Abstract:

Efforts to encourage Americans to improve their diets and to eat more nutritious foods presume a wide variety of these foods are accessible to everyone. But for some Americans and in some communities, access to healthy foods may be limited. Policies to improve access to healthful foods have been implemented at Federal, state and local levels of government. Past research has focused on ways to determine whether and what portions of the population experience limited access to healthful food, but very few studies have attempted to estimate food access for the entire nation. This paper describes refined methods for measuring food access on a national level and for specific population characteristics. It also provides updated estimates of the number of people in the U.S. with limited access to healthy and affordable food. Population data from the 2010 Decennial Census, income and vehicle access data from 2006-2010 American Community Survey, and a 2010 composite list of supermarkets were used. Distance to the nearest supermarket has not changed greatly for the population since 2006. New estimates also show that half of the U.S. population lives within 2 miles of three supermarkets, with a median distance to the third nearest supermarket of 1.9 miles.
Introduction and Background

Efforts to encourage Americans to improve their diets and eat more nutritious foods presume a wide variety of these foods are accessible to everyone. But for some Americans and in some communities, access to affordable healthy foods may be limited. If healthy foods can only be obtained with great effort, those affected by poor access may have poorer diets and higher rates of diet-related disease such as obesity and diabetes. The costs and effort required to access healthful food may also contribute to food insecurity if a household has to spend scarce budget and time resources traveling to a store that sells healthy food. And the lack of full-service stores in some neighborhoods may also make participation in the Supplemental Nutrition Assistance Program less attractive, since it is more difficult to redeem benefits.

Upon request from Congress in 2009, the Economic Research Service of the USDA published a report that estimated the extent of food access limitations in the U.S., reviewed literature and conducted analyses on the effects of food access on food choices and health, studied the causes and consequences of food deserts, and outlined policy options and future research (USDA, 2009) (See: http://www.ers.usda.gov/Publications/AP/AP036/). After the release of this report, ERS also worked with an interagency working group composed of staff from USDA, Health and Human Services, and Treasury to develop a census tract-level definition of food deserts in order to start identifying areas of the Nation that may be in need of improved food access.¹ ERS also developed the Food Desert Locator

¹ This definition defines food deserts as low-income census tracts where a substantial number or share of residents has low access to a supermarket or large grocery store. Tracts qualify as a “low-income” if they have either a poverty rate of 20 percent or higher or a median family income at or below 80 percent of the area’s median family income. Low-access is defined as more than 1 mile from a supermarket or large grocery store in urban areas and as more than 10 miles from a supermarket or large grocery store in rural areas.¹ Distances to supermarkets and large grocery stores are measured using the distance between the geographic center of the 1-km square grid cell and the nearest supermarket or large grocery store. To be considered a food desert tract, at least 33 percent of the tract population or at least 500 people in the tract must have low access to a supermarket or large grocery store.
(http://www.ers.usda.gov/Data/FoodDesert/index.htm), an on-line mapping tool that presents a spatial overview of the location of food desert census tracts and selected characteristics of the population in food desert tracts (ERS, 2012a).

The estimates from the USDA 2009 report and the Food Desert Locator both use population data from the 2000 Census of the Population and store location data from 2006. The purpose of this study is to update and expand the analysis in USDA 2009 with more recent data from the 2010 Census of the Population, the 2006-2010 American Community Survey, and an updated list of stores from 2010. The analysis in this study is important because the past decade has seen substantial changes in population characteristics such as an aging population, migration and immigration, and wide swings in the economic well-being of households as the U.S. economy expanded and contracted. Food retail store development has also changed responding to market, population and economic conditions.

This paper updates estimates of the number and percentage of people with food access limitations across selected population characteristics that were in the 2009 Report to Congress (USDA, 2009). The rest of this paper is structured as follows. The next section reviews the recent literature on food access, with a particular focus on estimates of food access in the U.S. as they have changed since the 2009 USDA report. Following that is a section describing the data, methods and definitions used to update measurements of food access limitations. Estimates of indicators of food access for the population overall and for subpopulations as first reported in USDA (2009) are then presented. These indicators describe overall population trends between 2000 and 2010 and trends in grocery and food retail, updated estimates of access to food retailers, new measures of food retail access for Alaska and Hawaii, and measures of access to a
variety of food stores. The paper concludes with a summary and discussion of future directions for research.

**Literature Review**

USDA (2009) provided the first national-level estimates of the extent to which people and neighborhoods faced limitations accessing healthy and affordable food. It included several novel methods for characterizing food access across the nation that built upon a sizable literature on food access limitations, almost all of which were from studies of local areas. Since the report’s release, several other studies have estimated food access limitations. This section reviews the recent national-level literature on the measurement of food access limitations.

We do not review literature on the relationship between food access and diet. As part of the 2009 USDA report, ERS sponsored a 2-day workshop at the Institute of Medicine (IOM) and the National Research Council (NRC) to explore, review and discuss the literature on the relationship between food access and diet and health (IOM and NRC, 2009). At the time of the IOM/NRC workshop, many studies had found an association between the level of access to healthy food and diet and health outcomes (see Larson et al., 2009). However, almost all of these studies used cross-sectional data and methods that cannot discern whether food access had a causal role in determining diet and diet-related health. Since then, studies that use longitudinal data and other methods to tease out cause and effect have been published. Findings from one study that examined diet quality did not show an affect of access to healthy food retailers and supermarkets in particular (Boone-Heinonen et al., 2011). Evidence with respect to body mass index (BMI) and obesity showed mixed results--two longitudinal studies showed no effect of supermarket access on BMI and obesity (Block et al., 2011; Boone-Heinonen et al., 2011), while
Methods and Findings in the 2009 USDA Assessment

The majority of estimates of food access measure the level of access in an area or neighborhood--what we call area-based measures of access.\(^2\) Area-based measures make sense in the context of research that tries to understand how the food environment affects diet and related health outcomes. Area-based measures can also indicate the degree to which the problem of limited access is concentrated, which is useful for determining which types of policies should be considered in order to reduce the impact of limited access. But area-based measures often infer that everyone in the same area has the same access to healthy food. In reality, there is heterogeneity in access for individuals within an area. That is, individuals have different resources available to them--income, vehicle ownership, social and family networks, and time--and these differences in resources are likely to translate into differences in access.

