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Spatial Patterns of Food Access in the Appalachian Region of the US

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Spatial Patterns of Food Access in the Appalachian Region of the US

By

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An abstract of
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Abstract

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By Jared Gingrich

Procuring healthy food is becoming more difficult in many regions of the US, especially largely rural regions such as Appalachia. Spatial data on grocery store locations, household income, and vehicle availability were used to calculate a novel metric, the food access score, for this region. According to the food access score, 60% of the population has poor access to food across Appalachia, with larger areas of poor access in Central West Virginia and eastern Kentucky. Average food access in Appalachia is worse than a similar average calculated for the US as a whole. Including small grocery stores and farmers markets alongside large grocery stores increases the food access score, especially in rural areas. This suggests that local food retailers can act as a significant source of food in rural areas with otherwise poor food access, although this is highly dependent on the locations of these stores and markets. The food access score is compared to current methods for determining food deserts in the US, based upon thresholds corresponding to food desert criteria. When compared to food desert classifications, this methodology attributes a much larger share of the poor access population to rural areas, which shifts the understanding of the relative differences in food access between rural and urban contexts.

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1. Introduction

1.1 Food Access and Food Deserts

Access to healthy food for individuals, households, and communities is increasingly difficult in many rural areas of the United States (Piontak & Schulman, 2014). Food access, or the ability to obtain healthy and nutritious food, is dependent on availability of food, distance, and modes of travel to food, as well as the ability to afford food (Ver Ploeg, Dutko, et al., 2015). Rural communities have experienced a decades-long decline in the number of grocery stores, as numerous small stores are replaced by a few larger ones (Bailey, 2010; Morton & Blanchard, 2007; Piontak & Schulman, 2014). Healthy foods tend to cost more rural communities, making proper nutrition cost-prohibitive (Hardin-Fanning & Rayens, 2015; Morris et al., 1990). The rural population also tends to have lower incomes and higher poverty rates than the urban population (Economic Research Service, 2021c; Office of Policy Development and Research, 2021). These characteristics of the rural population suggest that food access should also be a significant problem for rural places. However, this is not necessarily borne out by current measures of food access, specifically the classification of food deserts.

Food deserts denote areas where people are far from a grocery store and cannot afford to buy groceries (Rhone et al., 2019). This term was first formalized by a Nutrition Task Force in Great Britain in the late 1990s to describe places with poor access to food (Cummins & Macintyre, 2002a; Wrigley, 2002). Despite the rapid expansion of literature on food deserts since the emergence of this term, there has not been a clear consensus on what constitutes a food desert. Studies tend to develop definitions of food deserts to reflect individual research questions and the contexts (McEntee, 2009; Ver Ploeg, Dutko, et al., 2015; Walker et al., 2010). Across studies, several characteristics are commonly used to define food deserts, including a greater distance to the nearest grocery store or few nearby grocery stores, lower socioeconomic status,

and limited vehicle or public transportation options (Caraher et al., 1998; Cummins & Macintyre, 2002a; Lang & Caraher, 1998; McEntee, 2009; Ver Ploeg, Dutko, et al., 2015; Wrigley, 2002). Household surveys of food security in the US have identified that greater distances to the nearest store, limited access to vehicles, and limited economic resources are also common characteristics of the food insecure population (Holben, 2002). These three factors that influence access to food—distance to the nearest store (distance-to-store), income and poverty (economic), and vehicle availability (vehicle)—are referred to as indicators of access and are outlined in Table 1. Using these indicators, food access is a function of distance-to-store, economic access, and vehicle access, and food deserts are places in which criteria for one or more of the indicators of access are met (Ver Ploeg, Dutko, et al., 2015).

