and vegetable markets, and fitness/recreational centers. Obesity prevalence was highest (24.5 percent) in low-COS neighborhoods and obesity prevalence lowest (11.7 percent) in high-COS category neighborhoods.

Small grocers, bodegas and corner stores contribute to convenience and comfort in densely populated areas. Morland et al. (2002 a, b) and Jetter (2006) both argue that small grocers do not provide the level of access to groceries that supermarkets provide. In Horowitz et al. (2004) only 18 percent of stores in East Harlem carry five recommended items compared to 58 percent in the predominantly white Upper East Side, although the total number of stores per capita is twice as high in East Harlem. East Harlem is an area with large Hispanic and black populations (6 percent white) and the Upper East Side of New York, is largely white (84 percent). East Harlem has a high prevalence of adults with obesity (31 percent) and diabetes (15 percent) compared to the Upper East Side with an adult prevalence of obesity (7 percent) and diabetes (2 percent). Jetter (2006) argues that lack of availability in small grocery stores located in low-income neighborhoods, and the higher cost of the healthier market basket may be a deterrent to eating healthier among very low-income consumers. Only 8 percent of black Americans within Morland et al. (2002b) live in a census tract with at least one supermarket compared to 31 percent of white Americans. Among white Americans 42 percent lived in a census tract with at least one grocery store compared to 73 percent of black Americans who lived in areas with small grocery stores. Little association is documented between the presence of small grocers and healthy eating.

Transportation is an element of access as well as availability. Most large metropolitan areas, including Philadelphia have extensive automobile roadways and public transit systems, providing much more flexibility and coverage than smaller urban and suburban communities. For instance, in an urban Iowa community, about one-quarter of pantry users in urban neighborhoods said there was no affordable transportation to grocery stores in their community (Garasky, Morton and Greder 2004). Morland et al. (2002a) also identify the difference in mobility represented by participants with white residents having three times greater access to private transportation than black Americans living in similar locations. White Americans select groceries from a larger geographic area. The results from Morland et al. (2002b) show black Americans reported increased intake of fruits and vegetables when a supermarket is within their tract, averaging a 32 percent increase in fruit and vegetable consumption with every supermarket.

G. Fruit and Vegetable Retail Grocers

The U.S. Department of Agriculture designates supermarkets, convenience stores, small grocers and specialized food stores as traditional food retailers. Non-traditional food retailers are shopping warehouses, superstores, such as Kmart and Target and variety stores including dollar stores (U.S. Department of Agriculture 2007). Morland et al. (2002a) cite the 1997 United States Economic Census and state that supermarkets and grocery stores sell 92 percent of the volume of all annual sales of food and beverage stores in the United States. The 2002 Economic Census reports that in 1997 the U. S. had 69,461 supermarkets, including 2,957 in Pennsylvania. Median grocery market size increased to nearly 45,000 square feet nationally (Dunkley, Helling and Sawicki 2004). Grocery establishments, include supermarkets, and an assortment of smaller businesses, such as, convenience stores and corner stores that are primarily engaged in retailing food, such as canned and frozen foods; fresh fruits and vegetables; and fresh and prepared meats, fish, and poultry. The market structure of U.S. supermarkets has gone through rapid changes since 1995. For the top eight grocery store chains in the United States, food sales lingered between 26 and 28 percent throughout the 20th Century. Between 1995 and

2000, the same chains carried nearly 50 percent of food sales, indicative of market consolidation and franchise expansion among supermarkets (McLaughlin 2004). Also stores are larger than in the past and have many more departments ranging from clothes to cosmetics, but produce is increasing in importance.

Competitive advantage for supermarkets lay in lower prices but also in store size, technology, equipment innovations, and trained associates and better products which include promotions. Supermarkets also strategize using a complete demand system examining how consumers will shop for a range of items and combine other reasons to be in the store. Promotion strategies for produce include loss leader and local pricing, designation of prominent shelf space, promotional material, newspaper ads, in-store demonstrations, samplings, informative signage and talking with customers about products (Himmelheber 2008). Supermarkets are facing mounting pressure for transparency and traceability in their supply of fresh produce and meat supplies (Major 2008). Bech-Larson and Esbjerg (2006) explore the role of fruits and vegetables in creating a pleasant experience for shoppers and in creating differentiation with other retail grocers. Traditional grocers prior to the age of self service and efficiency presented a calmer more deliberate shopping experience where fruits and vegetables can be handled, smelled and compared directly rather than through packaging as with most products. High perishability requires pre purchase quality inspection and freshness and quality create a standard of store credibility. Produce is a major element in grocery shopping. One strategy engaged by Price Chopper in Kansas City is to offer 900 varieties of fresh fruits and vegetables from over 70 family farms in the region (McTaggart 2008).

Understanding customers is essential to success for grocers. The United Fresh Produce Association honors produce managers from supermarket chains and independent retailers for innovative techniques to reach communities and advance sale of fresh produce (Major 2006). Managers are recommended for strategies in merchandising, special displays and promotions community service and commitment to customer satisfaction (Major 2006). Strategies winning managers engage are promotion of "5 a day For Better Health Program" advanced by Healthy People, interactive school programs on-site and at schools; creative displays and cross merchandising produce with other non-food items, and outreach to seniors in centers and clubs.

Supermarkets have demonstrated increases in sales and profits from produce departments in the past 30 years. Nationally produce departments of supermarkets are expanding and given credit for adding aesthetic value to shopping experiences. Chanil and Major (2006) posted significant results in an article summarizing highlights from the 2006 Produce Operations Review published in the Progressive Grocer. Chanil and Major (2006), state that, supermarkets benefit from $43.5 billion in fresh produce sales for a 12-month period ending August 30, 2006. This number exceeds the previous year by 4.9 percent. Chanil and Major (2006) state that produce departments captured 12.4 percent of total store sales, an increase from 11.7 percent during the previous year. Additional facts from the report include total store selling space for produce increased by 0.5 percent to 12.6 percent; total produce selling space per store averaged 2,725 square feet an increase of 25 square feet from 2005 and the average per-store produce items are 290. McConnon(2008) cautions that retailers are feeling the economic pinch and dominant retailers are leaning towards offering fewer selections in order to cut costs.

Mclaughlin (2004) argues that whereas most retail areas are dominated by a few suppliers, fruit and vegetable growers number in the thousands and are spread throughout the United States, varying seasonably and geographically. The market structure of produce suppliers remains volatile even as supermarkets have undergone consolidation. The perishability of fresh produce and the close association between weather conditions and product create dramatic fluctuations in costs for purveyors. McLaughlin (2004: S85) cites 75 percent of the cost of produce to consumers is for transport and marketing; ¼ is for the grower. The precariousness of produce costs are not easily absorbed by smaller retail establishments.

A few large supermarket chains dominate the majority of food supply to the U. S. population, but inner city residents are largely omitted from this distribution channel. Inner city locations are serviced more frequently by independent retailers and non-chain supermarkets. Where large independent grocers fail to provide stores, neighborhoods are dependent upon the goods made available by smaller grocers. The entire trend of expanding fresh produce departments promotion, display and community outreach is bypassing inner city neighborhoods, and exacerbating disparities in health between minorities and majority populations. In large, dense urban areas, such as Philadelphia the retail grocery environment is a diverse range of vendors, establishments and products. Throughout Philadelphia small grocers and corner stores are present in every neighborhood and much more common than supermarkets. Corner stores range in size from less than 100 square feet to several hundred feet and small grocers can extend to several thousand square feet (Dunkley, Helling and Sawicki 2004). This diversity in establishment size is repeated in the diversity of food products and quality available across the surrounding neighborhoods, but with “fringe” stores stocking non-perishables, non-food and long life products as the most common retail outlet (Mari Gallagher Consulting 2007). Whereas snacks, cigarettes, sweetened beverages, and canned products are widely available in establishments of all sizes, healthy choices are infrequent and only reliably found in supermarkets of a much larger average size.

H. Retail obstacles in low income urban neighborhoods

Difficulties in retailing in low income inner city neighborhoods are well documented. Pothukuchi (2005) describes the “urban disadvantage” for retailers including cramped space, old infrastructure, limited parking, and poor access to highways for distribution. The competitive advantage of larger store size and technological innovations present two challenges to congested, old neighborhoods. Additionally Bates and Robb (2008) state that retailing in low income minority neighborhoods is associated with low business viability compared to non-minority neighborhoods. Stokes (2006) identifies de-industrialization and federal disinvestment, furthermore he blames “undermanaged public space’, crime and racial divisions as push factors.

Positive and effective strategies are difficult to identify. Pothukuchi (2005) explains that systematic, citywide grocery initiatives are rare, with such efforts limited to particular sites or developments. Successful initiatives are characterized by political leadership, competent public agency participation, and, often, partnerships with nonprofit agencies. Stokes (2006) examines the introduction of a business improvement districts (BIDs) as marketing tools to urban neighborhoods as a mechanism to increase community involvement and leverage funds form city governments. Through his case study of the Frankford neighborhood in Philadelphia, he recommends the potential of

BIDs, but cautions that raising funds and coordinating services are ongoing issues. Pothukuchi (2005) pinpoints private initiatives, and grassroots coordination and demand as two essential elements for neighborhood business prosperity.

The low percentage of minorities involved in business enterprises may also be a factor in low levels of investment in minority neighborhoods. Black Americans account for just over 12 percent of the U.S. population, they account for only 3.5 percent of the nation's retail trade entrepreneurs (Rauch 1997). Black retail trade entrepreneurs are also less successful than U.S. retail trade entrepreneurs overall. Rauch (1997) identifies that the limited ties between black retailers and wholesalers and manufacturers are an obstacle, which some minorities have overcome through ethnic collective action and use of ethnic networks. Lu and Lo (2007) refer to Chinese grocery shoppers in Toronto and how ethnic identity rather than economic rationale influences choice of shopping venue. Without the advantage of an ethnic network in business Blacks need to establish a competitive retail advantage. To compete with large retailers smaller stores have formed retail groups for purchasing and supplying inter-store cooperation. Voluntary chains, similar to franchising are another option. Minority franchising is a strategy to draw minority populations into retailing but often the strategy is most successful in suburban populations rather than blighted urban neighborhoods (Shubart 2006). Williams (2002) stresses that amongst relatively deprived populations, economic necessity remains the chief reason for using informal, second-hand and non-chain retail modes of goods acquisition. Participation in alternative retail channels indicates exclusion from mainstream shopping trends.

Franchising is one controversial business tactic for economic growth in low income neighborhoods. Franchising businesses account for nearly four percent of the U.S. private sector economy (Shubart 2006). Franchising in urban neighborhoods allows residents to find work in local neighborhoods, but then less advantaged areas have greater access to fast food (Burns and Inglis 2007). Franchisers have greater access to capital than many independent operators, but many people franchising equates with fast food. Creating access to fast food for populations already suffering disproportionately high prevalence of chronic health conditions related to nutrition and diet seems contradictory.

The opportunity does exist in the fact that indicators show that suburban saturation of supermarkets may make the unmet customer demand of low income areas more attractive (Pothukuchi 2005).

I. Food insecurity in Pennsylvania

Pennsylvania is a state with the lowest number of households classified as food insecure. Yet Pennsylvania demonstrated a 1.2 percent increase in prevalence in food insecurity from 1998 through 2003 (Nord, Andrews and Carlson 2004). Local level statistics fall within the realm of non-profit organizations actively combating poverty and food insecurity through volunteerism and local campaigns. Agencies such as the Pennsylvania Hunger Action Center and the Food Trust in Philadelphia offer data on residents within the Philadelphia region who are food insecure. In Pennsylvania 9.8 percent of all households are food insecure according to the Pennsylvania Hunger Action Center. The Philadelphia Health Management Corporation states that nearly 122,000 households in Southeastern Pennsylvania, with 61,000 children, must reduce the size of meals or skip meals entirely because they cannot afford food purchases (2004).

The expanse of floor space and shelf space designated to fresh produce in grocery stores across the United States in the last 30 years has increased (McLaughlin 2004). In spite of large expansion in suburban areas many inner city neighborhoods with extremely high population densities have limited availability for fresh produce and healthy food choices. The Food Trust (2006) has documented a low number of grocery stores per capita in Philadelphia neighborhoods and estimates that Philadelphia has 70 too few supermarkets in low income neighborhoods across the city. The Food Trust utilized GIS technology to map locations of supermarket sales, income and diet related mortality. Access to supermarkets is unevenly distributed across the city and supermarket sales are concentrated indicating that large numbers of persons are traveling outside of their neighborhoods for groceries. The Food Trust mapped supermarkets by weekly sales volume and supermarket sales relative to total population demonstrating areas of high concentration and large sections of the city without major grocery stores. In addition the Food Trust acquired data from the Philadelphia Health Management Corporation (PHMC) and identified areas of Philadelphia with the greatest need by relating low sales, low income and high numbers of diet-related deaths. Access is treated as distance to supermarkets and most calculations are based on supermarket sales. A second Food Trust document, “Food Geography: How Food Access Affects Diet and Health”, describes how low income and minority communities are by far the hardest hit by obesity and diet related illnesses. The number of food sources is also designated as an indicator of food environments.

The four dominant messages presented in this argument are that food insecurity is an enormous issue in the United States. Secondly that societal food insecurity leads to individual health effects, thirdly environmental conditions are influential on individual healthy food consumption and finally that the spatial pattern of fruit and vegetable retail has created less accessibility and availability to many urban neighborhoods.

In recent years the USDA estimates that 11-13 million U. S. residents experience food insecurity annually. Food insecurity includes household and individual food consumption. Food insecurity patterns do not exactly parallel patterns of poverty. Food insecurity is being addressed through social programs, but efforts to address attitudes of consumers are critical to instill individual habits of healthy food consumption.

Among groups suffering from food insecurity in the United States are urban populations including children, seniors, immigrants, low-income, black and Hispanic populations. Family structure, disability, poor mental and emotional health, culture and local environment all contribute to personal food intake. Typical households spend slightly more than 60 minutes for daily food consumption, with an additional 30 minutes per day for meal preparation and clean up. Individuals spend six to eight minutes shopping a day whereas household grocery shoppers spend 40 to 45 minutes per day. The eating environment is the social component of food consumption such as if people eat in a group, in a family setting, regularly, scheduled, without distractions, but also includes taste and presentation of food.

A component of a deprived neighborhood is lack of access to quality and healthful groceries. Patterns of food concentration and food paucity exist in urban areas. Rather than food deserts are areas of lower proportion or lower quality of healthy food choices. Many neighborhoods are served by smaller retail outlets with fewer healthy choice options. Many urban areas have a larger presence of ‘fringe retailers’ which may offer some staple groceries but allocate more shelf space to fast moving items such as alcohol and snacks. Although public transportation provides mobility in high density urban areas, persons depending on public transit may have fewer grocery choices.

In the last fifteen years the supermarket retail sector has experienced rapid market consolidation, resulting in fewer large chains with many franchise establishments. The competitive advantage for many stores lay in lower prices, larger floor size, multiple departments, high profile marketing and emphasis on customer satisfaction. Fresh fruit and vegetables have gained importance for consumers and as an aesthetic component of shopping. Community outreach and education has become a marketing tool for large grocers. Although grocery retailers have consolidated, produce distributors are still dispersed and diverse by product, perishability and seasonal availabilities. Inner city areas are not easily served by large supermarket retailers and are being passed over as national trends in healthier food availability become typical in less densely populated suburbs and smaller cities and communities.

The confined spaces of high density urban areas require that large and small grocers maximize product display and place less emphasis on aesthetics or shopping ambiance. Large and small grocers maximize frontage with basic and critical demand items which provide assurance of customer consumption rather than riskier or experimental products which may result in profit loss. Inner city grocers are limited in size for conveniences such multiple departments or large parking lots, and often service lower income communities. The diversity of communities with a shopping area can provide additional complexity in meeting customer demands. Positive retail strategies in low income urban neighborhoods require more public-private cooperation in the form of business improvement districts and bridge-building across diverse ethnic elements within local proximity. Another strategy is sponsorship of retail groups or voluntary chains which create coordinated strategies across grocery outlets to service communities. Expansion of large grocer franchises within the urban neighborhoods is desirable, but principally businesses which promote healthy food options rather than fast food.

Chapter 3: Geographical analyses of food environments

The objective of this chapter is to review research within the field of geography and geographic information science particularly relevant to this research dissertation. The previous chapter reviewed a range of academic fields including nutrition, family and community health, marketing and food retail strategies. Many fields overlap and influence the concept of the local food environment. High prevalence of obesity and related chronic diseases throughout the United States has spurred interest in grasping what is meant by the local food environment.

Three geographic concepts require definition, the functional region of a supermarket, accessibility, and a nutritionally underserved area. Regions and accessibility are two research concepts in geography which have been explored extensively. Nutritionally underserved is a term I suggest which may be appropriate for areas or sections of communities which are not well served with basic nutritional foods for home consumption. If nutritionally underserved areas can be defined this signifies that local food environments may be a contributing factor to increase in chronic disease and food insecurity.

Geographic information science (GIScience) has emerged as a research field in the era of digital technology from the field of geography and spatial analysis. Spatial and location analyses are traditional research approaches within geography which emphasize the role of distance, separation and spatial variation in site selection for a facility or application. GIScience employs a range of emerging digital tools and techniques to engage in measurement and placement in space. The tools of GIScience include conceptual and physical modeling of spatial relationships, data representation, visualization of point and area data, spatial interaction modeling and data capture. GIScience incorporates interactive analysis using a range of exploratory or querying approaches to consider conceptualizations and applications of regions and accessibility, age old tools of geographic research. Geographic Information Systems (GIS) and related geospatial technologies are employed to identify best sites with greater precision and less uncertainty, and to maximize the number of views in which data may be presented. This dissertation presents exploratory data views.

GIScience engages exploratory spatial data analysis extending beyond physical site delimitation to encompass study of less distinct boundaries of individual decisions and behaviors. This is the realm of cognition of geographic information (Montello 2005). I define neighborhood regions of availability and access. The type of small area analysis presented in this dissertation is a research tact which utilizes the power of GIS and statistical tools to provide new insight to local community issues (Whitman et al. 2004).

A. Regions

Regions are vast fields of study within geography and many interpretations and methods of defining regions are available. Haggett (2001) places regional analysis along with spatial analysis and ecological analysis as the primary research approaches within the field of modern geography. Regionalization is a tool for categorization of spatial data into similar sets based on common characteristics. Regions are generalizations for simplifying presentation of spatial data cartographically, as in the case of economic regions, agricultural regions or political regions. Regional boundaries are subject to interpretation.

Regional analysis often leads to demarcation of a discrete boundary across a transitional geographic area. Delimited regions are referred to by other terms, including coverages, ranges, catchments, or service areas as in the cases of Murray (2005) and Shortt et al. (2005). Service areas may be regular or irregular, contiguous or non-contiguous. Service area or coverage definition is often heuristic modeling; creation of approximate models for optimization of a specific problem. In this research, I define functional or nodal regions. Functional regions are based upon interaction between a core or central location usually providing a service, and the surrounding area or hinterland which provides a reciprocating service. An example of a functional region is a store, as the centroid or node and the surrounding neighborhoods which comprise the market area. Haggett (2001) describes nodal regions, as having boundaries which fade gradually, rather than be sharply defined. Gradual fading or fuzziness of regional boundaries creates areas of marginal service, or areas of transition between adjacent nodes. “Fuzziness” refers to ambiguity in definition and many geographic studies refer to fuzzy boundaries, fuzzy logic or fuzzy landscape analysis GIS (Malins and Metternicht 2006; McIntosh and Yuan 2005). Fuzziness is also characteristic of the edges of functional regions including service areas. In this research study fuzziness between service areas, creates areas of marginal or poor accessibility to groceries for some neighborhoods.

Most spatial boundary analysis occurs within physical geography in terms of vegetation or ecological phenomena (Webster and Maestra 2004; McIntire 2004; Kent et al. 2006). The range of methods to determine the boundary or practical extent of the hinterland includes floating catchments and gravity models. The term “wombling” has come to denote the process of barrier analysis or edge detection (Lu and Carlin 2005).

Murray (2005) explores analysis of transitional areas with set theory. Murray (2005) refers to this regional delimitation as the set covering problem (SCP). SCP is not particular to geographic study or spatial studies but emanates from set theory in mathematics.

In human geography regional examples include “noise-control area” demarcation (Van der Merwe and von Holdt 2005) and political redistricting in the United States following the decennial census (Winburn 2008; Byerly and Carbo 2006). Shortt et al. (2005) study the problem of methods of defining general practitioner catchment areas. Another application in health studies is the regionalization and boundary delimitation of health service areas or emergency response areas. An example of the process to define health regions based on need is the procedure to identify and define medically underserved areas (MUAs) in the United States. The concept of the medically underserved area arose from the need to prioritize areas of health care disadvantage during the 1970s (Ricketts et al. 2007). MUAs, medically underserved populations (MUPs), and Health Professional Shortage Areas (HPSA) have been defined and linked to many federal health and welfare support programs.

Murray (2005) accentuates the usefulness of GIS for modeling service coverage, partial service coverage and service overlap between providers. Murray refers to this as the set-covering problem where a minimal number of servers are designed to service a coverage area. This application is frequently employed for public services such as emergency response and in private business to maximize operating efficiency.

Region building methods include use of defined geo-political boundaries as well. In human geography regional boundaries are often attributed to readily available administrative units such as states or counties. Although convenient for presentation, administrative units are often not as informative as more precisely calculated regional boundaries. This method of utilizing previously established spatial units is referred to as the containment method. The containment method is limited in the generation of regional boundaries using political boundaries or previously defined spatial unit which are not ideal for volatile or flexible boundaries used for provision of services, shopping or entertainment. Supermarket service areas are examples of functional or nodal regions.

Regions generalize and simplify data presentation. The limitation to data regionalization is that particular data is marginalized. The benefit of examining disaggregated data is the level of detail which can be gleaned from each datum within a study. Regionalization requires disaggregate data be merged with proximate data to form areas of common value, indicating that individual cases may be overlooked in favor of the majority cases. Aggregated data such as presented in regions tends to override individual cases for presentation of more dominant characteristics. This is referred to as ecological fallacy whereby each datum is merged to a common value rather than representing its true value. The modifiable areal unit problem introduced by Openshaw and Taylor (1981) is another limitation of regionalization or aggregation of data. There is no single correct unit or area of aggregation for all data. Data may be aggregated and assessed manifold ways at varying units of geographic detail.

B. Accessibility

Related to service area coverage is a second concept requiring operalization, accessibility. Accessibility can be calculated through various measurements of physical distance or costs in terms of time or convenience. Access to health care has been a widely studied topic. Mobley et al. (2006) examine preventable hospitalizations as a means to study access to primary care for seniors. Duck-Hye, Goerge and Mullner (2006) suggest a two step implementation of the gravity model examining both service providers and customers. The gravity model is a geographic tool for measuring accessibility. Guagliardo et al. (2007) studied accessibility to neighborhood pharmacies and asthma medication using a series of maximum times.

Church and Marston (2003) provide a review of measures of accessibility. They summarize the “Container Method” which a measurement of gross accessibility within a given area as the simplest form of access. Church and Marston (2003) differentiate between gross and relative accessibility. The probabilistic model interjects customer selection as an intervening opportunity into the pool of options in selection of a service provider, as when shoppers determine their destination through trip chaining for multiple activities. Marston and Golledge (2003) discuss ‘relative accessibility’ as differences in mobility among individuals within the same geographic space. Marston and Golledge (2003) engage this concept for individuals visually impaired and Church and Marston (2003) provide a second example for individuals relying on wheelchairs across a college campus compared to ambulatory individuals. The relative access for an individual using a wheelchair is 5.25 times greater than an ambulatory person leaving an adjacent office on a short trip to a food cart outside a building. They measured the relative access in time spent to reach the food cart, 40 seconds for an ambulatory person and 3 minutes and 30 seconds for the person relying on a wheelchair. Whereas gross access is simplistic, relative access relates the differences in user groups. Relative access can be used to determine what barriers exist for various user groups, such as shoppers relying on foot or public transportation.

Spatial accessibility research in urban neighborhoods includes studies of location of food stores in low income compared to higher income neighborhoods (Morland et al. 2002a) in Detroit (Schulz et al. 2008), Los Angeles (Blair-Lewis et al. 2005) and New York (Moore and Diez Roux 2006). Many spatial analytical studies revolve around the physical distance consumers need to travel to grocery stores. Other studies emphasize travel time to stores as a measure of accessibility. One commonly referenced model is the Huff Model (Wang 2006; Okabe, Shiode and Okunuki 2006; Haines, Simon and Alexis 1972). The Huff model incorporates the size of the retail location, distance or travel time to the retail center, number of available retail centers and probability of a consumer traveling to a given store. The Huff model also specifies a discrimination parameter. Desarbo et al. (2002) refers to the discrimination parameter as attractiveness for individuals who use particular retail brands in some applications of gravity models. Previous work has focused on the drawing power and size of merchandise offering, but no importance attached to advertising tactics. Haines et al. (1972) examine the travel distance to grocery stores according to demographic and socioeconomic variables and utilize the Huff Model as an approach to analyze retail attractiveness of a store. They concluded that there is no difference in the size of the geographic market area for food among central city neighborhoods, and low income residents had a market area of similar size to other economic groups. Another comment Haines et al. (1972) include are that zoning laws are not enforced strictly in low income areas leading to establishment of small food stores which open to serve local consumer needs for grocery products. Some inner city neighborhoods are significantly far distances from large supermarkets with larger stock supply which increases the attractiveness of store to consumers and allows customers to meet more needs at a single location.

Wang (2006:57) considers gravity models, and in particular, the Huff Model as methods for assessing geographic accessibility. Wang approaches accessibility by defining trade areas based on distance calculations from a central location. Wang's central location is either a customer or a store. Gravity models incorporate distance and store attractiveness. Gravity to a store is calculated using the store's attractiveness to consumers and distance is friction when approaching a store. The Huff Model introduces the concept of "perceived utility" of a store for a consumer among alternatives, which is weighted, creating a value for store attractiveness, with distance calculated as a friction coefficient (Wang 2006:59). Consumers in local areas have multiple choices for grocery products and the Huff Model allows probability of selection of various alternatives rather than requiring a decision based on distance or "breaking point" between stores. Nakanishi (1974) describe a multiplicative competitive interaction model (MCI) which incorporates additional factors beyond distance and attractiveness such as image or other store characteristics. Okabe, Shiode and Okunuki (2006) describe a computational method for estimation of retail demand on a street network. Rather than shortest path, they apply the Huff model to customer and store locations along a network, such as street networks utilized by consumers, pedestrians and drivers. Street and store demand estimation for consumers can be determined applying the Huff model on a street network.

Parker and Campbell (1998) consider accessibility to physicians and medical services. They apply GIS and spatial analysis to examine equality of access to primary medical care, attempting to assess patterns of utilization of health services including primary medical care and emergency providers examining factors including distance, age, sex and income of users. In addition to physical distance, calculated through networks and straight line distance, Parker and Campbell (1998) use travel time to services as a measure of accessibility, and use Thiessen polygons to determine the closest service provider. They examine the effect of distance on utilization of services, and examine home and automobile ownership of residents in several neighborhoods and apply an index to measure socio-economic disparity.

C. Healthy Food Markets

Related to the idea of accessibility is the concept of a healthy choice grocery store. Among many retail establishments how is a consumer to identify a healthy market among alternatives. Sufficient amounts of food are a basic necessity of life and varieties of food choices are an essential component of quality of life everywhere. A neighborhood with quality living conditions includes a source of food. The presence of a store or source of healthy foods raises neighborhood residential value (Proscio 2006), although defining a quality source and a healthy market remains an ambiguous task. Supermarkets and fresh grocers with large selections of fresh produce, fresh meats, poultry and seafood clearly provide healthful food choices. Neighborhoods with one or more supermarkets with produce, dairy and meat departments are quite clearly and richly supplied with healthy choices. Less clear are the healthy choice value of smaller supermarkets, small grocers and convenience stores. Smaller grocers often provide staple groceries including bread, milk, fruit, vegetables, eggs, rice, beans, and meats, but the selection of staple groceries are overshadowed by less healthy and less basic needs such as cigarettes, lottery tickets, candy, snacks, sodas and sweets. Kipke et al. (2007) found that in Los Angeles neighborhoods of 62 small grocers only 18 percent sold fruits and vegetables. Mari Gallagher Consulting identifies convenience stores which de-emphasize healthy food choices in favor of less basic, high turnover items such as beer, liquor and tobacco products as ‘fringe’ stores. Thus urban neighborhoods are serviced irregularly by supermarkets with a multitude of healthy choice items to fringe establishments which may or may not stock canned foods. Franco et al. (2008) developed a healthy food availability index (HFAI) derived from a scale developed by Glanz et al.. (2005), the Nutrition Evironment Measures Survey in Stores (NEMS-S). Both the HFAI and NEMS-S assess differential availability, quality and price of healthy food items across urban neighborhoods. Both studies include fresh fruits and vegetables, milk, ground beef, frozen dinners and bread. Only HFAI took into account shelf space as a factor in measuring availability.

D. Nutritionally Underserved Areas

Rather than identify food deserts, a more appropriate study may be to identify nutritionally underserved neighborhoods or populations. In the past the federal government has tried to identify medically underserved areas and population. A similar initiative may be to identify those populations without sufficient access to basics of healthy living, such as food or shelter. As discussed in previous sections access to a resource is not simply a matter of distance but also of mobility and need. A study by Laraia et al. (2004b) examines the proximity of supermarkets as a health concern for pregnant women. Laraia et al. (2004b) create an index to rate the quality of diet among pregnant women and state that women living more than 4 miles from supermarkets had a much higher odds ratio of a low index value and low quality diet. Glanz et al. (2005) describe healthy nutrition environments and provide an overview for possible measures for nutrition environments. They refer to schools as a source of food for children, and the positive influence of fruit and vegetable availability at school. Low income neighborhoods have higher prevalence of fast food and a lower presence of supermarkets. Glanz et al. (2005) also refer to trends in eating away from home and the adverse effects of poor quality groceries in low income neighborhoods. Low quality groceries encourage eating out with larger portions and higher fat. Glanz et al. (2005) identify four types of nutrition environments and two paths of influence. Environmental influences include which impact individual’s nutritional choices are community factors, consumer factors, organizational factors and informational factors.

During the 1990s, detractors recommended more scientific methods of defining MUAs. A primary criterion of MUA designation is the population to practitioner ratio, although the precise ratio remains a point of contention. 4000:1 was set initially, but revised to 3500:1, 3000:1 and 1500:1. Office based primary care visits are used as a metric, but some areas have depressed values. The lower values are interpreted as a lower level of service to the local population or indicative of restrictive conditions on demands for physicians. The proposed new formula for MUA designation integrates opposing factors such as the number of reduced visits caused by access barriers but also the number of increased visits caused by delayed health care (Ricketts et al. 2007). Spatial analysis, geography’s contribution to analysis of local food environments is that data can be regionalized. Regional boundaries are open to interpretation. Whereas definitive boundaries are convenient for analysis transitional boundaries may be more representative of actual geography. Access is based on distance but access is relative for various populations within an area. In this situation small distances may still present barriers to access to healthy foods. Gravity models area tool employed by geographers to examine accessibility including not only distance but also attractiveness of a place. A nutritionally underserved area is a term I introduce to describe a local area without any source of fresh fruit or vegetables within a short travel distance. Availability of fresh produce to all communities is difficult to ensure and should not be treated as a guaranteed condition of urban living. Fresh produce is swiftly perishable and this characteristic along with decrepit infrastructure and poor economic conditions may lead to local areas of deprivation.

