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Desert or Mirage? An Examination of Food Deserts in Iowa Cities

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Abstract

Food insecurity affects millions of Americans and has been widely recognized as a significant health and economic issue. Because of this, researchers have sought to develop ways to identify areas that are prone to food insecurity, which have become known as food deserts. Food deserts have been broadly defined through a confluence of three factors: low income, a lack of vehicle access, and a predetermined distance from a healthy food retailer. But research into food deserts in Iowa is limited, and the most prominent source of information on this topic, the Food Access Research Atlas created by the U.S. Department of Agriculture, has been criticized for its questionable methodologies. The goals of this project are twofold. First, in an attempt to provide more accurate and up-to-date maps of food deserts in the Iowa cities of Waterloo and Des Moines, this project used GIS techniques, food-access measurement variables from a range of studies, and a nutritional audit of smaller food retailers excluded from the USDA's analysis to produce a variety of maps of areas of low food access. These maps were compared to see if different techniques of evaluating the spatial landscape of food access in urban areas yields similar results.

Chap 1: Introduction

The list of things a human cannot physically live without is short: air, water and food. The first surrounds us at all times. The second is freely available in water fountains, public buildings and restaurants. But food is different. Food is a commodity. It's sold at various prices across a range of quantities and qualities. Its availability is not guaranteed and is instead found in stores scattered throughout an area its populace is expected to visit during its hours of operation. Because of this, access to food is not equitable - a product that is elemental to the continuation of life is easier to acquire for some more than others. It is for this reason that an advanced capitalist nation such as the United States still faces the problem of hunger, or, as it is generally referred to in research addressing the issue, food insecurity.

Significance of the Study

The concept of food insecurity is defined by the U.S. Department of Agriculture as a diet deprived of quality, variety or desirability, or, more severely, when it is characterized by disrupted eating patterns and reduced food intake (USDA 2022). These are categorized as low food security and very low security, respectively. In 2021, 10.2% (13.5 million) of households in the United States were food insecure, including 3.8% (5.1 million households) that had very low food security. These levels of food insecurity and food access have been called a public health emergency (Hutton et al. 2022) and are widely recognized as a significant health and economic issue (LeClair and Aksan 2014).

The health impacts where food sources are non-existent, extremely limited, or costly lead to poor health outcomes. Research has demonstrated that food shortages can lead to a higher risk of heart attack and stroke, higher rates of diabetes, obesity, and other chronic diseases, and lower life expectancy (Hutton et al. 2022). Children experiencing food insecurity can see declines in social skills and can fall behind more frequently in math and reading. They have a higher prevalence of poor health and dental decay, suffer more frequently from anxiety, depression and other forms of psychiatric distress, and more commonly experience headaches and stomach aches, anemia, and asthma. Children with poor food security also have a higher prevalence of chronic illness and often have poorer health outcomes during adulthood (Long 2020).

While the health risks are clear, identifying causes for food insecurity is generally accepted as a complex issue that can vary by county and between urban and rural regions (Chen and Clark 2016). Barriers to food accessibility can be tied to information, such as research that suggests lower education can be tied to lower consumption of fruit and vegetables (Wrigley et al. 2002), or economics, including factors of poverty, food prices and transportation costs (Bilkova and Krizan 2018). But one of the most commonly utilized measures of food insecurity is geographic - the physical distance to and accessibility of large grocery stores from various neighborhoods (Chen and Clark 2016).

This focus on the spatial aspect of food access has led to a growing body of research that points to structural inequalities in the food retail environment. In the United States, geographic areas with a high proportion of low-income or African American residents were underserved by food retailers. Distance to supermarkets was also farther

for those living in low-income areas and for areas with a high proportion of African Americans (Beaulac et al. 2009). Studies have found that this lack of access in low-income areas further inhibits the ability of disadvantaged populations to maintain nutritious and balanced diets (Chen and Clark 2016). This link is strengthened by research that found that the poorest zip codes in 21 of the nation's largest metropolitan areas had a little over half of the grocery square footage that existed in wealthier zip codes (Crowe 2018).

With concern for food access disparities growing, significant efforts have been made to map areas of low food access, which are also commonly called "food deserts," although the term has been subject to recent criticism (Widener 2018, Teigen De Master and Daniels 2019). The most common tool to aid in this effort is Geographic Information Systems (Hutton et al. 2022). GIS tools in particular have enabled the widespread quantification and visualization of food deserts by combining layers of spatial data on grocery store location and density with food access metrics, such as transportation availability and distance to markets. Researchers have also incorporated other indicators into maps such as income, race, ethnicity, and various measures of commute times and distances (Teigen De Master and Daniels 2019).

Research in locating areas with low food access is happening across the country, but studies examining its prevalence in Iowa are lacking. Perhaps one of the largest efforts to map areas of low food access is the USDA's Food Access Research Atlas, which identifies census tracts of low food access in many Iowa cities, including Des Moines, Cedar Rapids, Iowa City and Waterloo. Recent research, however, has questioned the accuracy of the USDA's maps, noting that the department's methodology

excludes smaller local markets and stores (Teigen De Master and Daniels 2019). These information gaps in food retailers included in food desert analysis have led to inaccurate maps of supposed low-food-access areas that researchers knew contained abundant food options (Hutton et al. 2022, Teigen De Master and Daniels 2019).

Research Questions

Given the pressing social and equitable concerns of food insecurity, it is vital that stakeholders receive information about where the problem most critically occurs. To complete this work, the project seeks to answer the following questions:

- Where are areas of low food access located in Iowa cities?
- Do maps of areas with low food access that include smaller neighborhood and convenience stores differ from maps of areas with low food access that are based only on large stores and supermarkets?

Chapter 2: Literature Review

Defining Food Deserts

To the best of our knowledge, the term “food desert” was first uttered in the 1990s by a Scottish public housing resident describing her neighborhood to an ethnographer. Scholars, practitioners and the public soon leapt upon this evocative metaphor as a shorthand for describing spatialized inequality in the access of healthy and affordable food (Teigen De Master and Daniels 2019). Interest in these spatial disparities of healthy food access has been on the rise in the past two decades (Chen and Clark 2016). And although there is a wealth of research into the causes of low food access and the techniques to map and define food deserts, the methodologies and definitions of what constitutes a food desert varies and even the extent to which food deserts exist at all is debated (Beaulac et al. 2009).

The 2008 Farm Bill, Section 7527, defines a food desert as “an area ... with limited access to affordable and nutritious food, particularly such an area composed of predominantly lower-income ... communities.” But there are many criteria researchers have used to identify food deserts. Beaulac et al. reviewed thousands of food desert studies from 1966-2007, and found geographic studies compare the accessibility of different types of food stores, while market-basket studies compare a selection of food items across areas in terms of availability, variety and price. Outcomes of food desert studies include average distance to nearest food stores, store density by area or population, average selling space, availability and variety of items, price of food, and food quality. Food deserts also typically fall between income lines, as populations living below the poverty line are more likely to be underserved by food retailers. Studies have also shown that supermarkets in low-income areas had less selling space and offered

fewer options for healthy food. These structural inequalities can exacerbate the food access issue presented by food deserts, amplifying the disadvantages of low-income populations who are already limited in their ability to purchase food (Beaulac et al. 2009).

Studies in public health and urban planning have applied both low-income status and low access to supermarkets to identify food deserts. Various geographic boundaries, such as zip codes, census tracts, and census block groups, have also been used. A national study by the US Department of Agriculture relied on a 1-by-1-kilometer grid. Measures to define a low-income area and its vulnerable population have included zip codes with a median household income at the bottom quintile of the national level (less than 80% of the surrounding area), census tracts with more than 20% of the population living below the poverty level, and a 1-by-1-kilometer grid with more than 40% of its population at or below 2 times the poverty level (Jiao et al. 2012).

Distance from identified disadvantaged areas - usually described in terms of a poverty threshold combined with a lack of vehicle access - is a cornerstone of food desert identification, but there is little agreement on what measure of distance to use. Coveney and O'Dwyer, writing in 2009, defined a food desert as a dwelling more than 2.5 kilometers (about 1.5 miles) from the nearest supermarket in a census district where the proportion of households without a car was in the top quartile for all census districts within the area of their study - Adelaide, South Australia. Jaskiewicz et al. 2016 used a distance of two miles from census block centroids for measures that required a specific distance. Other distance thresholds that have been used for urban residents include 0.8

km, 1 km, 1 mile, 2 km, and 2.5 km. In rural areas, 10 miles has been used (Jiao et al. 2012).

And while there are many definitions of the factors to consider in defining food deserts, when it comes to mapping those areas, there is widespread agreement on the appropriate tool to employ: Geographic Information Systems (GIS).

GIS use in mapping food deserts

Dowler et al. (2001) were amongst the first to systematically document food deserts using descriptive mapping. In a case study of a UK town, they found large networks of streets and estates without any shops selling fresh fruit and vegetables, and where any available fruit and vegetables were expensive. As spatial data and GIS software became more widely available to researchers, mapping and geospatial analysis have been the predominant methods to study food environments. Reviews of literature in the early 2010s found that more than half of the research on food environments used geospatial analysis (Shannon et al. 2021), and GIS has been described as the most utilized form of food security assessment (Hutton 2022).

GIS tools have enabled the widespread quantification and visualization of food deserts by combining layers of spatial data on supermarket location and density with food access metrics, such as transportation availability and distance to markets. Metrics have become increasingly detailed and refined over time, as mappers have incorporated additional indicators into food desert maps, such as income, race, ethnicity, the presence/ absence of certain foods, and various measures of commute times and distances (Teigen De Master and Daniels 2019). Maps are a powerful tool to

display these metrics and data, offering striking visuals of disparities in ways that motivate political action. They are also intuitively understood by both policymakers and the general public and suggest a clear path for intervention by highlighting areas of concern (Shannon et al. 2021).

The development of GIS tools brought revolutionary progress in the analytical research methods utilized in food accessibility mapping, but the results of these maps depend on the way distance is measured. A study by Bilkova et al. in 2017 compared the two most common approaches to measure distance in GIS - Euclidean distance and shortest network distance. The Euclidean distance approach uses buffer tools, while network distance using the network analyst tool in ArcGIS, which measures distance based on the existing network of streets and sidewalks. The study concludes that the shortest network distance seems to be the most appropriate for investigating accessibility to food stores in urban environments.

A 2016 study by Jaskiewicz et al. summarized and compared numerous methods of measuring spatial access. These include the container measures, which counts the number of stores within a given geographic area, but does not take into account the possibility of a resident crossing a border to shop, and the coverage measure, counts the number of stores within a specific distance, but does not account for competition or differences in their attractiveness. The study also examined the minimum distance measure, which calculates the distance to the closest store from a census block centroid. The study used network analysis to calculate distance, following the street network. The results displayed wide variation in high and low access locations between measures, prompting the authors to conclude that the choice of the measures used to

calculate potential spatial accessibility to retail food stores influences study results (Jaskiewicz et al. 2016).

GIS can also analyze numerous methods of travel using parameters of both distance and time. It can then layer this information onto a geocoded map of food retail outlets that have been stratified based on the average cost of their offerings. Jiao et al. displayed this flexibility in a 2012 study seeking new ways to identify food deserts in King County, Washington. The study used five different measurements of poverty combined with vehicle access. It also added an economic component by stratifying supermarkets by food price, with the assumption that low-income populations need to access low-cost supermarkets. By using different low-income populations and comparing different modes of transportation, including walking, bicycling, riding the bus and driving, the study concluded that estimates of populations living in food deserts depend on how the criteria are defined and what measurement techniques are employed (Jiao et al. 2012).

But while GIS is the most common method researchers use to map food deserts, it's not without flaws.

Limitations of GIS food desert maps

Shannon et al. detailed a number of limitations with maps and the geospatial analysis of food environments. Maps can minimize factors other than distance that affect food access and can neglect the active role of food consumption in terms of daily mobility patterns, ties to workplaces, and connections to or the care of friends and family. The study also noted that geographic access to food is more than physical

proximity, it can also be related to daily travel patterns or reliance on ride-sharing networks. Homes are also not always proxies for people, and most conventional maps are not able to communicate the responsibilities, such as employment and childcare, that move people from place to place (Shannon et al. 2021).

GIS techniques are also susceptible to misclassification due to inaccuracies in source data. Various studies have encountered gaps in the public records for food retailers - with some being either no longer open or not located at the listed location. This suggests it is fairly common to misclassify residents as having geographic access when they do not (Caspi et al. 2012). To avoid this inaccuracy, many studies verify the locations of food retailers used in mapping food deserts through second-hand verification in the form of in-person visits or phone calls.

While distance from food retailers has been shown to impact the quality of food eaten (Coveny and O'Dwyer 2009), qualitative studies on food deserts have shown that distance to a store is not the only factor informing shopping decisions. A 2018 study examined a poor, mostly African American neighborhood in South Dallas, using study groups to understand how its residents, who lived in a neighborhood classified as a food desert, accessed food. The study found that, despite several neighborhood grocery stores, many residents traveled greater distances - up to a 30 minute drive or a two-and-a-half hour bus ride - to shop for groceries. Some made the trip because the prices in the neighborhood stores were too high, while others claimed that the quality of the meats and produce was higher in the stores that were farther away.

Finally, a major drawback of GIS mapping is the inability to determine what products are actually available to residents in neighborhoods not served by a major

grocery store. It is for this reason, and others, that a number of studies have highlighted issues with the largest effort to map food efforts to date - the U.S. Department of Agriculture's Food Research Atlas.

The USDA Food Research Atlas and the Case of the Missing Grocery Store(s)

The most comprehensive map of food accessibility at the census-tract level is the USDA Economic Research Service Food Access Research Atlas. It is widely used by government policy makers to guide policy interventions to improve food access (Isokpehi et al. 2020). The dataset consists of 72,864 census tracts and 147 variables, with several definitions of food deserts that combine income level and vehicle access with distance from large grocery stores and supermarkets. The project uses urban distance measures of ½ mile and 1 mile to gauge food accessibility.

And while the Food Access Research Atlas is the largest and most utilized index for food security assessment, research has called into question the accuracy and completeness of the underlying data used to develop the tool. One study noted its exclusion of small community stores and found that it lagged in accounting for store closures. In the analysis, the study found that almost 6% or total food sources and over 15% of healthy food sources were missing from the original data set (Hutton 2022). An issue highlighted by Teigen De Master and Daniels in 2019 is that the atlas does not include smaller local markets and stores, which led to some parts of their study area,

Providence, Rhode Island, to be characterized as food deserts when the region was known to have abundant food options (Teigen De Master and Daniels 2019).

In general, supermarkets and large grocery store chains are often exclusively used in food desert studies because they are reasoned to reliably offer the greatest variety of high-quality fresh produce at the lowest cost. But one of the growing challenges of measuring food access with GIS is the inconsistency of the categorization of retail stores included in the analysis. Some studies distinguish between chain supermarkets and independent grocery stores, others group them all together (Caspi et al. 2012). In the Caspi et al. 2012 study, the analysis did not use small grocery stores in the study, citing research that they possess a high degree of variability in the variety and quality of their merchandise. Other studies (Coveney and O'Dwyer 2009) have used similar reasoning to exclude smaller stores from their analysis.

But conclusions as to whether easy access to supermarkets improves one's diet and overall quality of life have also been mixed. Residents of a food desert may not have access to a supermarket, but other types of small food retailers such as a local butcher, fruit and vegetable market, baker, or ethnic and specialty food stores may exist. Local accessibility to these kinds of smaller food stores may improve residents' access to healthy foods. Although this type of geographical access may exist, food type, quality, and price should also be examined to help understand diet and consumer costs of life in a food desert (Larsen and Gilliland 2008). And while computer-based GIS mapping is a suitable and powerful initial step in evaluating food access, supplementation with on-the-ground observation is necessary, as first-hand determination of what items food retailers actually offer is essential (LeClair and Askan 2014).

Teigen De Master and Daniels developed a research approach to bring in the smaller stores and bodegas left out of the USDA's analysis. Using the USDA Thrifty Meal Plan, which suggests a shopping list for families on a limited budget, they developed a shopping list and then visited different stores in Providence to record how many items on the list could be found. Using this form of market basket survey, they created a metric based on these results and mapped out food deserts accordingly. In the end, the study found a range of 33-95% of available items from the Thrifty Meal Plan shopping list, leading to the conclusion that many of the smaller corner stores and bodegas meet many of the criteria for community food security.

Chapter 3: Methods

Description

In an attempt to provide more accurate and up-to-date maps of food deserts in select Iowa cities, this project will analyze how changing the variables used to identify areas of low food access will change the output of different measurement techniques. Specifically, this project will determine whether the inclusion of smaller food retailers will change the areas designated as low food access. It will also survey the availability of nutritious food at those smaller food retailers to determine if they can be relied upon to supply a healthy diet to the neighborhoods it serves. In the end, the project will use GIS analysis techniques to produce maps using the stores that can supply a healthy diet, employing methods that will be expanded on below. These maps will help understand how the inclusion of smaller food retailers affects maps of areas with low food access.

Study Area

This project focused on the Iowa metropolitan areas of Des Moines and Waterloo, which both contain census tracts designated as areas of low food access by the USDA, measured by the three components critical to food desert designation: poverty, distance from a food retailer and a lack of vehicle access.

Figure 1: Census tracts in Waterloo, Iowa designated as food deserts by the USDA

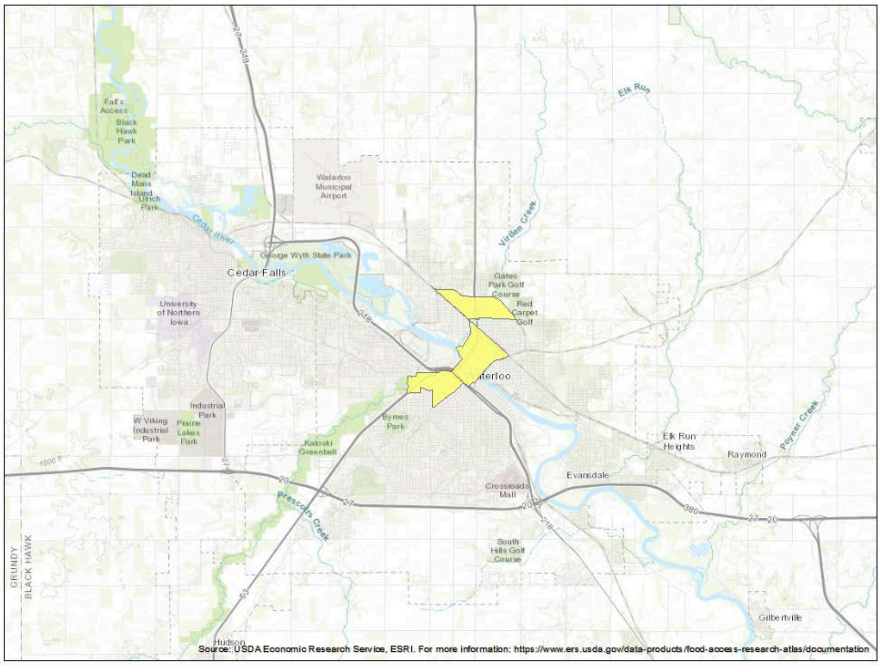
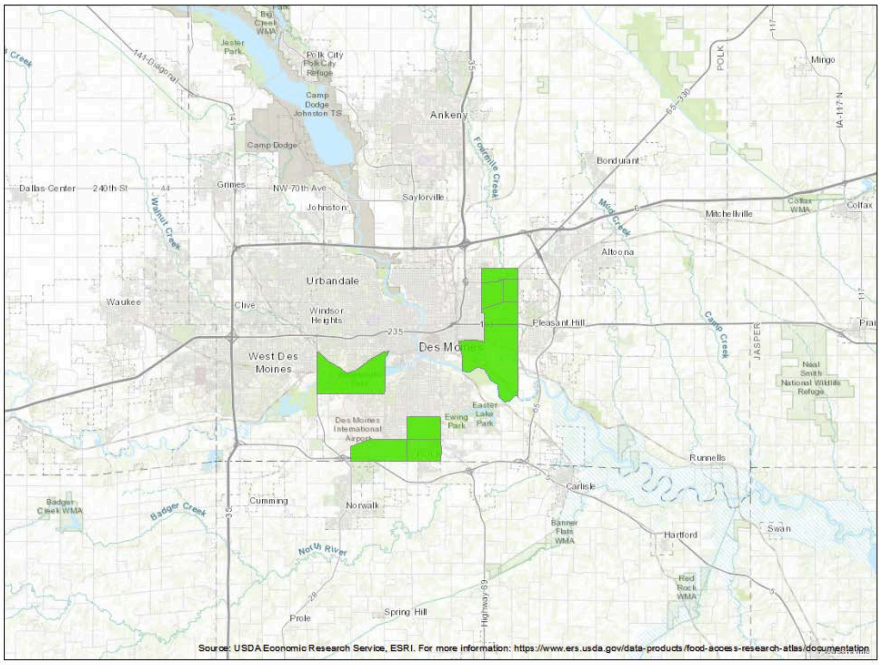


Figure 2: Census tracts in Des Moines, Iowa designated as food deserts by the USDA



Analysis Methods

First, information on food retailers was collected in the study area. The list of retailers was compiled through the use of Standard Industrial Classification code, which has been used in previous food desert studies (Jaskiewicz et al. 2016). All food retailers in the SIC code of 5411 were included, this included food markets, snack products, convenience stores, food products - retail, grocers - retail, markets - kosher, grocers - ethnic foods, and grocers - health foods. These stores were geocoded for use in GIS data processing and were vetted for location accuracy by visiting each location in person.

These stores were then surveyed to determine the variety of healthy food options they offer following the methods laid out in a 2019 study by Teigen De Master and Daniels, where stores were ranked based on the amount of food that could be acquired from a shopping list the study authors derived from the USDA's Thrifty Meal Plan. The Thrifty Food Plan is one of four food plans USDA develops that estimates the cost of a healthy diet across various price points – the Thrifty, Low-Cost, Moderate-Cost and Liberal Food Plans. The Thrifty Food Plan is the lowest cost of the four. It represents a nutritious, practical, cost-effective diet prepared at home for a "reference" family, which is defined in law as an adult male and female, ages 20-50, and two children, ages 6-8 and 9-11. USDA calculates the Thrifty Food Plan using a mathematical model, or equation, based on the cost of food, the nutrients in food, nutrition guidance and what Americans eat. The Thrifty Food Plan is made up of specific amounts of various food categories – such as dark green vegetables, whole fruit and poultry – that together comprise a practical, cost-effective diet that meets dietary guidance.

This study created a nutritional audit composed of items on both the Thrifty Meal Plan and the Nutrition Environment Measures Survey (NEMS), which has been used in other studies to evaluate the nutritional landscape of different grocery retailers (Gustafson et al. 2013). NEMS was developed as a tool to provide observational measures of the nutrition environment within retail stores to assess the availability of healthy options, price, and quality. NEMS is an organization funded with support from the National Institutes of Health, the United States Agricultural Department, the Robert Wood Johnson Foundation, the Georgia Cancer Coalition, the Center for Disease Control and Prevention, and the Center for Health Behavior Research at the University of Pennsylvania.

The study calculated the percentage of healthy food options each location provides and ranked them accordingly. The stores that qualify to offer sufficient healthy food options were used in GIS analysis to produce maps of areas of low food access.

The project followed USDA criteria to identify areas of low food access, which are designated through an intersection of poverty, distance to grocery stores and access to a vehicle (USDA 2021). The project defined low-income census tracts along USDA lines:

- The tract's poverty rate is 20 percent or greater; or
- The median family income does not exceed 80 percent of statewide median family income or, if in a metropolitan area, the greater of 80 percent statewide median family income or 80 percent of metropolitan area median family income.

The project used census block groups as proxies for neighborhoods and distance to food retailers will be calculated from the population-weighted centroids of the block

groups provided by the U.S. Census Bureau, similar to other food desert studies (Jaskiewicz et al. 2016, Bilkova et al. 2017).

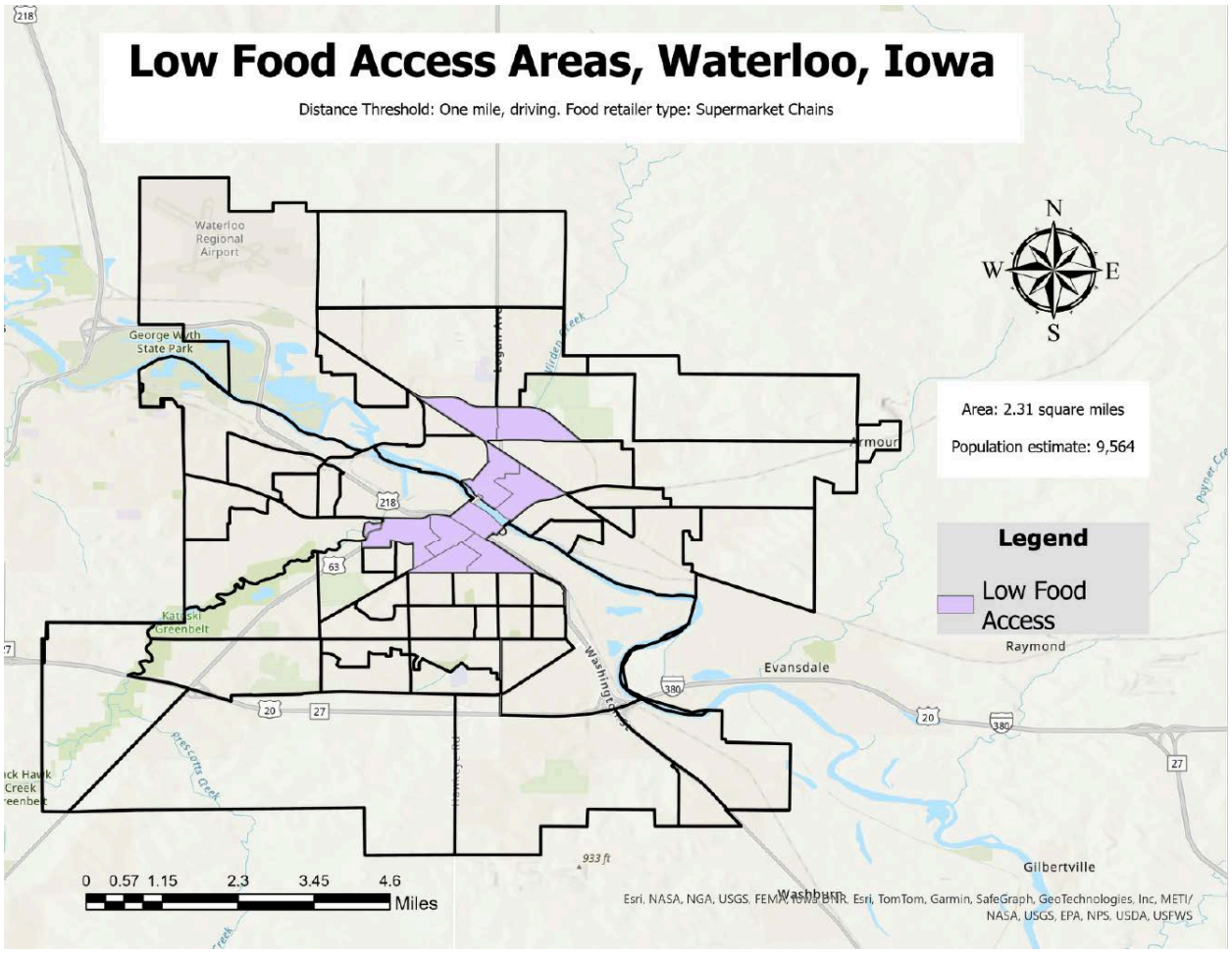
To calculate distances to food retailers from census tracts that meet the definition of low food access, the project used the network analysis method, following the street network. The minimum distance to the healthiest food retailer was calculated using the Closest Facility function in the Network Analyst extension in ArcGIS Pro. This distance was calculated to four different groupings of food retailers determined by the results of the nutritional audit. The first group includes major supermarket chains, including Hy-Vee, Fareway, ALDI, Wal-Mart and Target. The second group includes every store that sold every item on the nutritional audit. The third group includes non-convenience stores that sold every item on the nutritional audit. The fourth group includes every store that sells fresh fruits and vegetables.

As a third indicator of low food access, the project included vehicle availability data from the American Community Survey obtained by the U.S. Census Bureau. The project followed the methodology from the USDA's Food Access Research Atlas that census tracts would be designated low-vehicle access if it contained more than 100 households with no vehicle access.

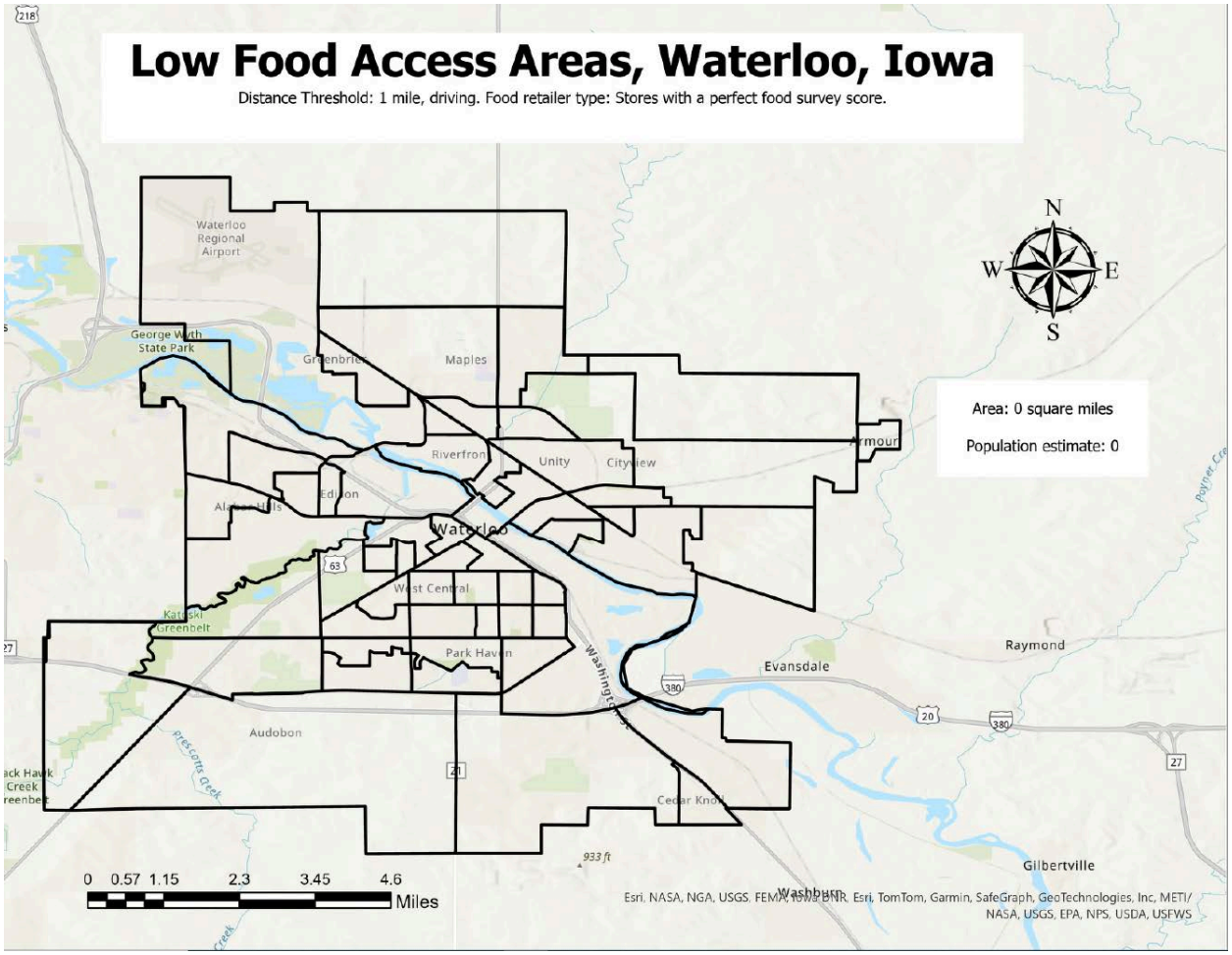
Census block groups that exceeded the distance threshold and resided within tracts designated as low-income and low vehicle access would be considered areas of low food access.

Chapter Four: Results

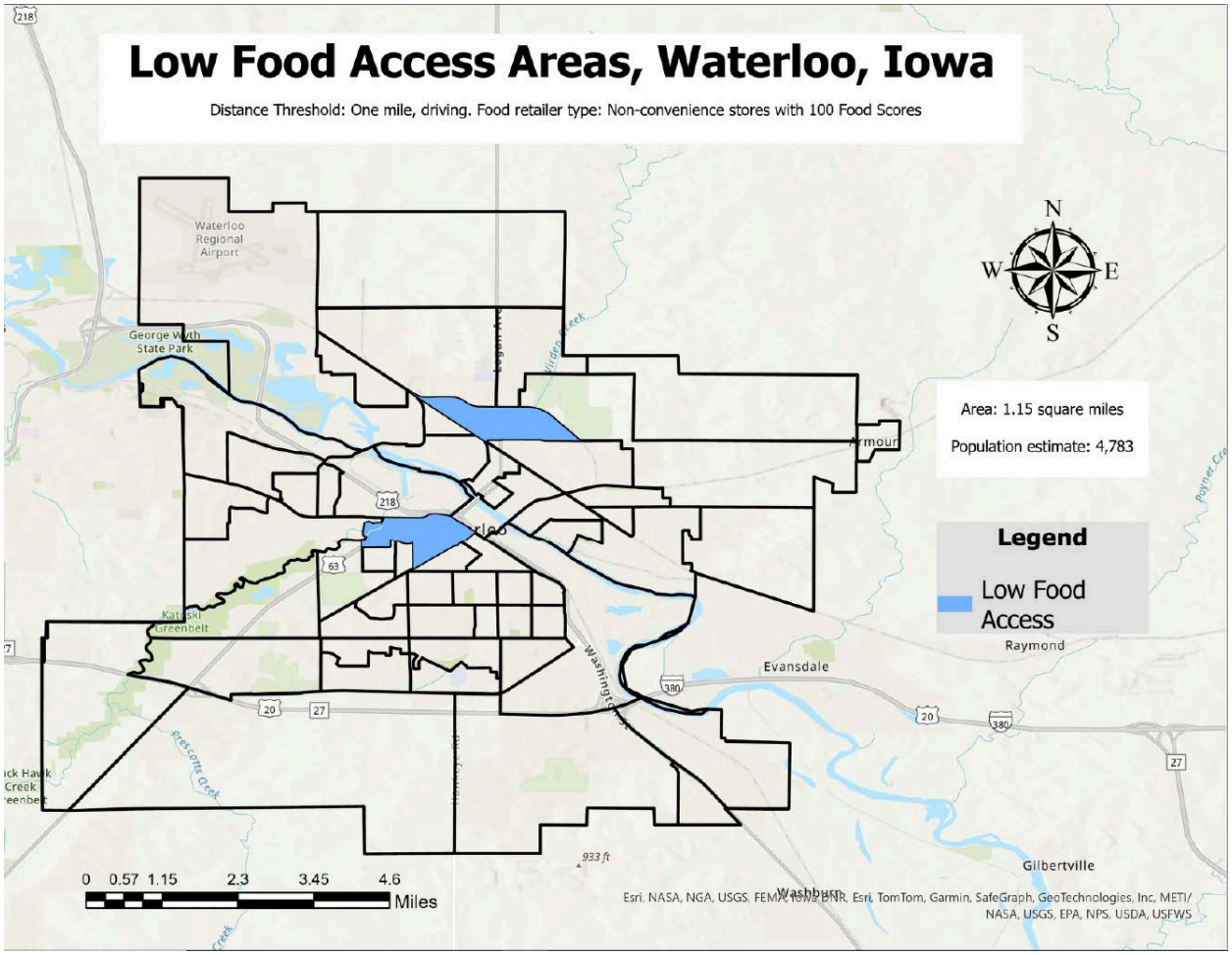
Waterloo Results



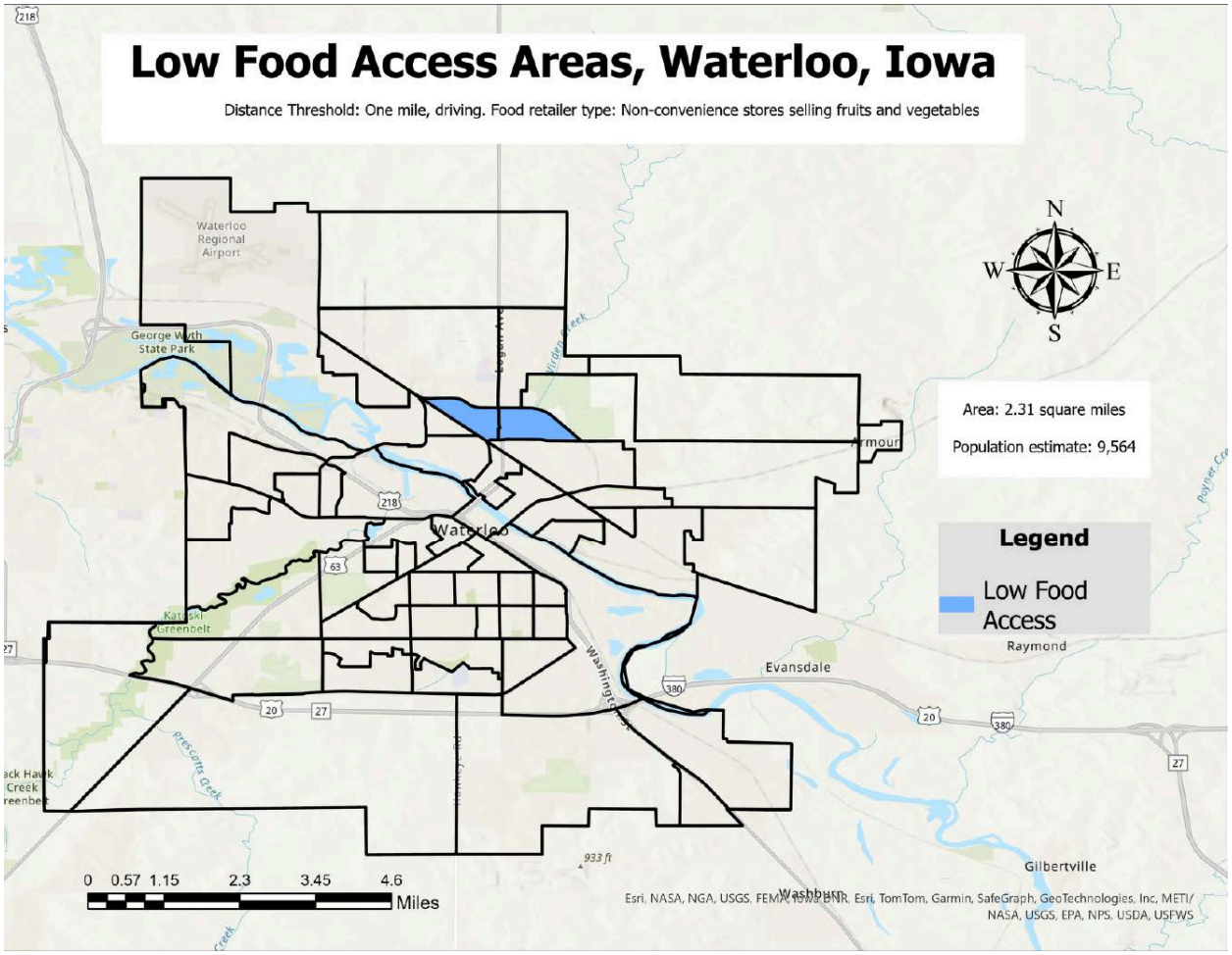
Map 1: **Areas of low food access using a distance threshold of 1 mile driving**. The food retailer configuration was major supermarket chains, including Hy-Vee, Fareway, ALDI, Wal-Mart and Target. This group of stores was used as a baseline for comparison to other groups using this distance measurement. The area of low food access had an area of 2.31 square miles and an estimated population of 9,564.