A key innovation of the USDA 2009 report was that it included both individual and area-based measures of access on a national level. One key area-level measure from the report estimates that 23.5 million people or 8.4 percent of the U.S. population live in low-income neighborhoods that are more than one mile from a supermarket or large grocery store. This is a typical area-based measure in the food access literature, which often focus on low-income neighborhoods because they contain higher concentrations of residents who are likely to have the most difficulty accessing stores. Neighborhoods are, however, heterogeneous—not all low-

\(^2\) See Ver Ploeg and Breneman (2012), Box 1 and Box 2, for a summary of the types of measures of food access that have been implemented in the literature.
income people live in low-income neighborhoods and not all people who live in low-income neighborhoods have low-incomes. Further, almost all households that are far from a supermarket have access to personal vehicles, which is likely to be a good indicator of individuals’ access to food stores. USDA (2009) estimates that 2.3 million, or 2.2 percent of all households, are more than a mile from a supermarket and do not have access to a vehicle. An additional 3.4 million (3.2 percent) are between one half-mile to 1 mile from a supermarket and without a vehicle.

USDA (2009) also estimated self-reported food access barriers from direct questions on food access from the 2001 Current Population Survey. Responses to these questions show that nearly 6 percent of all U.S. households did not always have the food they wanted or needed because of access-related problems. Another innovation of the 2009 USDA report was that it matched data from the American Time Use Survey (ATUS), a nationally representative sample of households that recorded information on time use to census tract-level information on the distance to the nearest supermarket to understand differences in time use and travel modes for grocery shopping trips. Estimates based on these data show that people living in low-income areas more than a mile from the nearest supermarket spent more time traveling to a grocery store (19.5 minutes) than the national average (15 minutes).

Based on these different estimates, USDA (2009) concluded that between 2 to 5 percent of households and about 4 to 8 percent of the population indicated some difficulty in accessing healthy food.

A methodological innovation in the USDA (2009) report was to use 1 kilometer-square grid estimates of population characteristics to measure distance to supermarkets for population subgroups. The report used Socioeconomic Data and Applications Center (SEDAC) population data from the 2000 Census of Population (SEDAC, 2006). These data provide two important
benefits for the analysis. First, they give better estimates of where people and households are located than data on larger geographic areas, such as census tracts. Second, the process of allocating census data to 1-square-kilometer grid cells transforms the irregular shapes and sizes of census geographies into regularized grid cells, providing for faster spatial computation needed for national-level analysis. The updated analysis in this report uses a similar process to allocate more recent population data to the one half-kilometer-square grid level which allows for even greater precision in measuring distance.

**Food Deserts Definition and Food Desert Locator**

The 2009 USDA report did not specifically identify areas as food deserts. Further, while the 1-km square grid based measures increase precision in measuring how far people are from grocery stores and provide consistency in defining geographic areas across the country, they are not widely used geographic units. Instead, ERS worked with the interagency working group to develop a definition of food deserts using census tracts as the geographic unit of analysis. This definition defined food deserts as low-income census tracts where a substantial number or share of residents has low access to a supermarket or large grocery store. Tracts qualify as a "low-income” if they have either a poverty rate of 20 percent or higher or a median family income at or below 80 percent of the area's median family income. Low-access is defined as more than 1 mile from a supermarket or large grocery store in urban areas and as more than 10 miles from a

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3 The grids were still used to measure how far people are from stores, which was then aggregated at the tract level.
5 This definition of low-income is used by the New Markets Tax Credit (NMTC) program. NMTC is a program run by Treasury that permits taxpayers to receive a credit against Federal income taxes for making qualified equity investments in designated Community Development Entities. Tracts are designated as NMTC eligible if they meet either a low-income definition based on poverty rates or if the tract median income is below an area median income threshold.
supermarket or large grocery store in rural areas. Distances to supermarkets and large grocery stores are measured using the distance between the geographic center of the 1-km square grid cell and the nearest supermarket or large grocery store. To be considered a food desert tract, at least 33 percent of the tract population or at least 500 people in the tract must have low access to a supermarket or large grocery store.

Application of these criteria results in 6,529 tracts (or about 10 percent of all tracts) in the continental U.S. meeting the definition of a food desert—roughly 75 percent of which are urban and 25 percent rural. A total of 13.6 million people or 4.9 percent of the total 2000 U.S. population, with limited access live in these tracts. These tracts can be mapped at: http://www.ers.usda.gov/data/fooddesert/.

Other National Measures of Food Access

Several other national-level measures of food deserts have been developed recently. These measures use a variety of techniques and are utilized for different purposes, but all have noteworthy innovations. Ver Ploeg and Breneman (2012) review and critique these methods in detail.

The Reinvestment Fund (TRF), a Philadelphia area community development organization that finances neighborhood revitalization, developed a national-level measure of low access areas (LAA’s) and a tool to map these areas (http://www.trfund.com/). LAAs are clusters of census block groups where residents are relatively farther from supermarkets than high-income block groups that are otherwise similar in terms of population density and car ownership rates (The

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4 For this analysis, tracts were considered rural if the centroid of that tract is located in an area with a population of less than 2,500. All other tracts are considered urban tracts.
Reinvestment Fund, 2011). To more fully characterize the extent to which LAAs are
underserved by supermarkets, estimates of the amount of grocery leakage, which is the
difference between estimates of grocery demand in the LAA and the amount of grocery sales in
the LAA, are estimated. Based on these methods, TRF estimates that 23 million people or 8.7
percent live in Low Access Areas.

The CDC’s Healthy Tracts measure, published in the 2009 State Indicator Report on Fruit
and Vegetables (CDC, 2009), takes a census tract-based approach. The Healthy Tracts measure
considers a census tract healthy if there is a healthy food retailer within one half-mile of the tract
boundary. A healthy food retailer is one that typically carries fruits and vegetables—
supermarkets, large grocery stores, warehouse clubs and fruit and vegetable markets. The state-
level indicator is the percentage of state census tracts containing healthy food retailers.
Nationally, 72 percent of census tracts contained at least one healthy food retailer within the tract
or one half-mile of its border.

