MEASURING FOOD DESERTS: A COMPARISON OF MODELS MEASURING THE SPATIAL ACCESSIBILITY OF SUPERMARKETS IN PORTLAND, OREGON

by

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Title: MEASURING FOOD DESERTS: A COMPARISON OF MODELS MEASURING THE SPATIAL ACCESSIBILITY OF SUPERMARKETS IN PORTLAND, OREGON

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Dr. Neil Bania

Food deserts are low-income, urban areas that have poor spatial access to supermarkets. To date, researchers have developed theories about the food desert phenomenon's public health and fiscal implications in the form of diet-related health problems and its impact on the efficiency of government transfer payments, like food stamps. Researchers have also devised a number of ways to measure the presence and severity of food deserts, though progress still needs to be made toward establishing reliable, practical and feasible food desert measures. Using geographic information systems (GIS), this study employs three measures of supermarket accessibility to determine the presence and severity of food deserts in Portland, Oregon. It also compares

the sensitivity of the measures to changes in inputs with the goal of generating advice for planners about accurate, low-cost ways to measure supermarket access in their communities.

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Dedication

To Ifiok

For his caring and patience, for listening thoughtfully, for always believing in me.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER I

INTRODUCTION

Background

Food Deserts: Discovery

In the mid-1990s, social workers and researchers in the United Kingdom observed that many neighborhoods characterized by substantial social deprivation or low income levels lacked supermarkets. Interviews with residents revealed many did not own automobiles and that they were relying on nearby small independent or convenience stores for their food shopping needs (Whelan, Wrigley, Warm, & Cannings, 2002). Lower rates of automobile ownership have long been an accepted characteristic of low-income populations, making the physical composition of low-income neighborhoods, specifically the local provision of essential services, particularly important (Morris & Carstairs, 1991).

Further research confirmed small, independent grocers and conveniences stores charged substantially higher prices and offered a limited selection of fresh and healthy foods (Cummins & Macintyre, 2002; Wrigley, Warm, Margetts, & Whelan, 2002). The knowledge that low-income residents were less likely to own automobiles, combined with evidence that the small stores within walking distance charged higher prices and carried fewer healthy foods lead researchers to theorize that, in general, a lack of supermarket access may translate into a reduction in physical access to opportunities to purchase healthy foods. Socially deprived, low-income neighborhoods that lacked supermarkets became known as 'food deserts'.

The Urban Grocery Gap: Discovery

In the United States in the mid-1990s, researchers were also interested in supermarket access for low-income populations. University of Connecticut Food Marketing Policy Center researchers, Cotterill and Franklin, produced a landmark study titled, "The Urban Grocery Store Gap" (1995), in which they documented a statistically significant relationship between public assistance rates and supermarket access in 21 major urban areas.[1] Specifically, their study found "a significant negative relationship between the percent of households on public assistance and stores per capita, which means that we have been able to document in a statistical fashion that zip codes with a larger public assistance load do have fewer stores per capita in these twenty-one large cities which account for approximately thirty percent of the U.S. population" (Cotterill & Franklin, 1995, p. 7).. Their study also reported descriptive statistics at the zip code level on per capita income, number of supermarkets and square feet of supermarket retail space. They found that, on average, zip codes with the lowest per capita income had fewer supermarkets and fewer square feet of supermarket retail space.

[1] The 21 urban areas included in the study were: Atlanta, GA; Boston, MA; Bridgeport, CT; Chicago, IL; Cleveland, OH; Dayton-Springfield, OH; Detroit, MI; Hartford, CT; Houston, TX; Los Angeles, CA; Memphis, TN; Minneapolis, MN; New Haven, CT; New Orleans, LA; New York, NY; Oakland, CA; Philadelphia, PA; San Antonio, TX; St. Louis, MO; Washington, DC; and Wichita, KS (Cotterill & Franklin, 1995).

Supermarket Disinvestment: Systematic Patterns of Unequal Access

The Cotterill and Franklin study spawned a whole body of supermarket access research in the United States that sought to document and explain what became known as "the urban grocery gap," a lack of supermarkets in urban areas. Table 1 shows that, from 1980 to 1990, the number of supermarkets in some major metropolitan areas in the United States decreased between five and thirty percent. Evidence like these lead many researchers to conclude not only that urban areas had fewer supermarkets, but that the reason urban areas had fewer supermarkets was due to a pattern of systematic disinvestment on the part of companies (Eisenhauer, 2001; Nayga & Weinberg, 1999; Pothukuchi, 2005).

Table 1

Change in number of supermarkets in US metro areas, 1980-1990

Metro area[a]	Number of supermarkets 1980	1990	% Change
Baltimore	101	70	-30.7
Boston	145	120	-17.2
Chicago	582	469	-19.4
Cleveland	171	134	-21.6
Denver	36	30	-16.7
Detroit	234	195	-16.7
Indianapolis	139	102	-26.6
Los Angeles	875	694	-20.7
Miami	189	193	2.1
Milwaukee	116	110	-5.2
New York	775	563	-27.4
Philadelphia	131	121	-7.6
San Francisco	58	48	-17.2
Washington, DC	61	57	-6.6
Total	3613	2906	-19.6

[a] Metro areas are defined as that portion of an MSA considered to be the central/core county with population of 1,000,000 or more in 1990.

Source: US Department of Agriculture.

Note. From "Supermarket access in the inner cities," by R.M. Nayga and Z. Weinberg, 1999, *Journal of Retailing and Consumer Services, 6(3)*, p. 142.

Why Supermarkets Leave

Pothukuchi (2005) contends the departure of supermarkets from urban areas is due to the changing nature of cities' physical landscape. "Over the past 5 decades, supermarkets have abandoned the inner city for suburban and exurban locations, which offered more land for parking, easier loading and unloading by trucks, convenient access to highways and arterials, and a development context for much larger stores" (Pothukuchi, 2005, p. 232). Some researchers also suggest that, in addition to the physical attractiveness of suburbs, social and demographic changes play a role in supermarket disinvestment. According to Nayga and Weinberg (1999), "supermarkets have fled the inner cities of America for a variety of reasons, including declining middle class population, civil unrest, the higher cost of doing business, and a more spacious and secure environment in suburban areas. In fact, almost one-half of the supermarkets in the three largest US cities closed during the period 1970-1990" (p. 141).

Food Desert or Urban Grocery Gap: What is the Difference?

Food desert and urban grocery gap literature both examine low-income, urban populations' access to supermarkets. In general, the main goal of a food desert study is to identify specific, low-income areas that lack supermarket access and to somehow quantify that lack of access (Apparicio, Cloutier, & Shearmur, 2007; Larsen & Gilliland, 2008). Studies whose goal is to document a pattern of unequal distribution of supermarkets in low-income or largely minority neighborhoods throughout cities, states or nations, are most closely related to urban grocery gap literature (Alwitt & Donley, 1997; Zenk et al., 2005).

Why Supermarket Access is Important

Low-income populations' lack of supermarket access has important public policy implications. One significant effect of lack of supermarket access is its negative impact on diet. Eisenhauer (2001) writes:

> For those urban shoppers with access to a nearby supermarket, then, the prospect of obtaining healthy, reasonably priced food is much less complicated. Further, the elimination of additional travel time and expense is likely to improve quality of life simply by reducing stress related to grocery shopping. And while the presence of a nearby supermarket is not a guarantee of healthy eating habits, it certainly improves the chances for poor urban shoppers and their families to include fresh, unprocessed and low-glycemic foods in their diets and enjoy the benefits of improved nutrition. (p. 130)

This assertion that access to supermarkets can reasonably be expected to make eating healthier easier is supported by recent studies. At least three studies have shown that low-income residents with poor supermarket access eat fewer fruits and vegetables than those with better supermarket access (Rose & Richards, 2007; Wrigley et al., 2002; California Center for Public Health Advocacy, PolicyLink, & UCLA Center for Health Policy Research, 2008).

Lack of supermarket access also affects the efficiency of government transfer payments, like food stamps. When people shop at more expensive food retailers, food stamps and public assistance dollars do not go as far to improve peoples' health and well-being as they could if those dollars were spent at supermarkets (Nayga & Weinberg, 1999; Pothukuchi, 2005).

Food Deserts: Conceptual and Operational Definitions

The British government's social and health policy literature of the 1990s "used the term 'food deserts' to describe areas of relative exclusion where people experience physical and economic barriers to accessing healthy food" (Reisig & Hobbiss, 2000, p. 138). As Reisig and Hobbiss (2000) contend, "The term [food desert] 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. 138). Similarly, Shaw (2006) contends food deserts have physical, geographical components (lack of nearby access) and attitudinal components (for social or lifestyle reasons people do not purchase healthy food). She goes on to suggest that:

> Classifying 'food deserts' according to their causative factors may facilitate the development of a more precise definition, or perhaps suggest an alternative name for the unsupportive food environments, for example, 'food denial situations', where 'denial' includes 'self-denial'. This would cover the 'attitudinal' situations described above where consumers have physical and financial access to a healthy

> diet but choose, for reasons of time pressure, lifestyle or cultural preferences, not to purchase healthy food. This is a very different situation from consumers in deprived neighbourhoods who cannot afford either healthy food or the travel required to purchase it, but ultimately the medical problems of failing to consume a healthy diet are similar, whatever the reason for non-consumption. (p. 246)

However, scholarship published in the "Special topic: 'food deserts' in British Cities" issue of *Urban Studies* (2002) still plays a defining role for many food desert researchers. Those studies defined a food desert as an urban area in which residents lack reasonable, spatial access to 1) fresh fruits and vegetables, 2) foods from all the major food groups required for a 'modest but adequate diet', and 3) food items priced competitively compared to the same item in a higher income neighborhood (Wrigley et al., 2002; Wrigley, Warm, & Margetts, 2003; Wrigley, 2002; Clarke, Eyre, & Guy, 2002; Whelan et al., 2002; Wrigley, Guy, & Lowe, 2002). Most food desert researchers accept this conceptual definition, but operationalize the concept in different ways.

All the recent North American food desert studies cited in this study defined reasonable access as having a supermarket within walking distance, and all have used supermarkets that belong to chains as their proxy for fresh, affordable food (Apparicio et al., 2007; Larsen & Gilliland, 2008; Zenk et al., 2005).

Supermarket Accessibility Measures

In addition to identifying the food desert phenomenon and defining its parameters, researchers have also devised a number of ways to measure its presence and severity. However, there is no consensus on which measures should be used to assess whether a community's low-income residents have adequate access to fresh, affordable food.

The types of supermarket accessibility measures employed by food desert researchers can be organized into three categories: provision, accessibility, and model-based (Clarke et al., 2002).

Provision Measures

Provision measures measure the number of supermarkets or supermarket retail square footage per capita for a selected geography. "The Urban Grocery Store Gap," Cotterill and Franklin's 1995 study of supermarket access, is the most recognized and widely cited study that used provision measures. They used zip code level demographic data from the 1990 Population Census and a comprehensive list of supermarkets to calculate the number of stores per capita and amount of retail sales area per capita for 21 major U.S. urban areas. They found a significant statistical relationship between high public assistance rates and reduced supermarket provision (Cotterill & Franklin, 1995).

Accessibility Measures

Accessibility measures measure low-income neighborhoods' proximity to supermarkets. In access research, proximity can mean travel time or distance. Food desert researchers employing proximity measures generally use geographic information systems (GIS) to measure the distance between the centroid of a neighborhood and the nearest supermarket (Apparicio et al., 2007; Larsen & Gilliland, 2008; Zenk et al., 2005).

Model-based Measures

Model-based measures combine measures of multiple aspects of access to generate a spatial interaction model that attempts to predict which areas are underserved by supermarkets. Some measures included model-based measures are: provision (retail space per household), accessibility (nearest store), attractiveness of store (stores with lower prices are more attractive to low-income residents; stores with higher prices and more specialty wares are more attractive to higher income residents), household income, and grocery spending (Clarke et al., 2002). The goal of the model-based measure is to predict where residents shop and to assess their level of access to stores they can afford. In addition, Clark et. al (2002) wanted to use the model to predict what impact the development of different types of new stores would have on access levels, their base assumption being that a fit between consumers in need and the type of store was required to improve access. In other words, for example, the development of a high-priced, specialty store could not be expected to improve access for low-income residents.

Origins of the Measures Used in this Study

This study replicates and expands on the measures devised by Apparicio, Cloutier and Shearmur (2007) for their study of supermarket access on the Island of Montreal, Quebec, Canada. Keeping in mind that, even when using the same inputs, different access measures have been shown to produce different results, Apparicio et. al chose to use three accessibility measures that assess multiple aspects of populations' access to supermarkets: proximity, variety, and competition (Apparicio et al., 2007; Talen, 2001; Talen & Anselin, 1998). Most food desert studies employ one provision or accessibility measure that serves to answer the question of whether low-income residents have a level of supermarket access similar to that of higher income residents or whether low-income residents have a supermarket near their home. The Apparicio et. al (2007) study is unique because it is one of the few food desert studies that employs multiple access measures, and it makes an effort to refine and tailor the access measures employed to the specific purpose: assessing whether low-income residents have local access to affordable, healthy food.