Each of the indicators of access represents a distinct means of access to food. Distance to the nearest store measures the ease of reaching a source of food, working under the assumption that shorter distances equate to better access. Studies of this indicator have found that areas with greater distances to the nearest store tend to have fewer healthy food options and that an increase in distance inversely correlates with the consumption of nutritious foods (Rose & Richards,

Table 1: Indicators of Access

Indicator of Access	Description	Influence on food access
Distance-to-Store (Physical dimension of access)	Reaching the nearest provider of healthy and nutritious food. Areas with greater distances to the nearest store tend to have fewer healthy food options. Greater distances can inversely correlate with the consumption of nutritious foods. (Rose & Richards, 2005; Ver Ploeg et al., 2009; Wrigley, 2002)	Increasing distance-to-store leads to a decrease in food access.
Economic (Economic dimension of access)	Afford food, based on income, poverty, and relative differences in prices. Lower incomes or higher poverty make the purchase of heathy and nutritional foods more difficult, and lower income areas tend to have fewer options for purchasing healthy foods. (Caraher et al., 1998; Cummins & Macintyre, 2002b; Ver Ploeg, Dutko, et al., 2015; Wrigley, 2002)	Increasing economic access leads to an increase in food access.
Vehicle (Physical dimension of access)	Using a personal vehicle to reach a provider of heathy and nutritious food. Vehicles are the primary means of transportation to the grocery store in the US. Lacking access to a vehicle can impede the ability to reach a wider range of food options. (Caraher et al., 1998; Ver Ploeg, Dutko, et al., 2015; Ver Ploeg, Mancino, et al., 2015)	Increasing vehicle access leads to an increase in food access.

2005; Ver Ploeg et al., 2009; Wrigley, 2002). Economic access to food is another common indicator of access to food, measuring the ability to purchase food. Limited economic resources make the purchase of heathy and nutritional foods more difficult, and lower income areas tend to have fewer options for purchasing healthy foods (Caraher et al., 1998; Cummins & Macintyre, 2002b; Ver Ploeg, Dutko, et al., 2015; Wrigley, 2002). Vehicle access is an important measure of how people access food in conjunction to the distance to the nearest store. Vehicles are the primary means of transportation to the grocery store in the US, and lacking access to a vehicle can impede the ability to reach a wider range of food options (Caraher et al., 1998; Ver Ploeg, Dutko, et al., 2015; Ver Ploeg, Mancino, et al., 2015). Access provided by one of these means can make up for a lack of access in others. For example, living within walking distance of a store can reduce the need for a vehicle, while access to a vehicle reduces impact of a lack of nearby groceries (Ver Ploeg, Dutko, et al., 2015). Recent years have seen the rise of grocery delivery services, which can also help overcome limited vehicle access, albeit with the additional cost of delivery, making these services not necessarily suitable for those with limited economic access (Rummo et al., 2020). Therefore, the combination of these indicators of access provides a more comprehensive model of food access than any indicator individually.

Working within this model of food deserts, studies have addressed food access at a variety of scales, from the neighborhood level to the national level. Early studies on food deserts tended to be urban-centric, and the classification of food deserts has remained largely focused on food access in urban contexts. Pioneering studies in the UK evaluated food access within inner-cities (Cummins & Macintyre, 1999, 2002b), and this concept has since been applied to investigations of the distribution of food deserts within numerous US cities (Gallagher, 2006; Raja et al., 2008; Russell & Heidkamp, 2011). Research on urban food access has moved beyond the spatial distribution of food deserts to study the intersectionality of food access with

demographic, socioeconomic, and retailer characteristics (Walker et al., 2010). Other research has investigated site-specific ways to address food deserts, through urban gardens, farmers markets, and other community-focused and neighborhood-level initiatives (Chavez, 2013; Pothukchi, 2007). In contrast, there has been little attention paid to problems with food access that are unique to rural communities. Rural studies of food access, both within the framework of food deserts and separate from this conceptual model, tend to focus on the more limited number of food retailers (Morris et al., 1992; Morton et al., 2005; Morton & Blanchard, 2007; Powell et al., 2007) or the greater distance to reach those retailers in rural communities (McEntee & Agyeman, 2009; Rhone et al., 2019). As such, rural food access remains a gap in food deserts literature.