ESRI, a private company that provides geographic information systems (GIS) software
and consulting services has also developed area-based measures of food access. Supermarket
walking (number of supermarkets within a one-mile walking distance) and supermarket driving
scores (number of supermarkets within a 10-minute drive) of neighborhoods were developed
(Richardson, 2010). An innovation of the ESRI method is to use network distance instead of
Euclidean (straight-line) distance, which accounts for the distance one would have to drive or
travel from one destination to another using existing roadways and walkways. Based on the
score, the study finds that 20 percent of U.S. households have poor access to healthy food.

In 2011, the Food Research Action Center (FRAC) sponsored a question on the Gallup-
Healthways Well-Being Index project for a large nationally-representative sample: “In the city
or area where you live, is it easy or not easy to get affordable fresh fruits and vegetables?” (FRAC, 2011). Just over 8 percent of households reported that they did not have easy access to affordable fresh fruits and vegetables. The responses to this question provide a useful indicator of affordability and access to one kind of healthy food. But the question is problematic for understanding access limitations because it conflates affordability and access--it is not possible from the responses to distinguish between a household that has difficulty affording fresh fruits and vegetables regardless of their level of access and a household that has difficulty accessing retailers that sell fresh fruits and vegetables.

Data, Definitions and Methods

The overall data and methodological strategy used to estimate food store access and food deserts for this paper are quite similar to those used in USDA (2009). However, some enhancements to data and methods were implemented. This section describes the methods used to estimate population-level food store access using 2010 data. We discuss where and how current methods diverge from those used in USDA (2009).

2010 Store Directory Development

The methods used to develop a 2010 directory of stores selling healthful, affordable food are similar to those used in USDA (2009). Two lists of stores were combined: a list of stores authorized to accept SNAP benefits and a list of stores from Trade Dimensions TDLinx®, a proprietary store directory. Each source provided the store name and address from which geo-coded location coordinates (latitude and longitude) were derived to measure distance from the
center of each grid cell to the nearest store. In total there were 39,877 stores in the 2010 merged directory. The majority of stores in the merged list were in both data sources—28,693. Of the remaining stores, 7,195 were only found in the TDLinx list and 3,989 were only found in the SNAP store list. Details on how these data sources were merged to provide a comprehensive national listing can be found in Appendix A.

The combined directory includes only retail food stores that offer a full range of food products including fresh meat and poultry, produce, dairy, dry and packaged foods, and frozen foods and that have at least $2 million or more in annual sales.5 Stores meeting these criteria were assigned to one of three store types: supercenters—large stores usually 100,000 square feet of floor space in size, with a separate grocery area and general merchandise area under a single roof; supermarkets—stores that are typically smaller than a supercenter and that primarily sell food and non-food grocery products; and large grocery stores—smaller stores that sell a full range of foods, with annual sales of $2-$4 million.6 Throughout the rest of this report, we use the general term “supermarket” to refer to this combined list of all three types of stores.7

In both the 2006 and 2010 ERS store directories, military commissaries—whose size and product offerings are comparable to supermarkets—were excluded because they are only available to active-duty military personnel. Similarly, warehouse club stores—such as Costco, BJ’s, and Sam’s Club—were also excluded because a membership fee is required.

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5 The sales and product offering criteria follow established retail food industry standards used to define a supermarket.
6 The combined directory used in USDA (2009) also included these three types of stores, however, separate estimates of store numbers and types were not presented.
7 There are a couple of exceptions to this in tables where the types of stores are broken out separately.
Population Data

This analysis utilizes population data from the 2010 Census of the Population and the 2006-2010 American Community Survey (ACS). We draw total population, age, race and ethnicity data at the block level from the 2010 Census. We use 2006-2010 ACS data for tract-level poverty rates, as well block-group level data on income-to-poverty ratios and vehicle availability.

The ACS is an on-going survey that replaced the Census long form after 2000 and asks similar questions, relying on monthly, independent samples to collect data for small areas (i.e. census tracts and block groups) in both the US and separately for Puerto Rico. By producing 1-year, 3-year, and 5-year estimates, the ACS provides more continuous measurement than the decennial Census. For each survey year, approximately 3 million households and 2.5 percent of the expected residents of group quarters are sampled, with a slightly higher sampling rate for group quarters in 16 states with particularly small group quarters populations. Data is published in multi-year estimates of 5 years and 3 years on a rolling basis, as well as for single-year estimates. Five-year estimates are intended to replace the long form of the decennial Census and thus include data for all statistical, legal and administrative geographies for the most recent five years of data collection; 3-year estimates are released for geographies of 20,000 residents or more; and 1-year estimates are provided only for entities with a population of 65,000 or greater. The data collection process lasts for three months for each sample and includes data collection by mail, phone, and personal interview. The process operates in continuous cycles so that, at any given time, multiple samples are in different phases of data collection (US Census Bureau, 2009).
We use the 2006-2010 5-year data, which is the most recent data available at the smaller levels of geography required for a detailed analysis. In 2010, the ACS covered 99.1 percent of all households and 81 percent of all group quarters populations, to reflect approximately 94.6 percent of the U.S. population. The response rates from 2006 through 2010 were 97.5 or higher. For our analysis, all data are taken at the smallest geographic area that is available to minimize error involved in downcasting the data to half-kilometer-square grid cells.

**Downcasting Population Data to Half-kilometer Square Grids**

A methodological innovation in USDA (2009) was to use 1 kilometer-square grid estimates of population characteristics to measure distance to supermarkets for population subgroups. The report used Socioeconomic Data and Applications Center (SEDAC) population data from the 2000 Census of Population (SEDAC, 2006). These data provide two important benefits for the analysis. First, they give better estimates of where people and households are located than data on larger geographic areas, such as census tracts. Second, the process of allocating census data to grid cells transforms the irregular shapes and sizes of census geographies into regularized grid cells, providing for faster spatial computation needed for national-level analysis. The updated analysis in this report uses a similar process to allocate more recent population data to the one half-kilometer-square grid level which allows for even greater precision in measuring distance. Further details of this downcasting method can be found in Appendix A.
Measuring Distance and Other Indicators of Food Store Access

In measuring access to affordable, nutritious food, we consider distance measures in addition to socio-economic characteristics that are likely to play a role in food access. Distance to the nearest supermarket or large grocery store is used as the primary measure of access. For each half-kilometer grid cell, we calculate the Euclidean distance from the geographic center of the cell to the geographic center of the cell with the nearest supermarket or large grocery store. Using this calculation, we present estimates of the population living less than one-half mile, between one half-mile and one mile, and greater than a mile from the nearest supermarket. In estimates that separately consider urban and rural areas, a separate categorization of access is used for rural areas. This categorization considers those within 10 miles, those between 10 and 20 miles, and those 20 or more miles away from the nearest supermarket.

