FINDING FOOD DESERTS:

A STUDY OF FOOD ACCESS MEASURES IN THE PHOENIX-MESA URBAN AREA

by

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DEDICATION

Eighty-two percent of this thesis is dedicated to my parents, Carl and Cynthia, for all the usual reasons and plenty of weird ones as well. I love you and thanks for loving me.

The remainder is dedicated to the rest of my village. Thanks for the overflowing love and support.

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I would also like to thank coffee.

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LIST OF ABBREVIATIONS

APHA	American Public Health Association
CDC	Centers for Disease Control and Prevention
DHHS	Department of Health and Human Services
ERS	Economic Research Service
FAO	Food and Agriculture Organization
FMI	Food Marketing Institute
GIS	Geographic Information System
HFAI	Healthy Food Availability Index
NAICS	North American Industry Classification System
UA	Urban Area
USDA	United States Department of Agriculture

ABSTRACT

Adequate access to healthy food is often considered a basic human right and ensuring that all communities have equal access to healthy food options has emerged as a focus of environmental justice activists and public policy in the United States. Increased attention and interest in locating food deserts over the last decade has resulted in many attempts at identifying areas with insufficient access to healthy foods. Many researchers and agencies have developed specific measures of food access, but these measures and indicators have not been compared methodically in terms of food desert locations identified or populations affected. This study examines and compares how varying the definition of 'food desert' impacts the extent of food desert geographies using three of the most common food desert methodologies centered around proximity, variety and competition. The results illustrate that the areas of the Phoenix-Mesa Urban Area that are classified as food desert differ depending on the methodology being used. This study shows that anywhere from 6% - 80% of the 562 low income block groups in the Phoenix-Mesa Urban Area can be designated as food deserts and the population residing in these areas with poor access to healthy food is estimated to be anywhere from 25,000 to 233,000 residents. In spite of this wide range, the geographic overlap was high with all three methodologies. The findings illustrate a need for clearer definitions regarding conceptual differences when measuring food access.

CHAPTER 1: INTRODUCTION

Food is essential for sustaining human life, providing the nutrients and calories that deliver the energy necessary for people to go about their day to day activities. Availability and access to food that provides optimal nutrition is essential for the security of community food sources and public health. This concept of food security is described by The Food and Agricultural Organization (FAO) of the United Nations as existing "when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life" (Section 1, Food and Agriculture Organization 1996). However, there is a growing body of research that show that there are disparities in access to safe and nutritious food based on income, ethnicity and social status.

1.1 Food Insecurity

In 2014, the United States Department of Agriculture's Household Food Security Report stated that an average of 14% of US households experienced food insecurity in 2013 which is essentially unchanged from 15% of US households in 2012 (USDA-ERS 2014). A more problematic statistic from the USDA website states that out of the US households with children, 20% experienced food insecurity in 2013. The most widely used measure of food deprivation in the US is the definition from the USDA which describes food insecurity as not having consistent access to adequate food because of lack of money or limited resources at points during the year (USDA 2013).

The factors at the root of food insecurity such as access, availability and affordability are also the factors that influence food choices (Azuma, et al. 2010), and studies have linked these environmental factors to residents' health risks, finding that obesity and other health risks are

more common among low income, predominantly African American or Latino communities than in predominately White and Asian communities (Morland 2002). Diets that include fresh fruits, vegetables and whole grains can reduce the risk of obesity and many diet-related diseases (Hsin-Chia Hung 2004) and have been shown to be less accessible to residents who live in low income communities where corner mini markets and liquor stores are more prevalent than grocery store options. The variables that influence the connections between diet, health, socioeconomic status and accessibility of healthy foods in communities are complex. Many research studies have highlighted the relatively low levels of food access for many lower-income, minority populations with limited financial resources and lack of mobility. Studies by Moreland et al (2006) and Larson et al (2009) have concluded that high access to supermarkets and grocery stores and low access to convenient stores have healthier diets and lower obesity levels. In addition, many studies have shown that access to healthy food in the United States is unevenly distributed throughout regions and that supermarkets and other fresh food stores are less likely to be located in low-income and minority communities where convenience, fast-food and liquor stores are more plentiful and accessible than grocery store options.

These inequalities in food access and health risks are indicators of an unsustainable food system. The American Public Health Association defines a healthy and sustainable food system as one that "provides healthy food to meet current food needs while maintaining healthy ecosystems that can also provide food for generations to come with minimal negative impact to the environment. It is humane and just, protecting farmers and other workers, consumers and communities" (Policy 200712, APHA 2007). Creating and maintaining equal and easy access to healthy food is vital to our shared health. The most common outlet for this food is the grocery

store as it provides the most consistent and reliable way to access a wide variety of nutritionally dense and affordable food options.

1.2 Food Deserts

The notion of food deserts and the causes and consequences of limited access to food has attracted the attention of researchers and food activists over the last three decades. Grocery store gaps were first identified in the U.S. as low income, inner-city areas that were underserved by grocery store outlets which had vacated these areas to migrate to the wealthier suburbs (Winne 2008). These studies, in turn, were then applied in the UK and Canada (Whelan, et al. 2002). In the early 1990's, residents of a public housing development in western Scotland began using the term food deserts which was then incorporated into a report by the Policy Working Group for the Government's Low Income Project Team of the Nutrition Task Force in 1995 (Cummings and Macintyre 2002). It was in this report that the food desert was first formally defined as an urban area where residents could not afford to purchase food that was both healthy and affordable (Beaumont et al, 1995). Application of the phrase 'food desert' was expanded to rural areas in 2006 when Blanchard was exploring food access in rural Mississippi (2006). Today, food deserts, food access, and food justice are concepts studied in communities all over the world, amplifying the questions, variables, and procedures used for defining and refining geographical locations to be labeled 'food deserts.'

The overview of the research for this thesis has found an array of patterns, from very obvious food deserts in some areas to uniform distribution of food sources in others, but the variables and specifics of the actual definitions considered in each study have varied from author to author. For example, Hendrickson et al. (2006) found urban areas that had less than 10 stores and no stores with 20 or more employees and classified them as food deserts while Gallagher

(2008) defines food deserts as large areas that contain no mainstream grocery stores. Morton and Blanchard (2007) considered whole counties where all residents lived further than ten miles to the nearest grocery store, which included all of the rural areas in their study area, as food deserts while the USDA (2013) uses the definition "a low income census tract where a substantial number or proportion of residents has low access to a supermarket or large grocery store" (p. 1) to map food deserts on the Food Access Research Atlas. Many other social scientists go beyond these conventional definitions and include other socioeconomic, demographic, physical, financial, educational and cultural factors in their analysis.

1.3 Food Desert Definition Gaps

The word 'desert' is a powerful mental image of an area that is lacking. The term food desert, at its simplest, is an area where residents are lacking or do not have acceptable access to food sources. When researchers investigate food deserts there is no standard definition or procedure and the definitions, variables and methodologies that they use vary. This variation in definition and approach creates inconsistency and ambiguity in the validity of their results, providing outcomes that can lead to differing or even contradictory opinions about the extent of the food desert problem and its actual location.

For example, the introduction to this field of research began in Britain in the 1990s, when researchers tried to identify neighborhoods that had limited access to healthy food options (Beaumont, et al. 1995). Ten years later, Reisig and Hobbiss (2000) stated "the term has remained conceptual rather than being an operational term by which geographical areas can be identified and indeed is proving hard to define given that the ease with which people access food is a function of more than geography" (p. 137) and Levin (2011) also states that the concept of

the food desert is still vague, imprecise and open-ended in these studies. One more decade later, there continues to be a lack of consensus for a definition for food deserts.

Most researchers agree on defining food deserts using the same general features. This list of features includes: lack of healthy food, poor access to food, lack of local grocery stores, low income residents, limited transportation options, underserved neighborhoods, and affordable groceries. However, the problem arises when researchers move to define and delineate these conceptual terms listed above to the quantitative definitions needed for scientific study. For instance, how do you measure "lack of healthy food" in and what parameters should be taken into consideration to measure "lack of healthy food" in a neighborhood? Rose et al (2009) points out that depending on the definitions, researchers will arrive at different results in food desert studies based on those definitions and the methodology used.

1.4 Objectives of This Study

The objective of this paper is to illustrate how the existence and extent of food deserts can change depending on the specific definitions used when applied to the same geographic area. Through review and re-creation of some of the contributions to food access literature, food deserts will be identified in the Phoenix-Mesa Urban Area based on the major food desert elements of proximity, density/variety and competition.

The remainder of this thesis is structured as follows. Chapter Two reviews the characteristics of a food environment, summarizes the current body of research on food access and food deserts, and examines the variables used to measure food access. Chapter Three describes the study area, the data sources and collection process, and the three methodologies that this thesis will use to compare food desert geographies. Chapter Four presents a detailed

outline of the three methodologies and an analysis of their results. Chapter Five reviews the findings of this thesis and includes recommendations for future food desert research.

CHAPTER 2: BACKGROUND AND LITERATURE REVIEW

As presented in the first chapter, the increasingly popular terms of 'food desert' and 'food swamp' are evocative metaphors used in discussions of food access and food security; however, their meanings can change depending on the researcher and lack specific definitions. Nevertheless, food deserts have been studied and used by many researchers in a variety of fields such as public health, geography, social justice, urban planning and business as a tool for identifying and quantifying food insecurity, as a factor in public health, and as an indicator of sustainable food systems. These researchers have identified a number of measureable indicators for locating food deserts which include acceptable travel distances, grocery store size and quality of food (Wrigley, et al. 2002; Zenk, et al. 2005; Shaw 2006; Apparicio, Cloutier and Shearmur 2007; Group 2008; Kowalski-Jones, et al. 2009; McEntee and Agyeman 2010).

Depending on the indicator used and thresholds defined to model the food environment, results can be inconsistent even when applied to the same study area. For example, Rose et al. (2009) studied the census tracts in New Orleans and how expanding the supermarket data to include convenience and drug stores that carried some fresh food changed the extent of the food desert areas in the neighborhoods. The results showed that only one tract was always classified as a food desert, located in the Lower Ninth Ward, and only one tract of the eight was never classified as a food desert. Kowalesiki-Jones et al (2009) measured food deserts three ways by using datasets sourced from different agencies and looking at different demographic variables in Salt Lake County, Utah. Their findings also suggested that food deserts varied across neighborhoods depending on the discrepancies in the datasets chosen and variables used. In order to more clearly understand these inconsistencies, this chapter will discuss the most common food desert methodologies and elements used in food desert research.

2.1 Setting the Food Environment

The food environment consists of places where a person might eat or have access to food; this could include home, work, school, restaurants, grocery stores and farmer's markets. These places may not all be contained in the person's neighborhood, however, researchers have shown that people do tend to make food choices based on the food outlets available in their immediate neighborhood (Furey, Strugnell and McIlveen 2001). Food desert studies select a study area boundary and illustrate the food environment with data from business directories or databases to classify food outlets in terms of whether or not there is adequate access to healthy and nutritious food options (Kowalski-Jones, et al. 2009). Supermarkets and grocery stores are the most reliable and recognizable way to supply healthy and nutritious food options in most communities (although some studies use additional outlets such as convenience stores, farmers markets, ethnic food stores and community gardens.

2.2 Food Desert Geography

Food accessibility is a measure of the ease of obtaining healthy food options in a given neighborhood (Farley, et al. 2009). The majority of the time in food desert studies, this is interpreted as the physical or accessibility of food stores that supply healthy food options and it is these spatial factors such as location and distribution that have been frequently analyzed in food desert studies (Wendt, et al. 2008).

2.2.1 Defining Accessibility

Researchers measure food accessibility by linking food sources to neighborhood residents in some way (Rose, et al. 2009). Food desert studies generally use either proximity or density of healthy food stores to define what is and what is not considered adequate access to healthy food options in a study area. Numerous other studies such as the study by Apparicio (2007) and

Gallagher (2008), competition in the food environment has been included as well. The proximity approach evaluates the distance to food sources by measuring distances. The density approach quantifies or computes in some way the access or availability of food stores or travel times within a food environment (Charreire et al., 2010).

2.2.2 Defining Distance Thresholds

The main focus in spatial and geographical food desert studies is generally on distance-based measurements. The question that this poses is "What are reasonable walking and driving distances to the food outlets?" Researchers have formulated and used many different time-based distance measurements for walking, driving and public transportation methods. A 15 minute walk is general assumed and accepted to be equal to 1000 meters with a walking speed of 4 kilometers per hour (VerPloeg, 2009). For drivability, researchers assumed a driving speed of 60 kilometers per hour and assume a reasonable access when driving is 15 kilometers (Ver Ploeg, 2009). However, some studies consider multiple thresholds of time and distance such as Eisenburg and Silcott in 2010. Identifying thresholds for reasonable walking or driving distances are important because that is what define the buffer size or boundaries around areas or the points of food access such as grocery stores or farmers markets and the points of food stores or a geographic unit that delineate what is acceptable food access and what is a food desert. For example, the density or number of food stores within a buffer could be used to estimate a household's accessibility to food stores (Thornton et al., 2005).

2.2.3 Measuring Distances

Distances can be measure in three forms: Euclidean, Network or Manhattan. Manhattan distance is based on a grid system and is almost never used in food desert research as there are few perfect grid systems in urban environments (Zenk et al., 2005). Euclidean distance is 'as the

crow flies' or the straight line distance between two points of interest. A more realistic representation of movement is Network distance which measures the distance between origin and destination along streets and sidewalks or other transportation network usually using the shortest path (Levinson and El-Geneidy, 2009). In the majority of food desert studies, researchers use either Euclidean or Network distance buffers to measure a reasonable walking or driving distance to food outlets (Thornton et al, 2011).

2.3 Geographic Units

Researchers have used a variety of geographical aggregation units to depict neighborhoods in food desert studies depending on the size of their study area, the focus of their study and what census data is available in their area. Most studies rely on census geographies or political jurisdictions to define their neighborhood divisions. In the United States, researchers most often use census tracts (Eisenburg and Silcott, 2010; Rose et al, 2009), block groups (e.g., Gordon et al 2010; Kowaleski-Jones et al, 2009; Russell and Heidkamp, 2011) and the smallest enumeration unit that the US Census Bureau uses, the census block (Parsons, 2012). In UK studies, electoral divisions, which are roughly equivalent to US census tracts, are most often used (Clarke et al, 2002; Guy and David, 2004). In Canadian studies, the census tract (Apparicio et al, 2007; Larsen and Gilliland, 2007; Martin Prosperity Institute, 2010) or smaller divisions such as enumeration area or dissemination area (e.g., Kershaw et al, 2010) have been used. Very few studies have used city-defined or even resident defined neighborhoods and neighborhood boundaries are seldom as simple as choosing an administrative unit (Smoyer-Tomic et al, 2006). Examination of the appropriate neighborhood units is important for more useful and authentic research and policy making.