Apparicio et. al (2007) acknowledges supermarket access may have multiple aspects related to the specific experience of food shopping and attempts to operationalize the key concepts of 'affordable' and 'local.' The inclusion of three measures, proximity, variety and competition, attempts to address unique aspects of supermarket access. Proximity is important because research shows low-income people are less likely to own an automobile. Variety is important because research into retail choice suggests people value variety and do not always shop at the supermarket that is closest to home (Handy, 1996). Finally, competition is an accepted price control mechanism, which is important when evaluating access for low-income populations.

Purpose of the Study

The purpose of this study is to investigate the nature of low-income individuals' access to supermarkets in the Portland, Oregon metropolitan area and to make progress toward developing reliable, efficient and cost-effective methods for measuring supermarket accessibility. To achieve this, this study:

1) Investigates whether there is a systematic pattern of unequal supermarket access between high and extreme poverty areas and non-poverty areas;
2) Identifies low-income areas that lack access to supermarkets; and
3) Tests the sensitivity of the measures used to changes in type of distance input and choice of geography.

CHAPTER II

DATA

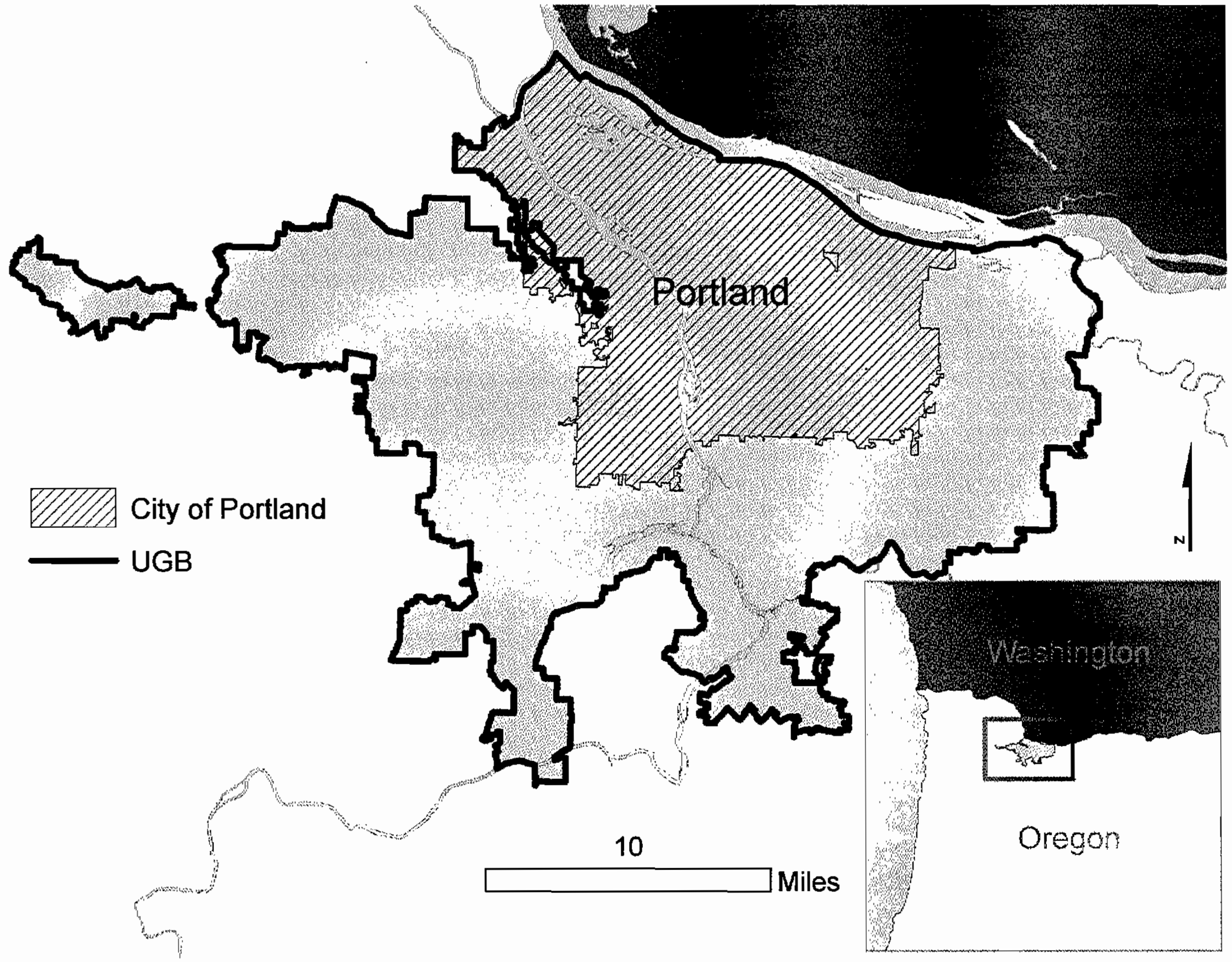
Study Area

The study area consists of the 243 census tracts that are completely contained within Portland, Oregon's metropolitan area urban growth boundary (UGB) (see Figure 1). The study's 243 census tracts contain 722 census block groups and 18,203 census blocks. Because the focus of this study is an assessment of low-income, urban residents' access to supermarkets, the UGB provides a natural study boundary. However, tracts that contain census blocks that lie outside the UGB were excluded to reduce aggregation error, an issue that will be discussed further in the explanation of access measures.

In 2000, the US Census reported the 243 tracts in the study area had 1,071,817 residents. At the time, 113,627 people (11.4%) in the study area were living below the federal poverty level. Three census tracts in the study area are considered extreme poverty tracts, tracts in which 40 percent or more residents live in poverty. Twenty-four tracts in the study area are considered high poverty tracts, tracts in which between 20 and 39.9 percent of residents live in poverty (Greene, 1991; Jargowsky & Bane, 1990)

Figure 1

Study area. Portland, Oregon's metropolitan urban growth boundary (UGB)



Poverty Data

Data about poverty in the study area came from the 2000 US Census. For each tract, a ratio of the total people for whom poverty status was determined to the total people residing in that tract was calculated. This ratio is the poverty rate used in the study (see Figure 2).

Supermarket Data

Supermarkets were chosen for inclusion in this study based on criteria consistent with the body of food desert literature. Stores had to 1) sell a full range of products, including fresh fruit and vegetables, dairy and meat, and 2) be part of a chain or be directly affiliated with a distribution system responsible for supplying multiple stores (as is the case with many Portland-area Thriftway stores; some are independently owned and some are part of either Lamb's or Bale's grocery chains).

Supermarket business characteristics and addresses were collected from ReferenceUSA, an online database of business information compiled from phone books, public records, and US Postal Service records ("ReferenceUSA: An infoUSA Company"). Searches within the database were conducted using the 2007 North American Industry Classification System (NAICS) code for supermarkets, 445110.

The list of stores gathered from the database was checked for completeness and accuracy by visiting each chain's corporate website. For some stores, the extent of products carried and ownership details were confirmed by telephone. The final list of

147 supermarkets generally belong to 18 supermarket chains: Albertson's, Cost Cutter, Food 4 Less, Fred Meyer, Grocery Outlet, Haggen Food, Lamb's, Market of Choice, New Seasons, QFC, Safeway, Save-A-Lot, Thriftway (Bale's, Lamb's and independent), Trader Joe's, Whole Foods, Wild Oats, WinCo, and Zupan's Markets (see Appendix A for a complete list of supermarkets included in the study).

Using geographic information systems software, ArcGIS 9.2, 145 of the 147 stores were successfully geocoded to street files from Metro, Portland's metropolitan regional government (see Figure 3).

Figure 2

Poverty rate by census tract, Portland, Oregon metropolitan area

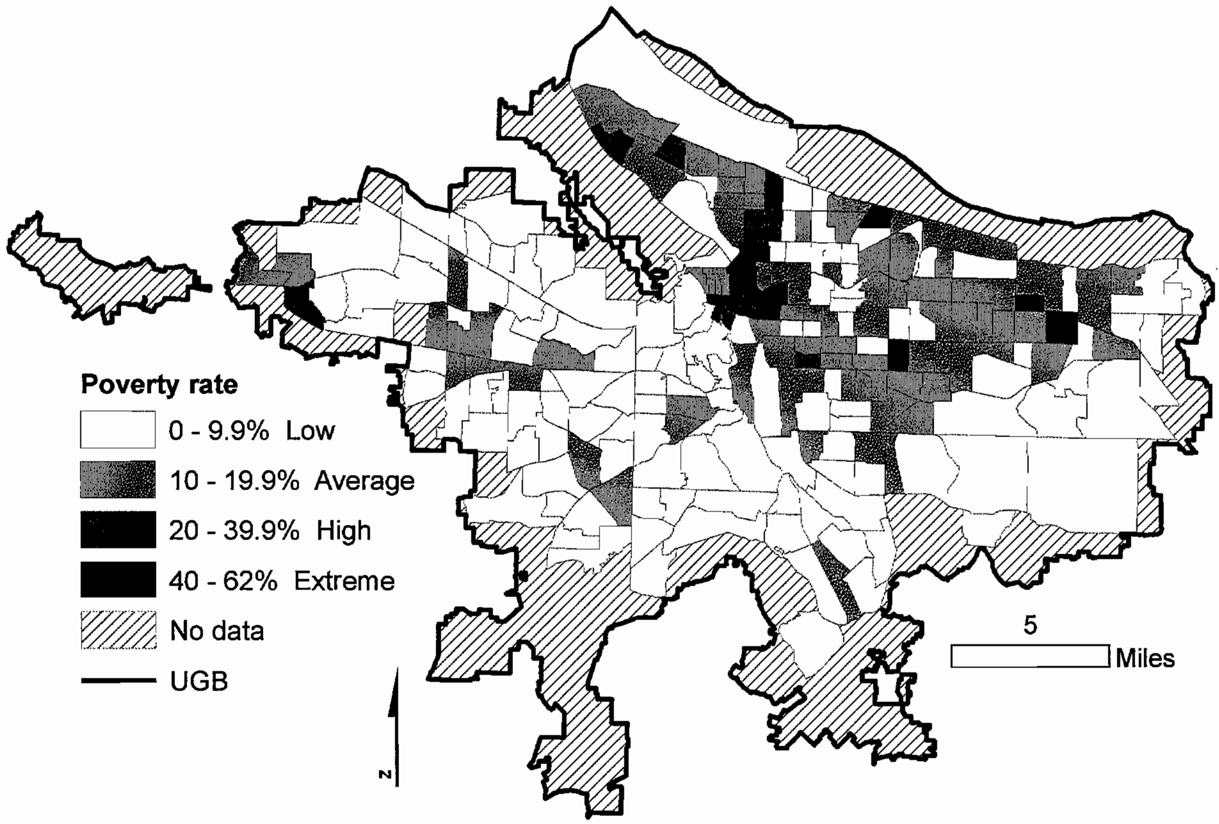
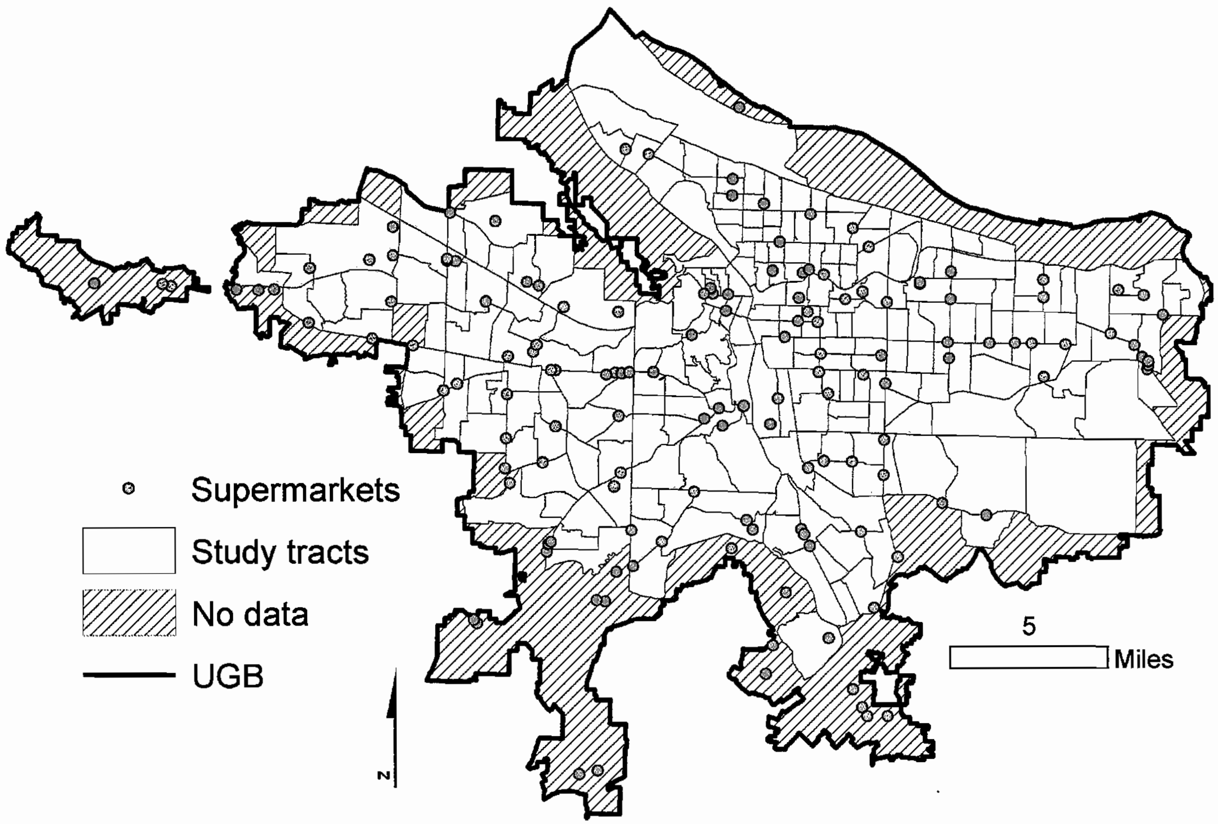