Studies on food deserts covering the extent of the US have been conducted primarily by the US Department of Agriculture's Economic Research Service (ERS). The ERS created the Food Desert Locator and its successor, the Food Access Research Atlas, to map the locations of food deserts across the US (Ver Ploeg, Dutko, et al., 2015). The ERS defines food deserts at the census tract level, which is the smallest geographic unit delineated by the US Census Bureau with widely available data on income, poverty, and vehicle access (Economic Research Service, 2021b). According to the original ERS definition, food deserts describe places where criteria for each of the indicators of access are met. This definition does not incorporate criteria for vehicle access, and it classifies rural and urban food deserts based on different distance-to-store thresholds (Ver Ploeg, Dutko, et al., 2015). An urban census tract is a food desert if a significant proportion of the population lives more than 1 mile away from a store, while a rural census tract is a food desert only if a proportion of the population is more than 10 miles from a store. Based on this definition, 12.8% of census tracts in the US are classified as food deserts. 14.5% of the urban population lives in a food desert, compared to only 6.6% of the rural population

(Economic Research Service, 2021a).[1] These findings suggest that food access is a larger issue in urban contexts than in rural ones.

The inconsistent distance-to-store criteria between rural and urban census tracts and the lack of vehicle criteria in the original ERS definition are primary critiques of this method of determining food deserts (Ver Ploeg, Dutko, et al., 2015). To address these critiques, the ERS developed an additional food desert definition that removes the distinction between rural and urban census tracts and incorporates vehicle access (Economic Research Service, 2021b; Ver Ploeg, Dutko, et al., 2015). Vehicle criteria are grouped with the distance-to-store criteria in the physical dimension of access, while economic criteria comprise the economic dimension of access. In this revised definition, both rural and urban census tracts are defined by a significant number of households that are more than half a mile from a store and do not have access to a vehicle, or a significant proportion of the population that is more than 20 miles from a store. According to these criteria, 14.0% of US census tracts are food deserts, with 12.4% of the rural population and 14.6% of the urban population living in food deserts (Economic Research Service, 2021a).[2] This narrows the gap between the urban and rural food desert populations, but limited access to food remains a more common characteristic of urban contexts.

The evaluation of food access at a national scale has made it possible for food deserts to become the focus of policy initiatives, both at the state and national level, with allocation of funding for the development of grocery stores in areas with poor food access (Bitler & Haider, 2011; Ver Ploeg, Dutko, et al., 2015). However, the ERS approach to food deserts has a limited ability to evaluate differences in food access between census tracts. Both versions of this food desert model flatten the broad spectrum of food access into a single binary classification. If any

[1] Rural and urban designations based on ERS classifications of rural and urban census tracts. See Food Access Research Atlas Documentation (Economic Research Service, 2021b).
[2] Rural and urban designations based on ERS classifications of rural and urban census tracts.

of the indicators of access are not met, a census tract is not considered to be a food desert. This erases the relative differences in food access across areas that qualify as food deserts and across those that do not. It also misses the amplification of poor access to food in areas that are far from a store, low income, and have few vehicles (Ver Ploeg et al., 2009). These potential interactions between the indicators of access are missed in the discrete and conditional ERS food desert model. Furthermore, the ERS focuses exclusively on large grocery stores and supermarkets as retailers that provide access to food. Some communities, particularly in rural areas, rely more heavily on small or local grocery retailers like Independent Grocers Alliance (IGA) stores (Chavez, 2013; Cho & Volpe, 2017; Morton & Blanchard, 2007; Ver Ploeg, Dutko, et al., 2015). These same rural communities are ones in which alternative food retailers, such as farmers markets, can fill the niche left by closing grocery stores (Alfonso et al., 2012; Gillespie et al., 2007). Not considering the positive impact of these alternative food options discounts local means of supplementing food access in the absence of the stores that are traditionally considered to provide access to food. While the ERS definition of food deserts is useful for policymaking and the allocation of funding to areas that meet its specific criteria, it ignores the larger trends and complexities of food access, particularly those related to food access in rural communities.