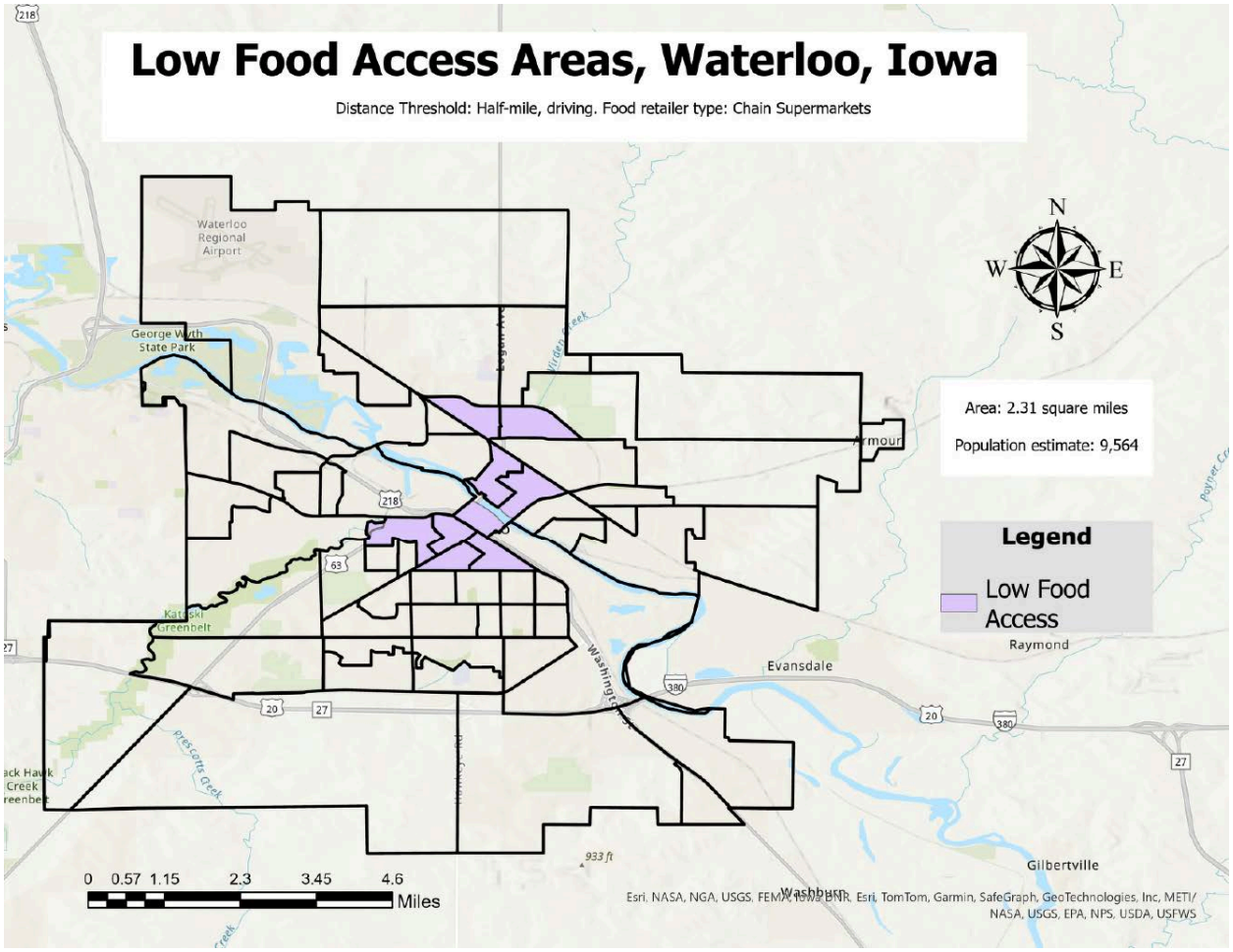
Map 2: **Areas of low food access using a distance threshold of 1 mile driving.** The food retailer configuration was all food retailers that sold every item on the food survey. This method found no areas of low food access in the study area.



Map 3: **Areas of low food access using a distance threshold of 1 mile driving.** The food retailer configuration was all non-convenience stores that sold every item on the food survey. The area of low food access had an area of 1.15 square miles and an estimated population of 4,783. Using this method reduced the size of the area by 50.21 percent and the estimated population by 49.98 percent from the baseline food retailer configuration of only major supermarket chains.

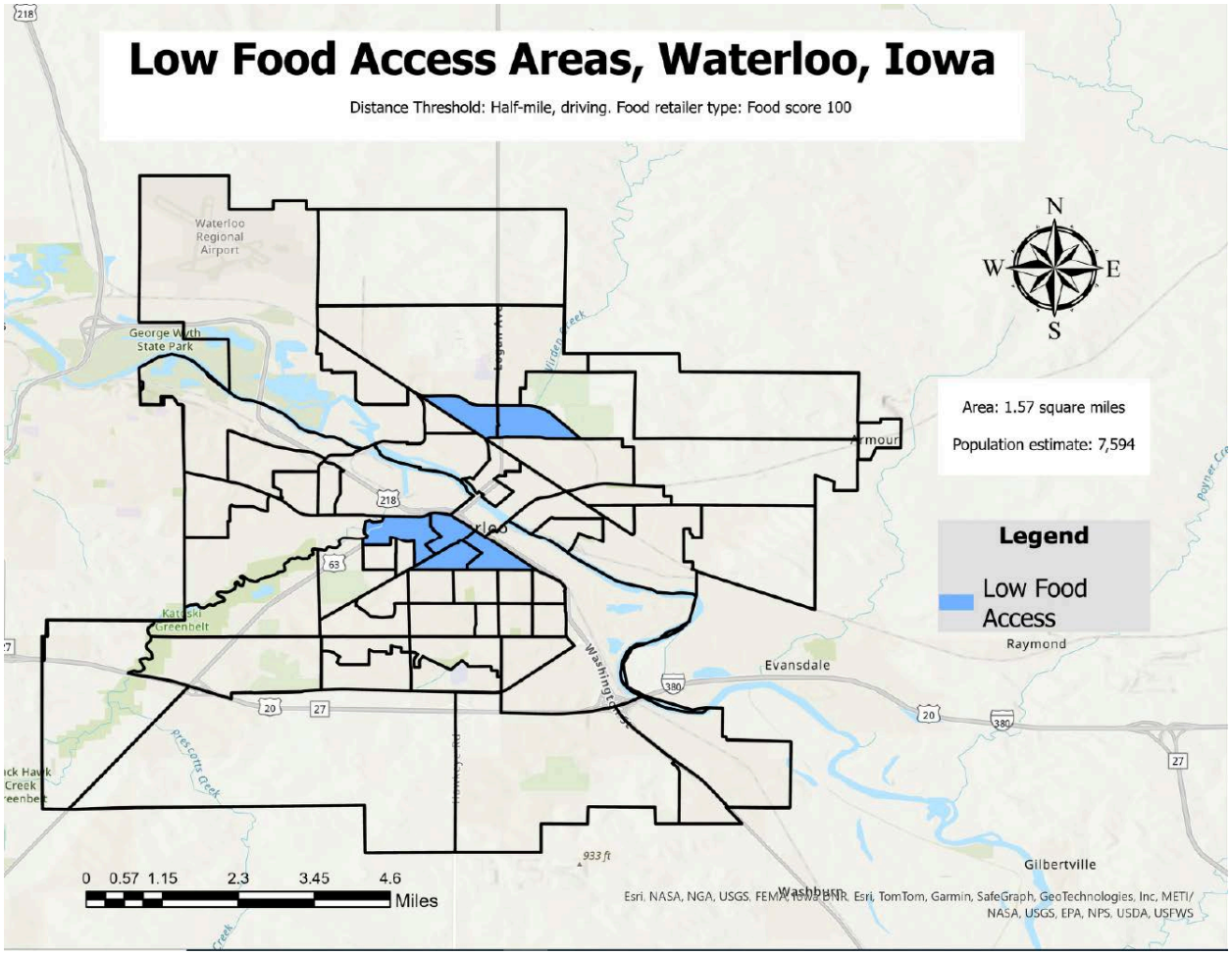


Map 4: **Areas of low food access using a distance threshold of 1 mile driving.** The food retailer configuration was all non-convenience stores that sold fresh fruit and vegetables. The area of low food access had an area of 0.61 square miles and an estimated population of 1,945. Using this method reduced the size of the area by 73.59 percent and the estimated population by 79.66 percent from the baseline food retailer configuration of only major supermarket chains.



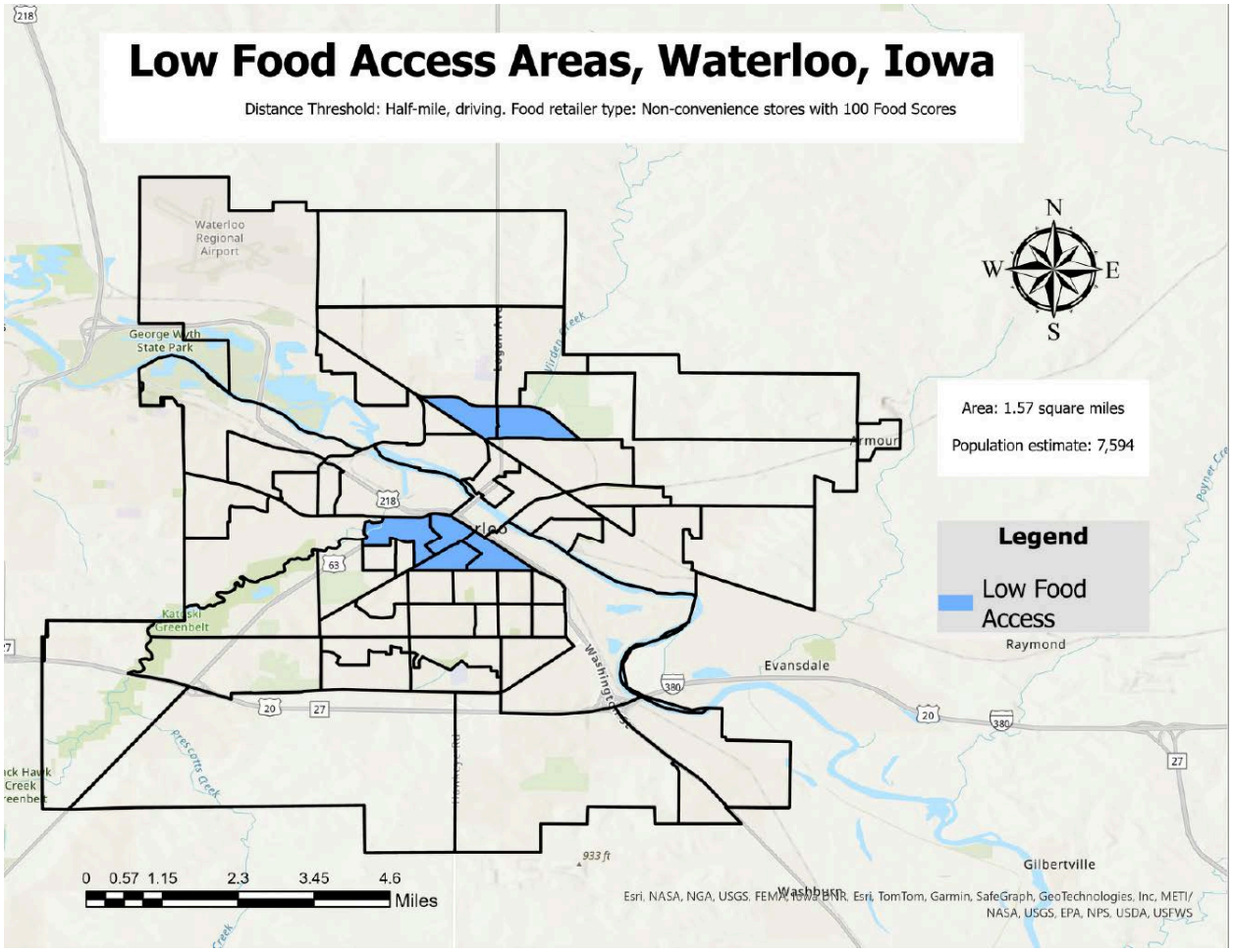
Map 5: **Areas of low food access using a distance threshold of 0.5 miles driving.**

The food retailer configuration was major supermarket chains, including Hy-Vee, Fareway, ALDI, Wal-Mart and Target. This group of stores was used as a baseline for comparison to other groups using this distance measurement. The area of low food access had an area of 2.31 square miles and an estimated population of 9,564. The area identified as low food access did not differ from the one-mile threshold.



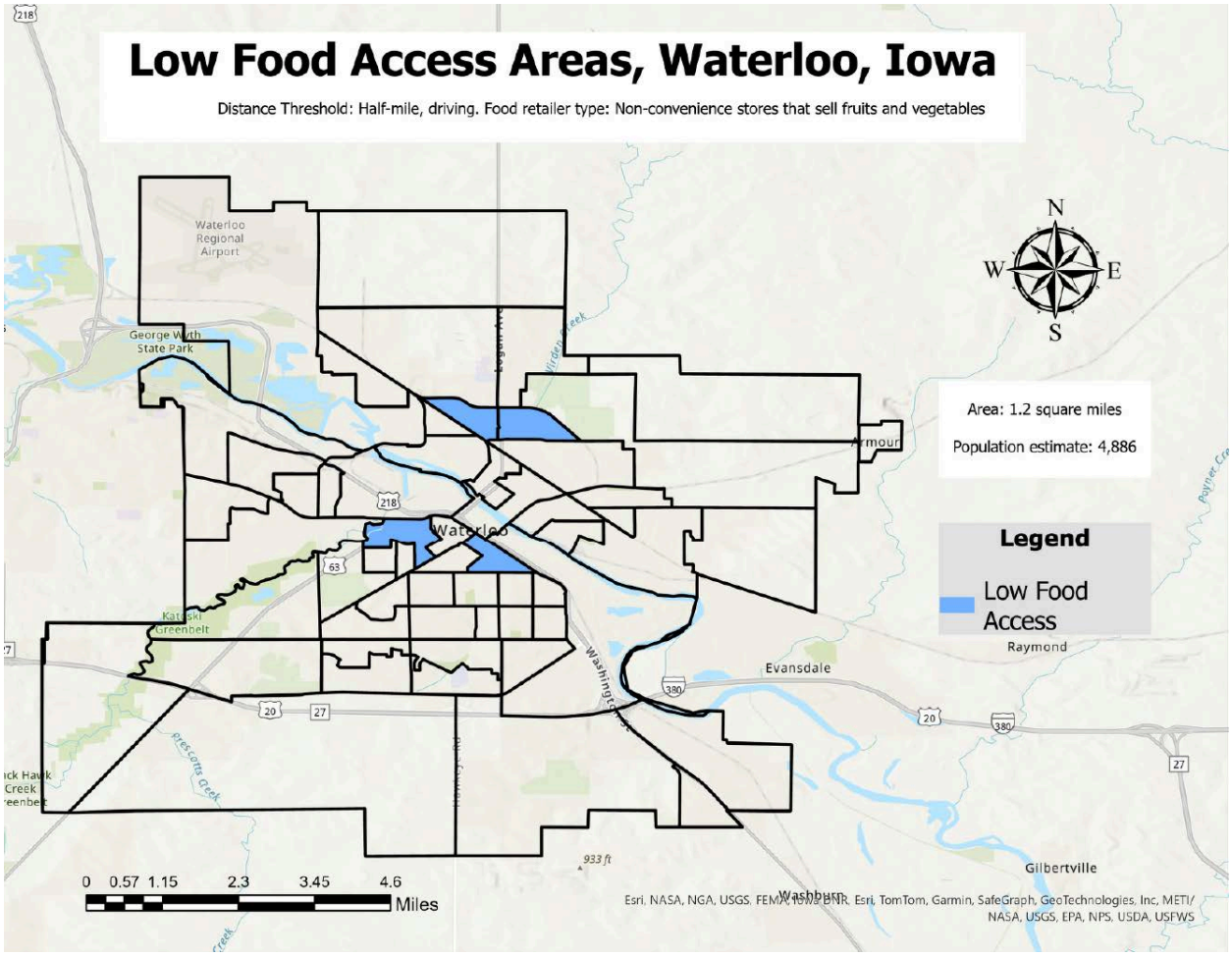
Map 6: **Areas of low food access using a distance threshold of 0.5 miles driving.**

The food retailer configuration was all non-convenience stores that sold fresh fruit and vegetables. The area of low food access had an area of 1.57 square miles and an estimated population of 7,594. Using this method reduced the size of the area by 32.03 percent and the estimated population by 20.59 percent from the baseline food retailer configuration of only major supermarket chains.

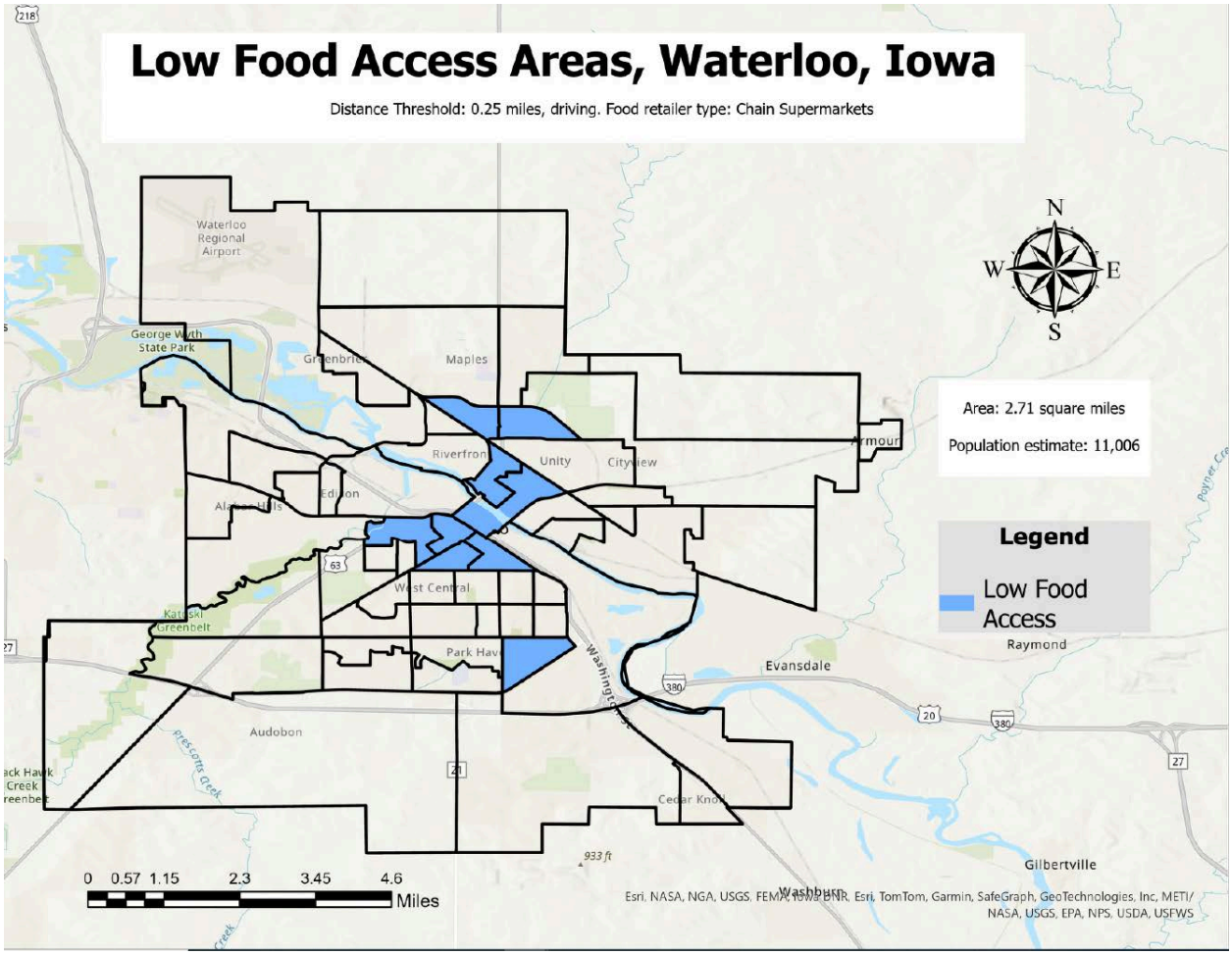


Map 7: **Areas of low food access using a distance threshold of 0.5 miles driving.**

The food retailer configuration was all non-convenience stores that sold every item on the food survey. The area of low food access had an area of 1.57 square miles and an estimated population of 7,594. Using this method reduced the size of the area by 32.03 percent and the estimated population by 20.59 percent from the baseline food retailer configuration of only major supermarket chains.

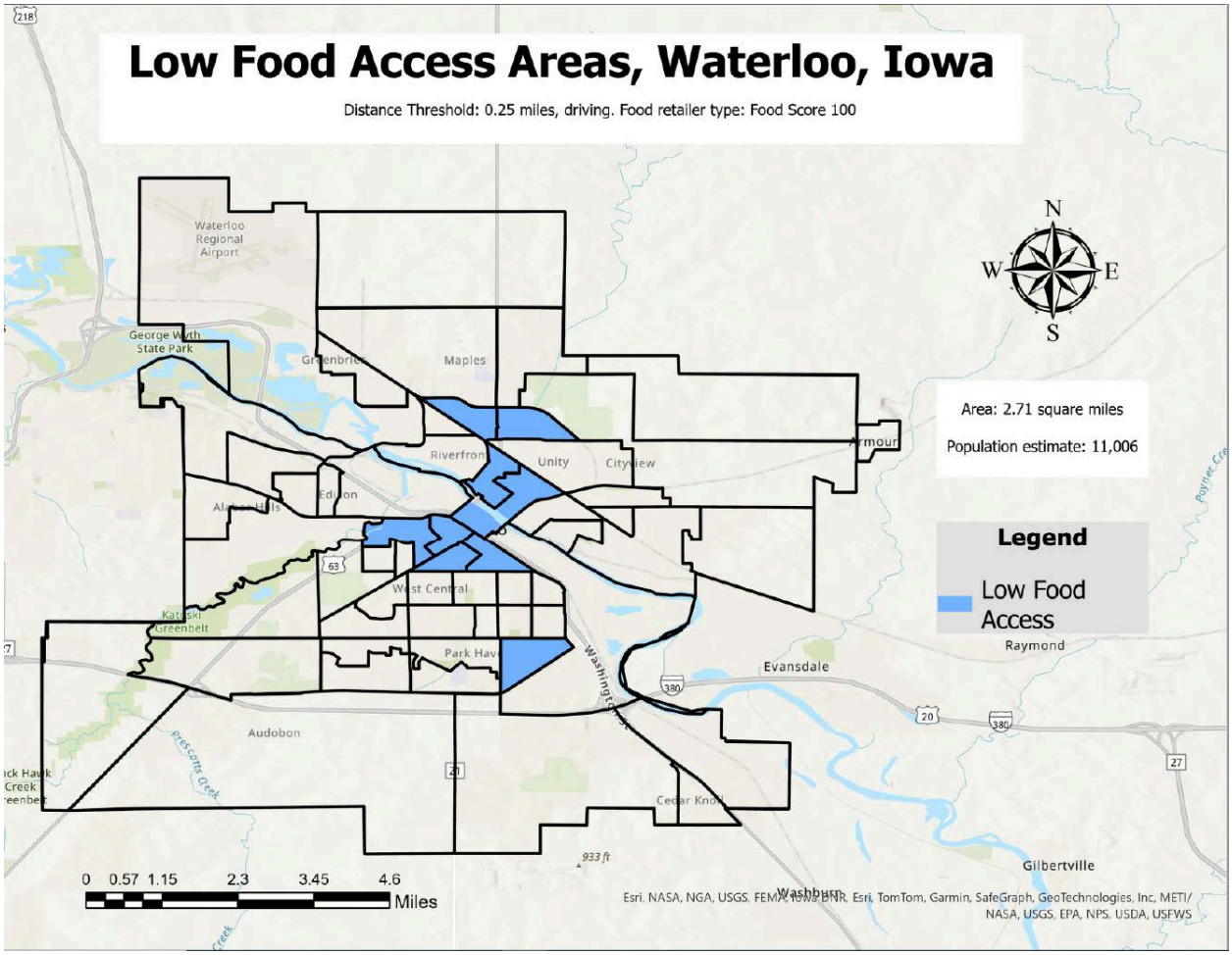


Map 8: **Areas of low food access using a distance threshold of 0.5 miles driving.** The food retailer configuration was all non-convenience stores that sold fresh fruit and vegetables. The area of low food access had an area of 1.2 square miles and an estimated population of 4,886. Using this method reduced the size of the area by 48.05 percent and the estimated population by 48.91 percent from the baseline food retailer configuration of only major supermarket chains.

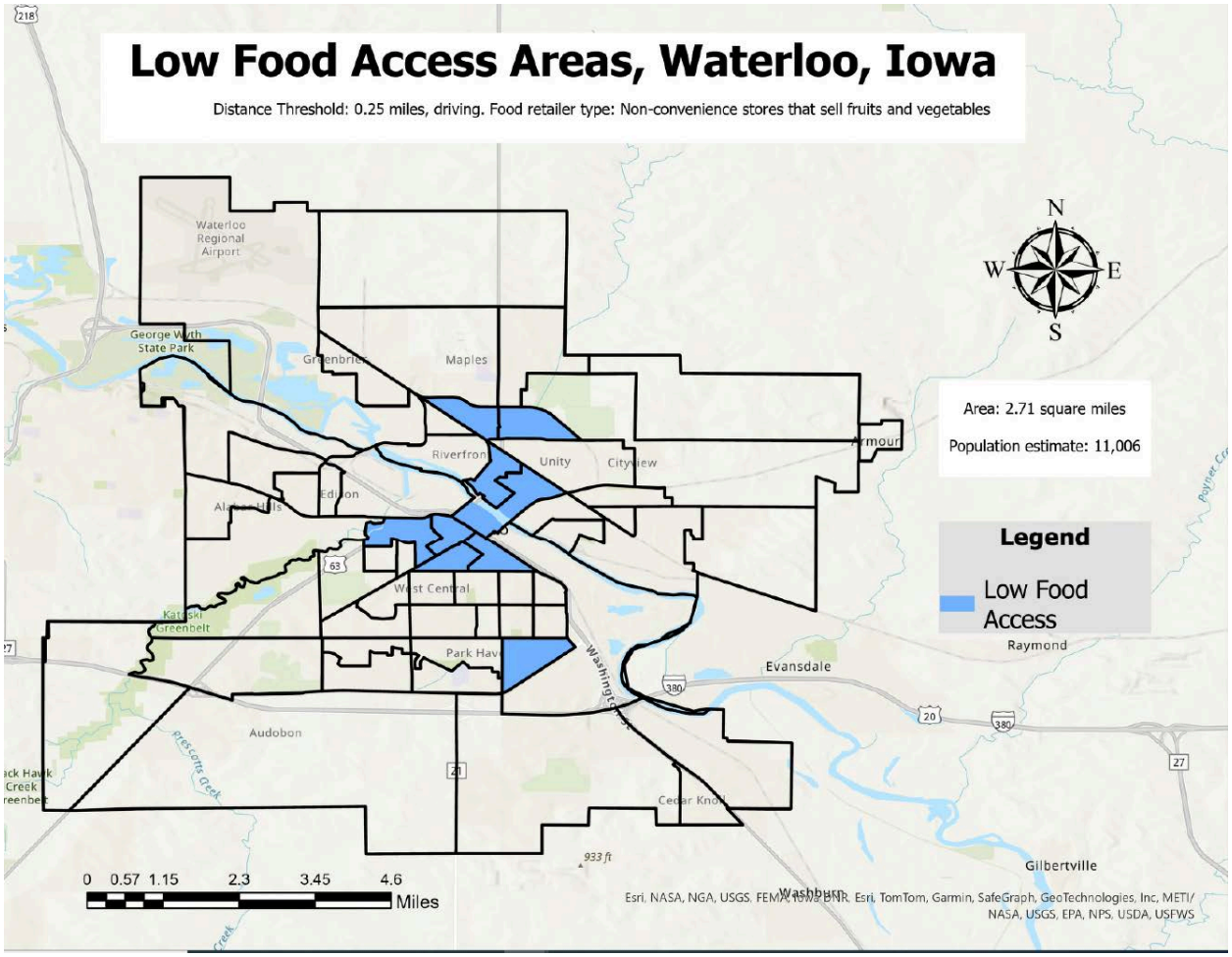


Map 9: **Areas of low food access using a distance threshold of 0.25 miles driving.**

The food retailer configuration was major supermarket chains, including Hy-Vee, Fareway, ALDI, Wal-Mart and Target. This group of stores was used as a baseline for comparison to other groups using this distance measurement. The area of low food access had an area of 2.71 square miles and an estimated population of 9,564.

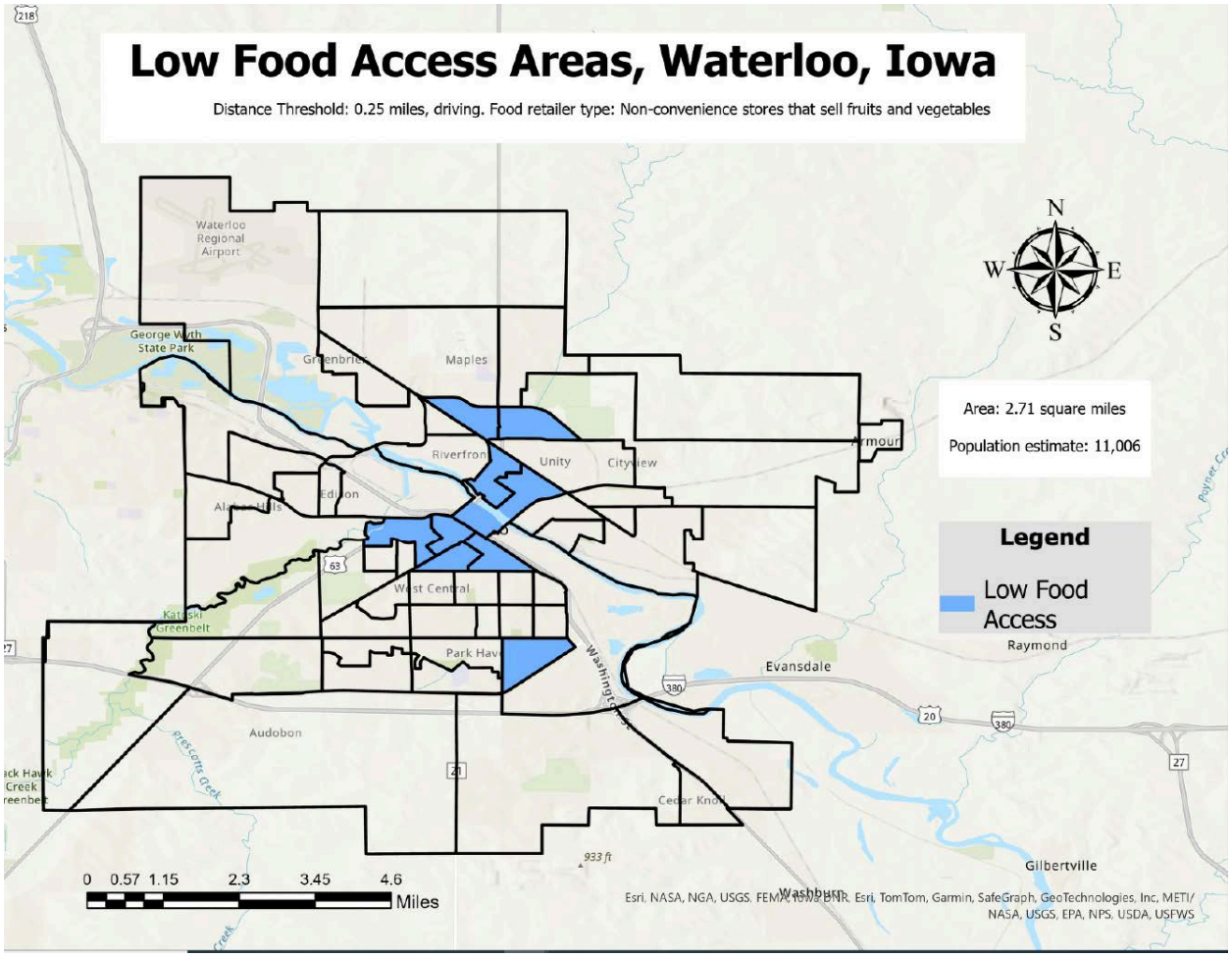


Map 10: **Areas of low food access using a distance threshold of 0.25 miles driving.** The food retailer configuration was all food retailers that sold every item on the food survey. The area of low food access had an area of 2.71 square miles and an estimated population of 9,564. There was no change from the baseline.