Figure 3

Spatial distribution of supermarkets, Portland, Oregon metropolitan area



CHAPTER III

METHODS AND ANALYSIS

The three accessibility measures employed in this study evaluate multiple aspects of low-income populations' access to supermarkets: proximity, variety, and competition. First, I will discuss the logic and mechanics of the selected measures. Then, I will discuss the variations on the measures that were devised to test their sensitivity.

Accessibility Measures

Measure 1 evaluates proximity by measuring the mean distance to the nearest supermarket. Measure 2 evaluates variety by measuring the number of supermarkets located within 1000 meters (3280 feet) (a reasonable walking distance that is equal to about a 15-minute walk for an adult in an urban setting) (Apparicio et al., 2007; Larsen & Gilliland, 2008). Measures 3a and 3b both measure competition by evaluating the mean distance to three supermarkets belonging to different chains and different parent companies (3a) and to different chains (3b). Apparicio et. al (2007) only categorized supermarkets by chain in their measure of competition. However, supermarket parent companies own multiple chains within the study area and this study varies the grouping of supermarkets to test what affect common ownership might have on access.

All the measures in this study (except one, which will be discussed in the variations section) were calculated with Euclidean, block-level distance inputs that were then aggregated to tract level. For example, in Measure 1, the mean distance to the nearest supermarket is the population weighted average of the distance between all the tract's component blocks and the nearest supermarket. The result is a tract-level access measure that accounts for variations at the block level.

Ideally, this study would have used the shortest distance along the street network between each block and each supermarket, instead of the Euclidean distance, as the input for each measure. Unfortunately, the time and computing capacity the Network Analyst extension of ArcGIS required to perform that calculation for all 18,203 census blocks to all 145 supermarkets was not available. However, using a sample of network distances from the study area, a regression of network distance on Euclidean distance revealed a nearly linear relationship (adjusted r-squared 0.969). Because Measure 2 is based on an acceptable walking distance, these findings made it possible to adjust the distance upon which the measure was based (lengthened consistent with the relationship established in the regression model) to more accurately reflect the distance one would walk along a street network.

Finally, the block-to-store distances were weighted by population, assigning a weight proportional to population to all blocks.

Equations

Measure 1

$$z_1 \frac{\sum_{b \in i} w_b (\min | d_{bs} |)}{\sum_{b \in i} w_b},$$

Where:

z_1 = mean distance between census tract and nearest supermarket.

d_{bs} = distance between block centroid and supermarket *s*.

w_b = total population of block *b* (entirely included in census tract *i*).

Measure 2

$$z_2 \frac{\sum_{b \in i} w_b \sum_{j \in s} s_j}{\sum_{b \in i} w_b},$$

Where:

z_2 = mean number of supermarkets within 3280 feet of census tract population.

S = all supermarkets.

S_j = number of supermarkets within 3280 ft of the block centroid (d_{bs} < 3280).

w_b = total population of block *b* (entirely included in census tract *i*).

Measure 3a

$$z_{3a} \frac{\sum_{b \in i} w_b \sum_s \frac{d_{bs}}{n}}{\sum_{b \in i} w_b},$$

Where:

z_{3a} = mean distance between census tract population and n different chain-name supermarkets that also belong to different parent companies.

d_{bs} = distance between block centroid and supermarket s; d_{bs} is sorted in ascending order.

n= number of different chain-name supermarkets belonging to different parent companies to be included in measure (here n=3).

w_b = total population of block b (entirely included in census tract i).

Measure 3b

$$z_{3b} \frac{\sum_{b \in i} w_b \sum_s \frac{d_{bs}}{n}}{\sum_{b \in i} w_b},$$

Where:

z_{3b} = mean distance between census tract population and n different chain-name supermarkets.

d_{bs} = distance between block centroid and supermarket s; d_{bs} is sorted in ascending order.

n= number of different chain-name supermarkets to be included in measure (here n=3).

w_b = total population of block b (entirely included in census tract i).

Testing Sensitivity: Variations on the Accessibility Measures

In this study, using block-level or tract-level distance data as the distance input in the accessibility equations makes a difference of tens of thousands of pieces of data. For example, Figure 4 shows one study tract and its component block centroids. The example tract is ringed by a buffer with a radius of 3,280 feet to illustrate the number of stores within a reasonable walking distance, as defined in this study. Figure 5 shows the tract centroid of the same study tract. Using block-level distance data as the distance inputs for Measure 1, for example, requires measuring the distance between every block centroid and every supermarket in the study area. As Figures 4 and 5 illustrate, using tract-level distance inputs simplifies the process of measuring access considerably.

Figure 4

Example study tract and component block centroids

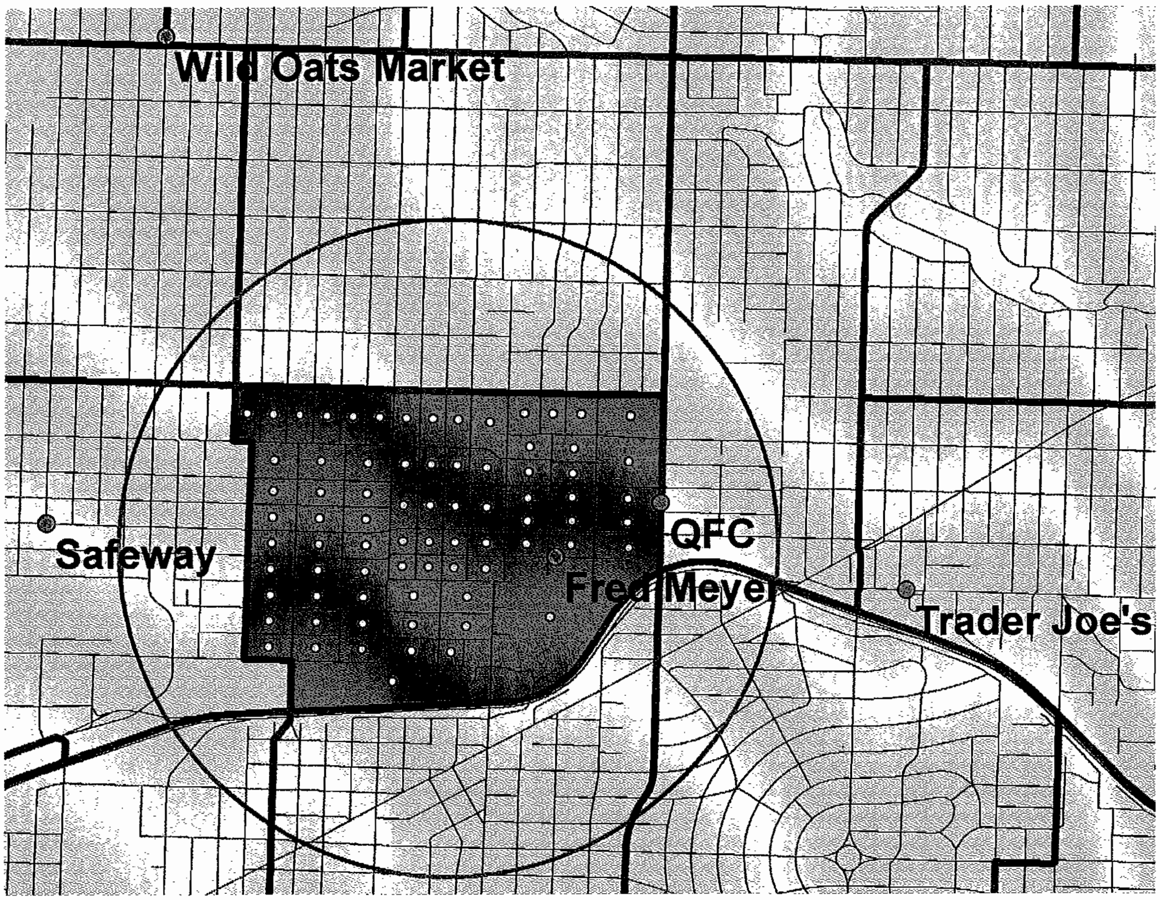
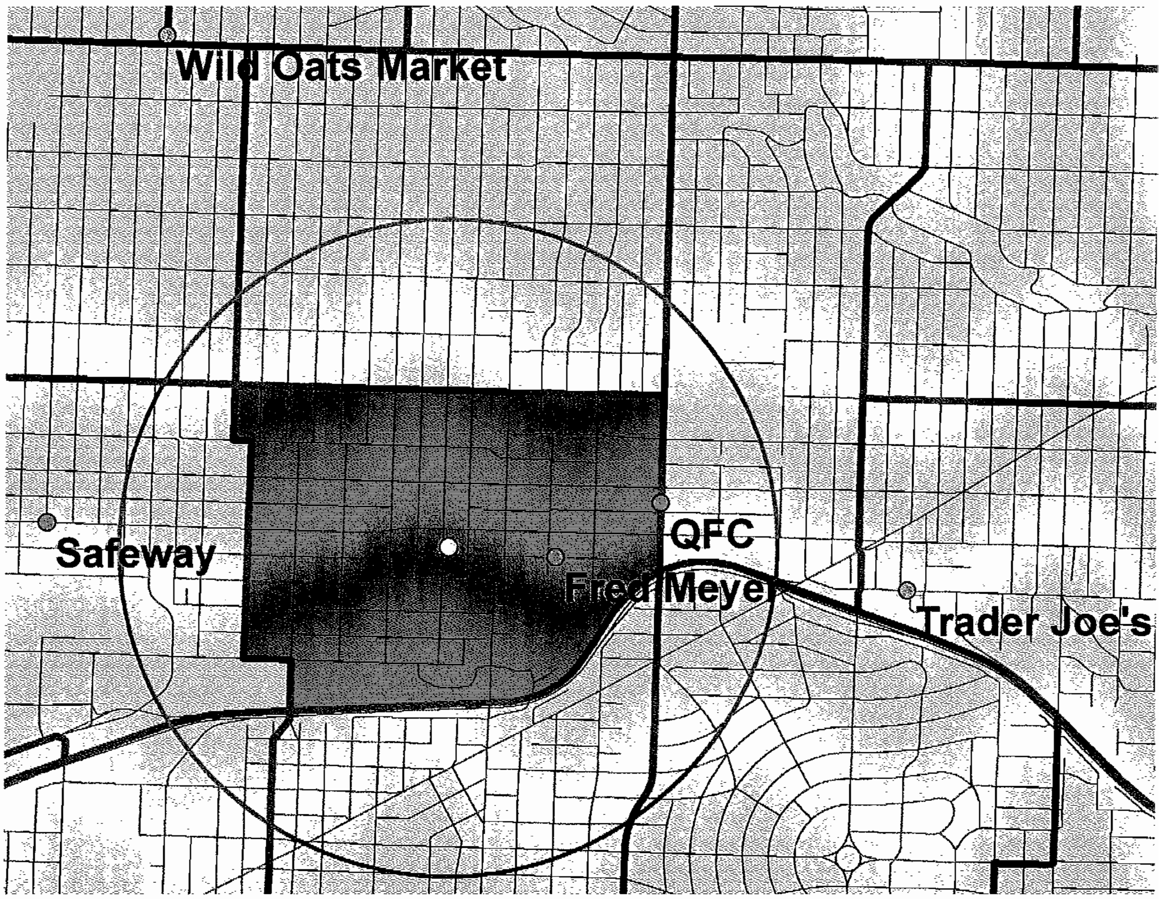


Figure 5

Example study tract and tract centroid



Practitioners who want to gauge their community's access to supermarkets may not have the time or technical resources to use thousands of pieces of block-level data as inputs. With this in mind, this study also tested variations on Measures 1, 2, 3a and 3b by altering geography and level of aggregation required. A total of seven variations were tested with geographies and inputs ranging from census-block-level to census-tract-level. Table 2 provides a summary of measure variations.