Chapter 4: Methodology

The research design and method of analysis for each hypothesis is detailed in this chapter. Philadelphia with its documented shortage of grocery stores (Food Trust 2006), is the study area of this research. The research process includes data collection and data processing tasks. The key software tools utilized are ArcGIS 9.1 and 9.2, Office Pathfinder 2.9 and 3.1 and PASW 17.0 and Geoda 9.5i. Initially a restaurant inspection file (PDF) was downloaded from the City of Philadelphia's official web site and grocery locations obtained from this PDF file were geocoded to create a geographic data file. Following geocoding, a field survey was conducted within the study area. Demographic data was compiled from the U.S. Census Web Site and additional health data was obtained from the Philadelphia Health Management Corporation (PHMC), a non-profit organization conducting health research in the Philadelphia Metropolitan Area. Beyond geocoding, data processing includes network analysis, creating summary tables, service area and overlay analysis. ArcGIS Network Analyst is used to create two networks for analysis. The first network is a street network using all streets within the study area. The second network is a public transit network using rail lines, subway, trolley lines and streets which are public transit routes throughout the study area. Modelbuilder in ArcGIS was used to automate a process which created probability tables for each supermarket.

The research process is an ecological analysis. Data is compiled and examined at several geographies. Census block groups and census tracts are compact spatial units used to provide population counts across the study area. Census tracts are comprised typically of multiple census block groups. Supermarket service areas and gap areas are created using service area analysis. When service areas are created around supermarkets and grocer sites, their boundaries do not adhere to census tract or census block group boundaries, but dissect and shear these enumeration units. In spite of boundaries not strictly adhering to census units, census units are used to calculate populations falling within service areas and gap areas. The centroid of each census unit is used to assign the census unit to service areas or gap areas. If the centroid is located within the bounds of the supermarket service area, then the entire census block group is categorized as well serviced. Of the 285 census block groups within the study area, the mean census block group area is .05 square miles but the median is .026 square miles. Three census block groups in Grays Ferry are extremely large but with low populations which skew the mean. These range in area from 1.18, 1.05 and 0.73 square miles and account for 2.96 sq miles (20 percent) of the study area. The population within these census block groups is 707 persons. The decision was made to allow include these areas in the research study because these populations are very likely to fall within the gap areas for supermarket accessibility and although low in number are the specific population that this study attempts to identify.

Whereas census block groups are the basic enumeration unit within the study, urban residents don't identify with census units. Residents of Philadelphia and other urban areas identify with neighborhoods or sections of cities characterized by features such as parks, main streets, ethnic or historical places of social significance. Even neighborhood boundaries are difficult to delimit as is demonstrated by the Health Department neighborhoods in Philadelphia which number 45 compared to the Philadelphia Planning Commission neighborhoods numbering 68. Neighborhoods offer more consequence to individual residents and to planning authorities than do census units, thus neighborhoods remain a tool for urban area planning and analysis. In this study the final discussion of supermarket service areas and gaps areas, served and underserved populations is aggregated and discussed at the neighborhood level in order to concern the communities.

A. Philadelphia Neighborhoods

The initial step was determining a study area representative of many urban neighborhoods. Philadelphia is a high density and large metropolitan city with 1.5 million people with a diverse demographic mix. The city is a core of the Philadelphia-Camden-Wilmington, PA-NJ-DE-MD Metropolitan Statistical Area with an estimated population of 5,822,368 people in 2.2 million households (US Census 2007). Philadelphia is also historical, established in 1681 by William Penn (Dunn and Dunn 1982). The neighborhoods within this research study were outlying townships at that time and were incorporated as Philadelphia County in 1854. The communities included Southwark, Moyanmensing, Kingsessing, Blockley and Passyunk. Southwark was the oldest settlement extending westward and southward from South Street and the Delaware River. The area was characterized by a seafaring population and industry, with machine shops and iron works along the Delaware waterfront extending southward to the US Navy Yard (Thayer 1982:75).

Philadelphia experienced steady growth increasing to 400,000 residents by 1850 and over 2 million residents by 1950. Since 1950 Philadelphia has experienced population loss, mainly through exodus of white populations to suburban areas. Older areas, such as South Philadelphia, experienced population losses of 15 to 30 percent

(Wolf 1982:708). Non-white populations compensated with high population growth but the net change was a loss of population.

As Philadelphia and many U.S. industrial cities experienced economic decline, Philadelphia embraced small enterprise. The recession left few large employers within the city. Suburban population growth led to retail growth in suburban areas. In response to decline in retail dominance of central Philadelphia smaller neighborhood entrepreneurs undertook ventures to meet local needs and maintain retail quality. Gentrification took effect in some neighborhoods, but the forced relocation of neighborhood residents was contentious. Philadelphia has continued to experience population and economic decline and racial tension into the 21st Century. Figure 4.1 and 4.2 demonstrate characteristics of Philadelphia by census tract using US Census data from 2000. Figure 4.1a presents the proportion of African Americans across Philadelphia and Figure 4.1b presents median income using 1999 household data. Figure 4.2a presents the proportion of adult workers using public transit to travel to work. Figure 4.2b is the population density distribution throughout the city.

Figure 4.1 Philadelphia by census tracts

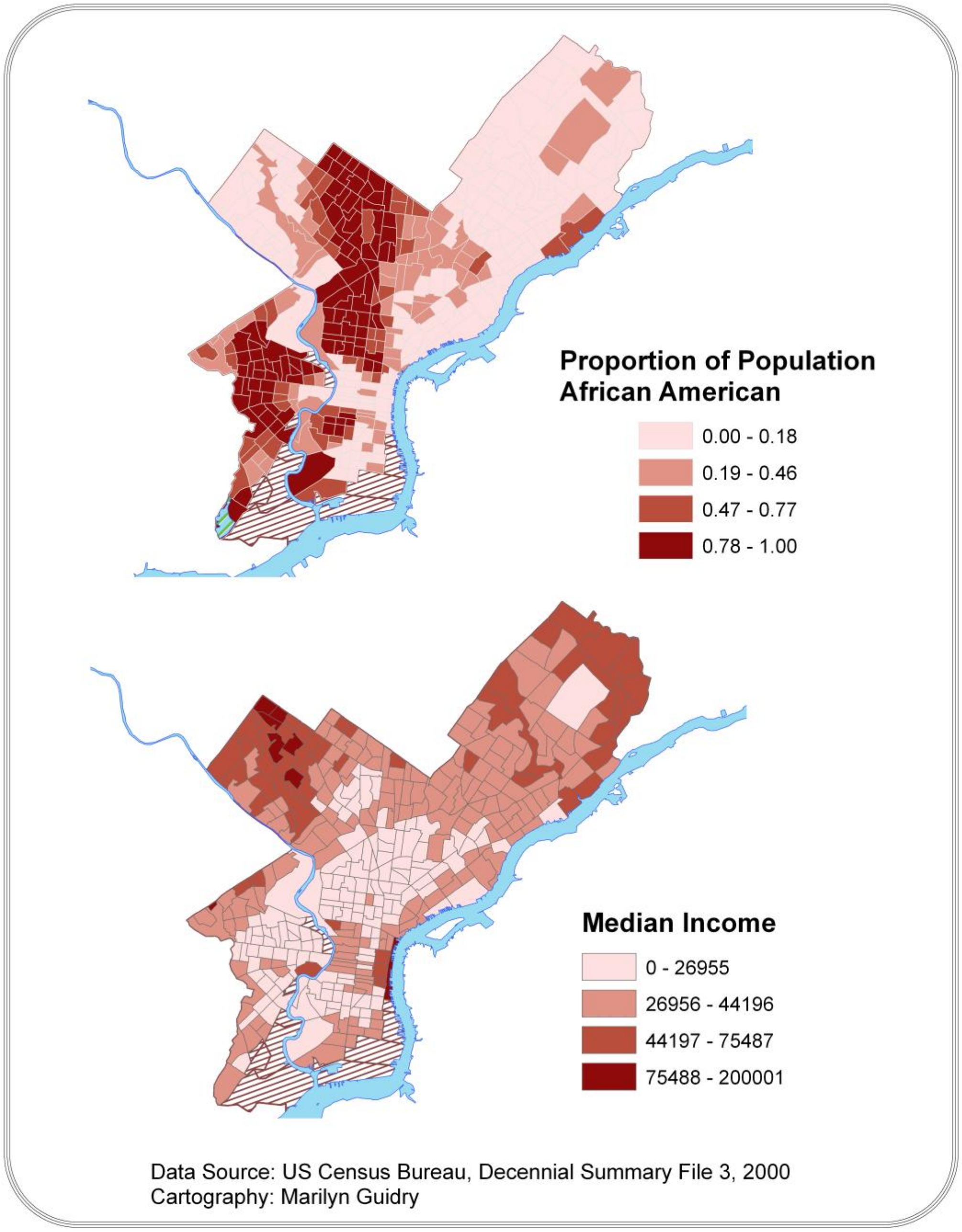
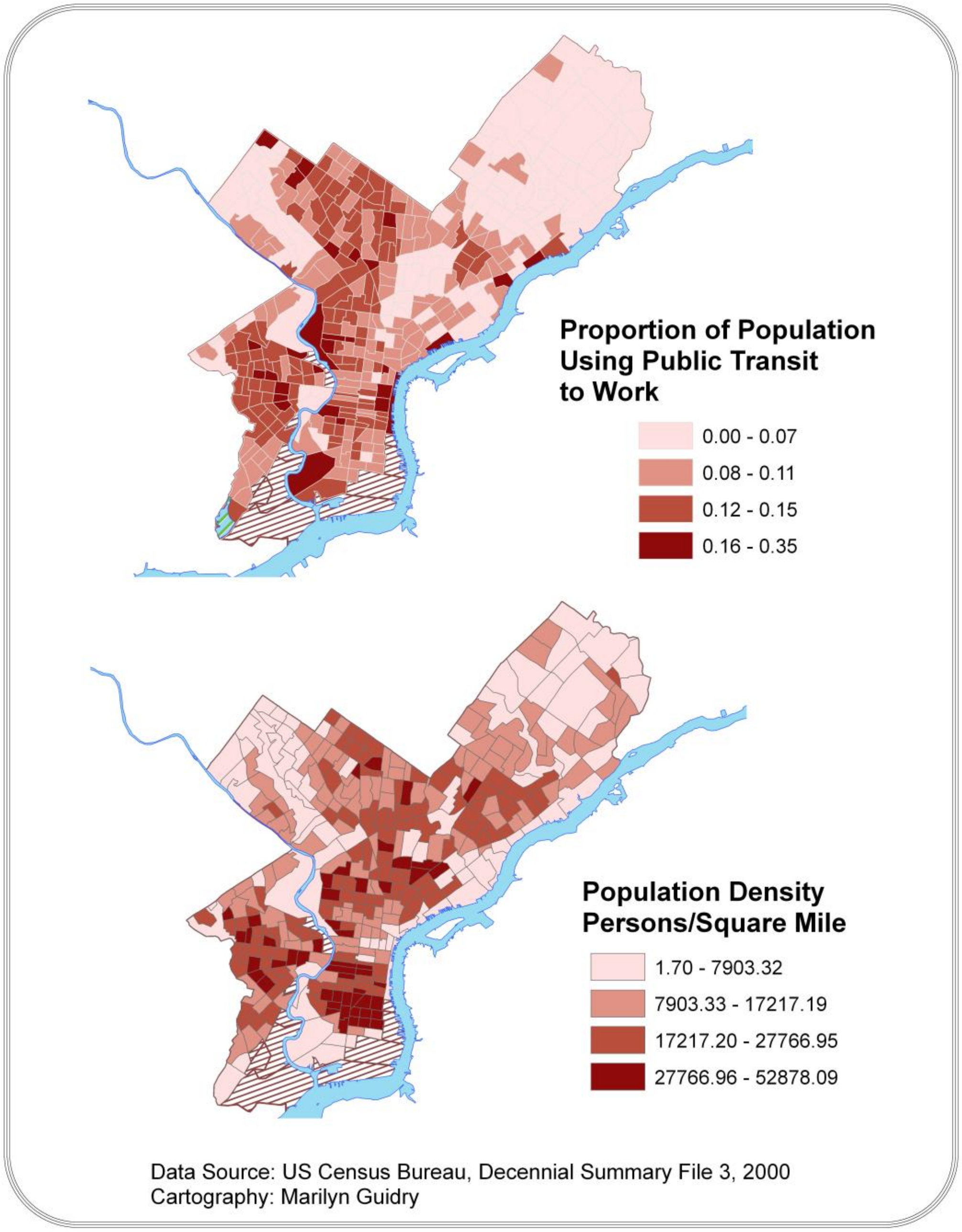


Figure 4.2 Philadelphia by census tracts



The south and southwest sections of the city were selected as the study area. The neighborhoods selected as the study area are contiguous and have a relatively separated geography. The study area has natural water boundaries on three sides. The Delaware River bounds the city and study area on the south, southeast and east. Tinicum Marsh and the John Heinz National Wildlife Refuge at Tinicum bound the study area on the southwest, and Mill Creek and Cobbs Creek form the western boundary separating Philadelphia from Delaware County, Pennsylvania. Mill Creek flows southward to empty into the Tinicum Marsh. The John Heinz Wildlife Refuge was established in 1972 encompassing 200 acres of freshwater tidal marsh area which overlaps the boundaries of Philadelphia and Delaware Counties (US Fish and Wildlife 2009).

Only the northern boundary of the study area is adjacent to the communities of center city Philadelphia and west Philadelphia. South Street is the northern boundary of the study area in South Philadelphia and Baltimore Pike is the boundary between Southwest and West Philadelphia. The study area is 15.05 square miles of high density residential and commercial land with a resident population of 231,249 persons. The study area includes 57 populated census tracts and ten unpopulated census tracts. The census tracts comprise Philadelphia Planning Commission Planning Analysis Sections (B) South Philadelphia, and (C) Southwest Philadelphia. The neighborhoods are defined by the Philadelphia Department of Public Health. Much of the area designated to these neighborhoods is industrial or non-residential and is not included in the study. This transect of neighborhoods also demonstrate high population density and mixed proportions of white and African-American residents, the two largest racial groups represented in Philadelphia. Table 4.1 displays demographic comparisons and Figure 4.3 displays the study area cartographically. The neighborhoods display a relatively similar annual median income ranging from a low $22,394 in Grays Ferry-Passyunk to a high of $36,687 in Pennsport-Queen Village, a neighborhood gentrified in the 1970s (Wolf 1982). Each neighborhood has a high percentage of households without vehicles, which emphasizes the role of public transit for mobility. The Southeastern Pennsylvania Transit Authority (SEPTA) operates a comprehensive public transit system including buses, trolleys, subway and regional rail which has serviced the study area and the Philadelphia Metropolitan Area since 1968 (Wolf 1982: 718). Demographic data presented in Table 4.1, was retrieved from US Census Bureau Web site using the Data Download Center for the census block groups in Philadelphia.

Table 4.1: Philadelphia Neighborhoods and Study Characteristics

Neighborhood	Area (sq miles)	Pop density (persons/sq mile)	Proportion Households without a vehicle	Proportion African American	HH income
Eastwick-Elmwood	2.39	18137.86	0.32	0.53	29,163
Grays Ferry-Passyunk	4.75	14176.31	0.51	0.57	22,394
Paschall Kingsessing	2.54	23396.20	0.48	0.85	24,842
Pennsport-Queen Village	0.72	28109.43	0.42	0.24	36,687
Schuykill-Point Breeze	1.19	27391.09	0.61	0.84	23,230
Snyder-Whitman	0.83	37635.02	0.39	0.13	28,281
South Broad-Girard	1.28	33307.38	0.37	0.16	32,885
Southwark-Bella Vista	0.84	34715.42	0.47	0.20	26,512

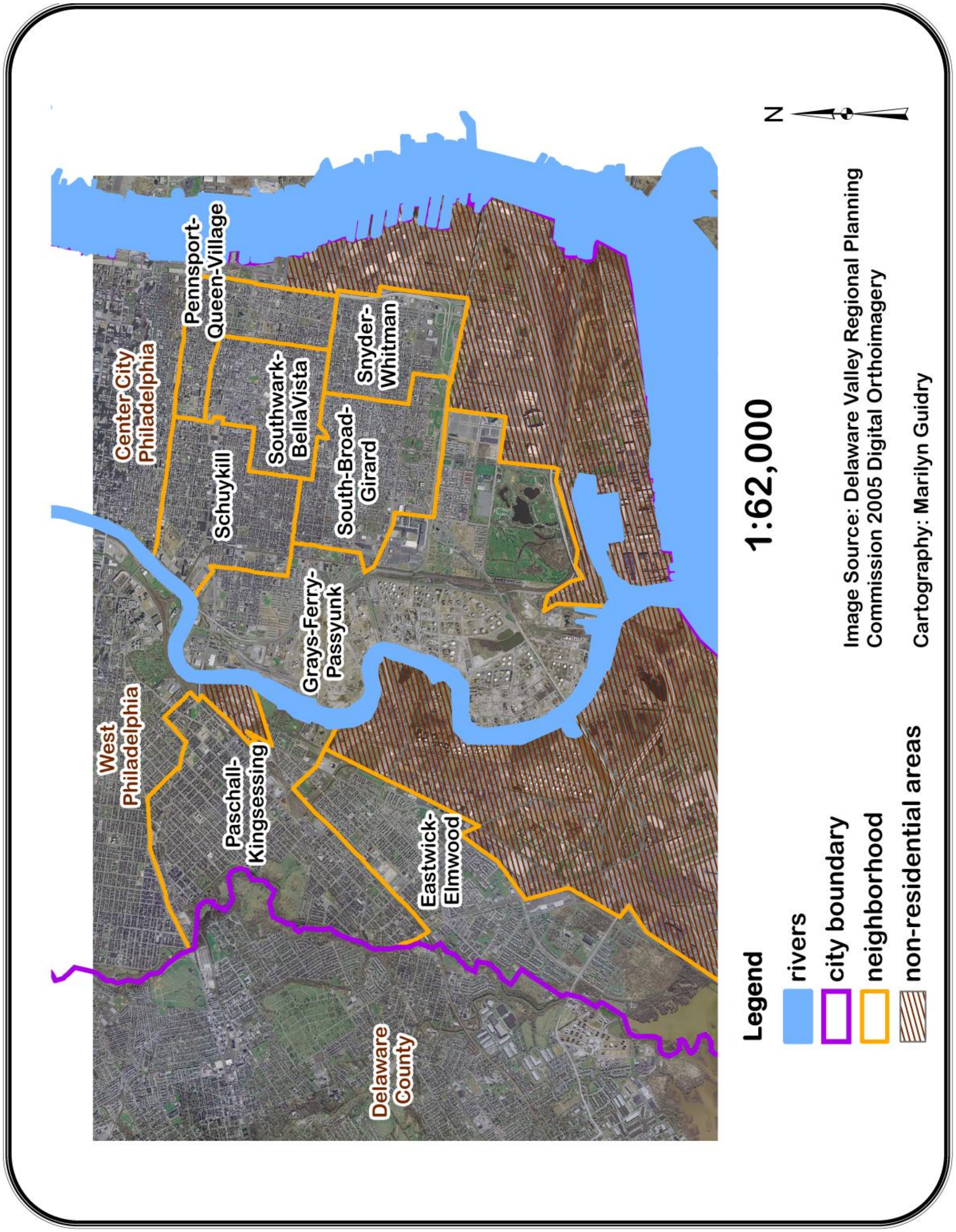
US Census Data 2000

The neighborhoods comprise a transect running east to west across the southern edge of Philadelphia. Six neighborhoods comprise South Philadelphia including Pennsport-Queen Village, Southwark-Bella Vista, Snyder-Whitman, South Broad-Girard Estates, Schuylkill-Point Breeze and Gray's Ferry-Passyunk. These neighborhoods are largely compact in shape and predominantly residential areas interspersed with commercial streets such as Broad Street, Washington Avenue and Oregon Avenue. Pennsport-Queen Village and Gray's Ferry are exceptions with irregular shapes. Pennsport-Queen Village is the smallest neighborhood in size but is elongated and narrow in two branches, one extending westward along South Street from the Delaware River, and a second arm extending southward along the Delaware River. Gray's Ferry is a sprawling neighborhood with interspersed residential, commercial and industrial tracts. Gray's Ferry covers most land of the eastern bank of the Schuylkill River. Because of the presence of large industrial tracts Gray's Ferry has the largest land area, the lowest population at 16,281 residents (7.0 percent) and the lowest population density (14,176 persons per square mile) of all neighborhoods.

Pennsport-Queen Village is adjacent to the southside of center city Philadelphia. Pennsport-Queen Village is home to 19,841 residents (8.6 percent of the study population) and has the highest median income in the study area at $36,687. Southwark-Bella Vista is a compact, mixed residential and commercial neighborhood to the south and west of Pennsport-Queen Village with a median income of $26,512 and holding 12.3 percent of the study population. Southwark-Bella Vista is home to Philadelphia's Italian Market an open market, running several blocks down 9th Street, which provides fresh fruit, vegetable and meat products to the entire urban community. Schuykill is the neighborhood which extends west along South Street where Pennsport-Queen Village ends, to the Schuykill River. Schuykill is a pre-dominantly African-American neighborhood housing 12.2 percent of the study population with median income of $23,230. Snyder-Whitman is south of Pennsport-Queen Village and Southwark-Bella Vista and is close to the Delaware River but separated by several unpopulated census tracts which house commercial areas including several shopping centers with large chain grocers. Snyder-Whitman has 24,665 residents (10.7 percent) with a median income of $28,281. South Broad-Girard Estates is south of Southwark-Bella Vista and Schuykill neighborhoods, bounded on the south and west by Gray's Ferry and bounded by Snyder-Whitman on the east. South Broad-Girard Estates has the second highest median income at $32,885 and the second higher number of residents at 38,215 (16.5 percent).

Two large neighborhoods comprise Southwest Philadelphia, Eastwick-Elmwood and Paschall-Kingsessing. These neighborhoods contain all the land area of Philadelphia between the Schuykill River on the east and Cobb's Creek which forms the western boundary of Philadelphia, separating Philadelphia from Delaware County, Pennsylvania. Paschall-Kingsessing is bounded on the north by Baltimore Avenue which separates southwest Philadelphia from west Philadelphia. Paschall-Kingsessing has the largest neighborhood population with 47,258 residents (20.4 percent) and a median income of $24,842. Paschall-Kingsessing is a pre-dominantly African-American neighborhood (85 percent).

Figure 4.3 Study area and neighborhoods



Eastwick-Elmwood has 28,461 residents and a median income of $29,163. Eastwick-Elmwood is separated from Paschall-Kingsessing on its west by a regional rail line which forms a physical barrier between the neighborhoods. Eastwick-Elmwood is large in land area (2.39 square miles), but the southern segment of the neighborhood falls within the John Heinz National Wildlife Refuge at Tinicum which forms a marshy land preserve and a natural boundary to the residential community.

B. Philadelphia Health Management Corporation

The data used to study obesity has been collected by the Philadelphia Health Management Corporation (PHMC) and compiled in the Community Health Database 2006. PHMC conducts a community survey of five counties in Southeastern Pennsylvania biannually including 13000 respondents with approximately 5000 respondents from Philadelphia including both children and adults.

Surveys were conducted using telephone random digit dialing to identify households and random last birthday for individuals within households. The survey had a 24 percent non-response rate with household data aggregated to census tract. The survey includes over six hundred variables and includes height/weight, BMI, servings of fruits and vegetables, neighborhood grocery choices and demographic information.

In Table 4.2, data collected by the Philadelphia Health Management Corporation in 2000, is presented indicating obesity levels per neighborhood and the citywide average. The PHMC survey item of most value to this research is the level of healthy food (fruit and vegetable) intake by household and individual within each census tract. This will be correlated with accessibility to healthy food determined by average shelf space of healthy foods.

Table 4.2: Philadelphia neighborhoods and projected obese population 2006

Neighborhood	%Adults Obese (Age 18+)	Females (%)	Males (%)
Eastwick-Elmwood	34.8	29.0	43.8
Paschall Kingsessing	27.6	39.1	5.7
Grays Ferry-Passyunk	24.8	27.9	22.4
Snyder-Whitman	31.2	23.9	36.9
Schuykill-Pt Breeze	25.9	35.2	15.9
South Broad-Girard	28.9	29.3	28.4
Southwark-Bella Vista.	21.5	12.3	28.1
Pennsport-Queen Village	17.0	16.9	17.4
Philadelphia	27.9	30.4	24.8

2006 PHMC Household Health Survey

C. Food Site Data

To study availability of fresh fruits and vegetables in Philadelphia neighborhoods, a database compiled by the Office of Food Protection, Division of Environmental Health Services of the Philadelphia Department of Public Health is geocoded and mapped (2006). This restaurant inspection database was published on-line in June 2006, and includes data from January 1, 2004 through May 30, 2006. All sites in this database were processed and geocoded using an ArcGIS 9.1 address locator. All data within the Office of Food Protection database file for this research were drawn from the retail food category of the restaurant inspection database. The Office of Food Protection retail food sub-categories are listed as restaurant – eat-in, restaurant – private club; prepared food take-out; grocery market; supermarket; caterer; caterer-commissary; community service; general convenience; hotel/motel; general public establishment; curb market; mobile food vendor; and vending machine. From this list only grocery market, supermarket, general convenience, curb market and mobile food vendor were compiled for field research. After beginning field work the category prepared food take-out was also added to the data layer. Although prepared food take-out consists predominantly of fast food, Chinese carryout and pizza shops, it also includes delicatessens. Delicatessens provide a combination of prepared sandwiches and groceries, many stocking small fresh vegetable displays and similar in characteristics to small grocers. In order to completely identify fresh fruit and vegetable options, the prepared food take-out category was included. The descriptions of the Office of Food Protection, Retail Food sub-categories used in this study are described in Table 4.3.

Table 4.3: Philadelphia Department of Public Health Office of Food Protection retail food subcategories and descriptions

Retail Food Subcategory	Count Surveyed	Description	Examples
Supermarket	20	Establishment, >5000 square feet, that principally offers for sale food products to individuals for direct consumption or preparation.	SuperFresh, Acme
Grocery Market	362	Establishment, < than 5000 square feet, that principally offer for sale food products to individuals for direct consumption or preparation.	Multi-service facilities such as WAWA, 7-eleven, grocery, deli, variety, or other types of stores markets.
General Convenience (may be < or > 5000 square feet)	226	Establishments that are not specifically oriented to foods sales that offer a variety of food products, prepared or prepackaged, along with other merchandise items.	K-mart, Wal-Mart, Pharmacy outlets, gasoline sales kiosks, gift shops, video stores, dollar stores
Mobile Food Vendor	59	Establishment, that is non-permanent, that handles food. Delivery vehicles, operated by wholesalers or processors for delivery of ordered products, are exempt.	Establishment, that is non-permanent, that handles food. Delivery vehicles, operated by wholesalers or processors for delivery of ordered products, are exempt.
Curb Market	23	Streetside market tables	Mainly found in the Italian Market
Prepared Food Take-Out	94	Establishment that principally offers for sale prepared foods for consumption off premise.	Fast food, without seating for eat-in service, malls stores, steak, hoagie, and pizza shops, Chinese food take-outs.

D. Field Data Collection

Using the sites geocoded from the Office of Food Protection as base data, a research team of Cheyney University students and this researcher visited all grocery sites in the neighborhood study area. The survey had two objectives. The first objective was to collect data on square footage of stores providing groceries to the community and to estimate the square footage of shelf space designated to fresh fruits and vegetables. The second objective was to document items identified in the market basket. Market baskets can be useful to assess population economically vulnerable to food insecurity (Williams, James and Kwan 2004, Nutrition Dietetics 61:4 208-214, The Illawarra Healthy Food Price Index, pricing index trends 2002-2003).

In this study I utilize a similar tool with a select list of healthy and typical food choices. The suggested market basket items include a list of regularly purchased shopping items which are readily available in many small grocers as well as larger supermarkets. The items represent a typical item with a healthy option of the same type to check availability. The items are selected based on the likelihood of being found and not impacted by expiration dates or short shelf life. Two exceptions are bread and milk where expiration date may impact cost. The items adhere to the Dietary Guidelines for Americans 2005 as recommended by the U.S. Department of Agriculture and the NIH Dietary Approaches to Stop Hypertension (DASH) eating plan. The food groups encouraged for a healthy diet include fiber-rich fruits and vegetables, whole-grain products, fat-free or low-fat milk products and low sodium foods. Healthy or recommended fats include fish, nuts and vegetable oils. The market basket of items below represents a food item typically purchased by American consumers for food preparation and a healthier choice based on the DASH recommendations. The

Pennsylvania Women Infant and Children Food and Nutrition Program (WIC) lists high fiber items as desirable, including dried beans, tuna and whole grain products.

Table 4.4: Market basket

Typical Grocery Choice	**Healthy Choice**
white/enriched rice	whole-grain/brown rice
½ gallon whole milk	½ gallon low fat milk
Canned tuna in oil	Canned tuna in water
Butter/Margarine	Low fat spread
Beans-canned	Beans-dried
Salt, iodized	Salt substitute
Mayonnaise	Low fat mayonnaise
Sugar	Low fat sugar substitute

The purpose in collecting data on a select group of market items is to document the typical products available in supermarkets and corner stores and the availability of healthy food options for residents of various neighborhoods. Corner stores typically designate minimal floor space to refrigerated items and thus most items are packaged and have longer shelf lives. The items above represent market items with a high likelihood of being available in many corner stores across neighborhoods. In addition to these market items, the field surveys identified if the following products are available in the grocery store: fresh fruits, fresh vegetables, prepared and unprepared meats and juice. The market basket items are utilized minimally in this study but will provide a base for future healthy choice studies.

In this study healthy food shelf space is compared across neighborhoods as an indicator of healthy food availability. In an earlier pilot study using GPS for data collection, and GIS technology for analysis on grocery food sites within a low income and largely African-American neighborhood in Philadelphia, the average shelf space for healthy foods, including produce, milk and juice, is approximately 2.2 percent of total grocery floor space. The Progressive Grocer reported that the average percentage space in supermarkets designated to fresh produce increased to 12.6 percent in 2006, up from 11.9 percent in 2005 (Chanil and Major 2006).