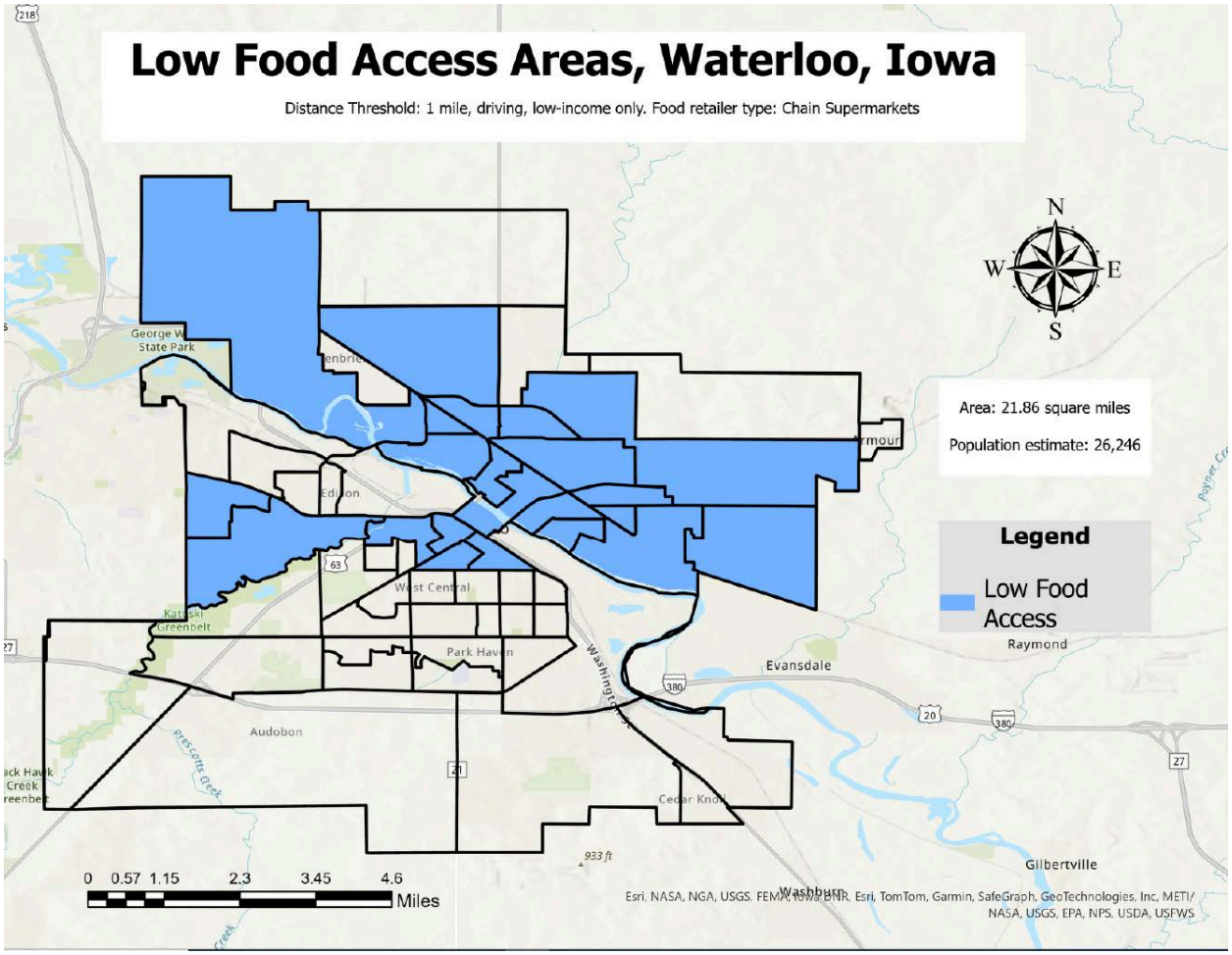


Map 11: **Areas of low food access using a distance threshold of 0.25 miles driving.**

The food retailer configuration was all non-convenience stores that sold every item on the food survey. The area of low food access had an area of 2.71 square miles and an estimated population of 9,564. There was no change from the baseline.

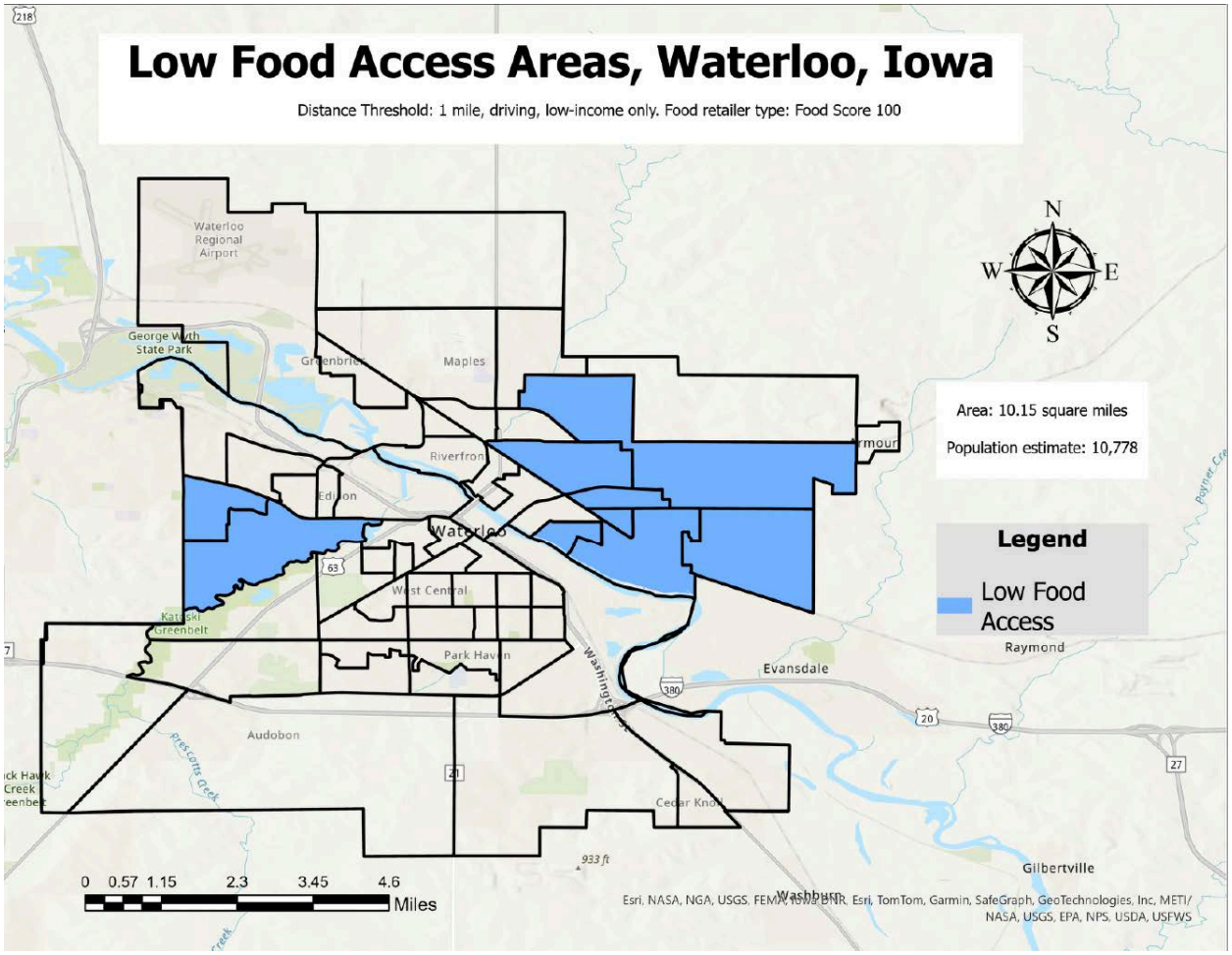


Map 12: **Areas of low food access using a distance threshold of 0.25 miles driving.** The food retailer configuration was all non-convenience stores that sold fresh fruit and vegetables. The area of low food access had an area of 2.71 square miles and an estimated population of 9,564. There was no change from the baseline.

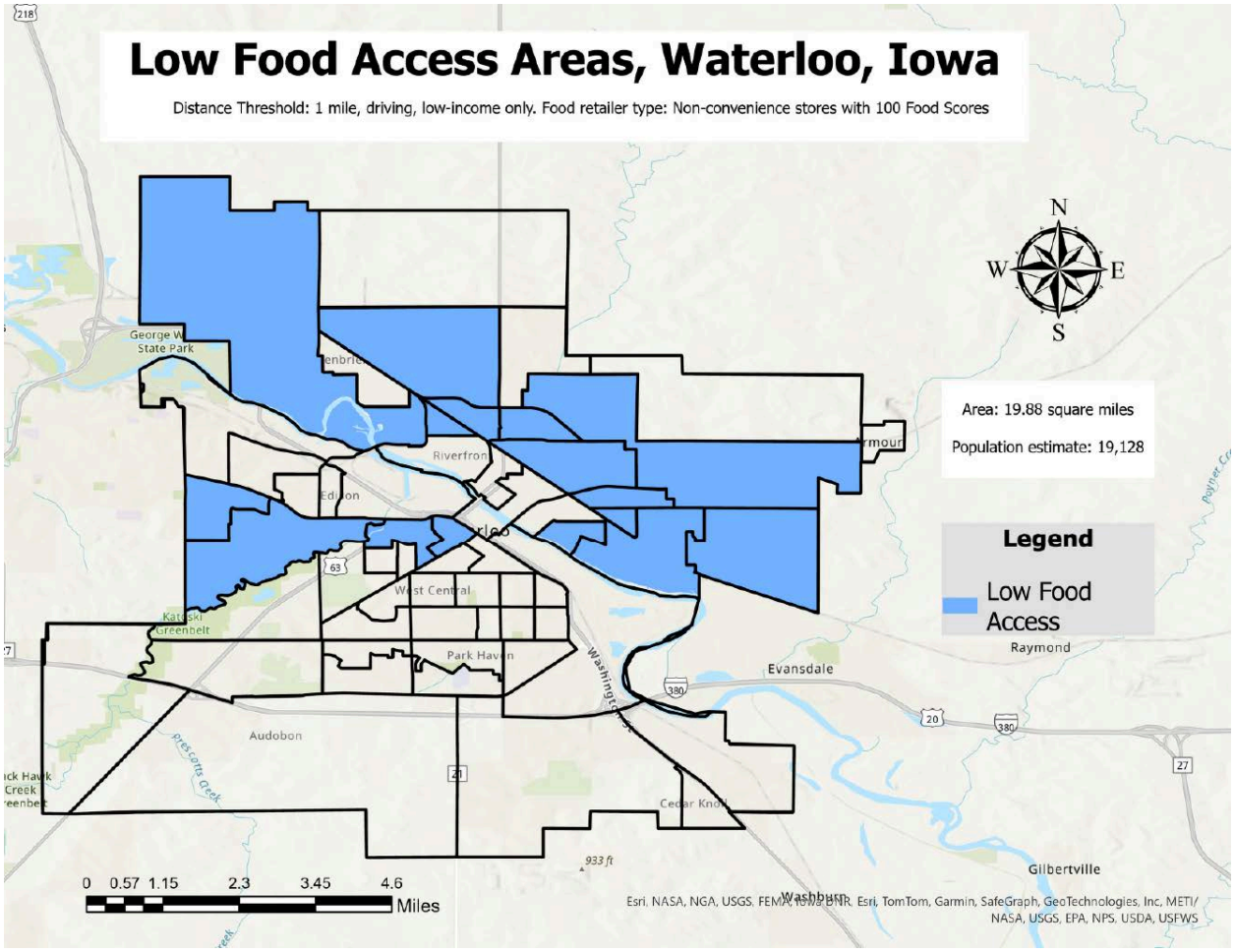


Map 13: **Areas of low food access using a distance threshold of 1 mile driving.**

Vehicle access was not considered in this analysis. The food retailer configuration was major supermarket chains, including Hy-Vee, Fareway, ALDI, Wal-Mart and Target. This group of stores was used as a baseline for comparison to other groups using this distance measurement. The area of low food access had an area of 21.86 square miles and an estimated population of 26,246.

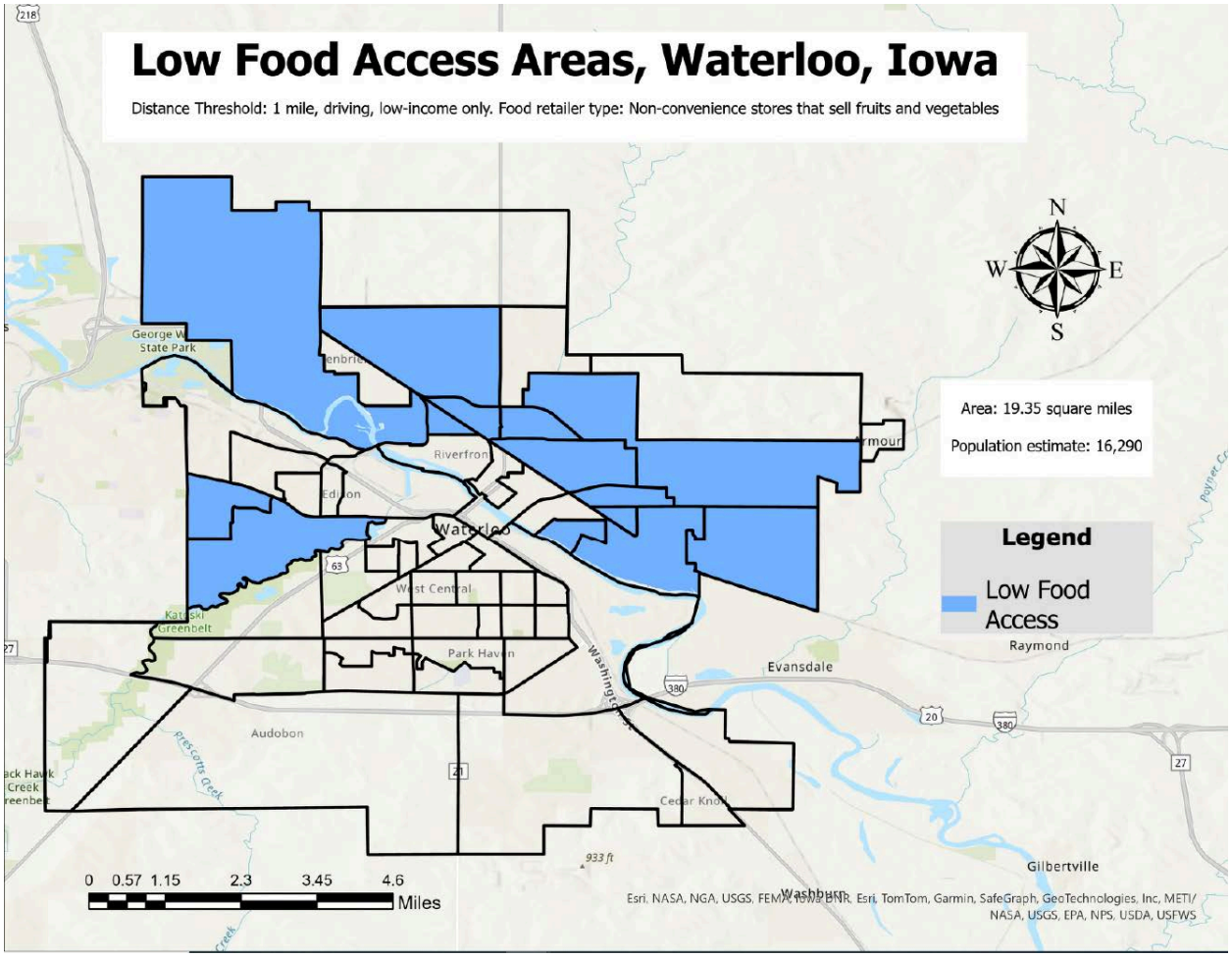


Map 14: **Areas of low food access using a distance threshold of 1 mile driving.** Vehicle access was not considered in this analysis. The food retailer configuration was all food retailers that sold every item on the food survey. The area of low food access had an area of 10.15 square miles and an estimated population of 10,778. Using this method reduced the size of the area by 53.56 percent and the estimated population by 58.93 percent from the baseline food retailer configuration of only major supermarket chains.



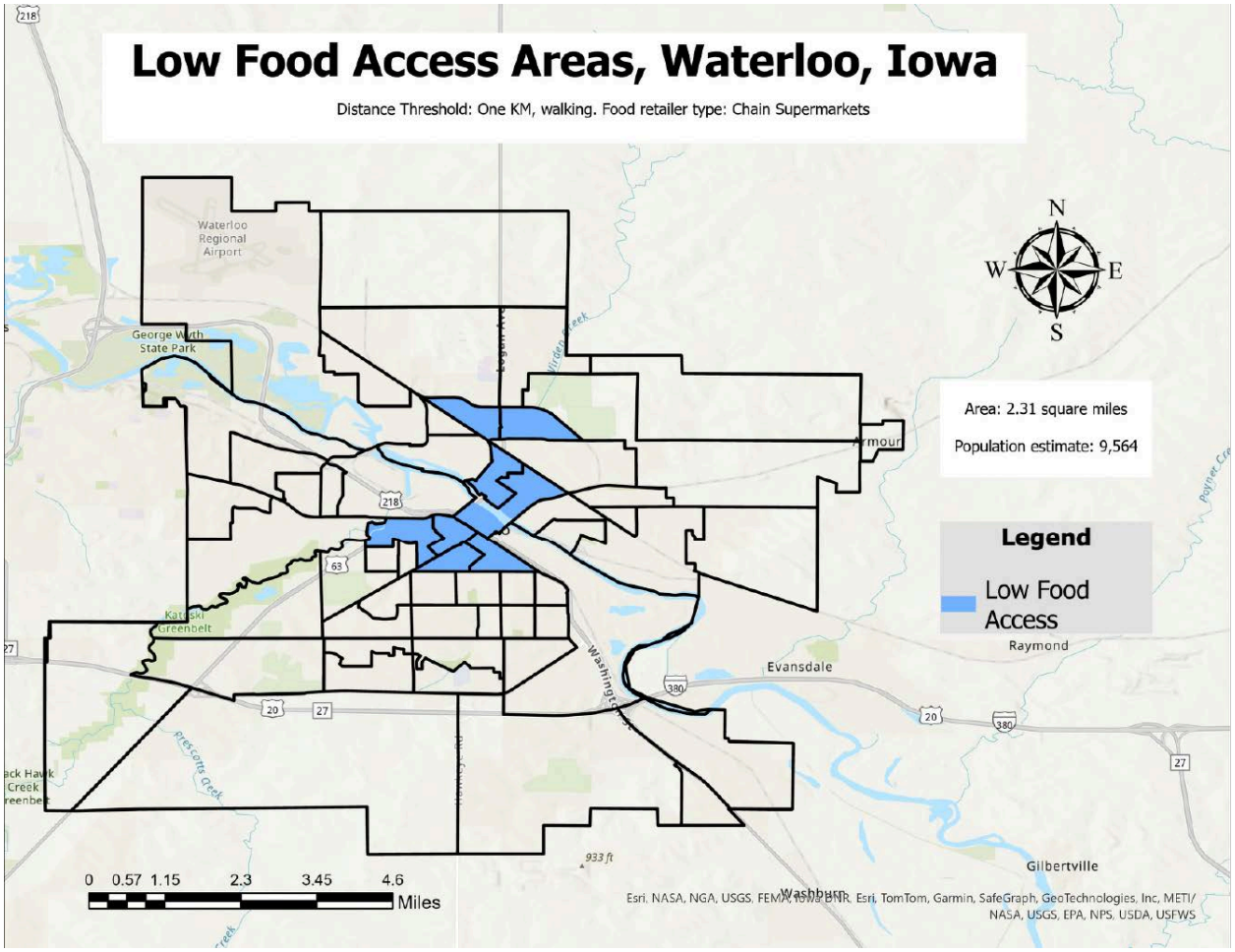
Map 15: **Areas of low food access using a distance threshold of 1 mile driving.**

Vehicle access was not considered in this analysis. The food retailer configuration was all non-convenience stores that sold every item on the food survey. The area of low food access had an area of 19.88 square miles and an estimated population of 19,128. Using this method reduced the size of the area by 9.05 percent and the estimated population by 27.12 percent from the baseline food retailer configuration of only major supermarket chains.

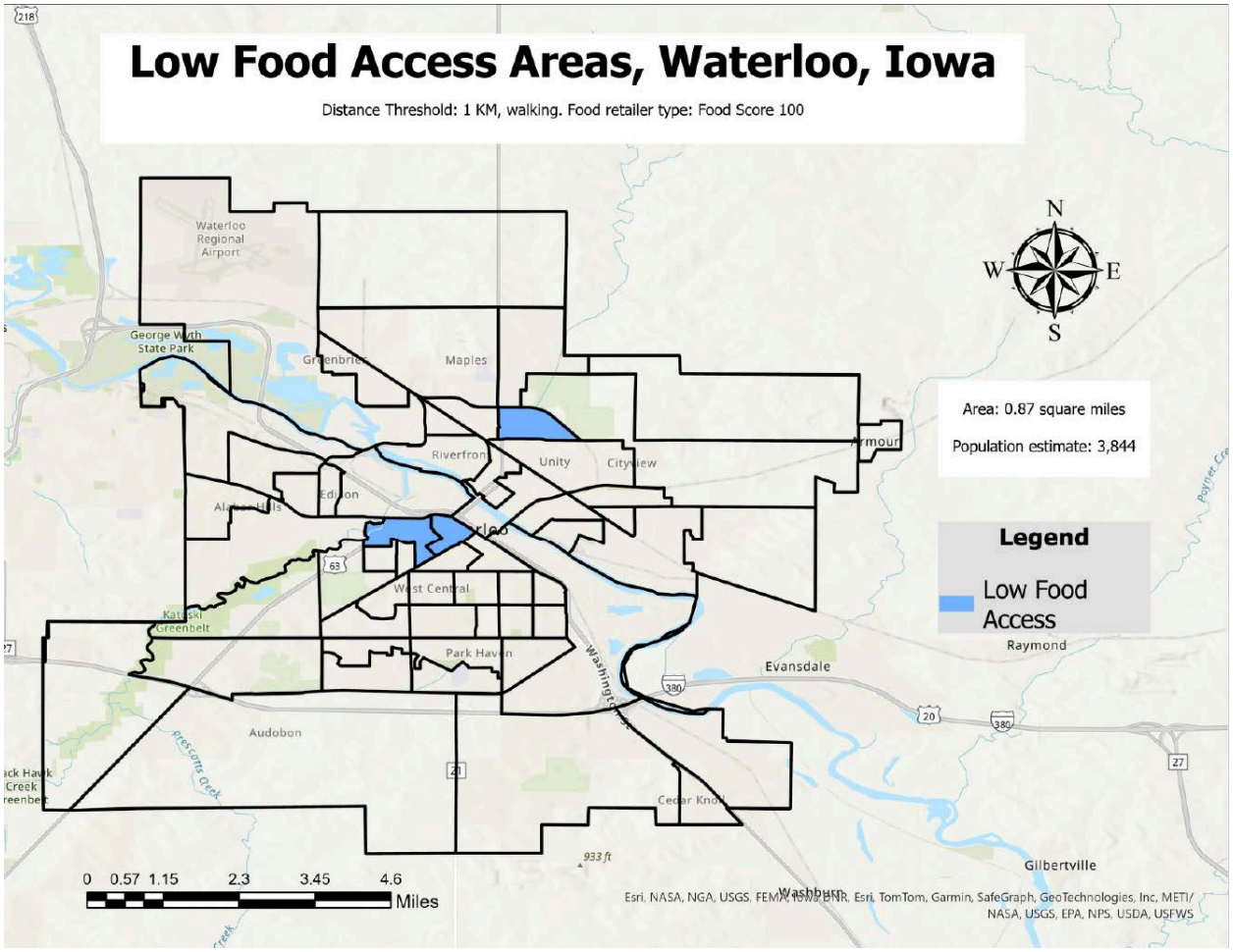


Map 16: **Areas of low food access using a distance threshold of 1 mile driving.**

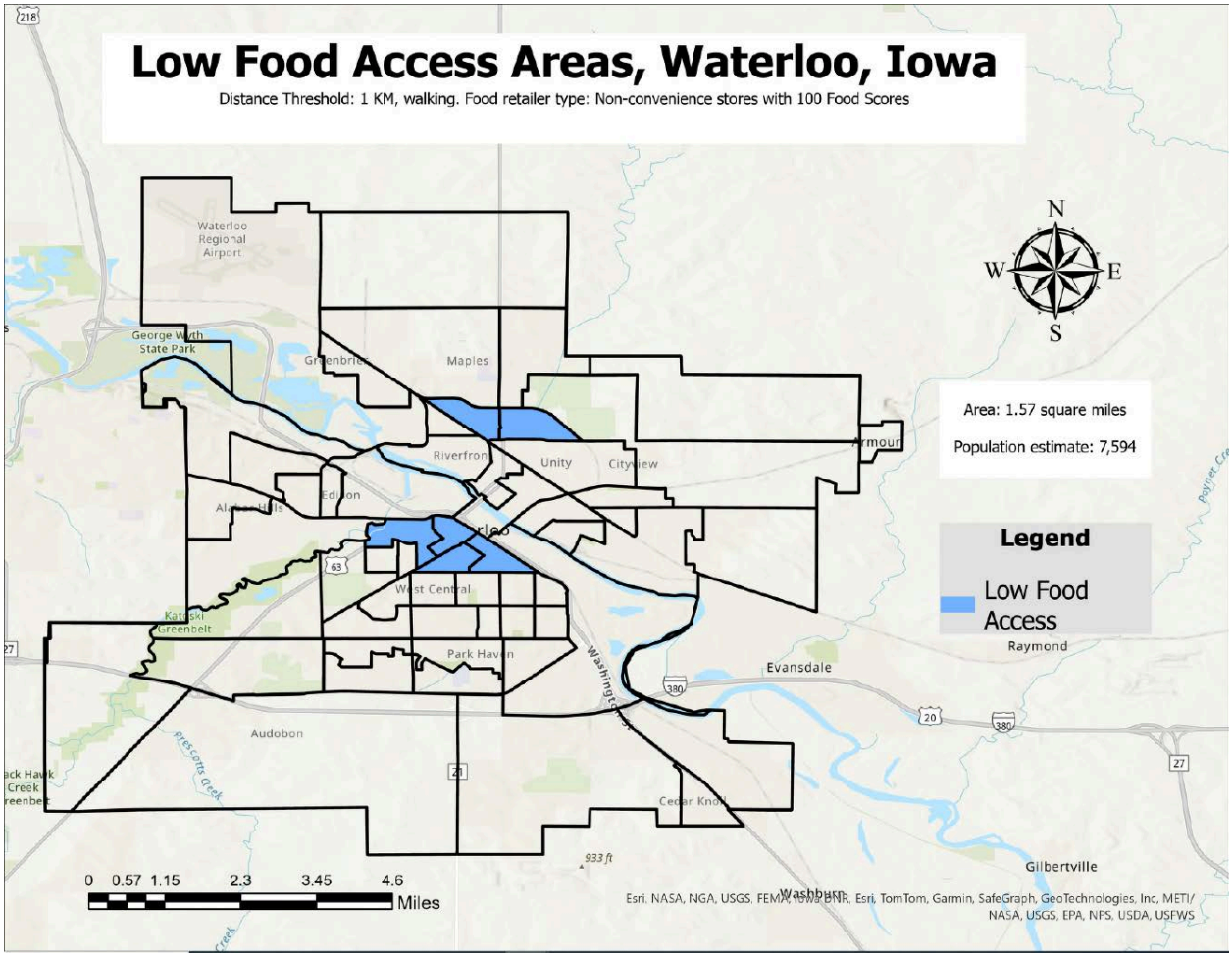
Vehicle access was not considered in this analysis. The food retailer configuration was all non-convenience stores that sold fresh fruit and vegetables. The area of low food access had an area of 19.35 square miles and an estimated population of 16,290. Using this method reduced the size of the area by 11.48 percent and the estimated population by 37.93 percent from the baseline food retailer configuration of only major supermarket chains.



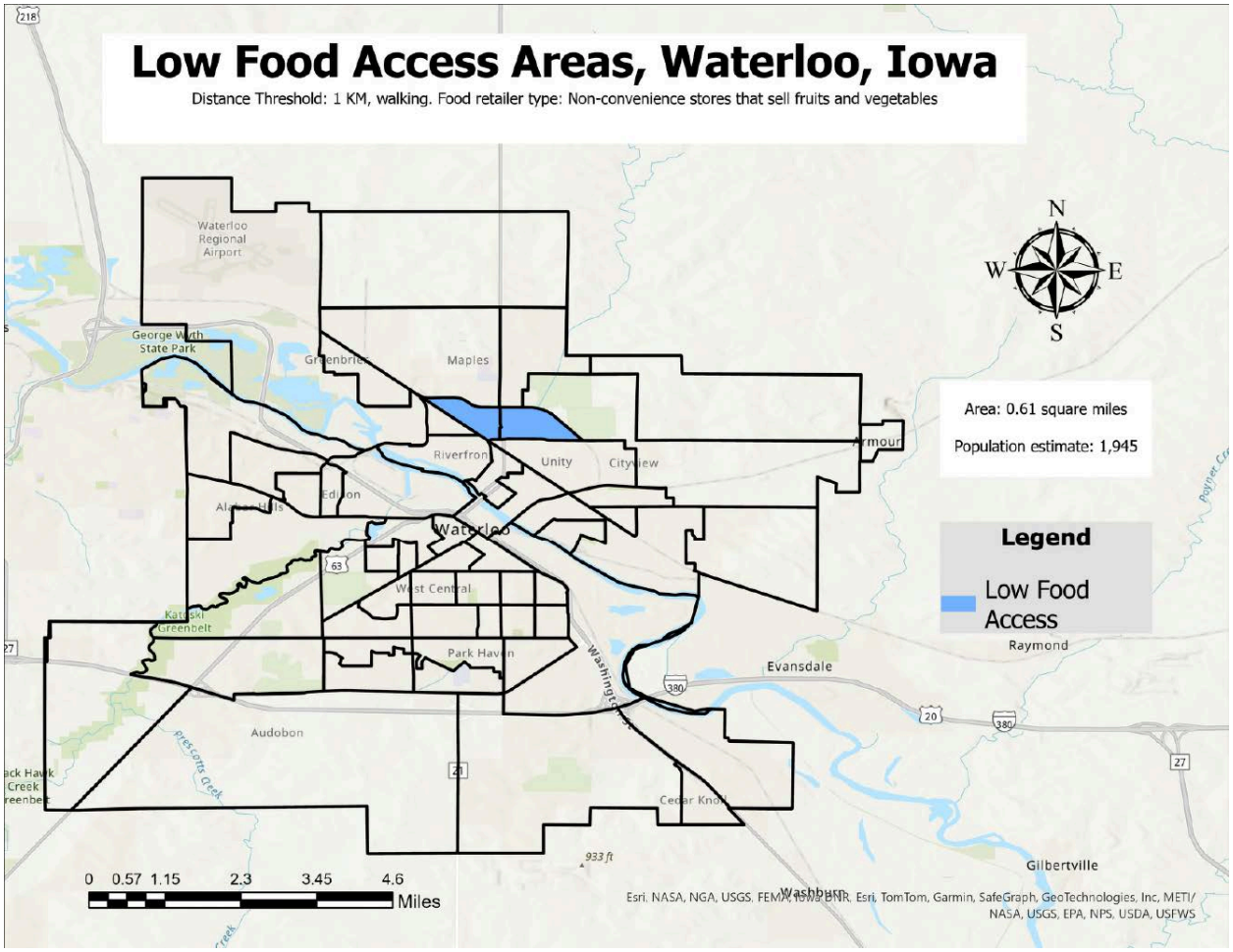
Map 17: **Areas of low food access using a distance threshold of 1 kilometer walking.** The food retailer configuration was major supermarket chains, including Hy-Vee, Fareway, ALDI, Wal-Mart and Target. This group of stores was used as a baseline for comparison to other groups using this distance measurement. The area of low food access had an area of 2.31 square miles and an estimated population of 9,564.



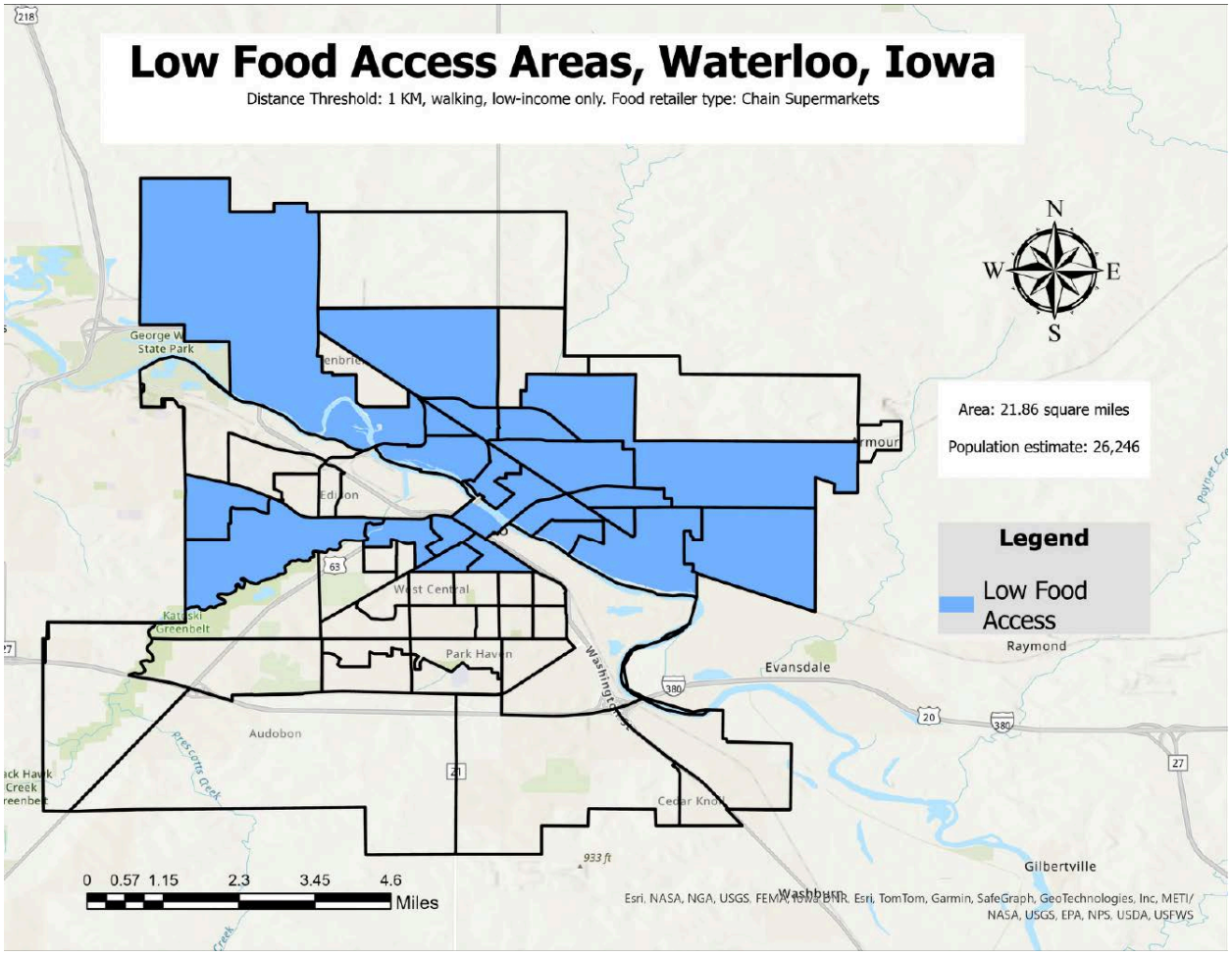
Map 18: **Areas of low food access using a distance threshold of 1 kilometer walking.** The food retailer configuration was all stores that sold every item on the food survey. The area of low food access had an area of 0.87 square miles and an estimated population of 3,844. Using this method reduced the size of the area by 62.33 percent and the estimated population by 59.81 percent from the baseline food retailer configuration of only major supermarket chains.