2.4 Socio-economic Variables

Since access to healthy food is increasingly seen as an environmental justice issue, the association between lack of food access and community member's socioeconomic status has been increasingly investigated. Poverty is a substantial barrier in accessing food in low-income areas and it has been shown that smaller grocery stores located in urban areas are located in low-income areas (Alwitt 1997, Hendrickson, Smith and Eikenberry 2006). Hendrickson, Smith and Eikenberry (2006) found that stores are smaller, food prices are higher and food quality is poorer in areas where poverty is the highest. Due to financial difficulties, residents in disadvantaged neighborhoods may not be able to afford cars or other modes of transportation to easily access food stores that are not in their neighborhood or farther away. Income, vehicle ownership, education level, employment, ethnicity, age and other socioeconomic and demographic variables are important factors that are frequently used in food access studies. Blanchard (2006) points out that the socio-demographic characteristics of food deserts are important for developing specific policy that alleviates the problems of the populations that are affected by food deserts.

2.5 Measuring Food Access and Locating Food Deserts

Putting the definition of a food desert into action and identifying the methods and data used to characterize these areas vary drastically across studies (as discussed in Chapter 1) resulting in diverse or contradictory findings on the extent of the problem and perhaps where the problem is actually located. In order to better understand this variety in how researchers measure food access and identify food deserts, a variety of food desert studies have been compared based on their food desert variables such as spatial accessibility standards, data aggregation units and other variables used (Appendix A).

A study by Clarke et al. in 2002 focused on food access in the urban areas of Leeds/Bradford and Cardiff was measured using a 500-meter buffer zone around each grocery store or supermarket to represent a reasonable walking distance for the residents. A deprivation score was developed based on socioeconomic level and car ownership to define and locate the disadvantaged areas of their study area. Their results indicated that there were six defined food desert areas where residents had high deprivation scores and also lived outside of the grocery store buffer zone service area.

In Madison, Wisconsin, Coombs et al. (2010) also looked at food deserts from a very classical standpoint and located any neighborhoods that were beyond a one mile grocery store buffer zone. The assumption was made that healthy and nutritious food options can only found in grocery stores and any areas beyond the grocery store buffer zone, with no grocery stores nearby, are food deserts. They also mentioned the importance of analyzing racial composition, income level and vehicle ownership in food desert studies, although they did not outline any thresholds for these variables.

Another study by Schlundt in 2010 created a score as a way of measuring and classifying access in Nashville, Tennessee. A Food Desert Score was calculated as an index to identify neighborhoods that may be considered food deserts by using the city planning department's business license database to identify the locations of major grocery stores. Schlundt then buffered these grocery stores with a 0.5-mile buffer and calculated the distance from each residential parcel to the nearest major grocery store and to the nearest bus stop. He used the distances to score each census block. His Food Desert Score scale of -37 to 60 was calculated and any parcel with a score of 20 or greater was considered to be a food desert which indicated that four areas could be considered food deserts in the neighborhoods of North Nashville, South

Nashville, East Nashville and Edgehill. That same year, the Commercial Policy Review (2010) also identified food deserts in these neighborhoods, but the results and spatial extents of the food deserts varied slightly as they used a 1000-meter buffer zone around grocery stores and obtained their grocery store locations from a different database.

Other studies looked at previously identified food desert areas in order to investigate the concept and variables involved in food security. For example, Winter (2010) examined the relationship between food deserts and food insecurity in Ontario, Canada by comparing the food desert areas for the census years 1996, 2001, and 2006. Before identifying food deserts for each year, she established an Accumulation Risk Factor (ARF) by considering select demographic and socioeconomic characteristics of the enumeration and dissimilation areas, creating an index to define potential food insecure communities. She created a buffer of 509 meters around fresh food outlets and then analyzed whether the fresh food zone was easily accessible via public transportation. Her findings showed that food deserts are more likely to be found in EAs and DAs that score high in the ARF index and by comparing the three different time periods, she was able to conclude that the total food desert area has, in fact, declined over time in these communities.

Smoyer-Tomic et al. (2006) implemented a study covering 212 neighborhoods in Edmonton, Alberta by calculating the spatial accessibility to grocery stores using both the proximity (shortest path) and density (number of grocery stores within a 1000-meter network buffer around the centroids of each postal zone). They identified food deserts as neighborhoods where access to grocery stores falls in the lowest quartile of the study groups and also are comprised of residents that belong to vulnerable demographic subgroups such as the top quartile

of low income, no car ownership, and elderly population. The results indicated that six suburban neighborhoods in the Edmonton area were considered food deserts.

In an extensive and very often cited study by Apparicio et al in 2007, a similar methodology was used that quantified food deserts in Montreal Canada by measuring the geographical access based on distance to the nearest supermarket (proximity), the number of supermarkets within a 1000-meter buffer (density), and competition based on food and prices. They also developed a social deprivation index that would more clearly define food desert areas when used alongside the three supermarket accessibility measurements. The results of this study show that although access to supermarkets varied in each census tract, there are no food deserts in Montreal.

In a 2008 study, Larsen and Gilliland measured healthy food accessibility in London, Ontario for the years 1961 and 2005, based on network walking routes and public transportation routes. Network Analyst in ArcMap was used to calculate proximity to the nearest grocery stores using the shortest network path and also the density, or number, of grocery stores within 1000-meters of each block centroid. A socioeconomic index at the census tract level was developed and used when assessing the level of supermarket accessibility. They identified one food desert in an east London neighborhood.

The Department of Urban Design and Planning at the University of Washington's College of Built Environments created a food system assessment and researched food access in the Puget Sound region of Washington in 2011. The report was then used to create a Food Policy Blueprint for the State which assisted in identifying and locating food desert areas as well as providing information to policymakers and food system stakeholders that would guide future policy development. The research team located census blocks that lacked grocery stores within a

half-mile network walking distance and lacked grocery stores within a network quarter-mile of bus stops. They also took into consideration socioeconomic variables such as areas of low income, areas with low vehicle ownership and locations of elderly populations. They found that the urban core areas of the Puget Sound region have the greatest access to grocery stores while the urban peripheries, or suburbs, have lower access and face greater challenges in accessing healthy and nutritious foods.

Anthony and Lee (2010) had previously used a similar methodology as the Washington Department of Urban Design and Planning, but had defined different spatial and socioeconomic thresholds for a study in Los Angeles, California. A one-mile network buffer was created around each grocery store as a "proxy of the service area". They then identified food desert as any census block groups that were located outside of these service areas that also had a normalized poverty rate that was 1.5 standard deviations or greater of the overall poverty rates for the population in the city. The results indicated that food deserts are more likely to be found in the neighborhoods in Downtown and Southeast Los Angeles.

O'Dwyer and Coveney in 2006 compared the availability and accessibility of grocery stores in Australia over four different Local Government Areas (LGAs). They created a 2.5-mile network buffer around each area and used drive time to measure the accessibility of supermarkets. They then defined food deserts as the areas in the top quartile of low income residents that have no vehicle access without regard to the proximity of the residents' homes to the supermarkets. According to their findings, food deserts existed in some degree in the three LGAs of Port Adelaide-Enfield, Playford and Onkaparinga.

In some studies researchers created unique ways to identify food deserts by taking into consideration different combinations of store accessibility, socioeconomic and demographic

variables. Eisenburg and Silcott (2010) identified and mapped different stages of food deserts in Franklin, Ohio by creating multiple network buffers of 0.25 mile, 0.5 mile, and 1 mile to measure the walk-to-store service area and also considered drive times of 5 minutes, 10 minutes and 20 minutes to evaluate the drive-time-to-store in their study area. The drive time to a grocery store was scored for each census tract from one to three with 3 being the longest drive time. Additional weight was given to any drive time over 20 minutes. Walk-to-store was scored either a 1, 2, 5, or 7. Socioeconomic and demographic variables were evaluated and scored with various scores given for level of household income, vehicle ownership rate and population density. Food desert potential was classified as either Severe, Strong, High, or Moderate depending on the resulting score for each census tract. Their findings concluded that although there are many residents in Franklin County that live in close proximity to grocery stores that are still vulnerable to food insecurity due to poverty, lack of car access and low population density.

While most studies analyze the presence or absence of grocery stores, a few also take into consideration the presence of other food venues such as fast food locations or gas stations. Gordon et al. (2010) developed a Food Desert Index based on access to grocery stores, gas stations and bodegas that supply healthy food, and fast food restaurants for each block group in New York City. These food access index components were measured, ranked and scored as low, medium, and high to create a scale range of 3 (poor) to 9 (high) to describe the level of accessibility to healthy and unhealthy food options for each block group. The relationship between variables such as race and ethnicity and median income of the block groups were also analyzed. The Food Desert Index and the demographic variables were combined to create a total food desert score. They found a clear correlation between these variables and the lowest scores were found in East and Central Harlem, and the North and Central Brooklyn neighborhoods

which were also the neighborhoods that were found to have the highest proportions of minority residents and also the lowest median household incomes. The highest food desert scores were found in the Upper East Side, which is a predominantly white, upper-income neighborhood.

Baltimore City's Food Policy Initiative and the Johns Hopkins Center for a Livable Future (2010) have also developed a food desert index by determining distance thresholds to healthy food outlets as well as the quality and quantity of the food options themselves and also include socioeconomic variables at the block group level for the City of Baltimore. The resulting Healthy Food Availability Index (HFAI) assigns scores from 0 to 26 to each food store based on the completion of a Nutrition Environment Measurement Survey (NEMS). A score of 8.8 or greater means that the food outlet is an acceptable source of healthy food. A quarter mile buffer was drawn around these acceptable sources. Block group household income at or below 185 percent of the federal poverty level, and where 40% of households do not have access to a vehicle, that are located outside of these acceptable access buffer zones were identified as food deserts. The mapped results visually show that food desert block groups are more likely to be found in the inner city of Baltimore.

Mari Gallagher was the first publicize the term food swamp, a metaphor that is useful for describing nutrition issues in some neighborhoods. The term refers to areas where high calorie and nutritionally empty food sources, such as fast food outlets, outweigh healthier options (Rose et al. 2009). The Mari Gallagher Research and Consulting Group has famously conducted food swamp studies in Chicago and Detroit by calculating the average distance from fringe food venues and the average distance to healthy food outlets to create a Food Swamp Score. This Food Swamp Score shows areas that have an imbalance of healthy food options.

Understanding factors related to food deserts and improving access to healthy and affordable food was the goal in all of these reviewed papers, however, each of these measures was based on different definitions and methods for determining food access. Studies that have been conducted over the same study area to compare and contrast the results of separate methodologies and analyses in terms of the areas identified or the size of the population affected have not been done. A systematic evaluation of these food access measures using the same data and study area would demonstrate the differences, validity and accuracy of the results that come from different study methodologies.

CHAPTER 3: METHODOLOGY

This chapter will review the chosen study area, the data sources used and the food desert definitions being compared in this study. A food desert for this thesis will be generally designated as an area of a city that is economically disadvantaged with relatively low access to sources of healthy food, which is taken from Larsen and Gilliland's 2008 food desert study in London, Ontario and is a good top-level definition with which the majority of food desert studies begin. In order to apply this definition and locate the parts of a study area that are food deserts, most researchers choose to consider some combination of interconnected characteristics found in their study area to compare to their defined accessibility measure. Apparicio et al (2007) chose to identify accessibility measures based on proximity, variety and competition whereas most food desert studies focus on characteristics that fall under only one of those measures. The food environment needs to be characterized and measures of access are then created by connecting the population to the food environment. Finally, acceptable standards or thresholds need to be set in place in order to categorize an area as having low access to healthy food.

Section One describes the study area and scale of analysis for the methods used in this thesis. Section Two describes the data sources needed to re-create the studies in the Phoenix-Mesa Urban Area and Section Three is a step-by-step description of the methodology used to calculate food deserts according to the previously described Food Desert Models. Section Four discusses the limitations to this study.

3.1 Study Area and Scale of Analysis

This thesis uses the US Census designated Phoenix-Mesa Urbanized Area (Figure 1) which is defined as a territory made up of 50,000 or more people and is comprised of "a densely settled

core of census tracts and/or census blocks that meet the minimum population density requirements (Urban Area Criteria, United States Cenus Bureau 2010)." The scale of analysis for this study will be at the block group level as it is most similar in size to natural neighborhood boundaries, ranging from 600 to 3,000 people or 240 to 1,200 housing units. The block group level is also the smallest unit for which population and other characteristics are provided due to privacy concerns. Although most food desert studies reviewed for this thesis used units at the census tract level, using the smaller block group will increase the precision with which food deserts are located and also decrease the potential modifiable areal unit problem (MAUP). The MAUP is a statistical bias which can occur during the spatial analysis of aggregated point data where results differ when the same analysis is applied to the same data, but different aggregation units are used. For example, a methodology using data aggregated by county will produce results that will vary from the same methodology using data aggregated at the census tract level. Using data aggregated to the block group level will increase the precision of locating areas that have low access to healthy food sources. In order to implement changes, it is important to examine the spatial distribution of food access at as fine a geographic scale as possible (Raja et al. 2008). Phoenix is recognized to have food deserts by the USDA Food Access Research Atlas and it is a discussion that enters the local political sphere, but there has been no fine grained food desert study applied to this area.