Distance-based measures of access are estimated on a national level and across subgroups of the population--by income level, race and ethnicity, age, and household vehicle ownership. Note, in the first results section, which updates estimates from USDA (2009), individuals are considered low-income if their family income is at or below 200 percent of Federal poverty thresholds for family size and areas (grids) are considered low-income if more than 40 percent of the grid population has income at or below 200 percent of the poverty level.

Additionally, we consider access differently in rural areas than in urban, due to differences in population density and development between these types of places. The Census defines urban clusters and urban areas to distinguish urban from rural places. Urban clusters are densely developed territories with at least 2,500 people but fewer than 50,000. Urban areas are

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8 Precisely, vehicle ownership is measured for occupied housing units, and considers any car, truck or van of 1-ton-load capacity or less as a vehicle.
the most densely-developed of urban geographies, with 50,000 or more people. Areas not meeting the urban cluster or urban area definition are considered rural.

**Changes in Population Characteristics**

Changes in the total U.S. population and in the macro-economy may affect estimates of food access limitations. The total population of the U.S. grew by 9.7 percent between 2000 and 2010, up from 281.4 million to 308.7 million (Mackun and Wilson, 2011). There was also a large swing in the health of the national economy between 2000 and 2010 (precisely, in 2006-2010 which is the time period over which the income data were collected). In 2000, the economy was very strong and real household income levels were at all time high levels (DeNavas-Walt et al., 2011). The decade since 2000 saw one modest recession that began in late 2001 and one severe recession that began in late 2007 and continued through most of 2009. Over this period, real household income was largely stagnant, fell substantially as the 2007 recession hit, and has continued to fall from the peak in 2000 (DeNavas-Walt et al., 2011). Falling incomes will mean that more people are poor and that there are more poor neighborhoods. The poor economy could also mean fewer grocery stores nationwide, because consumers have less money to spend on food and thus some stores lose profits and subsequently close. Both overall food expenditures and at-home food expenditures fell between 2008 and 2009.

Table 1 offers insight into income distribution in the United States and how the income distribution of the population has changed since 2000. Individuals are defined as low-income if the income of the family in which they live is below 200 percent of the Federal poverty threshold
given family size. Comparing numbers from the 2000 Decennial Census and the 2006-2010 American Community Survey, the percent of the population classified as low-income has increased from 28.8 percent to 31.9 percent. Nearly all of the increase has taken place in urban areas. The percent of low-income people in urban areas rose from 28.5 percent in 2000 to 32.7 percent in 2006-2010. Meanwhile, the percent low-income in rural areas remained constant at 29.6 percent.

We are also interested in the income characteristics of the neighborhoods where people live. Low-income areas are defined as areas where more than 40 percent of the population has income at or below 200 percent of Federal poverty thresholds. Over the past decade, the percent of the population residing in low-income areas has increased from 25.5 percent to 31.4 percent. Again, in urban areas the increase has been more dramatic, rising from 26.1 percent to 33.7 percent. This is in contrast with the relatively smaller increase in rural areas (23.6 to 25.2 percent).

The concentrations of low-income residents in both rural and urban areas have grown more pronounced over the past several years. Low-income individuals represent a larger share of the population of low-income areas, overall and in both rural and urban areas, in 2010 when compared to 2000, which is not surprising given the recession of 2007-2009.

While the study of food access generally does not concentrate on moderate and high-income areas, there are some interesting trends evident in the income characteristics of individuals living in these areas. In general, when compared with low-income areas, moderate and high-income neighborhoods tend to be more homogenous in terms of resident income level. In both 2000 and 2010, and across rural and urban areas, moderate or high-income households comprise over three-quarters of the residents in moderate- and high-income neighborhoods. In
urban areas, the concentration has become slightly less pronounced, with the percentage of residents with moderate or high income falling from 79.5 to 77.9 percent. In rural areas the opposite is true, with the percent rising from 76.6 to 77.4.

The demographic characteristics presented here are consistent with characteristics reported in USDA (2009) (Table 2). In 2010, about 36 percent of the population is non-minority. This is a larger proportion than the 30.7 percent minority population in 2000. Minorities are overrepresented in low income areas--in both 2000 and 2010, at about 55.5 percent of the population in low income areas in 2010. In moderate and high income areas, the large majority of residents are non-minority, comprising nearly 73 percent of the population in these neighborhoods in 2010 (compared with nearly 78 percent in 2000).

Since 2000, the elderly population age 65 and over has slightly increased as a proportion of the total population, from 12.4 percent to 13.0 percent. This increase is slightly larger in moderate- and higher-income areas, where the elderly population increased from 12.9 percent to 13.8 percent (compared with an increase in low-income areas from 11.2 to 11.4 percent).  

The rows at the bottom of Table 2 provide a summary of vehicle availability for the nation as well as within low income and moderate and high income areas. In 2000, just over one-tenth of households did not have a vehicle. By 2010 that percentage had fallen to 8.8, almost a 15 percent drop. However, as expected, vehicle ownership rates are lower in low income areas. In 2010 over 15 percent of households in low income neighborhoods did not have access to a vehicle, compared with 6 percent in moderate- and high-income areas.

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9 We include these measures since the elderly may face more obstacles in accessing food due to physical mobility restrictions and reduced access to vehicles.
Changes in the Number of Food Stores between 2006 and 2010

The total number of supercenters, supermarkets, and large grocery stores decreased slightly between 2006 and 2010 (Table 3). The number of supercenters and large grocery stores increased, while supermarkets declined in number. The increase in large grocery stores may be due, in part, to our use of better individual store sales data in 2010 for some large grocery stores in the SNAP directory, which were not available in 2006.