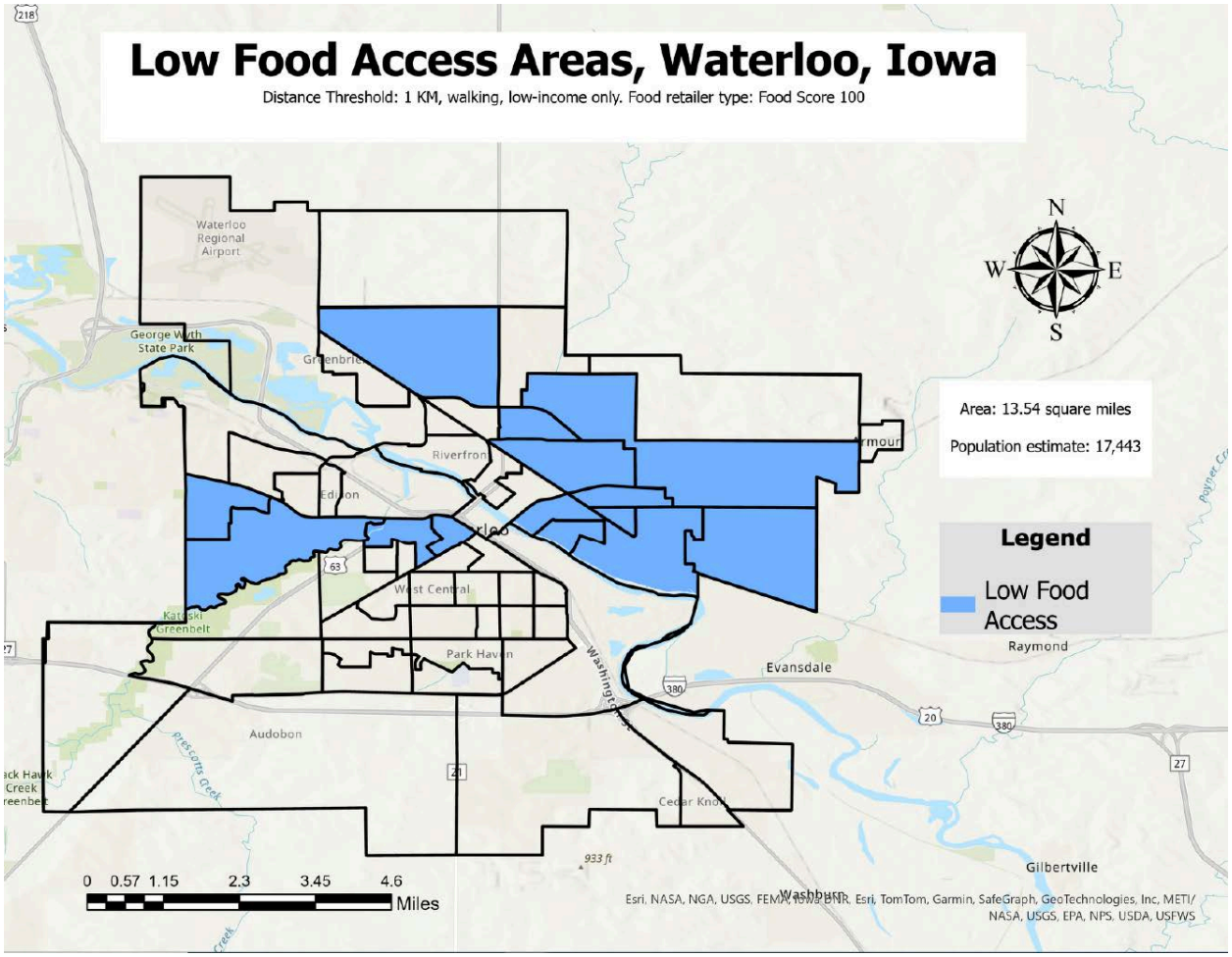
Map 19: **Areas of low food access using a distance threshold of 1 kilometer walking.** The food retailer configuration was all non-convenience stores that sold every item on the food survey. The area of low food access had an area of 1.57 square miles and an estimated population of 7,594. Using this method reduced the size of the area by 32.03 percent and the estimated population by 20.59 percent from the baseline food retailer configuration of only major supermarket chains.



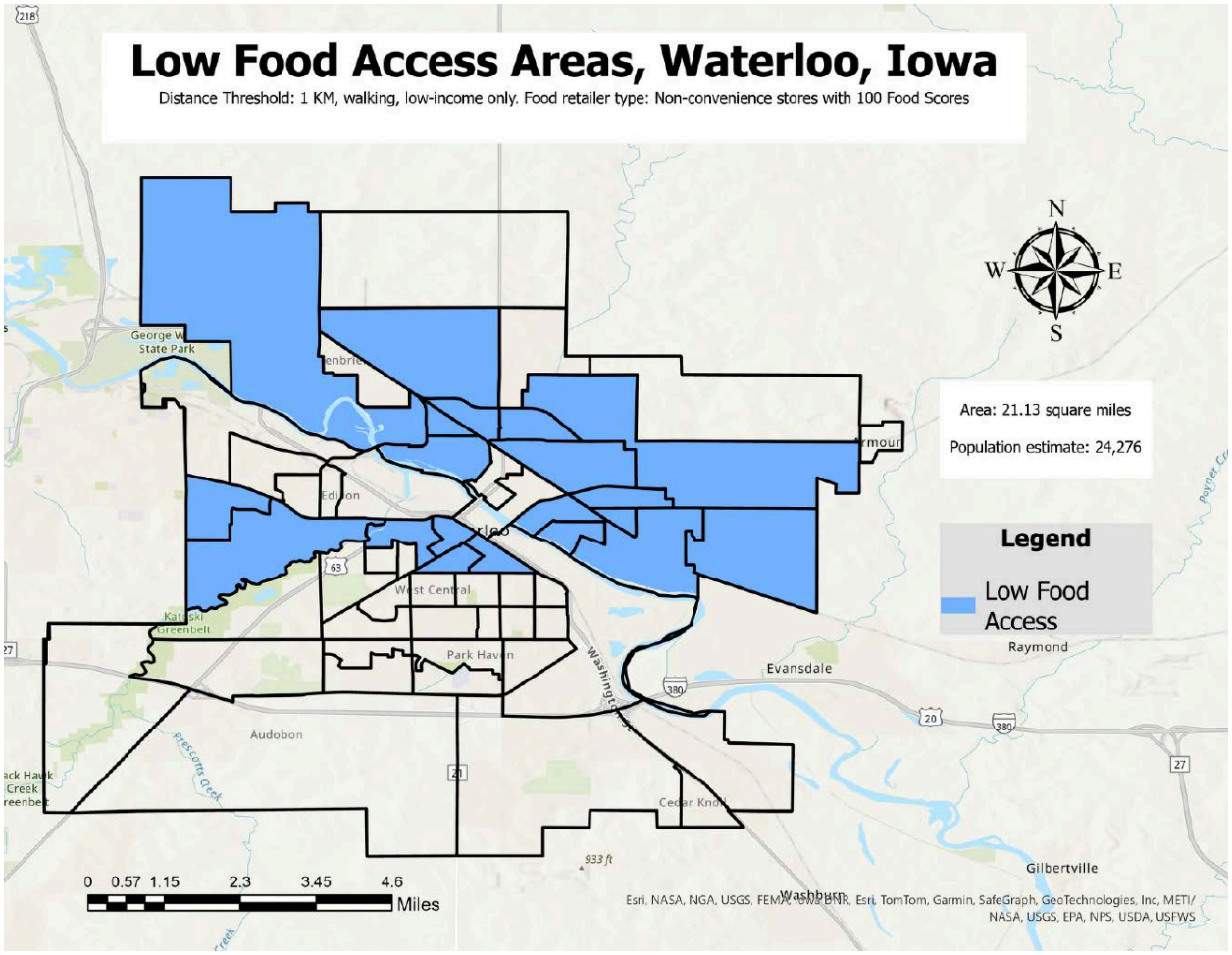
Map 20: **Areas of low food access using a distance threshold of 1 kilometer walking.** The food retailer configuration was all non-convenience stores that sold fresh fruit and vegetables. The area of low food access had an area of 0.61 square miles and an estimated population of 1,945. Using this method reduced the size of the area by 73.59 percent and the estimated population by 79.66 percent from the baseline food retailer configuration of only major supermarket chains.



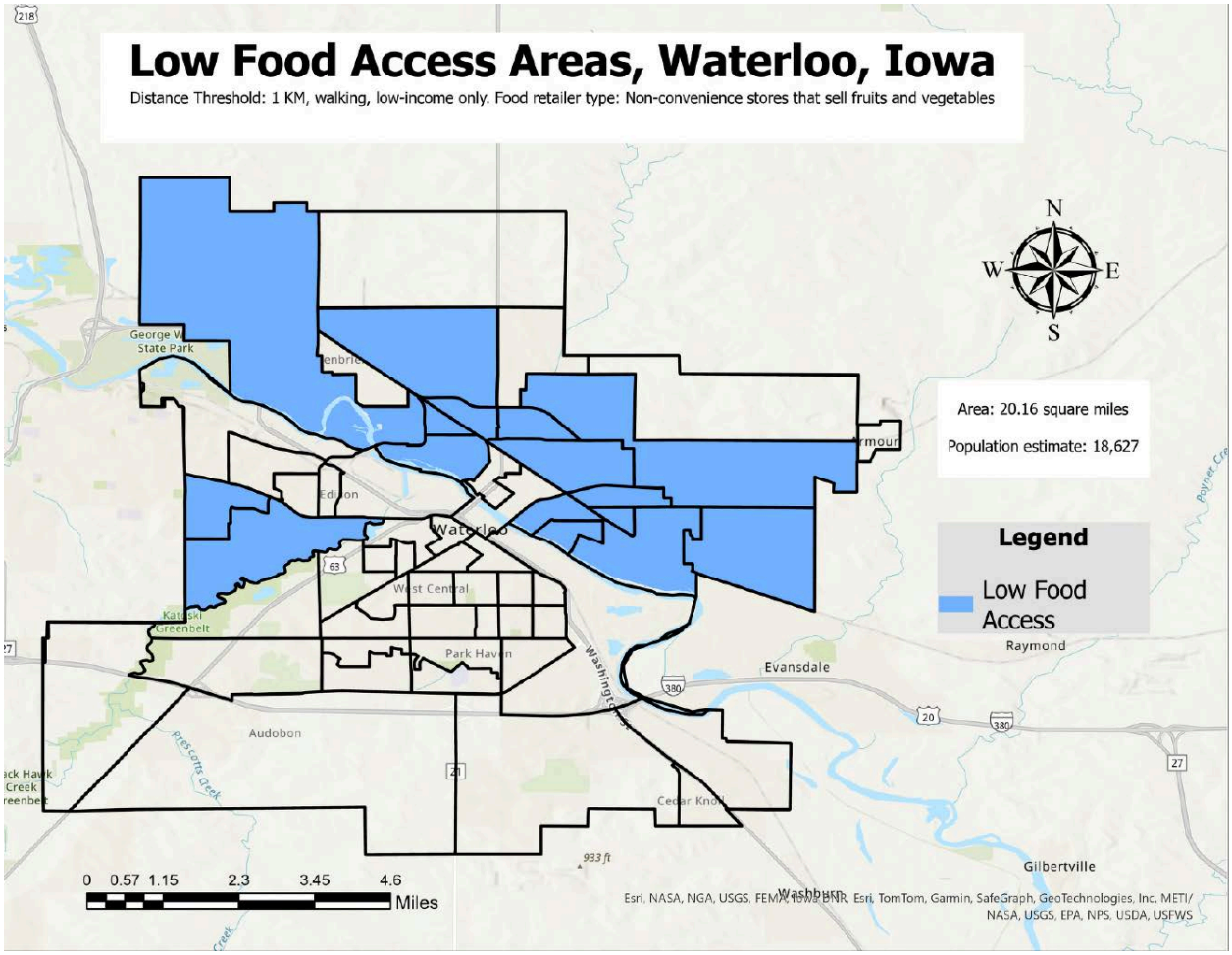
Map 21: **Areas of low food access using a distance threshold of 1 kilometer walking.** Vehicle access was not considered in this analysis. The food retailer configuration was major supermarket chains, including Hy-Vee, Fareway, ALDI, Wal-Mart and Target. This group of stores was used as a baseline for comparison to other groups using this distance measurement. The area of low food access had an area of 21.86 square miles and an estimated population of 26,246.



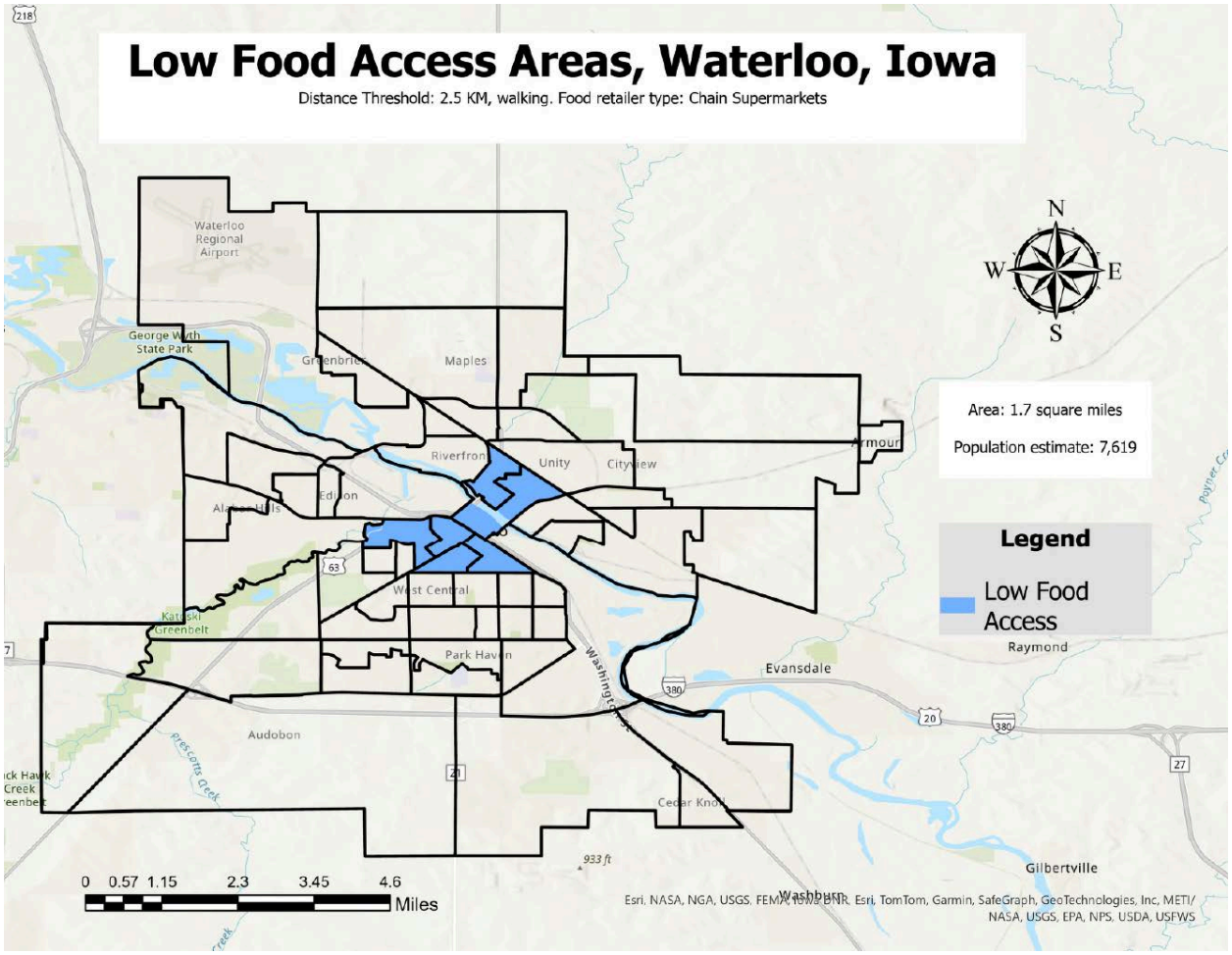
Map 22: **Areas of low food access using a distance threshold of 1 kilometer walking.** Vehicle access was not considered in this analysis. The food retailer configuration was all food retailers that sold every item on the food survey. The area of low food access had an area of 13.54 square miles and an estimated population of 17,443. Using this method reduced the size of the area by 38.06 percent and the estimated population by 33.54 percent from the baseline food retailer configuration of only major supermarket chains.



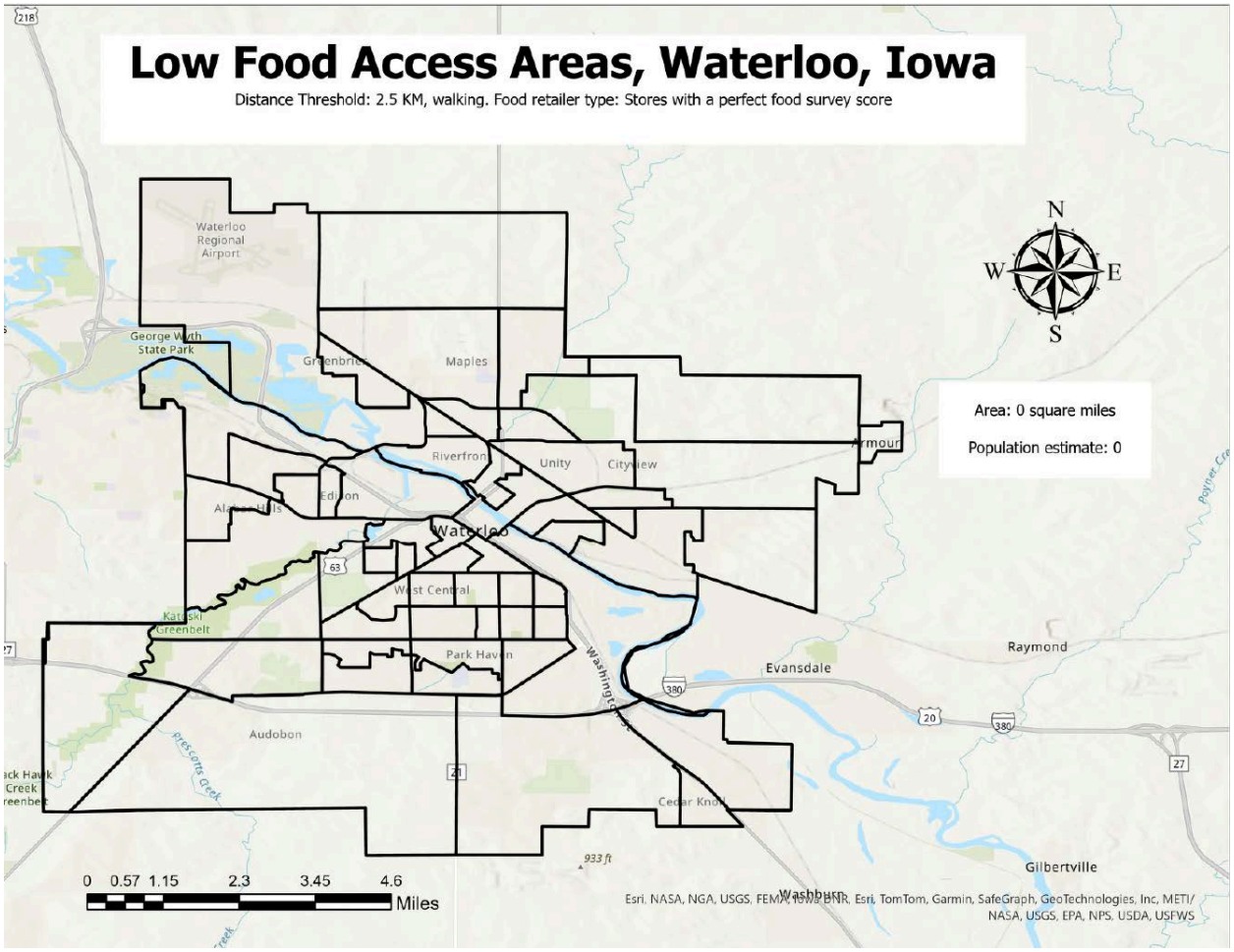
Map 23: **Areas of low food access using a distance threshold of 1 kilometer walking.** Vehicle access was not considered in this analysis. The food retailer configuration was all non-convenience stores that sold every item on the food survey. The area of low food access had an area of 21.13 square miles and an estimated population of 24,276. Using this method reduced the size of the area by 3.33 percent and the estimated population by 7.51 percent from the baseline food retailer configuration of only major supermarket chains.



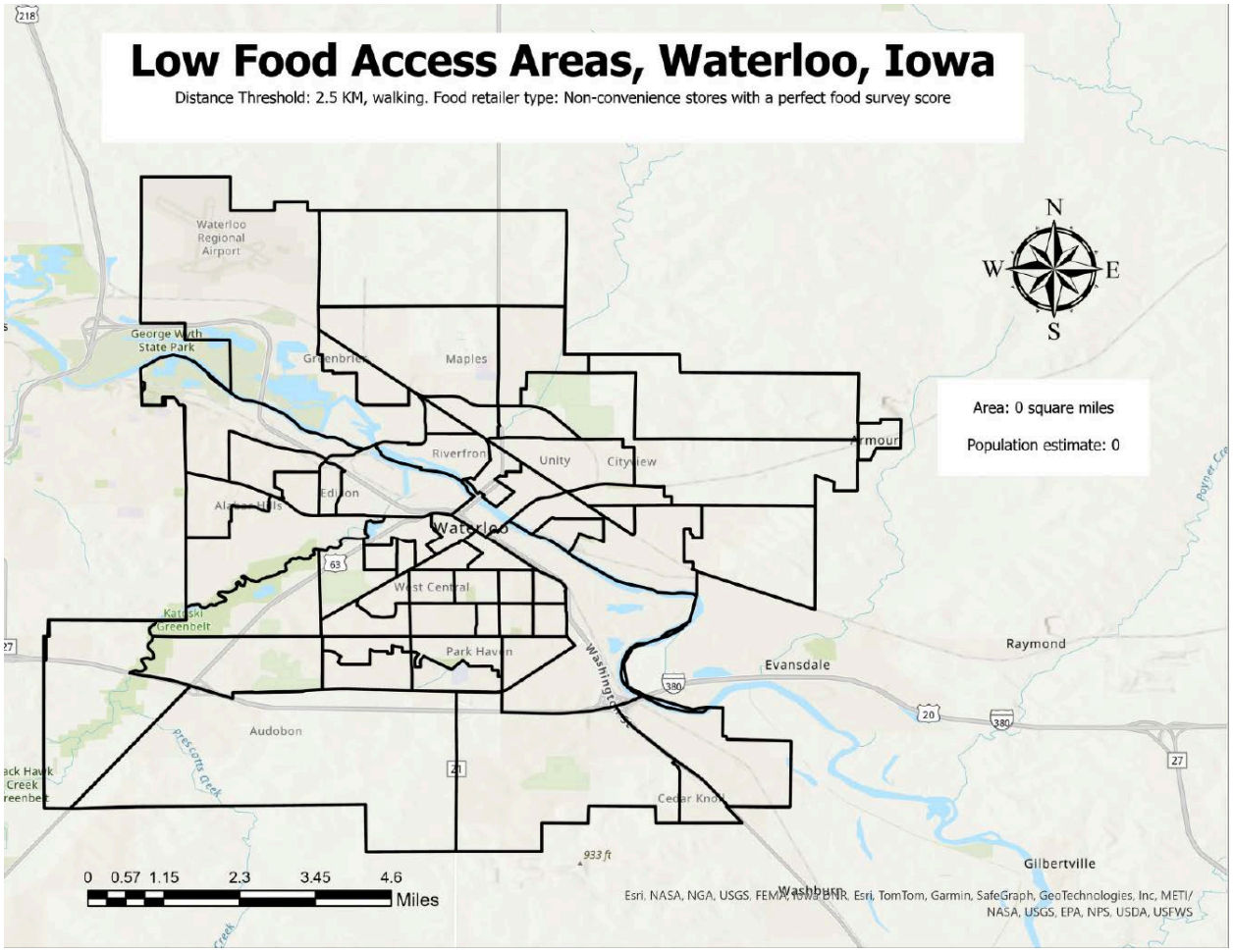
Map 24: **Areas of low food access using a distance threshold of 1 kilometer walking.** Vehicle access was not considered in this analysis. The food retailer configuration was all non-convenience stores that sold fresh fruit and vegetables. The area of low food access had an area of 20.16 square miles and an estimated population of 18,627. Using this method reduced the size of the area by 7.77 percent and the estimated population by 29.02 percent from the baseline food retailer configuration of only major supermarket chains.



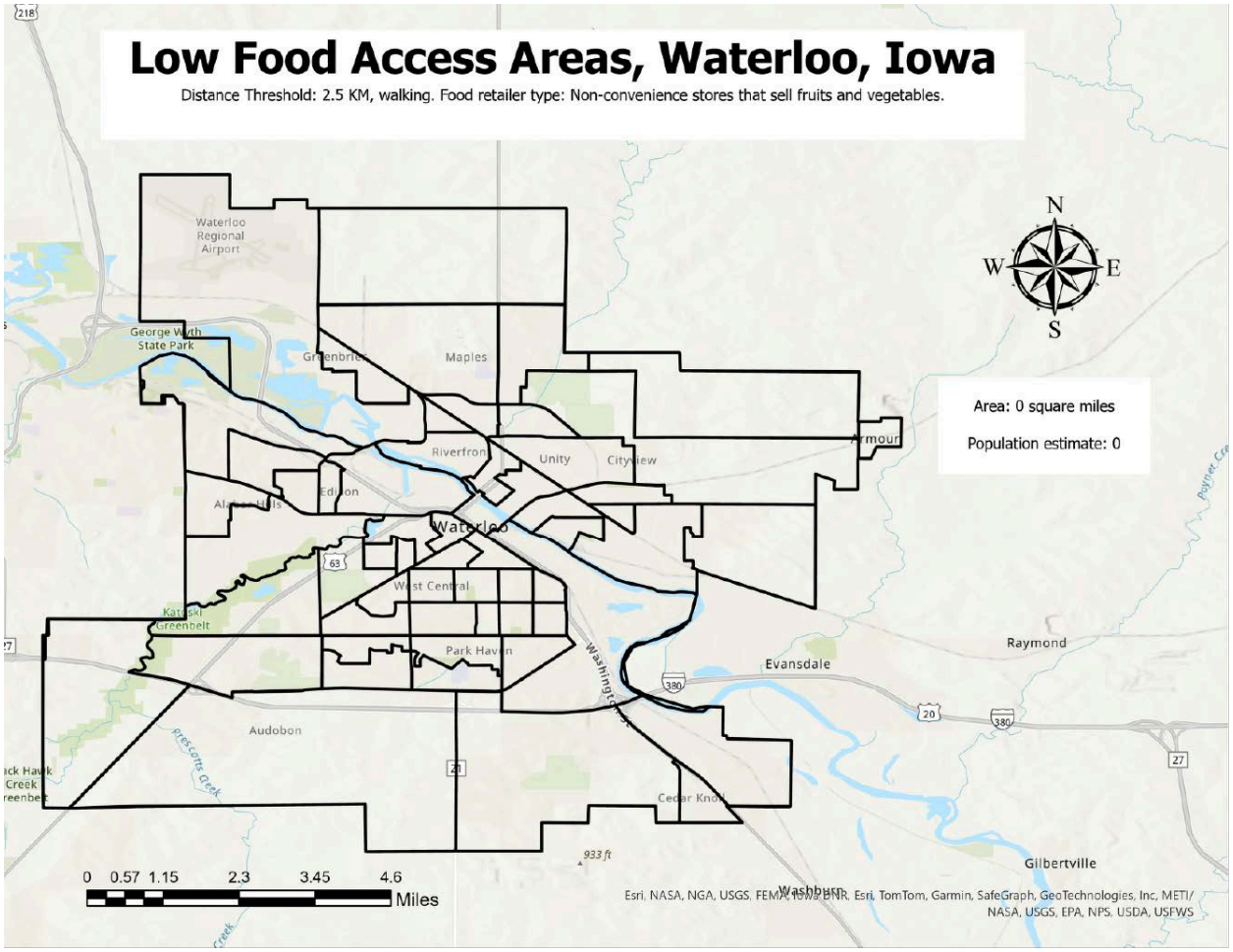
Map 25: **Areas of low food access using a distance threshold of 2.5 kilometers walking.** The food retailer configuration was major supermarket chains, including Hy-Vee, Fareway, ALDI, Wal-Mart and Target. This group of stores was used as a baseline for comparison to other groups using this distance measurement. The area of low food access had an area of 1.7 square miles and an estimated population of 7,619.



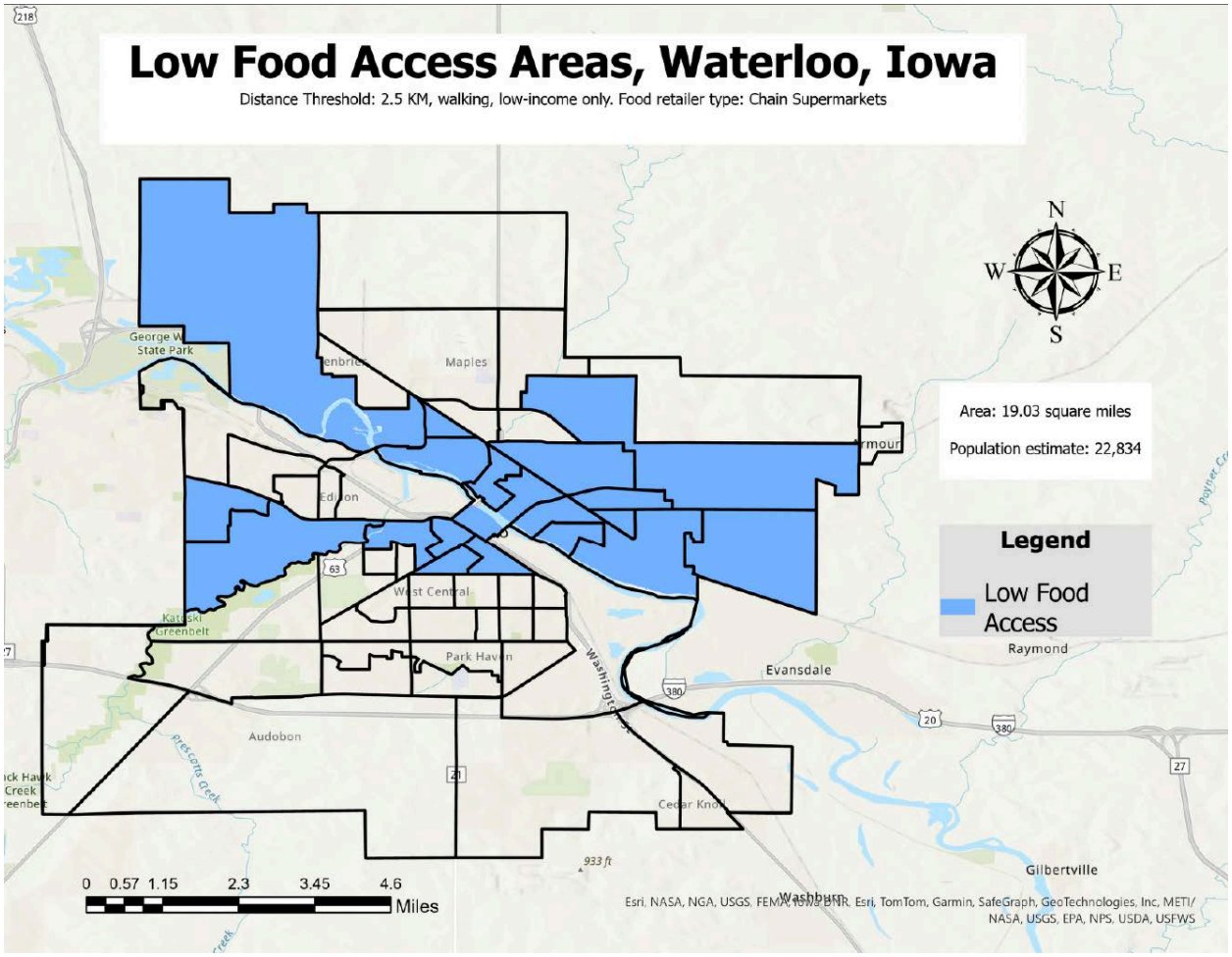
Map 26: **Areas of low food access using a distance threshold of 2.5 kilometers walking.** The food retailer configuration was all food retailers that sold every item on the food survey. This method found no areas of low food access in the study area.



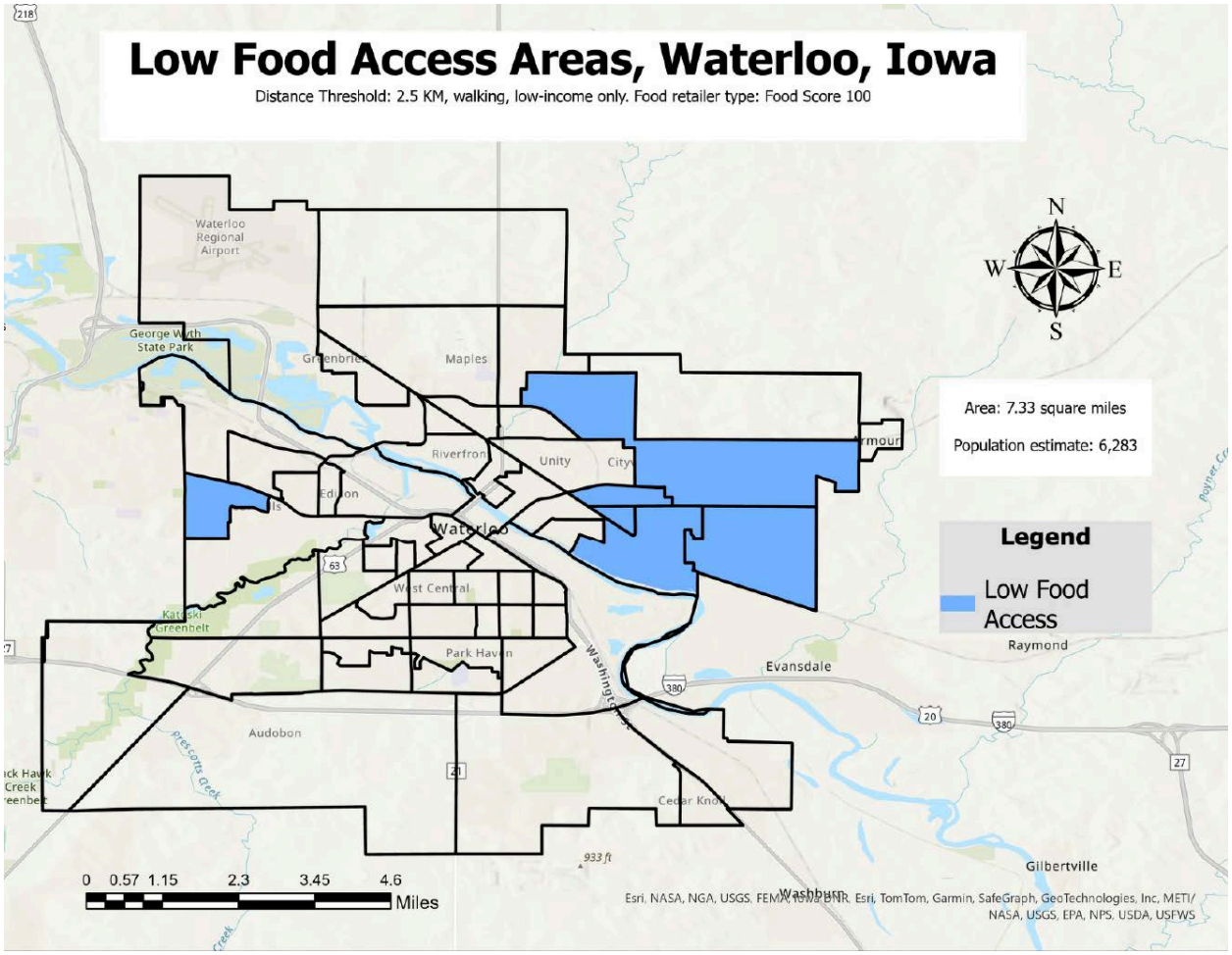
Map 27: **Areas of low food access using a distance threshold of 2.5 kilometers walking.** The food retailer configuration was all non-convenience stores that sold every item on the food survey. This method found no areas of low food access in the study area.