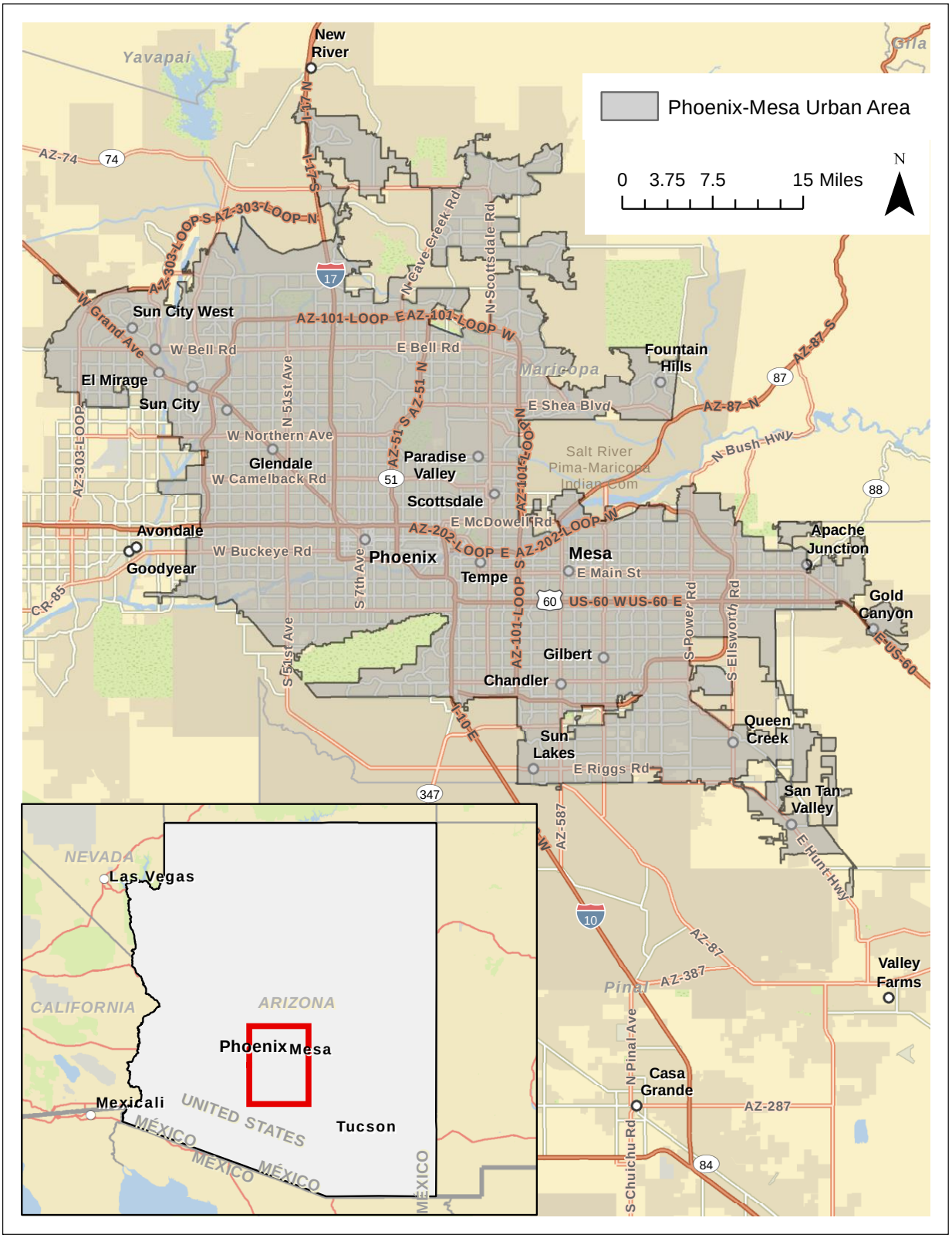

Figure 1 Study Area: The Phoenix-Mesa Urban Area

The City of Phoenix itself is the state capital, largest city in the state of Arizona and sixth-largest city in the Nation. There are approximately 3,444,822 people living in the Phoenix-Mesa Urbanized Area according to ACS 5-year estimates (American Community Survey 2011). The population is predominantly White (59%) and Hispanic (30%) with a median family income of $54,000 per year and a per capita income of $24,000 per year. Between 1990 and 2000, the metropolitan Phoenix area grew by 45%, adding approximately one million new residents and adding one million more in the decade to follow which made it the fastest growing metropolitan area in the Nation welcoming an average of 273 people per day during this time. This expansion and influx of people fueled expansive new home development and expanding suburbs. Despite periodic political efforts to reinvigorate the urban core, Phoenix has the least developed urban core of any large city in America. The Phoenix Metro area stretches approximately 60 miles from Apache Junction in the East to Buckeye on the West, and 50 miles from Cave Creek in the North to Queen Creek in the South.

In 2009, the City of Phoenix implemented an ambitious 17-point plan to transform Phoenix into the most sustainable city in America. This plan included the initiative PHX Renews as a project for introducing urban farming and social space into downtown and various urban farming policies which will include community gardens as an acceptable primary land use with the intention of relieving food desert issues and urban infill plans to bring focus back to the neglected downtown areas and strengthen the urban core.

3.2 Data and Sources

Each of the studies reviewed in Chapter 2, began with setting the food environment in terms of study area, food outlet locations and what was considered a healthy food outlet. The data for this

thesis was collected from the US Census Bureau and the business databases ReferenceUSA and Dun and Bradstreet. A summary of these spatial datasets is provided in Table 1.

Table 1 Summary of Spatial Data

Dataset	File type	Data type	Details	Source	Temporal resolution of the dataset
Grocery store locations	Shapefile	point feature class	All grocery store locations with a SIC code 5411	ReferenceUSA	Up to date through May 2014
Fast food locations	Shapefile	point feature class	All fast food locations with a DB code of Eating Places, Fast Food Restaurants	Dun & Bradstreet	Up to date through May 2014
Census block groups	Shapefile	polygon feature class	All block groups units within Arizona	US Census Bureau	Boundaries published 2010 and ACS estimations valid through 2013
TIGER/line street network files	Shapefile and .dbf	polyline feature class	street network within Arizona	US Census Bureau	Published January 12, 2014
Phoenix-Mesa Urban Area	Shapefile	polygon feature class	Case study area	US Census Bureau	Boundaries valid as of 2010

Census data was obtained from the US Census and American Community Survey websites at Census.gov and included a shapefile of boundaries for all census block groups in Arizona. Although using Census data at the tract level is the most often seen unit in food desert

studies, the block group is smaller, most similar to natural neighborhood boundaries, and allows for a finer-grained analysis and pin pointing food deserts with a level of greater detail. Characteristics included in the datasets are the total number of households in each block group, total number of households living below the poverty line for each block group, neighborhood population density, and median household income among others. The US Census Bureau defines the term "low income" as living at 55% of the median income. The 2010 median household income for Maricopa County was $53,596. 55% of this value is $29,477. Any block group with a US Census determined median household income in 2010 less than or equal to this calculated value or estimated as having 20% of the population living below the poverty level based on the American Community Survey Table S1701: Poverty Status in the Past 12 Months was selected as a low income block group for this analysis. Figure 2 below shows the 562 Low income or Below Poverty Level block groups in the Phoenix-Mesa Urban Area. It can be seen that the majority of these block groups are in the South Phoenix Area or are located close to State Route 60 which runs diagonally through Phoenix. Approximately one quarter of the total block groups located within the Phoenix-Mesa Urban Area are designated as low income or below poverty level.

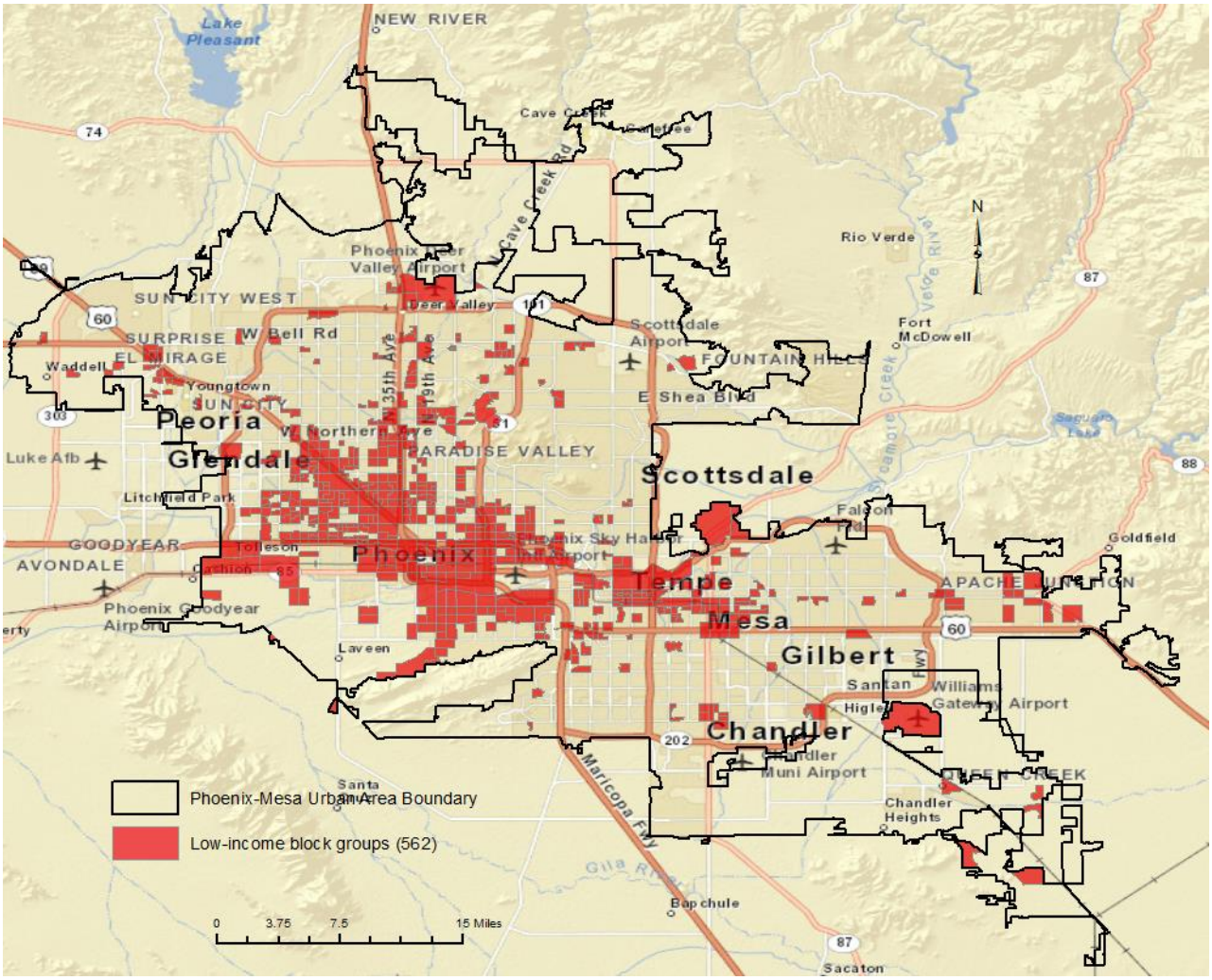

Figure 2 Low Income Block Groups

In order to locate food deserts in the Phoenix area, this study will use grocery stores as they are the most common and reliable provider of healthy food as they consistently have greater availability of healthy food options than other stores (Glanz 2007). The grocery stores used in this analysis are all "full-service" meaning that they sell staple food items from all food groups including meat, beans, bread, vegetables, fruits and dairy. Convenience stores and gas stations tend to primarily carry processed foods and alcohol which do not meet the needs of the entire community and dis-qualify them as viable healthy food outlets (Glanz 2007). While some

convenience stores and gas stations do carry some staple food items and fresh produce, the availability of these items is highly variable depending on the store and is generally not very affordable when available in convenience and gas stations (Chung 1999). Ethnic markets were included in the grocery store list if they adhered to the full-service definition. Costco, Sam's Club and other member only food outlets were not included as access to these stores requires a paid membership, which is a significant barrier to low income populations. Prospective healthy food outlets and grocery store locations were obtained through ReferenceUSA, which compiles business characteristics and addresses from telephone directories and public records (ReferenceUSA 2014). The list of Maricopa County businesses with SIC code 5411, which is the SIC code for grocery stores, originally included convenience stores and gas stations. To refine the list, known convenience stores and any business described as convenience market were deleted, such as Circle K, Arco or QuikMart. The rest of the stores were confirmed using Google and telephone calls to determine if they were a convenience store or a grocery store. In addition, all stores of grocery chains that had known closures in the last two years, such as Basha's and Fry's, were called and eliminated from the list if the lines were disconnected.

The list of grocery store locations sourced from ReferenceUSA included a table with each store's latitude and longitude coordinates for the centroid of each stores building footprint as well as an address for every store. These stores were geocoded using ArcMap 10.2.2 and clipped to the Phoenix-Mesa Urban Area boundary. This eliminated any stores in the dataset that did not fall within the boundaries of the study area. The stores were then re-projected from the original Geographic Coordinate System to NAD 1983 HARN StatePlane Arizona Central FIPS 0202 which was necessary for the precise distance measurements needed for this analysis. The spatial distribution of the final 288 grocery stores included in this analysis can be seen in Figure

3. It is common for some street intersections to have more than one grocery store in competition and these location points may be stacked on the map at this scale.

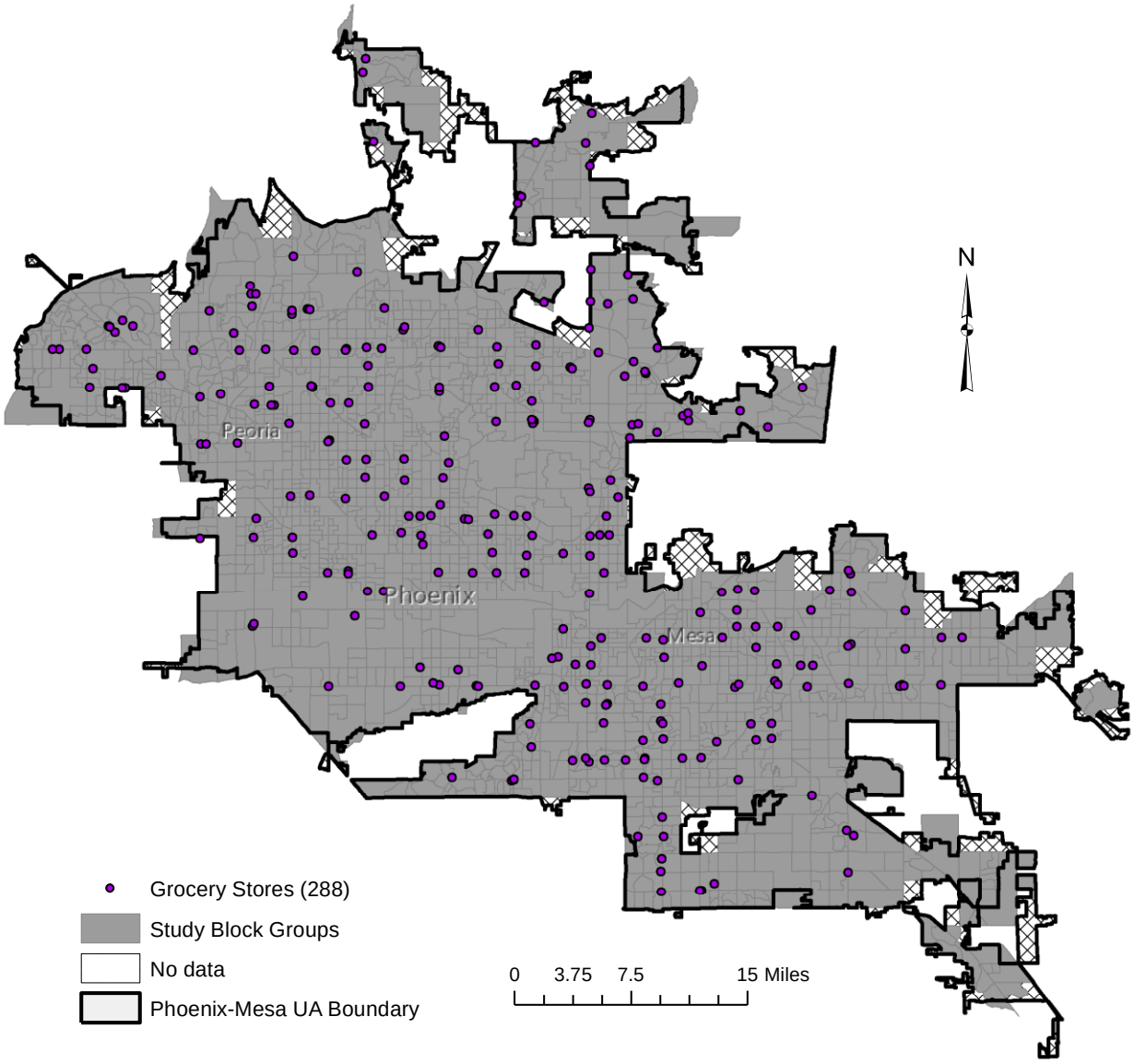

Figure 3 Spatial Distribution of Supermarkets in the Study Area

Fast food restaurants were sourced from Dun and Bradstreet which includes classifications for all Eating Places and also sub-classifications of Sit Down Restaurants and Fast Food Restaurants. The locations listed in the Fast Food Restaurants classification were refined,

clipped, geocoded and re-projected using the same process for grocery stores as described above. The spatial distribution of the 648 fast food locations can be seen in Figure 4. Again, it is very common for some street intersections to have multiple fast food locations due to competition and zoning. These location points may be stacked on the map at this scale.