Table 2

Variations on study accessibility measures

Variation	Geography	Inputs	
		Distance from supermarket to:	Distance calculation
1	Tract level measures	Block centroids	Euclidean
2	Tract level measures	Block group centroids	Euclidean
3	Tract level measures	Tract centroids	Euclidean
4	Block group level measures	Block centroids	Euclidean
5	Block group level measures	Block group centroids	Euclidean
6	Block level measures	Block centroids	Euclidean
7	Tract level measures	Tract centroids	Network distance

CHAPTER IV

RESULTS

Is Unequal Access a Systematic Pattern?

This study found no evidence of a systematic pattern of unequal supermarket access in the study area's low-income neighborhoods. Actually, the Pearson coefficients of correlation between accessibility and poverty rate for Measures 1, 3a and 3b show a significant, though weak, negative relationship between the poverty rate and access (see Table 3). For Measure 1, the negative relationship between poverty rate and average distance to the nearest supermarket means higher poverty areas are associated with shorter average distances to the nearest supermarket. The same is true for Measures 3a and 3b.

Table 3

Pearson correlations between accessibility measures and poverty rate

Accessibility measure	Correlation with poverty rate
Measure 1: Nearest supermarket	-.261**
Measure 2: Number of supermarkets within 3280 feet	.188*
Measure 3a: Average distance to three closest chain-name supermarkets (with different parent companies)	-.267**
Measure 3b: Average distance to three closest chain-name supermarkets	-.269**

* $p < .01$. ** $p < .001$.

The Pearson coefficient of correlation between accessibility and the poverty rate for Measure 2 shows a significant, though weak, positive relationship. That means that higher rates of poverty area associated with more supermarkets within walking distance.

Analyzing the accessibility measures geospatially also provides interesting insights consistent with the above findings. Spatial autocorrelation statistics for the three measures show that areas with similar levels of access are not particularly clustered within the study area. The four measures' values of Moran's I ranged between 0.34 and 0.47 (see Table 4). If areas with similar access levels were clustered systematically, the values of Moran's I would be expected to be closer to 1.0 (Griffith, 2003). For example, if a pattern of supermarket disinvestment in low-income areas existed across the study area, access levels would be consistently lower in those areas and the spatial autocorrelation statistics would show evidence of clumping by access level.

Table 4

Spatial autocorrelation statistics

Accessibility Measure	Moran's I [a]	z-score
Measure 1: Nearest supermarket	0.34	8.66
Measure 2: Number of supermarkets within 3280 feet	0.38	9.78
Measure 3a: Average distance to three closest chain-name supermarkets (with different parent companies)	0.47	12.03
Measure 3b: Average distance to three closest chain-name supermarkets	0.47	12.24

[a] Calculated with a queen binary connectivity matrix (1 where census tract *i* and *j* are contiguous; 0 otherwise).

However, these findings simply mean unequal access for low-income populations is not a consistent trend over the study area as a whole. It does not mean food deserts, neighborhoods where high poverty and poor access coincide, do not exist.

Locating Food Deserts

To locate food deserts, it is necessary to review areas where high poverty rates and poor accessibility coincide. In the Portland metropolitan area, the tracts with the highest poverty rates are generally located in northeast Portland. The three tracts categorized as areas of extreme poverty, and many of the high poverty tracts, are located in northeast Portland. Tracts with high poverty levels are also found in north and southeast Portland, east Portland/Gresham, and to the far west in Hillsboro.

According to the results of each accessibility measure, every tract in the study area was assigned an access level: Very High, High, Low or Very Low[2]. For Measure 1,

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[2] Access levels (Very High, High, Low or Very Low) were assigned following the taxonomy employed by Apparicio et. al (2007):

Measure 1: Tracts categorized as having Very High access had their nearest supermarket located within 1640 feet (less than half the maximum, reasonable walking distance). High access tracts' nearest supermarket was located within 1640 and 2459 feet. Low access tracts' nearest supermarket was located within 2460 and 3279 feet. Very Low access tracts' nearest supermarket was located at the maximum reasonable walking distance or further.

Measure 2: Tracts categorized as having Very High access had an average of three or more supermarkets located within walking distance (3280 feet). High access tracts had an average of 2.0-2.9 supermarkets within walking distance. Low access tracts had an average of 1.0-1.9 supermarkets within walking distance. Very Low access tracts had an average of fewer than 1.0 supermarket within walking distance.

Measures 3a & 3b: Tracts categorized as having Very High access had at least three different chain name supermarkets with different parent companies (or simply different chain names, respectively) located within walking distance (3280 feet). High access tracts had three different chain name supermarkets within 3280 and 4919 feet. Low access tracts had three different chain name supermarkets within 4920 and 6559 feet. Very Low access tracts had three chain name supermarkets located an average of more than 6560 feet away.

tracts whose nearest supermarket was not within walking distance were assigned the Very Low level of access. Tracts whose nearest supermarket was located at varying distances within the maximum reasonable walking distance were assigned Low to Very High levels of access (see Figure 6). For Measure 2, tracts with an average of fewer than one supermarket within walking distance were assigned the Very Low level of access. Tracts with one or more supermarkets within walking distance were assigned Low to Very High levels of access (see Figure 7). For Measures 3a and 3b, tracts whose average distance from three different chain-name supermarkets exceeded double the reasonable walking distance were assigned the Very Low level of access. Tracts whose three different chain-name stores were closer were assigned Low to Very High levels of access (see Figures 8 and 9).

Figure 6

Measure 1 access categories: Average distance to nearest supermarket

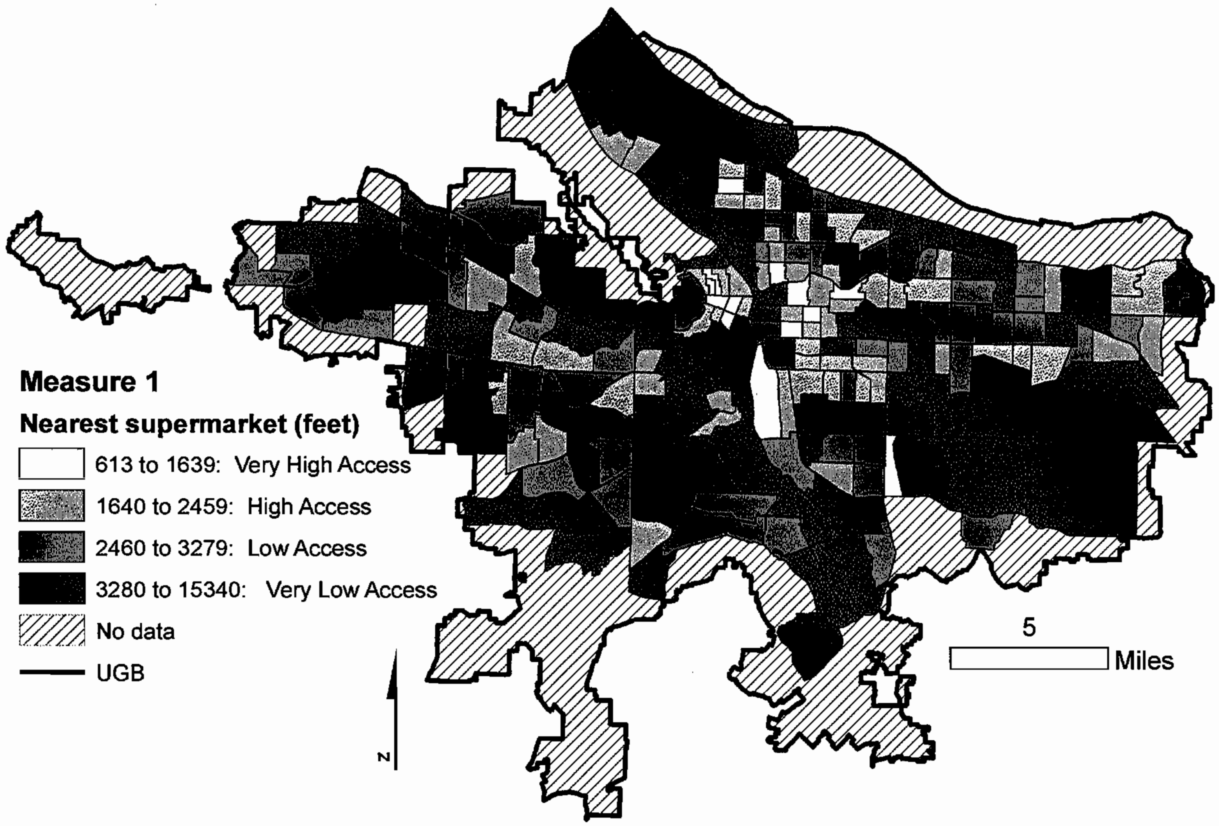


Figure 7

Measure 2 access categories: Number of supermarkets within walking distance

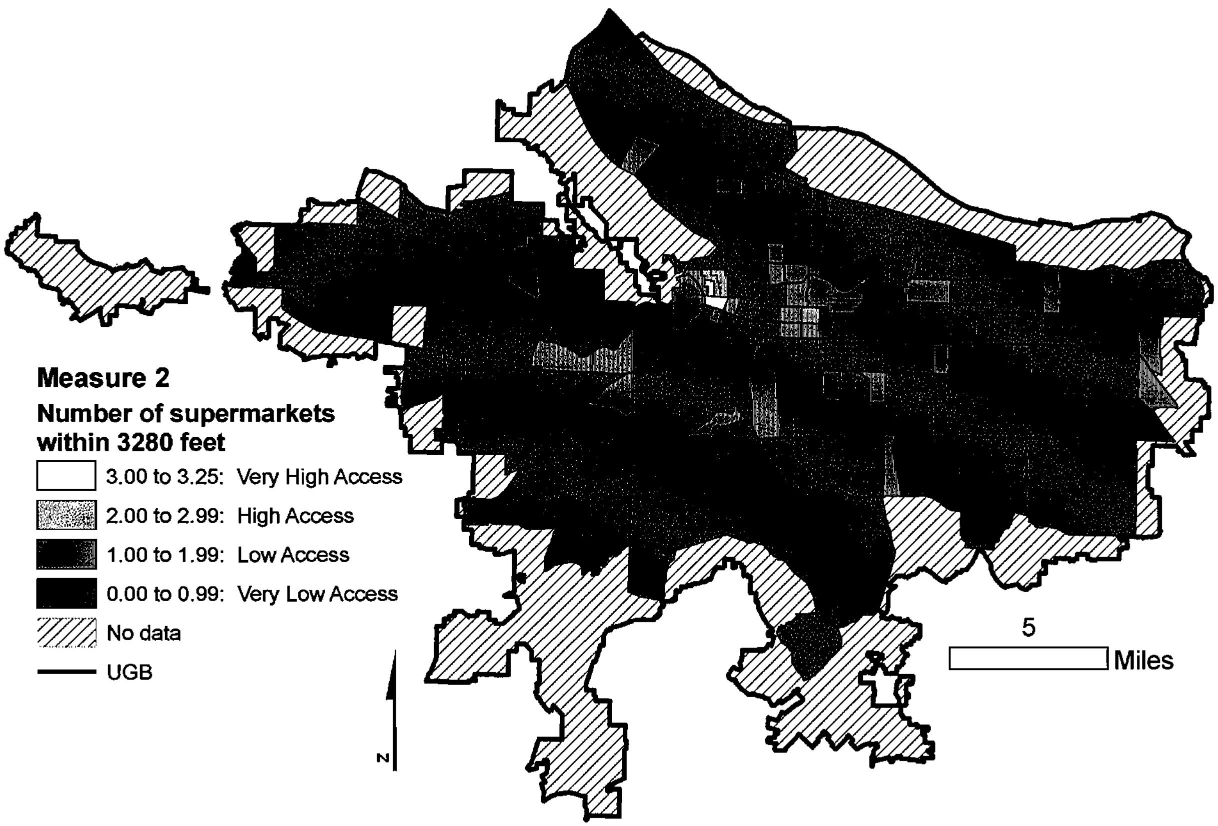


Figure 8

Measure 3a access categories: Average distance to three closest different chain-name supermarkets (different parent companies)