The total enumeration of the study area food enabled a detailed characterization of healthy food stores. Field data collection of healthy food stores in the Philadelphia neighborhoods consisted of a walking and driving survey checking each point geocoded from the Office of Food Protection database listed as a grocery market, general convenience store, supermarket, mobile food vendor, curb market and restaurant primarily as prepared food and takeout. This totals 837 sites within the study area. Of the 837 sites, 784 were visited and surveyed. Fifty three sites were eliminated prior to the field survey based on the name of the establishment which indicated that the store was not a site which typically provides groceries, but were either specialty shops or another type of business. The survey took place between November 2006 and March 2007. The geocoded point data was uploaded to a Trimble Geoexplorer XH GPS unit. A data dictionary was developed for the survey using Office Pathfinder which was uploaded to the Geoexplorer XH GPS. As each site was approached in the field a data screen was raised on the GPS unit and the GPS was used to identify the correct location. Surveyors verified the name and address of the establishment directly into the unit and entered the establishment to estimate total floor size, fresh fruit and vegetable shelf space and the presence of items on the market basket. Surveyors also made note of parking facilities and whether public assistance program flyers were posted on the facility. The surveyors carried flyers identifying themselves as Cheyney University students collecting data for a research study on healthy food choices in neighborhood stores. The measurement for floor space was determined by standing in a corner of the store and using a handheld laser to approximate store dimensions. A similar technique is used to measure total fresh fruit and vegetable space. In large supermarkets this figure is determined as an estimate of the floor space of produce sections. In small grocers the fresh fruit and vegetable shelf space is designated by eye, approximating 2 square feet for each crate of fruit or vegetables displayed across the floor.

Several difficulties encountered during the survey included erroneous positional and attribute data. Some stores had gone out of business, changed names or moved or were closed when the surveyors visited. Additionally in some stores the management was not willing to have students record information in the store until an owner or manager was present. This required making a second visit to the store when a manager was present. Often if a manager was not present the employee would telephone the manager directly and after informing the manager of the research objectives, we would record information. Many of the store clerks in the city were Hispanic with English as a second language. If language was a difficulty often the employee would telephone the manager to have us speak directly to the owner or manager. In large stores we would go to the customer service desk and inform the associates we were conducting a survey in the store. The students carried a flyer in English and Spanish which explained the research objective and provided contact information for myself.

Of the 784 surveyed, 512 sites did not stock fresh fruits or vegetables and the remaining 272 did stock some fresh fruits or vegetables. In addition to fresh produce, 96 stores also stocked canned, dried or frozen fruits and vegetables.

E. Healthy Food Store Categories

The following categories were established to discuss the types of food establishments within the study area. The “Healthy Food Store” (C4) category includes large supermarkets with produce sections offering a range of food choices and fresh fruit and vegetable options. C4 stores have a total floor space greater than 5000 square feet. The range is from 5000-35,000 square feet and includes 10 large chain supermarkets including Pathmark (2), Acme(1), Whole Foods(1), Shop Rite (3) and Superfresh (2), and BJ’s Wholesale Club(1). The percent shelf space for produce ranges from 10-30 percent. This category is the large supermarkets. The survey determined that 19 supermarkets are located throughout the study area which are designated in the table above as (C4) or healthy food stores. Of the 19 supermarkets within the study area, three sites actually fall outside the residential areas into adjacent unpopulated census tracts. In addition to the large supermarkets in the study area, one supermarket located within the ¼ mile buffer of the study area in central Philadelphia was included to control for possible edge effects. Edge effects refer to the possibility that residents within the study area, but living near an edge of the study area are likely to shop at grocers outside the study area. Some population within the study area is likely to be drawn to grocers outside the study area. To account for this population I created and ¼ mile buffer along the northern boundary of the study area which is adjacent to central Philadelphia and west Philadelphia. Any supermarkets or small grocers selling fresh fruits and vegetables within this buffer zone were included in the study as elements of the local food environment. Residents of Pennsport-Queen Village may also be drawn to the supermarket in central Philadelphia as a grocery resource. Within the buffer area no small grocers were added to the study.

The group designated as “limited healthy food choices (C3) includes 161 small grocers of less than 5000 square feet but which stock all basic groceries and some healthy food choice item and more space designated to fresh fruits and vegetables. This category also includes seven markets with total floor size greater than 1000 square feet but small percentages of floor space designated to fresh produce. Basic grocers (C2) included 93 small grocers with total floor space typically less than 1000 square feet which include, many items on the market basket list with minimal fresh fruits or vegetables (examples: potatoes and onions, bananas on the counter, four square feet or less). In this category were largely independent grocers and some local chains including Peralta, Cruz, Torres, some variety stores, but also included four Seven-Elevens and a Sunoco Mini-Mart. In addition to fresh produce most of these stores carried milk products, unprepared meat products, dried or canned beans, sugar, salt.

Limited groceries (C1) is a category that includes stores falling in the general convenience category which sell some canned and long life grocery products, but is primarily other household items, examples include Dollar Magic, Rite Aid, CVS (96). The C1 category includes a large number of non-chain businesses which stock snacks, beverages, cigarettes and products with high turnover. This category is referred to as the “fringe” stores by Mari Gallagher during a study in Detroit neighborhoods.

The final category is local stores which may offer vending machines and snacks as a secondary product but are without staple grocery products. “No groceries” designated (C0) are categorized as general convenience in the Office of Food Protection Database, but this category included laundry mats with vending machines or establishments which sell candy such Mark's Auto Tags, beer distributors (416). These stores are general convenience stores but of non-food items. This category also includes the fast food, Chinese takeout and pizza shops designated as 'Prepared food -Takeout'.

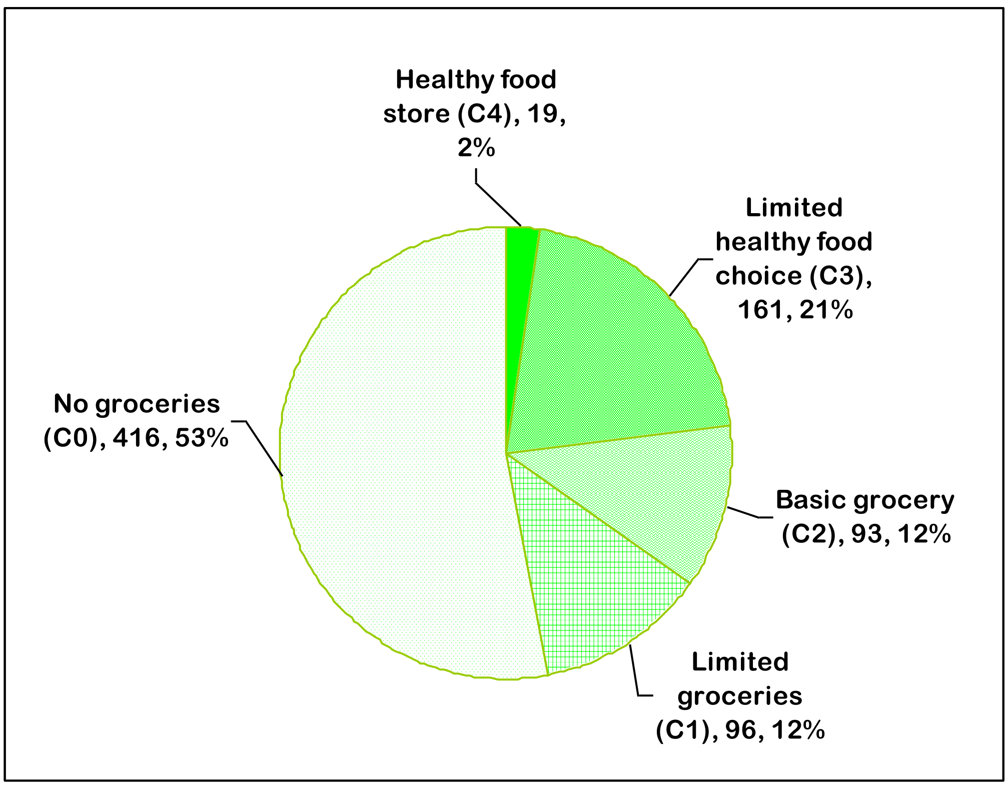
F. Strategy to Address Hypothesis 1: Supermarket Service Areas

After food sites had been enumerated and categorized the first hypothesis as stated: In south and southwest Philadelphia some residential areas fall outside functional regions of large supermarkets; focuses on determining the functional region of the large supermarkets in the study area. Regions, as discussed in chapter 3 have subjective or fuzzy boundaries. To demonstrate this concept I create regional or service area boundaries for supermarkets based on the highest probability of local grocery shoppers selecting a particular shopping destination. In this study census block groups are used as the spatial building block for each region. After creating high probability shopping destinations for residents of each census block group, I implement a ten minute service buffer around each large supermarket. By overlaying the service buffer with the probability regions, census block groups which fall outside the service region are illustrated.

Table 4.5: Food site categories

Category	Food Options	Number of Stores within study area
Healthy food store (C4)	Fresh produce, with floor size at least 5000 square feet	19
Limited healthy food choice (C3)	Fresh produce available but floor size ranges from 1000 to 5000 square feet	161
Basic grocery (C2)	Fresh produce available but total floor size is less than 1000 square feet	93
Limited groceries (C1)	Some groceries available including canned, dried or frozen fruits and vegetables	96
No groceries (C0)	General convenience stores for non-food household items	416

Figure 4.4: Food site categories and counts



The likelihood of neighborhood patronage of a supermarket is determined using the Huff model, a gravity model which takes into consideration the attractiveness of each store. I employed the Huff Model to determine which of the 19 supermarkets have the highest probability as a shopping destination for each of 285 census block groups. The initial step is to create an origin-destination matrix using a network analysis. One supermarket falling within a ¼ mile buffer of the northern edge of the study area is also included to minimize edge effects. Due to its proximity to the study area and its location in central Philadelphia, this supermarket most likely draws shoppers from within the study area so it is included. The origin-destination (OD) matrix is between these 20 supermarkets and the 285 census block group centroids which represent neighborhoods. This creates 5700 routes between all origins and destinations. Distance of each neighborhood from each supermarket and an attractiveness variable for each supermarket produce a probability for residents from each neighborhood shopping at each supermarket. Below is the Huff Model which allows the probability of a shopper selecting a particular store to be determined among multiple options. In this case (U) represents the utility or gravity potential of a single supermarket as a proportion of all possible selections. In this case there are 20 possible shopping destinations for the residents of the study area. (P) represents the probability of a shopper, residents of a neighborhood represented by a census block group centroid, shopping at each particular store.

$$P_{ij} = \frac{U_{ij}}{\sum_{k=1}^{n} U_k}$$

P_{ij} is the probability of an individual from a neighborhood or census tract selecting a particular supermarket and U_{ij} U_k is the utility of a store j and k or the gravity kernel (Wang 2006).

After creating the OD matrix, the distance of the route from origin to neighborhood is attached to the origin as an attribute. The inverse of the distance is used in the Huff Model to create a probability value for a resident of any neighborhood to shop at each of the supermarkets in the study area. Figure 4.5 presents the extensiveness of the Southeast Pennsylvania Transit Authority (SEPTA) public transit system throughout the study area. Figure 4.6 demonstrates the shortest track distance from each census block centroid to a supermarket in the study area. The OD matrix actually calculates distances between all origins and all destinations within the study area. In the appendix, Tables A1, A2, A3 are complete copies of probabilities for shoppers from each census block group to shop at each supermarket.

A variation of the Huff Model presented below incorporates an attractiveness value (S) for each supermarket within the study area in addition to distance. I use three measures of attractiveness and produce three maps of high probability that residents of each census block will shop at a particular store. Initially probability is calculated using simple proximity of a neighborhood to a store based on network distance. Secondly, probability is determined with an attractiveness variable (S).

Figure 4.5 Public transit network in south and southwest Philadelphia

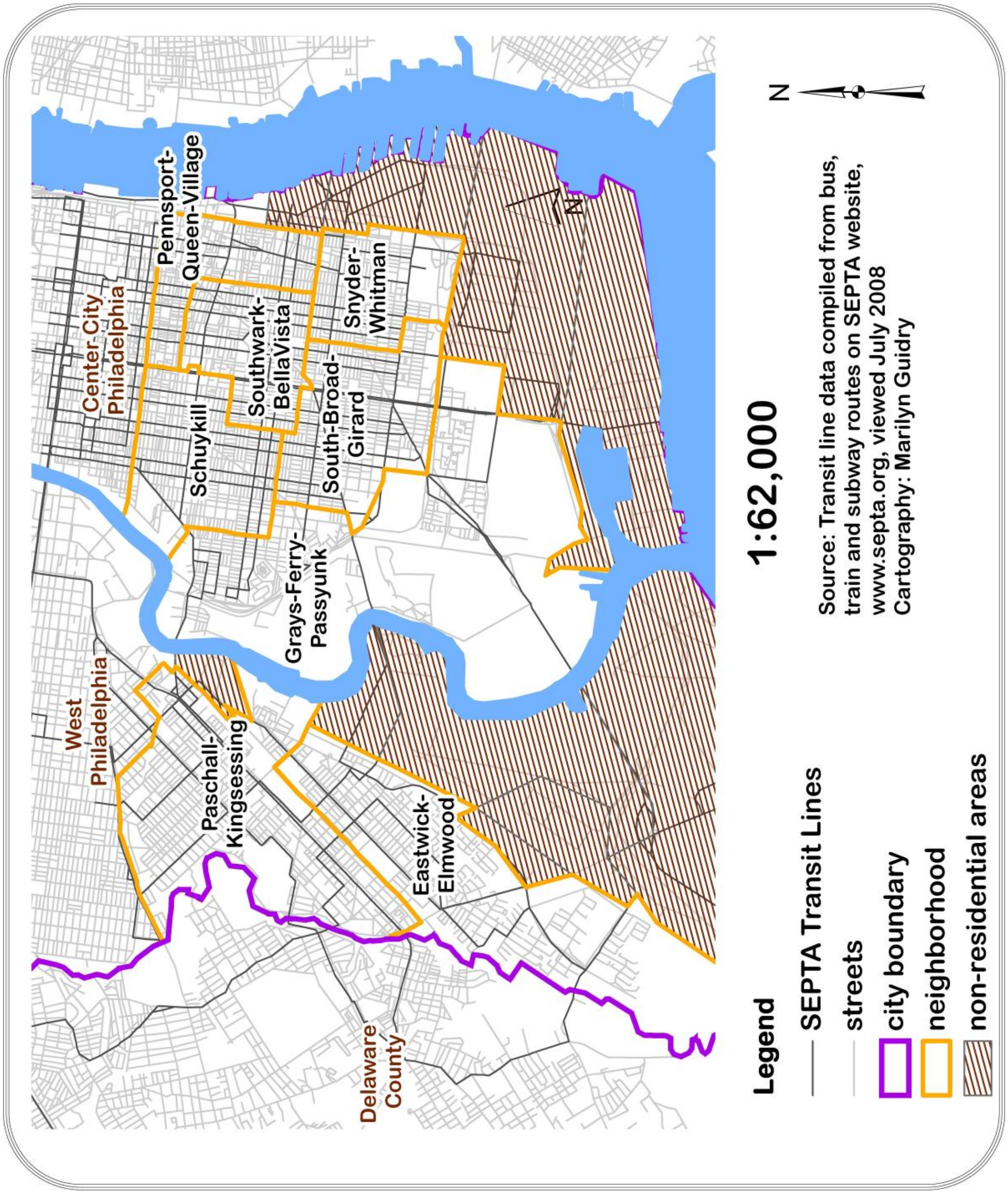
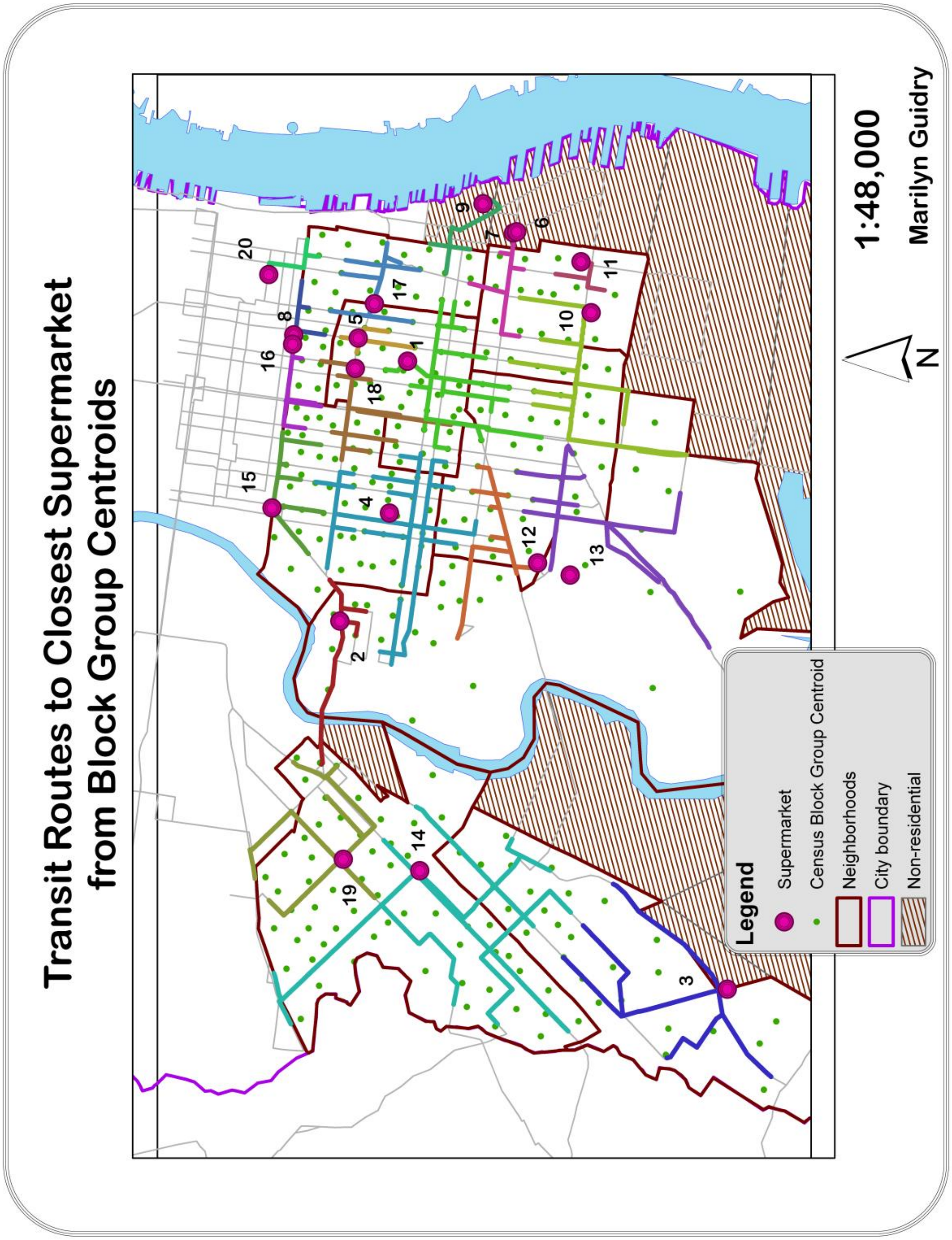


Figure 4.6 Shortest transit route from census block group centroids to supermarkets



Attractiveness in this study is calculated using total floor size for each of the large supermarkets and in a second calculation the percent of floor space designated to fresh fruits and vegetables. (D) represents the distance each store is from each neighborhood within the study area. The product of attractiveness and the inverse of the distance is called the gravity potential. The gravity potential when placed over the sum of all choices produces the probability of a shopper from a particular neighborhood selecting a particular store based on both distance and attractiveness. (β) is the distance friction coefficient which is this case is assumed to be 2, the square of distance from neighborhood to store. The formula is as follows:

$$\mathrm{P}_{\mathrm{ij}} = S_j\, d_{ij}^{-\beta} / \sum_{k=1}^{n} (S_k d_{ik}^{-\beta})$$

Where S is attractiveness, D is distance ; β is the distance friction coefficient, and $S_j d_{ij}^{-\beta}$ is the gravity potential measuring the impact of a store j on a demand at location I (Wang 2006).

Three factors used to determine attractiveness for each store, proximity to a census block (PB1), total floor space of the supermarket (PB2) and the percent of shelf space designated to fresh fruits and vegetables (PB3). Each attractiveness factor creates a slightly different customer region for each large supermarket. From each of these calculations I attribute the supermarket with the highest probability as a shopping destination for each neighborhood to create the probability region for each attractiveness factor. I use three probability regions to determine if distance, store size and distance, or fruit and vegetable shelf space and distance create changes in regional structure. I gauge the spatial change of each region and the change in population served as the spatial structure changes. Census block groups provide spatial dimensions and population counts for probability regions.

The second stage to address shopping regions are to calculate travel times from each neighborhood to the most probable shopping destination using three modes of transportation, walking, driving and mass transit. The design for this step is a two step floating catchment (2SFC), which creates a buffer around supply locations (supermarkets) and then creates buffers around demand locations (census block groups). Using a second function of network analysis to create a facility service area, creates a 10 minute travel buffer for each of these transportation modes. In this stage I use census block group polygons to buffer in order make a better representation of neighborhood area. In these cases I used a ten minute travel distance around each supermarket and a ¼ mile buffer around each neighborhood. The calculation of transit time employs a multi-modal network analysis incorporating components of the SEPTA trolley lines, SEPTA subway and SEPTA bus lines which service the study area. SEPTA operates more than 20 bus routes, four electric trolley routes and one subway route which transect the study area. The transit routes provide service to several large shopping centers with supermarkets from the neighborhoods within the study area. The functional region of the transit system is 10 minutes of travel time. The functional region for drivers is a 10 minute drive time to reach the supermarket.

The expected service area of each supermarket is determined using a ¼ mile buffer around each supermarket based on the trade area analyses utilized in the

Progressive Grocer. The Progressive Grocer identifies trade service areas for high density urban areas such as New York City as 0.2 miles distance, 0.5 miles distance and one mile distance (McTaggert 2005). Trade service areas for other urban areas such as Nashville, Tennessee are one mile, three mile and five mile distances (Major 2008). The third step assesses the distance each census block group is from the supermarket service area to determine if each census block group has access to the local supermarket or if particular census block groups fall outside the acceptable range for a supermarket service area.

G. Strategy to Address Hypothesis 2: Supermarket Gap Areas

By calculating the supermarket service areas in Hypothesis 1, the areas which fall outside the supermarket service areas are also defined. Hypothesis 2 states that, in south and southwest Philadelphia, residential areas or gaps, which fall outside functional regions of supermarkets, are dependent on small grocers. To ascertain which areas are gaps between supermarket service areas I use census block polygons to represent local neighborhoods within the study area. For each of the 285 census block groups, I create a ¼ mile walking buffer. This creates 285 individual buffer polygons. The 285 census block groups and their buffers are divided into three categories. If a census block group falls completely within the supermarket service area, the census block is well served. If a census block and its buffer fall outside the supermarket service area, then that census block group is considered a gap area. If a census block group or its buffer fall partially within the supermarket service area, the census block group is classified as transitional, indicating that some portion of the census block group is within an acceptable walking distance to the supermarket. Using the census block groups as population units, I determine the total population with access to large supermarkets, those populations with poor access and the number of persons falling into a transitional zone which has uncertain access to large supermarkets. Supermarket service areas and gaps are determined for users of three modes of transportation, pedestrians, public transit riders and drivers of private vehicles.

To examine the relationship between the role of grocers and the local areas which they serve, a correlation coefficient is calculated for demographic characteristics of each type of service or gap area and the density of grocers. Store density is influenced by factors such as population density. Several variables are considered as inputs. Prior to statistical analysis in a study examining geographically selected data, the level of spatial autocorrelation is measured. The general model to explain the distribution of small grocers in gap areas treats grocer density (grocdens) as the dependent variable with several independent covariates including population density, population in poverty, households with no vehicles, proportion of population using public transportation to travel to work and proportion African American. The covariates listed in Table 4.6: Census Variables and Table 4.7: Calculated Variables are derived from a collection of research studies examining urban conditions and access to services. Glanz et al. (2005) refer to environmental variables which contribute to community nutrition environments including food types, access, organizational components and the consumer nutrition environment.

Race and income are two covariates commonly employed for neighborhood food analysis (Befort et al. 2006; Alwitt and Donley 1997). Other factors include gender (Ayala et al. 2005), immigrant status and public assistance, including food stamps (Public Health Nutrition 2008; Dinour, Bergen and Yeh 2007). Bhargava, Jolliffe and

Howard (2008) examine household food insecurity status. Access and mobility are important factors. Researchers include analyses of the uses of public transit and private vehicles for food access (Blumenberg and Manville 2004; Burns and Inglis 2007). Clifton (2004) and Dixon et al. (2007) analyze personal mobility strategies for individuals which contribute to patterns of food consumption. Population density is one neighborhood characteristic not identified in earlier studies but which has a function in provision of services to communities. Population density impacts trip generation and is a characteristic of urban form (Lin and Yang 2009).

Spatial autocorrelation is a characteristic of data selected by geographical characteristics rather than randomly. Geographically based data violate the rule of random data in statistical theory. A measure of spatial autocorrelation indicates the strength of the relationship between spatial location and the attributes of the data. In this case all data is selected from an area of 15 square miles within the city of Philadelphia. Positive spatial autocorrelation occurs when a direct relationship between locations and values are demonstrated. Spatial autocorrelation can also be negative or zero. Negative autocorrelation occurs when an inverse relationship exists between locations and attributes. Zero spatial autocorrelation represents a random data distribution. A test of spatial autocorrelation is Moran's I, which is calculated in ArcGIS Spatial Statistics and in GeoDa, a second spatial statistical software package. Positive or negative autocorrelation indicates that the relationship between grocer density and demographic covariates may be more accurately represented through a spatial regression model rather than ordinary least squares regression.

Table 4.6 Census variables

Census Code	Description
p001001	Total population
p006003	Total population: Black or African American alone
p053001	Median household income in 1999 Households
p030005	Total population using public transportation for work
p064002	Total population receiving public assistance income
p0087001	Total population for whom poverty status is determined
p0087002	Total population for whom poverty status is determined in 1999 below poverty level
h001001	Total housing units
h044003	Total housing units: Owner occupied: No vehicle available
h044010	Total housing units: Renter occupied: No vehicle available

Table 4.7 Calculated variables

careasqmile	Area in square miles	Shape_Area/27878400 sq ft per mile
cpopdens	Population per square mile	P001001/cAreaSqmile
cafam	Proportion African American	P006003/P001001
cpubass	Proportion receiving public assistance income	P064004/P001001
cpubtrans	Proportion using public transportation	P030005/P001001
cpopbepv	Proportion of population living below poverty level	P0087002/P0087001
chousnvh	Proportion of households with no vehicle	(H044003 + H044010)/H001001
totfloor	Total grocery floor space	primary survey data
fruitss	Fresh fruit and vegetable floor space	primary survey data
grocdens	mean density of small grocers stocking fresh fruits and vegetables per square mile	
prodacc	produce accessibility rate	the sum of FruitSS divided by total population per 1000 population

Following the measure of spatial autocorrelation, bivariate correlations are calculated between demographic and geographic characteristics of gaps and service areas. In order to examine the demographic characteristics of supermarket service areas and gap areas several census variables are compiled at the census block group level. In addition to the census variables several additional variables calculated from the census counts are also included. Census variables are listed in Table 4.6 and calculated variables are listed in Table 4.7.

The calculated variable careassqmile is created by converting the total area for shapes from square feet to square miles. The base data are projected in NAD State Plane Pennsylvania South (feet) and for each new shape created areas is calculated in square miles. Grocer density is calculated as the the simple density of grocers stocking fresh fruits and vegetables per square mile per census block group. An ordinary least square (OLS) regression is calculated with grocer density as the dependent variable. Several potential covariates include population density per square mile (cpopdens), proportion of residents who are black (cafam), proportion of residents receiving public assistance (cpubass), proportion of residents using public transportation to travel to work (cpubtrans), proportion of residents living below the poverty level (cpopbepv) and proportion of households with no vehicle (chousnvh).

In the supposed absence of spatial autocorrelation, multivariate OLS regression is employed to model the relationship between the density of small grocers in gap areas and covariates. With a measure of either positive or negative spatial autocorrelation, spatial regression models are explored. In these analyses since all data are from a specific region of Philadelphia, I anticipate positive autocorrelation for demographic variables. Also since supermarkets are a service industry and vary in density along with population, I expect positive spatial autocorrelation for food sites as well. In the event of positive spatial autocorrelation a spatial regression model is also calculated to measure the strength of the relationship between grocer density across the study area, the above covariates and spatial error or effect on the relationship. Two spatial regression models are commonly used to measure the strength of the spatial effect on the dependent variable, the spatial lag model and the spatial error model. Diagnostic statistics are used to determine which model better represents the spatial effect of the relationship.

H. Strategy to Address Hypothesis 3: Produce Accessibility

The strategy to address hypothesis 3 is derived from the land area that is classified as supermarket service area and gap areas and the populations residing in each of these areas. Hypothesis 3 states that, in south and southwest Philadelphia, the rate of produce accessibility for gap areas is lower than corresponding functional areas of supermarkets.

Once the stores servicing the gap areas and populations residing within supermarket gap areas are identified, total square footage of fresh fruit and vegetable shelf space is used to create the rate of produce accessibility per 1000 population. Produce accessibility is the proportion of fresh fruit and vegetable shelf space per grocer floor space calculated as a rate per 1000 population. This step is repeated for pedestrian and public transit service areas and gaps. Produce accessibility is assessed for all gap and service areas designated in the previous section describing the strategy for hypothesis 2. Analysis for hypothesis 3 is similar to procedures for hypothesis 2. Whereas hypothesis 2 suggests that the density of grocers is dependent on local demographic characteristics, hypothesis 3 similarly suggests that the spatial distribution of the produce accessibility rate is also dependent on local demographics. Analysis for hypothesis 3 is similar to the previous section examining spatial autocorrelation, bivariate analysis and data regression. The general model to explain the rate of produce accessibility (prodac1) in gap areas includes possible covariates, population density, proportion of population in poverty, households with no vehicles, proportion of population using public transportation to travel to work and proportion African American.

The outcome of the measure of spatial autocorrelation will determine if OLS regression or spatial regression provides a more accurate model of the relationship produce accessibility rates across the area. Similarly to hypothesis 2, I anticipate a positive measure of spatial autocorrelation and the use of spatial regression model to explain the relationship between produce accessibility and demographic characteristics.