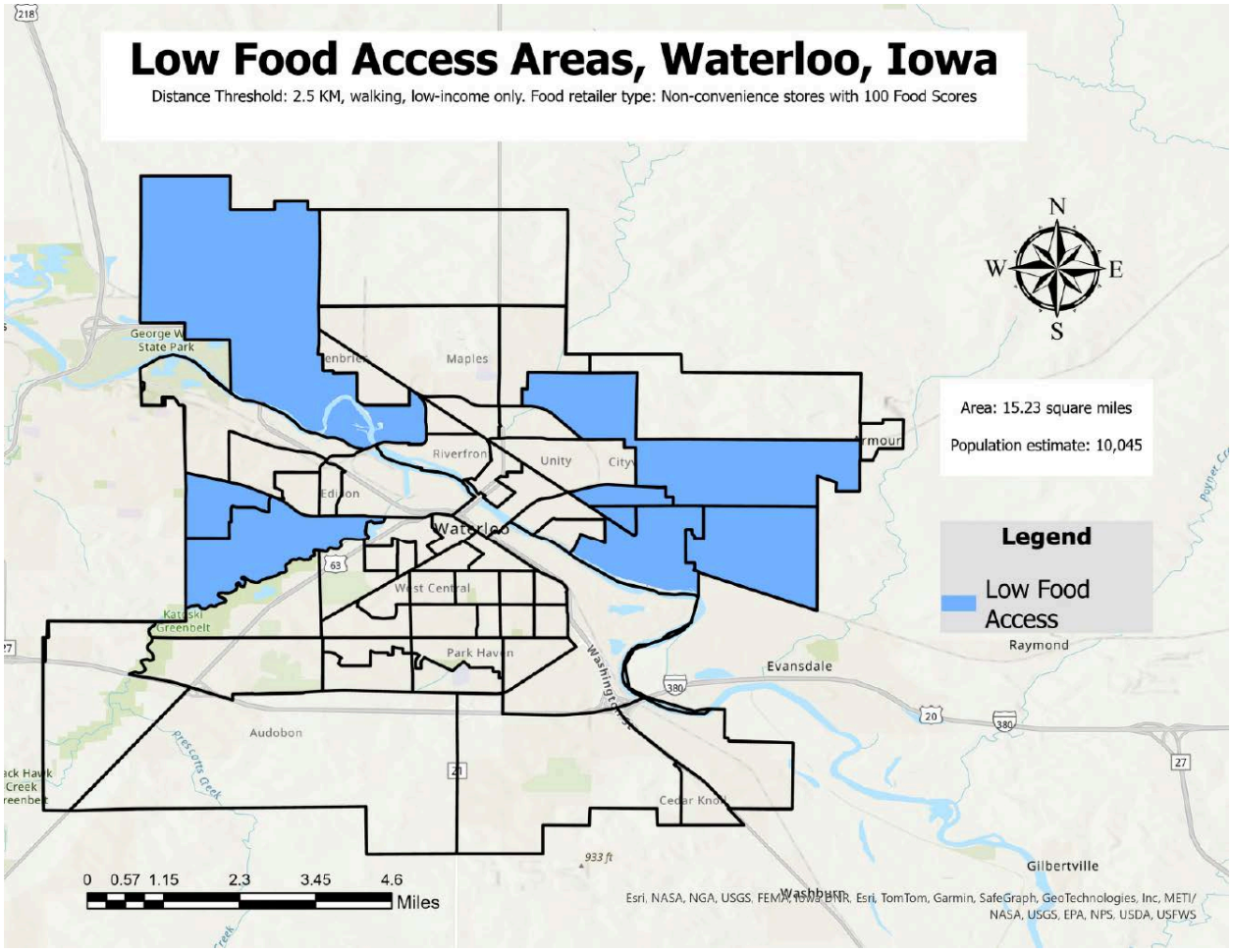
Map 28: **Areas of low food access using a distance threshold of 2.5 kilometers walking.** The food retailer configuration was all non-convenience stores that sold fresh fruit and vegetables. This method found no areas of low food access in the study area.



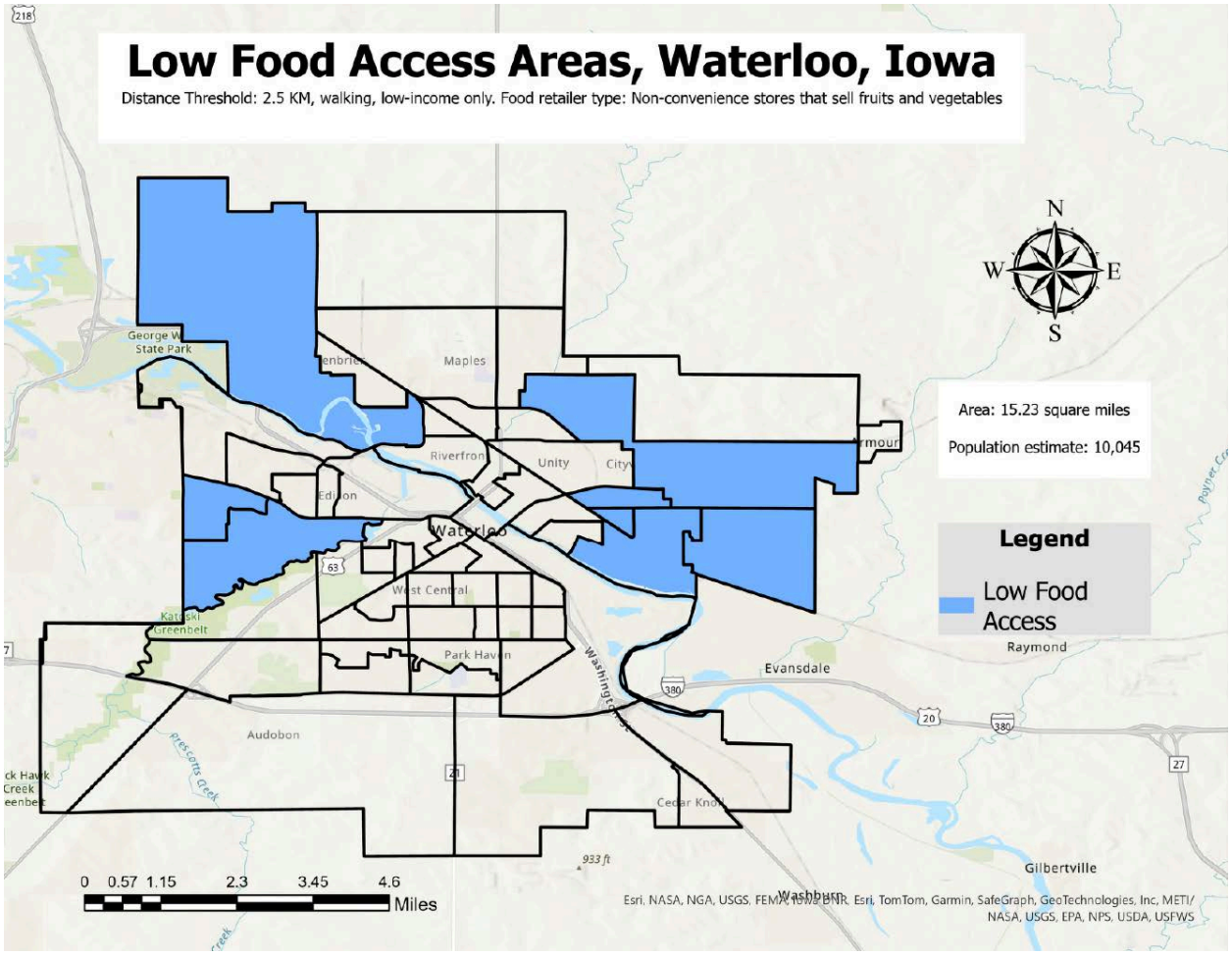
Map 29: **Areas of low food access using a distance threshold of 2.5 kilometers walking.** Vehicle access was not considered in this analysis. The food retailer configuration was major supermarket chains, including Hy-Vee, Fareway, ALDI, Wal-Mart and Target. This group of stores was used as a baseline for comparison to other groups using this distance measurement. The area of low food access had an area of 19.03 square miles and an estimated population of 22,834.



Map 30: **Areas of low food access using a distance threshold of 2.5 kilometers walking.** Vehicle access was not considered in this analysis. The food retailer configuration was all food retailers that sold every item on the food survey. The area of low food access had an area of 7.33 square miles and an estimated population of 6,283. Using this method reduced the size of the area by 61.48 percent and the estimated population by 72.48 percent from the baseline food retailer configuration of only major supermarket chains.



Map 31: **Areas of low food access using a distance threshold of 2.5 kilometers walking.** Vehicle access was not considered in this analysis. The food retailer configuration was all non-convenience stores that sold every item on the food survey. The area of low food access had an area of 15.23 square miles and an estimated population of 10,045. Using this method reduced the size of the area by 19.96 percent and the estimated population by 56.01 percent from the baseline food retailer configuration of only major supermarket chains.



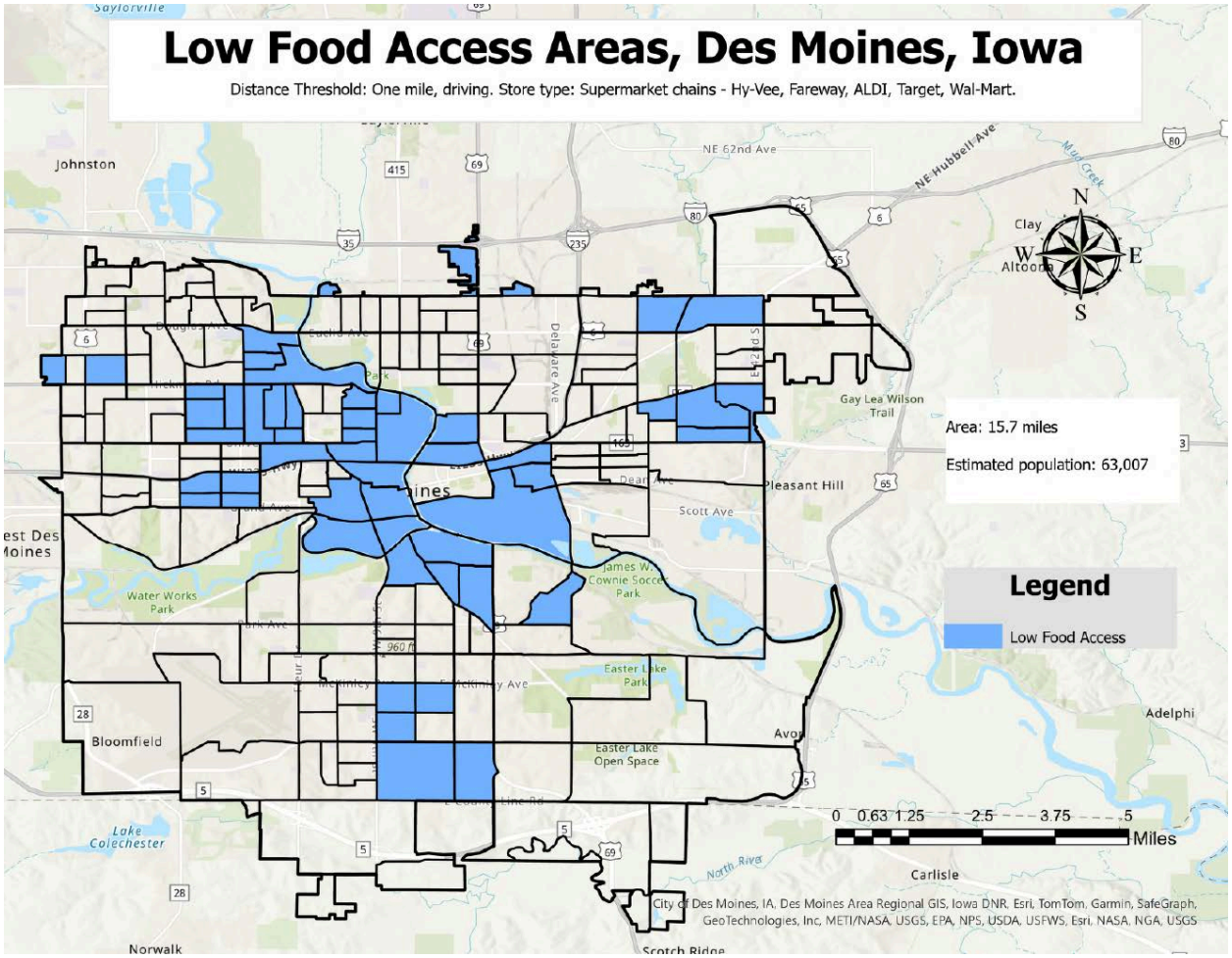
Map 32: **Areas of low food access using a distance threshold of 2.5 kilometers walking.** Vehicle access was not considered in this analysis. The food retailer configuration was all non-convenience stores that sold fresh fruit and vegetables. The area of low food access had an area of 15.23 square miles and an estimated population of 10,045. Using this method reduced the size of the area by 19.96 percent and the estimated population by 56.01 percent from the baseline food retailer configuration of only major supermarket chains.

Table 1: **Results from the different distance and food retailer configurations in Waterloo.**

Name	Distance	Store Category	Square Miles	Estimated population
Map 1	1 mile, driving	Chain Supermarkets	2.31	9564
Map 2	1 mile, driving	Perfect food score	0	0
Map 3	1 mile, driving	non-convenience, 100 FS	1.15	4783
Map 4	1 mile, driving	Non-convenience stores that sell fruits and vegetables	0.61	1945
Map 5	0.5 mile, driving	Chain Supermarkets	2.31	9564
Map 6	0.5 mile, driving	Perfect food score	1.57	7594
Map 7	0.5 mile, driving	non-convenience, 100 FS	1.57	7594
Map 8	0.5 mile, driving	Non-convenience stores that sell fruits and vegetables	1.2	4,886
Map 9	0.25 mile, driving	Chain Supermarkets	2.71	11006
Map 10	0.25 miles, driving	Perfect food score	2.71	11006
Map 11	0.25 driving	non-convenience, 100 FS	2.71	11006
Map 12	0.25 driving	Non-convenience stores that sell fruits and vegetables	2.71	11006
Map 13	1 mile driving, low income only	Chain Supermarkets	21.86	26,246
Map 14	1 mile driving, low income only	Perfect food score	10.15	10778
Map 15	1 mile driving, low income only	non-convenience, 100 FS	19.88	19128
Map 16	1 mile driving, low income only	Non-convenience stores that sell fruits and vegetables	19.35	16290

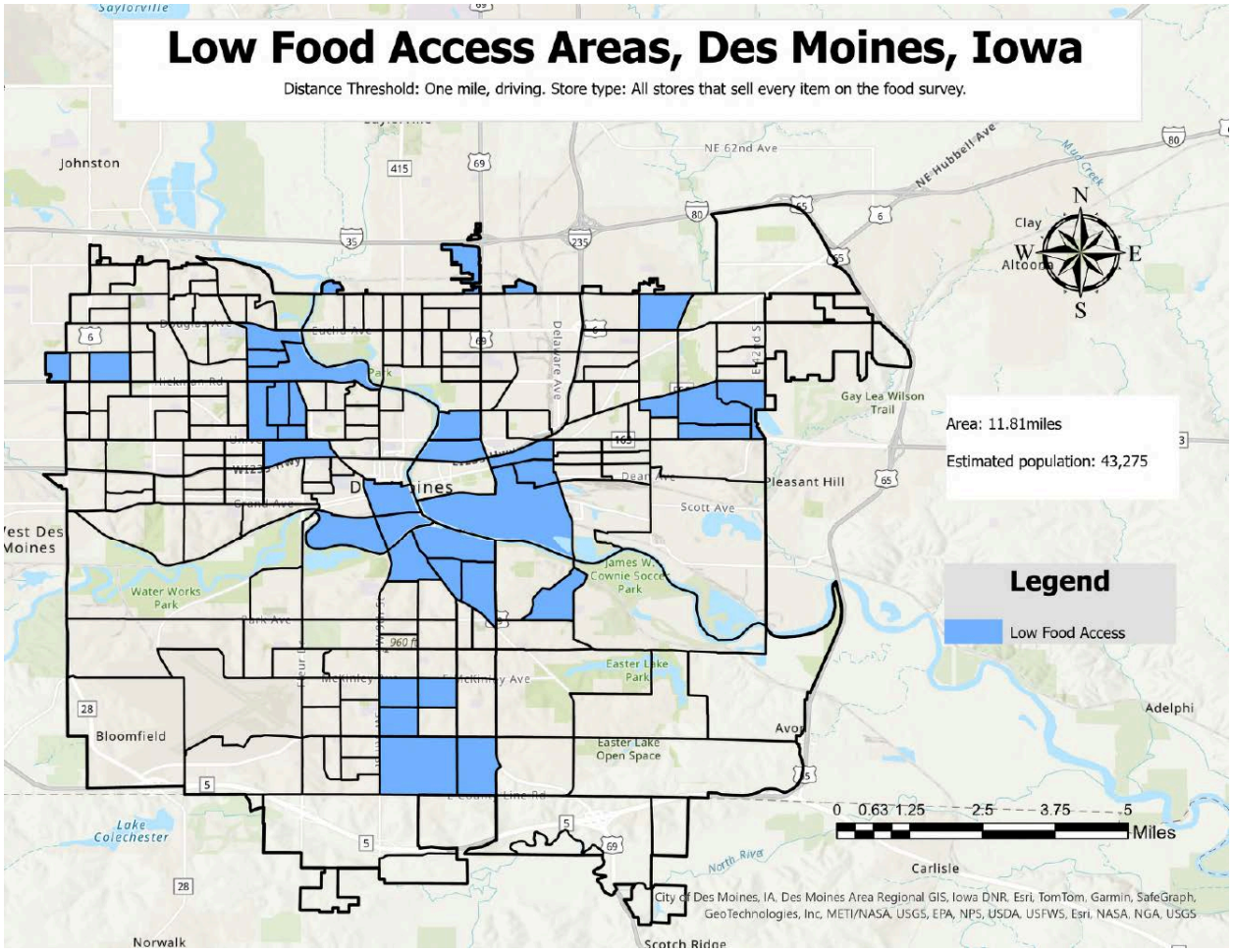
Map 17	1 km, walking	Chain Supermarkets	2.31	9564
Map 18	1 km, walking	Perfect food score	0.875	3844
Map 19	1 km, walking	non-convenience, 100 FS	1.57	7594
Map 20	1 km, walking	Non-convenience stores that sell fruits and vegetables	0.615	1945
Map 21	1 km, walking, no vehicles	Chain Supermarkets	21.86	26246
Map 22	1 km, walking, no vehicles	Perfect food score	13.54	17443
Map 23	1 km, walking, no vehicles	non-convenience, 100 FS	21.13	24276
Map 24	1 km, walking, no vehicles	Non-convenience stores that sell fruits and vegetables	20.16	18627
Map 25	2.5 km, walking	Chain Supermarkets	1.7	7619
Map 26	2.5 km, walking	Perfect food score	0	0
Map 27	2.5 km, walking	non-convenience, 100 FS	0	0
Map 28	2.5 km, walking	Non-convenience stores that sell fruits and vegetables	0	0
Map 29	2.5 km, walking, no vehicles	Chain Supermarkets	19.03	22834
Map 30	2.5 km, walking, no vehicles	Perfect food score	7.33	6283
Map 31	2.5 km, walking, no vehicles	non-convenience, 100 FS	15.23	10045
Map 32	2.5 km, walking, no vehicles	Non-convenience stores that sell fruits and vegetables	15.23	10045

Des Moines results



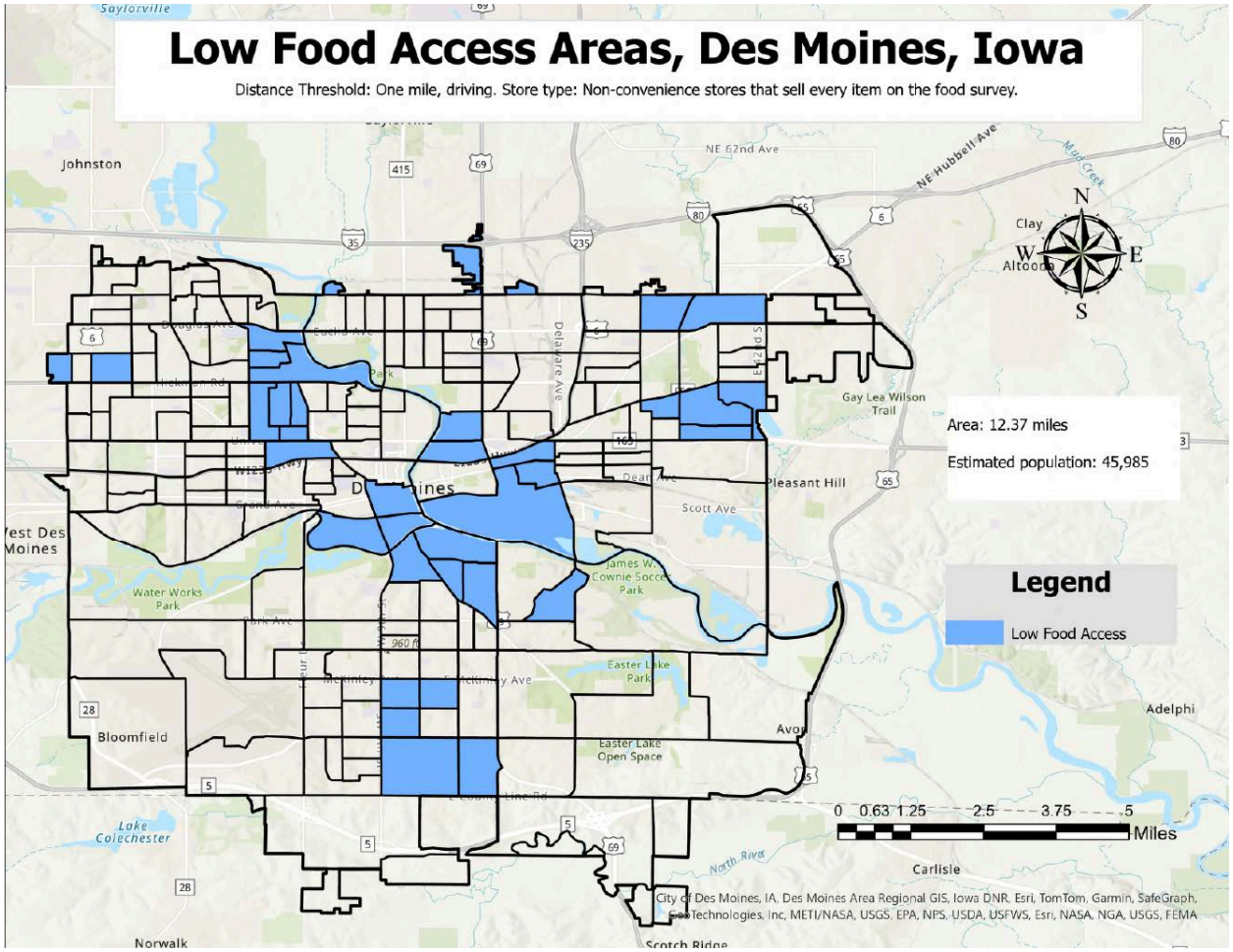
Map 33: **Areas of low food access using a distance threshold of 1 mile driving.**

The food retailer configuration was major supermarket chains, including Hy-Vee, Fareway, ALDI, Wal-Mart and Target. This group of stores was used as a baseline for comparison to other groups using this distance measurement. The area of low food access had an area of 15.7 square miles and an estimated population of 63,007.



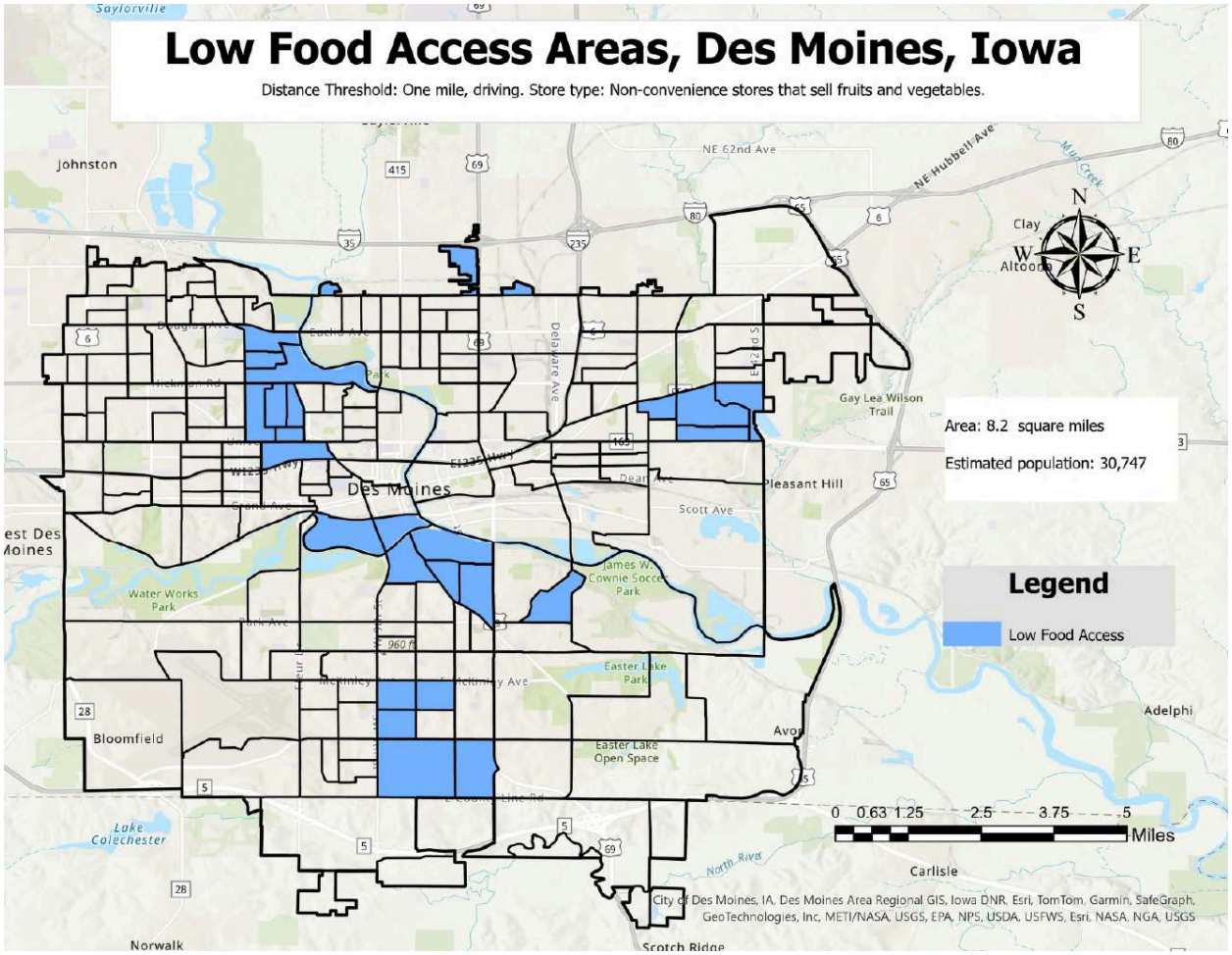
Map 34: **Areas of low food access using a distance threshold of 1 mile driving.**

The food retailer configuration was all food retailers that sold every item on the food survey. The area of low food access had an area of 11.81 square miles and an estimated population of 43,275. Using this method reduced the size of the area by 24.76 percent and the estimated population by 31.3 percent from the baseline food retailer configuration of only major supermarket chains.



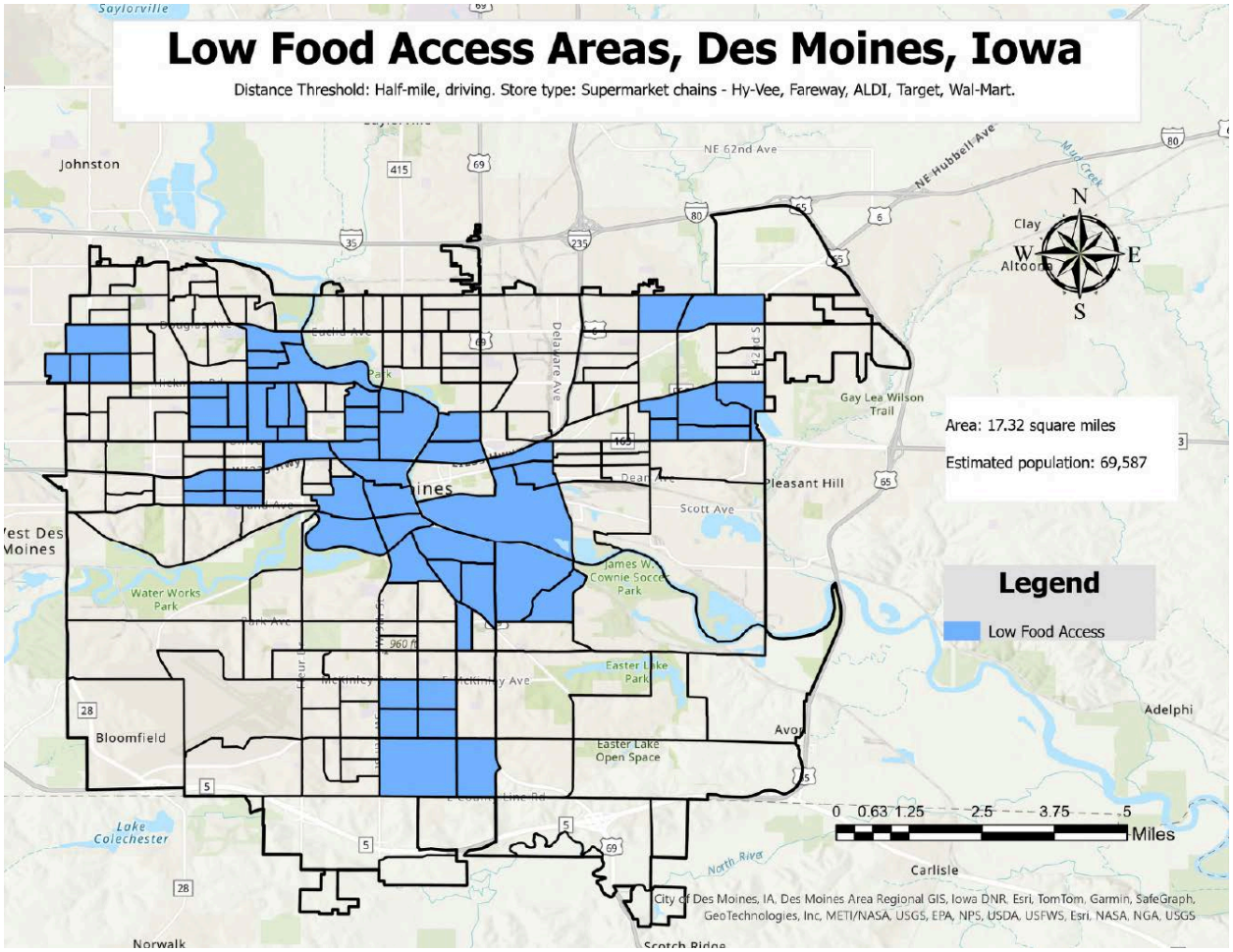
Map 35: **Areas of low food access using a distance threshold of 1 mile driving.**

The food retailer configuration was all non-convenience stores that sold every item on the food survey. The area of low food access had an area of 12.37 square miles and an estimated population of 45,985. Using this method reduced the size of the area by 21.2 percent and the estimated population by 27 percent from the baseline food retailer configuration of only major supermarket chains.



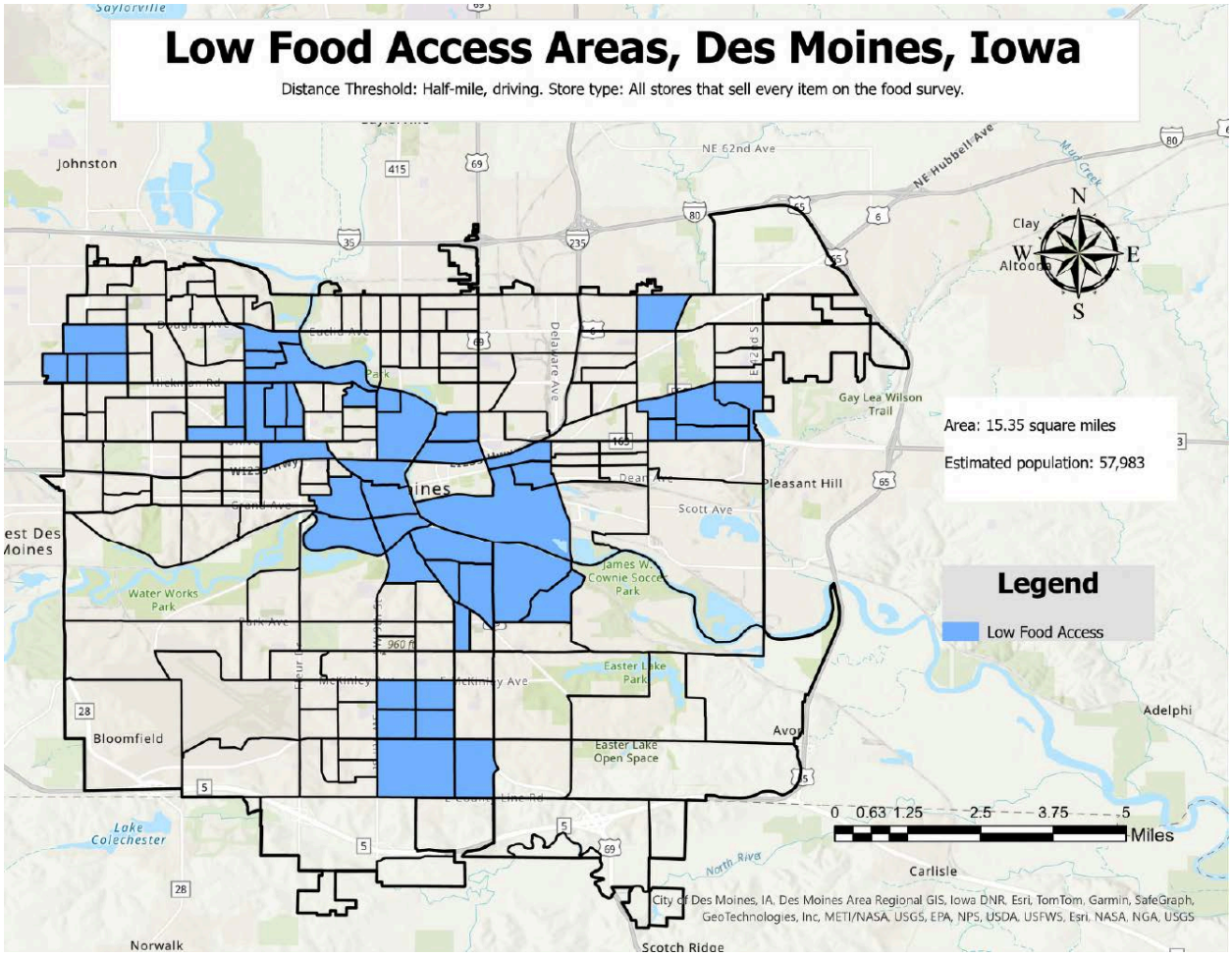
Map 36: **Areas of low food access using a distance threshold of 1 mile driving.**

The food retailer configuration was all stores that sold fresh fruit and vegetables. The area of low food access had an area of 8.2 square miles and an estimated population of 30,747. Using this method reduced the size of the area by 47.7 percent and the estimated population by 51.2 percent from the baseline food retailer configuration of only major supermarket chains.



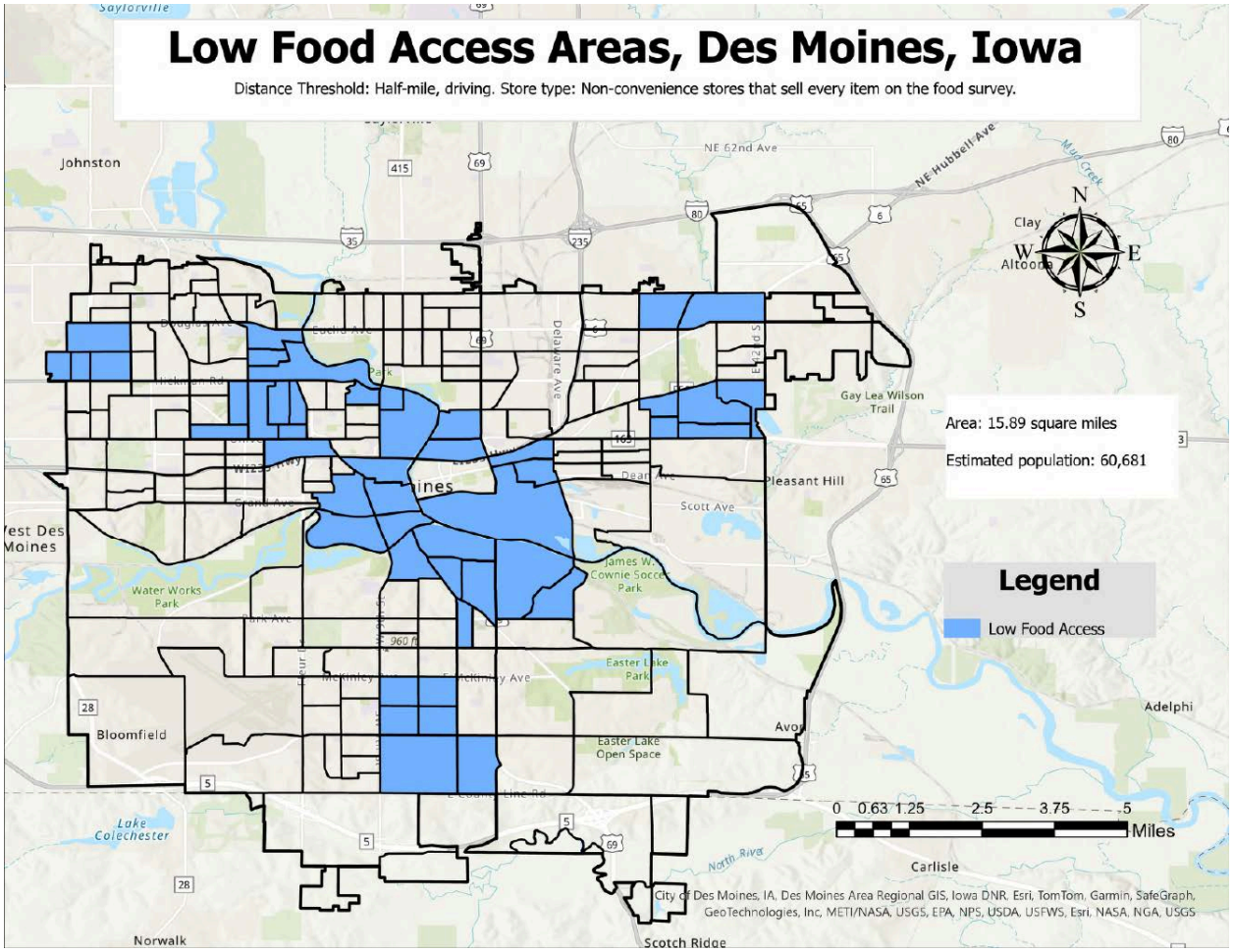
Map 37: **Areas of low food access using a distance threshold of 0.5 miles driving.**

The food retailer configuration was major supermarket chains, including Hy-Vee, Fareway, ALDI, Wal-Mart and Target. This group of stores was used as a baseline for comparison to other groups using this distance measurement. The area of low food access had an area of 17.32 square miles and an estimated population of 69,587.