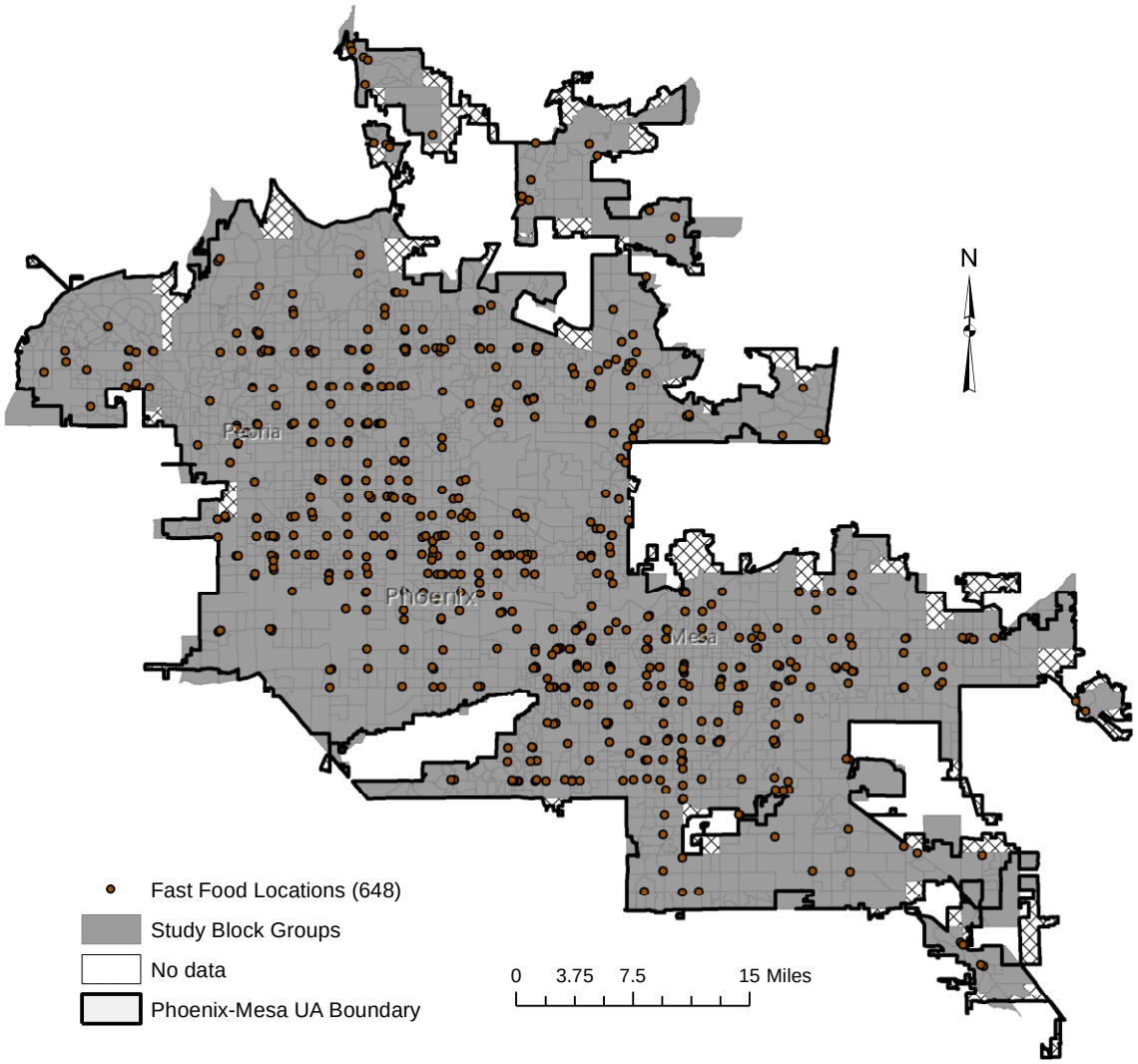

Figure 4 Spatial Distribution of Fast Food Restaurants in the Study Area

Another factor that needs to be clearly defined in a food desert study is access. This study will define areas as having good access if they are within 0.62 miles (1 km) from a grocery

store. One kilometer is used to represent a maximum reasonable walking distance for an adult. This distance is used in many of the reviewed food desert studies and highlighted in the USDA Food Desert Report to Congress (Ver Ploeg 2009) as being the critical distance that is most often implemented. While this walking distance is for the average population, it still may be more than some people would be able or willing to walk, such as the elderly or handicapped (Apparicio, Cloutier and Shearmur 2007) and could be seasonal as the average summer temperature in Phoenix is over 100 degrees. This accessibility measure will be calculated using Maricopa County Street Network data that has been sourced from the Arizona State University GIS Repository and the Network Analyst extension in ArcMap 10.2.2. Network Analyst allows for a more accurate measurement as it takes into consideration barriers and street routes which allows for a more realistic measurement of travel.

Light rail as a form of transportation was not included in this study because access to grocery stores is not a primary use of the light rail and there are very few grocery stores located along the route or near the light rail stops. Only 10 stores are located within the 0.62 mile walking distance of a light rail stop indicating that this was not an intended purpose of the light rail. Access by car and bus will also be excluded from the scope of this study, although consideration of those aspects would be interesting for a different study. In low income populations, not everyone has regular access to automobiles and this study is focused on including the entire community. Using a bus for transportation to and from the grocery store is an option for low income households that do not have access to a vehicle and would be feasible since 201 of the 288 bus stops the study area are within a 1 km walking distance of a food store, but this access measure introduces additional decisions regarding total travel time that combines walking to the bus that is beyond the scope of this study.

3.3 Food Desert Models

A general process will be employed for each of the methods below as illustrated in Figure 5. The data was prepared as discussed in the previous section. The parameters for what constitutes a food desert will be defined for each method, then the parameters will be applied to search for existing food deserts.

Figure 5 Methodology Flowchart

The parameters for each method in Figure 5 are described and illustrated below.

3.3.1 Method 1: Proximity

The first illustration of food deserts in the Phoenix-Mesa Urban Area is the simplest most widely used measure of food access which is simply based on a reasonable walking distance to the nearest supermarket. Researchers such as Apparicio (2007), Larsen & Gilliland (2008) and Zenk et al (2005) measure this proximity distance as the distance from the centroid of their chosen neighborhood unit to the nearest grocery store. Using the Network Analyst in ArcMap 10.2.2, grocery stores can be set as facilities and a network distance of 0.62 miles (1 kilometer) will be used to define each store's service area. Using the tool Select by Location, the low income block groups that do not have their centroid in a grocery store's service area, could be designated as food desert areas.

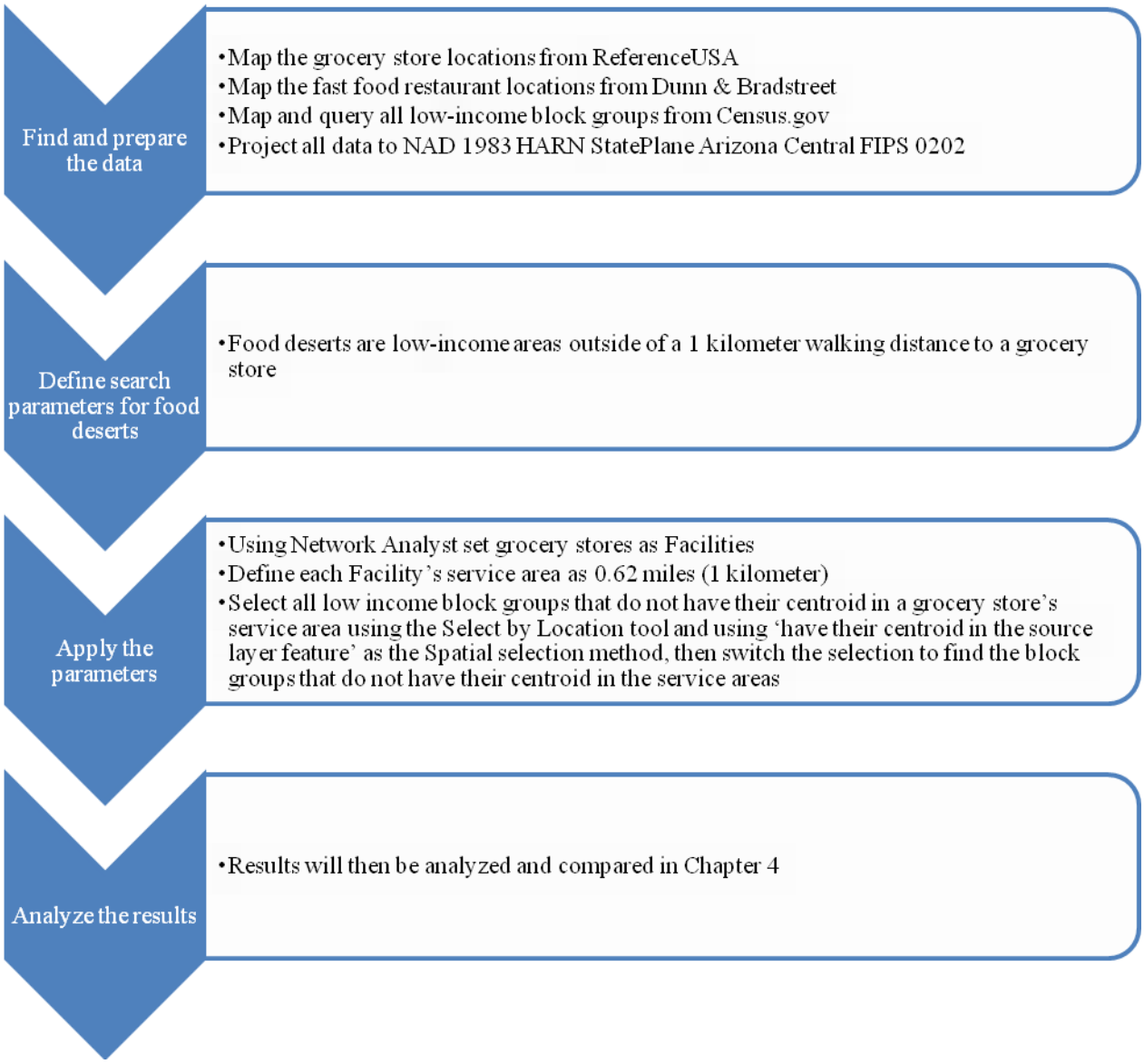

Figure 6 Method 1: Proximity Methodology Flowchart

3.3.2 Method 2: Variety

Food accessibility can be measured as the density or variety of food stores within walking distance in a neighborhood. This can be done by joining each of the grocery store point locations to the polygons in the low income block group layer. A count of 1 will be given to every grocery store point which can be summed when spatially joined to the block group polygon layer. This

will create a sum of the grocery stores contained within each low income block group. The classification scheme modelled after the research of Apparicio et al in 2007 can then be applied by ranking the block groups as having Very High, High, Low or Very Low Access.