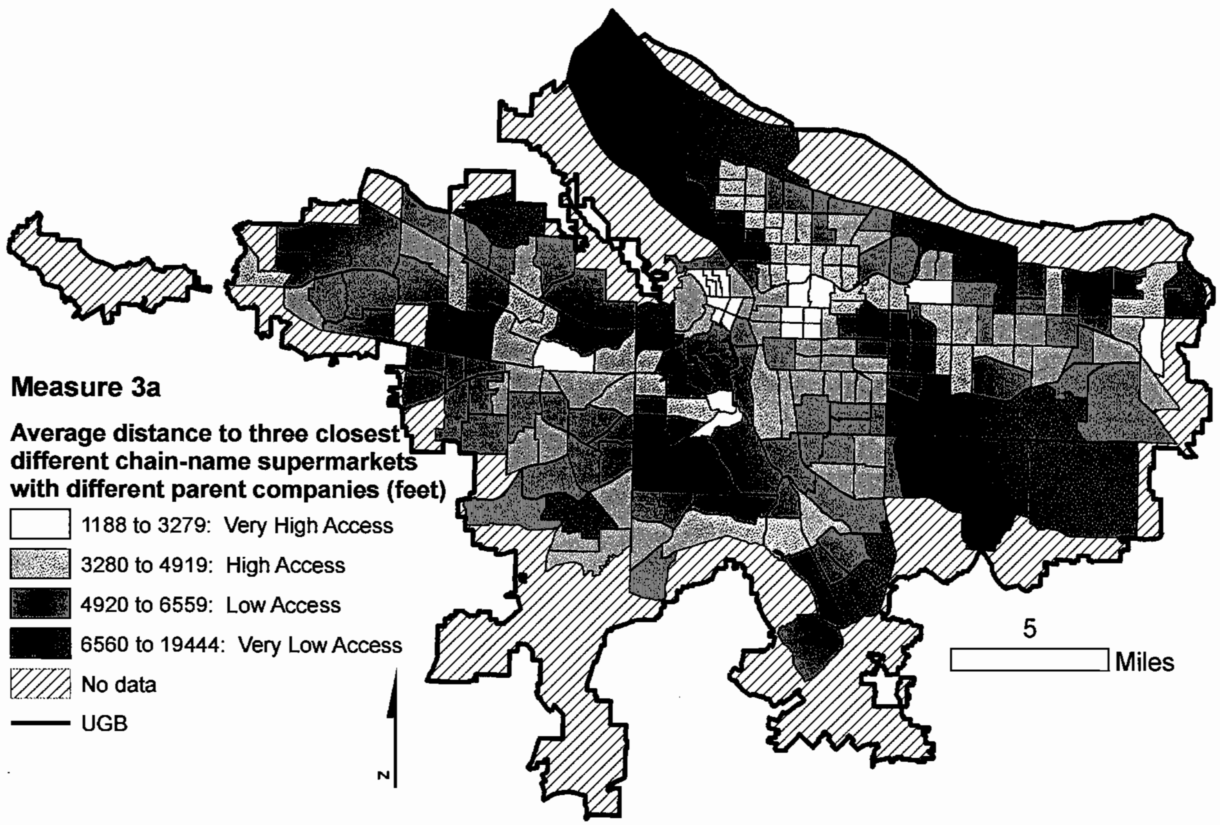
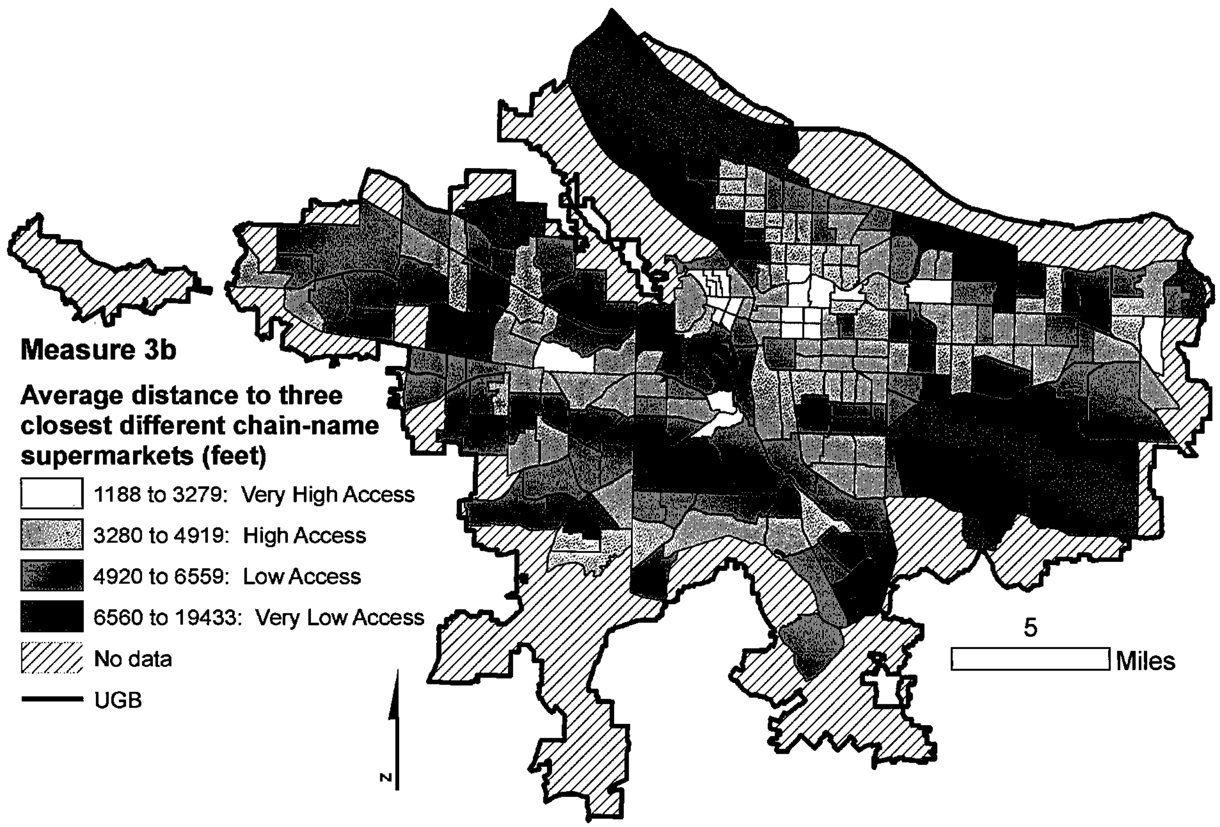


Figure 9

Measure 3b access categories: Average distance to three closest different chain-name supermarkets



Food Deserts Identified

The three extreme poverty tracts in the study area were found to have Very High or High levels of supermarket access. However, 14 of the 24 high poverty tracts in north Portland, northeast Portland, southeast Portland, east Portland/Gresham and Hillsboro had Low or Very Low levels of supermarket access. These tracts represent food deserts (see Figure 10 and Appendix B).

Another way to visualize the food desert phenomenon in the context of this study's parameters is to create a reasonable walking distance buffer around each supermarket. Figure 11 clearly shows high poverty tracts that are not within walking distance of any of the study area's supermarkets.

Figure 10

Poverty rate and food deserts

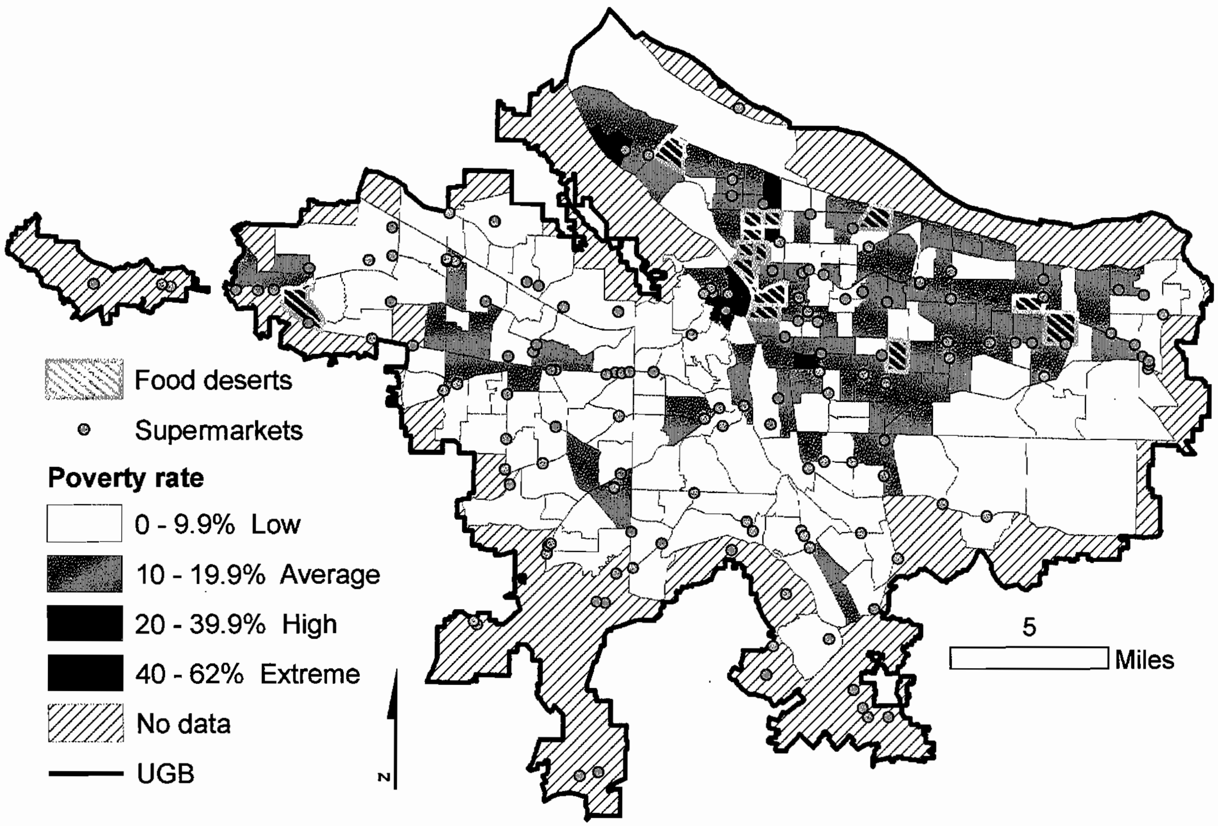
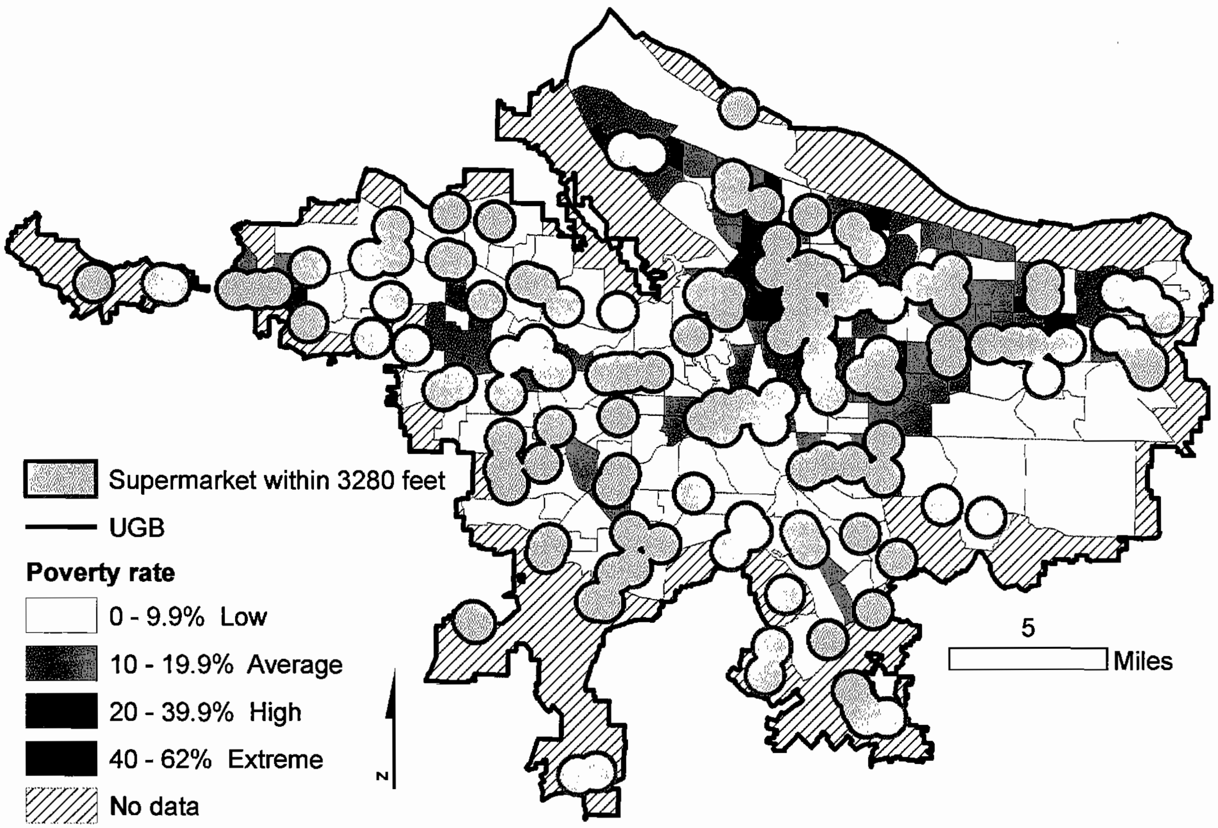


Figure 11

Areas located within walking distance of supermarkets



Sensitivity of Measures

In this study, four variations on tract-level measures were tested. Tables 5 through 8 show the Pearson coefficients of correlation between Measures 1, 2, 3a and 3b calculated using block, block group, tract, and tract shortest network distance inputs. Calculating the Pearson coefficient of correlation between the measures tests to what extent the measures are related, or whether they are measuring similar concepts. Measures 1, 3a and 3b are highly correlated, suggesting there is a relationship between the concept of nearest supermarket and average distance to three closest competing supermarkets.