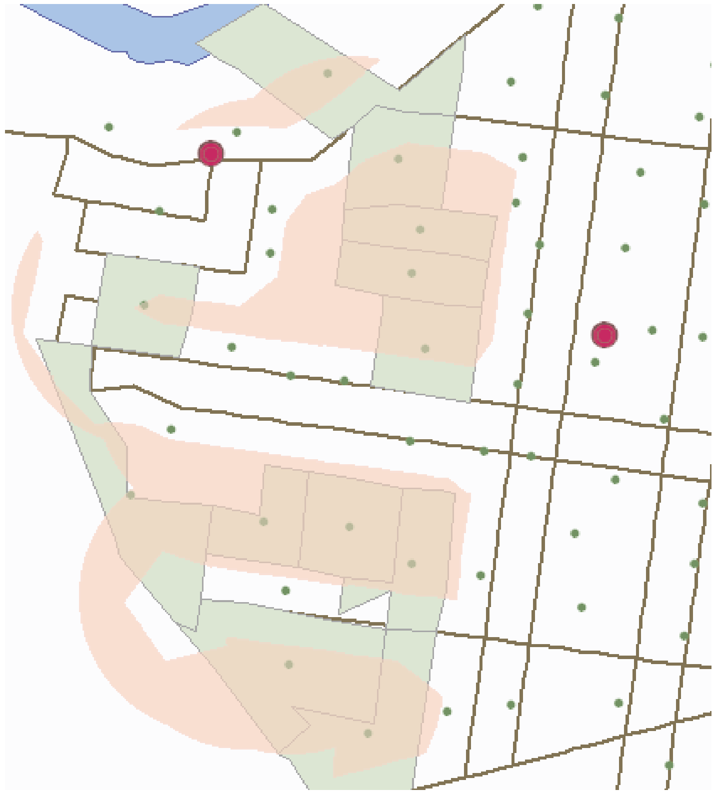
I. Strategy to Address Hypothesis 4: Fruit and Vegetable Intake

Hypothesis 4 states that, within our sample of neighborhoods in south and southwest Philadelphia, accessibility to large supermarkets is positively correlated with neighborhood's aggregate intake of fruits and vegetables. To determine the correlation between availability of fresh fruits and vegetables and intake of fruits and vegetables, I use data provided by the Philadelphia Health Management Corporation, Community Health Database from 2006. One variable collected during the survey is average fruit and vegetable intake for each census tract in the study area. In the first step of this analysis a network analysis is conducted to create a probability of each block group utilizing a particular supermarket based on distance. An outcome of this network analysis is an origin-destination (OD) matrix for census block groups and supermarkets. In this stage of analysis, accessibility for each census tract is calculated as the median of shortest distances to supermarkets for each census block group in the census tract produced in the original OD matrix. A correlation coefficient is calculated to measure the association between variability of fruit intake per census tract and access to groceries including fresh fruits and vegetables, based on the mean shortest distance. At the neighborhood geography, the median shortest distance of census tracts to supermarkets represents the accessibility value. A correlation coefficient is created to associate accessibility and aggregate intake of fruits and vegetables for each neighborhood.

J. Research Limitations

The techniques utilized in this study incorporate use of isolines, polygons and polygon centroids in turn to represent the spatial limits of portions of the study area. The network analysis utilizes point coverages as the location of neighborhoods and shopping destinations. Whereas a point is the single form of representation for a supermarket, neighborhoods are more accurately depicted as areas or census block group polygons rather than as centroids. Figure 4.7 demonstrates a situation where gap areas identified through geoprocessing overlay with census block groups. The large circles indicate supermarkets, and the lines are public transit routes. The square and rectangular features represent census block groups. The small points are census block group centroids. The irregular polygons represent the gap areas identified through network and buffer analysis. The census block groups with a centroid which fall within the irregular gap polygons are used to constitute the population within the gaps. In Figure 4.7 eleven census block group centroids fall within the gap area, so the populations of these eleven census block groups contribute to the gap population for this step in the analysis. This example attempts to present some difficulties in approximating gap areas and populations using small enumeration units such as census block groups.

Figure 4.7 Example gap area boundaries overlaying census block groups



Administrative units such as census block groups provide a convenient spatial building block but more flexibility in neighborhood boundary definition may provide more precise results.

The probability areas make the simplification that residents and consumers will utilize the closest supermarket which underestimates average distance traveled such as in Shortt et al. (2005).

Chapter 5: Results

A. Probable Supermarket Service Regions

Hypothesis 1 states that in south and southwest Philadelphia some residential areas fall outside functional regions of large supermarkets. Three different probability maps were created for each supermarket destination. Census block centroids were used as the point of origin of potential shoppers, and a street network provided in ArcGIS 9.2 to calculate distances. The first region presented in Figure 5.1 is based on simple proximity of each census block centroid to each supermarket. Figure 5.1 is the depiction of supermarket service regions based on the Huff model. Figure 5.2 and Figure 5.3 are two probability distributions derived by the inclusion of attractiveness variables and distance. Figure 5.2 illustrates regions created with an attractiveness value determined by total floor space. Figure 5.3 presents the probability regions determined using an attractiveness value based on proportion of fresh fruit and vegetable shelf space. Table 5.1 shows the proportion of population served by each supermarket in the three probability maps, considering different attractiveness values. The probability maps are created using a transit network rather than Euclidean distance. The use of a street network results in irregular polygons and the placement of some supermarkets at the edges of service areas rather than in the center. Whereas most neighborhoods of south Philadelphia have dense gridded street networks, other neighborhoods, notably Greys Ferry and Eastwick-Elmwood have low density street networks, interrupted with industrial or vacant tracts. This accounts for skewed shape of some service areas around supermarkets. An example includes the census block groups east of the Schuylkill River on Figure 5.1 attributed as a probability area for Shop Rite (Supermarket 12) rather than for BJ’s (Supermarket 13). In the appendix, Tables A1, A2, and A3 present the demographic characteristics of the populations within the probability region for each supermarket. Table A1 presents demographics for the probability region determined through simple distance or proximity of census block groups to a supermarket. Table A2 presents data applying total floor size as an attractiveness factor. Table A3 presents demographic data when fruit and vegetable shelf space is applied as an attractiveness factor.

Five of the 20 supermarkets have service regions ranging in size from 1.52 to 2.53 square miles. The largest two service areas are in Southwest Philadelphia. The other three large supermarket regions provide for the large sparsely populated areas of the Gray’s Ferry neighborhood. Nine supermarkets demonstrate moderately-sized service areas ranging in size from 0.23 - 0.93 square miles and five supermarkets have small service regions from 0.05 – 0.15 square miles. One supermarket, Save a Lot #252, located in an unpopulated census tract, does not demonstrate a gravity potential within this analysis, as it is overshadowed by supermarkets within the same local area.

Shop Rite in Eastwick-Elmwood (Supermarket 3, Fig 5.1-Fig 5.3) has the largest gravity potential, drawing residents from 2.53 square miles. Although the area is large it is less dense than other sections of the study area. The total local population estimated to shop at Shop Rite is 19,340 persons. Shop Rite is the only supermarket in Eastwick-Elmwood, the second largest neighborhood following Gray’s Ferry. Adding total floor space as an attractiveness factor does not change its gravity potential, but the attractiveness of fresh fruits and vegetables increases the gravity potential to 24,907 persons and increase the service region to 2.79 square miles, extending into Paschall-Kingsessing.

Table 5.1: Populations served by supermarkets in three probability regions

	Name	Attractiveness Shortest Distance (Mean in Feet ± S.D.)	Population Served	Area (Sq Miles)	Attractiveness Total Floor Size	Population Served	Area (Sq Miles)	Attractiveness Fruit & Vegetable Shelf Space	Population Served	Area (Sq Miles)
		PB1			PB2			PB3		
1	Acme Market	11163.41 ± 8370	30514 (13.20)	0.83	18000	33293 (14.4)	0.90	2290	35686 (15.43)	0.97
2	Pathmark	10802.15 ± 4903	10791 (5.38)	1.52	20000	15835 (6.85)	1.17	1490	13169 (5.69)	1.01
3	Shop Rite	21569.44 ± 7434	19340 (10.18)	2.53	9291	19340 (8.36)	2.53	2627	24907 (10.77)	2.79
4	Young's Harvest	10094.13 ± 6492	28246 (12.21)	0.88	5500	11309 (4.89)	0.36	214	14181 (6.13)	0.44
5	P and F Giordano	12046.27 ± 8553	4341 (3.05)	0.15	6273	1198 (0.52)	0.05	500	1721 (0.74)	0.08
6	Shop Rite #530	15793.85 ± 9055	8559 (6.20)	0.23	20570	4980 (2.15)	0.14	3148	8559 (3.70)	0.23
7	Save A Lot #252	15845.82 ± 9055	0	0.00	8406	0	0.00	194	0.00	0.00
8	Whole Foods Mkt	13419.64 ± 8433	1289 (1.0)	0.05	10000	1802 (0.78)	0.06	1687	529 (0.23)	0.02
9	Super Fresh	16806.04 ± 9164	0	0.00	35264	1063 (0.46)	0.05	4362	0.00	0.00
10	Pathmark #552	15080.75 ± 8348	19199 (14.98)	0.71	29760	30849(13.34)	1.25	3880	23396 (10.12)	1.07
11	Aldi/Goodwill	16422.41 ± 8735	3058 (1.32)	0.33	6155	1464 (0.63)	0.05	350	1464 (0.63)	0.05
12	Shop Rite	10986.64 ± 4953	16545 (7.15)	1.89	21958	24439 (10.57)	0.91	2083	17203 (7.44)	0.67
13	BJ's Wholesale Club	12002.03 ± 4693	4399 (1.90)	1.80	27178	5064 (2.19)	3.73	3513	5630 (2.43)	3.79
14	Save A Lot	14623.67 ± 6940	32416 (14.02)	1.96	10313	32416 (14.02)	1.96	1202	29200 (12.63)	1.75
15	Thriftway South	11882.57 ± 6285	8444 (3.65)	0.38	6992	6169 (2.67)	0.19	337	5835 (2.52)	0.19
16	Super Fresh #747	13259.3 ± 8350	2036 (0.88)	0.09	13935	1750 (0.76)	0.08	4136	9187 (3.97)	0.42
17	1st Oriental	12707.07 ± 8835	11979 (5.18)	0.43	11893	6730 (2.91)	0.26	2790	16780 (7.26)	0.55
18	Hung Vuong	11604.98 ± 8260	4187 (1.81)	0.25	16507	7171 (3.10)	0.35	401	247 (0.11)	0.03
19	54th Street Great	14976.47 ± 6987	23953 (10.36)	0.93	9612	22541 (9.75)	0.83	861	21602 (9.34)	0.88
20	Super Fresh #730	15454.24 ± 8830	1953(0.84)	0.08	24549	3836 (1.66)	0.14	4249	1953 (0.84)	0.08
			231249.00	15.03	312156	231249.00	15.03	40314	231249.00	15.03

Save A Lot of Paschall-Kingsessing (Supermarket 14, Fig 5.1-Fig 5.3) has the second largest gravity potential drawing residents from 1.96 square miles and serving a population of 32,416 from two neighborhoods, Paschall-Kingsessing and Eastwick-Elmwood. Total floor space does not change the gravity potential of Save a Lot, and the inclusion of fresh fruit and vegetable shelf space as an attractiveness factor actually detracts from its service potential diminishing its shopping population to 29,200, a loss of over 3000 persons. This indicates that the proportion of floor space dedicated to fresh fruits and vegetables fails to provide a sufficient level of service to surrounding areas. A store with a large service area but which with a service area which diminishes when fresh food and vegetable shelf space is included as an attractiveness factor may indicate a gap area in service provision. This does occur within this study.

The next largest gravity potential is demonstrated by Shop Rite of Oregon Avenue (Supermarket 12, Fig 5.1-Fig 5.3) located in the neighborhood South Broad – Girard Estates. This supermarket and the BJ’s Wholesale Club located in Gray’s Ferry (Supermarket 13, Fig 5.1-Fig 5.3) are within close proximity. Shop Rite has a service area of 1.89 square miles and BJ’s has a service area of 1.80 square miles. Whereas both Shop Rite and BJ’s provide service to Gray’s Ferry, Shop Rite also draws a large population from South Broad-Girard Estates. Shop Rite is on the boundary between Gray’s Ferry and South Broad-Girard Estates, but it is the only supermarket in South Broad-Girard Estates. The estimated shopping population at Shop Rite is 16,545 persons, whereas BJ’s draws from sparse Gray’s Ferry with a population of 4,399. Large stores such as BJ’s often market volume products to customers which may not be attractive to pedestrians or residents relying on public transit.

Figure 5.1 Supermarket regions based on shortest network distance (PB1)

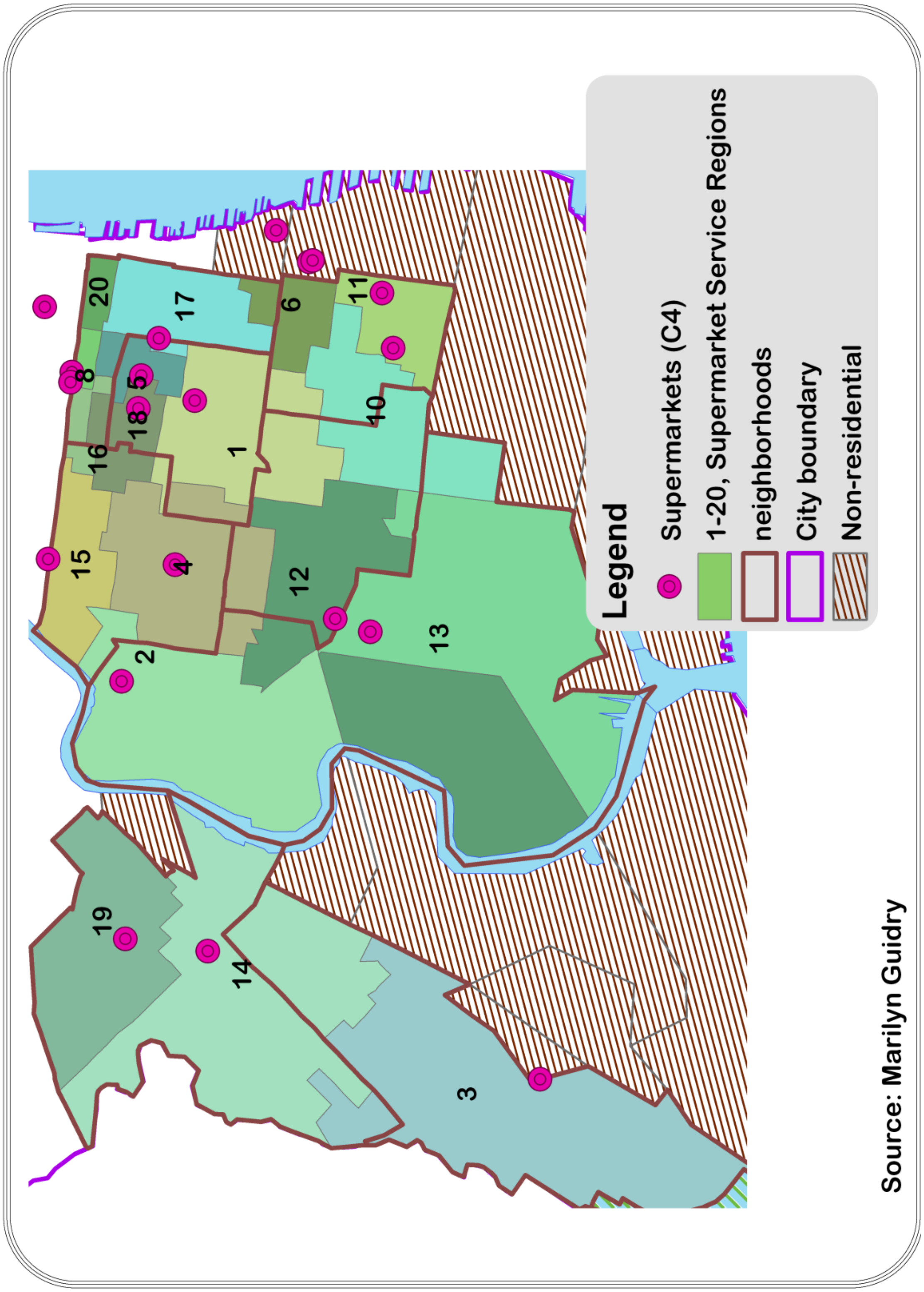


Figure 5.2 Supermarket regions based on attractiveness: total floor space (PB2)

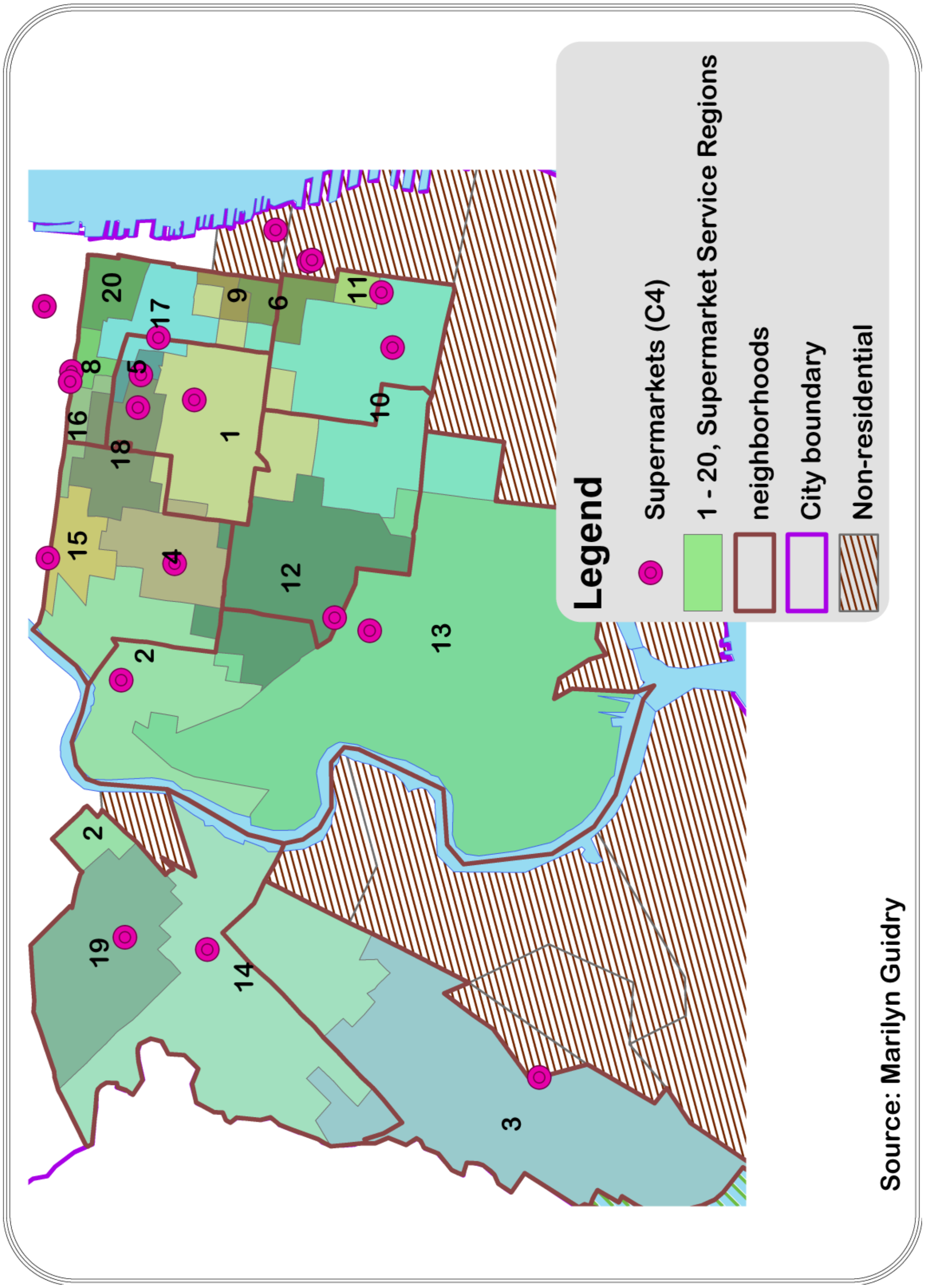
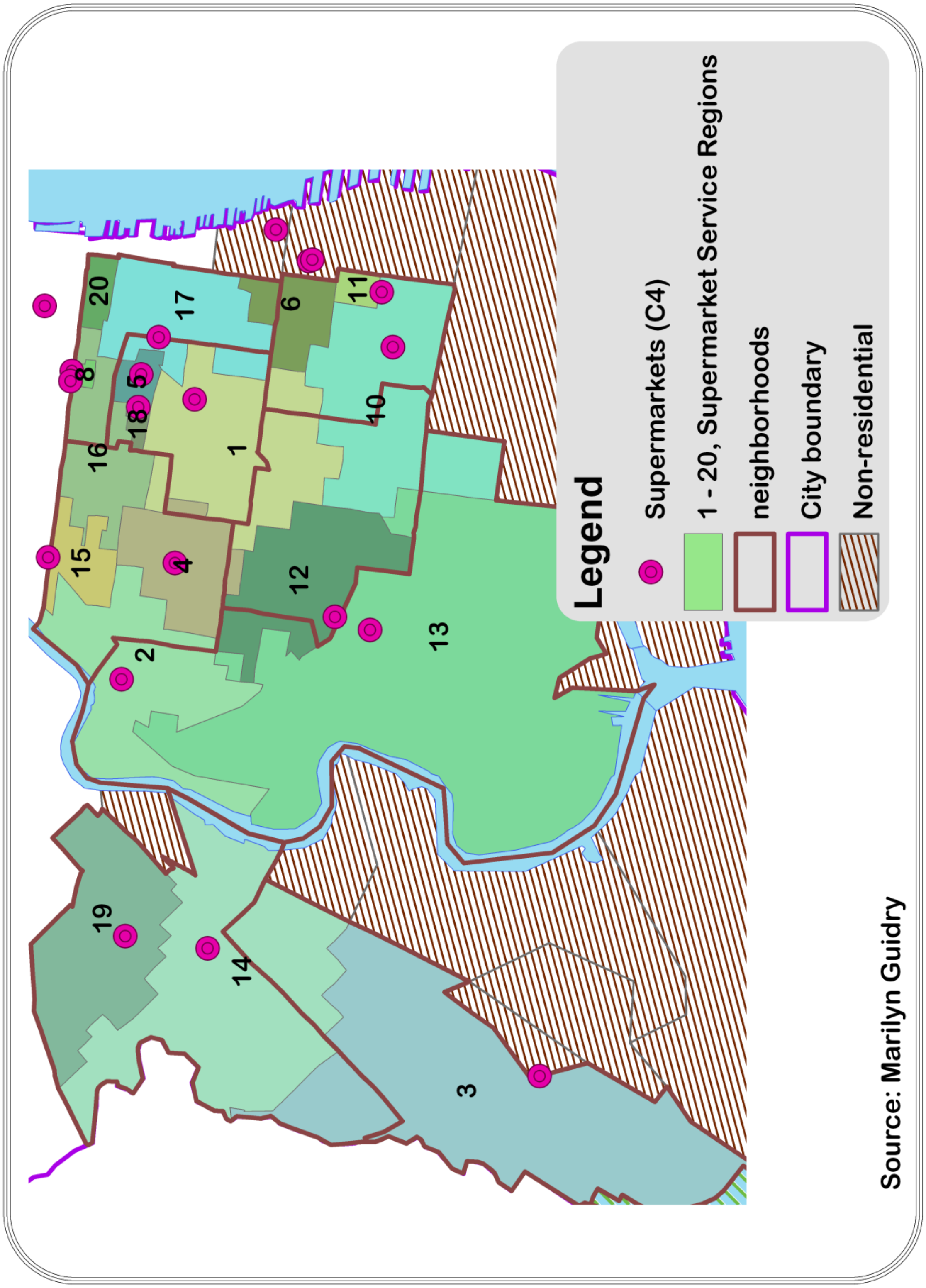


Figure 5.3 Supermarket regions based on attractiveness: fruit and vegetable shelf space (PB3)



Both Shop Rite and BJ's are large stores, and the effect of including total floor size as an attractiveness factor increases the gravity potential of both stores. Sections of Gray's Ferry neighborhood originally attracted to Shop Rite, are attracted to BJ's by the inclusion of floor size. Whereas Shop Rite's service region decreases in size (to .91 sq miles) due to the loss of Gray's Ferry, it extends its service area further into densely populated neighborhoods of South Broad-Girard Estates and Schuylkill-Point Breeze. Shop Rite increases its shopping population to 24,439 persons. BJ's increases both in area (3.73 square miles) and in population served (5,064) by the inclusion of total floor size. BJ's service area increases in size (3.79 sq miles) and population (5,630) by inclusion of fruit and vegetable shelf space as an attractiveness factor. Shop Rite increases from its original gravity potential with inclusion of fresh fruit and vegetable shelf space to a shopping population of 17,203.

Pathmark of Gray's Ferry has a large gravity potential, drawing 10,791 shoppers from 1.52 square miles, mainly from Gray's Ferry but with a small section extending into Schuylkill- Point Breeze. The inclusion of total floor size as an attractiveness factor increases the population served to 15, 835 people by extending further into more densely populated Schuylkill-Point Breeze and across the Schuylkill River to include portions of Paschall-Kingsessing. Pathmark's service region loses land to BJ's in Gray's Ferry when total floor space is included, so although population served increases, the service area decreases to 1.17 square miles. Addition of fruit and vegetable shelf space also causes Pathmark's gravity potential to diminish from the attractiveness of its total floor area, but the net is a population gain from the original service population to 13,169 potential shoppers.

The next largest service area is the 54^{th} Great Value service region (0.93 sq miles) in Paschall-Kingsessing. Paschall-Kingsessing is quite dense so the population served according to the Huff model is 23,953 persons. Inclusion of total floor area as an attractiveness factor actually decreases the service region of 54^{th} Street Great Value to 0.83 square miles and diminishes the population served to 22,541. The inclusion of fruit and vegetable shelf space increases spatial area (0.88 sq miles) but decreases the population served to 21,602 persons.

Young's Harvest Market has a service region of 0.88 square miles in the center of Schuylkill-Point-Breeze, drawing potentially 28,246 shoppers. Spatial area and population served declines when total floor size and fresh fruit and vegetable shelf space are included. Young's is the smallest of all the supermarkets in the study area with a total floor area of 5,500 square feet. This small total floor space and small fresh fruit and vegetable department cause the service region to diminish to 0.36 square miles and only serve a population of 11,309.

Schuylkill-Point Breeze has a second supermarket, Thriftway South Square, located on South Street. Thriftway has a service region of 0.38 square miles in Schuylkill-Point Breeze and a gravity potential to draw 8,444 local shoppers. When the attractiveness factors are included, Thriftway's service area and the potential shopping population decline to 0.19 square miles and to a potential local shopping population of 5835. Thriftway's location on the northern boundary of the study area indicates that much of its service region falls outside the extent of this study.

Acme Market of Southwark-Bella Vista has a service region of 0.83 square miles according to the Huff model but increases in service area and population served with inclusion of the attractiveness factors. Acme's service region increases to 0.97 square miles and the total population served increases from 30,514 to 35,686 persons as total floor space and fresh fruits and vegetable space is included. In addition to Acme, two other non-chain supermarkets are located within Southwark-Bella Vista, Hung Vuong and P and F Giordano. Hung Vuong and P and F Giordano are closely situated north of Acme. Hung Vung has a service region which includes sections of Southwark-Bella Vista and overlaps into sections of Schuylkill-Point Breeze and Pennsport-Queen Village. Hung Vuong's service region and potential population increase when total floor size is included growing from 0.25 to 0.35 square miles, and 4,187 to 16,507 potential shoppers. Hung Vuong's service area declines when fresh fruit and vegetable shelf space is included to 0.03 square miles.

P and F Giordano is also a smaller supermarket with a 0.15 square mile service area and a gravity potential for 4,341 shoppers according to the Huff model. Including total floor area and fresh fruit and vegetable shelf space as attractiveness values decrease area and gravity potential to 0.05 square miles and a potential population of 1,198 persons.

Pennsport-Queen Village has three supermarkets within its bounds and is served by two supermarkets just outside the study area. Two supermarkets are located on South Street, Superfresh #747 and Whole Foods Market. Superfresh #747 has a service region of 0.09 square miles, mainly in Pennsport-Queen Village, but extending into Schuylkill-Point Breeze as well. Whole Foods Market services only Pennsport-Queen Village with a service region of 0.05 square miles according to the Huff Model. Both Superfresh #747 and Whole Foods Market increase service area when the attractiveness values are included. Superfresh #747 increases from a potential of 2,036 shoppers to 9,187 potential shoppers in a service region of 0.42 square miles. Whole Foods increases its service region with its total floor size. Its service region decreases to 0.02 square miles when shelf space for fresh fruits and vegetables are included. A third supermarket within this neighborhood is the 1st Oriental. The 1st Oriental has a service region of 0.43 square miles with 11,979 potential shoppers, according to the Huff model. Although total floor size does not increase its gravity potential, the inclusion of fresh fruit and vegetables increases the service area to 0.55 square miles with a local shopping population of 16,780 persons.

Two supermarkets fall outside the study area but provide services for residents of Pennsport-Queen Village. These are a Superfresh #730 in Center City Philadelphia and Superfresh Columbus Boulevard in an unpopulated census tract situated between the neighborhood boundary and the Delaware River. Superfresh #730 has a service region of 0.08 square miles which increases to 0.14 square miles when total floor space is included. The population served increases from 1,953 to 3,836. The Superfresh Columbus Boulevard has a gravity potential in Pennsport-Queen Village only when total floor space is included as an attractiveness factor. The service area is then 0.05 square miles with a potential for 1,063 potential shoppers.

Snyder-Whitman is serviced by two supermarkets within its bounds and by a Shop Rite #530 which falls outside the neighborhood in an adjacent unpopulated census tract. Pathmark #552 has a service region of 0.71 square miles according to the Huff model, which expands to 1.25 and 1.07 square miles, respectively, when the attractiveness factors total floor area and fresh fruit and vegetable shelf space are included. The population served expands from 19, 199 persons to a high of 29,760 potential shoppers. Aldi is within Snyder-Whitman with a service region of 0.33 square miles serving 3,058 potential shoppers according to the Huff model. Aldi's service region extends into Pennsport-Queen Village. Total floor space and fresh fruit and vegetable floor space as attractiveness factors actually decrease Aldi's service region. Shop Rite #530 is located in an unpopulated census tract adjacent to Snyder-Whitman and has a service region of 0.23 square miles drawing potentially 8,559 persons. Attractiveness variables do not increase the service region.

In summary, every neighborhood has at least one supermarket within its bounds. The area with the highest concentration of supermarket coverage is in Southwark-Bella Vista and Pennsport-Queen Village, particularly close to South Street and the northern edge of the study area. These are two of the smallest neighborhoods, but each of these two neighborhoods has access to four or more supermarkets. The best supermarket coverage within the study area is eight supermarkets for 48,212 people in 1.56 square miles. The other neighborhoods are larger in area, not quite as densely populated, but with much less proximity to supermarkets. Schuylkill-Point Breeze, Snyder-Whitman, Gray's Ferry and Paschall-Kingsessing each have two supermarkets. Eastwick-Elmwood and South Broad-Girard Estates are the two neighborhoods with a single supermarket. Excluding Southwark-Bella Vista and Pennsport-Queen Village in South Philadelphia, there are seven supermarkets to serve 107,328 people in an area of 8.05 square miles. In Southwest Philadelphia, three supermarkets serve 75,709 in 4.93 square miles.

The attractiveness variables effect on the size of the service areas. Two stores had a large increase in service area size when including total floor size, Pathmark #552 in Snyder-Whitman and BJ's Wholesale Market in Gray's Ferry. Pathmark #552 increased from 0.71 to 1.25 square miles. Within Snyder-Whitman Pathmark #552 competes only with Aldi which lost service area when total floor size was included. BJ’s Wholesale Market also expanded tremendously from an original gravity potential of 1.80 square miles to 3.73 square miles when total floor space is included. The disadvantage to BJ’s is that most of the area gained through an increased attractiveness of total floor space is in low density Gray’s Ferry. Five other supermarkets experienced small growth in gravity potential (0.1 square miles or less) with the inclusion of total floor size. Three stores had absolutely no change in gravity potential based on total floor space and ten stores experienced a contraction in service area. Two of the ten stores which lost service area include Shop Rite of South Broad-Girard Estates and Pathmark of Gray’s Ferry. These stores both lost service area to BJ’s, in low density areas of Gray’s Ferry, so loss of service area did not result in the loss of population served. The general trend is that smaller, non-chain supermarkets lost gravity potential and their service regions and populations served contracted with inclusion of total floor size as an attractiveness factor.