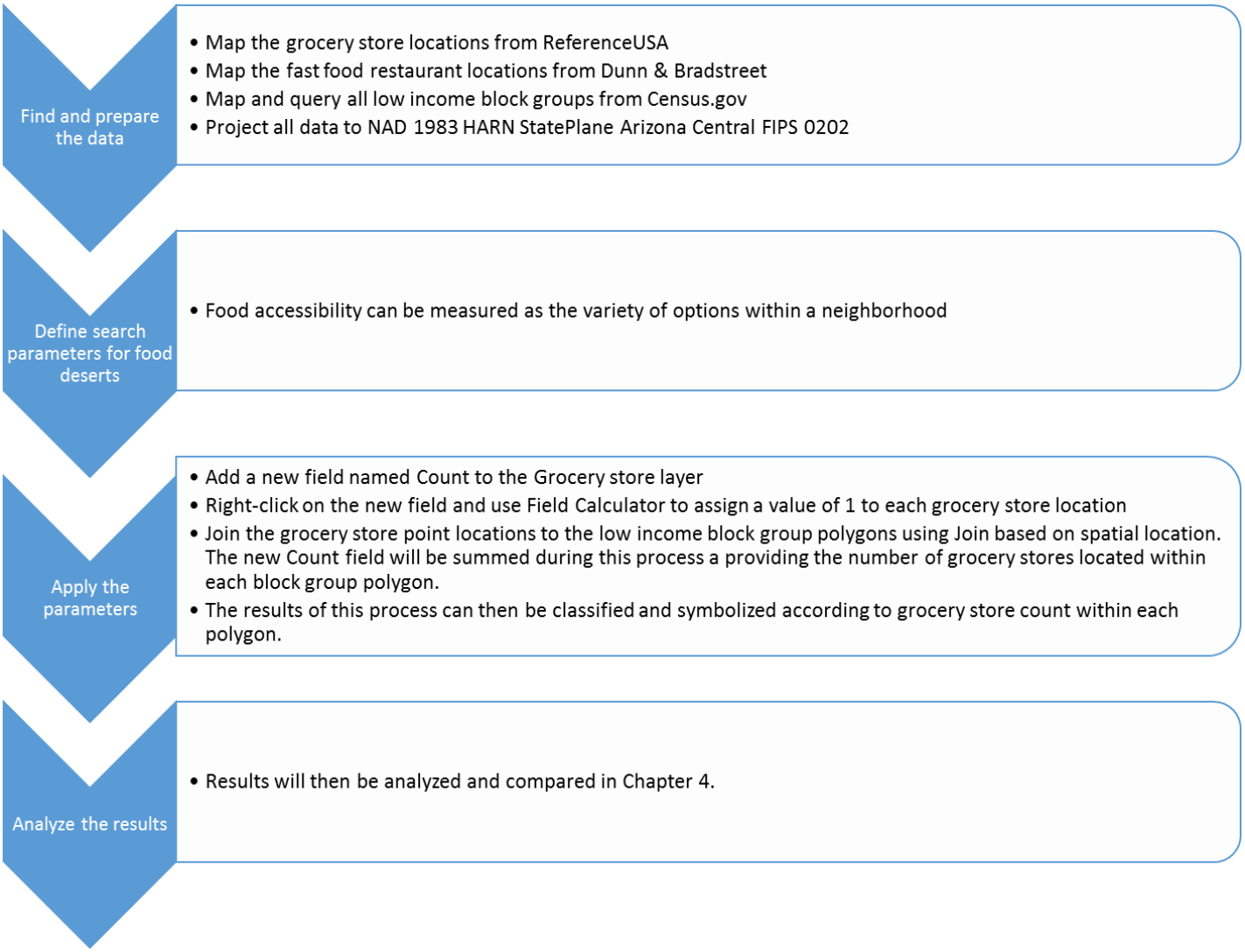

Figure 7 Method 2: Variety Methodology Flowchart

3.3.3 Method 3: Competition

A location where a resident has to look harder to find healthy foods over fast food or corner store options can be considered a food swamp. This method measures competition by calculating the distance from each block group centroid to the closest grocery store location and the distance from each block group centroid to any fast food location using the Near tool in ArcMap 10.3. The Near tool measures the distance between two features by calculating the shortest separation between them. The grocery store to fringe food venue ratio can then be calculated within the attribute table to create a food swamp score that can be used to describe healthy food accessibility (Gallagher Group 2011).

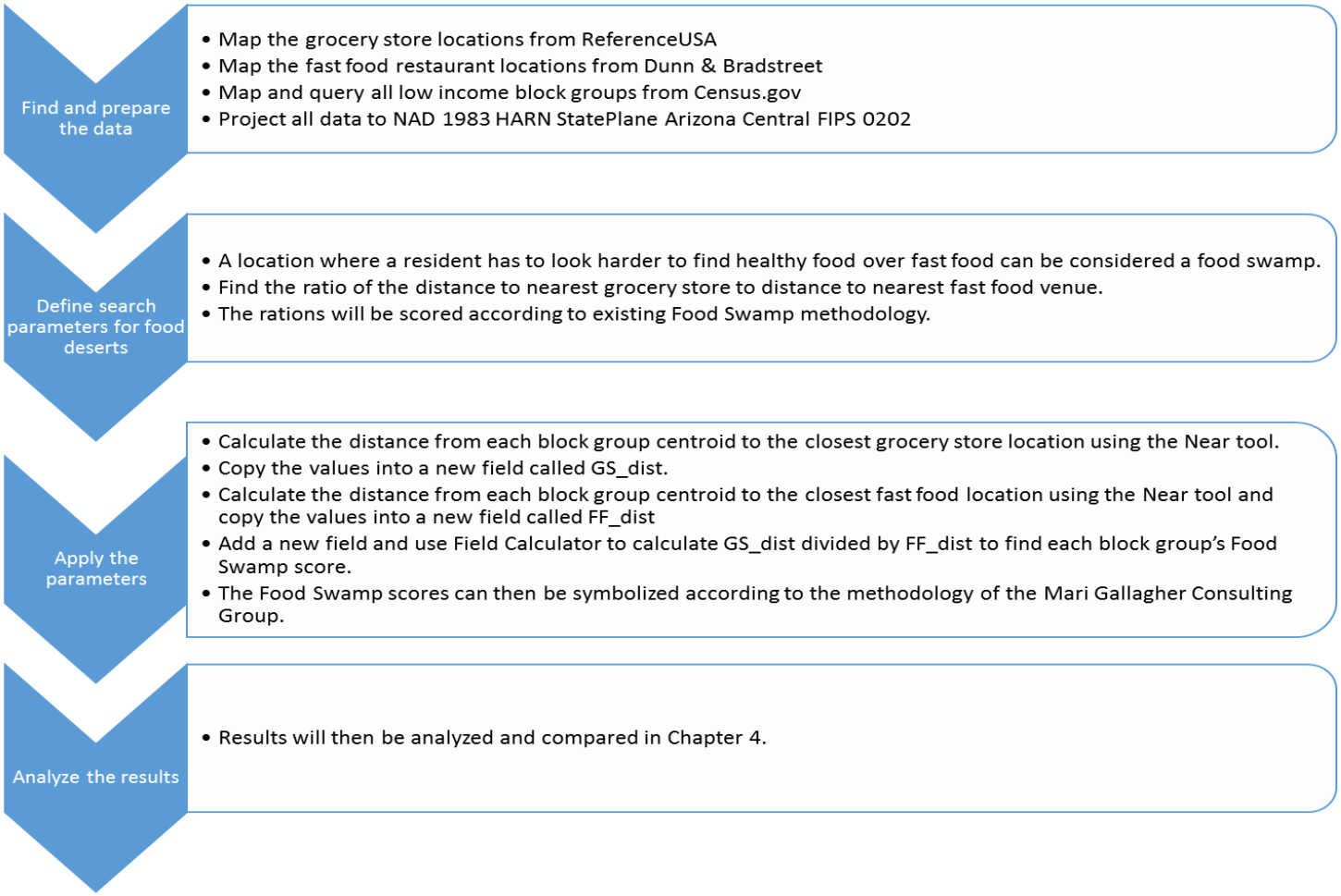

Figure 8 Method 3: Competition Methodology Flowchart

3.4 Limitations of This Study

Even with the refinement of the list of grocery stores and fast food locations, there are potentially more or less stores within the Phoenix-Mesa Urban Area as stores are constantly opening and closing and updated records would take some time to populate through ReferenceUSA. It is also complicated to predict where people are actually shopping due to options, preferences and other variables that make people choose one store over another (Pearson, Russell, Campbell and Barker, 2005). Discovering where people shop and why would require an extensive door to door survey that is beyond the scope of this study. Another limitation is that roads were used to create the walking network and may result in distances that may not be fully accurate as people may cut across parking lots or corners.

Information regarding the geospatial accuracy of the grocery store and fast food locations was not provided by either ReferenceUSA or Dun and Bradstreet. This accuracy will factor into the results of this analysis because it involves calculating precise distances between locations which are then compared to predefined boundaries and thresholds. For instance, the third method, evaluating competition, will measure the distance from the census block group centroid to the nearest grocery store and the nearest fast food location. A study comparing completeness and the validity of geospatial accuracy of these information agencies by Liese, et al. (2010) explored these particular differences. They found that geospatial accuracy varied depending on the scale of the analysis and that more than 80% of locations provided by these information agencies were geocoded to the correct US Census tract, but that only 29% (Dun and Bradstreet) to 39% (ReferenceUSA) were correctly located within 100 meters of the actual location on the ground. These measurement errors will impact the results of this analysis.

Glanz et al (Glanz, et al. 2005) & (K. Glanz 2009) identified two aspects of the food environment including the "community nutritional environment" which they defined as the number, type, location and accessibility of food outlets as well as the "consumer nutritional environment" which is defined by what the consumers encounter in food outlets, such as price and quality. This study does not account for any consumer nutritional environment.

CHAPTER 4: RESULTS

As discussed in previous chapters, three different food access definitions were calculated for the US Census designated Phoenix-Mesa Urban Area which includes of a total of 2414 block groups, 982 of which are considered Low-income or Below Poverty Level (Figure 2). The widely recognized definition of a food desert as a disadvantaged area of a city with relatively poor access to sources of healthy and affordable food options was used and measured three ways. The data used in all three methods was prepared as discussed in Chapter 3. The grocery store and fast food lists were scrubbed and checked for accuracy, then geocoded. The Census block group data was loaded into ArcMap, projected and clipped to the Phoenix-Mesa Urban Area study boundary. A query on the block group layer was set so that only the low income and below poverty block groups were displayed and used for this analysis.

4.1 Method 1: Proximity

Food desert indicator Method 1 used the simplest and most widely used measure of food access by just considering spatial accessibility and measuring the proximity of low income residents to a grocery store. Using the Network Analyst extension in ArcMap 10.2.2 and the Maricopa County Street Network data described in Chapter 3, grocery stores were set as Facilities and a network distance of 0.62 miles was used to define each grocery store's service area. The grocery store service area across the study area can be seen in Figure 9. It can be seen that the majority of the area within the Phoenix-Mesa Urban Area has limited walking access to grocery stores whether or not the area is considered low income including a significant swath of land that is lacking in grocery store service just south of Phoenix itself.

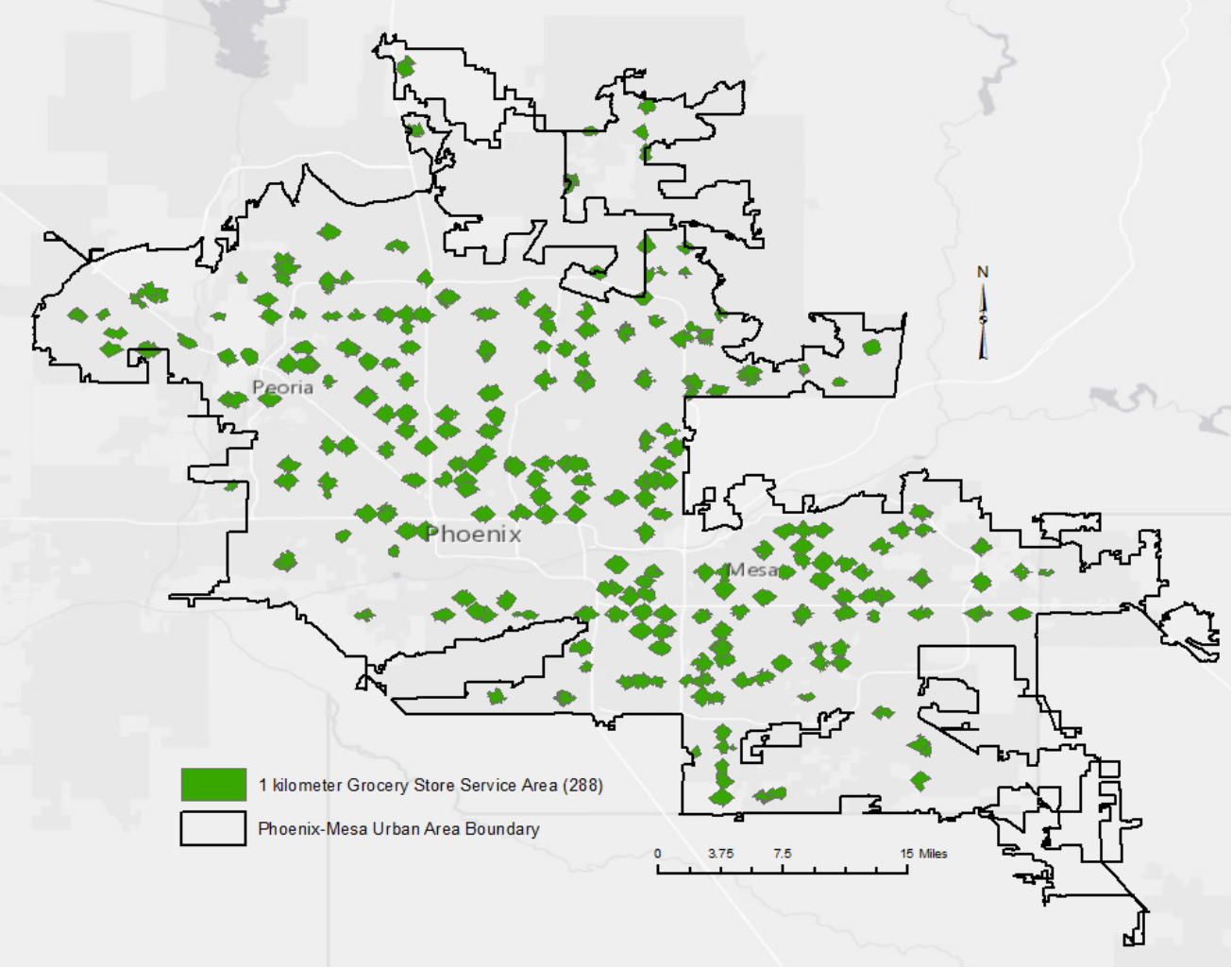

Figure 9 Neighborhood Areas within Walking Distance of Grocery Stores.

Using the Select by Location tool, the low income block groups that did not have their centroid in the service area were selected and designated as food desert areas (Figure 10).