1.2 Study Site

The problems faced by the rural population tend to be more prevalent in some regions of the US than in others. One such area is Appalachia, a largely rural region of the eastern US. Appalachia (Figure 1) refers to a cultural region associated with the Appalachian mountains, and is comprised of 420 counties across thirteen states (Appalachian Regional Commission, 2009)[3]. Of the 25 million people living in Appalachia, over 10 million live in rural areas, accounting for

[3] The Appalachian Regional Commission (ARC), which makes this designation of Appalachia, was founded in the 1960s as part of the Appalachian Regional Development Act, intended to combat the endemic issues faced by the residents of the region (Appalachian Regional Commission, 2020).

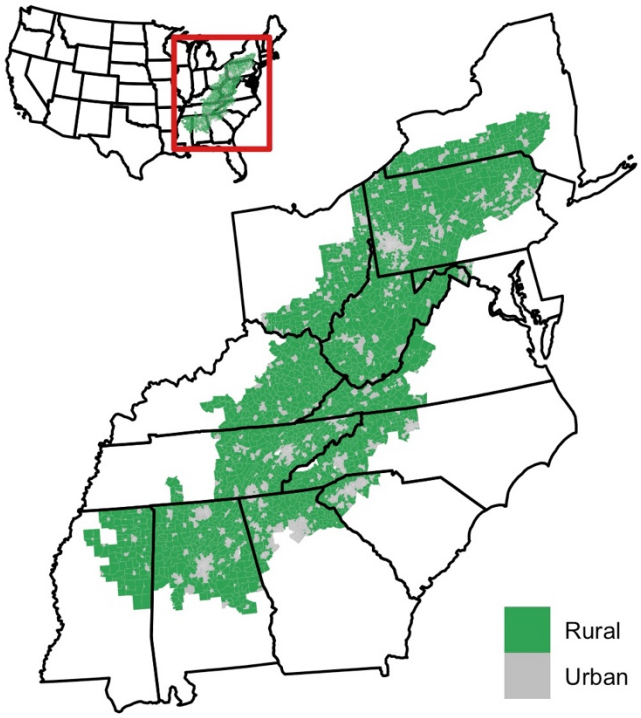

Figure 1: Appalachia, showing rural (green) and urban (grey) census tracts. Rural tracts are those with a greater rural population count. Urban tracts are those with a greater urban population count. Based on 2010 Census Urban Area designations (Census 2012). Figure shown in greater detail in Appendix

42.3% of the Appalachian population (Census Bureau, 2012).[4] As shown in Table 2, the median household income is lower and the poverty rate is higher for Appalachian than for the US as a whole, and these differences are further exacerbated when examining the rural portion of Appalachia alone (Pollard & Jacobsen, 2021). Research on Appalachia has investigated problems associated with the lack of transportation infrastructure within the region, including access to healthcare services, employment, and education opportunities (EBP US, Inc., 2020). The rural nature of

Table 2: US and Appalachian Median Household Income and Poverty Rates. Rural defined based on 2013 Urban Influence Codes. Data from the Appalachian Regional Commission 2015-2019 American Community Survey Chartbook (Pollard & Jacobsen, 2021)

	Median Household Income	**Poverty Rate**
United States	$62,843	13.4%
Appalachia	$51,916	15.2%
Rural Appalachia	$40,975	20.9%

[4] Rural areas defined as census tracts where a majority of the population lives in an urban area or cluster, from the 2010 Census Urban Area designations (Census Bureau, 2012). See *Methods*.

Appalachia leads to specific issues of access and well-being, but how this translates to food access specifically has not be well studied.