Regardless of geography, Measure 2 shows a significant, though moderate, negative relationship with the other measures. These statistics suggest, on average, that tracts with nearer nearest supermarkets tend to also have more stores within walking distance. However, the correlation between Measure 2 and each of the other measures is not nearly as strong as the correlation between Measures 1, 3a and 3b. This might be explained by the almost categorical nature of Measure 2 in that only stores within 3,280 feet are included, whereas the other three measures are continuous because they capture a full range of distance variation.

Table 5

Pearson correlations between tract-level measures, aggregated from block level inputs (Euclidean distance)

n=243	Measure 1	Measure 2	Measure 3a	Measure 3b
Measure 1	-	-.692**	.857**	.864**
Measure 2	-.692**	-	-.668**	-.669**
Measure 3a	.857**	-.668**	-	.993**
Measure 3b	.864**	-.669**	.993**	-

** p < .001.

Table 6

Pearson correlations between tract-level measures, aggregated from block group level inputs (Euclidean distance)

n=243	Measure 1	Measure 2	Measure 3a	Measure 3b
Measure 1	-	-.665**	.843**	.853**
Measure 2	-.665**	-	-.639**	-.639**
Measure 3a	.843**	-.639**	-	.993**
Measure 3b	.853**	-.639**	.993**	-

** p < .001.

Table 7

Pearson correlations between tract-level measures, tract level inputs (no aggregation; Euclidean distance)

n=243	Measure 1	Measure 2	Measure 3a	Measure 3b
Measure 1	-	-.599**	.831**	.839**
Measure 2	-.599**	-	-.535**	-.543**
Measure 3a	.831**	-.535**	-	.991**
Measure 3b	.839**	-.543**	.991**	-

** p < .001.

Table 8

Pearson correlations between tract-level measures, tract level inputs (no aggregation; network distance)

n=243	Measure 1	Measure 2	Measure 3a	Measure 3b
Measure 1	-	-.571**	.852**	.851**
Measure 2	-.571**	-	-.501**	-.500**
Measure 3a	.852**	-.501**	-	1.000**
Measure 3b	.851**	-.500**	1.000**	-

** p < .001.

Tables 9 through 12 show how closely each measure is related to itself when distance input geography is varied. For example, Table 9 shows the Pearson coefficient of correlation between Measure 1 calculated with block, block group, tract and tract shortest network distance inputs. Despite changes in level of aggregation, Measure 1 is highly correlated. The same is true for Measures 3a and 3b (see Tables 11 and 12).

Table 9

Pearson correlations between Measures 1 (block, block group, tract, and tract shortest network distance inputs)

n=243	Block	Block group	Tract	Tract (ND)
Block	-	.960**	.929**	.879**
Block group	.960**	-	.948**	.886**
Tract	.929**	.948**	-	.940**
Tract (ND)	.879**	.886**	.940**	-

** p < .001.

Table 10

Pearson correlations between Measures 2 (block, block group, tract, and tract shortest network distance inputs)

n=243	Block	Block group	Tract	Tract (ND)
Block	-	.884**	.791**	.739**
Block group	.884**	-	.755**	.699**
Tract	.791**	.755**	-	.847**
Tract (ND)	.739**	.699**	.847**	-

** p < .001.

Table 11

Pearson correlations between Measures 3a (block, block group, tract, and tract shortest network distance inputs)

n=243	Block	Block group	Tract	Tract (ND)
Block	-	.983**	.972**	.897**
Block group	.983**	-	.977**	.888**
Tract	.972**	.977**	-	.918**
Tract (ND)	.897**	.888**	.918**	-

** p < .001.

Table 12

Pearson correlations between Measures 3b (block, block group, tract, and tract shortest network distance inputs)

n=243	Block	Block group	Tract	Tract (ND)
Block	-	.983**	.972**	.909**
Block group	.983**	-	.978**	.897**
Tract	.972**	.978**	-	.928**
Tract (ND)	.909**	.897**	.928**	-

** p < .001.

Tables 13 through 20 show the Spearman's Rho, or rank order, coefficients of correlation between the measures.

Table 13

Spearman's Rho correlations between tract-level measures, aggregated from block level inputs (Euclidean distance)

n=243	Measure 1	Measure 2	Measure 3a	Measure 3b
Measure 1	-	-.924**	.818**	.830**
Measure 2	-.924**	-	-.812**	-.823**
Measure 3a	.818**	-.812**	-	.986**
Measure 3b	.830**	-.823**	.986**	-

** p < .001.

Table 14

Spearman's Rho correlations between tract-level measures, aggregated from block group level inputs (Euclidean distance)

n=243	Measure 1	Measure 2	Measure 3a	Measure 3b
Measure 1	-	-.853**	.805**	.821**
Measure 2	-.853**	-	-.758**	-.764**
Measure 3a	.805**	-.758**	-	.986**
Measure 3b	.821**	-.764**	.986**	-

** $p < .001$.

Table 15

Spearman's Rho correlations between tract-level measures, tract level inputs (no aggregation; Euclidean distance)

n=243	Measure 1	Measure 2	Measure 3a	Measure 3b
Measure 1	-	-.818**	.792**	.809**
Measure 2	-.818**	-	-.642**	-.661**
Measure 3a	.792**	-.642**	-	.982**
Measure 3b	.809**	-.661**	.982**	-

** $p < .001$.

Table 16

Spearman's Rho correlations between tract-level measures, tract level inputs (no aggregation; network distance)

n=243	Measure 1	Measure 2	Measure 3a	Measure 3b
Measure 1	-	-.755**	.821**	.819**
Measure 2	-.755**	-	-.590**	-.588**
Measure 3a	.821**	-.590**	-	1.000**
Measure 3b	.819**	-.588**	1.000**	-

** $p < .001$.

Table 17

Spearman's Rho correlations between Measures 1 (block, block group, tract, and tract shortest network distance inputs)

n=243	Block	Block group	Tract	Tract (ND)
Block	-	.950**	.913**	.862**
Block group	.950**	-	.930**	.868**
Tract	.913**	.930**	-	.928**
Tract (ND)	.862**	.868**	.928**	-

** $p < .001$.

Table 18

Spearman's Rho correlations between Measures 2 (block, block group, tract, and tract shortest network distance inputs)

n=243	Block	Block group	Tract	Tract (ND)
Block	-	.842**	.720**	.625**
Block group	.842**	-	.699**	.599**
Tract	.720**	.699**	-	.808**
Tract (ND)	.625**	.599**	.808**	-

** p < .001.

Table 19

Spearman's Rho correlations between Measures 3a (block, block group, tract, and tract shortest network distance inputs)

n=243	Block	Block group	Tract	Tract (ND)
Block	-	.977**	.957**	.856**
Block group	.977**	-	.964**	.847**
Tract	.957**	.964**	-	.891**
Tract (ND)	.856**	.847**	.891**	-

** p < .001.

Table 20

Spearman's Rho correlations between Measures 3b (block, block group, tract, and tract shortest network distance inputs)

n=243	Block	Block group	Tract	Tract (ND)
Block	-	.976**	.958**	.877**
Block group	.976**	-	.964**	.864**
Tract	.958**	.964**	-	.907**
Tract (ND)	.877**	.864**	.907**	-

** $p < .001$.

Interestingly, when measuring the distance between supermarkets and census tract centroids (no aggregation), the accessibility measures produce very similar results regardless of whether the distance was measured by Euclidean or network distance (see Table 21).

Table 21

Pearson correlations between tract-level measures using Euclidean and network distance inputs

Euclidean distance Tract-level accessibility measures (from tract centroids)	Network distance Tract-level accessibility measures (from tract centroids)
Measure 1: Nearest supermarket	.940**
Measure 2: Number of supermarkets within 3280 feet	.847**
Measure 3a: Average distance to three closest chain-name supermarkets (with different parent companies)	.918**
Measure 3b: Average distance to three closest chain-name supermarkets	.928**

** p < .001.

The results of tract-level measures that use an average of all the Euclidean distances between supermarkets and all their component census blocks are also very similar to those that only use the Euclidean distance from the tract centroid as the distance input (see Table 22).

Table 22

Pearson correlations between tract-level measures using block-level inputs and tract-level inputs (no aggregation)

Euclidean distance Tract-level accessibility measures (from block centroids)	Euclidean distance Tract-level accessibility measures (from tract centroids)
Measure 1: Nearest supermarket	.929**
Measure 2: Number of supermarkets within 3280 feet	.791**
Measure 3a: Average distance to three closest chain-name supermarkets (with different parent companies)	.972**
Measure 3b: Average distance to three closest chain-name supermarkets	.972**

** $p < .001$.

CHAPTER V

DISCUSSION

Limitations and Considerations

When thinking about the implications of the results of this study, a few limitations and considerations need to be examined.

Measuring Distance: Euclidean versus Network Distance

Euclidean distance was used to measure distances between points and generate inputs for the accessibility measures (with the exception of Variation 7) employed in this study. Shortest network distance is the preferred method of distance measurement in supermarket accessibility research. However, distance, whether assessing walkability or other forms of travel, is a proxy for travel time and some researchers have suggested travel time is the more potentially meaningful input for assessing access (Zenk et al., 2005);

Data Freshness and its Relationship to Identifying Food Deserts

Poverty data from the 2000 US Census is now more than eight years old. The way low-income populations are distributed spatially throughout the study area may have changed dramatically. Because food deserts are low-income areas, by definition, it would be important to somehow verify the low-income status of the identified tracts before formulating policy intervention.

Categorizing Poverty

Categorizing census tracts by poverty level is arbitrary. However, even the researchers who established the accepted poverty categories of 'high' (20-39.9% below poverty level) and 'extreme' (40% or more below poverty level) acknowledge there may be little difference between life in a high poverty census tract and life in a tract in which 19 percent of residents live below the poverty level (Greene, 1991; Jargowsky & Bane, 1990).

Bias Toward Walkability

The construction of the accessibility measures has a strong bias in favor of walkability. Though walkability is an important concept for people who do not own automobiles, assigning access levels based on whether a supermarket is within walking distance may be too rigid a classification (Handy, 1996).

Store Selection Criteria

From the initial list of 265 grocery stores, 108 stores that do not fit the study criteria were eliminated. These stores included convenience stores, ethnic food stores, grocery co-ops, and discount stores that do not carry fresh produce, dairy products or meat. Also eliminated were single-outlet, independent grocery stores. Though stores were eliminated based on the criteria established by the body of food desert literature, when considering the practical implication of this work, I believe it is important to note that some of the eliminated stores certainly provide residents with opportunities to purchase healthy food. However, chain-name supermarkets' buying power, distribution networks and selection make them the accepted proxy for fresh, affordable food access. For this reason, stores that carry a limited selection of products, like convenience and discount stores, are not included. Ethnic food and other stores that cater to only a segment of the population are also eliminated because it cannot be assumed they meet the needs of the entire community. Finally, co-ops and independent grocers are eliminated because the affordability of their goods has not been adequately evaluated in literature and one can reasonably expect substantial variability in their offerings.

Distribution of Poverty: What Impact Does Concentration Have on Measuring Food Deserts?

Many researchers assume people of different income levels self-select into certain areas of cities and that the suburbs, with their sprawling development patterns, do not attract large numbers of low-income residents (Apparicio et al., 2007). When this assumption holds, it is easier to measure the extent to which low-income residents lack services and be relatively certain policy interventions are meeting the needs of the community's most vulnerable members.

The 14 food deserts identified in this study were home to approximately 47,130 low-income residents in 2000. By addressing the food access needs of the residents of these tracts, policy makers would be serving more than half of the total low-income residents who lack adequate supermarket access (62%). However, that still leaves almost 30,000 low-income residents in the study area who live in Low and Very Low access tracts with no assistance (see Table 23). Clearly, the food desert concept does not capture the full picture of the supermarket access problem.