The inclusion of fresh fruit and vegetable shelf space as an attractiveness factor also had impacts. Whereas, originally I had planned on using the percentage of fresh fruit and vegetable space as a factor, the low percentages failed to create variation in the service areas created for the supermarkets. To increase variation, I used the absolute shelf space designated to fresh fruits and vegetables. With this factor included, six supermarkets visibly increased their service regions, ten stores decreased their service regions and the service region of four stores did not change. The stores which increased service region were all large chain grocers, Acme, Shop Rite, Superfresh, Pathmark and BJ’s with one exception. First Oriental is a local grocer which has a large fresh produce department and was able to increase its service area when this factor is included. The stores which suffered a contraction in service area included some chains (Pathmark and Shop Rite), several local grocers, (P and F Giordano, Hung Vuong), and local chains (Save A Lot and 54th Street Great Value). The loss of service area for Pathmark and Shop Rite did not convert into much loss of population served since most area was in low density areas of Gray's Ferry.

B. Supermarket Service Gaps

Following the creation of probable supermarket service regions, an additional service area analysis was applied to supermarkets, to determine the population living within a ten minute service area. Service regions for pedestrian populations, transit populations and shoppers driving private vehicles were created. The network analysis of a 10 minute service area for private vehicles, encompassed the entire study area and extended well into other portions of Philadelphia, Delaware County, Pennsylvania and New Jersey via bridges crossing the Delaware River. The conclusion is that those households with access to private transportation are adequately served within the study area and have access to stores in adjacent areas. The ten minute driving service area does not include any addition travel impedances for parking, traffic, construction or other hindrances which may prolong the travel time to supermarkets. Considering the heavy congestion and population density in this area, the network analysis is a simple study, a more sophisticated study with more accurate depiction of actual travel patterns within and around the study area might influence the accessibility outcome for drivers. Drivers of private vehicles are not included within the next sections of this analysis, which focus on accessibility for pedestrians and riders of public transit.

The Progressive Grocer identifies that the standard service region for supermarkets is calculated as ¼ mile. This is equivalent to a five minute walking distance, at a rate of 3.3 miles per hour. To prevent underestimating the pedestrian population served, a ten minute walking buffer was created around each supermarket. Figure 5.4 presents a map of supermarket service areas determined using a ten minute walking buffer. Data presented in Table 5.2 describes the spatial dimensions and total population of the pedestrian service area. The 10 minute walking buffer of the supermarkets covers 29.9 percent or 4.50 square miles of the residential study area and a population of 101,181 (43.8 percent of total) residents. An additional 4.64 square miles falls into gap areas greater than a 10 minute walk covering a population of 57,031 (24.7 percent). The remaining 5.39 square miles is categorized as transitional and holds a population of 73, 037 residents (31.6 percent). Transitional populations do not fall clearly within a gap area or a service area, where access is not easily measured. This transitional area represents the fuzzy area of the supermarket service area boundary. Whereas the software tool allows us to lay down a precise service area boundary, in reality residents determine their own boundary. Transitional areas for the pedestrian population were included because of the variability in comfort walking different distances among individuals. For many people a ten minute walk is comfortable. For other individuals, such as senior residents, children or individuals with health conditions, ten minutes walking can present an obstacle. The inclusion of a transitional group emphasizes that a large population still exists with tentative accessibility to groceries. Figure 5.5 presents the spatial distribution of supermarket service areas, gap areas and transitional areas for the pedestrian population.

Figure 5.4 Supermarket service regions, pedestrians

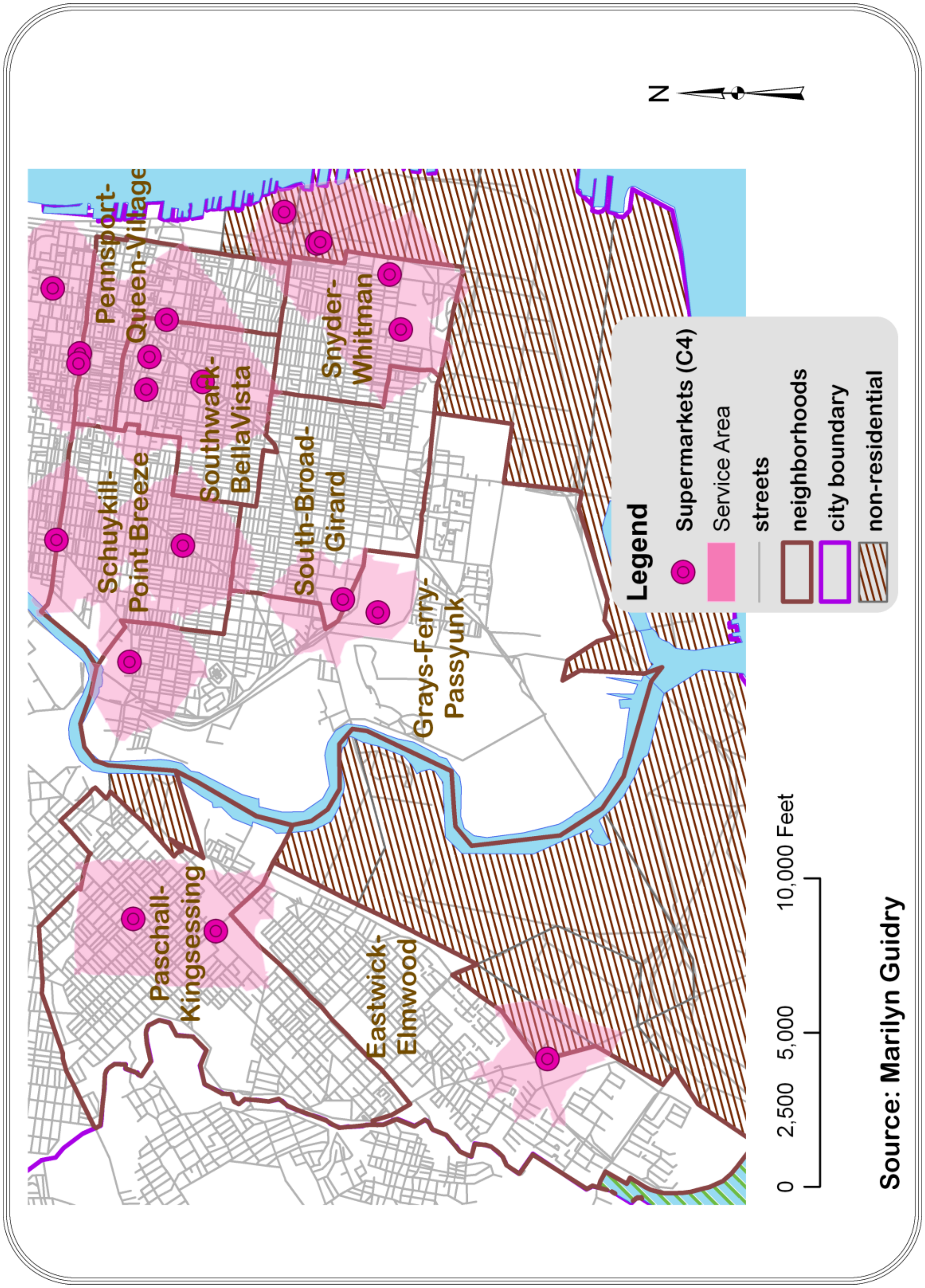


Figure 5.5 Supermarket service gaps and transition areas for pedestrians

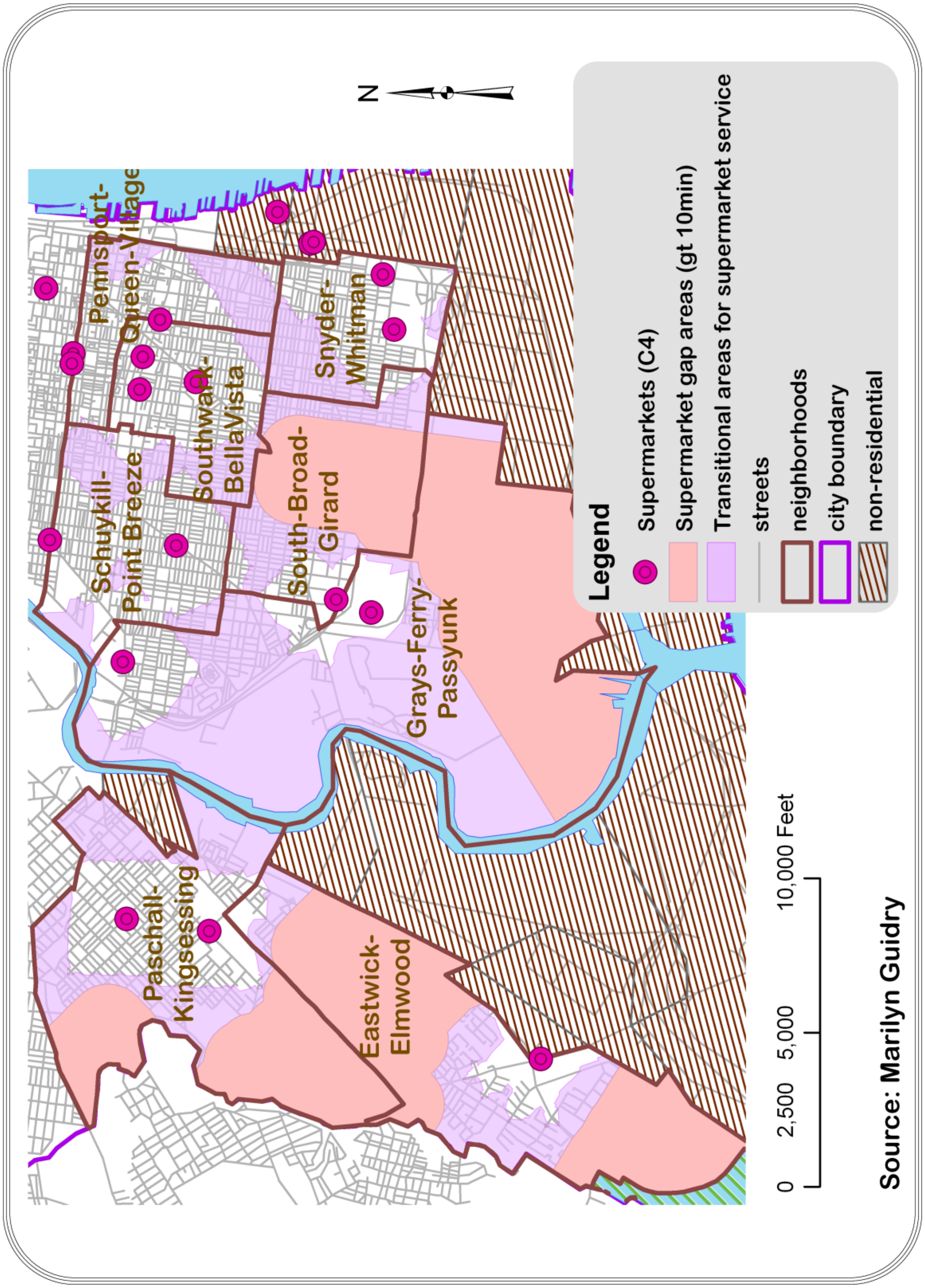


Table 5.2 Supermarket service areas and gap areas for pedestrians within 10 minutes

Area	Number of Census Block Groups	Total Population	Area * (Sq miles)
Gap Areas	65	57,031	4.64
Transitional Areas	84	73,037	5.39
Supermarket Service Areas	136	101,181	4.50

To further characterize the importance of gap areas as compared to supermarket service areas, a bivariate correlation analysis with the census and geographic data variables was conducted. The complete Pearson correlation tables are included in the appendix, tables A4 through A7. A Pearson's correlation analysis indicates that the categories in Table 5.2, represented by the variable (gapstat), demonstrates a small but significant positive correlation between gapstat and population density ($r = 0.167$) and proportion of households without vehicles ($r = 0.202$). Both these correlations are significant at $p < .01$. Gapstat represents the classification of census block groups into supermarket service areas, transitional areas or gaps. Gapstat is not significantly correlated with other demographic variables. The Pearson's correlation reveals a high positive correlation between population density (cpopdens) and the total number of households (h001001); and a high positive correlation between the proportion of the population below poverty level (cpopbepv) and proportion of households without vehicles (chousnvh). In future analyses the variables the total number of households and proportion of the population below poverty are omitted to diminish issues with multicollinearity. To further examine the correlation between the three categories included in gapstat, three additional binary variables are created; gapdich1, gapdich2 and gapdich3. Gapdich1 represents all 149 census tracts in supermarket gap areas and transitional areas as a nominal variable with a value of '1' and the remaining 136 census block groups falling within the supermarket service areas are represented with a value '0'. Gapdich1 is used to selectively identify the relationship between gap areas and service areas. The second variable, gapdich2 codes only census block groups in gap areas as '1' and supermarket service areas and transition areas as '0'. A third dichotomous variable is gapdich3 which codes all transitional areas as '1' and groups gap areas and supermarket service areas as '0' is also examined. The purpose of this variable is to identify any association between census block groups considered transitional not falling within a gap or service area with demographic variables. The Pearson's correlation coefficients produced when examining these three dichotomous variables only demonstrated a statistically significant negative correlation between gapdich2 and households without vehicles (chousnvh) ($r = -0.236$, $p < 0.01$) and a statistically significant negative correlation between gapdich2 and population density ($r = -0.183$, $p < 0.05$).

Table 5.3 presents the data for the supermarket access for riders of public transit. Whereas the large majority of the population has access to supermarkets within ten minutes by public transit, there remains 42 census blocks, representing 11.5 percent of the study population outside this service area. The public transit network analysis indicates that 243 of 285 census block group centroids are within ten minutes transit time to a supermarket. Figure 5.6 demonstrates the transit routes connecting each census block group centroid to a supermarket. Figure 5.7 demonstrates the area which falls within ten minutes travel time to a supermarket via public transit. The public transit network analysis is quite basic. The transit routes do not indicate whether each neighborhood is linked through a single mode of transit or whether multiple modes of transit are employed. The transit network simply demonstrates that each census block group has access to a supermarket via public transit within ten minutes according to speed limit travel times across the neighborhoods. This network does not incorporate traffic patterns or congestion. Nor does this network include frequency of buses, trains or subway, daytime, nighttime, weekday or weekend hours. An additional study question is how many neighborhoods are serviced by a single transit mode and how many neighborhoods and individuals are required to transfer or utilize two modes of transit to reach their shopping destination. If wait time at stops and walk time to transit stops are included then accessibility to supermarket via public transit may not be as extensive.

Table 5.3: Supermarket service areas and gap areas within 10 minutes by public transit

Area	Num of Census Block Groups	Total Population	Area * (Sq miles)
Gap Areas	39	22,913	4.85
Service Areas	243	208,336	9.67

The Pearson's bivariate analysis of census block groups falling within transit gap areas utilizes the variable tgapstat which codes the two categories presented in Table 5.3, transit gap areas and transit supermarket service areas. Tgapstat demonstrates small but statistically significant correlations with several demographic variables, as presented in Table 5.4. Public transit gap status (tgapstat), demonstrated a negative correlation with proportion of African Americans (cafam), proportion of population receiving public assistance (cpubass) and proportion of population below poverty (cpopbepv) and a positive correlation with number of households (h001001), population density (cpopdens) and grocer density (grocdens).

In no case was produce accessibility correlated with any other factors at a significant level. Tables presenting the Pearson's correlation matrix between produce accessibility and gap status variables and other study area characteristics are presented in appendix tables A8 through A11.

Table 5.4 Significant correlation coefficients (Pearson's) with public transit gap status (tgapstat)

Variables	Coefficient (ρ)	Probability
Number of Households (h001001)	0.176	.003
Proportion of Population African American (cafam)	-0.134	.024
Proportion of Population receiving public assistance (cpubass)	-0.242	.000
Population per square mile (cpopdens)	0.415	.000
Proportion of Population below poverty (cpopbepov)	-0.160	.007
Mean grocer density (grocdens)	0.280	.000

When considering the relationship between public transit gap status and grocer density (grocdens), a stronger positive correlation is indicated. Whereas the Pearson's correlation did not indicate an association between pedestrian gap status (gapstat) variables and grocer density (grocdens), the transit gap status variable (tgapstat) demonstrates a positive association ($\rho = 0.28$, $p < 0.01$). Tgapstat also has significant associations, presented in Table 5.4 with number of households (h001001), proportion of African American population (cafam), population density (cpopdens), proportion of population receiving public assistance (cpubass) and proportion of population below poverty (cpopbepv). The strongest association tgapstat has is with cpopdens, ($\rho = 0.415$, $p < 0.01$), indicating that location in a transit service area is directly correlated with population density.

A subsequent step is to determine which census block groups fall into both pedestrian service gaps and public transit service gaps (gapstat2). Thirty one census block groups fall into both gaps. Table 5.5 demonstrates the areas of overlap which fall outside the ten minute walking buffer and the ten minute public transit buffer of supermarkets.

Table 5.5 Overlap areas of pedestrian and public transit gaps

Area	Num of Census Block Groups	Total Population	Area * (Sq miles)
Gap Areas	31	18,021	5.36
Service Areas	254	213,228	9.17

The Pearson's bivariate analysis of census block groups falling within transit gap areas utilizes the variable gapstat2 which codes the two categories presented in Table 5.5. total Pearson's correlation values are in Table A7. Thirty one census block groups fall within both pedestrian and public transit gap areas, 254 census block groups fall in either a pedestrian service area or a public transit service area or both. Gapstat2 demonstrates small but significant correlations with several demographic variables as presented in Table 5.6.

Table 5.6 Significant correlations for pedestrian and public transit gaps

Covariate	Coefficient (ρ)	Probability
Number of Households (H001001)	.124	.037
Proportion of population receiving public assistance income (cpubass)	-.221	.000
Proportion of population using public transportation (cpubtrans)	-.133	.025
Population per square mile (cpopdens)	.384	.000
Proportion of population living below poverty level (cpopbepov)	-.157	.008
Mean density of small grocers stocking fresh fruits and vegetables per square mile (grocdens)	.240	.000

Figure 5.6 Public transit routes from census block group to closest supermarket

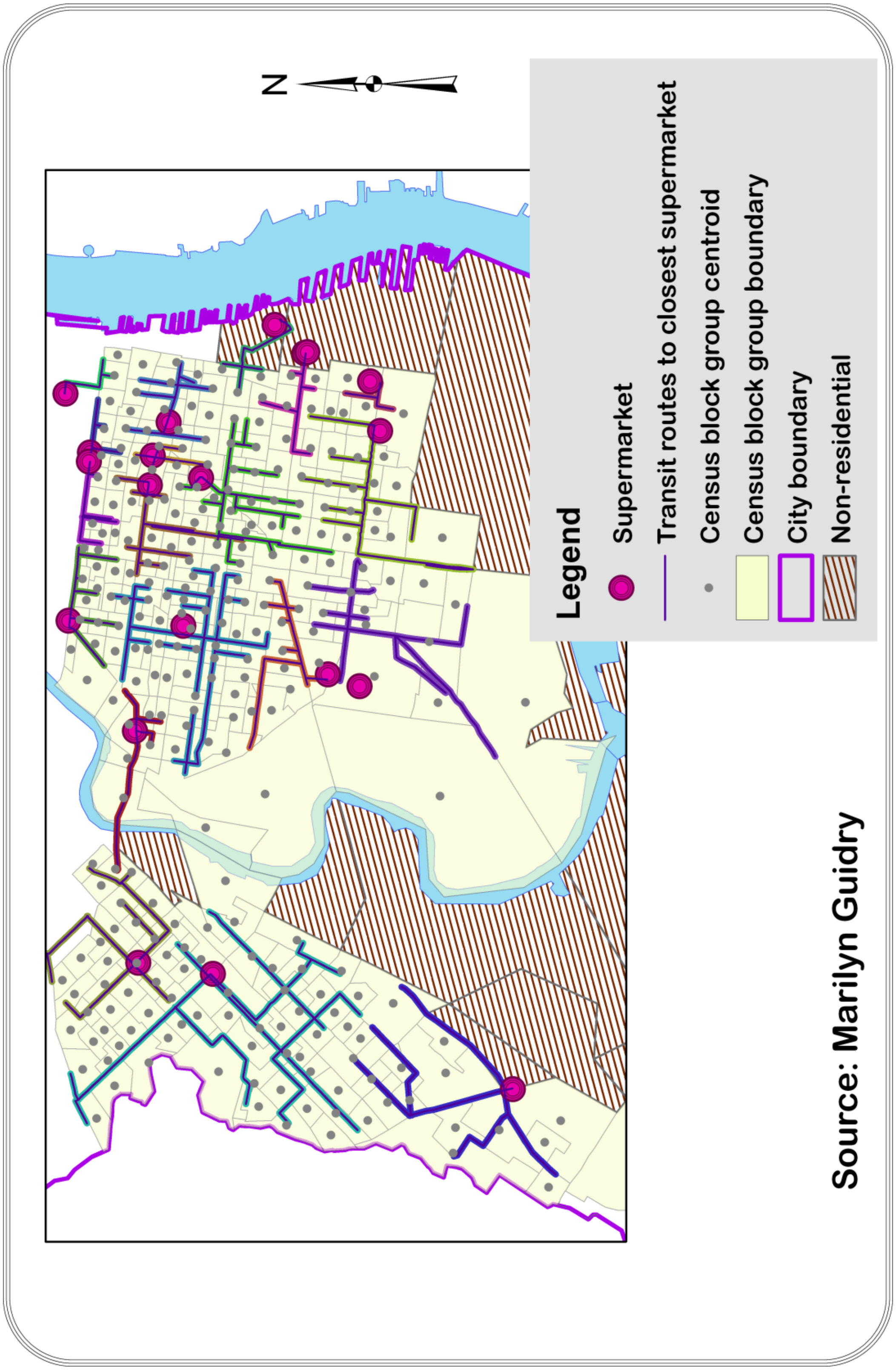


Figure 5.7 Public transit gap and service areas

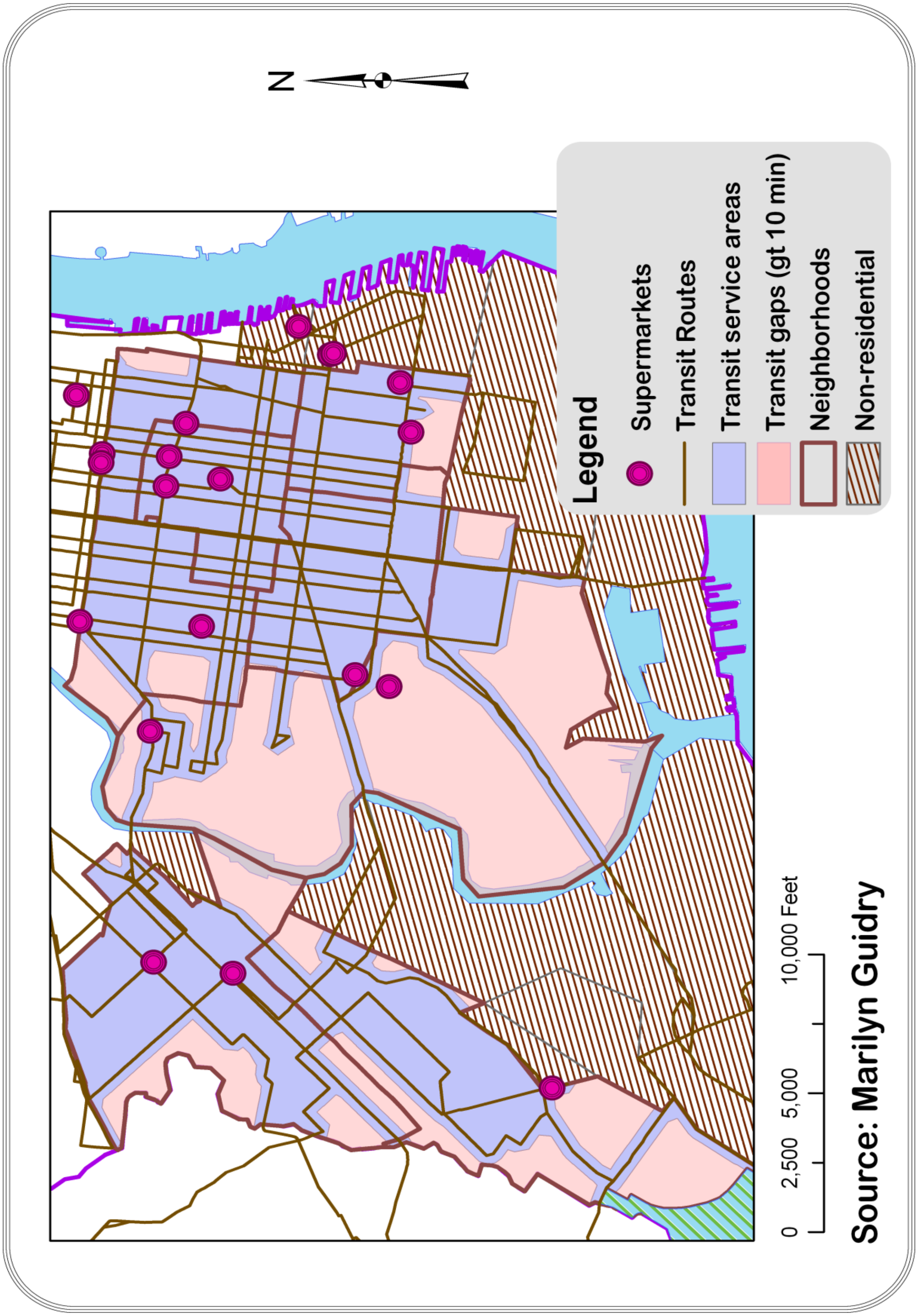


Table 5.7 summarizes mean values for several demographic variables of census block groups which fall into gaps and service areas as defined for pedestrians and users of public transit. ANOVA is used to determine the significance of the means for pedestrian areas (gapstat), because of the inclusion of a third transitional category. T-Tests are used to determine significance of variables for the public transit areas (tgapstat) and for census block groups in gaps and service areas for gapstat2 as well. Table 5.7 indicates that significant differences in means exist for grocery density (grocdens) and population density (cpopdens) in gaps and transitional zones of pedestrian service areas. Additionally significant differences in means exist between all three categories within the pedestrian service areas for households without a vehicle (chousnvh). Descriptive tables of the ANOVA and post hoc Tamhane test, and graphic plots of the means for gaps, transitional areas and service areas are included in the appendix, tables A12, A13 and A13a.

For public transit gaps the t-test indicates that mean number of households (h001001); mean population density (cpopdens); mean proportion of African American population (cafam); mean proportion of population receiving public assistance (cpubassis); and mean density of grocers carrying fresh fruit and vegetables (grocdens) are significant ($p < 0.05$).

For census block groups falling into both pedestrian and public transit gap areas mean number of households (h001001); mean population density (cpopdens); mean proportion of population receiving public assistance (cpubass); mean proportion of population relying on public transit (cpubtrans) and mean density of grocers carrying fresh fruit and vegetables (grocdens) are complete t-test statistical results are for tgapstat are included in the appendix (Table A14).

Table 5.7 Population characteristics of supermarket service regions and gaps

	Total Study Area (Mean ± SD)	Pedestrian Areas (Gapstat)			Public Transit Areas (Tgapstat)		Pedestrian & Transit Areas (Gapstat2)	
		Gaps	Transitional	Service Region	Gaps	Service Region	Gaps	Service Region
Census Block Groups	285	65	84	136	42	243	31	254
Mean Num of Households (H001001)	368.79 ± 192.8	385.3	392.1	346.5	287.1*	382.9*	300.6*	377.1*
Mean Population Density (cpopdens)	26744.32 ±13853	22095*	27665	28398*	12938*	29131*	11540*	28600*
Mean Proportion Af Amer Pop (cAfAm)	0.52 ± 0.39	0.47	0.49	0.56	0.64*	0.97*	0.63	0.5
Mean Proportion Pop Receiv Public Assist (cpubass)	0.05 ± 0.10	0.06	0.06	0.04	0.11*	0.04*	0.11*	0.04*
Mean Proportion Pop Using Public Transit (cpubtrans)	0.14 ± 0.14	0.12	0.15	0.14	0.16	0.13	0.19*	0.13*
Mean Proportion Households No Vehicle (chousnvh)	0.46 ± 0.17	0.39*	0.48*	0.49*	0.48	0.46	0.45	0.46
Mean Proportion of Pop Below Poverty Level (cpopbepv)	0.27 ± 0.16	0.25	0.30	0.26	0.33	0.26	0.34	0.26
Mean Density of Small Grocers w/F&V (grocdens)	31.44* ± 36.09	23.58*	37.92*	31.19	7.20*	35.62*	6.65*	34.47*

*The mean difference is significant ($p < 0.05$).

Hypothesis 2 states that in south and southwest Philadelphia, residential areas or gaps, have a lower density of grocers than supermarket service areas. Urban areas within supermarket gaps are more likely to rely on small grocers with inconsistent quality of healthy food offerings. This analysis produced gap areas across the neighborhood study area for pedestrian and transit populations residing 10 minutes or more from a supermarket. The gap areas for pedestrians equal 4.64 square miles (31.0 percent) of the 15.05 square mile study area. Four well defined pedestrian gaps are identified. Of the four gap areas, one is east of the Schuylkill River in south Philadelphia, and three west of the river in southwest Philadelphia. Figure 5.5 portrays pedestrian gaps. Within these gaps the number of smaller grocers stocking fresh fruit and vegetables were examined to check the extensiveness of produce availability. Small grocers stocking fresh fruit and vegetables are categorized as C2 and C3 in Table 4.5: Food Site Categories for this analysis. Grocers falling into C2 and C3 categories are grouped as high quality grocers in Figure 5.8. Figure 5.8 presents the distribution of high quality grocers across the study area including pedestrian gap areas. Within the pedestrian gaps 53 small grocers provide fresh fruit and vegetables. Thirty-six of the 161 small stores categorized as C3 with limited healthy food choices service these gap areas. Seventeen of 93 C2 stores fall within the service gaps. Although the small grocers provide additional resources to census block groups without a supermarket within ten minutes, there remains an additional 2.74 square miles of gap areas without a small grocer. This area encompasses 11 census block groups with a population of 6,860 persons.

The public transit supermarket gap areas are equal to 5.62 square miles but are partitioned into multiple small separate areas. Figure 5.7 presents the public transit gap areas. The largest gap areas are in Gray’s Ferry along the Schuylkill River and in the southern portion of Eastwick-Elmwood near the John Heinz Wildlife Refuge at Tinicum.

Most other census block groups falling into public transit gap areas are small areas on neighborhood perimeters. Small gap areas are in Paschall-Kingsessing, Eastwick-Elmwood, Gray's Ferry, Schuylkill-Point Breeze, Snyder-Whitman and Pennsport-Queen Village.