1.3 Study Goals

This study has three goals. First, it seeks to better understand the state of food access within Appalachia. To do so, the study proposes an alternative to the existing discrete classifications used to define food deserts by measuring food access as a function of continuous variables. This novel methodology, known as the Food Access Score (FAS), addresses limitations of the ERS food desert model (FDM) and provides an alternative to the discrete classification of food deserts. Overall, this approach creates a metric of food access that accounts for local food assets (additional food options) and measures, rather than categorically classifies, key variables of access such as incomes, vehicle access, and distances to stores in rural communities. Second, this investigation measures how food access changes when taking into account additional food options. It moves beyond an evaluation of the role of large grocery stores alone and considers the impact that local food retailers—small grocery stores and farmers markets—can have on food access. In doing so, it builds upon case studies of the role of individual farmers markets in the communities they serve to assess the impact that alternative food options can have on food access on a broader geographic scale. Third, this investigation compares the distribution of the FAS within Appalachia to an average FAS for the US as a whole and evaluates the FAS against the FDM classification of rural and urban food deserts within this region of the US.

2. Methods

To achieve the goals stated above, this investigation proposes an alternative method of measuring food access, called the Food Access Score (FAS). The FAS uses continuous measures of the three indicators of access—distance-to-store, economic access, and vehicle access—to

calculate an additive model of access, avoiding binary food desert classifications. To calculate the indicators of access, grocery store and farmers market locations were acquired from state and national retailer directories, described in greater detail below, while vehicle access, and household income datasets were accessed from the American Community Survey (ACS) five-year estimates for 2015-2019 (Census Bureau, 2020b, 2020c, 2020d). The ACS published data at the census tract level, the standard geographic unit used in this investigation, which coincided with the geographic units used in the FDM (Economic Research Service, 2021b). Rural and urban classifications used the 2010 Census Urban Area designations at the census block level, the smallest census geographic unit that is used to build all larger units, including census tracts (Census Bureau, 2011a-m, 2012). From the census block level designations, rural and urban population counts were aggregated to the census level (Census Bureau, 2019a-m). Rural tracts are those with a greater rural population count, while urban tracts have a greater urban population count. Out of the 6126 census tracts within the study region, 2494 were classified as rural, 3618 were classified as urban, and 14 had a population of 0 and were subsequently dropped from this investigation. Dataset construction and data analyses were performed using the open-source programs QGIS and R (QGIS.org, 2020; R Core Team, 2020).

2.1 Distance-to-Store Indicator of Access

The distance-to-store analysis required both the location of population and the location of stores and other food retailers within Appalachia. This was performed using the QGIS *Distance to Nearest Hub* tool, which calculated Euclidean (linear) distance between two layers of geospatial data.[5] The base layer of this analysis was created using 2010 census block population data (Census Bureau, 2011a-m).[6] Census blocks were split over a 500m square grid, generated to

[5] The use of Euclidean distance is the standard approach for food access distance analyses (Ver Ploeg, Mancino, et al., 2015). This methodology increased comparability with other measures of food access.
[6] Census 2010 is the most recent census block-level population and household data available. More up-to-date population analyses could be computed after the Census 2020 data is published.

cover the extent of the study region. The split grid cells were identified by both a grid cell ID and a census block code, and each was assigned a proportional population count based on the area of the census block contained within the cell. Where grid cells intersect multiple census blocks, the population was computed as the sum of the proportional population counts of each census block intersected by the cell. The centroids of the population grid cells were generated, representing each of the split census block subsections contained within the cell. Store locations formed the hub dataset of the distance to nearest hub analysis. All stores within a 20-mile buffer[7] of Appalachia in the USDA SNAP/EBT store database were categorized according to store type (Retailer Policy and Management Division, 2021a), using store names and locations in conjunction with online information about each store. The USDA SNAP/EBT dataset was then combined with farmers market locations from national and state farmers market directories (Agricultural Marketing Service, 2021; Commonwealth of Pennsylvania, 2021; Department of Agriculture and Markets, 2021; Farmers Market Authority, 2021; Georgia Department of Agriculture, 2021; Kentucky Department of Agriculture, 2021; Maryland Department of Agriculture, 2021; Mississippi Department of Agriculture and Commerce, 2021; New Jersey Department of Agriculture, 2021; North Carolina Department of Agriculture and Consumer Services, 2021; Ohio Proud, 2021; Pick Tennessee Products, 2021; South Carolina Department of Agriculture, 2021; Virginia Department of Agriculture and Consumer Services, 2021; West Virginia Food and Farm Coalition, 2021). Subsets of the store locations contained within this combined dataset were used for each of the distance to store analyses.