Table 23

Overall supermarket access by measure and population affected

	Access measures								Population affected			
Access level	M1 Tracts	M1 %	M2 Tracts	M2 %	M3a Tracts	M3a %	M3b Tracts	M3b %	Total residents	%	Residents in poverty	%
Very High	13	5%	2	1%	20	8%	21	9%	46,769	4%	7,917	7%
High	61	25%	3	1%	91	37%	97	40%	238,091	22%	29,581	26%
Low	55	23%	31	13%	91	37%	85	35%	315,278	29%	32,955	29%
Very Low	114	47%	207	85%	41	17%	40	16%	471,679	44%	43,174	38%
	243	100%	243	100%	243	100%	243	100%	1,071,817	100%	113,627	100%

CHAPTER VI

CONCLUSION

Future Research

The Importance of Qualitative Research

Food desert researchers have traditionally been interested in not only quantifying low-income populations' level of access to fresh, affordable food, but also in conducting qualitative analysis of residents' food shopping experiences. Conducting this study left me wondering how residents of the food deserts identified have been meeting their food shopping needs and by what means they travel to supermarkets, if at all. Even very sophisticated quantitative measures cannot capture the complexity of personal preference and individual decision making. Early food desert research relied heavily on interviews with residents to document many dimensions of the food desert phenomenon, including transportation barriers, and it is important for food desert researchers to continue this tradition.

Where to Locate: What Motivates Supermarkets?

To formulate policy intervention, identifying low-income neighborhoods that lack reasonable access to supermarkets is an important first step, but it is not the only step. Understanding something about what motivates supermarkets to locate in some areas and not others can help planners understand why there are no supermarkets in underserved neighborhoods. Urban grocery gap literature details a number of reasons why supermarkets leave urban areas, the vast majority of which have to do with operating costs and profit margins. However, I contend additional research in two specific areas could be particularly informative:

1) Whether land-use regulations, like zoning, impact urban properties' attractiveness to supermarkets; and
2) Case studies of successful, urban supermarkets.

Will Public Sector Intervention Succeed in Bringing Supermarkets to Urban Areas?

As the evidence linking spatial access to healthy food with improved eating habits mounts, planners and policy makers have begun to implement programs to bring healthy food within residents' reach. For example, the State of Pennsylvania is investing $30 million in its Fresh Food Financing Initiative, "an innovative program that works to increase the number of supermarkets or other grocery stores in under-served communities across Pennsylvania" ("Supermarket Campaign"). Conducting program evaluations of public sector initiatives aimed at encouraging supermarket investment in specific areas will be an important area of future food desert research.

Advice for Urban Planners

On a practical, local level, the first important step in tackling a problem like a food desert is measuring its presence and severity. The strong correlation between accessibility measures in this study, despite changes in inputs, lets urban planners know they have a good chance of being able to detect food deserts in their communities even if they have limited resources. Even simply identifying low-income census tracts and measuring the distance between the tract centroid and the nearest supermarket can begin to generate a picture of access planners can use to begin to proactively address the food access needs of their community's most vulnerable populations.

APPENDIX A

STUDY SUPERMARKETS

Albertsons (SUPERVALU Inc.)
8155 SW Hall Blvd, Beaverton, OR 97005, Washington Co.
Census tract: 410670310051002

Albertsons (SUPERVALU Inc.)
6055 SW 185th Ave, Aloha, OR 97007, Washington Co.
Census tract: 410670317043000

Albertsons (SUPERVALU Inc.)
14800 SE Sunnyside Rd, Clackamas, OR 97015, Clackamas Co.
Census tract: 410050221031009

Albertsons (SUPERVALU Inc.)
11 S State St, Lake Oswego, OR 97034, Clackamas Co.
Census tract: 410050202001009

Albertsons (SUPERVALU Inc.)
16199 SW Boones Ferry Rd, Lake Oswego, OR 97035, Clackamas Co.
Census tract: 410050203021028

Albertsons (SUPERVALU Inc.)
19007 S Beavercreek Rd, Oregon City, OR 97045, Clackamas Co.
Census tract: 410050223006025

Albertsons (SUPERVALU Inc.)
25691 SE Stark St, Troutdale, OR 97060, Multnomah Co.
Census tract: 410510103032021

Albertsons (SUPERVALU Inc.)
1855 Blankenship Rd, West Linn, OR 97068, Clackamas Co.
Census tract: 410050207002000

Albertsons (SUPERVALU Inc.)
30299 SW Boones Ferry Rd, Wilsonville, OR 97070, Clackamas Co.
Census tract: 410050227044001

Albertsons (SUPERVALU Inc.)
7500 SW Baseline Rd, Hillsboro, OR 97123, Washington Co.
Census tract: 410670324052058

Albertsons (SUPERVALU Inc.)
888 NE 25th Ave, Hillsboro, OR 97124, Washington Co.
Census tract: 410670326065000

Albertsons (SUPERVALU Inc.)
16030 SW Tualatin Sherwood Rd, Sherwood, OR 97140, Washington Co.
Census tract: 410670321031011

Albertsons (SUPERVALU Inc.)
5850 NE Prescott St, Portland, OR 97218, Multnomah Co.
Census tract: 410510075001021

Albertsons (SUPERVALU Inc.)
5415 SW Beaverton Hillsdale Hwy, Portland, OR 97221, Multnomah Co.
Census tract: 410510068022015

Albertsons (SUPERVALU Inc.)
10830 SE Oak St, Milwaukie, OR 97222, Clackamas Co.
Census tract: 410050208002016

Albertsons (SUPERVALU Inc.)
14300 SW Barrows Rd, Tigard, OR 97223, Washington Co.
Census tract: 410670318091003

Albertsons (SUPERVALU Inc.)
16200 SW Pacific Hwy, Tigard, OR 97224, Washington Co.
Census tract: 410670319062016

Albertsons (SUPERVALU Inc.)
11070 SW Barnes Rd, Portland, OR 97225, Washington Co.
Census tract: 410670301002021

Albertsons (SUPERVALU Inc.)
18425 NW Old West Union Rd, Portland, OR 97229, Washington Co.
Census tract: 410670315111002

Albertsons (SUPERVALU Inc.)
451 NE 181st St, Portland, OR 97230, Multnomah Co.
Census tract: 410510096062000

Albertsons (SUPERVALU Inc.)
12102 SE Division St, Portland, OR 97266, Multnomah Co.
Census tract: 410510082023013

Bale's Market Place (Bale's)
19133 Willamette Dr, West Linn, OR 97068, Clackamas Co.
Census tract: 410050205022006

Cost Cutter Foods
1800 NW Fairview Dr, Gresham, OR 97030, Multnomah Co.
Census tract: 410510104052007

Danielsons Fresh Marketplace

1500 Molalla Ave, Oregon City, OR 97045, Clackamas Co.
Census tract: 410050225001023

Food 4 Less (Kroger)
7979 SE Powell Blvd, Portland, OR 97206, Multnomah Co.
Census tract: 410510007012017

Food For Less
2444 E Powell Blvd, Gresham, OR 97080, Multnomah Co.
Census tract: 410510104083002

Fred Meyer (Kroger)
11425 SW Beaverton Hillsdale Hwy, Beaverton, OR 97005, Washington Co.
Census tract: 410670313001028

Fred Meyer (Kroger)
15995 SW Walker Rd, Beaverton, OR 97006, Washington Co.
Census tract: 410670316111041

Fred Meyer (Kroger)
16301 SE 82nd Dr, Clackamas, OR 97015, Clackamas Co.
Census tract: 410050221042043

Fred Meyer (Kroger)
1839 Molalla Ave, Oregon City, OR 97045, Clackamas Co.
Census tract: 410050226011051

Fred Meyer (Kroger)
22855 NE Park Ln, Wood Village, OR 97060, Multnomah Co.
Census tract: 410510103042002

Fred Meyer (Kroger)
19200 SW Martinazzi Ave, Tualatin, OR 97062, Washington Co.
Census tract: 410670320023026

Fred Meyer (Kroger)
2497 SE Burnside Rd, Gresham, OR 97080, Multnomah Co.
Census tract: 410510104065008

Fred Meyer (Kroger)
2200 Baseline St, Cornelius, OR 97113, Washington Co.
Census tract: 410670329012019

Fred Meyer (Kroger)
6495 SE Tualatin Valley Hwy, Hillsboro, OR 97123, Washington Co.
Census tract: 410670324063028

Fred Meyer (Kroger)
22075 NW Imbrie Dr, Hillsboro, OR 97124, Washington Co.
Census tract: 410670326054001

Fred Meyer (Kroger)
6850 N Lombard St, Portland, OR 97203, Multnomah Co.
Census tract: 410510041021023

Fred Meyer (Kroger)
100 NW 20th Pl, Portland, OR 97209, Multnomah Co.
Census tract: 410510048002007

Fred Meyer (Kroger)
6615 NE Glisan St, Portland, OR 97213, Multnomah Co.
Census tract: 410510017017024

Fred Meyer (Kroger)
3805 SE Hawthorne Blvd, Portland, OR 97214, Multnomah Co.
Census tract: 410510013012015

Fred Meyer (Kroger)
7404 N Interstate Ave, Portland, OR 97217, Multnomah Co.
Census tract: 410510038022000

Fred Meyer (Kroger)
7555 SW Barbur Blvd, Portland, OR 97219, Multnomah Co.
Census tract: 410510060022011

Fred Meyer (Kroger)
1111 NE 102nd Ave, Portland, OR 97220, Multnomah Co.
Census tract: 410510081003016

Fred Meyer (Kroger)
11565 SW Pacific Hwy, Tigard, OR 97223, Washington Co.
Census tract: 410670307001001

Fred Meyer (Kroger)
7700 SW Beaverton Hillsdale Hwy, Portland, OR 97225, Washington Co.
Census tract: 410670303002001

Fred Meyer (Kroger)
3030 NE Weidler St, Portland, OR 97232, Multnomah Co.
Census tract: 410510025022001

Fred Meyer (Kroger)
14700 SE Division St, Portland, OR 97236, Multnomah Co.
Census tract: 410510092022010

Fred Meyer (Kroger)
5253 SE 82nd Ave, Portland, OR 97266, Multnomah Co.
Census tract: 410510005021024

Fred Meyer (Kroger)

8955 SE 82nd Ave, Portland, OR 97266, Multnomah Co.
Census tract: 410050222011002

Fred Meyer (Kroger)
14700 SE Mcloughlin Blvd, Milwaukie, OR 97267, Clackamas Co.
Census tract: 410050213001012

Grande Foods
1619 N Adair St, Cornelius, OR 97113, Washington Co.
Census tract: 410670329012015

Grocery Outlet
2925 NW Division St, Gresham, OR 97030, Multnomah Co.
Census tract: 410510098011011

Grocery Outlet
878 Molalla Ave, Oregon City, OR 97045, Clackamas Co.
Census tract: 410050225001031

Grocery Outlet
15705 SW 116th Ave, King City, OR 97224, Washington Co.
Census tract: 410670319062046

Grocery Outlet
15810 SE Mcloughlin Blvd, Milwaukie, OR 97267, Clackamas Co.
Census tract: 410050218021004

Grocery Outlet, Beaverton
3855 SW Murray Blvd, Beaverton, OR 97005, Washington Co.
Census tract: 410670314021035

Grocery Outlet, Hillsboro
354 S First Ave, Hillsboro, OR 97123, Washington Co.
Census tract: 410670325002012

Haggen Food & Pharamacy
19701 Highway 213, Oregon City, OR 97045, Clackamas Co.
Census tract: 410670316102002

Haggen Food & Pharmacy
18000 NW Evergreen Pkwy, Beaverton, OR 97006, Washington Co.
Census tract: 410670318081009

Haggen Food & Pharmacy
9055 SW Murray Blvd, Beaverton, OR 97008, Washington Co.
Census tract: 410670320021001

Haggen Food & Pharmacy (not geocoded)
8515 SW Tualatin Sherwood Rd, Tualatin, OR 97062, Washington Co.