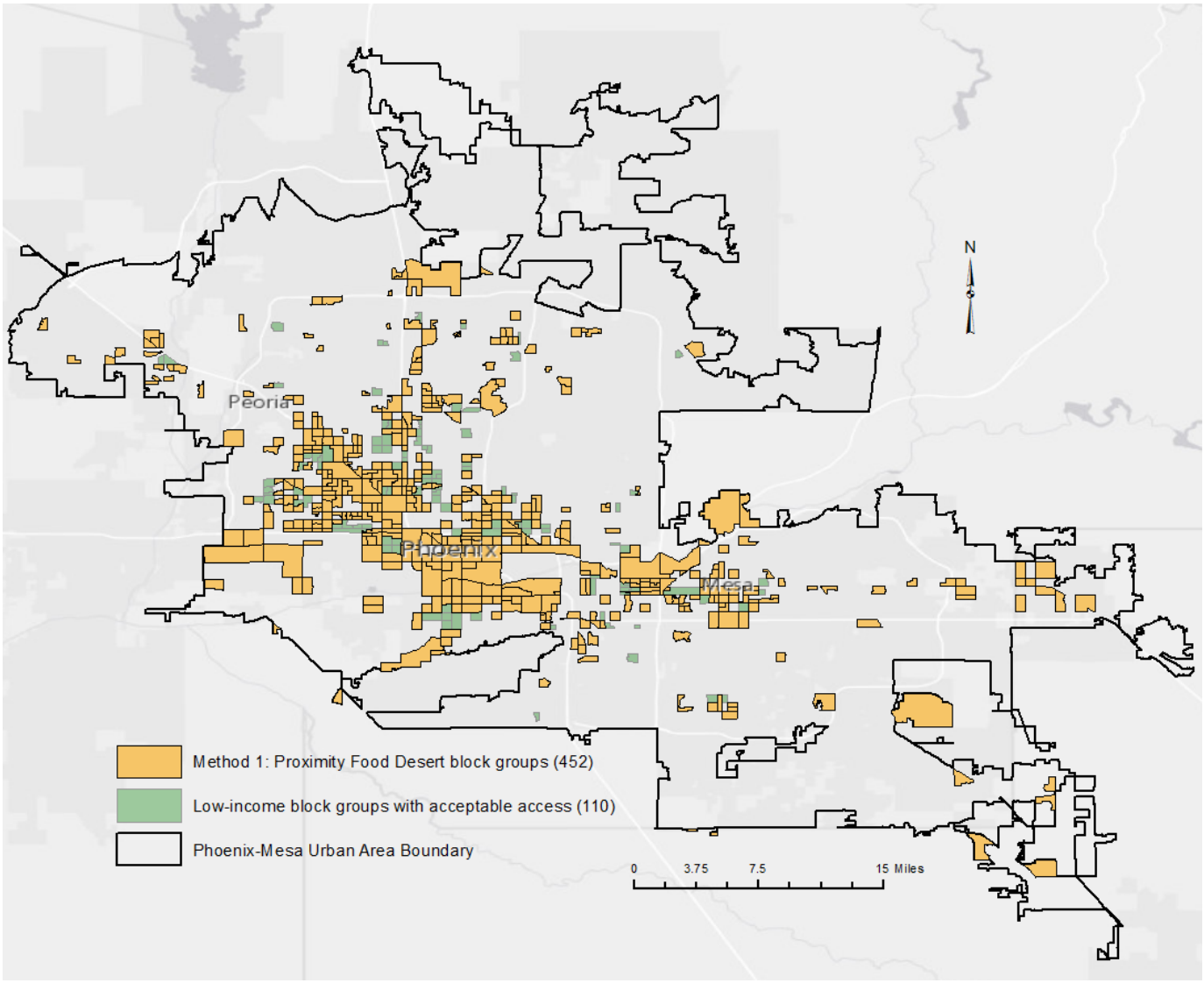

Figure 10 Method 1: Food Deserts Based on Proximity to the Nearest Grocery Store.

This method characterizes 80% of the low income block groups as food deserts. Since this method indicated that the majority of the low-income block groups lack access, the same cluster pattern of block groups in South Phoenix and along State Route 60 running diagonally through Phoenix can be seen.

The proximity method is most notably used by the USDA ERS to locate food deserts and focuses on areas that are simply low income and have low food access. An important limitation

of this method is that although network distances were used because they are a truer representation of how people move through cities, accessibility is not the same as walkability. Network distances do not take into consideration the presence or absence of sidewalks, safe pedestrian street crossing or public security all of which could be significant barriers for food access.

Although this thesis used the smaller block group level aggregation units, the MAUP was not completely eliminated. It is possible that this method inflates the food desserts problem areas because it does not account for larger area block groups whose centroids may not fall within the buffer, but do have some area that falls within the grocery store service area.

4.2 Method 2: Variety

Method 2 measured food access as the variety of food store options within a neighborhood. A new field called Count was added to the grocery store layer's attribute table and Field calculator was used to give every grocery store location a count of 1. The grocery store point locations were then spatially joined to the block group polygon layer using Join Data based on spatial location and the new Count field created a sum of the grocery store point counts within each low income block group polygon.

The resulting attribute table revealed that there was no block group containing more than five grocery stores within walking distance of the block group centroids, only one containing exactly 5 and very few that contained 4 grocery stores. Because of this, a 4-tier classification method adopted from Apparicio et al in 2007 can then be applied and a score of Very High Access to Very Low Access was assigned to each block group (Figure 11) and symbolized in the map below.

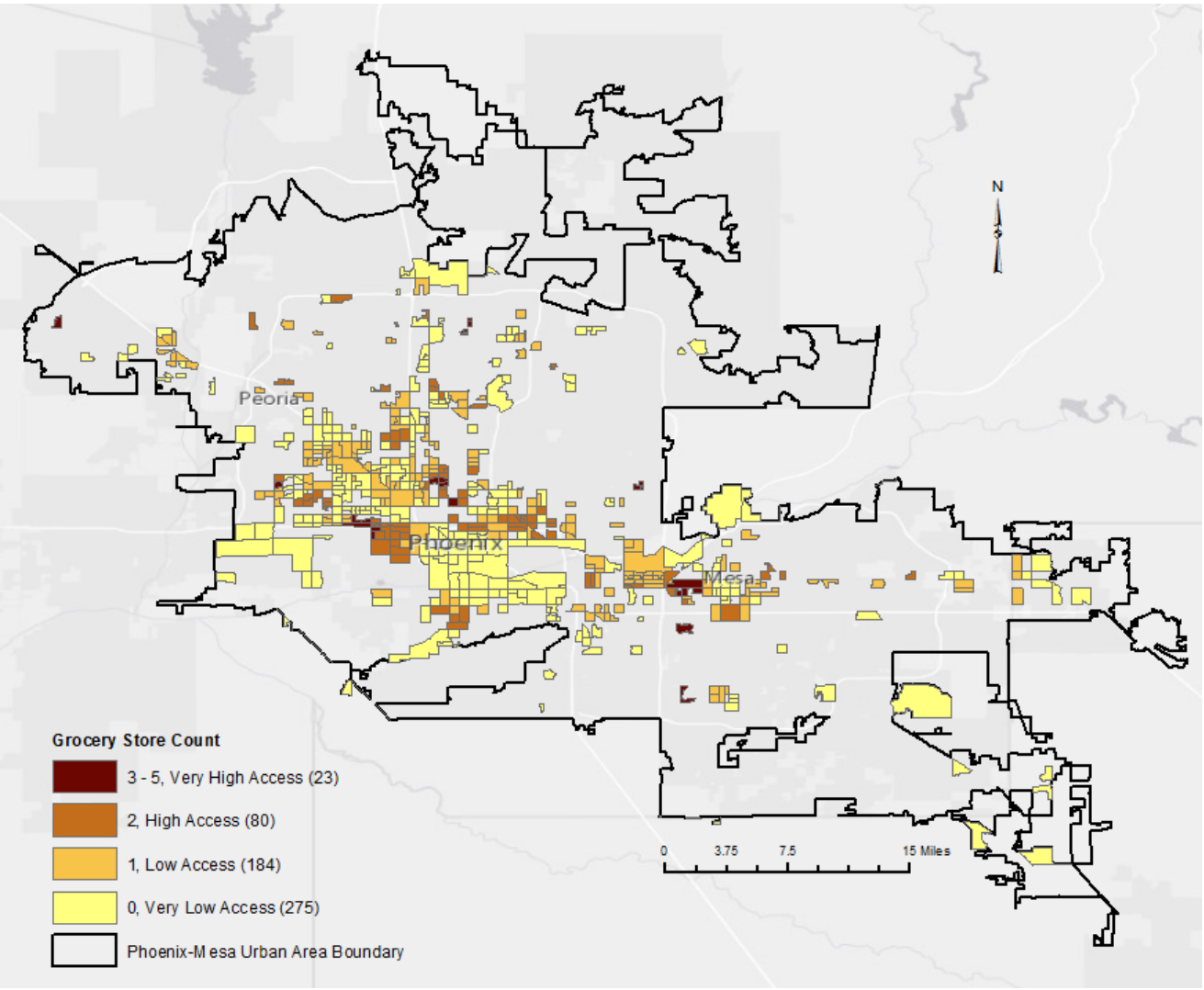

Figure 11 Method 2: Access Based on the Number of Grocery Stores within a 1 km Walking Distance

Very High Access block groups contained 3+ grocery stores, High Access contained 2 grocery stores, Low Access contained only 1 grocery store and Very Low Access contained no grocery stores. This method classified 184 of the 562 low income block groups as having Low Access to a grocery store, meaning that the block group only contained 1 grocery store and had no other options. It also classified 275 block groups as having Very Low Access to grocery stores. This leaves only 103 block groups that have acceptable access by this method's criteria. It is important to note that this method does not take into account any grocery stores that lie just

beyond the block group's boundary. It is possible that residents that live towards the edges of the block group boundaries have close access to grocery stores that fall within a neighboring block group.

Method 2 identifies a large cluster of block groups in the South Phoenix area as having Very Low Access to food stores. All 275 of the Very Low Access block groups were also identified as food deserts in Method 1 as seen in Figure 12 below.

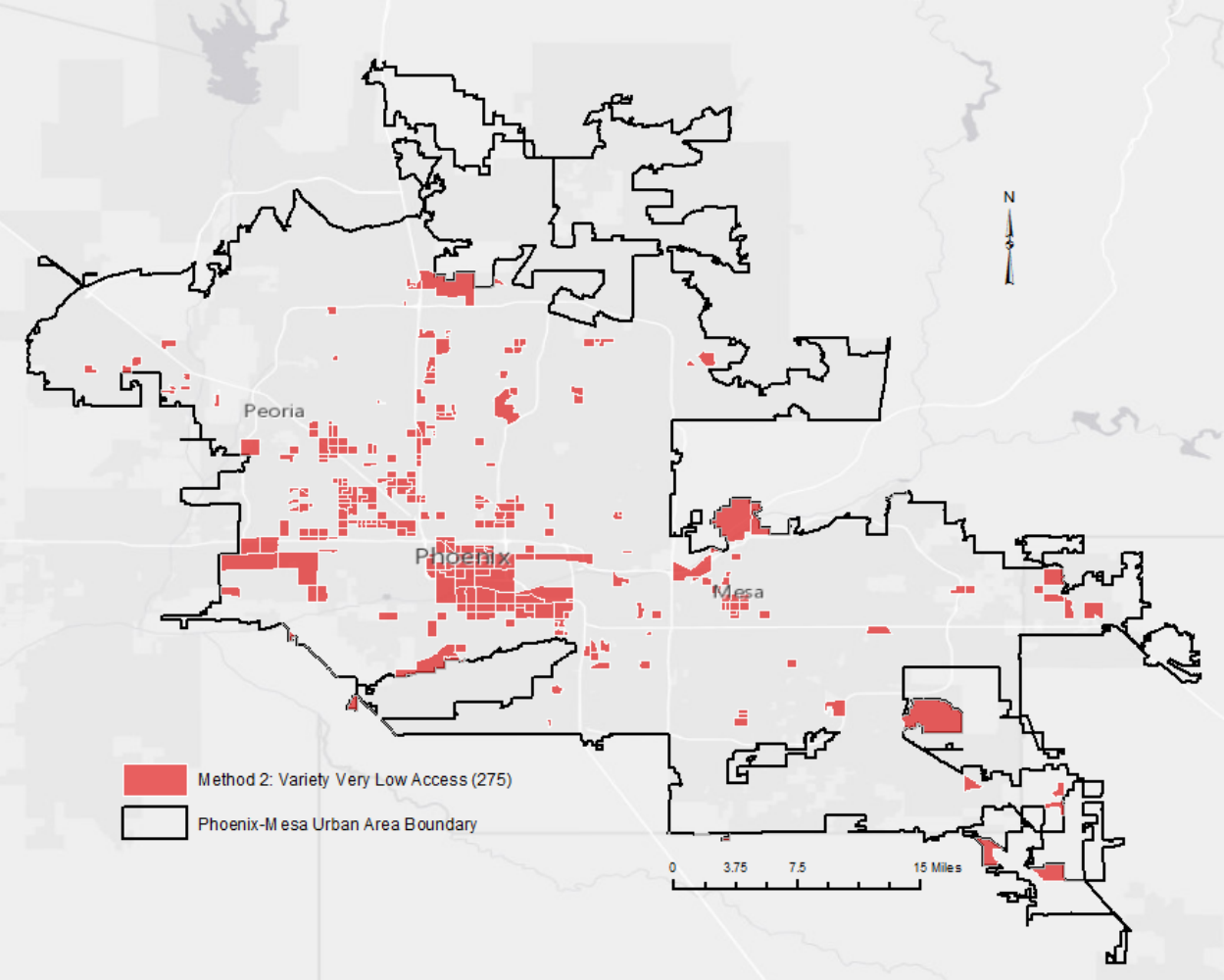

Figure 12 Potential Food Deserts Classified by Both Methods 1 and 2

4.3 Method 3: Competition

Method 3 identifies food swamps which are areas where a resident has to look harder for healthy foods because cheaper, calorie dense, nutrient empty foods, such as fast food, are more accessible. The Near tool in ArcMap was used to calculate the distance from each block group's centroid to the nearest grocery store location. This tool measures the distance between two features by calculating the shortest separation between them. In this case, it calculated the shortest distance between every block group's centroid to the closest grocery store locations and returned the distance to the nearest one in the output in the table. This distance was then copied into a new field in the attribute table. The Near tool was used again to find the distance from each centroid to the nearest fast food venues. A new field was added to the attribute table and Field calculator was used to calculate the grocery store to fringe food ratio which creates a food swamp score that can be used to describe healthy food accessibility. These scores were then classified according to the methodology of the Mari Gallagher consulting group. Ratio scores up to 1.3 were rated as Low meaning that a grocery is close and fringe food is more distant. Scores between 1.4 and 2.0 were rated as Average and scores over 2.0 were classified as High, where the fringe food is close and it takes longer to travel to the grocery store. The results of the Food Swamp analysis can be seen in Figure 13.