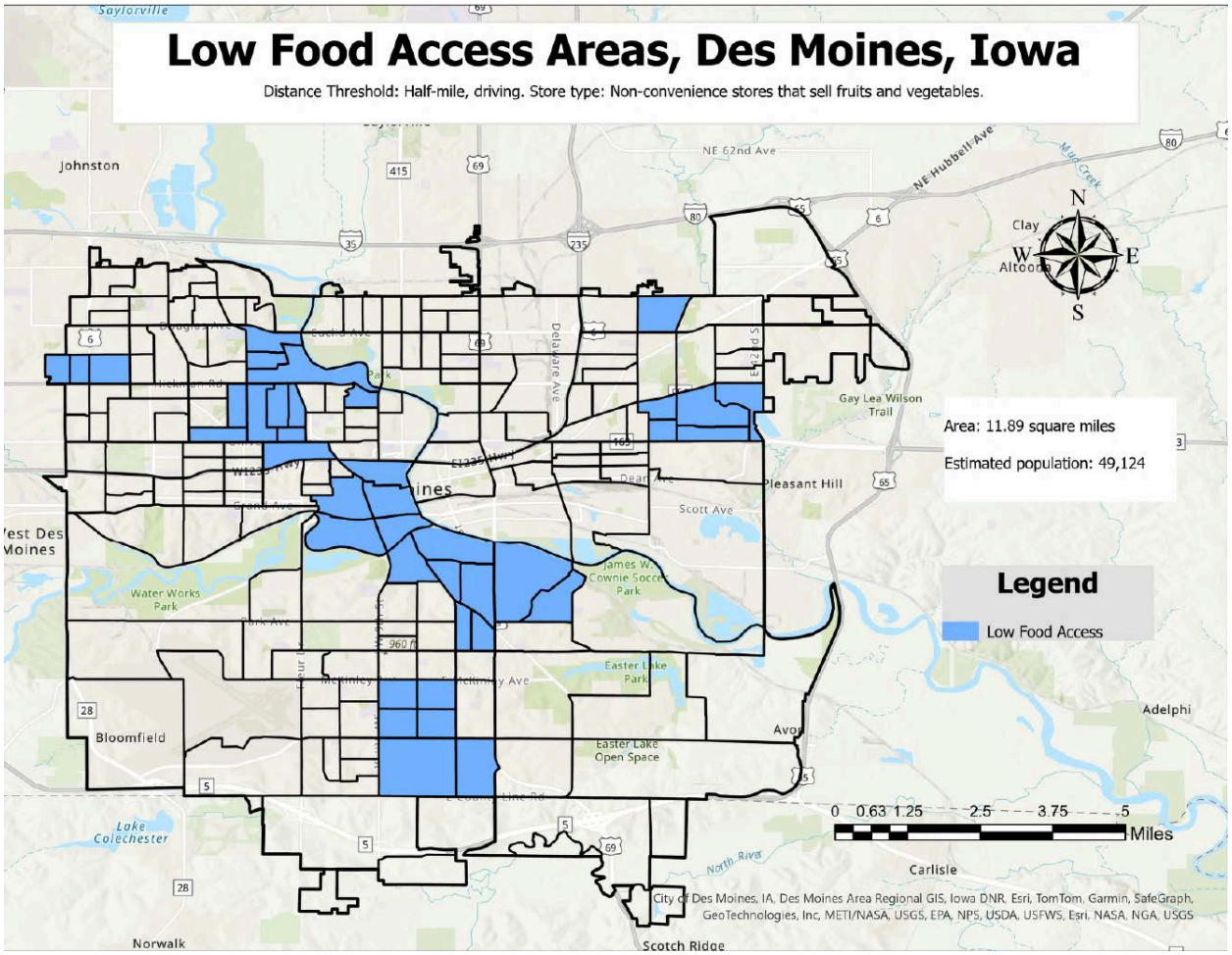
Map 38: **Areas of low food access using a distance threshold of 0.5 miles driving.**

The food retailer configuration was all stores that sold every item on the food survey. The area of low food access had an area of 15.35 square miles and an estimated population of 57,983. Using this method reduced the size of the area by 11.3 percent and the estimated population by 16.6 percent from the baseline food retailer configuration of only major supermarket chains.



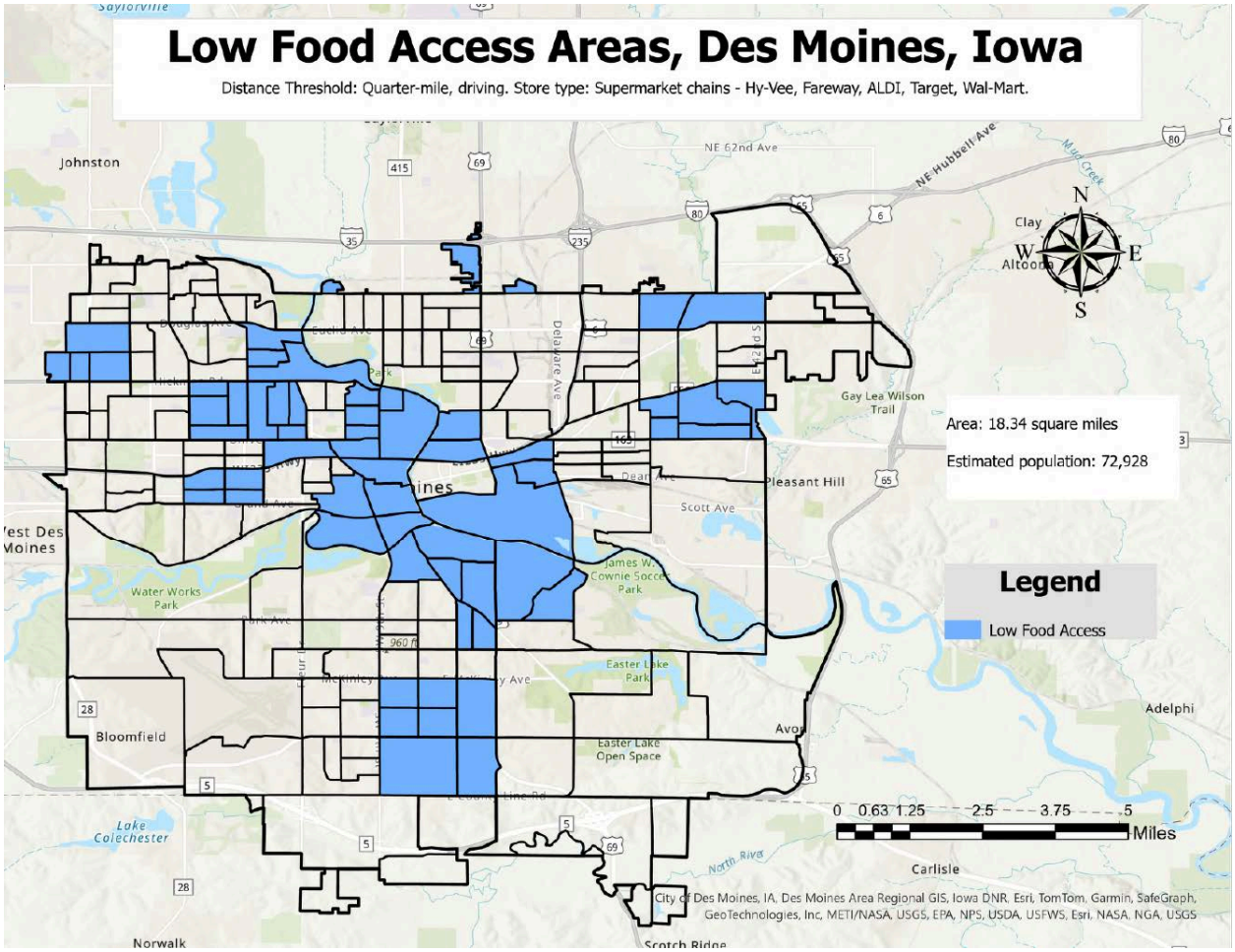
Map 39: **Areas of low food access using a distance threshold of 0.5 miles driving.**

The food retailer configuration was all non-convenience stores that sold every item on the food survey. The area of low food access had an area of 15.89 square miles and an estimated population of 60,681. Using this method reduced the size of the area by 8.2 percent and the estimated population by 12.7 percent from the baseline food retailer configuration of only major supermarket chains.

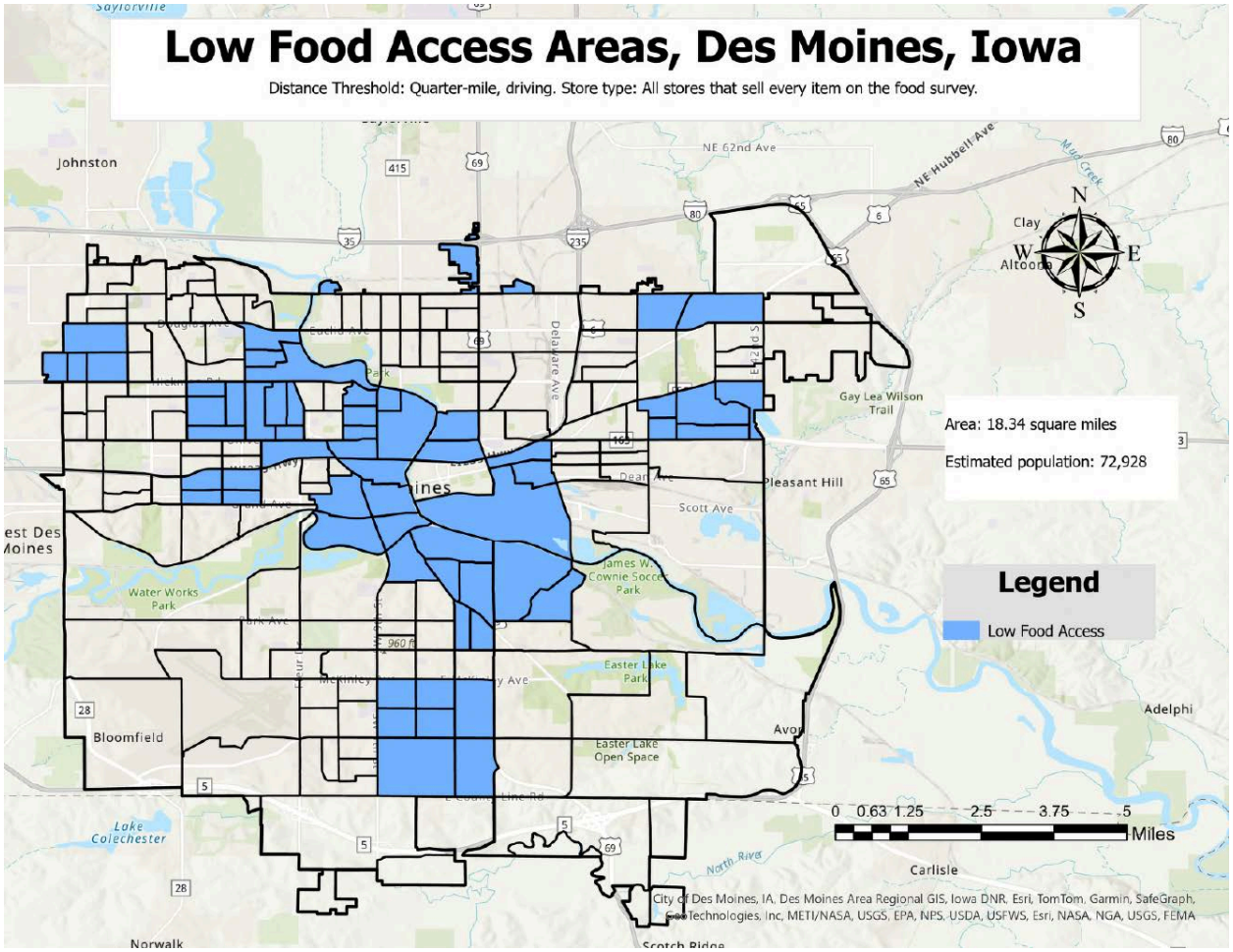


Map 40: **Areas of low food access using a distance threshold of 0.5 miles driving.**

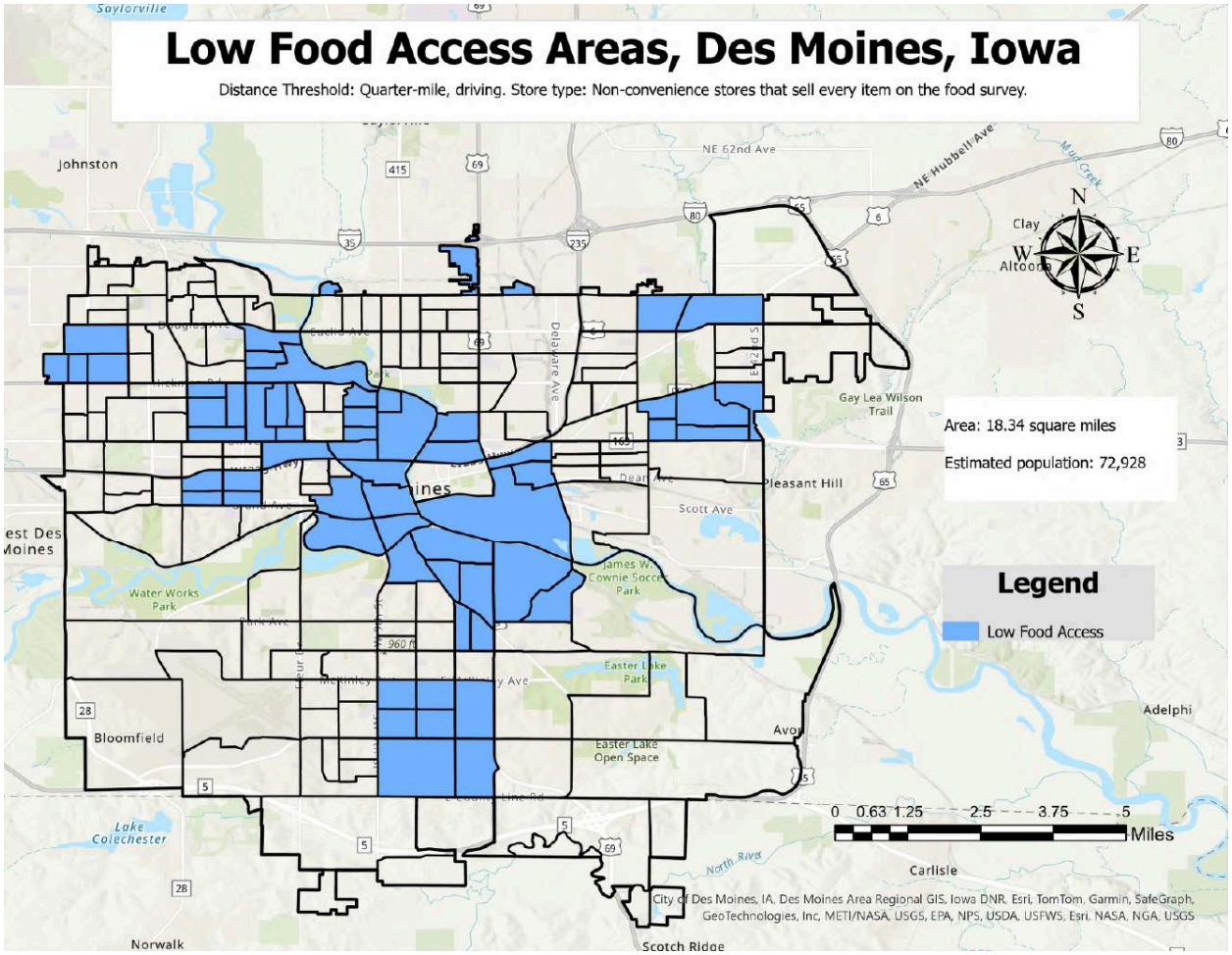
The food retailer configuration was all stores that sold fresh fruit and vegetables. The area of low food access had an area of 11.89 square miles and an estimated population of 49,124. Using this method reduced the size of the area by 31.3 percent and the estimated population by 29.4 percent from the baseline food retailer configuration of only major supermarket chains.



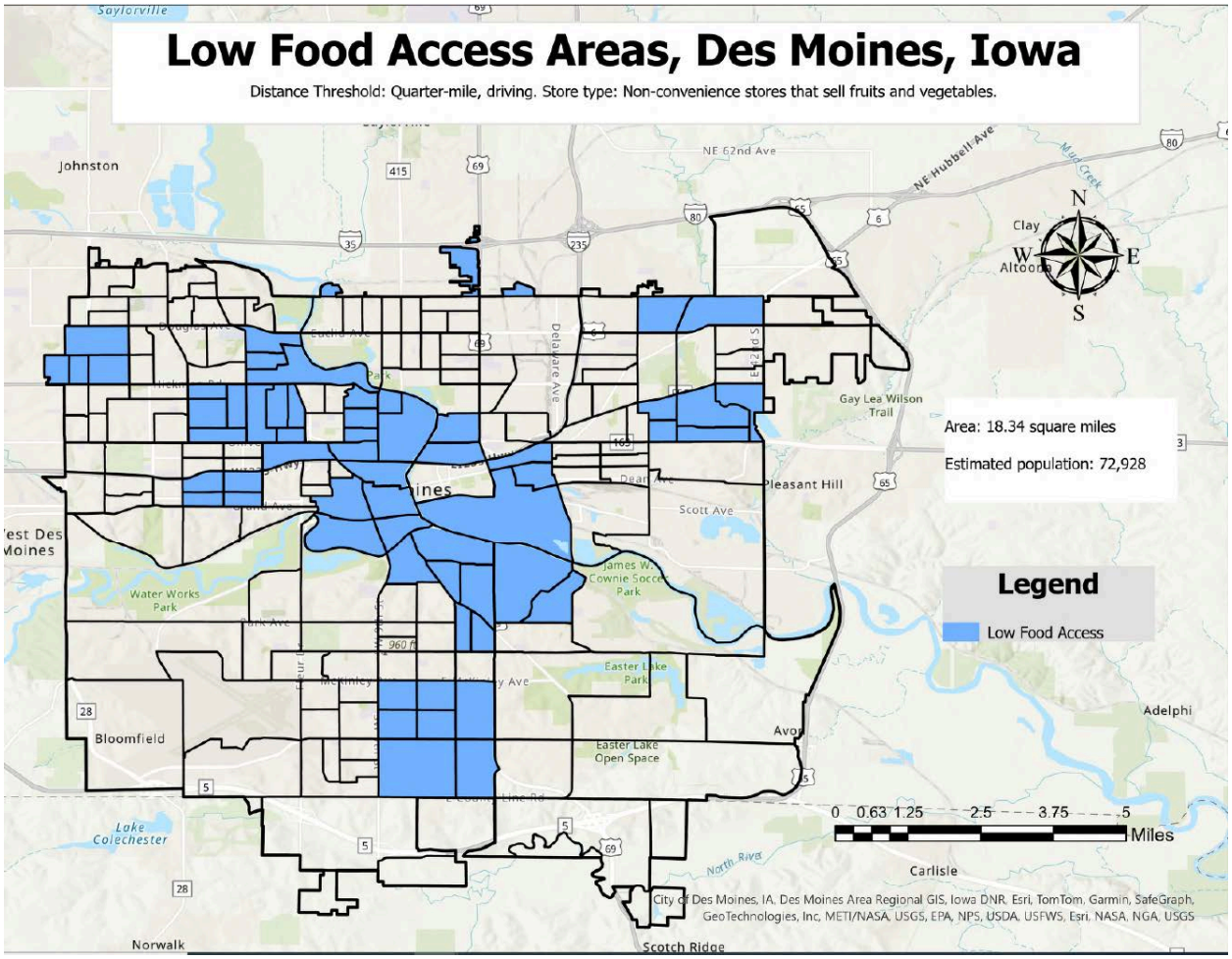
Map 41: **Areas of low food access using a distance threshold of 0.25 miles driving.** The food retailer configuration was major supermarket chains, including Hy-Vee, Fareway, ALDI, Wal-Mart and Target. This group of stores was used as a baseline for comparison to other groups using this distance measurement. The area of low food access had an area of 18.34 square miles and an estimated population of 72,928.



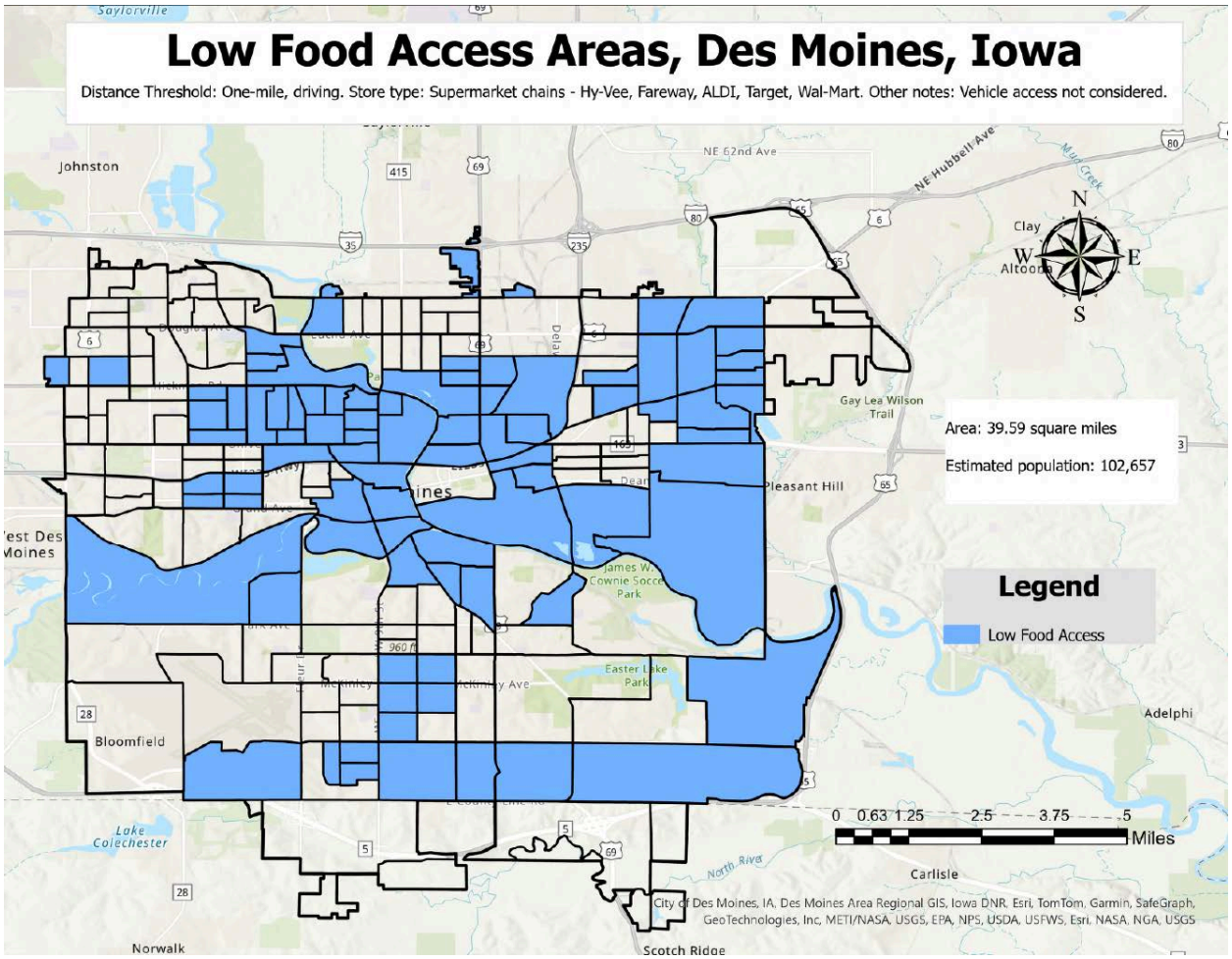
Map 42: **Areas of low food access using a distance threshold of 0.25 miles driving.** The food retailer configuration was all stores that sold every item on the food survey. The area of low food access had an area of 18.34 square miles and an estimated population of 72,928. There was no change from the baseline.



Map 43: **Areas of low food access using a distance threshold of 0.25 miles driving.** The food retailer configuration was all non-convenience stores that sold every item on the food survey. The area of low food access had an area of 18.34 square miles and an estimated population of 72,928. There was no change from the baseline.

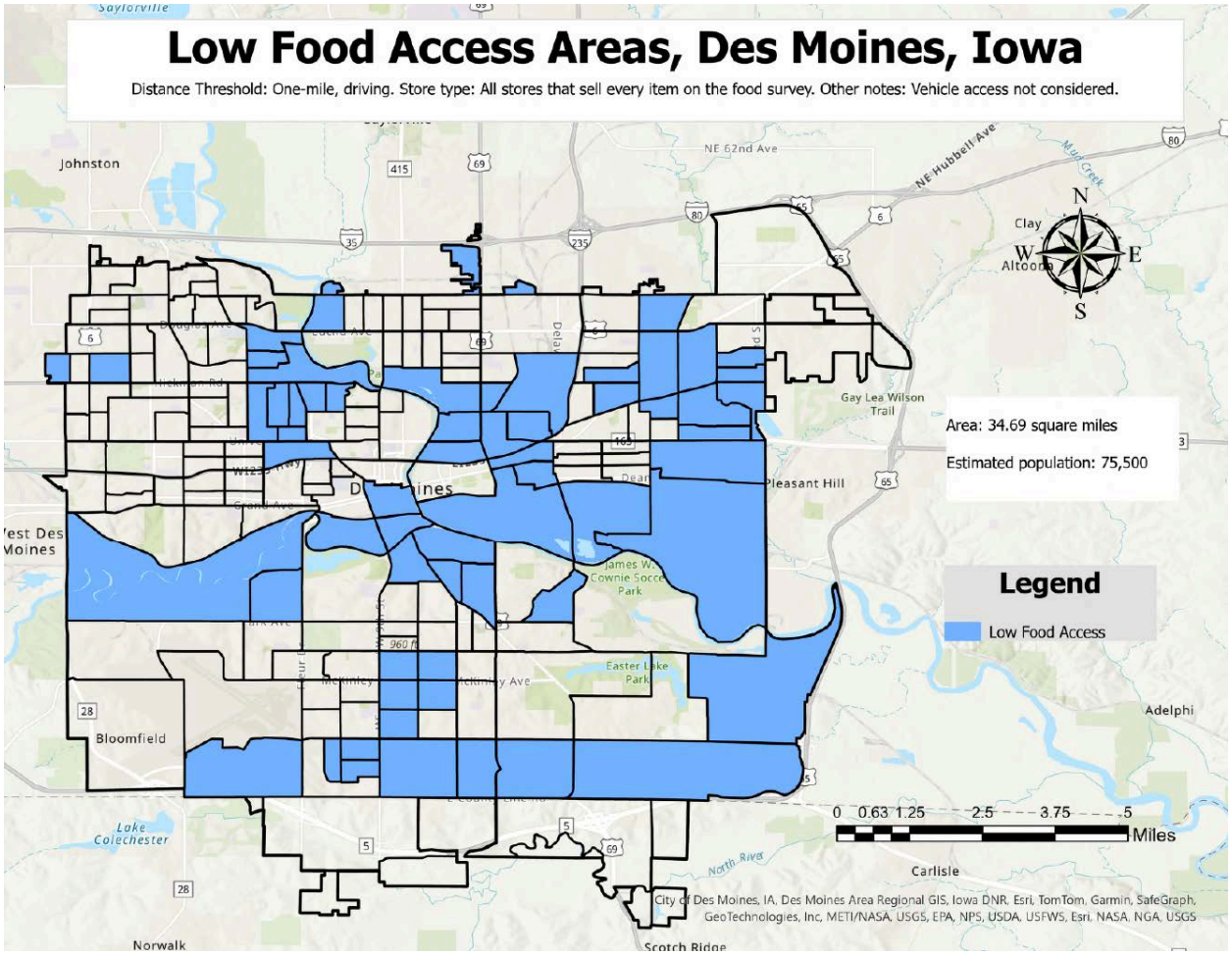


Map 44: **Areas of low food access using a distance threshold of 0.25 miles driving.** The food retailer configuration was all stores that sold fresh fruit and vegetables. The area of low food access had an area of 18.34 square miles and an estimated population of 72,928. There was no change from the baseline.



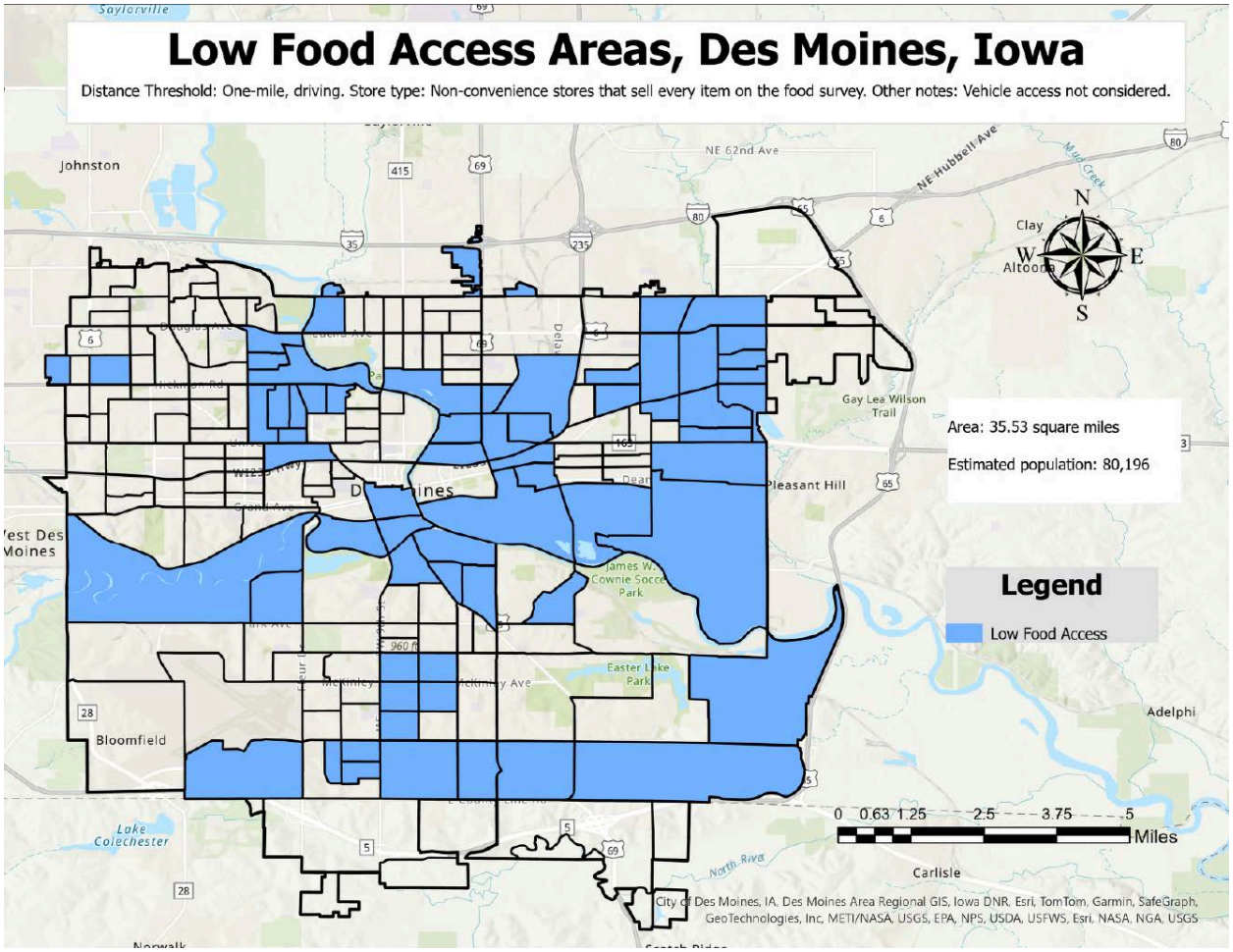
Map 45: **Areas of low food access using a distance threshold of 1 mile driving.**

Vehicle access was not considered in this analysis. The food retailer configuration was major supermarket chains, including Hy-Vee, Fareway, ALDI, Wal-Mart and Target. This group of stores was used as a baseline for comparison to other groups using this distance measurement. The area of low food access had an area of 39.59 square miles and an estimated population of 102,657.



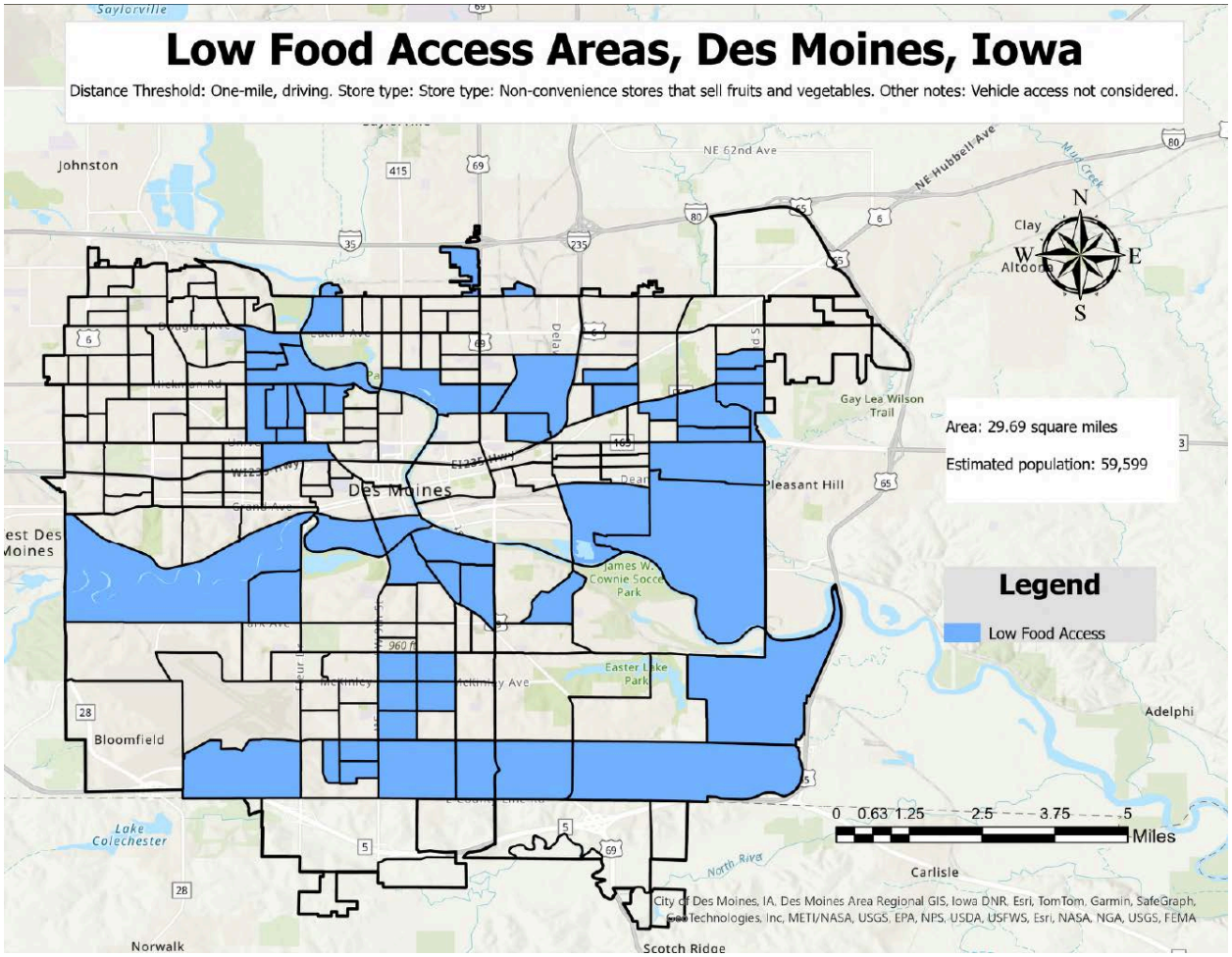
Map 46: **Areas of low food access using a distance threshold of 1 mile driving.**

Vehicle access was not considered in this analysis. The food retailer configuration was all stores that sold every item on the food survey. The area of low food access had an area of 34.69 square miles and an estimated population of 75,500. Using this method reduced the size of the area by 12.3 percent and the estimated population by 26.4 percent from the baseline food retailer configuration of only major supermarket chains.