The past decades have seen a large growth in the share of grocery shopping at non-traditional grocery stores—supercenters, warehouse clubs, and other stores (Leibtag, 2005) and an increase in the share of Supplemental Nutrition Assistance Program (SNAP) benefits redeemed at superstores (Food and Nutrition Service, 2012).

Despite the rapid growth of supercenters over the past decade, supermarkets still outnumber other types of stores and account for more than three-quarters of the total number of food retailers in our 2010 directory. The share of retailers that are supermarkets is down from almost four-fifths of food retailers in 2006. Large grocery stores were the second-largest store type in 2010. Their share and total numbers increased slightly from 2006, followed by supercenters, whose share and number both grew over the four years.

In low-income areas, the largest proportional increase between 2006 and 2010 was in the number of supercenters, which increased by 353 stores or 49.1 percent from 2006. This was followed by large grocery stores, which grew by 739 stores or 36.5 percent, and supermarkets, which increased by 2,588 stores or 31.6 percent of the total number of supermarkets in 2006.

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10 Comparisons between years are limited to the Continental U.S., due to the lack of store counts by income area for Alaska and Hawaii in 2006. See Table C-2 for 50-State total store counts in 2006 and 2010 and by income area in 2010.
The number of stores in moderate- to higher-income areas has decreased from 2006 to 2010 for each store type.

Comparisons over time of store numbers in low-income and moderate/high income areas are tenuous because the number of low-income areas has increased. Thus, the differences in stores numbers for each of these areas may be attributed more to the income status of an area than to the opening or closing of stores.

**Population-level Estimates of Food Store Access**

**Distance to the nearest supermarket**

The distribution of distance to the nearest supermarket (plotting the cumulative density function (CDF) for the total 2010 population compared with 2006 estimates) illustrates the proportion of the total population in 2010, depicted by the red line, and in 2006, depicted by the blue line, living within a specific distance of the nearest supermarket (figure 1). As the figure shows, the distribution of the population in relation to their distance from the nearest supermarket has not changed markedly since 2006. In both years, though, about 85 percent of the population appears to live within 3 miles of the nearest supermarket, and nearly the entire population lives within 10 miles. This suggests that, while individuals may have moved farther from or closer to a supermarket between 2006 and 2010, the location of the overall population with respect to supermarkets has not changed much.

The distribution of distance to the nearest supermarket for low-income areas compared with moderate/higher income areas shows that for most distances, low-income areas are closer to supermarkets than high income areas (figure 2). For distances of more than 5 miles, the opposite
is true, although differences between low- and moderate/high income areas are small, which reflects the small percentage of the population that lives far from a supermarket. Close to 70 percent of all low-income areas are within one mile of a supermarket compared with about 55 percent of all moderate-/high-income areas. Although low-income areas are close to stores on average, though, it is important to note that some may still be located far from a store.

The income levels of neighborhoods are a general indicator of the resources available in a neighborhood, but neighborhoods are not homogenous. Low-income neighborhoods may contain many residents with higher income and moderate and higher income neighborhoods may contain many residents who are poor. Focusing solely on low-income neighborhoods will miss some households that potentially experience barriers accessing healthy foods.

The cumulative distribution of distance to the nearest supermarket for low-income individuals compared with moderate/high income individuals shows small differences in the distributions of distance to a supermarket between these two populations (figure 3). Those with low income are closer to supermarkets than those with moderate/high incomes for most of the distribution, except at the right tail of the distribution.

**Urban Food Store Access**

Map 1 uses the St. Louis, Missouri area to illustrate supermarket access by population density and for low-income areas. One-mile radius circles are drawn around each supermarket in the area and population density for the half-kilometer-square grids are shown by shading, with lighter areas being less dense and darker areas denser. Low-income half-kilometer-square grids are represented by cross-hatching. The map shows that sections of the middle of St. Louis and in
the northern and northwest parts of the city have densely populated areas outside of one mile from a supermarket. The East St. Louis, Illinois area on the east side of the Mississippi, although less densely populated, also has very large swaths of areas that are low-income and outside of one mile from a supermarket.

**Rural Food Store Access**

Approximately 26.5 percent of the US population is located in rural census tracts as defined by the US Census Bureau. Map 2 shows supermarket access in South Dakota, again using shading to indicate more densely populated areas and cross-hatches to indicate low-income areas. In contrast to the St. Louis map, this map uses 10- and 20-mile radii around supermarkets to indicate access levels. The map shows that significant portions of the state are outside of 20 miles of a supermarket, and that many of these areas are low-income areas. These parts of the state are sparsely populated, but there are still areas with sizable numbers of people far from supermarkets, including some Tribal areas.

**Distance to Three Supermarkets**

Estimates of the distance to the nearest healthy food retailer are useful indicators of the ease of access to one source of healthy food and whether an adequate source of healthy food is available. But this measure alone may not be a good indicator of the price or quality of food in that nearest supermarket, nor whether there are other sources of healthy food just beyond the nearest supermarket or if that supermarket is the only one for miles. For example, if a number of supermarkets are relatively close by, competition on price, quality, and other store amenities is
likely to be greater and consumers are likely to benefit. If a supermarket is the only one nearby, there is likely to be less competition on these attributes. Previous studies have used measures of the distance to 3 supermarkets, supercenters or large grocery stores selling healthy foods in order to capture more of this concept of competition (Apparicio et al., 2007 and Sparks et al., 2009). We estimate the median distance to the 3rd nearest supermarket by population characteristics, first for the whole country and then separately for urban and rural areas (Table 4).

Half the population in the U.S. is within 2 miles of 3 supermarkets. This measure gives some indication of the highly competitive nature of grocery retail in much of the U.S. as many consumers have 3 choices of supermarkets within 2 miles of their home. In urban areas, the median is slightly shorter—1.6 miles—and in rural areas, the median is 6.2 miles.