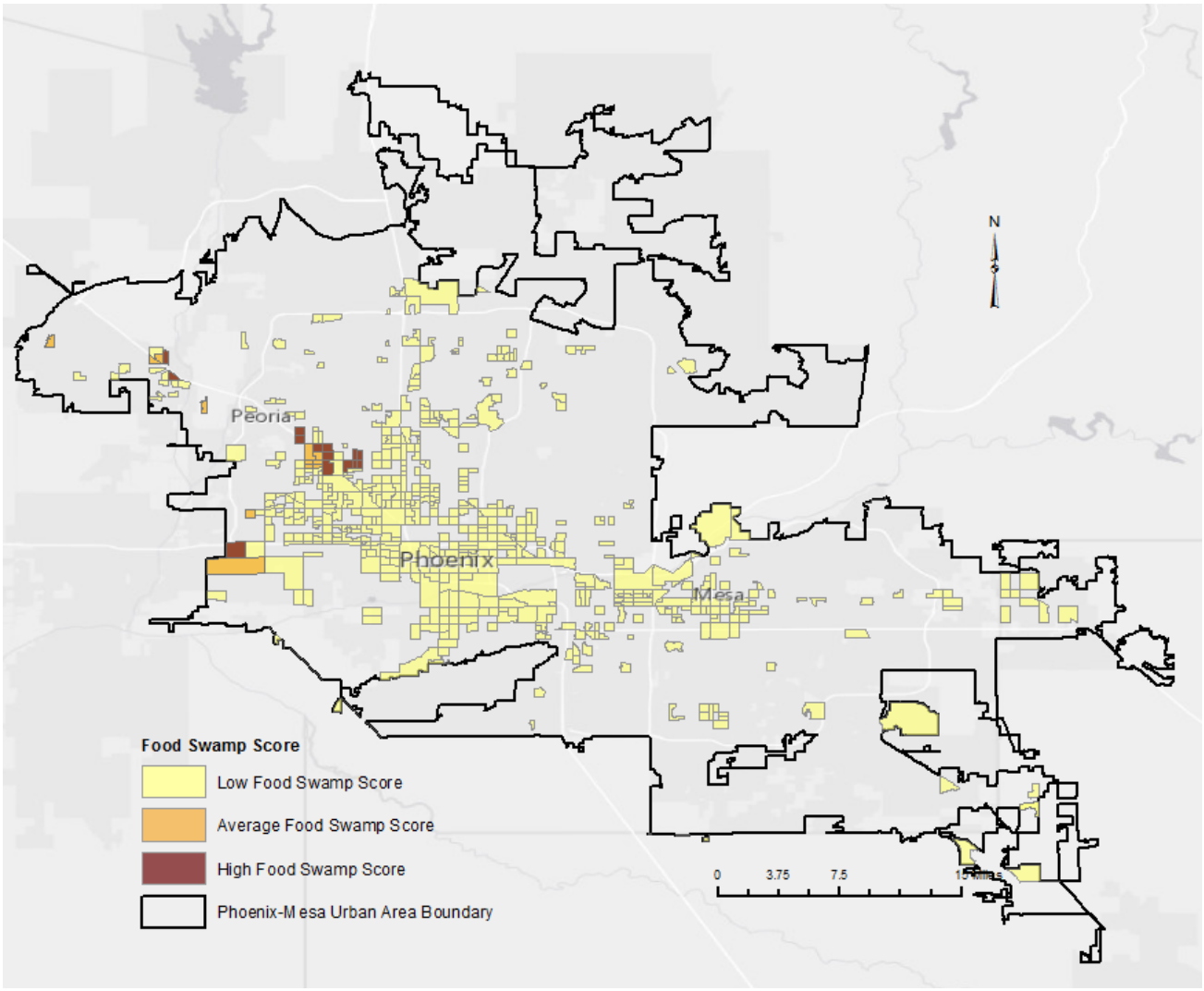

Figure 13 Method 3: Food Swamp Scores.

This food swamp method classified only 35 block groups as having an Average Food Swamp score when you consider fringe food options as competition and 37 as having a High Food Swamp Score. Fifty-one of these food swamp block groups were also identified by both Method 1 and Method 2, however it also classified 21 food deserts that were not picked up by Method 1 or Method 2 (Figure 14). The majority of these Very High Food Swamp Scores are seen along the highway where there are many truck stops for travelers heading out of town. It

makes sense that low-income block groups along the highways would have to travel farther for grocery stores as there is a high presence of fast food for truckers and travelers.

This method takes into consideration competition and balance of healthy and unhealthy food options. A Food Balance Score is created by calculating the average distance from a census block centroid to any "mainstream food venue" (healthy grocery outlet) and dividing this by the average distance to a "fringe food venue" (such as fast-food restaurant or unhealthy corner store). The scores are then weighted by population density within each census block (Gallagher Group, 2011). The benefit of this method is the ability to compare the saturation of good and bad food options within a specified area.

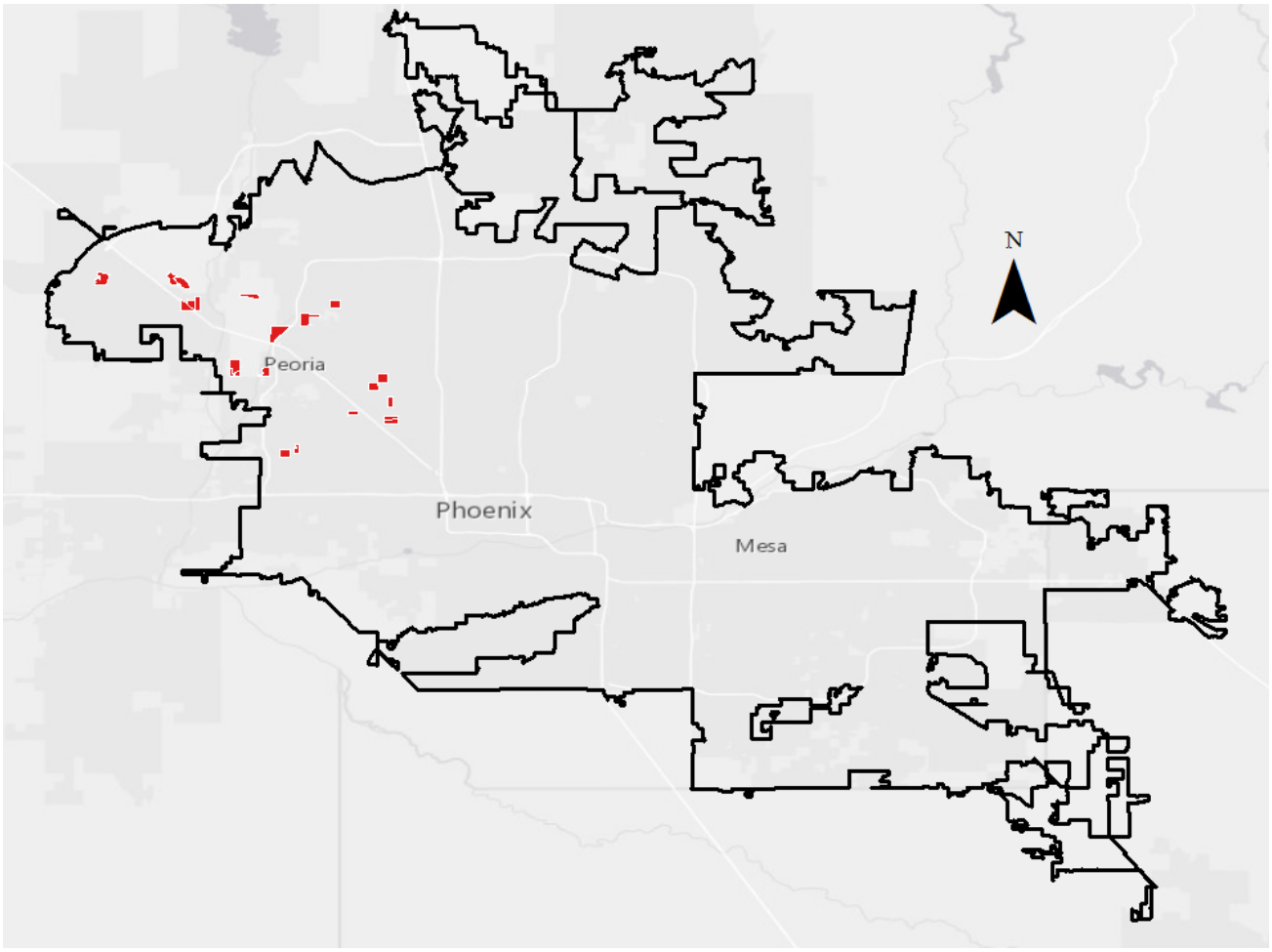

Figure 14 Food Swamp Block Groups That Were Not Previously Identified by Methods 1 and 2

4.4 Review of the Findings

Marked differences were observed in which census block groups had poor food access with the fewest number of block groups being identified by the Competition method, followed by the Variety measure and lastly the Proximity measure. The comparison table (Table 2), shows that according to the Competition method only 35 (6.2%) of the low income census block groups in the study area were designated as food swamp areas compared to 184 (32.7%) according to the Variety method. The Proximity method identified the majority of the low income block groups, 452, as a food desert areas.

Table 2 Attributes of Areas Designated as Having Poor Food Access According to Three Methods

	Proximity	Variety	Competition
Number of Block Groups	452	184	35
Total Low Income Block Groups (Percentage)	80%	33%	6%
Affected Population (Persons)	233,438	136,198	25,906
Minority Population (Percentage)	43%	41%	38%

Access to a supermarket based on proximity and variety is a problem for a large percentage of low income block groups in the Phoenix-Mesa Urban Area. Results indicate that residents are inhibited in their ability to access affordable nutritious food because they do not live within walking distance of a grocery store and may not have access to reliable transportation. This was shown both in Method 1 and Method 2. 80% of low income block groups are located out of a grocery store's service area in Method 1. According to the US Census data this equates to approximately 233 thousand people in the Phoenix-Mesa Urban Area.

Minority population percentage for each method was calculated by summing the minority population data in the US Census Table P5 (US Census, 2010) for all block groups designated as

food deserts and calculating the percentage of the summed total population for each block group. Populations considered minority include Black or African American, American Indian or Alaska Native, Asian, Native Hawaiian or Other Pacific Islander, Some other race, More than one race, Hispanic or Latino and Not Hispanic or Latino by race. The State of Arizona as a whole and the Phoenix-Mesa Urban Area have minority percentages of 42% and 29% respectively. The minority percentage in food desert areas for all three methods are higher than the urban area as a whole, but are similar when looking at the whole state of Arizona.

Research has shown that easy access to all food, rather than specifically healthy foods may be a more important factor in explaining obesity and health disparity among low-income populations in that many studies find a correlation between limited food access and a lower intake of nutritious foods. The Food Swamp method can quantify this with a Food Swamp Score, however, in the Phoenix-Mesa Urban Area, it appears that block groups with low food swamp scores are located along a well-travelled highway and low ratios would make sense given the large amount of fast food locations catering to truckers and travelers in these areas.

In Method 1 (Proximity), all census block groups that fell outside of walking distance to a supermarket considered food deserts, meaning that only supermarkets were perceived as being the only sources of healthy and affordable food options. However, there is some research that argues that by ignoring these alternative sources of healthy food such as farmers markets and ethnic or specialty stores, food deserts areas are likely to be overestimated (Bodor et al, 2008; Neckerman et al, 2009; VerPloeg, 2009).

Method 2 (Variety), measures food availability taking into consideration that people have preferences and can make decisions about where they shop. Block groups that have no grocery stores are considered very low access and block groups that contain only one option are still

considered low access. This method also does not take into consideration any other food outlet options such as farmers markets and or smaller stores. Method 3 measures the availability of both healthy and unhealthy foods and is focused on the ease of access to healthy foods.

Method 3 (Competition), also measures food availability and preferences as in Method 2, but takes into consideration the whole food landscape. Even in neighborhoods with grocery stores, the amount of fast food options can crowd out healthy food options. This is a main concern for those with busy families that may grab the easiest option or those that lack nutrition education. This is a problem because there are clear relationships between high access to fast food and negative health outcomes such as obesity and diabetes (Moreland et al 2002).

CHAPTER 5: DISCUSSION

Food access and varying food desert definitions in the Phoenix-Mesa Urban Area were explored using three different methodologies. The findings in this study showed that depending on the definition of food desert, the results can change extensively within the study area. In order to visualize where the inconsistencies were located, the results were mapped and analyzed. According to Method 1, a very large portion of the study area and most of the low income block groups included in this analysis were classified as food deserts. Food desert extent and location decreased with Method 2 and almost disappeared when Method 3 was applied. The results from these three different methodologies produced inconsistent results when it comes to finding areas that lack access to and availability of food.

5.1 Summary of Findings

The review of food desert literature showed that there is wide variability and inconsistency in definitions, variables or thresholds used for defining and locating food deserts. The results of this analysis show a systematic comparison between the three different measures of food access and highlight the similarities and differences between these measures.

This study replicated three measures of healthy food accessibility based on the same data using the most common definitions of proximity, variety and competition. This approach focused on the differences in results that can occur when different methods are used over the same geographic area of the Phoenix-Mesa Urban Area and demonstrated some substantial differences in coverage.

The simplest most widely used measure of food access is based on a reasonable walking distance to the nearest supermarket. Grocery store service areas were calculated and intersected with the centroids of low income block groups which designated 80% of the low income block

groups as potential food deserts. Because the only food sources included in this study were grocery stores, this method may have overestimated the food desert extent if farmers markets, ethnic food stores had been included.

The second method measured food access as the variety of food stores within a neighborhood and assigned a classification of Very High Access, High Access, Low Access or Very Low Access. The majority of the low income block groups fell into either the Low Access or Very Low Access categories.

The third method takes into consideration how hard a resident has to look to find food healthy or unhealthy. The Food swamp method measures competition by calculating the distance to the nearest grocery store location and the distance to any fast food location to create a ratio. The healthy food to fringe food ratio was then used to create a Food Swamp score based on the research of the Mari Gallagher Group. This method only designated 35 block groups as having significantly more difficulty getting to a grocery store. It also may indicate that in some areas that have been indicated as having poor access through methods one and two, the low income block groups have a hard time accessing any food. Residents need to travel equally far to get to a healthy food or fringe food venue. This method may be better suited to denser urban cores and may not produce significant results due to the sprawling nature of the Phoenix-Metro Area.

5.2 Significance of findings

Research on locating food deserts, access to healthy food choices and environmental injustice issues related to food security suggest that living in a food desert contributes to poor diet quality and higher risk for serious diseases. Many food activists consider equal access to food a basic human right and demand policy changes that will change the food environment for residents

living in food desert areas. This study has shown that there are in fact significant differences in the locations and extent in food accessibility in the Phoenix-Mesa Urban Area.

The proximity method specifically targets low income populations that have low access to food outlets and identified by far the most block groups out of the three methods. The variety method may be the most natural as it takes into consideration choice and preference of where residents may shop.