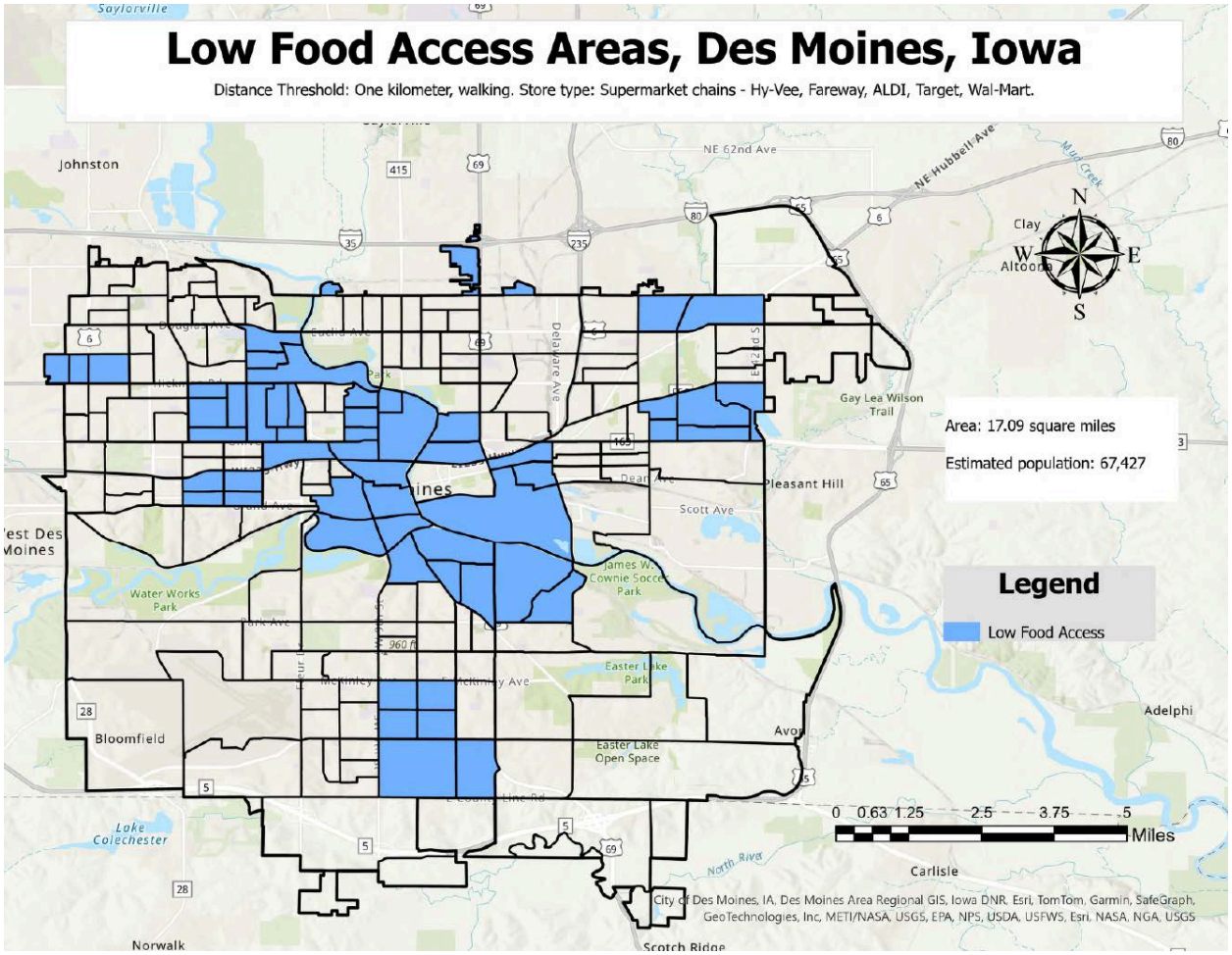
Map 47: **Areas of low food access using a distance threshold of 1 mile driving.**

Vehicle access was not considered in this analysis. The food retailer configuration was all non-convenience stores that sold every item on the food survey. The area of low food access had an area of 35.53 square miles and an estimated population of 80,196. Using this method reduced the size of the area by 10.2 percent and the estimated population by 21.8 percent from the baseline food retailer configuration of only major supermarket chains.

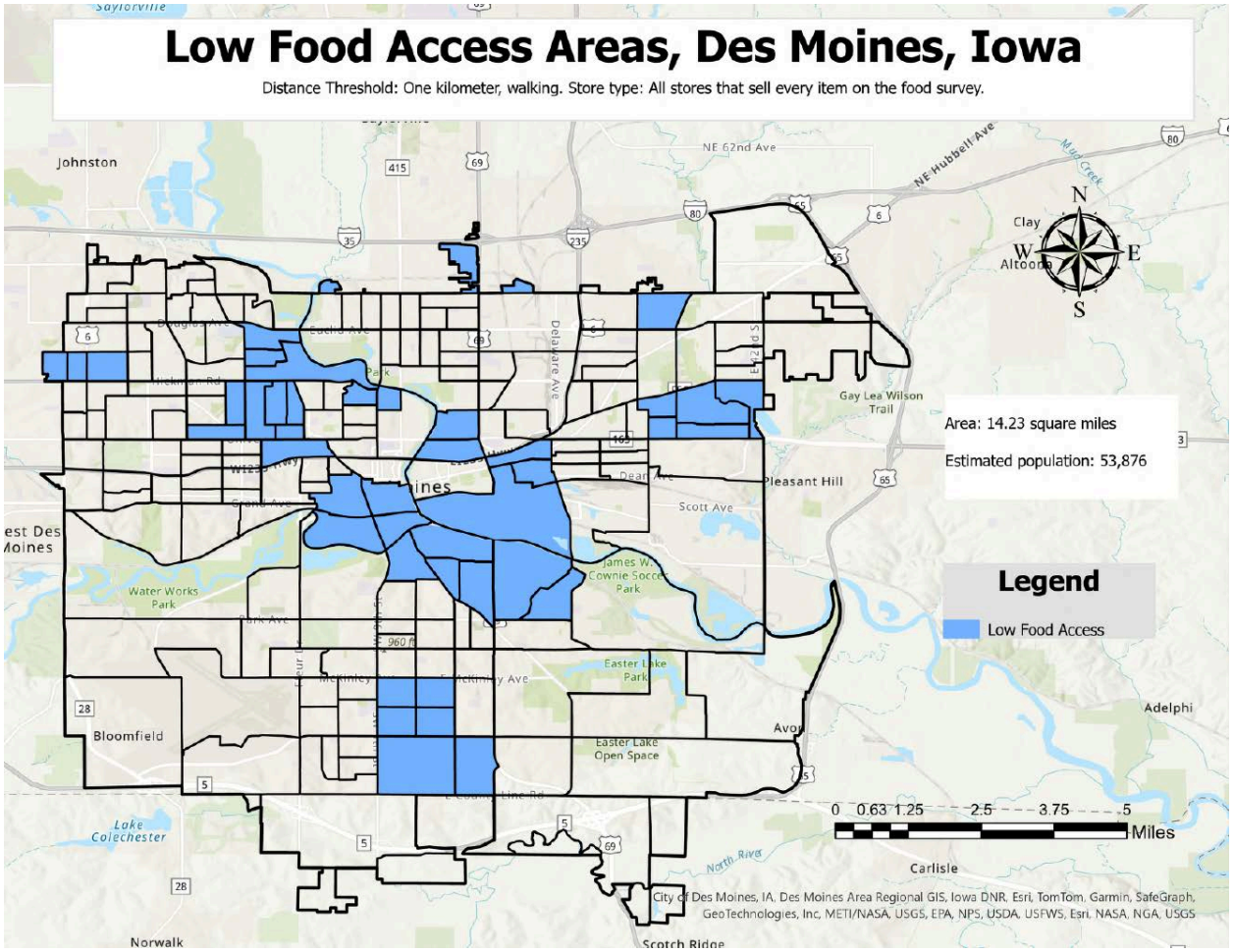


Map 48: **Areas of low food access using a distance threshold of 1 mile driving.**

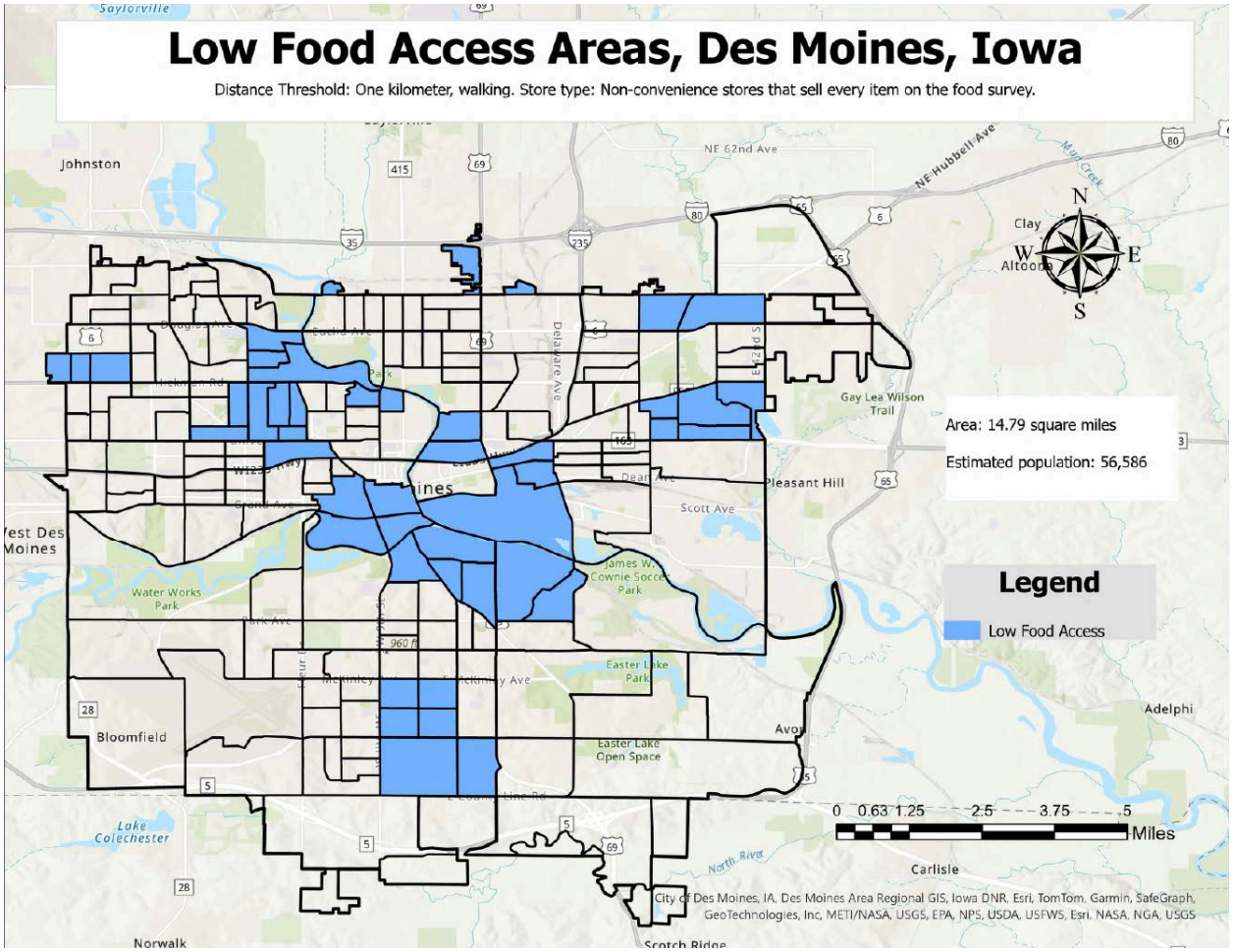
Vehicle access was not considered in this analysis. The food retailer configuration was all stores that sold fresh fruit and vegetables. The area of low food access had an area of 29.69 square miles and an estimated population of 59,599. Using this method reduced the size of the area by 25 percent and the estimated population by 41.9 percent from the baseline food retailer configuration of only major supermarket chains.



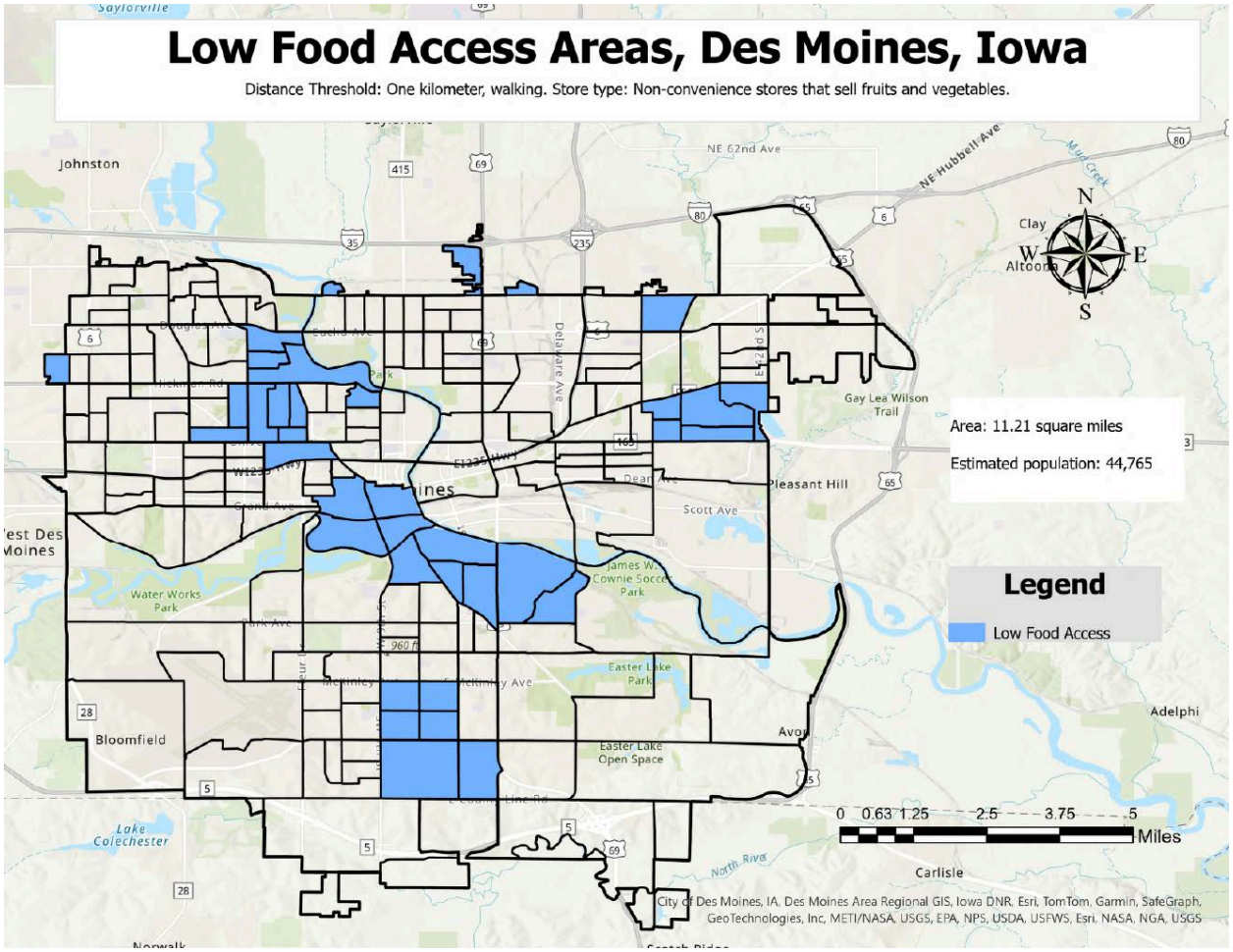
Map 49: **Areas of low food access using a distance threshold of 1 kilometer walking.** The food retailer configuration was major supermarket chains, including Hy-Vee, Fareway, ALDI, Wal-Mart and Target. This group of stores was used as a baseline for comparison to other groups using this distance measurement. The area of low food access had an area of 17.09 square miles and an estimated population of 67,427.



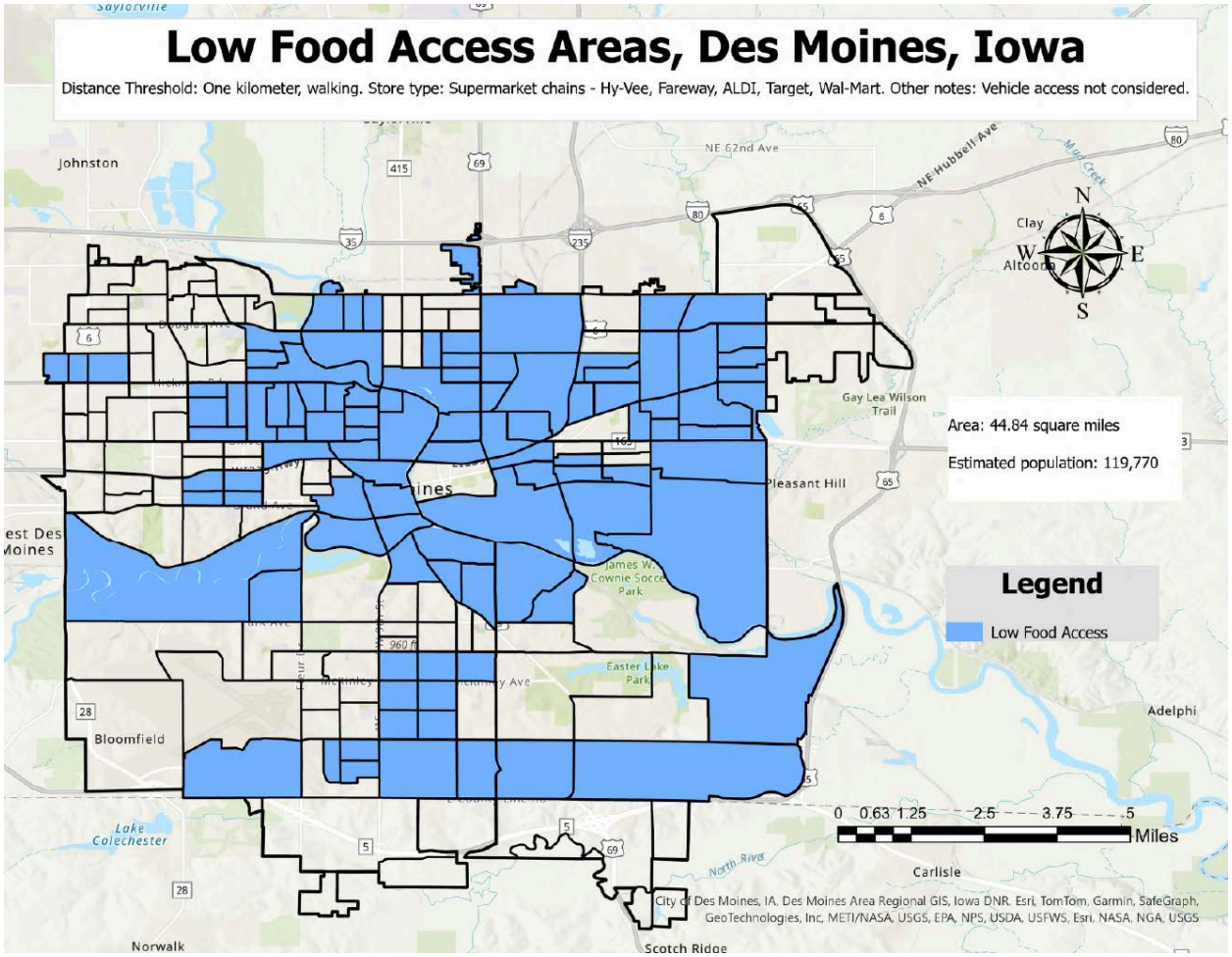
Map 50: **Areas of low food access using a distance threshold of 1 kilometer walking.** The food retailer configuration was all stores that sold every item on the food survey. The area of low food access had an area of 14.23 square miles and an estimated population of 53,876. Using this method reduced the size of the area by 16.7 percent and the estimated population by 20.1 percent from the baseline food retailer configuration of only major supermarket chains.



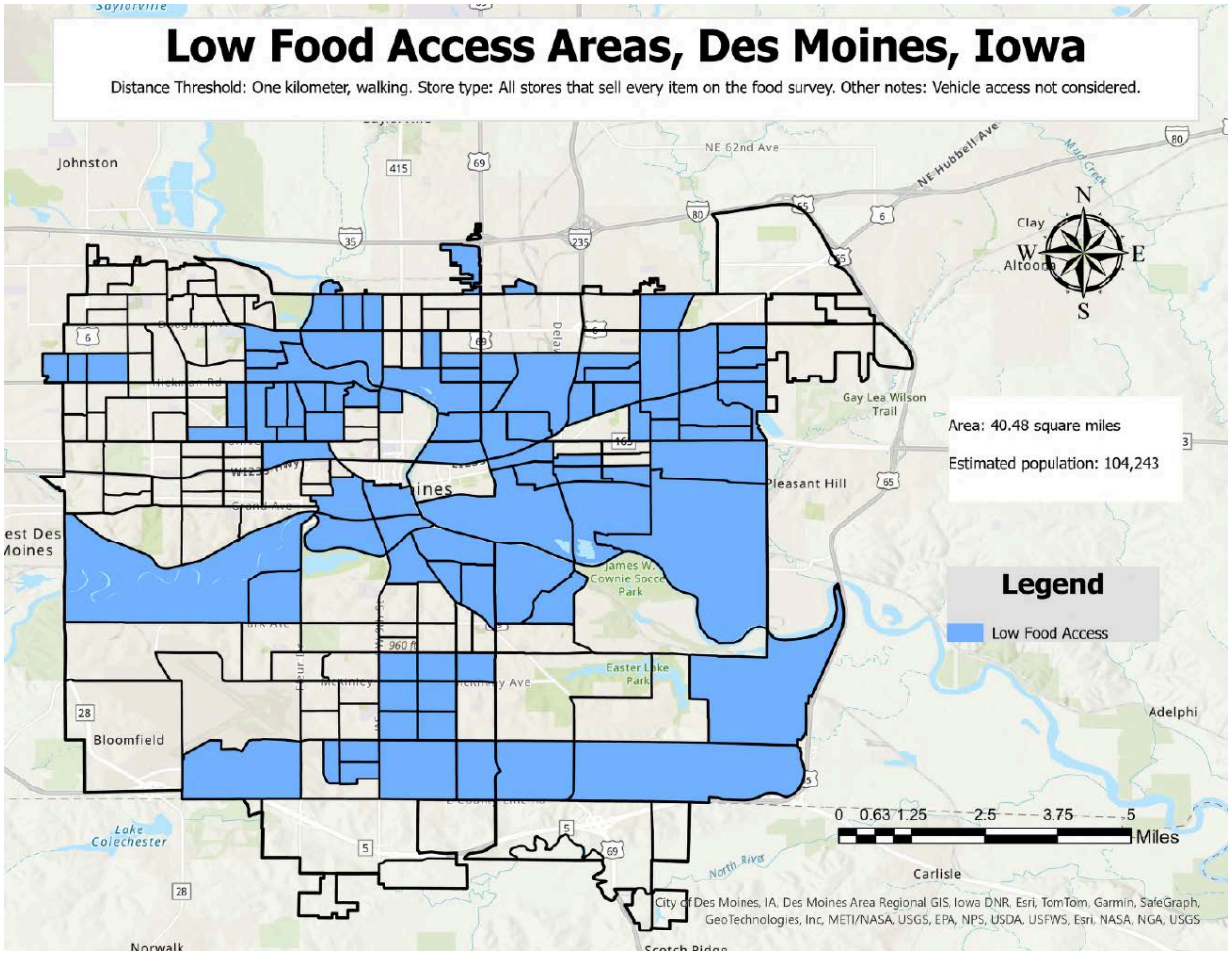
Map 51: **Areas of low food access using a distance threshold of 1 kilometer walking.** The food retailer configuration was all non-convenience stores that sold every item on the food survey. The area of low food access had an area of 14.79 square miles and an estimated population of 56,586. Using this method reduced the size of the area by 13.4 percent and the estimated population by 16.1 percent from the baseline food retailer configuration of only major supermarket chains.



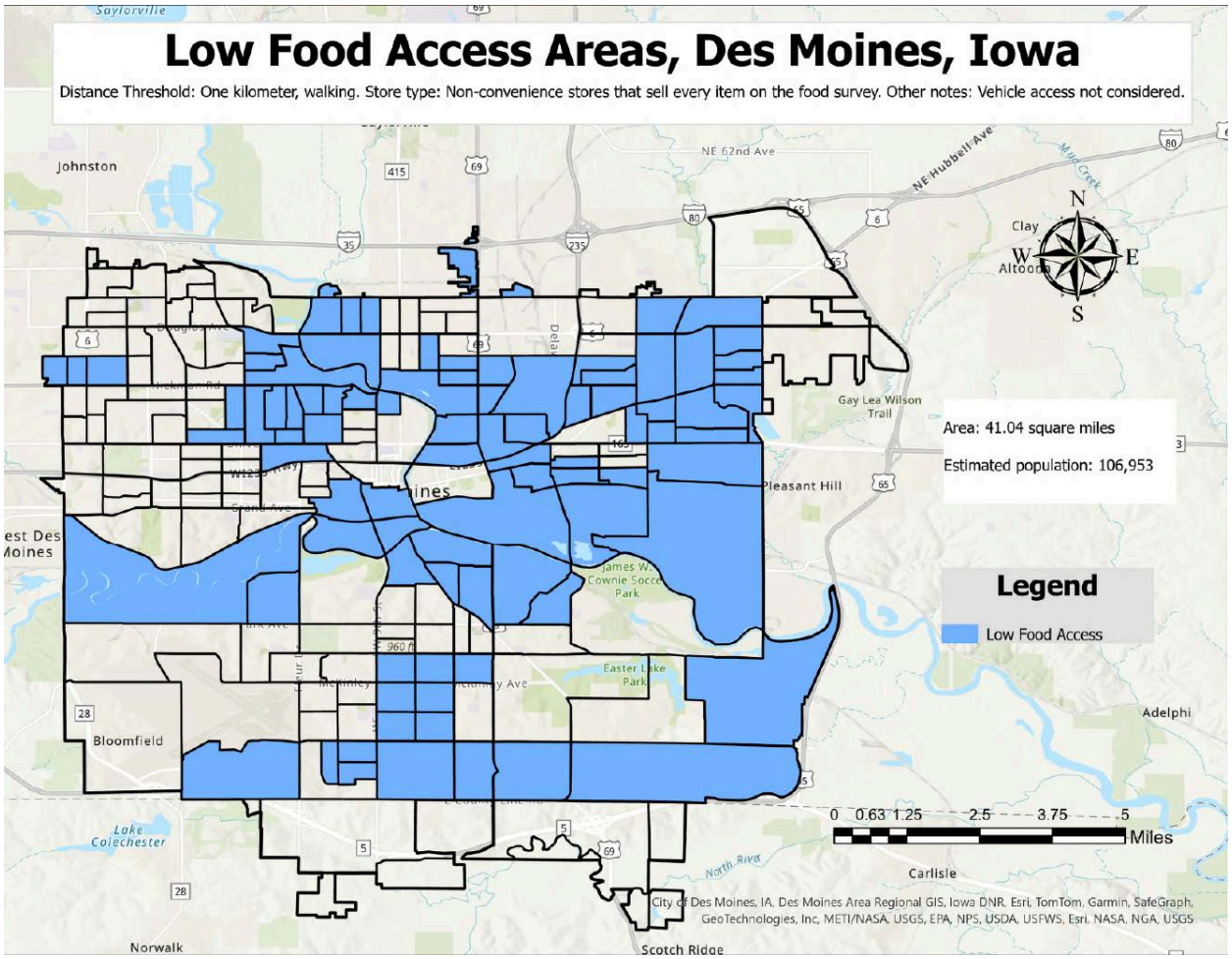
Map 52: **Areas of low food access using a distance threshold of 1 kilometer walking.** The food retailer configuration was all stores that sold fresh fruit and vegetables. The area of low food access had an area of 11.21 square miles and an estimated population of 44,765. Using this method reduced the size of the area by 34.4 percent and the estimated population by 33.6 percent from the baseline food retailer configuration of only major supermarket chains.



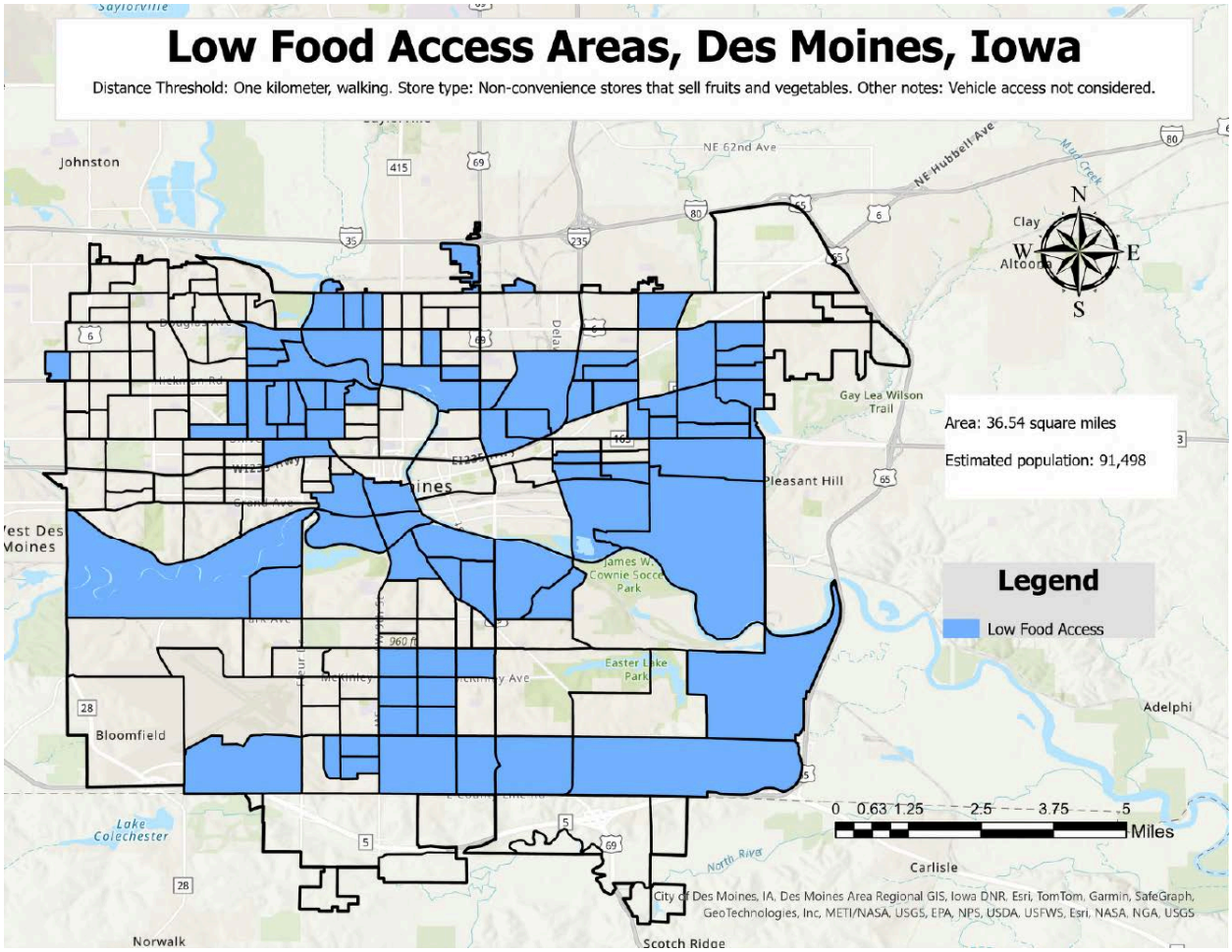
Map 53: **Areas of low food access using a distance threshold of 1 kilometer walking.** Vehicle access was not considered in this analysis. The food retailer configuration was major supermarket chains, including Hy-Vee, Fareway, ALDI, Wal-Mart and Target. This group of stores was used as a baseline for comparison to other groups using this distance measurement. The area of low food access had an area of 44.84 square miles and an estimated population of 119,770.



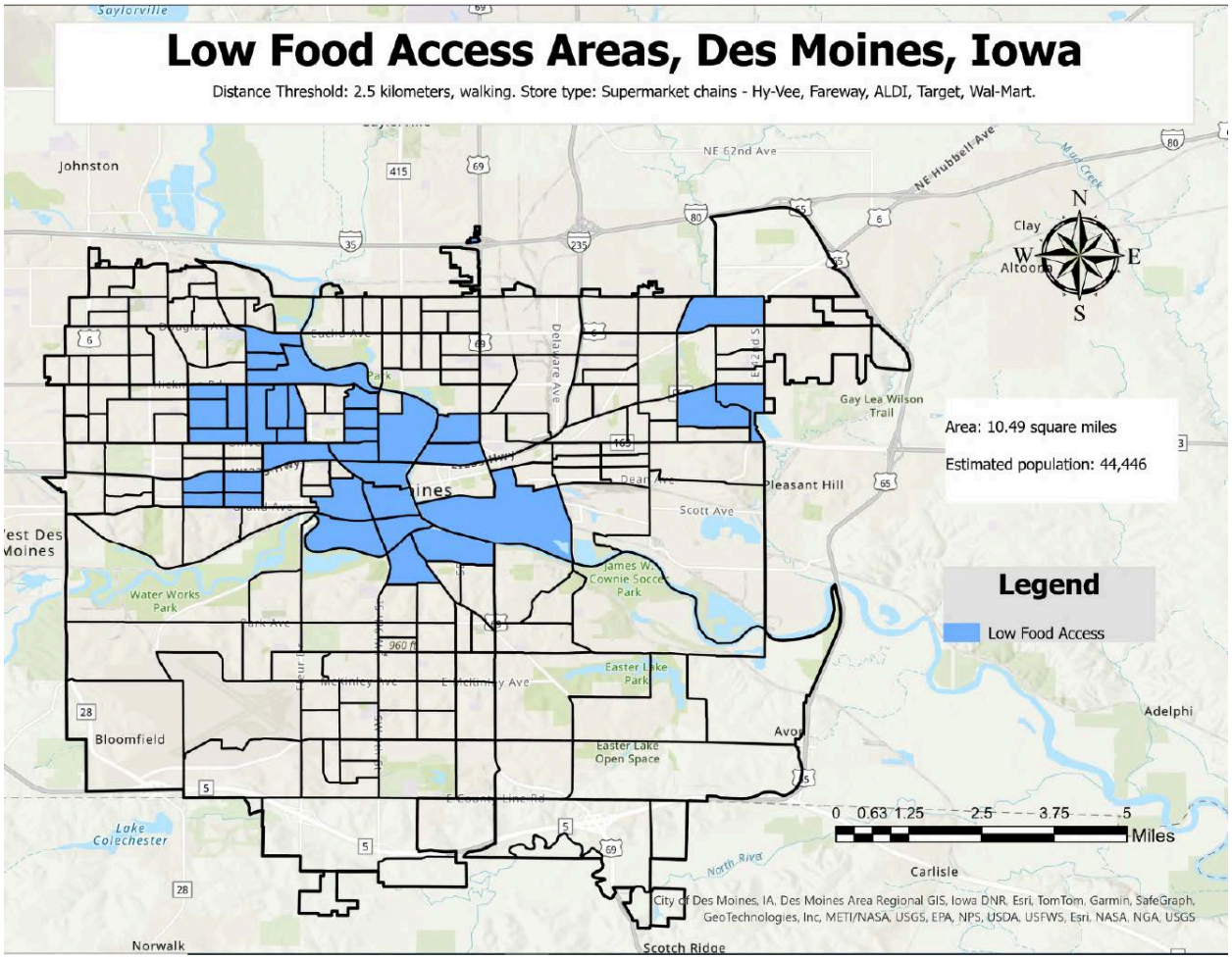
Map 54: **Areas of low food access using a distance threshold of 1 kilometer walking.** Vehicle access was not considered in this analysis. The food retailer configuration was all stores that sold every item on the food survey. The area of low food access had an area of 40.48 square miles and an estimated population of 104,243. Using this method reduced the size of the area by 9.7 percent and the estimated population by 12.9 percent from the baseline food retailer configuration of only major supermarket chains.