The same general patterns across subpopulations exist for measures of distance to the nearest 3 supermarkets as they do for the nearest store. However, differences in the distance to the 3 nearest supermarkets between subpopulations are smaller than differences to the nearest supermarkets. Although low-income individuals are on average, 0.3 of a mile closer to the nearest supermarket than higher income individuals, there is less difference in distance to 3 supermarkets and almost no difference in urban areas. Some concern has been raised that using a measure of the distance to the nearest supermarket is a poor indicator of quality and affordability of stores, especially for low-income individuals, where the nearest supermarket may not be as high of quality of a supermarket in higher income neighborhoods or there may be few other options nearby so that prices may be higher at that one supermarket. To the extent that the distance to the nearest 3rd supermarket is an indicator of competition, differences across income levels seem to be minimal.
Conclusions and Future Research

This study used data from the 2010 Decennial Census, the 2006-2010 ACS, and a 2010 composite list of supermarkets to provide more recent population-level estimates of spatial access to supermarkets that reflect recent changes population characteristics, the macroeconomy, and supermarket locations. The study also enhanced estimates of the where populations are located based on projections of these population data to one-half kilometer square grid cells, from which, estimates of distance to the nearest supermarket are made. These enhanced grid cell estimates provide better measurement of distance.

Our results show first that for the entire population, distance to the nearest supermarket did not change greatly when more recent population and supermarket location data are used. We also find that low income areas and low income individuals are generally closer to supermarkets than moderate/high income areas and individuals. Despite this finding, some low-income areas are still far from supermarkets, and residents of these areas may face access barriers. In new national-level analysis, we also estimated the distance to the nearest three supermarkets for the entire population. These results suggest that more than half the population is within 2 miles of three supermarkets.

Future research will also examine supermarket access for subpopulations and for rural and urban areas separately. We will also provide estimates of vehicle ownership and supermarket access. Vehicle ownership is currently not considered in USDA’s Census tract definition of food deserts, but this updated analysis finds that very few people who live more than a mile from the store do not own vehicles.
The results of this study provide impetus for further research on the measures of food access and the effects of macroeconomic, demographic, and local market changes and how changes in methodology may affect estimates of food access.

This analysis uses the location of supermarkets and large grocery stores as a proxy for access to healthy foods. Consequently, it is limited by not including many other food retail stores that may have an array of healthy food choices. Another limiting factor of our definition of a supermarket or large grocery store is that the industry definition—having $2 million or more in annual sales—has not been updated to reflect inflation over many years. As a result, some smaller grocery retailers may meet this definition, but they may not be what is typically considered a large, full-service grocery store. Future analysis could examine how sensitive our results are to different definitions of large grocery stores (e.g. excluding stores with sales between $2-4 million annually). Additionally, due to limited national data, this analysis does not consider smaller food retailers such as corner stores, farmers’ markets and produce stands that may provide fresh and nutritious foods, as well.

Straight-line distance measures are used to measure access to food retailers. Existing roadways, natural and man-made barriers, and other factors may mean that the distance consumers have to walk or drive to a store may be farther than the estimated straight-line distance. Other studies have employed network distance measures to account for these factors. Doing this on a national level, however, would require more computational resources than we have. To test the sensitivity or our estimates, one potential analysis could use selected states or cities as case studies, for which food access measures would be estimated using both network and straight-line distances. Performing any of the enumerated sensitivity analyses could provide
guidance for future efforts to measure food access, as well as additional detail on the estimates in this report.
Enhanced Data and Methods for Estimating Access to Affordable and Nutritious for Population Characteristics

Draft: 6/4/2012    NOT FOR CITATION

References


Economic Research Service. 2012b. “Food CPI and Expenditures: Table 1” Food CPI and Food Expenditures Briefing Room,


Figure 1 Distance to the nearest supermarket for the Continental U.S., 2006 vs. 2010

Cumulative share of the population
Figure 2 Distance to the nearest supermarket for low-income areas compared with moderate/high income areas, 2010

Cumulative share of the population

Distance to nearest supermarket (mi)
Figure 3 Distance to the nearest supermarket for low-income populations compared with moderate/high income populations, 2010
Map 1 Supermarket access in St. Louis, Missouri
Map 2 Supermarket access in South Dakota
Table 1 Changes in income of the population and of low-income areas: Overall, urban and rural for 2000 and 2010

<table>
<thead>
<tr>
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<td>Number</td>
<td>Percent</td>
<td>Number</td>
<td>Percent</td>
<td>Number</td>
<td>Percent</td>
<td>Number</td>
<td>Percent</td>
<td>Number</td>
<td>Percent</td>
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<td>Percent</td>
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<tr>
<td>Total low-income population</td>
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<td>73.9</td>
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<td>71.2</td>
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<td>151.1</td>
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<td>151.7</td>
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<td>406.7</td>
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<td>211.4</td>
<td></td>
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<td></td>
<td>68.2</td>
<td></td>
<td>81.2</td>
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<td>71.3</td>
<td>25.5</td>
<td>96.4</td>
<td>31.4</td>
<td>55.2</td>
<td>26.1</td>
<td>76.0</td>
<td>33.7</td>
<td>16.1</td>
<td>23.6</td>
<td>20.4</td>
<td>25.2</td>
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<td>Total population in moderate/high income areas</td>
<td>208.3</td>
<td>74.5</td>
<td>210.3</td>
<td>68.6</td>
<td>156.2</td>
<td>73.9</td>
<td>149.6</td>
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<td>52.1</td>
<td>76.4</td>
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<td>74.8</td>
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<td>Low-income population in low-income areas</td>
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<td>50.5</td>
<td>51.2</td>
<td>53.1</td>
<td>28.3</td>
<td>51.3</td>
<td>40.8</td>
<td>53.8</td>
<td>7.7</td>
<td>47.8</td>
<td>10.3</td>
<td>50.7</td>
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<td>Moderate/high income in low-income areas</td>
<td>35.3</td>
<td>49.5</td>
<td>45.2</td>
<td>46.9</td>
<td>26.9</td>
<td>48.7</td>
<td>35.1</td>
<td>46.2</td>
<td>8.4</td>
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<td>49.3</td>
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<td>Low-income population in moderate/high income areas</td>
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<td>21.4</td>
<td>46.7</td>
<td>22.2</td>
<td>32.0</td>
<td>20.5</td>
<td>33.0</td>
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<td>23.4</td>
<td>13.7</td>
<td>22.6</td>
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<td>Moderate/high income population in moderate/high income areas</td>
<td>163.8</td>
<td>78.6</td>
<td>163.6</td>
<td>77.8</td>
<td>124.2</td>
<td>79.5</td>
<td>116.5</td>
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<td>39.9</td>
<td>76.6</td>
<td>47.0</td>
<td>77.4</td>
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### Table 2 Changes in selected population characteristics: Overall and by income of area of residence for 2000 and 2010