The distance-to-store analysis was computed three times. For these analyses, the combined store dataset was subset to extract 1) the locations of only large grocery store, 2) the locations of all grocery stores, and 3) the locations of grocery stores and farmers markets. Large

[7] The buffer captures stores that are outside of Appalachia but are the closest store for people living within Appalachia.

grocery stores indicates the retailers classified as large grocery stores, super markets, and supercenters in the database of historic SNAP retailers (Retailer Policy and Management Division, 2021b). All stores that were categorized as groceries but were not classified as large grocery stores in the SNAP/EBT database were considered small grocery stores. Farmers markets included retailers categorized as such in the SNAP/EBT database and those listed in the state and national farmers market directories. After running each of distance-to-store analyses, grid cells were rejoined into the original census blocks according to census block code and the average distance to store value for each census block was calculated. Distance-to-store was then further aggregated to the census tract level (Census Bureau, 2019a-m). The number of census tracts with a distance-to-store greater than 0.5 miles using this methodology was compared with the number of tracts that meet the FDM distance-to-store criteria (Table 4).

A limitation of the SNAP/EBT dataset is that it does not include stores that are not authorized to accept SNAP/EBT. However, this is one of the few comprehensive and freely available datasets on store locations. Many directories are limited to individual major retailers or singular localities, while others are proprietary, like the Nielsen Trade Dimensions TDLinx directory (Ver Ploeg et al., 2009). Fleischhacker et al. report that government directories, like the USDA SNAP/EBT dataset, have a high level of agreement with directly collected data on store locations (Fleischhacker et al., 2013). To assess the comparability of this store location dataset with that used in the FDM, the population counts farther than 0.5 miles, 1 mile, 10 miles, and 20 miles are compared to the FDM population counts published in the ERS Food Access Research Atlas, which are shown in Table 3 (Economic Research Service, 2021a). This also evaluated the impact of calculating distance-to-store using only locations that are authorized to accept SNAP/EBT. The reported accuracy of this dataset and agreement with the FDM distance-to-store analysis made the SNAP/EBT dataset appropriate for the purposes of this investigation.

Table 3: Agreement between FAS and FDM distance-to-store analyses. Showing percent of population at or beyond each of the distances calculated for the FDM. FAS using large grocery stores alone. FDM data from the Food Access Research Atlas documentation (Economic Research Service, 2021b).

Distance Threshold	Food Access Score	Food Desert Model	Agreement between population counts (%)
0.5 miles	88.51%	85.08%	96.57%
1 mile	68.51%	63.15%	94.64%
10 miles	2.36%	1.56%	99.20%
20 miles	0.01%	0.01%	99.99%

For the distance-to-store analysis incorporating farmers markets, there is significant variability in the number of entries in each state farmers market directory. Moreover, the way that these farmers markets are recorded is not consistent. Pennsylvania and South Carolina, for example, also include the locations of farms with on-farm sales and roadside produce vendors (Commonwealth of Pennsylvania, 2021; South Carolina Department of Agriculture, 2021). By combining each of these farmers market directories and the National Farmers Market Directory (Agricultural Marketing Service, 2021) and verifying the listings, this investigation captures as many of these markets as possible.