Figure 5.8 Distribution of grocers stocking fresh fruit and vegetables and gap areas both for pedestrians and public transit

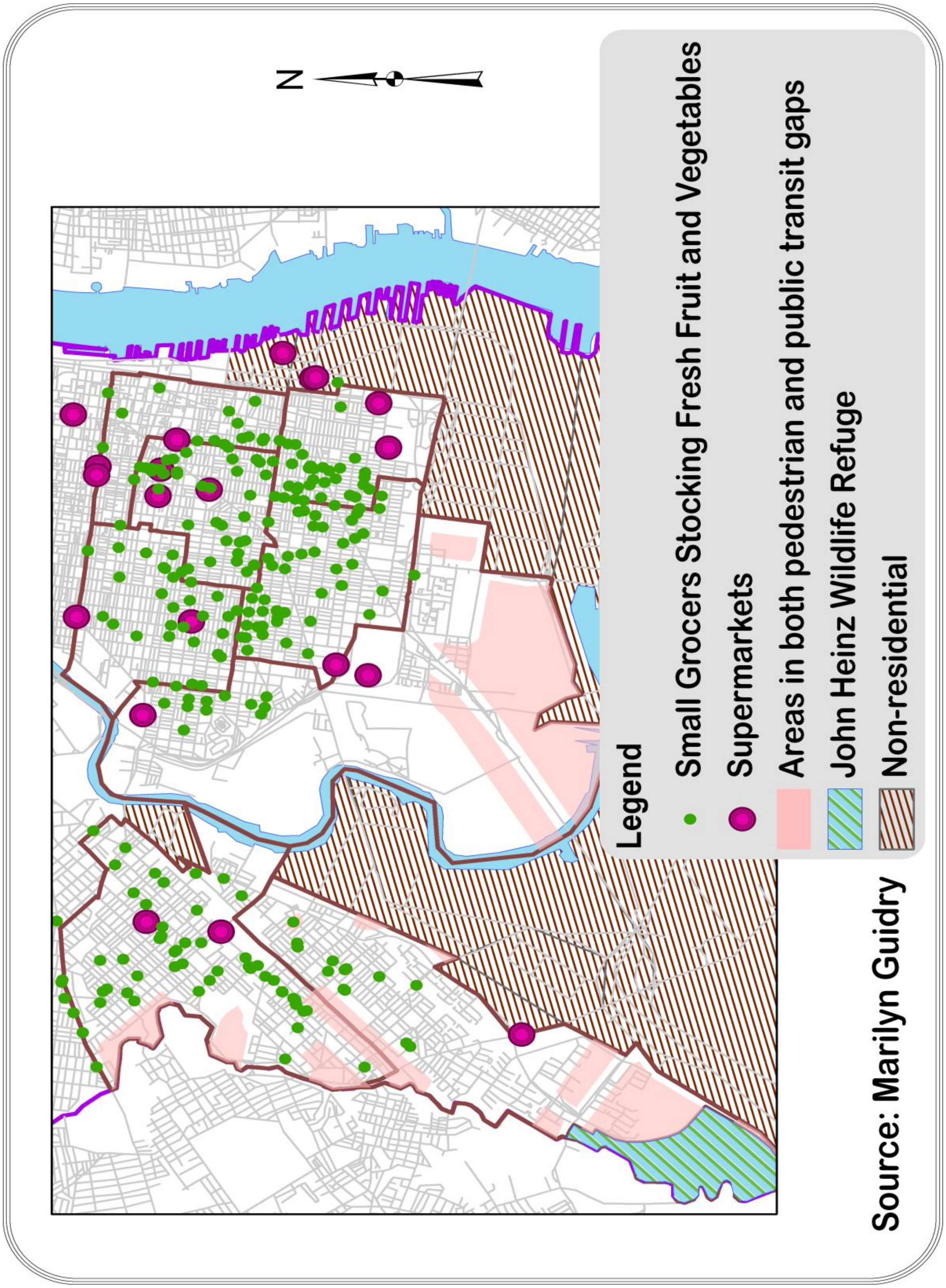


Table 5.8 presents grocer density means in gaps and supermarket service areas for pedestrian and public transit areas. Grocer density rates are not significantly different in pedestrian gaps and service areas as demonstrated by data in Table 5.8. Ninety-five percent confidences intervals for grocer density means for pedestrian service areas and gaps show large overlaps for gapstat, gapdich1, gapdich2, and gapdich3 variables. The grocer density mean for pedestrian gap areas (23.58 grocers per square mile) is lower than the comparable grocer density mean for the entire service area (31.44) and for pedestrian service areas (31.19), but the 95 percent confidence intervals overlap suggesting the difference is not significant.

Alternatively, in the cases of the public transit gaps and service areas (tgapstat), and areas in both pedestrian and transit gaps (gapstat2) grocer density mean data does demonstrate that the 95 percent confidence interval between the means clearly do not overlap suggesting that grocer density is significantly different for these areas. The mean grocer density for public transit service areas is (35.29 grocers per square mile) and the confidence interval extends from 30.61 to 39.97 grocers per square mile. For public transit gap areas the mean grocer density is 7.13 grocers per square mile with a 95 percent confidence gap of 4.23 to10.03 grocers per square mile. Similarly, for areas falling into both public transit and pedestrian gap areas, the mean grocer density is 6.34 grocers per square mile with a 95 percent confidence interval of 3.65 to 9.64 grocers per square mile, compared to a larger grocer density mean of 34.39 for public transit service areas. The 95 percent confidence interval extends from 29.84 to 38.95 grocers per square mile. The conclusion from mean grocer density data in Table 5.8 is that pedestrian gaps, transition areas and supermarket service areas, fail to suggest a significant difference in grocer densities.

Table 5.8 Grocer density means and confidence intervals for gap and service areas

Area	Variable	Mean (grocers/ sq mile)	N	Std. Dev	Std. Error of Mean	95% Confidence Interval for Mean	
						Lower Bound	Upper Bound
Total Study Area		31.44	285	36.09	2.14	27.23	35.65
Pedestrian Gap Area	(gapstat)	23.58	65	32.96	4.09	15.41	31.74
Pedestrian Transition Area		37.92	84	37.54	4.10	29.78	46.07
Pedestrian Service Area		31.19	136	36.10	3.10	25.07	37.32
Gaps & transitions grouped	(gapdich1)	31.66	149	36.20	2.97	25.80	37.53
Service Areas		31.19	136	36.10	3.10	25.07	37.32
Gaps	(gapdich2)	23.58	65	36.72	2.48	28.88	38.64
Service Areas & Transitions grouped		33.76	220	32.96	2.48	15.41	31.74
Service areas & gaps grouped	(gapdich3)	28.73	201	35.22	2.48	23.83	33.63
Transition Areas		37.92	84	37.54	4.10	29.78	46.07
Public Transit Gap Area	(tgapstat)	7.13	39	8.95	1.43	4.23	10.03
Public Transit Service Area		35.29	246	37.27	2.38	30.61	39.97
Ped & Transit Gap Area	(gapstat2)	6.34	31	8.83	1.61	3.05	9.64
Ped or Transit Service Area		34.39	254	36.94	2.31	29.84	38.95

Mean grocer density is significantly different for public transit gaps and service areas and for areas falling into both pedestrian and public transit gaps, compared to other areas which are within either pedestrian service area or a public transit service area. Thus this data does support hypothesis 2 which states that the grocer density for gap areas do fall significantly lower than supermarket service areas, but only when including public transit gap areas.

Table 5.9 Spatial autocorrelation values for variables

Variable	Description	GeoDa Moran's I (Queen Contiguity)	ArcGIS (Polygon Continuity)	Variance	Z-Score
p001001	Total Population	0.391	0.409	0.0014	11.06
h001001	Total Households	0.281	0.299	0.0014	8.11
p0053001	Median Income	0.287	0.280	0.0014	7.59
cpopdens	Population per square mile	0.511	0.515	0.0014	13.87
cafam	Proportion African American	0.772	0.784	0.0014	20.99
cpubass	Proportion receiving public assistance income	0.294	0.294	0.0012	8.49
cpubtrans	Proportion using public transportation	0.192	0.188	0.0014	5.16
cpopbepv	Proportion of population living below poverty level	0.195	0.195	0.0014	5.35
chousnvh	Proportion of households with no vehicle	0.29	0.302	0.0014	8.18
grocdens	mean density of small grocers stocking fresh fruits and vegetables per square mile	0.007	0.017	0.0013	0.55
prodac1	produce accessibility rate	0.026	0.039	0.0008	1.52
fruitss	Fresh fruit and vegetable floor space	0.028	0.032	0.0012	1.02
totfloor	Total grocery floor space	0.057	0.061	0.0013	1.82

Significance testing and cartographic representation have already supported hypothesis 2 in that spatial disparities exist in grocer densities which provide fruits and vegetable shelf space across the study area. Additional analytical tools are regression, spatial autocorrelation and spatial regression. Spatial autocorrelation refers to the characteristic of many geographic phenomena that features in close proximity to each other also share similar attribute values. Positive and statistically significant spatial autocorrelation exists for all demographic variables within the study area as demonstrated in Table 5.9. Only grocer density (grocdens), total floor space (totfloor), fruit and vegetable shelf space (fruitss) and produce accessibility (prodac1) demonstrate low spatial autocorrelation. With positive spatial autocorrelation significant for several covariates, this suggests that a spatial regression may better represent the relationship between demographic covariates and grocer variables.

Ordinary regression with grocer density (grocdens) as the dependent variable was calculated for each variable of pedestrian gapstat (gapdich1, gapdich2 and gapdich3), tgapstat and gapstat2 with several demographic covariates and also a street density variable. For each of gapdich1, gapdich2 and gapdich3, R-squared is within a narrow range, 0.21 to 0.22. Although many demographic variables were tested the only significant covariates in each case were population density (cpopdens), and proportion of households without a vehicle (chousnvh). In the regression gapstat variables were not significant. Table 5.10 presents covariates and statistical significance for a model using gapdich1. In the appendix Table A16 presents summary output for OLS and spatial regression with grocer density (grocdens) as the dependent variable and covariates including gapdich1.

Table 5.10 OLS covariates and probabilities (gapdich1)

Variable	Coefficient	Std. Error	t-statistic	Probability
constant	-14.863	8.273	-1.796	0.073
streets_mi	0.101	0.125	0.807	0.420
gapdich1	5.541	4.020	1.378	0.169
cpopdens	0.001	0.000	6.750	0.000
chousnvh	37.610	12.766	2.945	0.003
cafam	-10.528	5.899	-1.784	0.075

Diagnostics were run in Geoda 0.9.5-i to determine if spatial regression would have an impact on the strength of the relationship. Table 5.11 presents results. Moran's Index indicates a positive value for spatial autocorrelation and both spatial lag and spatial error models are significant. A second indicator the Robust LM indicates that the spatial lag model remains significant whereas the spatial error model loses significance. With two diagnostic indicators demonstrating that the spatial lag model is significant, I selected to examine the spatial lag model during the next step for gapstat.

Table 5.11 Diagnostics for spatial dependence (gapstat)

TEST	MI/DF	Value	Probability
Moran's I (error)	0.250	7.676	0.000
Lagrange Multiplier (lag)	1	62.709	0.000
Robust LM (lag)	1	11.660	0.000
Lagrange Multiplier (error)	1	51.136	0.000
Robust LM (error)	1	0.085	0.770

The spatial lag model produces an R-squared = 0.427 with the following significance for covariates listed in Table 5.12.

Table 5.12 Spatial lag model covariates and probabilities (gapdich1)

Variable	Coefficient	Std.Error	z-value	Probability
w_grocdens	0.628	0.0566	11.091	0.000
constant	-20.044	7.019	-2.855	0.004
streets_mi	0.103	0.106	0.967	0.333
gapdich1	6.545	3.409	1.919	0.054
cpopdens	0.000	0.000	4.161	0.000
chousnvh	23.778	10.873	2.186	0.028
cafam	-3.245	5.0397	-0.644	0.519

The spatial lag model improves the strength of the modeled relationship between the covariates and grocery density (grocdens) from 0.22 in the OLS regression to 0.427 for the spatial lag regression model. This strong R-squared value is indicative that a spatial process is influencing the relationship between the independent variables and the dependent grocer density. The significance of the covariates, population density (cpopdens) and proportion of households without vehicles (chousnvh) remain significant. Gapdich1 actually became significant in the spatial lag model which is not the case in OLS regression. Gapdich2 and gapdich3 gained significance when spatial lag is applied as well. In the appendix, summary output for regression analysis for grocer density as a dependent variable with gapdich2 and gapdich3 as covariates are presented in tables A17 and A18.

Ordinary regression on grocer density (grocdens) with the public transit gap areas included as a covariate (tgapstat) produces an R-squared = 0.23 with tgapstat showing a significant contribution to the model along with covariates population density (cpopdens),proportion of households with no vehicle (chousnhv) and proportion African-American (cafam).

Table 5.13 OLS covariates and probabilities (tgapstat)

Variable	Coefficient	Std. Error	t-statistic	Probability
constant	-9.194	6.494	-1.415	0.1579
tgapstat	6.163	2.943	2.09	0.0371
cpopdens	0.001	0.000	6.014	0.000
chousnvh	37.449	12.652	2.95	0.003
cafam	-11.220	5.791	-1.937	0.053

Similar to the diagnosis for spatial dependence for the pedestrian service areas, the two indicators suggest that the spatial lag model is a significant representation of the model whereas only one diagnostic indicator demonstrates significance for the spatial error model. The spatial regression utilizes the spatial lag model for tgapstat.

Table 5.14 Diagnostics for spatial dependence (tgapstat)

TEST	MI/DF	Value	Probability
Moran's I (error)	0.250	7.633	0.000
Lagrange Multiplier (lag)	1	59.905	0.000
Robust LM (lag)	1	8.755	0.003
Lagrange Multiplier (error)	1	51.186	0.000
Robust LM (error)	1	0.0355	0.850

The spatial lag model produces an R-squared = 0.424 with the following significance for covariates listed in Table 5.15. Tgapstat and Cafam lose significance using the spatial lag model although Tgapstat is close to significant (0.068) at the 95% confidence level. Population density (cpopdens) and mean number of households without a vehicle (chounvh) remain significant. Summary output for OLS regression and spatial regression for this analysis are in Table A19.

Table 5.15 Spatial lag model covariates and probabilities (tgapstat)

Variable	Coefficient	Std.Error	z-value	Probability
w_grocdens	0.617	0.057	10.746	0.000
constant	-13.087	5.567	-2.350	0.0187
tgapstat	4.616	2.533	1.822	0.0683
cpopdens	0.000	0.000	3.610	0.000
chousnvh	23.546	10.896	2.160	0.030
cafam	-4.320	4.995	-0.864	0.387

R-squared values for gapstat2 are similar to results for both gapstat and tgapstat and are not presented here but in the appendix Table A20. Gapstat2 is not significant as a factor for OLS regression or either spatial regression model.

C. Spatial Distribution of Produce Availability

Twenty supermarkets serve the study area providing 40,314 square feet of fresh fruit and vegetable shelf space. An additional 254 small grocers provide 109, 937 square feet of floor space, and 7,591 square feet of fresh fruit and vegetable shelf space. The total floor space for supermarkets is 312,156 square feet. The average small grocer is 432.8 square feet with 6.9 percent of floor space designated to fresh fruits and vegetables. For supermarkets the average floor size is 15,608 square feet with 12.9 percent of floor space designated to fresh fruits and vegetables.

The produce availability rate is the total fruit and vegetable shelf space per 1000 population. Considering the entire, 15 square mile study area during the time of data collection March 2007, the produce availability rate is 467.44 square feet of fresh fruit and vegetable space per 1000 population. In the supermarket service areas the produce availability rate is 887.30 square feet of fresh fruits and vegetables per 1000 population, in transition areas the comparable rate is 79.61 square feet of fresh fruits and vegetables per 1000 population and 90.14 square feet per 1000 population in gap areas.

Table 5.16 Produce accessibility for gap and service areas

Area	Total population	Total Stores (Supermarket and Small Grocers)		
		Count	Fruit & Veg Shelf Space (Sq Feet)	Produce Accessiblity Rate (Fruit and Vegetable Shelf Space sq feet per 1000 persons)
Entire Study Area	231249	274	47905	467.44
Pedestrian Gaps	57031	52	2752	90.14
Pedestrian Transition	73037	91	3796	79.61
Pedestrian Service	101181	125	41256	887.30
Public Transit Gaps	22913	9	150	5.43
Public Transit Service	208336	265	47755	540.68
Pedestrian and Public Transit Gaps	18021	6	128	5.89
Pedestrian or Public Transit Service	213228	268	47777	521.74

I show that the rate of produce space per 1000 residents for gap areas is less than that of functional areas of supermarkets by showing that the 95 percent confidence intervals of these rates do not overlap. This is the case as demonstrated in Table 5.17, where mean produce accessibility rates for pedestrian gap areas extending from -22.99 to 203.28, do not overlap with the 95 percent confidence interval for pedestrian service areas (290.61 – 1484.0). Neither do 95 percent confidence intervals overlap for public transit gap areas (0.07-10.79) and public transit service areas (205.02 – 876.34).

Table 5.17 Produce access rates means and confidence intervals

Area	Variable	Mean	N	Std. Deviation	Std. Error of Mean	95% Confidence Interval for Mean	
						Lower Bound	Upper Bound
Total Study Area		467.44	285	2489.35	147.46	177.19	757.68
Pedestrian Gap Area	(gapstat)	90.14	65	456.59	56.63	-22.99	203.28
Pedestrian Transition Area		79.61	84	594.93	64.91	-49.50	208.72
Pedestrian Service Area		887.30	136	3518.55	301.71	290.61	1484.00
Gaps & transitions grouped	(gapdich1)	84.21	149	537.28	44.02	-2.78	171.19
Service Areas		887.30	136	3518.55	301.71	290.61	1484.00
Gaps	(gapdich2)	90.14	65	456.59	56.63	-22.99	203.28
Service Areas & Transitions grouped		578.91	220	2814.33	189.74	204.96	952.87
Service areas & gaps grouped	(gapdich3)	629.51	201	2926.27	206.40	222.51	1036.52
Transition Areas		79.61	84	594.93	64.91	-49.50	208.72
Public Transit Gap Area	(tgapstat)	5.43	39	16.52	2.65	0.07	10.79
Public Transit Service Area		540.68	246	2672.81	170.41	205.02	876.34
Ped & Transit Gap Area	(gapstat2)	5.90	30	18.54	3.39	-1.02	12.82
Ped or Transit Service Area		521.74	255	2626.90	164.50	197.77	845.70

Produce Accessibility is negatively correlated with proportion of population African American (cAfAm) at -0.157 at the p = 0.01 level and also close to significant with proportion of population below the poverty level (cpopbepv) with a correlation of -0.104 and close to significant with gapdich1 where Pearson's correlation = -0.105.

Ordinary regression with produce accessibility (prodac1) as the dependent variable was calculated for each variable of pedestrian gapstat (gapdich1, gapdich2 and gapdich3), tgapstat and gapstat2 with several demographic covariates and also a street density variable. For each of gapdich1, gapdich2 and gapdich3, tgapstat and gapstat2, R-squared is extremely low (0.062). Individual covariates which are significant include proportion of African American population (cafam) and proportion of households with no vehicles (chousnvh).

Table 5.18 OLS covariates and probabilities (gapstat))

Variable	Coefficient	Std.Error	z-value	Probability
constant	631.232	596.979	1.057	0.291
gapstat	223.380	188.406	1.185	0.236
cafam	-1184.567	436.826	-2.711	0.007
cpubass	303.809	1484.645	0.204	0.838
cpubtrans	-712.363	1080.196	-0.659	0.510
chousnvh	2249.47	1119.498	2.009	0.045
cpopdens	-0.0196	0.011	-1.637	0.102
cpopbepv	1821.83	1125.882	-1.618	0.106
streets_mi	12.160	9.209	1.320	0.187

Diagnostics for spatial analysis indicate that a spatial process is in effect and can be identified in a high Moran's I and the significance of spatial regression indicators. The spatial lag model fails to identify any covariates with a significant relationship to the spatial distribution of produce accessibility.

Table 5.19 presents a value for Moran's I, a diagnostic indicator of spatial autocorrelation for the model (0.35) indicating a higher value and spatial clustering.

Spatial regression models also are significant and once again the spatial lag model shows higher significance than the spatial error model. In each case diagnostics for spatial regression indicate that the spatial lag model will be significant and the model produces a moderately strong R-squared (0.366) in each case indicating a strong spatial process. Individual covariates, presented in Table 5.20 are not significant. In the appendix, tables A21 through A24 present regression summary output for the dependent variable produce accessibility (prodac1) with gap status and demographic covariates.

Table 5.19 Diagnostics for spatial dependence (gapstat)

TEST	MI/DF	Value	Probability
Moran's I (error)	0.346	9.477	0.000
Lagrange Multiplier (lag)	1	80.244	0.000
Robust LM (lag)	1	1.395	0.237
Lagrange Multiplier (error)	1	78.977	0.000
Robust LM (error)	1	0.127	0.720

Table 5.20 Spatial lag model covariates and probabilities

Variable	Coefficient	Std.Error	z-value	Probability
w_prodac1	0.652	0.053	12.216	0.000
constant	140.208	484.08	0.289	0.772
gapstat	25.496	152.767	0.167	0.867
cafam	-527.305	359.421	-1.467	0.142
cpubass	641.409	1201.34	0.533	0.593
cpubtrans	-781.682	874.029	-0.894	0.371
chousnvh	1390.772	907.550	1.532	0.125
cpopdens	-0.012	0.009	-1.277	0.201
cpopbepv	-1165.873	911.014	-1.279	0.201
streets_mi	9.393	7.455	1.260	0.208

D. Fruit and Vegetable Intake

Hypothesis 4 states that within this sample of neighborhoods in south and southwest Philadelphia, accessibility to large supermarkets is correlated with neighborhood's aggregate intake of fruits and vegetables. Of 57 census tracts included in the study, nine fall totally within pedestrian gap areas and nine fell totally within the supermarket service areas. The remaining 39 census tracts were partially within the supermarket service areas.

Fruit Intake is a variable collected by the Philadelphia Health Management Corporation during their biannual community health survey. I used 2006 survey data in this analysis. The survey question is "how many servings of fruits and vegetables do you eat on a typical day?" Although the survey has more than 13,000 respondents in southeast Pennsylvania, 603 survey responses were tabulated from the neighborhoods of south and southwest Philadelphia used as the study area in this dissertation. Of the 603 respondents in a mean of 2.41 servings of fruits and vegetables is recorded as presented in Table 5.21.

Table 5.21 Q65 # servings fruits and vegetables per day

Community Label	Mean	N	Std. Deviation
Eastwick-Elmwood	2.46	108	1.265
GraysFerry-Passyunk	2.51	35	1.624
Paschall-Kingsessing	2.40	116	2.050
Pennsport-Queens village	2.47	61	1.683
SBroad-GirardEstates	2.25	94	1.585
Schuylkill-Pt Breeze	2.42	57	1.357
Snyder-Whitman	2.27	45	1.572
Southwark-Bellavista	2.54	88	1.346
Total	2.41	603	1.590

Data was tabulated at the census tract level and thus is not readily comparable to data aggregated at the census block group. In this step accessibility is measured as the mean of the shortest distances from each census block group centroid within a census tract to a supermarket in the study area. Shortest distances from each census block group centroid to the closest supermarket is recorded in Table 5.1 on page 88. Census tracts range from one to eight census block groups within each tract. For each census tract the mean distance and the mean fruit intake are correlated to produce a Pearson's Correlation Coefficient for the 57 populated census tracts within the study area. The Pearson's Coefficient is extremely weak and suggests that a direct correlation does not exist between fruit intake for residents within each census tract and the shortest distance to a supermarket. The only factor which demonstrates a correlation with either fruit intake or mean distance is population density which recorded a -0.474 correlation coefficient with mean distance ($p < 0.01$).

In Table 5.22 the census tracts were allocated to gap areas and service areas for pedestrians (gapstat), public transit (tgapstat) and for both pedestrian and public transit gap areas(gapstat2) as in earlier analyses in this dissertation. For pedestrian areas, census tracts that were completely within a supermarket service area or gap areas were designated to each category. If a census tract had more than one gap category among its component census block groups then it was allocated transitional. The majority of census tracts were divided among categories and allocated transitional. For the public transit gap and service areas, if a census tract had any component census block group designated as a gap then it was designated as a gap. The same technique was used for the census tracts in both pedestrian and public transit gap areas. The results for these designations are insignificant and in all cases the 95 percent confidence intervals overlap indicating that differences in means are not signficant.

Table 5.22 Fruit intake means and confidence intervals

Area	Mean (Fruit Intake)	N	Std. Dev	Std. Error of Mean	95% Confidence Interval for Mean		Mean Distance (Feet)
					Lower Bound	Upper Bound	
Total Study Area	2.41	57	0.77	0.10	2.21	2.61	3317.25
Pedestrian Gap Area	2.39	9	1.20	0.40	1.47	3.31	5961.49
Pedestrian Transition Area	2.44	39	0.64	0.10	2.24	2.65	3131.50
Pedestrian Service Area	2.28	9	0.84	0.28	1.63	2.92	1477.92
Public Transit Gap Area	2.50	22	0.89	0.19	2.11	2.90	4068.82
Public Transit Service Area	2.35	35	0.68	0.12	2.11	2.58	2844.83
Ped & Transit Gap Area	2.60	19	0.92	0.21	2.16	3.04	4435.61
Ped or Transit Service Area	2.31	38	0.67	0.11	2.09	2.54	2758.06

This section of analysis was handicapped by the lack of fruit intake data at the census block group level which was available for earlier steps. A further limitation to this step in the analysis is that the PHMC data question actually tabulated the average number of fruit and vegetable servings eaten daily by respondents This question does not differentiate fresh fruits and vegetables and canned, dried or frozen produce. The data collected from supermarkets is fresh fruit and vegetable shelf space. The comparison between daily fruit and vegetable intake and produce access is diminished somewhat by the lack of agreement between data types. Although this mismatch is realized, the larger discrepancy and flaw in the analysis is the lack of data at an equivalent spatial scale between grocer density and produce accessibility and fruit and vegetable intake values.

Chapter 6: Summary and Policy Recommendations

This study demonstrates the spatial variation in food accessibility which exists within a small geographic area in south and southwest Philadelphia. The entire Philadelphia metropolitan region is well situated as a port and is centrally located on the eastern coast of the United States with access to local agriculture and international food resources through neighboring port cities. Food accessibility only becomes an issue as the geography is considered on a local scale. Extremely high population density, congested neighborhoods and local poverty create barriers on free movement of goods and services into some areas. The neighborhoods of south and southwest Philadelphia are densely populated. After mapping the location of major supermarkets (greater than 5000 square feet) in eight Philadelphia neighborhoods, I calculated a probable service area for each supermarket. The concept of a service region from a neighborhood perspective suggests that the populace of each residential area within an urban area should have ready access to resources such as supermarkets which provide basic and nutritional foods. From the business perspective, a supermarket service region is a likely customer base. Supermarkets are businesses and not charities and the products on the shelves are products that sell. When nutritional foods are not in demand they are not stocked or less product is stocked. Although nutrition and promotion of healthy living is a nationally recognized health priority in schools and communities, basic economics do not allow low income residents to participate in healthy eating trends that are commonplace in most areas of the United States. Strategies to facilitate availability and affordability of basic nutritional foods, such as fruits and vegetables are critical to addressing diet related health issues in low income neighborhoods. Supermarkets and small grocers require incentives and assurances to become involved as facilitators and health promoters to low income populations. Knowledge of healthy eating alone does not change personal behavior or enable individuals to change their health habits.

A service region may be calculated differently to meet various objectives. Distance between people and the supermarket is one factor consumers and retailers consider, but cost, convenience, and selection are additional factors. Each of these consumer preferences can be integrated to calculate a variation of a supermarket shopping region. Initially, in this dissertation, the supermarket service area was calculated using a minimum travel distance for residents of census block groups to a local supermarket. Secondly, I calculated probable supermarket service areas, using total floor space and total fruit and vegetable space as attractiveness factors for each supermarket as well as distance. Using three formulas for service region calculation demonstrates the flexibility and variability possible when delimiting geographic service regions. This is exploratory research and is valuable because consumer choices and decisions are influenced by many personal choices and preferences. In this study, the delimitation of service regions based on distance, total floor space and fruit and vegetable shelf space demonstrated clearly geographic variation and variation in populations served. The five stores with the largest service areas (and more oriented to persons driving) are in three large neighborhoods with the lowest population densities and higher proportions of African Americans. Two of these larger, less dense neighborhoods also contain higher proportions of persons without vehicles. Smaller neighborhoods with higher population densities have a greater density of supermarkets resulting in smaller service areas, typically less than mile in area. In summary, every neighborhood has at least one supermarket within its bounds, although neighborhoods such as Southwark-Bella Vista and Pennsport-Queen Village have a greater concentration of supermarkets offering residents a wide selection of groceries including fresh fruits and vegetables. The best supermarket coverage or access within the study area is eight supermarkets for 48,212 people in 1.56 square miles. Excluding Southwark-Bella Vista and Pennsport-Queen Village in South Philadelphia, there are seven supermarkets to serve 107,328 people in an area of 8.05 square miles. In Southwest Philadelphia, three supermarkets serve 75,709 people in 4.93 square miles. Even this simple descriptive analysis shows a discrepancy in access to groceries within a high density area of Philadelphia.

The attractiveness variables have some effect on the size of the service areas but effects vary. The most influential factor appears to be whether a store is chain or non-chain. Two stores had a large increase in service area size by including total floor size, Pathmark #552 in Snyder-Whitman and BJ's Wholesale Market in Gray's Ferry. Pathmark #552 service area increased from 0.71 to 1.25 square miles. Within Snyder-Whitman, Pathmark #552 competes only with Aldi which lost service area when total floor size was included. BJ's Wholesale Market also expanded tremendously from an original gravity potential of 1.80 square miles to 3.73 square miles when total floor space is included. The disadvantage to BJ's is that most of the area gained through an increased attractiveness of total floor space is in low density Gray's Ferry. The sheer size of BJ's indicates that the targeted market is a more distant driving population rather than the immediate neighborhood.

Five other supermarkets experienced small growth in gravity potential (0.1 square miles or less) with the inclusion of total floor size. Three stores had absolutely no change in gravity potential based on total floor space and ten stores experienced a contraction in service area. The general trend is that smaller, non-chain supermarkets lost gravity potential and their service regions and populations served contracted with inclusion of total floor size as an attractiveness factor. Smaller stores target local populations.

The inclusion of fresh fruit and vegetable shelf space as an attractiveness factor also had impacts. With this factor included, six supermarkets increased their service regions, ten stores decreased their service regions and the service region of four stores did not change. The stores which increased service region were all large chain grocers, Acme, Shop Rite, Superfresh, Pathmark and BJ's with one exception. First Oriental is a local grocer which has a large fresh produce department and was able to increase its service area when this is included. This trend with large chain supermarkets increasing the size of produce departments is similar to trends nationwide where fresh produce is an aesthetic factor, adding value to grocery shopping. Although smaller stores are marketing to local populations, space limits the size of produce displays and the range of choices offered to local neighborhoods.

Cartographic representation of supermarket service areas suggest that drivers and households with vehicles are readily supplied with accessible grocery stores. Problems and limited supermarket access areas appear as potential gaps for those individuals limited to walking and constrained to the use of public transit.