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<tr>
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<td>%</td>
<td>#</td>
<td>%</td>
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<td>%</td>
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<td>Race/ethnicity</td>
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<td>Minority</td>
<td>85.7</td>
<td>30.7</td>
<td>110.6</td>
<td>36.1</td>
<td>39.7</td>
<td>55.7</td>
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<td>Non-Minority</td>
<td>193.9</td>
<td>69.3</td>
<td>196.1</td>
<td>63.9</td>
<td>31.6</td>
<td>44.3</td>
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<tr>
<td>Age</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elderly (65 or older)</td>
<td>34.8</td>
<td>12.4</td>
<td>40.0</td>
<td>13.0</td>
<td>8.0</td>
<td>11.2</td>
</tr>
<tr>
<td>Under age 65</td>
<td>244.8</td>
<td>87.6</td>
<td>266.7</td>
<td>87.0</td>
<td>63.3</td>
<td>88.8</td>
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<td>Total Population</td>
<td>279.6</td>
<td>100.0</td>
<td>306.7</td>
<td>100.0</td>
<td>71.3</td>
<td>100.0</td>
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<td>Occupied housing units</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>without vehicles</td>
<td>10.8</td>
<td>10.3</td>
<td>10.2</td>
<td>8.8</td>
<td>4.5</td>
<td>17.9</td>
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<tr>
<td>Total Occupied Housing Units</td>
<td>104.9</td>
<td>100.0</td>
<td>116.0</td>
<td>100.0</td>
<td>25.1</td>
<td>100.0</td>
</tr>
</tbody>
</table>

NOTE: Population reported in millions.
Table 3 Changes in the number of stores by store type and by income level of area, 2006 and 2010

<table>
<thead>
<tr>
<th>Store Type</th>
<th>Continental U.S.</th>
<th>Low Income Areas</th>
<th>Moderate and Higher Income Areas</th>
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<tbody>
<tr>
<td></td>
<td>2006</td>
<td>2010</td>
<td>2006</td>
</tr>
<tr>
<td></td>
<td>Number</td>
<td>Percent</td>
<td>Number</td>
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<tr>
<td>Supercenter</td>
<td>3,089</td>
<td>7.8</td>
<td>3,432</td>
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<tr>
<td>Supermarket</td>
<td>31,652</td>
<td>79.5</td>
<td>30,519</td>
</tr>
<tr>
<td>Large grocery store</td>
<td>5,050</td>
<td>12.7</td>
<td>5,627</td>
</tr>
<tr>
<td>Total (Excludes Alaska and Hawaii)</td>
<td>39,791</td>
<td>100.0</td>
<td>39,578</td>
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</table>

Table 4 Distance to nearest 3 supermarkets: Overall and by population characteristics, 2010

<table>
<thead>
<tr>
<th>Population Characteristics</th>
<th>Overall Median Distance to Nearest 3rd</th>
<th>Urban Areas Median Distance to Nearest 3rd</th>
<th>Rural Areas Median Distance to Nearest 3rd</th>
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<tr>
<td>All individuals</td>
<td>1.9</td>
<td>1.6</td>
<td>6.2</td>
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<tr>
<td><strong>Income</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low-income individuals</td>
<td>1.8</td>
<td>1.5</td>
<td>7.1</td>
</tr>
<tr>
<td>Higher income individuals</td>
<td>2.0</td>
<td>1.6</td>
<td>5.9</td>
</tr>
<tr>
<td><strong>Race</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>2.2</td>
<td>1.7</td>
<td>6.4</td>
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<tr>
<td>Black</td>
<td>1.6</td>
<td>1.5</td>
<td>5.5</td>
</tr>
<tr>
<td>Asian</td>
<td>1.4</td>
<td>1.3</td>
<td>2.9</td>
</tr>
<tr>
<td>Native Hawaiian/Pacific Islander</td>
<td>1.5</td>
<td>1.4</td>
<td>4.2</td>
</tr>
<tr>
<td>American Indian/Alaska Native</td>
<td>2.7</td>
<td>1.6</td>
<td>10.0</td>
</tr>
<tr>
<td>Other or multiple</td>
<td>1.4</td>
<td>1.3</td>
<td>5.3</td>
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<tr>
<td><strong>Hispanic Ethnicity</strong></td>
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<td></td>
</tr>
<tr>
<td>Hispanic</td>
<td>1.4</td>
<td>1.3</td>
<td>5.0</td>
</tr>
<tr>
<td>Non-Hispanic</td>
<td>2.1</td>
<td>1.6</td>
<td>6.3</td>
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<td><strong>Age</strong></td>
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<td></td>
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<tr>
<td>Children (age 17 or less)</td>
<td>2.0</td>
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<td>6.1</td>
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<td>Working age (18 to 64)</td>
<td>1.9</td>
<td>1.6</td>
<td>6.2</td>
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<tr>
<td>Elderly (65 or older)</td>
<td>2.0</td>
<td>1.6</td>
<td>6.7</td>
</tr>
<tr>
<td>All Households</td>
<td>1.9</td>
<td>1.6</td>
<td>6.3</td>
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<tr>
<td><strong>Household Vehicle Ownership</strong></td>
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</tr>
<tr>
<td>Own vehicle</td>
<td>2.0</td>
<td>1.6</td>
<td>6.3</td>
</tr>
<tr>
<td>Do not own vehicle</td>
<td>1.3</td>
<td>1.2</td>
<td>6.8</td>
</tr>
<tr>
<td><strong>Low income areas</strong></td>
<td>1.6</td>
<td>1.4</td>
<td>8.1</td>
</tr>
<tr>
<td>High/moderate income areas</td>
<td>2.1</td>
<td>1.7</td>
<td>5.8</td>
</tr>
</tbody>
</table>

Estimates do not include Alaska and Hawaii.
Note: Population reported in millions
Appendix A
Technical Details on Data and Methods

Methods for developing and geo-coding a national list of stores

Methods to develop and assign geographic coordinates—or geo-code—a 2010 list of stores (consisting of large grocery stores, supermarkets, and supercenters) are largely consistent with the method used in USDA (2009). We note where methods for the 2010 analysis diverged from those used in USDA (2009) in this section of the appendix and explain the methods in more detail.