As food desert research evolves and food access policies in the United States progresses, the governments and agencies involved need to understand how their food access definitions impact the geographical extent of the problem. As this area of research continues to grow and become a bigger focus, researchers may want to consider working towards the synchronization of their various definitions.

5.3 Study Limitations

This study has several limitations beyond the limitations discussed in Chapter 3. The potential access that was measured in all three methodologies identified grocery stores where residents had the option to shop, without taking into consideration preferences or where residents actually shop (VerPloeg, 2009) and also the assumption that residents would always choose the healthiest option I distance allowed them to. Another limitation is that access to food stores was only measured by walking and access to transportation was not considered as it was beyond the scope of this study. Additionally, while thorough phone vetting was done in the data gathering phase, an in-store survey was not. An analysis of shelf space holding healthy food options versus junk options could be used to distinguish gas stations, convenience stores, and ethnic and specialty stores as responsible providers of healthy food options to be included in the analysis. Another factor that a survey could illustrate is any cost-based accessibility in low income areas.

There is also an assumption, in this thesis and any study that uses Census data, that the land use within each block group is homogeneous, which is not always the case. The use of a centroid point in these methods assumed an equal distribution of residential areas within the block group. Geographic reality is that residential areas cluster with other residential areas. This could potentially cause the population to be located in one corner of the block group which would have an impact on realistic walking distances.

5.4 Opportunities for Future Research

In previous chapters, food desert definition variations were discussed and, in some cases, the existence of food deserts was debated among scholars because of the different ways of defining and measuring food deserts. Because of all of the factors involved in locating food deserts, some researchers believe that a universal methodology will never be achieved that will produce accurate and realistic results. In order to advance this research, this thesis compared the results of the three most common methodologies applied to the same area and mapped the results so that the inconsistencies could be analyzed. As awareness of how different variables link the food environment, health and other environmental issues grows, policy makers will need a better understanding of what causes food deserts in urban neighborhoods. By properly selecting and analyzing food desert elements, analysts and decision makers can reduce errors and improve the comparability of the results across studies which they can then use to make confident decisions and solutions for their community's problems.

5.5 Recommendations for Future Research

The majority of the research in this area has focused on quantitative approaches, but even advanced mathematical formulations cannot quite capture such things as personal preferences, decision making or education regarding health. Surveys of individuals and households or the

contents of food outlets would add qualitative angles to this problem including data on food shopping behavior and decision making.

It would also be interesting to re-run all three of these methods taking into consideration other outlets of healthy food such as farmers markets and specialty or ethnic grocery stores. Both research by Rose et al (2009) and Short et al (2007) indicated that an area technically cannot be defined as a food desert based only on the absence of grocery stores and supermarkets when alternative sources of healthy and affordable food options are present in the given study area. It would be interesting to see how large of an impact the addition of those locations would make. Inclusion of those stores would at the very least provide food for the cultural preferences of the Latino communities that are predominant in the South Phoenix and Chandler food desert areas called out in this study.

In just about all food desert studies, household income and distance are assumed to be the most significant barriers when it comes to healthy food options. A more extensive set of variables and regression analysis would be interesting future research in order to measure food access and identify food deserts and which variables actually contribute more to the problem.

Appendix A: Reviewed Food Desert Studies

Researcher (year)	Study Area	Food Availability (Food Store Types)	Food Access Measure	Buffer Size	Buffer Shape	Data Aggregation Level	Socioeconomic & Demographic Variables	Findings
Anthony & Lee (2010)	Los Angeles, California	Supermarkets	Proximity, Density	1600 m	Network	Census Block Group	Income	Food deserts in Downtown area and Southeast Los Angeles.
Apparicio et al (2007)	Montreal, Quebec	Supermarkets	Proximity, Density, Variety	1000 m	Network	Census Tract Block	Income, Lone-parent families, Unemployment, Education, Recent immigrants	No food deserts found in Montreal.
Austin et al (2005)	Chicago, Illinois	Fast food outlets, School locations	Proximity to schools, Density	400 and 800 m	Circular	Census Tract	Household income, percentage of commercial land, located in or out of downtown	Fast food locations are concentrated near schools.
Baltimore City's Food Policy & Johns Hopkins Center (2010)	Baltimore, Maryland	Supermarkets, Convenience Stores, Corner Stores	Proximity, Density	400 m	Network	Block Group	Household income, Car ownership	Food desert located in inner-city area.

Baker et al (2006)	St Louis, Missouri	Supermarkets, Fast food outlets	Spatial Clustering to Supermarkets and Fast food	N/A	Circular	Census Tract	Household income, Ethnicity, Poverty level, Composite score of available supermarket and fast food locations	Income and ethnicity are associated with food deserts and an increased selection of fast food options.
Block & Kouba (2006)	Chicago, Illinois and neighboring communities of Austin and Oak Park	Supermarkets, Independent grocery stores, Convenience stores, Other food outlets	Proximity	0.25/0.5 /0.75/1 mile around food store	Circular	Neighborhood	Cost and Quality of produce, Car ownership	The type and number of grocery stores vary between Austin and Oak Park.
Block et al (2004)	New Orleans, Louisiana	Fast food outlets, Alcohol outlets, Location of highways	Density, Distance	0.5/1 mile	Circular	Census Tract	Ethnicity, Household income, Median home value	Fast food locations are geographically associated with predominantly black and low income neighborhoods.
Bodor et al (2008)	New Orleans, Louisiana	Supermarkets, Small food stores	Density, Proximity	100 m	Circular	Neighborhood	Age (Adults over 16 years old), Food intake surveys, household income, Education level, Occupation	Access to small food stores was only slightly associated with increased fruit consumption and no association was found between fruit and vegetable intake and access to supermarkets.
Burdette et al (2004)	Cincinnati, Ohio	Supermarkets, Fast food outlets	Network, Distance between child's home and playgrounds/ fast food outlets	N/A	N/A	Household	Age (Children 3-4 years old), Sex, Ethnicity, Household income, BMI, Household size, Emergency phone calls and Serious crime events	There is no association between fast food outlets proximity to playgrounds and overweight children.
Burns & Inglis (2007)	Casey, Melbourne, Australia	Supermarket, Fast food	Proximity by car and by bus	Modeled distance	Network	Collection Districts	Population density, SEIFA Deprivation index	Poorer areas had closer access to fast food while more advantaged areas had closer access to supermarkets.

Clarke et al (2002)	Cardiff & Leeds/Bradford, England	Co-op stores, Grocery stores, Discount stores, Multiple stores	Proximity, Density	500 m	Circular	Postal Sector	Household income, Car ownership, Retired/Inactive	The indicators identified six food deserts. Two in Leeds/Bradford and four in Cardiff.
Coombs et al (2010)	Madison, Wisconsin	Supermarkets, Full-service grocery stores	Proximity, Density	1600 m	Circular	Census Block	Household income, Car ownership, Ethnicity	Classic food desert areas in Southside & Eastside of Madison
Commercial Policy Review (2010)	Kitchener, Ontario	Grocery stores, Convenience stores	Proximity	1000 m	Circular	Neighborhood	None used	Food deserts in the south of Kitchener
Community Planning Studio (2010)	Prince George's County, Maryland	Grocery stores, Convenience stores, Liquor stores, Farmers Markets	Proximity, Density	800 m	Network, Circular	Block Group	Household income, Car ownership, Population	Three food deserts in the county
Donkin et al (1999)	London Town, England	Supermarkets, Greengrocer, Butcher, Other food outlets	Proximity	500 m	Circular	Postcode	Carters deprivation scores, Questionnaire, Price basket comparison, Density of population	There were few areas found where a person would have to walk more than 500 m and there were more food outlets present in higher populated areas.
Eisenburg & Silcott (2010)	Franklin County, Ohio	Grocery stores	Proximity	400/800/1600 m	Network	Census Tract	Household income, Car ownership, Population	Severe food deserts found in east Franklin county.
Frank et al (2006)	Atlanta, Georgia	Fast food, Restaurant, Convenience, Grocery stores	Proximity	0.25/1.25 mi around schools	Circular and Network	Census Tract	Walkability, Household income, Price basket, Spatial autocorrelation	There was spatial variation in type of food outlet across neighborhood by income, but not by walkability.
Gordon et al (2010)	New York City	Supermarkets, Bodegas, Fast food outlets	Proximity, Density	400 m	Network	Block Group	Household income, Ethnicity	Four food deserts were found in New York City
Jago et al(2007)	Houston, Texas	Food stores and restaurants	Proximity, Density	1 mi	Circular	Census Tract	Ethnicity, Education level, Age, BMI, Fruit and vegetable availability at home	Distance to food store was a positive indicator of healthy food availability at home.

Jeffery et al (2006)	Minnesota	Fast food, Other restaurant	Density, Competition	0.5/1/2 mi around home and work	Circular		Gender, Education, BMI, Hours of TV watched, Physical activity	There is positive association between "eating fast food" and having children, a high fat diet and BMI. However, no association between fast food proximity and BMI.
Kershaw et al (2010)	Saskatoon, Saskatchewan	Supermarkets, Fast food outlets	Proximity, Density, Variety	1000 m	Network	DA	Household income	Primary food deserts in central Saskatoon and also in surrounding neighborhoods
Kowaleski-Jones et al(2009)	Salt Lake County, Utah	Grocery stores	Proximity, Density	500 m	Circular	Block Group	Household income	Food desert results differed based on employed definition and dataset
Laraia et al (2004)	Wake County, North Carolina	Supermarket, Convenience store, Grocery store	Proximity, Density	0.5 mi	Circular	Household (Pregnant women)	Diet quality index, Age, Ethnicity, Education level, Household income, Marital status	Living at a distance greater than 4 miles from a supermarket had a negative association on diet quality.
Larsen & Gilliland (2008)	London (Ontario, Canada)	Supermarkets	Proximity, Density	500/1000 m	Network (by Public transit and vehicle)	Census Block	Education, single parenthood, unemployment, Low income	Food deserts exist in the east area of London.
Liu et al (2007)	Marion County, Indiana	Supermarket, Grocery store, Convenience store, Fast food	Proximity	2 km	Network	Neighborhood	Population density, Household income, BMI, satellite imagery of vegetation	Greener neighborhoods are associated with reduced risk of overweight children and distance between home and closest supermarket was an indicator of low BMI in lower population density neighborhoods.

Moore et al (2008)	New York City, North Carolina and Maryland	Supermarket, Other smaller stores	Density	1 mi	Kernel Density Method	Census Tract	Perceived availability of healthy food, Dietary patterns survey, Age, Gender, Ethnicity, Household income, Population density	People with no close supermarkets were less likely to have a healthy diet and supermarket density is a positive indicator of perceived healthy food availability.
O'Dwyer & Coveney (2006)	Adelaide, Australia	Supermarkets	Proximity, Density	2500 m	Network	Local Government Areas (LGA)	Car ownership, SEIFA	Many food deserts appear to exist within the LGAs depending on socio-economic differences.
Pearce et al (2006)	New Zealand	Food outlet, health facilities	Proximity	travel time	Network	Census Meshblock	N/A	There are variations in accessibility between neighborhoods.
Pearce et al (2007)	New Zealand	Supermarket, fast food, Convenience store	Proximity, Competition	travel time	Network	Census Meshblock	Socio-economic characteristics, Urban/rural status	Access to fast food is greater in more deprived neighborhoods and around more disadvantaged schools.
Pearce et al (2008)	New Zealand	Supermarket, Convenience store	Proximity	travel time	Network	Census Meshblock	Meshblock variables, Survey	Little evidence found that poor access to food is associated with lower fruit and vegetable intake.
Rose et al (2009)	New Orleans	Supermarkets, Fast food outlets	Proximity, Density	1000/2000 m	Network	Census Tract	Household income, Car ownership	Food desert rates range from 17% to 87 % based on the definition and factors used.
Russell & Heidkamp (2011)	New Haven, Connecticut	Supermarkets, Grocery stores	Proximity	400/800/1600 m	Network	Block Group	Household income, Car ownership, Poverty level	Sever food deserts found in east New Haven.
Schledt (2010)	Nashville, Tennessee	Grocery stores	Proximity	500 m	Circular	Census Block	Household income, Car ownership	Four food deserts found in study area.

Sharkey & Horel (2008)	Six different counties in rural Texas	Grocery store, Supermarket, Convenience store, Discount store	Proximity	N/A	network	Deprivation index, Minority composition, Population density	Household	There is better spatial access to food stores for neighborhoods with high socio-economic deprivation.
Smoyer-Tomic et al (2008)	Edmonton, Alberta	Supermarket, Fast food	Proximity	500/800 m	Circular around Block centroid, Network	Census Block	Ethnicity, SES, Age, Family status, Housing tenure, Urbanization	Fast food outlet density was higher in low-income neighborhoods.
Smoyer-Tomic et al (2006)	Edmonton, Alberta	Supermarkets	Proximity, Density	1000 m	Network	Postal Code	Household income, Elderly people, Car ownership	Six food deserts identified in suburban areas
Ball et al (2008)	Geelong area, Melbourne, Australia	Supermarket, Greengrocer, Convenience store, Fast food, Restaurants	Proximity, Competition	800 m	Network	Household	Survey, Socioeconomic and demographic variables	Children consumed more vegetables if they lived farther away from a supermarket or fast food outlet.
University of Washington (2011)	Puget Sound, Washington	Supermarkets	Proximity	800 m	Network	Census Block	Household income	Food deserts in suburban areas except King county
Winkler et al (2006)	Brisbane, Australia	Supermarket, Greengrocers	Proximity	2.5 km	Circular	Census collection districts	IRSD, Hours of operation	It is unlikely that living in a socioeconomically disadvantaged area presents fewer opportunities to purchase fruits and vegetables in urban areas.
Widener et al (2012)	Buffalo, NY	Grocery stores and mobile produce trucks	Competition	N/A	Spatial Optimization Model	Block groups		There are many areas in Buffalo with low access to grocery stores that may be alleviated by mobile food trucks.

Zenk et al (2005)	Detroit, Michigan	Supermarket	Proximity	N/A	Network (Manhattan)	Census Tract	Population density, Residents below poverty, Spatial autocorrelation	The most impoverished neighborhoods with African American residents were further from the nearest supermarket than were the most impoverished white neighborhoods.
Zenk & Powell (2008)	The fifty US States and the twenty largest cities in the US.	Fast food, Convenience store	Density	0.5 mi	Circular	Census tract	Ethnicity, Median income, Education level, Population density, Urbanization	Within 0.5 miles walking distance fast food and convenience stores were more available in the lowest income neighborhood and there were fewer food outlets in African American neighborhoods than white neighborhoods.

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