2.2 Economic Indicator of Access

The economic indicator of access was based on median household income data at the census tract level.[8] Some census tracts had missing or redacted median household income data for survey response and anonymity reasons. The missing data was replaced with the corresponding county data. The median household income data were modified as follows. First, data on median incomes for households with one member to seven or more members was obtained from ACS table B19019 (Census Bureau, 2020d). This household size categorization mimicked the use of poverty thresholds tailored to household size, reflecting the economic needs of households of various sizes. Second, median household incomes were adjusted according to

[8] Median *family* income was used for this indicator of access in the FDM. This investigation used median *household* income to avoid discounting non-family households.

the BEA Regional Price Parities index to take into account county-level variability in prices across metropolitan statistical areas and the non-metropolitan portions of each state (Bureau of Economic Analysis, 2020a, 2020b; Census Bureau, 2020a). For this adjustment, the Regional Price Parities index for all goods, excluding rents and other services was used. Finally, median household income for each household size was divided by the corresponding US median household income to calculate a proportion of the US average. This proportion, in conjunction with the adjustment to account for regional price variability, reflected the ERS defining economic access based on incomes relative to state or metropolitan area incomes (Economic Research Service, 2021b). An overall census tract-level median household income proportion was determined by calculating a weighted average of the proportions for each household size, based to the number of households in each size category, using data from ACS table B11016 (Census Bureau, 2020c). Larger proportions represented incomes higher than the US average, while smaller proportions represented incomes lower than average. The number of census tracts with a median household income proportion less than 0.8 (80%) was compared to the number of tracts that meet the FDM economic criteria (Table 4), evaluating this methodology relative to the ERS criteria.

2.3 Vehicle Indicator of Access

Vehicle access was based on household vehicle availability. Specifically, this investigation used the percentage of households in a census tract that do not have access to one or more vehicles. The total number of households and the number of households without access to a vehicle were published in table B08201 of the ACS (Census Bureau, 2020b), enabling a calculation of the percentage of households that lacked access to a vehicle. The FDM defines the threshold criteria for vehicle access at the 80th percentile of *number* of households with no vehicles at the census tract-level, across the US (Economic Research Service, 2021b). To mimic

this threshold, this investigation calculated the 80th percentile of *percent* of households with no vehicles for census tracts in the US. The number of census tracts that met this 80th percentile threshold was calculated, in order to compare the results of this methodology to the number of tracts that meet the FDM vehicle criteria (Table 4).

2.4 The Food Access Score

The FAS for each census tract within Appalachia was calculated using an additive model of the three indicators of access. This model scaled the indicators of access to reflect the influence of these indicators on food access, as shown in Table 1. The model inputs were first standardized by computing the Z-scores of each of the indicators of access.[9] The results of the Z-score transformations for the distance-to-store and vehicle indicators were inverted so that positive values indicated increasing access and negative values indicated decreasing access. Z-scores for the median household income proportions were not inverted, as higher proportions indicated greater economic access. Lacking a concrete method to assign weights to the indicators of access, each of the indicators were equally weighted within the model. This assumed that each contributes equally to providing access to food, mimicking the equal importance assigned to these same indicators in the FDM. The additive model of the Z-scores of the indicators of access yielded a continuous measure of food access.[10] This generated a measure of the relative quality of food access within the study region based on the standardized and combined values for each of the indicators of access. Better access to food was represented by a higher FAS, while worse food access was represented by a lower FAS. Distance from zero in either direction indicated the magnitude of better or worse food access. The Z-score transformations standardize the indicators of access only using data from within the study region, so the FAS methodology yields a relative

[9] This standardization was chosen to convert each of the indicators to a similar range of values, centering mean values at 0, without changing the shape of the distribution of the data.

[10] For comparable use of the z-score transformation in an additive model, see the Social Vulnerability Index (Cutter et al., 2003; Hazards and Vulnerability Research Institute, 2016).

measure of food access within Appalachia. To better visualize these results, FAS were binned according to standard deviations from the mean.