The Food and Nutrition Service changed the method used to assign store types for SNAP authorized stores in 2008. Where prior store types were assigned primarily using retailer self-classification, SNAP now uses confidential methods and more complete information obtained from a new application form for store authorization. To ensure that SNAP stores were comparable to those included in the TDLinx store directory, ERS requested a special tabulation of all SNAP stores meeting minimum annual sales (food and non-food items) and the inclusion of four major food group offerings: milk, meat, fruits and vegetables, and bread, in any form (canned, fresh, frozen). Almost 35,000 of 204,705 total stores met these criteria and were included in the 2010 ERS store directory.

The Trade Dimensions TDLinx® store directory consisted of 39,502 retail food stores with at least $2 million or more in sales (food and non-food). Additional information included annual sales volume range and store format, allowing for the identification of supercenters, supermarkets, and large grocery stores.
In addition to descriptive information, both SNAP and TDLinx provided the store name, address, and geo-coded location coordinates (latitude and longitude) to allow for measurement of distance from each grid area to the nearest store.

**Matching the TDLinx and SNAP store lists**

TDLinx and SNAP stores were merged and stores common to each were counted as the same store to avoid duplication. Both the geographic coordinates of each store’s location and the use of automated scripting in ArcGIS software to compare store names and addresses among potential matches were employed in the process of combining the two store lists. First, a proximity analysis using a 1/3 mile buffer to identify a subset of potential store matches from the two store lists was performed. Next, the resultant potential matches were analyzed through an automated script to compare the store name and address from each of the store lists. If there was an exact match on the names and addresses, the two stores were denoted as an exact match.

Both automated and manual review methods were used for the remaining unmatched stores based upon the type of match. Any partial matches such as having the same store name but a different street address, or the same street address but a different store name were manually reviewed to identify whether the stores matched. The Trade Dimensions *Marketing Guidebook* (2012) was used to verify current store names and addresses. Online sources, such as company Web sites and other online sources, including Google Maps were used to verify store name and location data. Any remaining unmatched stores in the same zip code area were manually checked for potential matches using the store name and street address. Once all store matches were identified, the store lists were combined into one data set encompassing the matched stores, TDLinx-only stores, and SNAP-only stores.
When a SNAP store matched to a TDLinx store, the TDLinx store classification was used. We did this because many SNAP “superstores” were found to include larger traditional supermarkets, mass-merchandise stores selling some food varieties, and supercenters, they were reclassified according to the TDLinx store definitions. For those SNAP stores that did not match to the TDLinx store directory, all large mass-merchandise stores that sell some food varieties but typically do not offer fresh meat and produce--such as Target, Wal-Mart, and Kmart—were eliminated (3,078 SNAP-only mass merchandise stores eliminated). SNAP-only large grocery stores that did not meet the minimum annual sales and food category requirement were also eliminated (1,620 SNAP-only stores eliminated). SNAP-only superstores were reclassified as supercenters if stores with the same name (but a different location) had been classified as a supercenter by TDLinx.

Assignment of the store locations for 2006 and 2010

Because store location is critical to measures of access, it is important to have the greatest possible consistency when comparing change in food access and food deserts between 2006 and 2010. Those stores common to both 2006 and 2010 directories had up to four different geographic coordinates assigned, depending on its source. When applying geo-codes to the 2010 stores, a protocol was developed to address potential inconsistencies of store location due to differences in geo-code precision. First, all 2010 stores that were also in the 2006 directory and had an address that was geo-coded to an exact street address in 2006 were assigned the 2006 geo-code to fix the location of those stores and to eliminate artificial change in store location between the two years. Second, the selection of location coordinates for the remaining stores

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11 Mass-merchandise stores are not considered grocery stores or supermarkets according to TDLinx definitions.
(those 2010 stores not present in 2006) was made based on the method used to obtain the geo-code. Stores that had been geo-coded to an exact street address were deemed to have the greatest accuracy, while stores that had been geo-coded to a zip code centroid were deemed to have a greater possibility of positional inaccuracy. For example, if the store was newly opened and had been geo-coded to an exact street address, then the 2010 coordinates were selected as the location of the store. Third, any remaining stores were either manually reviewed with the assignment of the geographic coordinates based upon the manual inspection, or taken from stores that had been geo-coded to a Census block group centroid or the centroid of a zip code + 4 polygon. Store locations that could not be determined manually were then assigned lat/long coordinates from population-weighted zip code centroids since store locations are most likely to be located in population centers.

Taken together, these methods ensure that the best available store location coordinates were applied, and that among stores common to both years, locations are consistent when used to compare change in access measures over time.

**Methods for developing ½-km square grids and downcasting population data**

To link supermarket distance with census population, housing, and urban characteristics, a grid-based approach was used. The grid-based approach provides a common unit for which all data inputs can be linked and efficiently aggregated and summarized at many levels of geography. It also provides a method for gaining greater spatial detail to population characteristic that are only available at more aggregate spatial resolutions. A grid composed of 500-meter cells, with a unique value for each grid cell, was developed for this study so that every half-kilometer region in the entire land area of the fifty states is represented by its own distinct
value. Based on this common grid cell identifier, we developed supermarket distance and grid population characteristics (e.g. low-income or urban), to the same common grid.

To allocate Census population data the unique value grid was overlaid with the census block geographies to get the combined set of block – grid cell pieces. The area of each of these pieces is used to calculate the area weighted average of block-level people or households counts at the grid-cell level. First for each of the block – grid cell pieces, we calculated the share of each block’s area. For each of these block – grid cell pieces we multiplied this share by the population of the block and then aggregated the populations to the grid cell level.

While most of our data were population counts from the 2010 Decennial Census, income and vehicle access came from the 2006 – 2010 American Community Survey (ACS) and were only available at the more aggregate block group level. These were apportioned to grid-cells through a population and area weighting technique. First the share of the block group population that was low income was calculated. The share was then multiplied by the population for all the blocks that made up that block group. The area weighting down-casting method discussed above was then used to allocate low income populations to the grid cell level.