Lamb's At Stroheckers Market (Lamb's)
2855 SW Patton Rd, Portland, OR 97201, Multnomah Co.
Census tract: 410510046022015

Market Of Choice Burlingame
8502 SW Terwilliger Blvd, Portland, OR 97219, Multnomah Co.
Census tract: 410510063003001

Market Of Choice West Linn
5639 Hood Street, West Linn, OR 97068, Clackamas Co.
Census tract: 410050206001033

New Seasons Market Arbor Lodge
6400 N Interstate Ave, Portland, OR 97217, Multnomah Co.
Census tract: 410510038033000

New Seasons Market Cedar Hills Crossing
3495 Cedar Hills, Beaverton, OR 97005, Washington Co.
Census tract: 410670314021000

New Seasons Market Concordia
5320 NE 33rd Ave, Portland, OR 97211, Multnomah Co.
Census tract: 410510031001000

New Seasons Market Mountain Park
3 SW Monroe Pkwy, Lake Oswego, OR 97035, Clackamas Co.
Census tract: 410050203032000

New Seasons Market Orenco Station
1453 NE 61st Ave, Hillsboro, OR 97124, Washington Co.
Census tract: 410670326054025

New Seasons Market Raleigh Hills
7300 SW Beaverton Hillsdale Hwy, Portland, OR 97225, Washington Co.
Census tract: 410670303002001

New Seasons Market Sellwood
1214 SE Tacoma St, Portland, OR 97202, Multnomah Co.
Census tract: 410510001007025

New Seasons Market Seven Corners
1954 SE Division St, Portland, OR 97202, Multnomah Co.
Census tract: 410510012023017

QFC (Kroger)
6411 SE Milwaukie Ave, Portland, OR 97202, Multnomah Co.
Census tract: 410510001001020

QFC (Kroger)
1835 NE 33rd Ave, Portland, OR 97212, Multnomah Co.

Census tract: 410510025021014

QFC (Kroger)
5544 E Burnside St, Portland, OR 97215, Multnomah Co.
Census tract: 410510018013016

QFC (Kroger)
7525 SW Barnes Rd, Portland, OR 97225, Washington Co.
Census tract: 410670301002008

QFC (Kroger)
4756 NW Bethany Blvd, Portland, OR 97229, Washington Co.
Census tract: 410670315102032

Safeway
20535 SW Tualatin Valley Hwy, Aloha, OR 97006, Washington Co.
Census tract: 410670316053013

Safeway
14555 SW Teal Blvd, Beaverton, OR 97007, Washington Co.
Census tract: 410670318092004

Safeway
6194 SW Murray Blvd, Beaverton, OR 97008, Washington Co.
Census tract: 410670318072007

Safeway
20151 SE 212th, Damascus, OR 97009, Clackamas Co.
Census tract: 410050222042018

Safeway
12032 SE Sunnyside Rd, Clackamas, OR 97015, Clackamas Co.
Census tract: 410050220001068

Safeway
95 82nd Dr, Gladstone, OR 97027, Clackamas Co.
Census tract: 410510104053014

Safeway
1455 NE Division St, Gresham, OR 97030, Multnomah Co.
Census tract: 410050202004005

Safeway
401 A Ave, Lake Oswego, OR 97034, Clackamas Co.
Census tract: 410050204012016

Safeway
17779 Boones Ferry Rd, Lake Oswego, OR 97035, Clackamas Co.
Census tract: 410510103031006

Safeway
2501 SW Cherry Park Rd, Troutdale, OR 97060, Multnomah Co.
Census tract: 410050205011060

Safeway
22000 S Salamo Rd, West Linn, OR 97068, Clackamas Co.
Census tract: 410510098032024

Safeway
1001 SW Highland Dr, Gresham, OR 97080, Multnomah Co.
Census tract: 410670332001046

Safeway
2836 Pacific Ave, Forest Grove, OR 97116, Washington Co.
Census tract: 410670324036012

Safeway (not geocoded)
2525 SE Tualatin Valley Hwy, Hillsboro, OR 97123, Washington Co.

Safeway
2177 NW 185th Ave, Hillsboro, OR 97124, Washington Co.
Census tract: 410670316102004

Safeway
20685 SW Roy Rogers Rd, Sherwood, OR 97140, Washington Co.
Census tract: 410670322001010

Safeway
1030 SW Jefferson St, Portland, OR 97201, Multnomah Co.
Census tract: 410510053002022

Safeway
3930 SE Powell Blvd, Portland, OR 97202, Multnomah Co.
Census tract: 410510008014018

Safeway
8330 N Ivanhoe St, Portland, OR 97203, Multnomah Co.
Census tract: 410510042002001

Safeway
4515 SE Woodstock Blvd, Portland, OR 97206, Multnomah Co.
Census tract: 410510004013024

Safeway
4320 SE King Rd, Milwaukie, OR 97206, Clackamas Co.
Census tract: 410050210003011

Safeway
5920 NE Martin Luther King Blvd, Portland, OR 97211, Multnomah Co.
Census tract: 410510037022000

Safeway
6901 NE Sandy Blvd, Portland, OR 97213, Multnomah Co.
Census tract: 410510029013020

Safeway
2800 SE Hawthorne Blvd, Portland, OR 97214, Multnomah Co.
Census tract: 410510012012021

Safeway
101 SE 82nd Ave, Portland, OR 97216, Multnomah Co.
Census tract: 410510017014000

Safeway
11919 N Jantzen Dr, Portland, OR 97217, Multnomah Co.
Census tract: 410510072012004

Safeway
8145 SW Barbur Blvd, Portland, OR 97219, Multnomah Co.
Census tract: 410510066021032

Safeway
15570 SW Pacific Hwy, Tigard, OR 97224, Washington Co.
Census tract: 410670308031006

Safeway
6745 SW Beaverton Hillsdale, Portland, OR 97225, Washington Co.
Census tract: 410670303002015

Safeway
13485 NW Cornell Rd, Portland, OR 97225, Washington Co.
Census tract: 410670315072016

Safeway
1541 NE 181st Ave, Portland, OR 97230, Multnomah Co.
Census tract: 410510096052000

Safeway
221 NE 122nd Ave, Portland, OR 97230, Multnomah Co.
Census tract: 410510081001009

Safeway
1100 NE Broadway St, Portland, OR 97232, Multnomah Co.
Census tract: 410510024023018

Safeway
16409 SE Division St, Portland, OR 97236, Multnomah Co.
Census tract: 410510097024003

Safeway

3527 SE 122nd Ave, Portland, OR 97236, Multnomah Co.
Census tract: 410510084002000

Safeway
14840 SE Webster Rd, Milwaukie, OR 97267, Clackamas Co.
Census tract: 410050218012000

Safeway
15099 SE Mcloughlin Blvd, Portland, OR 97267, Clackamas Co.
Census tract: 410050214002008

Save-A-Lot (SUPERVALU Inc.)
6828 SE Foster Rd, Portland, OR 97206, Multnomah Co.
Census tract: 410510005025012

Save-A-Lot (SUPERVALU Inc.)
6100 SE King Rd, Portland, OR 97222, Clackamas Co.
Census tract: 410050211001000

Save-A-Lot (SUPERVALU Inc.)
17420 SE Division St, Portland, OR 97236, Multnomah Co.
Census tract: 410510097022008

Thriftway, Bale's Cedar Mill (Bale's)
12675 NW Cornell Rd, Portland, OR 97229, Washington Co.
Census tract: 410670315074000

Thriftway, Bale's Farmington (Bale's)
17675 SW Farmington Rd, Aloha, OR 97007, Washington Co.
Census tract: 410670317053000

Thriftway, Hank's
661 SE Baseline, Hillsboro, OR 97123, Washington Co.
Census tract: 410670325001003

Thriftway, Lamb's Garden Home (Lamb's)
7410 SW Oleson Rd, Portland, OR 97223, Washington Co.
Census tract: 410670305012001

Thriftway, Lamb's On Scholls (Lamb's)
12220 SW Scholls Ferry Rd, Tigard, OR 97223, Washington Co.
Census tract: 410670310064011

Thriftway, Lamb's Wilsonville (Lamb's)
8255 SW Wilsonville Rd, Wilsonville, OR 97070, Clackamas Co.
Census tract: 410050227032010

Thriftway, Palisades Marketplace (Lamb's)
1377 SW Mcvey Ave, Lake Oswego, OR 97034, Clackamas Co.
Census tract: 410050204022000

Trader Joe's
11753 SW Beaverton Hillsdale Hwy, Beaverton, OR 97005, Washington Co.
Census tract: 410670313001046

Trader Joe's
15391 SW Bangy Rd, Lake Oswego, OR 97035, Clackamas Co.
Census tract: 410050203022009

Trader Joe's
2285 NW 185th Ave, Hillsboro, OR 97124, Washington Co.
Census tract: 410670316102004

Trader Joe's
4715 SE 39th Ave, Portland, OR 97202, Multnomah Co.
Census tract: 410510003011002

Trader Joe's
2122 NW Glisan, Portland, OR 97210, Multnomah Co.
Census tract: 410510048002001

Trader Joe's
4121 NE Halsey St, Portland, OR 97232, Multnomah Co.
Census tract: 410510027022007

Whole Foods Market
1210 NW Couch St, Portland, OR 97209, Multnomah Co.
Census tract: 410510050001114

Whole Foods Market
7380 SW Bridgeport Rd, Portland, OR 97224, Washington Co.
Census tract: 410670320023006

Wild Oats Market (Whole Foods)
3535 NE 15th Ave, Portland, OR 97212, Multnomah Co.
Census tract: 410510033021029

Wild Oats Market (Whole Foods)
2825 E Burnside St, Portland, OR 97214, Multnomah Co.
Census tract: 410510020003006

Wild Oats Natural Marketplace (Whole Foods)
2077 NE Burnside Rd, Gresham, OR 97030, Multnomah Co.
Census tract: 410510104064002

Winco Foods
3025 SW Cedar Hills Blvd, Beaverton, OR 97005, Washington Co.
Census tract: 410670313002022

Winco Foods

2511 SE First St, Gresham, OR 97030, Multnomah Co.
Census tract: 410510104064002

Winco Foods
1500 SW Oak St, Hillsboro, OR 97123, Washington Co.
Census tract: 410670325002008

Winco Foods
7330 NE Butler St, Hillsboro, OR 97124, Washington Co.
Census tract: 410670326054013

Winco Foods
1222 NE 102nd Ave, Portland, OR 97220, Multnomah Co.
Census tract: 410510081003017

Winco Foods
7500 Dartmouth Rd, Tigard, OR 97223, Washington Co.
Census tract: 410670307001020

Winco Foods
1950 NE 122nd Ave, Portland, OR 97230, Multnomah Co.
Census tract: 410510080022009

Winco Foods
11250 SE 82nd Ave, Portland, OR 97266, Multnomah Co.
Census tract: 410050222012003

Zupan's Markets
2340 W Burnside St, Portland, OR 97210, Multnomah Co.
Census tract: 410510047003013

Zupan's Markets
3301 SE Belmont St, Portland, OR 97214, Multnomah Co.
Census tract: 410510013014018

Zupan's Markets
8235 SW Apple Way, Portland, OR 97225, Washington Co.
Census tract: 410670304012000

Zupan's Markets
7221 SW Macadam Ave, Portland, OR 97219, Multnomah Co.
Census tract: 410510059002020

APPENDIX B

FOOD DESERT CHARACTERISTICS BY TRACT AND MEASURE

Food desert characteristics by tract and measure

Tract characteristics						Accessibility							
						Measure 1: Average distance to the nearest supermarket		Measure 2: Average number of supermarkets within walking distance		Measure 3a: Average distance to 3 different chain-name supermarkets (different parent companies)		Measure 3b: Average distance to 3 different chain-name supermarkets	
Tract	City/neighborhood	Population	Number in poverty	Poverty rate	Poverty category	Feet	Access level	#	Access level	Feet	Access level	Feet	Access level
41051003301	North East Portland	3223	1057	33%	High	2789	Low	0.39	Very Low	4474	High	4474	High
41067032403	Hillsboro	8588	1756	20%	High	3239	Low	0.27	Very Low	4831	High	4831	High
41051009606	East Portland	4721	1309	28%	High	3042	Low	0.50	Very Low	5464	Low	4918	High
41051008301	South East Portland	2687	684	25%	High	2580	Low	0.61	Very Low	5757	Low	4646	High
41051002301	North East Portland	2595	835	32%	High	3105	Low	0.32	Very Low	5043	Low	5015	Low
41051003401	North East Portland	3309	786	24%	High	3331	Very Low	0.26	Very Low	4829	High	4829	High
41051002100	North East/South East Portland	2283	626	27%	High	3625	Very Low	0.20	Very Low	4572	High	4505	High
41051001101	South East Portland	1915	493	26%	High	4315	Very Low	0.00	Very Low	4734	High	4728	High
41051007600	North East Portland	3760	939	25%	High	3739	Very Low	0.17	Very Low	6396	Low	6396	Low
41051003402	North East Portland	2770	861	31%	High	4779	Very Low	0.00	Very Low	5970	Low	5970	Low
41051002202	North East Portland	207	63	30%	High	3992	Very Low	0.00	Very Low	5837	Low	5506	Low
41051009801	East Portland/Gresham	4482	1321	29%	High	3718	Very Low	0.09	Very Low	5090	Low	4922	Low
41051004001	North Portland	6240	1761	28%	High	4087	Very Low	0.16	Very Low	8128	Very Low	8128	Very Low
41051002201	North East Portland	350	118	34%	High	5467	Very Low	0.00	Very Low	6678	Very Low	6617	Very Low

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