Considering pedestrian access, about 43.8 percent of residents are within a ten minute walk of a supermarket, 24.7 percent are in gap areas further than ten minutes walking from a supermarket and the remaining 31.6 percent are classified as transitional within this study, possibly within ten minutes. Small but significant variable correlations exist between pedestrian gap status (gap, service area or transition area) and population density and proportion of households without a vehicle. Grocer density rates are not significantly different in pedestrian gaps (23.58 grocers per square mile) and service areas (31.19 grocers per square mile). Spatial regression indicates a relationship (R-squared = .43), between grocer density and gap or service area status and population covariates. Spatial regression does not assume complete spatial randomness that ordinary regression assumes. In fact, spatial autocorrelation for population variables are positive indicating spatial clustering in the data, although grocer density has a low positive spatial autocorrelation. The gap status variables for pedestrians are significant in the spatial regression model, as are population density and proportion of households without a vehicle.

Hypothesis 3 suggests that the produce accessibility rate (square feet of fruit and vegetable shelf space per 1000 population) is significantly greater in supermarket service areas than in gap areas. In pedestrian service areas the produce accessibility rate is 887.30 square feet of fresh fruit and vegetables per 1000 population, and in pedestrian gap areas the produce accessibility rate is 90.14 square feet of fresh fruit and vegetables per 1000 population. The 95 percent confidence intervals around the means do not overlap indicating statistical significance. The spatial regression model does corroborate that residents of census block groups falling into pedestrian gap areas have less access to supermarkets and grocers stocking fresh fruits and vegetables in the study area. The spatial lag model the relationship produces an R-squared = .37 indicating a moderately strong relationship between the covariates and the dependent variable produce accessibility. No individual covariate is significant in this model. Although OLS regression is weak all other statistics indicate that a strong relationship exists between location in a pedestrian gap area and low access to fresh fruit and vegetables.

Many indicators support the hypothesis that public transit service gaps and service areas are credible geographic classifications to indicate areas of greater and lesser access to fresh fruits and vegetables. Considering public transit supermarket service, 11.5 percent or 22, 913 residents live in public transit gap areas, of greater than ten minutes by transit to a supermarket. Transit gaps demonstrate significant correlations with many covariates including, population density, proportion African American, proportion of households without vehicles, and proportion of households relying on public transit for transportation to work. Grocer density mean data does demonstrate that the 95 percent confidence interval between the means clearly do not overlap suggesting that grocer density is significantly different for public transit gaps and public transit service areas. The mean grocer density for public transit service areas is (35.29 grocers per square mile) and the confidence interval extends from 30.61 to 39.97 grocers per square mile. For public transit gap areas the mean grocer density is 7.13 grocers per square mile with a 95 percent confidence gap of 4.23 to10.03 grocers per square mile. Ordinary regression on grocer density (grocdens) with the public transit gap areas included as a covariate (tgapstat) produces an R-squared = 0.27 with tgapstat showing a significant contribution to the model along with covariates population density (cpopdens), proportion of households with no vehicle (chousnhv) and proportion African-American (cafam). The spatial lag model produces a stronger relationship (R-squared = 0.424) indicating a spatial process is influencing grocer density in pedestrian gap and service areas.

The mean produce accessibility rate for public transit gap areas is 5.43 square feet of fresh fruit and vegetable shelf space for 1000 population and the mean for public transit service areas is 540.68 square feet of fresh fruit and vegetable shelf space per 1000 population. The 95 percent confidence intervals clearly do not overlap; gap areas (0.07-10.79) and public transit service areas (205.02 – 876.34). Although OLS regression on produce accessibility did not demonstrate a relationship, spatial autocorrelation indicates spatial clustering. The spatial lag model produced a moderate value indicator for the strength of the relationship between the covariates and the dependent variable produce accessibility. Thus in conclusion many statistical indicators identify a clear disparity or discrepancy between the access to grocers and fresh produce in public transit service areas compared to public transit gap areas.

Subsequently I also examined the distribution of areas which fall into both pedestrian gaps and public transit gaps to identify particularly problematic areas. Approximately 7.8 percent of the population fall into areas designated as pedestrian gaps and public transit gaps, areas which also demonstrated significant correlations with several demographic variables. Similarly, for areas falling into both public transit and pedestrian gap areas, the mean grocer density is 6.34 grocers per square mile with a 95 percent confidence interval of 3.65 to 9.64 grocers per square mile, compared to a larger grocer density mean of 34.39 for public transit service areas. The 95 percent confidence interval extends from 29.84 to 38.95 grocers per square mile.

Several future research topics include closer analysis of transit services from gaps to supermarkets; the study of food intake at a smaller geographic unit; private sector marketing and how large volume retailers such as BJs provide services to local neighborhoods; and the role of community, non-profit or faith-based agencies as a means of providing service and to gap areas. In this analysis the areas designated as public transit gap areas are statistically significant in terms of population density from supermarket service areas. The public transit network analysis is quite basic. The transit routes do not indicate whether each neighborhood is linked through a single mode of transit or whether multiple modes of transit are employed. The transit network simply demonstrates that each census block group has access to a supermarket via public transit within ten minutes according to speed limit travel times across the neighborhoods. This network does not incorporate traffic patterns or congestion. Nor does this network include frequency of buses, trains or subway, daytime, nighttime, weekday or weekend hours. An additional study question is how many neighborhoods are serviced by a single transit mode and how many neighborhoods and individuals are required to transfer or utilize two modes of transit to reach their shopping destination. Shopping convenience is certainly affected by the number of buses and transfers a rider needs to make to shop. A detailed transit analysis may indicate a much larger number of residents living outside a convenient distance to a supermarket.

Secondly further research is needed to clarify the relationship between food intake and neighborhood availability of fresh fruits and vegetables. In this study the discrepancy between the geographic level of detail in food intake data and food site data limited the quality of the analysis. No relationship was determined between fruit intake by census tract and location in a supermarket service area or gap area. The first analyses of service areas and gap areas occurred in smaller geographic units, census block groups, which were aggregated to larger census tracks to conduct a correlation analysis with the food intake variable obtained from the Philadelphia Health Management Corporation (PHMC) community database health survey. The final hypothesis that food intake will correlate significantly with supermarket service gaps is not supported through this analysis. No correlation between food intake and food availability or gap or service area status was indicated at the neighborhood level or in supermarket service areas and gaps. Although the final analysis with food intake is not supportive of the idea of nutritionally underserved areas, the fact that public transit and pedestrian service gaps were delineated cartographically and further supported with statistical indicators do imply that gaps and service areas can be defined within local geographies.

A third area for additional research is the study of the characteristics of the stores and supermarkets providing services to high density gap areas. Large volume stores such as BJ's specialize in bulk packaging which is not conducive for populations who may be walking and riding a bus to shop. The location in gap areas for such stores seems to be a matter of lower land costs to accommodate expansive shopping floors and parking lots rather than provide service to a geographically local population. Although the local neighborhood reaps benefits from the proximity of such large stores, more distant and affluent neighborhoods may be the primary target for BJ's marketing. Benefits to the local neighborhood are a spin off effect rather than as a primary service.

Lastly once gap areas are identified, another task is to document the current services being rendered to such underserved areas and which agencies whether government services, non-profits or faith-based agencies are attempting to provide services. Another research agenda is to identify the coping mechanisms for residents in gap areas and the potential which exists for better service provision.

Policy recommendations include closer examination of food environments in localized geographic settings. Food environment needs to be improved but in concert with education and efforts to motivate urban populations. Areas in less dense fringe neighborhoods may be less well served than centrally, older, higher density neighborhoods. A closer examination of the populations limited in mobility to public transportation such as seniors, youth, disabled and low income.

Geographic regionalization and small area analysis are tools for examining local health disparities. Grocery counts are not informative and need supplemental examination as to the quality of groceries offered. Specific healthy foods should be examined and need to be made available. City and local government should be offering incentives for small business owners or chains to look at establishing retail groceries in neighborhoods with a lower density of stores providing fresh fruits and vegetables. A clear abundance of grocers and fresh fruit and vegetable offerings exists in some sections of south Philadelphia, particularly near Southwark-Bella Vista and Pennsport-Queen Village neighborhoods. Other neighborhoods such as Grays Ferry and Eastwick-Elmwood, are much larger geographically with relatively dispersed populations, and have remarkably fewer grocery resources available. Lower density neighborhoods with relatively dispersed grocery resources are at a relative disadvantage for fresh fruit and vegetables and face the larger problem of learning how to adopt healthy eating behaviors.

Appendix

Table A1: Huff Model Probability Regions for Supermarkets using simple distance (PB1)

Huff Model Probability Regions, Populations Served by Large Supermarkets

Probability Group 1 Regions (PB1)

Destination	FREQ	Total Population (p001001)	Mean Population per Census Block Group	Median Income (p053001)	Mean Proportion African American (cafam)	Mean Population receiving Public Assistance (cpubass)	Mean Population Relying on Public Transportation (cpubtrans)	Mean Households without a Vehicle (chousnvh)	Mean Population Density (cpopdens)	Mean Population Below Poverty Level (cpopbepov)
1	32	30514	953.56	24823.78	0.11	0.03	0.11	0.46	36688.62165	0.27
2	16	10791	674.43	22645.69	0.64	0.13	0.31	0.51	7083.04	0.29
3	19	19340	1017.89	29528.89	0.63	0.05	0.15	0.33	7655.18	0.22
4	40	28246	706.15	21846.58	0.88	0.02	0.17	0.59	32248.27	0.32
5	7	4341	620.14	35952.57	0.04	0.03	0.15	0.45	29499.51	0.15
6	7	8559	1222.71	28030.29	0.15	0.03	0.07	0.37	37035.59	0.22
8	2	1289	644.50	45442.50	0.13	0.00	0.11	0.34	26851.93	0.08
10	17	19199	1129.35	29970.24	0.05	0.06	0.08	0.34	26867.11699	0.17
11	3	3058	1019.33	35849.00	0.07	0.06	0.04	0.26	9368.298511	0.18
12	18	16545	919.16	31887.06	0.22	NA	NA	0.43	8735.82178	0.22
13	7	4399	628.42	26689.29	0.52	NA	NA	0.48	2443.146444	0.44
14	39	32416	831.17	25815.92	0.67	0.03	0.12	0.43	16533.16604	0.31
15	15	8444	562.93	30023.53	0.64	0.01	0.19	0.54	22168.60638	0.26
16	5	2036	407.20	20033.20	0.52	0.02	0.07	0.67	23326.95547	0.42
17	15	11979	798.60	37185.07	0.25	0.01	0.13	0.40	28101.31393	0.24
18	9	4187	465.22	27953.00	0.63	0.03	0.28	0.55	17059.99315	0.24
19	31	23953	772.67	24647.58	0.93	0.07	0.13	0.50	25619.93548	0.29
20	3	1953	651.00	49132.33	0.06	0.03	0.28	0.36	25255.72554	0.10

Table A2: Huff Model Probability Regions for Supermarkets using Total Floor Size (PB2)

Huff Model Probability Regions, Populations Served by Large Supermarkets

Probability Group 2 Regions (PB2)

Destination	FREQ	Total Population (p001001)	Mean Population per Census Block Group	Median Income (p053001)	Mean Proportion African American (cafam)	Mean Population receiving Public Assistance (cpubass)	Mean Population Relying on Public Transportation (cpubtrans)	Mean Households without a Vehicle (chousnvh)	Mean Population Density (cpopdens)	Mean Population Below Poverty Level (cpopbepov)
1	36	33293	924.81	23850.17	0.17	0.03	0.11	0.47	37035.84	0.29
2	26	15835	609.04	21854.35	0.76	0.10	0.25	0.55	13477.09	0.30
3	19	19340	1017.89	29528.89	0.63	0.05	0.15	0.33	7655.18	0.22
4	19	11309	595.21	20515.42	0.96	0.03	0.20	0.61	31330.51	0.33
5	2	1198	599.00	37924.00	0.03	0.05	0.12	0.39	23937.98	0.15
6	5	4980	996.00	30115.00	0.04	0.03	0.08	0.31	34567.01	0.16
8	3	1802	600.67	43556.33	0.11	0.00	0.10	0.42	28927.34	0.13
9	2	1063	531.50	47438.50	0.01	0.00	0.19	0.16	19579.67	0.15
10	26	30849	1186.50	30047.54	0.10	0.05	0.07	0.36	24621.09	0.19
11	1	1464	1464.00	36087.00	0.06	0.01	0.00	0.30	27233.66	0.13
12	25	24439	977.56	30439.84	0.37	0.07	0.20	0.44	27001.70	0.22
13	10	5064	506.40	25506.00	0.48	16.35	39.88	0.50	1357.62	0.43
14	39	32416	831.18	25815.92	0.67	0.03	0.12	0.43	16533.17	0.31
15	10	6169	616.90	29646.90	0.64	0.02	0.25	0.52	32062.74	0.23
16	5	1750	350.00	22014.00	0.44	0.02	0.07	0.68	20978.18	0.39
17	10	6730	673.00	37031.30	0.25	0.02	0.12	0.41	25768.06	0.23
18	15	7171	478.07	29188.07	0.73	0.02	0.26	0.58	20502.51	0.28
19	27	22541	834.85	24437.93	0.95	0.03	0.10	0.50	27214.85	0.30
20	5	3836	767.20	48408.00	0.09	0.02	0.25	0.33	26907.40	0.12

Table A3: Huff Model Probability Regions for Supermarkets using Fresh Fruit and Vegetable Shelf Space (PB3)

Huff Model Probability Regions, Populations Served by Large Supermarkets

Probability Group 3 Regions (PB3)

Destination	FREQ	Total Population (p001001)	Mean Population per Census Block Group	Median Income (p053001)	Mean Proportion African American (cafam)	Mean Population receiving Public Assistance (cpubass)	Mean Population Relying on Public Transportation (cpubtrans)	Mean Households without a Vehicle (chousnvh)	Mean Population Density (cpopdens)	Mean Population Below Poverty Level (cpopbepov)
1	38	35686	939.11	24370.55	0.19	0.11	0.03	0.47	36759.22	0.27
2	20	13169	658.45	21770.25	0.74	0.26	0.07	0.55	13035.98	0.30
3	26	24907	957.96	28936.58	0.57	0.15	0.05	0.32	8927.44	0.23
4	22	14181	644.59	20228.05	0.96	0.15	0.02	0.61	31934.08	0.33
5	3	1721	573.67	36289.67	0.08	0.13	0.06	0.45	21745.45	0.11
6	7	8559	1222.71	28030.29	0.15	0.07	0.03	0.37	37035.59	0.22
8	1	529	529.00	40625.00	0.19	0.20	0.00	0.30	26314.48	0.07
10	21	23396	1114.10	30999.52	0.05	0.08	0.06	0.33	21934.11	0.17
11	1	1464	1464.00	36087.00	0.06	0.00	0.01	0.30	27233.66	0.13
12	18	17203	955.72	34195.94	0.27	0.24	0.09	0.39	25533.78	0.17
13	11	5630	511.82	23807.45	0.51	36.27	14.88	0.52	1484.91	0.45
14	35	29200	834.29	25333.34	0.75	0.10	0.03	0.47	16651.93	0.32
15	9	5835	648.33	26209.11	0.68	0.23	0.02	0.55	30945.55	0.26
16	21	9187	437.48	29701.67	0.65	0.24	0.02	0.57	21894.45	0.29
17	20	16780	839.00	35464.65	0.21	0.12	0.02	0.41	30443.50	0.25
18	1	247	247.00	21420.00	0.64	0.00	0.00	0.85	7638.55	0.49
19	28	21602	771.50	24747.39	0.92	0.14	0.07	0.49	24589.56	0.29
20	3	1953	651.00	49132.33	0.06	0.28	0.03	0.36	25255.73	0.10

Table A4: Pearson's Correlation, Pedestrian Gap Status (gapstat) with Grocer Density and Study Covariates

Pedestrian Gaps and Supermarket Service Area Correlations, Grocer Density

		Gapstat	h001001	cafam	cpubass	cpubtrans	chousnvh	cpopdens	cpopbepv	grocdens
Gapstat	Pearson Correlation	1	-.093	.098	-.079	.054	.202**	.167**	-.008	.058
	Sig. (2-tailed)		.116	.100	.186	.366	.001	.005	.894	.329
	N	285	285	285	285	285	285	285	285	285
h001001	Pearson Correlation	-.093	1	-.282**	-.219**	-.430**	-.178**	.453**	-.069	.187**
	Sig. (2-tailed)	.116		.000	.000	.000	.003	.000	.242	.001
	N	285	285	285	285	285	285	285	285	285
cafam	Pearson Correlation	.098	-.282**	1	.021	.084	.504**	-.194**	.441**	-.115
	Sig. (2-tailed)	.100	.000		.726	.159	.000	.001	.000	.053
	N	285	285	285	285	285	285	285	285	285
cpubass	Pearson Correlation	-.079	-.219**	.021	1	.340**	.004	-.330**	.082	-.120*
	Sig. (2-tailed)	.186	.000	.726		.000	.946	.000	.166	.042
	N	285	285	285	285	285	285	285	285	285
cpubtrans	Pearson Correlation	.054	-.430**	.084	.340**	1	-.050	-.311**	-.116	-.130*
	Sig. (2-tailed)	.366	.000	.159	.000		.399	.000	.051	.028
	N	285	285	285	285	285	285	285	285	285
chousnvh	Pearson Correlation	.202**	-.178**	.504**	.004	-.050	1	.029	.634**	.128*
	Sig. (2-tailed)	.001	.003	.000	.946	.399		.620	.000	.031
	N	285	285	285	285	285	285	285	285	285
cpopdens	Pearson Correlation	.167**	.453**	-.194**	-.330**	-.311**	.029	1	-.064	.435**
	Sig. (2-tailed)	.005	.000	.001	.000	.000	.620		.284	.000
	N	285	285	285	285	285	285	285	285	285
cpopbepv	Pearson Correlation	-.008	-.069	.441**	.082	-.116	.634**	-.064	1	.027
	Sig. (2-tailed)	.894	.242	.000	.166	.051	.000	.284		.655
	N	285	285	285	285	285	285	285	285	285
grocdens	Pearson Correlation	.058	.187**	-.115	-.120*	-.130*	.128*	.435**	.027	1
	Sig. (2-tailed)	.329	.001	.053	.042	.028	.031	.000	.655	
	N	285	285	285	285	285	285	285	285	285

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table A5: Pearson's Correlation, Gap Status Dichotomous Variables (gapdich1, gapdich2, gapdich3) with Grocer Density and Study Covariates

Gapstat Sub-category Dichotomy Correlations, Grocer Density

		gapdich1	gapdich2	gapdich3	h001001	cafam	cpubass	cpubtrans	chousnvh	cpopdens	cpopbepv	grocdens
gapdich1	Pearson Corr	1	.512**	.614**	.064	-.099	.098	-.039	-.057	.010	-.055	.072
	Sig. (2-tailed)		.000	.000	.278	.096	.098	.514	.341	.872	.352	.226
gapdich2	Pearson Corr	.512**	1	-.354**	.158**	-.030	.030	-.004	.012	.117*	.012	.105
	Sig. (2-tailed)	.000		.000	.008	.613	.615	.949	.840	.048	.846	.077
gapdich3	Pearson Corr	.614**	-.354**	1	-.069	-.088	.080	-.044	-.072	-.093	-.082	-.012
	Sig. (2-tailed)	.000	.000		.245	.140	.176	.462	.228	.117	.167	.836
h001001	Pearson Corr	.064	.158**	-.069	1	-.282**	-.219**	-.430**	-.178**	.453**	-.069	.187**
	Sig. (2-tailed)	.278	.008	.245		.000	.000	.000	.003	.000	.242	.001
cafam	Pearson Corr	-.099	-.030	-.088	-.282**	1	.021	.084	.504**	-.194**	.441**	-.115
	Sig. (2-tailed)	.096	.613	.140	.000		.726	.159	.000	.001	.000	.053
cpubass	Pearson Corr	.098	.030	.080	-.219**	.021	1	.340**	.004	-.330**	.082	-.120*
	Sig. (2-tailed)	.098	.615	.176	.000	.726		.000	.946	.000	.166	.042
cpubtrans	Pearson Corr	-.039	-.004	-.044	-.430**	.084	.340**	1	-.050	-.311**	-.116	-.130*
	Sig. (2-tailed)	.514	.949	.462	.000	.159	.000		.399	.000	.051	.028
chousnvh	Pearson Corr	-.057	.012	-.072	-.178**	.504**	.004	-.050	1	.029	.634**	.128*
	Sig. (2-tailed)	.341	.840	.228	.003	.000	.946	.399		.620	.000	.031
cpopdens	Pearson Corr	.010	.117*	-.093	.453**	-.194**	-.330**	-.311**	.029	1	-.064	.435**
	Sig. (2-tailed)	.872	.048	.117	.000	.001	.000	.000	.620		.284	.000
cpopbepv	Pearson Corr	-.055	.012	-.082	-.069	.441**	.082	-.116	.634**	-.064	1	.027
	Sig. (2-tailed)	.352	.846	.167	.242	.000	.166	.051	.000	.284		.655
grocdens	Pearson Corr	.072	.105	-.012	.187**	-.115	-.120*	-.130*	.128*	.435**	.027	1
	Sig. (2-tailed)	.226	.077	.836	.001	.053	.042	.028	.031	.000	.655	

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table A6: Pearson's Correlation, Public Transit Gap Status (tgapstat) with Grocer Density and Study Covariates

Transit Gaps and Service Area Correlations, Grocer Density

		Tgapstat	h001001	cafam	cpubass	cpubtrans	chousnvh	cpopdens	cpopbepv	grocdens
Tgapstat	Pearson Correlation	1	.176**	-.134*	-.242**	-.071	-.030	.415**	-.160**	.280**
	Sig. (2-tailed)		.003	.024	.000	.231	.615	.000	.007	.000
	N	285	285	285	285	285	285	285	285	285
h001001	Pearson Correlation	.176**	1	-.282**	-.219**	-.430**	-.178**	.453**	-.069	.187**
	Sig. (2-tailed)	.003		.000	.000	.000	.003	.000	.242	.001
	N	285	285	285	285	285	285	285	285	285
cafam	Pearson Correlation	-.134*	-.282**	1	.021	.084	.504**	-.194**	.441**	-.115
	Sig. (2-tailed)	.024	.000		.726	.159	.000	.001	.000	.053
	N	285	285	285	285	285	285	285	285	285
cpubass	Pearson Correlation	-.242**	-.219**	.021	1	.340**	.004	-.330**	.082	-.120*
	Sig. (2-tailed)	.000	.000	.726		.000	.946	.000	.166	.042
	N	285	285	285	285	285	285	285	285	285
cpubtrans	Pearson Correlation	-.071	-.430**	.084	.340**	1	-.050	-.311**	-.116	-.130*
	Sig. (2-tailed)	.231	.000	.159	.000		.399	.000	.051	.028
	N	285	285	285	285	285	285	285	285	285
chousnvh	Pearson Correlation	-.030	-.178**	.504**	.004	-.050	1	.029	.634**	.128*
	Sig. (2-tailed)	.615	.003	.000	.946	.399		.620	.000	.031
	N	285	285	285	285	285	285	285	285	285
cpopdens	Pearson Correlation	.415**	.453**	-.194**	-.330**	-.311**	.029	1	-.064	.435**
	Sig. (2-tailed)	.000	.000	.001	.000	.000	.620		.284	.000
	N	285	285	285	285	285	285	285	285	285
cpopbepv	Pearson Correlation	-.160**	-.069	.441**	.082	-.116	.634**	-.064	1	.027
	Sig. (2-tailed)	.007	.242	.000	.166	.051	.000	.284		.655
	N	285	285	285	285	285	285	285	285	285
grocdens	Pearson Correlation	.280**	.187**	-.115	-.120*	-.130*	.128*	.435**	.027	1
	Sig. (2-tailed)	.000	.001	.053	.042	.028	.031	.000	.655	
	N	285	285	285	285	285	285	285	285	285

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table A7: Pearson's Correlation, Pedestrian and Public Transit Gap Status (gapstat2) with Grocer Density and Study Covariates

Pedestrian and Transit Gaps Correlations

		Gapstat2	h001001	cafam	cpubass	cpubtrans	chousnvh	cpopdens	cpopbepv	grocdens
Gapstat2	Pearson Correlation	1	.124*	-.104	-.221**	-.133*	.027	.384**	-.157**	.240**
	Sig. (2-tailed)		.037	.081	.000	.025	.656	.000	.008	.000
h001001	Pearson Correlation	.124*	1	-.282**	-.219**	-.430**	-.178**	.453**	-.069	.187**
	Sig. (2-tailed)	.037		.000	.000	.000	.003	.000	.242	.001
cafam	Pearson Correlation	-.104	-.282**	1	.021	.084	.504**	-.194**	.441**	-.115
	Sig. (2-tailed)	.081	.000		.726	.159	.000	.001	.000	.053
cpubass	Pearson Correlation	-.221**	-.219**	.021	1	.340**	.004	-.330**	.082	-.120*
	Sig. (2-tailed)	.000	.000	.726		.000	.946	.000	.166	.042
cpubtrans	Pearson Correlation	-.133*	-.430**	.084	.340**	1	-.050	-.311**	-.116	-.130*
	Sig. (2-tailed)	.025	.000	.159	.000		.399	.000	.051	.028
chousnvh	Pearson Correlation	.027	-.178**	.504**	.004	-.050	1	.029	.634**	.128*
	Sig. (2-tailed)	.656	.003	.000	.946	.399		.620	.000	.031
cpopdens	Pearson Correlation	.384**	.453**	-.194**	-.330**	-.311**	.029	1	-.064	.435**
	Sig. (2-tailed)	.000	.000	.001	.000	.000	.620		.284	.000
cpopbepv	Pearson Correlation	-.157**	-.069	.441**	.082	-.116	.634**	-.064	1	.027
	Sig. (2-tailed)	.008	.242	.000	.166	.051	.000	.284		.655
grocdens	Pearson Correlation	.240**	.187**	-.115	-.120*	-.130*	.128*	.435**	.027	1
	Sig. (2-tailed)	.000	.001	.053	.042	.028	.031	.000	.655	

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Table A8: Pearson's Correlation, Pedestrian Gap Status (gapstat) with Produce Accessibility and Study Covariates

Pedestrian Gaps and Supermarket Service Area Correlations, Produce Accessibility

		prodac1	gapstat	h001001	cafam	cpubass	cpubtrans	chousnvh	cpopdens	cpopbepv
prodac1	Pearson Correlation	1	.095	-.039	-.157**	.001	-.011	.001	-.006	-.104
	Sig. (2-tailed)		.109	.508	.008	.989	.848	.984	.915	.080
gapstat	Pearson Correlation	.095	1	-.093	.098	-.079	.054	.202**	.167**	-.008
	Sig. (2-tailed)	.109		.116	.100	.186	.366	.001	.005	.894
h001001	Pearson Correlation	-.039	-.093	1	-.282**	-.219**	-.430**	-.178**	.453**	-.069
	Sig. (2-tailed)	.508	.116		.000	.000	.000	.003	.000	.242
cafam	Pearson Correlation	-.157**	.098	-.282**	1	.021	.084	.504**	-.194**	.441**
	Sig. (2-tailed)	.008	.100	.000		.726	.159	.000	.001	.000
cpubass	Pearson Correlation	.001	-.079	-.219**	.021	1	.340**	.004	-.330**	.082
	Sig. (2-tailed)	.989	.186	.000	.726		.000	.946	.000	.166
cpubtrans	Pearson Correlation	-.011	.054	-.430**	.084	.340**	1	-.050	-.311**	-.116
	Sig. (2-tailed)	.848	.366	.000	.159	.000		.399	.000	.051
chousnvh	Pearson Correlation	.001	.202**	-.178**	.504**	.004	-.050	1	.029	.634**
	Sig. (2-tailed)	.984	.001	.003	.000	.946	.399		.620	.000
cpopdens	Pearson Correlation	-.006	.167**	.453**	-.194**	-.330**	-.311**	.029	1	-.064
	Sig. (2-tailed)	.915	.005	.000	.001	.000	.000	.620		.284
cpopbepv	Pearson Correlation	-.104	-.008	-.069	.441**	.082	-.116	.634**	-.064	1
	Sig. (2-tailed)	.080	.894	.242	.000	.166	.051	.000	.284	

**. Correlation is significant at the 0.01 level (2-tailed).

Table A9: Pearson's Correlation, Pedestrian Gap Status Dichotomous Variables (gapdich1, gapdich2, gapdich3) with Produce Accessibility and Study Covariates

Gapstat Sub-category Dichotomy Correlations, Produce Accessibility

		prodac1	gapdich1	gapdich2	gapdich3	h001001	cafam	cpubass	cpubtrans	chousnvh	cpopdens	cpopbepv
prodac1	Pearson Correlation	1	-.105	-.057	-.063	-.039	-.157**	.001	-.011	.001	-.006	-.104
	Sig. (2-tailed)		.076	.341	.287	.508	.008	.989	.848	.984	.915	.080
	N	285	285	285	285	285	285	285	285	285	285	285
gapdich1	Pearson Correlation	-.105	1	.519**	.618**	.111	-.100	.088	-.027	-.126*	-.114	.069
	Sig. (2-tailed)	.076		.000	.000	.062	.093	.138	.654	.033	.054	.245
gapdich2	Pearson Correlation	-.057	.519**	1	-.351**	.047	-.068	.045	-.071	-.236**	-.183**	-.067
	Sig. (2-tailed)	.341	.000		.000	.434	.253	.448	.232	.000	.002	.259
gapdich3	Pearson Correlation	-.063	.618**	-.351**	1	.078	-.047	.055	.036	.078	.043	.138*
	Sig. (2-tailed)	.287	.000	.000		.187	.433	.355	.544	.188	.469	.020
h001001	Pearson Correlation	-.039	.111	.047	.078	1	-.282**	-.219**	-.430**	-.178**	.453**	-.069
	Sig. (2-tailed)	.508	.062	.434	.187		.000	.000	.000	.003	.000	.242
cafam	Pearson Correlation	-.157**	-.100	-.068	-.047	-.282**	1	.021	.084	.504**	-.194**	.441**
	Sig. (2-tailed)	.008	.093	.253	.433	.000		.726	.159	.000	.001	.000
cpubass	Pearson Correlation	.001	.088	.045	.055	-.219**	.021	1	.340**	.004	-.330**	.082
	Sig. (2-tailed)	.989	.138	.448	.355	.000	.726		.000	.946	.000	.166
cpubtrans	Pearson Correlation	-.011	-.027	-.071	.036	-.430**	.084	.340**	1	-.050	-.311**	-.116
	Sig. (2-tailed)	.848	.654	.232	.544	.000	.159	.000		.399	.000	.051
chousnvh	Pearson Correlation	.001	-.126*	-.236**	.078	-.178**	.504**	.004	-.050	1	.029	.634**
	Sig. (2-tailed)	.984	.033	.000	.188	.003	.000	.946	.399		.620	.000
cpopdens	Pearson Correlation	-.006	-.114	-.183**	.043	.453**	-.194**	-.330**	-.311**	.029	1	-.064
	Sig. (2-tailed)	.915	.054	.002	.469	.000	.001	.000	.000	.620		.284
cpopbepv	Pearson Correlation	-.104	.069	-.067	.138*	-.069	.441**	.082	-.116	.634**	-.064	1
	Sig. (2-tailed)	.080	.245	.259	.020	.242	.000	.166	.051	.000	.284	