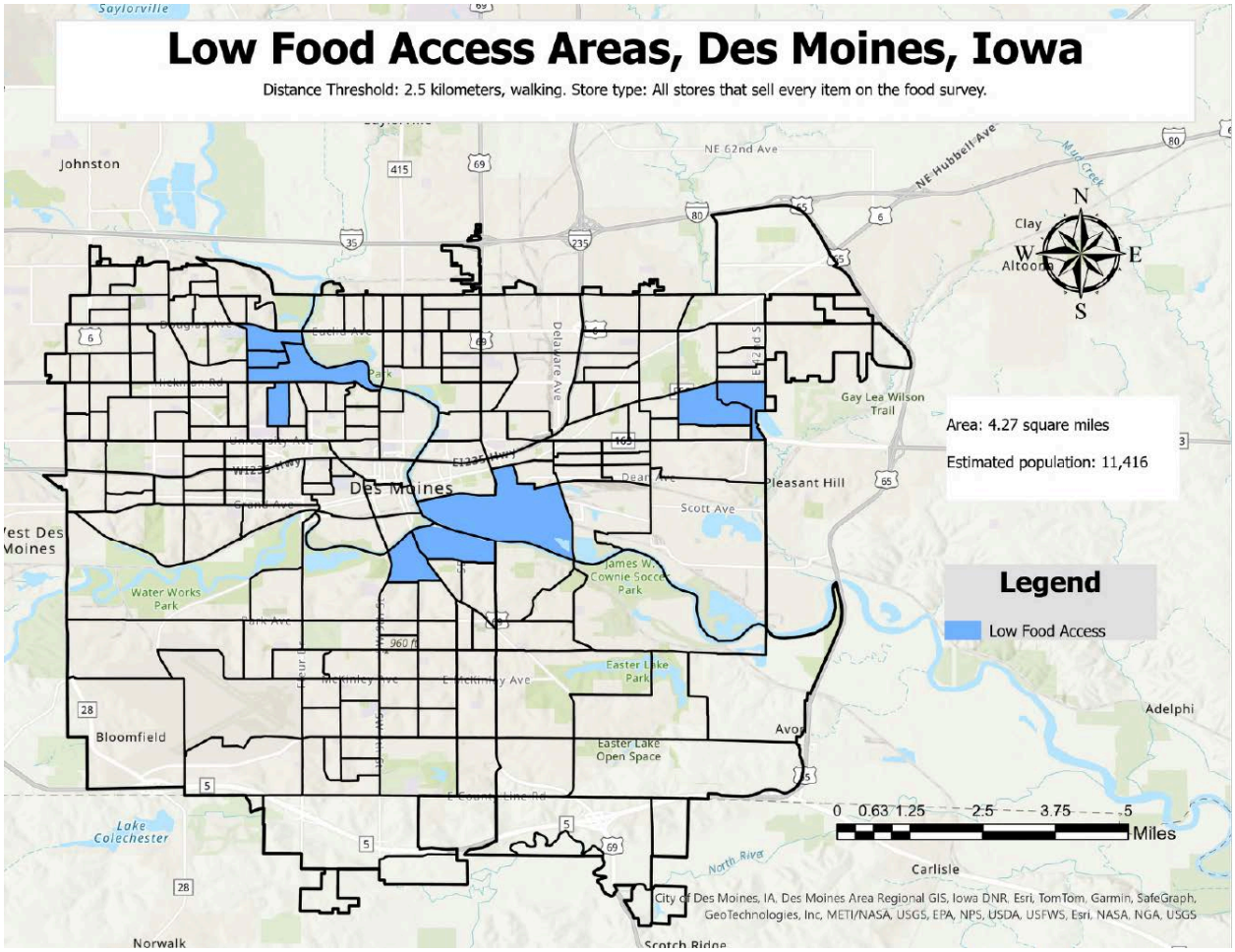
Map 55: **Areas of low food access using a distance threshold of 1 kilometer walking.** Vehicle access was not considered in this analysis. The food retailer configuration was all non-convenience stores that sold every item on the food survey. The area of low food access had an area of 41.04 square miles and an estimated population of 106,953. Using this method reduced the size of the area by 8.4 percent and the estimated population by 10.7 percent from the baseline food retailer configuration of only major supermarket chains.



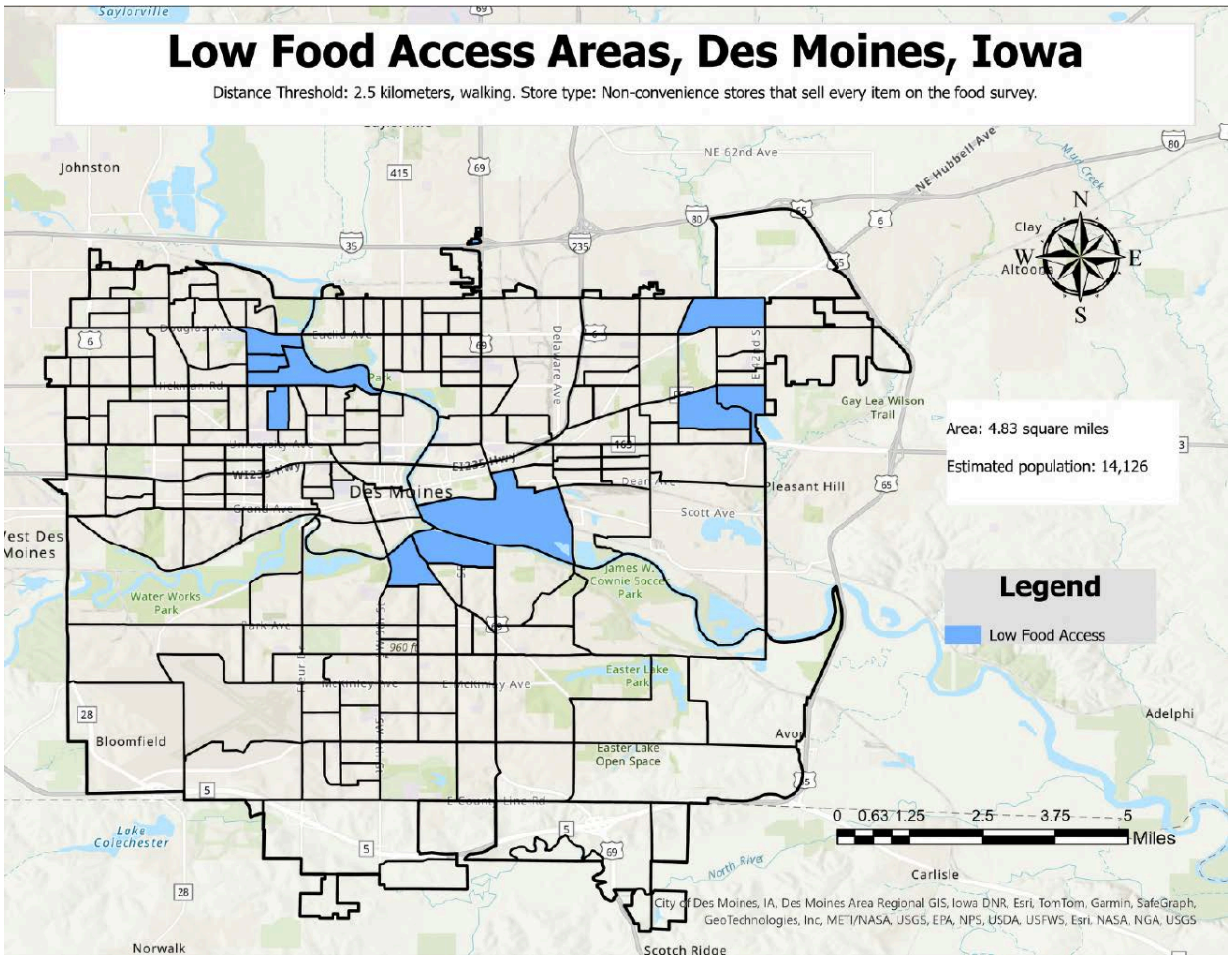
Map 56: **Areas of low food access using a distance threshold of 1 kilometer walking.** Vehicle access was not considered in this analysis. The food retailer configuration was all stores that sold fresh fruit and vegetables. The area of low food access had an area of 36.54 square miles and an estimated population of 91,498. Using this method reduced the size of the area by 18.5 percent and the estimated population by 23.6 percent from the baseline food retailer configuration of only major supermarket chains.



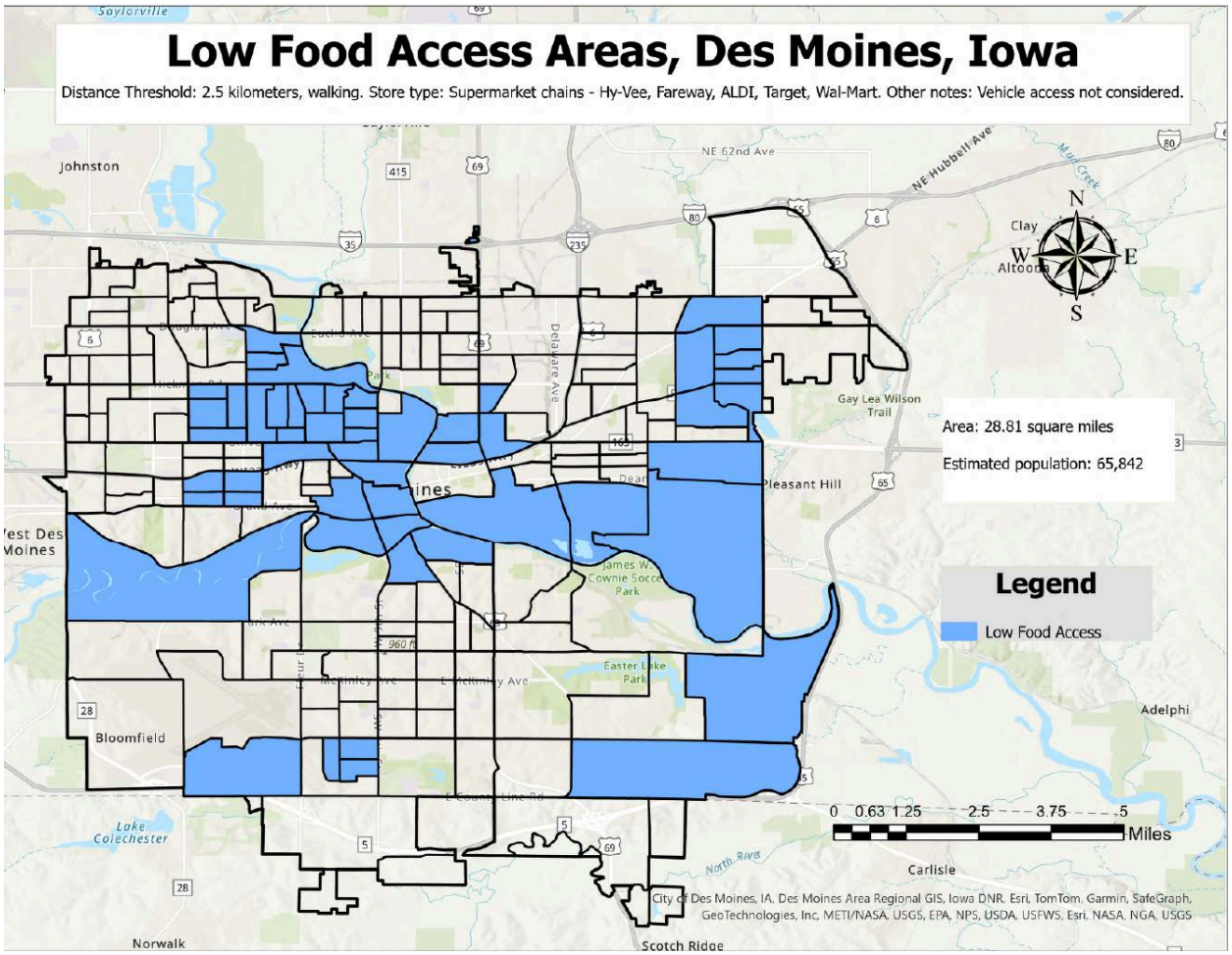
Map 57: **Areas of low food access using a distance threshold of 2.5 kilometers walking.** The food retailer configuration was major supermarket chains, including Hy-Vee, Fareway, ALDI, Wal-Mart and Target. This group of stores was used as a baseline for comparison to other groups using this distance measurement. The area of low food access had an area of 10.49 square miles and an estimated population of 44,446.



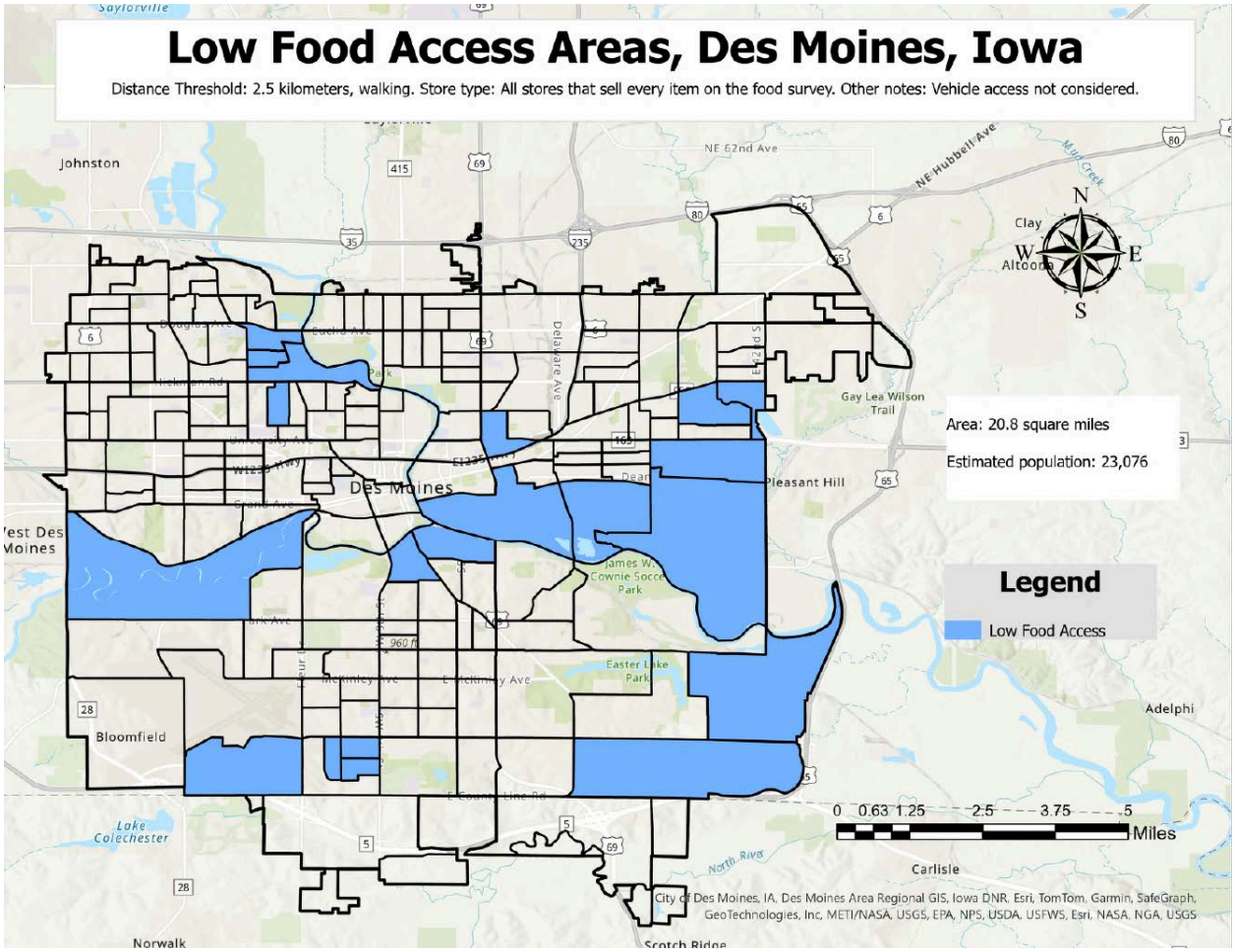
Map 58: **Areas of low food access using a distance threshold of 2.5 kilometers walking.** The food retailer configuration was all stores that sold every item on the food survey. The area of low food access had an area of 4.27 square miles and an estimated population of 11,416. Using this method reduced the size of the area by 59.2 percent and the estimated population by 74.3 percent from the baseline food retailer configuration of only major supermarket chains.



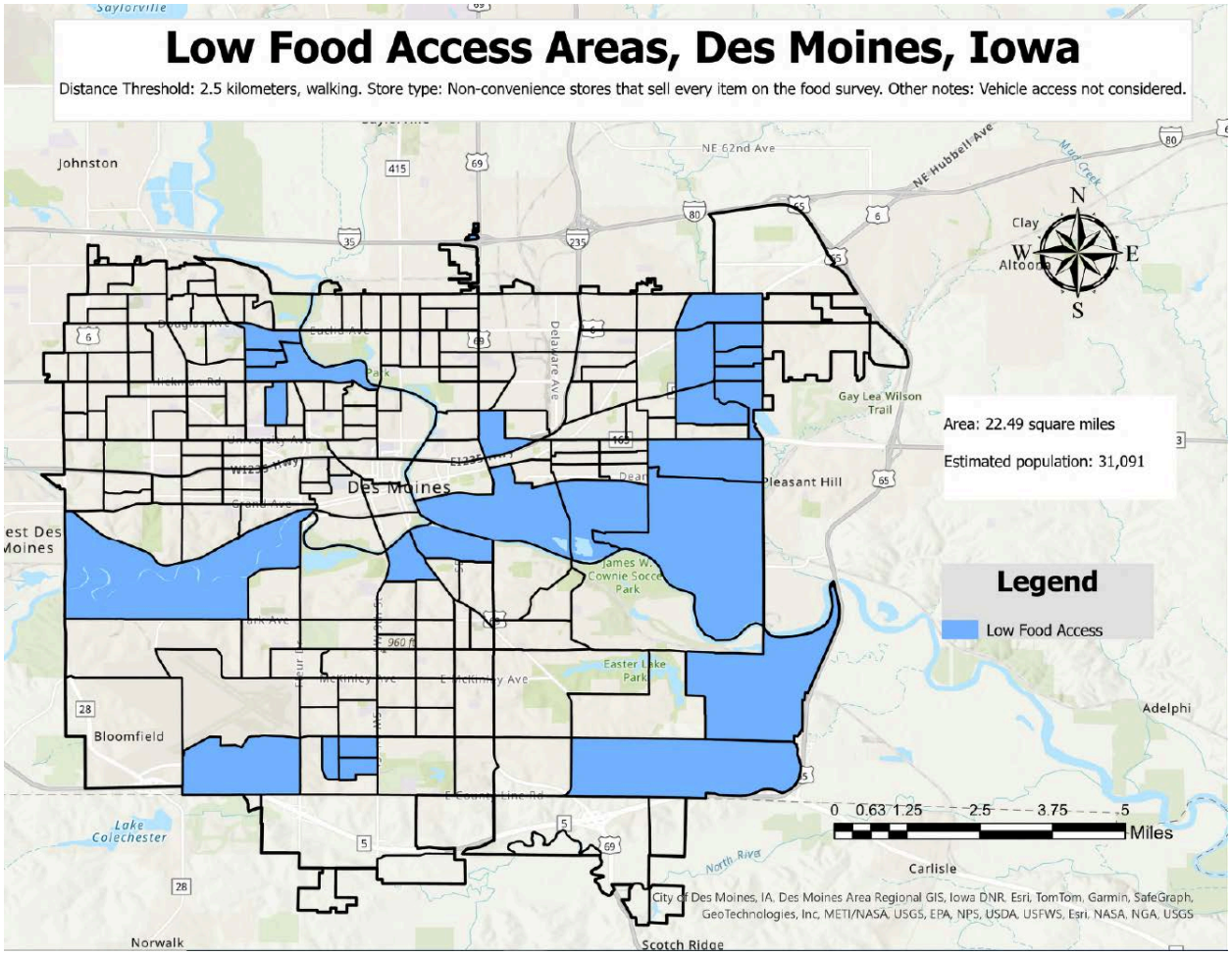
Map 59: **Areas of low food access using a distance threshold of 2.5 kilometers walking.** The food retailer configuration was all non-convenience stores that sold every item on the food survey. The area of low food access had an area of 4.83 square miles and an estimated population of 14,126. Using this method reduced the size of the area by 53.9 percent and the estimated population by 68.2 percent from the baseline food retailer configuration of only major supermarket chains.



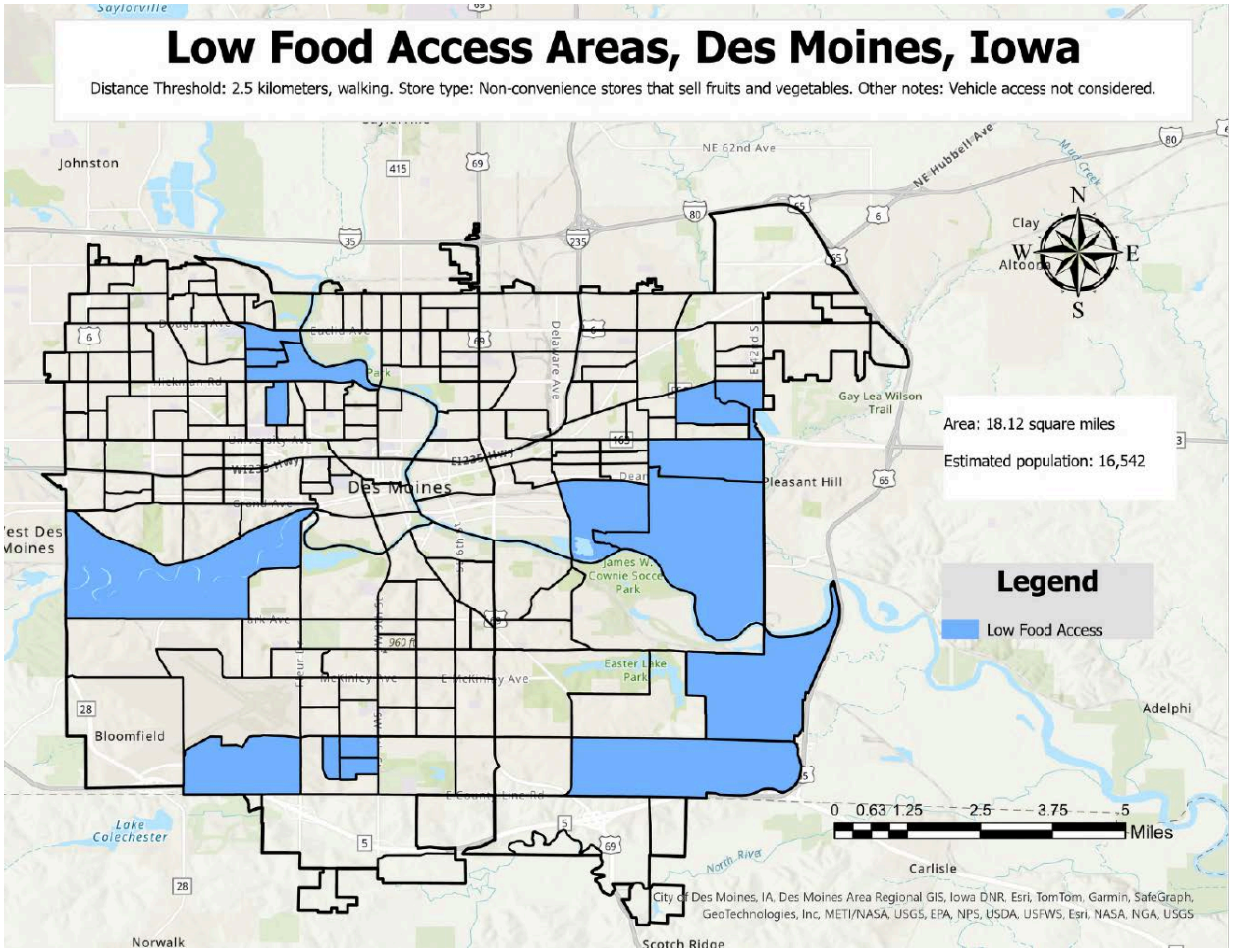
Map 61: **Areas of low food access using a distance threshold of 2.5 kilometers walking.** Vehicle access was not considered in this analysis. The food retailer configuration was major supermarket chains, including Hy-Vee, Fareway, ALDI, Wal-Mart and Target. This group of stores was used as a baseline for comparison to other groups using this distance measurement. The area of low food access had an area of 28.81 square miles and an estimated population of 65,842.



Map 62: **Areas of low food access using a distance threshold of 2.5 kilometers walking.** Vehicle access was not considered in this analysis. The food retailer configuration was all stores that sold every item on the food survey. The area of low food access had an area of 20.8 square miles and an estimated population of 23,076. Using this method reduced the size of the area by 27.8 percent and the estimated population by 64.9 percent from the baseline food retailer configuration of only major supermarket chains.



Map 63: **Areas of low food access using a distance threshold of 2.5 kilometers walking.** Vehicle access was not considered in this analysis. The food retailer configuration was all non-convenience stores that sold every item on the food survey. The area of low food access had an area of 22.49 square miles and an estimated population of 31,091. Using this method reduced the size of the area by 21.9 percent and the estimated population by 52.7 percent from the baseline food retailer configuration of only major supermarket chains.



Map 64: **Areas of low food access using a distance threshold of 2.5 kilometers walking.** Vehicle access was not considered in this analysis. The food retailer configuration was all stores that sold fresh fruit and vegetables. The area of low food access had an area of 18.12 square miles and an estimated population of 16,542. Using this method reduced the size of the area by 37.1 percent and the estimated population by 74.8 percent from the baseline food retailer configuration of only major supermarket chains.

Table 2: **Results from Des Moines**

Name	Distance	Store Category	Square Miles	Population
Map 1	1 mile, driving	Chain Supermarkets	15.7	63007
Map 2	1 mile, driving	Perfect food score	11.81	43275
Map 3	1 mile, driving	non-convenience, 100 FS	12.37	45985
Map 4	1 mile, driving	Non-convenience stores that sell fruits and vegetables	8.2	30747
Map 5	0.5 mile, driving	Chain Supermarkets	17.32	69587
Map 6	0.5 mile, driving	Perfect food score	15.35	57983
Map 7	0.5 mile, driving	non-convenience, 100 FS	15.89	60681
Map 8	0.5 mile, driving	Non-convenience stores that sell fruits and vegetables	11.89	49124
Map 9	0.25 mile, driving	Chain Supermarkets	18.34	72928
Map 10	0.25 miles, driving	Perfect food score	18.34	72928
Map 11	0.25 driving	non-convenience, 100 FS	18.34	72928
Map 12	0.25 driving	Non-convenience stores that sell fruits and vegetables	18.34	72928
Map 13	1 mile driving, low income only	Chain Supermarkets	39.59	102657
Map 14	1 mile driving, low income only	Perfect food score	34.69	75500
Map 15	1 mile driving, low income only	non-convenience, 100	35.53	80196

		FS		
Map 16	1 mile driving, low income only	Non-convenience stores that sell fruits and vegetables	29.69	59599
Map 17	1 km, walking	Chain Supermarkets	17.09	67427
Map 18	1 km, walking	Perfect food score	14.23	53876
Map 19	1 km, walking	non-convenience, 100 FS	14.79	56586
Map 20	1 km, walking	Non-convenience stores that sell fruits and vegetables	11.21	44765
Map 21	1 km, walking, no vehicles	Chain Supermarkets	44.84	119770
Map 22	1 km, walking, no vehicles	Perfect food score	40.48	104243
Map 23	1 km, walking, no vehicles	non-convenience, 100 FS	41.04	106953
Map 24	1 km, walking, no vehicles	Non-convenience stores that sell fruits and vegetables	36.54	91498
Map 25	2.5 km, walking	Chain Supermarkets	10.49	44446
Map 26	2.5 km, walking	Perfect food score	4.27	11416
Map 27	2.5 km, walking	non-convenience, 100 FS	4.83	14126
Map 28	2.5 km, walking	Non-convenience stores that sell fruits and vegetables	1.91	6141
Map 29	2.5 km, walking, no vehicles	Chain Supermarkets	28.81	65842
Map 30	2.5 km, walking, no vehicles	Perfect food score	20.8	23076
Map 31	2.5 km, walking, no vehicles	non-convenience, 100 FS	22.49	31091
Map 32	2.5 km, walking, no vehicles	Non-convenience stores that sell fruits and vegetables	18.12	16542

Chapter Five: Discussion

The results of this project join other studies highlighting the stark disparities that different measurement techniques for identifying areas of low food access can produce (Bilkova et al. 2009, Jaskiewicz et al. 2016, Leete et al. 2012, Teigen De Master and Daniels 2019). The size of areas of low food access broadly fluctuated as variables were removed or changed. Reductions of up to 100 percent in both size and population were observed with certain configurations of the variables. Unsurprisingly, low food access areas grew as the distance threshold increased or when variables such as vehicle access were no longer considered. Conversely, the areas shrank as more food retailers were added to the analysis. Given that all the variables and distance thresholds used in the project came from published studies, this casts doubt on the effectiveness of these variables to identify areas of low food access.

A unified definition

This project showcases the importance of a unified definition of how to identify areas of low food access (Leete et al. 2012). Standardizing the methodology would allow studies and areas of low food access across cities and communities to be compared, and give a reliable baseline for policymakers to target areas for food access mitigation measures. The research community surrounding this issue would be well-served to reach a consensus on how far a house or neighborhood must be from a food retailer to be deemed as having low food access. Other factors that should be

included involve the definition of low-income, whether vehicle access is considered, and what constitutes a healthy food retailer.

One of the main purposes of this study was to use on-the-ground observation to determine the abundance of healthy food offered in the study areas, similar to other studies (Teigen De Master and Daniels 2019, Lloyd, S. et al. 2011, LeClair and Aksan 2014). This fieldwork brought smaller food retailers, convenience stores and ethnic food into the analysis and significantly changed the shape and size of identified areas of low food access. In Waterloo, a combination of food stores that sold both fruits and vegetables, along with certain distance thresholds, yielded no areas identified as low food access. In Des Moines, configurations of food retailer types and distance threshold showed size and population reductions of almost 80 percent.

Given this result, it could be tempting to say that there are no food deserts in Waterloo or Des Moines. But such a conclusion sets aside many of the reasons researchers use only large food retailers in their analysis. Although some studies have shown that small, full-service food retailers meet many of the criteria for community food security by providing a wide variety of relatively low-cost foods (Short et al. 2007), other studies have noted that major chain supermarkets are more likely to be able to supply the range of foods at the core of a healthy diet (Leete et al. 2012, Coveney and O'Dwyer 2009). Studies excluding small grocery stores have also cited research that these stores possess a high degree of variability in the variety and quality of their merchandise (Caspi et al. 2012). These differences highlight the importance of a consensus on the definition of an area of low food access. Should we celebrate the smaller retailers bringing healthy food into an area otherwise bereft of that option? (Get

rid of the question) Or are we telling certain areas to only be happy with “good enough,” where they have access to some healthy food, but lack the degree of choice, price or quality present in other areas. These questions only increase in importance when considering research suggesting that healthy foods may be more expensive, and more difficult to obtain, in lower income areas compared with more affluent areas (Coveney and O’Dwyer 2009).

A consensus must also be reached on whether vehicle access should be considered in food access analysis. Some studies on food deserts include vehicle access (Chen and Clark 2016, O'Dwyer and Coveney 2006, Teigen de Master and Daniels 2019), while others did not (Caspi et al. 2012). The USDA’s Food Access Research Atlas has an option to include vehicle access in the output, but also has options that don’t include the variable. Studies have found that vehicle access is one of the most crucial barriers preventing lower income individuals from accessing healthy food and could be more important to alleviating low food access than even the proximity of healthy retailers (Wright et al. 2016). This project has demonstrated that the exclusion of vehicle access can substantially increase areas of low food access. Simply removing vehicle access as an analysis consideration increased the size and estimated population of low food access areas in Waterloo from 1.7 square miles and 7,619 people to 19.03 miles and 22,834 people, when using 2.5 kilometers in walking distance as a threshold. This is an enormous difference from the perspective of policymakers looking to allocate and target resources to mitigate food insecurity.

A consensus on a definition of how to measure areas of low food access doesn’t stop at vehicle access. How low-income areas are identified is also critical. This project

used poverty rate and income level to determine low-income areas. But other researchers have used a variety of different proxies for economic disadvantage including unemployment rate, percentage of residents with low levels of education or presence of single-parent or immigrant households (Leete et al. 2012). Another important variable to consider along economic lines is the cost of groceries, which this project did not consider. Research has shown that classifying supermarkets by cost clearly changed the identification of areas of low food access (Jiao et al. 2012).

Quality over quantity

Beyond the issues with changing variables and methodology, maps of food access also run into issues with the data itself. Studies in the field of food access generally rely on census data and census boundaries - either tracts, blocks or block groups - to define the borders of areas of low food access. But even block groups, the smallest geographic area the census defines, which were used in this project, are too large to broadly label as areas of low food access. A block group defined as meeting the criteria for low food access likely has households that don't meet that criteria. And, more importantly, households in areas that don't meet the criteria for having low food access, and hence would not be included in any map, could still have issues accessing healthy food. These households could be left with fewer resources to combat the challenge of food access (Leete et al. 2012).

This project used quantitative techniques to identify areas of low food access. But to fully understand where households suffering from this issue reside, qualitative

techniques, on individual households, need to be employed to fully understand the food-access landscape of neighborhoods and cities. The factors a household considers when making food purchasing decisions are simply too varied to be summarized within census designations. These factors differ not from block group to block group or even city block to city block. They could differ on a house-by-house basis. So, to then parse out certain variables and use them to identify broad areas as food deserts is not a valid approach to addressing the topic of food insecurity.

There have been some studies that have included qualitative techniques, which have yielded compelling results. One study found that people who perceived to live within walking distance of a supermarket ate more fruits and vegetables than those who indicated they did not live within walking distance of a supermarket. This finding could suggest that distance is a factor in people's decisions on where to purchase food (Caspi et al. 2012). Another qualitative study yielded challenges to food shopping that are often left out of food desert research. These included the quality of footpaths on the way to the store, how crossing streets can be difficult, and how having small children can make shopping challenging (Coveney and O'Dwyer). These findings suggest there could be significant contributing factors in a person's journey to the grocery store that aren't reflected in the most common variables used in food access analysis.

The next steps

Future studies on areas of food access should include a qualitative component. But they should also include aspects that were missing from this project. The cost of

groceries should be taken into account, as should other forms of transportation, such as buses and bicycles. A next step of analysis could also attempt to account for a limitation in food desert mapping noted in other studies - that food deserts reduce food accessibility to a binary - either a region is a food desert or it is not (Widener 2018). Since food deserts are mapped using some sort of boundary, be it census tracts, block groups or ZIP codes, this can lead to a Modifiable Areal Unit Problem (Hutton 2022). As an example, a neighborhood just across the border from an identified food desert might be excluded from the analysis because its particular geographic unit does not contain the necessary attributes (i.e. low-income or low vehicle access) to be considered as an area of low food access.

Chapter Six: Limitations

There were several limitations on this project. The first, mentioned in the discussion, is that the cost of groceries were not considered in the analysis. Other studies have highlighted the importance that price has on food-purchasing decisions, and it is unknown how the inclusion of cost as a variable would change the measurements of areas of low food access.

Another issue stems from the binary of using city boundaries - a block is either in or out as an area of low food access. This is problematic because both study areas, Waterloo and Des Moines, exist contiguously within a larger metropolitan area. So, it's possible that census block groups along the border of the city boundaries are within the specified distance of a healthy food retailer located in surrounding areas, such as West Des Moines or Cedar Falls. This could potentially affect what areas along the city boundary borders are included as areas of low food access.

Finally, it's possible that the list of food retailers used in this project are inaccurate or incomplete. While conducting the food survey, some food retailers would be observed that were not included in the list generated with Standard Industrial Classification (SIC) code. When this occurred, those stores were added to the analysis. So, it's possible some stores exist in both communities that were not included in the analysis. These omissions were likely due to limitations or missing data in the SIC code database used to generate the food retailer list for this project.

Chapter Seven: Conclusion

This project used a variety of distance threshold and food retailer groupings to identify a wide configuration of possible areas of low food access in both Waterloo and Des Moines. The project also demonstrated that on-the-ground research on the availability of groceries in stores throughout a community can increase the understanding of the food landscape and impact which areas are defined as food deserts in analysis. The size, in both land area and population, of areas of low food access identified in this study varied greatly depending on the variables included or excluded. Such variation will hopefully prompt discussion on the utility of food desert identification techniques in the world of policymaking, and engage stakeholders and research to delve into questions of how to make the techniques for identifying areas of low food access more consistent and accurate.

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