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table A10: Pearson's Correlation, Public Transit (tgapstat) with Produce Accessibility and Study Covariates

Transit Gaps and Service Area Correlations, Produce Accessibility

		prodac1	tgapstat	h001001	cafam	cpubass	cpubtrans	chousnvh	cpopdens	cpopbepv
prodac1	Pearson Correlation	1	.073	-.039	-.157**	.001	-.011	.001	-.006	-.104
	Sig. (2-tailed)		.218	.508	.008	.989	.848	.984	.915	.080
tgapstat	Pearson Correlation	.073	1	.163**	-.133*	-.179**	-.083	-.044	.371**	-.151*
	Sig. (2-tailed)	.218		.006	.025	.002	.160	.463	.000	.011
h001001	Pearson Correlation	-.039	.163**	1	-.282**	-.219**	-.430**	-.178**	.453**	-.069
	Sig. (2-tailed)	.508	.006		.000	.000	.000	.003	.000	.242
cafam	Pearson Correlation	-.157**	-.133*	-.282**	1	.021	.084	.504**	-.194**	.441**
	Sig. (2-tailed)	.008	.025	.000		.726	.159	.000	.001	.000
cpubass	Pearson Correlation	.001	-.179**	-.219**	.021	1	.340**	.004	-.330**	.082
	Sig. (2-tailed)	.989	.002	.000	.726		.000	.946	.000	.166
cpubtrans	Pearson Correlation	-.011	-.083	-.430**	.084	.340**	1	-.050	-.311**	-.116
	Sig. (2-tailed)	.848	.160	.000	.159	.000		.399	.000	.051
chousnvh	Pearson Correlation	.001	-.044	-.178**	.504**	.004	-.050	1	.029	.634**
	Sig. (2-tailed)	.984	.463	.003	.000	.946	.399		.620	.000
cpopdens	Pearson Correlation	-.006	.371**	.453**	-.194**	-.330**	-.311**	.029	1	-.064
	Sig. (2-tailed)	.915	.000	.000	.001	.000	.000	.620		.284
cpopbepv	Pearson Correlation	-.104	-.151*	-.069	.441**	.082	-.116	.634**	-.064	1
	Sig. (2-tailed)	.080	.011	.242	.000	.166	.051	.000	.284	

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Table A11: Pearson's Correlation, Pedestrian and Public Transit Gap Status (gapstat2) with Produce Accessibility and Study Covariates

Pedestrian and Transit Gaps Correlations, Produce Accessibility

		prodac1	gapstat2	h001001	cafam	cpubass	cpubtrans	chousnvh	cpopdens	cpopbepv
prodac1	Pearson Correlation	1	.063	-.039	-.157**	.001	-.011	.001	-.006	-.104
	Sig. (2-tailed)		.290	.508	.008	.989	.848	.984	.915	.080
	N	285	285	285	285	285	285	285	285	285
gapstat2	Pearson Correlation	.063	1	.120*	-.096	-.229**	-.133*	.022	.369**	-.165**
	Sig. (2-tailed)	.290		.042	.104	.000	.025	.707	.000	.005
	N	285	285	285	285	285	285	285	285	285
h001001	Pearson Correlation	-.039	.120*	1	-.282**	-.219**	-.430**	-.178**	.453**	-.069
	Sig. (2-tailed)	.508	.042		.000	.000	.000	.003	.000	.242
	N	285	285	285	285	285	285	285	285	285
cafam	Pearson Correlation	-.157**	-.096	-.282**	1	.021	.084	.504**	-.194**	.441**
	Sig. (2-tailed)	.008	.104	.000		.726	.159	.000	.001	.000
	N	285	285	285	285	285	285	285	285	285
cpubass	Pearson Correlation	.001	-.229**	-.219**	.021	1	.340**	.004	-.330**	.082
	Sig. (2-tailed)	.989	.000	.000	.726		.000	.946	.000	.166
	N	285	285	285	285	285	285	285	285	285
cpubtrans	Pearson Correlation	-.011	-.133*	-.430**	.084	.340**	1	-.050	-.311**	-.116
	Sig. (2-tailed)	.848	.025	.000	.159	.000		.399	.000	.051
	N	285	285	285	285	285	285	285	285	285
chousnvh	Pearson Correlation	.001	.022	-.178**	.504**	.004	-.050	1	.029	.634**
	Sig. (2-tailed)	.984	.707	.003	.000	.946	.399		.620	.000
	N	285	285	285	285	285	285	285	285	285
cpopdens	Pearson Correlation	-.006	.369**	.453**	-.194**	-.330**	-.311**	.029	1	-.064
	Sig. (2-tailed)	.915	.000	.000	.001	.000	.000	.620		.284
	N	285	285	285	285	285	285	285	285	285
cpopbepv	Pearson Correlation	-.104	-.165**	-.069	.441**	.082	-.116	.634**	-.064	1
	Sig. (2-tailed)	.080	.005	.242	.000	.166	.051	.000	.284	
	N	285	285	285	285	285	285	285	285	285

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table A12: Population characteristics of Supermarket Service Areas and Gaps

Test of Homogeneity of Variances

	Levene Statistic	df1	df2	Sig.
grocdens	3.755	2	282	.025
h001001	4.557	2	282	.011
cpopdens	3.587	2	282	.029
cafam	6.681	2	282	.001
cpubass	2.266	2	282	.106
cpubtrans	2.224	2	282	.110
chousnvh	1.617	2	282	.200
cpopbepv	2.566	2	282	.079

Table A13: ANOVA Gapstat

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
grocdens	Between Groups	7554.647	2	3777.323	2.939	0.055
	Within Groups	362420.640	282	1285.180		
	Total	369975.286	284			
h001001	Between Groups	130819.764	2	65409.882	1.769	0.172
	Within Groups	10427709.022	282	36977.692		
	Total	10558528.786	284			
cpopdens	Between Groups	1848475714.406	2	924237857.203	4.950	0.008
	Within Groups	52650518315.301	282	186703965.657		
	Total	54498994029.707	284			
cafam	Between Groups	0.448	2	0.224	1.467	0.232
	Within Groups	43.041	282	0.153		
	Total	43.489	284			
cpubass	Between Groups	0.024	2	0.012	1.103	0.333
	Within Groups	3.058	282	0.011		
	Total	3.082	284			
cpubtrans	Between Groups	0.031	2	0.015	0.735	0.481
	Within Groups	5.915	282	0.021		
	Total	5.945	284			
chousnvh	Between Groups	0.487	2	0.243	8.291	0.000
	Within Groups	8.280	282	0.029		
	Total	8.767	284			
cpopbepv	Between Groups	0.154	2	0.077	2.778	0.064
	Within Groups	7.822	282	0.028		
	Total	7.976	284			

Table A13a: Tamhane Post Hoc Test for ANOVA

Dependent Variable	(I) gapstat	(J) gapstat	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
grocdens	-1	0	-14.343	5.787	0.042	-28.322	-0.365
		1	-7.615	5.128	0.364	-20.011	4.780
	0	-1	14.343	5.787	0.042	0.365	28.322
		1	6.728	5.134	0.472	-5.652	19.108
	1	-1	7.615	5.128	0.364	-4.780	20.011
		0	-6.728	5.134	0.472	-19.108	5.652
h001001	-1	0	-6.830	34.740	0.996	-90.798	77.137
		1	38.762	29.843	0.482	-33.642	111.166
	0	-1	6.830	34.740	0.996	-77.137	90.798
		1	45.592	27.259	0.262	-20.236	111.421
	1	-1	-38.762	29.843	0.482	-111.166	33.642
		0	-45.592	27.259	0.262	-111.421	20.236
cpopdens	-1	0	-5569.954	2387.769	0.062	-11337.259	197.351
		1	-6303.701	1940.393	0.005	-11003.071	-1604.331
	0	-1	5569.954	2387.769	0.062	-197.351	11337.259
		1	-733.747	2038.396	0.978	-5658.636	4191.142
	1	-1	6303.701	1940.393	0.005	1604.331	11003.071
		0	733.747	2038.396	0.978	-4191.142	5658.636
cafam	-1	0	-0.021	0.060	0.981	-0.167	0.125
		1	-0.090	0.057	0.313	-0.227	0.048
	0	-1	0.021	0.060	0.981	-0.125	0.167
		1	-0.069	0.054	0.497	-0.199	0.062
	1	-1	0.090	0.057	0.313	-0.048	0.227
		0	0.069	0.054	0.497	-0.062	0.199
cpubass	-1	0	0.000	0.019	1.000	-0.046	0.046
		1	0.018	0.013	0.439	-0.014	0.051
	0	-1	0.000	0.019	1.000	-0.046	0.046
		1	0.018	0.017	0.616	-0.022	0.059
	1	-1	-0.018	0.013	0.439	-0.051	0.014
		0	-0.018	0.017	0.616	-0.059	0.022
cpubtrans	-1	0	-0.027	0.022	0.514	-0.079	0.025
		1	-0.023	0.018	0.508	-0.067	0.021
	0	-1	0.027	0.022	0.514	-0.025	0.079
		1	0.004	0.022	0.997	-0.048	0.057
	1	-1	0.023	0.018	0.508	-0.021	0.067
		0	-0.004	0.022	0.997	-0.057	0.048
chousnvh	-1	0	-0.097	0.030	0.005	-0.171	-0.024
		1	-0.099	0.025	0.000	-0.161	-0.038
	0	-1	.09725440109890*	0.030	0.005	0.024	0.171
		1	-0.002	0.025	1.000	-0.062	0.058
	1	-1	.09924430656109*	0.025	0.000	0.038	0.161
		0	0.002	0.025	1.000	-0.058	0.062
cpopbepv	-1	0	-0.056	0.031	0.206	-0.132	0.019
		1	-0.009	0.026	0.983	-0.072	0.055
	0	-1	0.056	0.031	0.206	-0.019	0.132
		1	0.048	0.024	0.137	-0.010	0.105
	1	-1	0.009	0.026	0.983	-0.055	0.072
		0	-0.048	0.024	0.137	-0.105	0.010

*. The mean difference is significant at the 0.05 level.

Table A14: T-Test for Public Transit Service Areas and Gaps

Group Statistics

	gapstat2	N	Mean	Std. Deviation	Std. Error Mean
h001001	1	254	377.114	191.848	12.038
	-1	31	300.613	190.172	34.156
cpopdens	1	254	28599.913	13152.239	825.245
	-1	31	11540.468	9476.733	1702.071
cafam	1	254	0.505	0.391	0.025
	-1	31	0.635	0.384	0.069
cpubass	1	254	0.038	0.086	0.005
	-1	31	0.112	0.189	0.034
cpubtrans	1	254	0.130	0.143	0.009
	-1	31	0.192	0.147	0.026
chousnvh	1	254	0.465	0.169	0.011
	-1	31	0.450	0.228	0.041
cpopbepv	1	254	0.260	0.149	0.009
	-1	31	0.344	0.268	0.048
grocdens	1	254	34.466	36.994	2.321
	-1	31	6.646	8.842	1.588

Table A14a: T-Test for Public Transit Service Areas and Gaps, Independent Sample Test

	Levene's Test for Equality of Variances		t-test for Equality of Means					95% Confidence Interval of the Difference
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower, Upper
h001001	.307	.580	3.253	60.013	.002	95.762	29.437	36.880, 154.645
cpopdens	.959	.328	8.576	62.126	.000	16192.948	1888.275	12418.493, 19967.403
cafam	.798	.372	-2.319	57.065	.024	-0.148	0.064	-0.275, -0.020
cpubass	35.797	.000	-2.364	43.235	.023	-0.071	0.030	-0.131, -0.010
cpubtrans	.319	.573	-1.227	57.187	.225	-0.029	0.024	-0.076, 0.018
chousnvh	8.725	.003	-.406	48.977	.686	-0.015	0.036	-0.088, 0.058
cpopbepv	22.443	.000	-1.928	46.224	.060	-0.076	0.039	-0.154, 0.003
grocdens	22.644	.000	10.336	263.590	.000	28.428	2.750	23.013, 33.844

Equal variances not assumed

Table A15: T-Test for Areas in pedestrian and public transit gaps and other areas (gapstat2)

Group Statistics

	gapstat2	N	Mean	Std. Deviation	Std. Error Mean
h001001	1	254	377.114	191.848	12.038
	-1	31	300.613	190.172	34.156
cpopdens	1	254	28599.913	13152.239	825.245
	-1	31	11540.468	9476.733	1702.071
cafam	1	254	0.505	0.391	0.025
	-1	31	0.635	0.384	0.069
cpubass	1	254	0.038	0.086	0.005
	-1	31	0.112	0.189	0.034
cpubtrans	1	254	0.130	0.143	0.009
	-1	31	0.192	0.147	0.026
chousnvh	1	254	0.465	0.169	0.011
	-1	31	0.450	0.228	0.041
cpopbepv	1	254	0.260	0.149	0.009
	-1	31	0.344	0.268	0.048
grocdens	1	254	34.466	36.994	2.321
	-1	31	6.646	8.842	1.588

Table A15a: T-Test for Areas in pedestrian and public transit gaps and other areas (gapstat2), Independent Sample Tests

	Levene's Test for Equality of Variances		t-test for Equality of Means					
								95% Confidence Interval of the Difference
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower, Upper
h001001	.051	.821	2.112	37.846	.041	76.501	36.215	3.178, 149.825
cpopdens	2.899	.090	9.019	45.465	.000	17059.446	1891.580	13250.681, 20868.210
cafam	.502	.479	-1.778	38.005	.083	-0.130	0.073	-0.278, 0.018
cpubass	22.786	.000	-2.148	31.524	.039	-0.074	0.034	-0.144, -0.004
cpubtrans	.653	.420	-2.208	37.269	.033	-0.062	0.028	-0.118, -0.005
chousnvh	3.843	.051	.354	34.147	.726	0.015	0.042	-0.071, 0.101
cpopbepv	28.055	.000	-1.726	32.305	.094	-0.085	0.049	-0.184, 0.015
grocdens	16.871	.000	9.891	191.468	.000	27.820	2.813	22.272, 33.367

Equal variances not assumed

Table A16: Regression Summary Output for Ordinary Least Squares (OLS); Spatial Lag and Spatial Error Regression Models; Dependent Variable Grocery Density (grocdens) and multiple covariates including gapdich1

Dependent Variable	GROCDENS		
Number of Observations	285		
Mean dependent var	31.44		
S.D. dependent var	36.03		
	OLS	**Spatial Lag**	**Spatial Error**
Number of Variables	6	7	6
Degrees of Freedom	279	278	279
R-squared	0.220	0.427	0.419
F-statistic	15.697		
S.E. of regression	32.171	27.272	27.470
Lag Coefficient		0.628	0.658

OLS

Variable	**Coefficient**	**Std.Error**	**t-Statistic**	**Probability**
constant	-14.864	8.273	-1.797	0.073
gapdich1	5.542	4.021	1.378	0.169
cpopdens	0.001	0.000	6.751	0.000
chousnvh	37.610	12.767	2.946	0.003
cafam	-10.528	5.899	-1.785	0.075
streets_mi	0.102	0.126	0.807	0.420

Spatial Lag

Variable	**Coefficient**	**Std.Error**	**z-value**	**Probability**
w_grocdens	0.628	0.057	11.092	0.000
constant	-20.044	7.020	-2.855	0.004
gapdich1	6.545	3.410	1.920	0.055
cpopdens	0.001	0.000	4.162	0.000
chousnvh	23.778	10.874	2.187	0.029
cafam	-3.246	5.040	-0.644	0.520
streets_mi	0.103	0.107	0.967	0.333

Spatial Error

Variable	**Coefficient**	**Std.Error**	**z-value**	**Probability**
constant	-1.091	9.440	-0.116	0.908
gapdich1	7.655	4.666	1.641	0.101
cpopdens	0.001	0.000	3.739	0.000
chousnvh	24.534	12.045	2.037	0.042
cafam	-10.877	8.620	-1.262	0.207
streets_mi	0.157	0.103	1.531	0.126
LAMBDA	0.658	0.057	11.458	0.000

Table A17: Regression Summary Output for Ordinary Least Squares (OLS); Spatial Lag and Spatial Error Regression Models; Dependent Variable Grocery Density (grocdens) and multiple covariates including gapdich2

Dependent Variable	GROCDENS		
Number of Observations	285		
Mean dependent var	31.44		
S.D. dependent var	36.03		
	OLS	**Spatial Lag**	**Spatial Error**
Number of Variables	6	7	6
Degrees of Freedom	279	278	279
R-squared	0.214	0.419	0.413
F-statistic	15.217		
S.E. of regression	32.279	27.463	27.594
Lag Coefficient		0.624	0.656

OLS

Variable	**Coefficient**	**Std.Error**	**t-Statistic**	**Probability**
constant	-8.777	8.097	-1.084	0.279
gapdich2	-0.600	4.869	-0.123	0.902
streets_mi	0.053	0.124	0.426	0.670
cpopdens	0.001	0.000	6.664	0.000
chousnvh	36.300	13.060	2.779	0.006
cafam	-11.400	5.885	-1.937	0.054

Spatial Lag

Variable	**Coefficient**	**Std.Error**	**z-value**	**Probability**
w_grocdens	0.624	0.057	10.870	0.000
constant	-14.533	6.910	-2.103	0.035
gapdich2	1.559	4.159	0.375	0.708
streets_mi	0.058	0.106	0.545	0.586
cpopdens	0.001	0.000	4.158	0.000
chousnvh	23.573	11.158	2.113	0.035
cafam	-4.311	5.052	-0.853	0.393

Spatial Error

Variable	**Coefficient**	**Std.Error**	**z-value**	**Probability**
constant	5.532	9.217	0.600	0.548
gapdich2	-3.660	6.884	-0.532	0.595
streets_mi	0.139	0.103	1.356	0.175
cpopdens	0.001	0.000	3.560	0.000
chousnvh	25.149	12.112	2.076	0.038
cafam	-12.301	8.597	-1.431	0.152
LAMBDA	0.656	0.058	11.397	0.000

Table A18: Regression Summary Output for Ordinary Least Squares (OLS); Spatial Lag and Spatial Error Regression Models; Dependent Variable Grocery Density (grocdens) and multiple covariates including gapdich3

Dependent Variable	GROCDENS		
Number of Observations	285		
Mean dependent var	31.44		
S.D. dependent var	36.03		
	OLS	**Spatial Lag**	**Spatial Error**
Number of Variables	6	7	6
Degrees of Freedom	279	278	279
R-squared	0.221	0.424	0.419
F-statistic	15.834		
S.E. of regression	32.140	27.339	27.452
Lag Coefficient		0.622	0.654

OLS

Variable	**Coefficient**	**Std.Error**	**t-Statistic**	**Probability**
constant	-10.966	7.271	-1.508	0.133
gapdich3	6.615	4.234	1.562	0.119
cpopdens	0.001	0.000	6.633	0.000
chousnvh	34.207	12.828	2.667	0.008
cafam	-10.422	5.893	-1.769	0.078
STREETS_MI	0.076	0.122	0.625	0.533

Spatial Lag

Variable	**Coefficient**	**Std.Error**	**z-value**	**Probability**
w_grocdens	0.622	0.057	10.963	0.000
constant	-14.945	6.186	-2.416	0.016
gapdich3	6.075	3.614	1.681	0.093
cpopdens	0.001	0.000	4.067	0.000
chousnvh	20.531	10.978	1.870	0.061
cafam	-3.446	5.049	-0.683	0.495
STREETS_MI	0.068	0.104	0.654	0.513

Spatial Error

Variable	**Coefficient**	**Std.Error**	**z-value**	**Probability**
constant	1.427	8.942	0.160	0.873
gapdich3	8.028	4.317	1.860	0.063
cpopdens	0.001	0.000	3.621	0.000
chousnvh	23.514	12.071	1.948	0.051
cafam	-10.534	8.593	-1.226	0.220
STREETS_MI	0.157	0.102	1.531	0.126
LAMBDA	0.654	0.058	11.317	0.000

Table A19: Regression Summary Output for Ordinary Least Squares (OLS); Spatial Lag and Spatial Error Regression Models; Dependent Variable Grocery Density (grocdens) and multiple covariates including tgapstat

Dependent Variable	GROCDENS		
Number of Observations	285		
Mean dependent var	31.44		
S.D. dependent var	36.03		
	OLS	**Spatial Lag**	**Spatial Error**
Number of Variables	5	6	5
Degrees of Freedom	280	279	280
R-squared	0.226	0.424	0.419
F-statistic	20.411		
S.E. of regression	31.985	27.351	27.475
Lag Coefficient		0.617	0.649

OLS

Variable	Coefficient	Std.Error	t-Statistic	Probability
constant	-9.194	6.494	-1.416	0.158
tgapstat	6.164	2.943	2.094	0.037
cpopdens	0.001	0.000	6.015	0.000
chousnvh	37.449	12.652	2.960	0.003
cafam	-11.221	5.792	-1.937	0.054

Spatial Lag

Variable	Coefficient	Std.Error	z-value	Probability
w_grocdens	0.617	0.057	10.746	0.000
constant	-13.088	5.567	-2.351	0.019
tgapstat	4.616	2.533	1.822	0.068
cpopdens	0.000	0.000	3.610	0.000
chousnvh	23.547	10.897	2.161	0.031
cafam	-4.321	4.996	-0.865	0.387

Spatial Error

Variable	Coefficient	Std.Error	z-value	Probability
constant	5.952	8.188	0.727	0.467
tgapstat	6.564	2.822	2.326	0.020
cpopdens	0.001	0.000	3.376	0.001
chousnvh	25.696	11.998	2.142	0.032
cafam	-11.915	8.501	-1.402	0.161
LAMBDA	0.649	0.058	11.114	0.000

Table A20: Regression Summary Output for Ordinary Least Squares (OLS); Spatial Lag and Spatial Error Regression Models; Dependent Variable Grocery Density (grocdens) and multiple covariates including gapstat2

Dependent Variable	GROCDENS		
Number of Observations	285		
Mean dependent var	31.44		
S.D. dependent var	36.03		
	OLS	**Spatial Lag**	**Spatial Error**
Number of Variables	5	6	5
Degrees of Freedom	280	279	285
R-squared	0.219	0.420	0.413
F-statistic	19.618		
S.E. of regression	32.126	27.439	27.607
Lag Coefficient		0.619	0.650

OLS

Variable	**Coefficient**	**Std.Error**	**t-Statistic**	**Probability**
constant	-9.206	6.568	-1.402	0.162
gapstat2	4.556	3.314	1.375	0.170
cpopdens	0.001	0.000	6.421	0.000
cafam	-11.348	5.819	-1.950	0.052
chousnvh	36.298	12.716	2.854	0.005

Spatial Lag

Variable	**Coefficient**	**Std.Error**	**z-value**	**Probability**
w_grocdens	0.619	0.057	10.810	0.000
constant	-13.047	5.623	-2.320	0.020
gapstat2	3.190	2.842	1.122	0.262
cpopdens	0.001	0.000	3.945	0.000
cafam	-4.405	5.016	-0.878	0.380
chousnvh	22.659	10.933	2.072	0.038

Spatial Error

Variable	**Coefficient**	**Std.Error**	**z-value**	**Probability**
constant	6.376	8.277	0.770	0.441
gapstat2	5.010	3.133	1.599	0.110
cpopdens	0.001	0.000	3.591	0.000
cafam	-12.458	8.544	-1.458	0.145
chousnvh	24.702	12.046	2.051	0.040
LAMBDA	0.650	0.058	11.144	0.000

Table A21: Regression Summary Output for Ordinary Least Squares (OLS); Spatial Lag and Spatial Error Regression Models; Dependent Variable Produce Accessibility (PRODAC1) and multiple covariates including gapdich1

Dependent Variable	PRODAC1		
Number of Observations	285		
Mean dependent var	473.748		
S.D. dependent var	2371.06		
	OLS	**Spatial Lag**	**Spatial Error**
Number of Variables	6	7	6
Degrees of Freedom	279	278	279
R-squared	0.056	0.386	0.390
F-statistic	3.309		
S.E. of regression	2328.380	1857.970	1851.740
Lag Coefficient		0.726	0.736

OLS

Variable	**Coefficient**	**Std.Error**	**t-Statistic**	**Probability**
constant	813.192	598.776	1.358	0.176
gapdich1	-491.485	290.992	-1.689	0.092
chousnvh	1399.734	924.001	1.515	0.131
cpopdens	-0.017	0.011	-1.509	0.132
cafam	-1361.651	426.958	-3.189	0.002
STREETS_MI	11.210	9.100	1.232	0.219

Spatial Lag

Variable	**Coefficient**	**Std.Error**	**z-value**	**Probability**
W_PRODAC1	0.726	0.049	14.727	0.000
constant	59.827	479.126	0.125	0.901
gapdich1	-71.793	232.710	-0.309	0.758
chousnvh	762.168	740.349	1.029	0.303
cpopdens	-0.011	0.009	-1.221	0.222
cafam	-578.665	348.041	-1.663	0.096
STREETS_MI	9.010	7.267	1.240	0.215

Spatial Error

Variable	**Coefficient**	**Std.Error**	**z-value**	**Probability**
constant	376.639	695.933	0.541	0.588
gapdich1	-49.533	324.041	-0.153	0.879
chousnvh	1204.584	816.994	1.474	0.140
cpopdens	-0.009	0.011	-0.835	0.404
cafam	-1130.095	623.706	-1.812	0.070
streets_mi	10.181	6.849	1.486	0.137
LAMBDA	0.736	0.049	15.092	0.000

Table A22: Regression Summary Output for Ordinary Least Squares (OLS); Spatial Lag and Spatial Error Regression Models; Dependent Variable Produce Accessibility (PRODAC1) and multiple covariates including gapdich2

Dependent Variable	GROCDENS		
Number of Observations	285		
Mean dependent var	473.748		
S.D. dependent var	2371.06		
	OLS	**Spatial Lag**	**Spatial Error**
Number of Variables	6	7	6
Degrees of Freedom	279	278	279
R-squared	0.048	0.386	0.390
F-statistic	2.796		
S.E. of regression	2338.560	1857.340	1851.170
Lag Coefficient		0.728	0.737

OLS				
Variable	**Coefficient**	**Std.Error**	**t-Statistic**	**Probability**
constant	482.784	586.637	0.823	0.411
gapdich2	-224.443	352.746	-0.636	0.525
cpopdens	-0.017	0.011	-1.519	0.130
chousnvh	1365.041	946.201	1.443	0.150
cafam	-1286.880	426.393	-3.018	0.003
streets_mi	14.078	9.006	1.563	0.119

Spatial Lag				
Variable	**Coefficient**	**Std.Error**	**z-value**	**Probability**
W_PRODAC1	0.728	0.049	14.833	0.000
constant	9.680	467.156	0.021	0.983
gapdich2	-31.569	280.677	-0.112	0.910
cpopdens	-0.011	0.009	-1.219	0.223
chousnvh	755.656	753.801	1.002	0.316
cafam	-565.611	345.529	-1.637	0.102
streets_mi	9.418	7.159	1.316	0.188

Spatial Error				
Variable	**Coefficient**	**Std.Error**	**z-value**	**Probability**
constant	402.676	679.567	0.593	0.553
gapdich2	-184.986	493.479	-0.375	0.708
cpopdens	-0.010	0.011	-0.869	0.385
chousnvh	1177.849	816.496	1.443	0.149
cafam	-1110.201	620.270	-1.790	0.073
STREETS_MI	10.308	6.820	1.511	0.131
LAMBDA	0.737	0.049	15.117	0.000

Table A23: Regression Summary Output for Ordinary Least Squares (OLS); Spatial Lag and Spatial Error Regression Models; Dependent Variable Produce Accessibility (PRODAC1) and multiple covariates including gapdich3

Dependent Variable	PRODAC1		
Number of Observations	285		
Mean dependent var	473.748		
S.D. dependent var	2371.06		
	OLS	**Spatial Lag**	**Spatial Error**
Number of Variables	6	7	6
Degrees of Freedom	279	278	279
R-squared	0.051	0.386	0.390
F-statistic	3.023		
S.E. of regression	2334.040	1857.620	1851.270
Lag Coefficient		0.728	0.738

OLS

Variable	**Coefficient**	**Std.Error**	**t-Statistic**	**Probability**
constant	411.967	528.068	0.780	0.436
gapdich3	-374.864	307.464	-1.219	0.224
cpopdens	-0.016	0.011	-1.401	0.162
chousnvh	1624.107	931.613	1.743	0.082
cafam	-1339.893	427.952	-3.131	0.002
STREETS_MI	14.100	8.853	1.593	0.112

Spatial Lag

Variable	**Coefficient**	**Std.Error**	**z-value**	**Probability**
W_PRODAC1	0.728	0.049	14.794	0.000
constant	0.675	420.960	0.002	0.999
gapdich3	-54.728	244.730	-0.224	0.823
cpopdens	-0.011	0.009	-1.200	0.230
chousnvh	793.763	744.491	1.066	0.286
cafam	-574.306	347.501	-1.653	0.098
STREETS_MI	9.423	7.054	1.336	0.182

Spatial Error

Variable	**Coefficient**	**Std.Error**	**z-value**	**Probability**
constant	333.516	669.722	0.498	0.618
gapdich3	25.567	295.217	0.087	0.931
cpopdens	-0.009	0.011	-0.830	0.407
chousnvh	1189.282	818.829	1.452	0.146
cafam	-1111.859	625.164	-1.779	0.075
STREETS_MI	10.324	6.846	1.508	0.132
LAMBDA	0.738	0.049	15.162	0.000

Table A24: Regression Summary Output for Ordinary Least Squares (OLS); Spatial Lag Models; Dependent Variable Produce Accessibility (PRODAC1) and multiple covariates including tgapstat

Dependent Variable	PRODAC1	
Number of Observations	285	
Mean dependent var	473.748	
S.D. dependent var	2371.06	
	OLS	**Spatial Lag**
Number of Variables	5	6
Degrees of Freedom	280	279
R-squared	0.052	0.364
F-statistic	2.168	
S.E. of regression	2341.760	1891.240
Lag Coefficient		0.655

OLS Variable	**Coefficient**	**Std.Error**	**t-Statistic**	**Probability**
constant	714.333	545.295	1.310	0.191
tgapstat	230.530	220.134	1.047	0.296
cafam	-1221.095	433.254	-2.818	0.005
cpubass	145.843	1487.066	0.098	0.922
cpubtrans	-418.206	1072.523	-0.390	0.697
chousnvh	2623.794	1096.940	2.392	0.017
cpopdens	-0.015	0.012	-1.308	0.192
cpopbepv	-1948.826	1124.360	-1.733	0.084

Spatial Lag Variable	**Coefficient**	**Std.Error**	**z-value**	**Probability**
W_PRODAC1	0.655	0.053	12.298	0.000
constant	305.437	442.052	0.691	0.490
tgapstat	108.560	177.802	0.611	0.541
cafam	-574.799	355.171	-1.618	0.106
cpubass	541.662	1201.159	0.451	0.652
cpubtrans	-634.779	866.192	-0.733	0.464
chousnvh	1490.741	887.147	1.680	0.093
cpopdens	-0.010	0.010	-0.993	0.321
cpopbepv	-1163.241	908.057	-1.281	0.200

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