To account for the role of smaller local food retailers like the IGA stores and farmers markets, the FAS calculation was replicated using three separate sets of store locations. These sets included 1) locations of all stores categorized as groceries, 2) locations of only large grocery stores and supermarkets, and 3) all grocery stores *and* farmers markets. The replications allowed for an evaluation of differences in food access when considering alternative food options. Each subsequent replication incorporated an additional group of food retailers that is understood to have a positive impact on food access in rural communities. The differences between the first FAS and the subsequent replications determined the increase in food access when considering additional food options in this model. This investigation standardized all three replications of the distance-to-store indicator using the mean and standard deviation from the large grocery store analysis. This ensured that standardization was uniform for each of the replications FAS and that differences between the replications were based solely on the increased number of food options in the distance-to-store analysis. As a result, the second and third FAS show a positive change from the first FAS, reflecting the assumption that small grocery stores and farmers markets do not negatively impact food access.

2.5 Comparison with National FAS and Food Desert Classifications

The FAS model was compared to an average FAS calculated for the US and the USDA FDM classifications for Appalachia. The US FAS was calculated using national averages for each of the indicators of access. Average distance-to-store was reported in the results of the FoodAPS National Household Food Acquisition and Purchase Survey (Ver Ploeg, Mancino, et al., 2015). Average median household income proportion and percent of households with no vehicles were calculated using ACS data, following the economic and vehicle indicator of access

methodology described above (Census Bureau, 2020b, 2020c, 2020d). The findings of this investigation were further contextualized relative to the FDM, comparing the results of the additive model against current food desert classifications. The FDM that does not distinguish between rural and urban census tracts is used for this comparison to best evaluate the differences in rural and urban food access.[11] The FAS and FDM criteria for each indicator of access and the way that these criteria are used to model food access can be found in Table 4. To evaluate where differences occur between these two methodologies, the number of census tracts within Appalachia that meet the criteria for each indicator of access were determined. For this comparison, distance-to-store was set to 0.5 miles, median household income proportion was set to 0.8 (80%), and the vehicle indicator was set to the 80th percentile of percent of households with no vehicles in the US (Table 4). The FAS was calculated using these FDM criteria, which allowed the FAS to be categorized according to a discrete definition of good or poor food access.

Table 4: FDM and FAS definitions: Criteria for each of the three indicators of access, the way the indicators are collapsed, and the combination method to yield a food desert classification or Food Access Score. FDM criteria from the Food Access Research Atlas documentation (Economic Research Service, 2021b).

	Food Desert Model	**Food Access Score**
Indicator of access		
Distance-to-Store	33% of population or 500 people are more than 20 miles from a store	Average distance to the nearest store
Economic	Poverty rate: 20% -OR- Median family income: 80% of state or metropolitan area median family income	Median household income, adjusted according to Regional Price Parities, as a proportion of US median household income
Vehicle	100 households with no vehicles* more than 1/2 mile from a store	Percent of households with no vehicles
Collapse	Binary: Criteria for indicators of access are met or not met	Z-score: Calculated for each of the indicators of access
Combination	Conditional classification: Food desert if all indicators of access are met, not a food desert if *any* of the criteria are not met	Additive model: The sum of the indicators of access

* 100 households roughly corresponds to the 80th percentile of number of households with no vehicles in the US.

[11] Since the original ERS food desert definition classifies rural and urban food deserts according to different distance-to-store thresholds, it is not suitable for this rural-urban evaluation.

The FAS computed using these values formed the lower threshold of the FAS categorization. With the lower threshold defined a certain distance below the US average FAS, the upper threshold for this categorization was defined as the same distance above the US average FAS. Values below the lower threshold indicated "Poor" food access, and those above the upper threshold indicated "Good" food access. The poor food access category approximated the classification of food deserts, while the good food access category was the inverse of this classification. Categorizations of the FAS were based on the replication calculated using large grocery stores alone. This is the subset of food options used for the FDM, so this replication makes for the most direct comparison of methodologies.

3. Results

3.1 Geographic patterns in the Food Access Score

Food access varies widely across Appalachia, but it tends to be worse in rural areas than in urban areas. FAS range from -9.13 (very poor food access) to 8.45 (very good food access), with a mean FAS of 0.00 (SD: 1.91). As shown in Figure 2, grouping census tracts according to

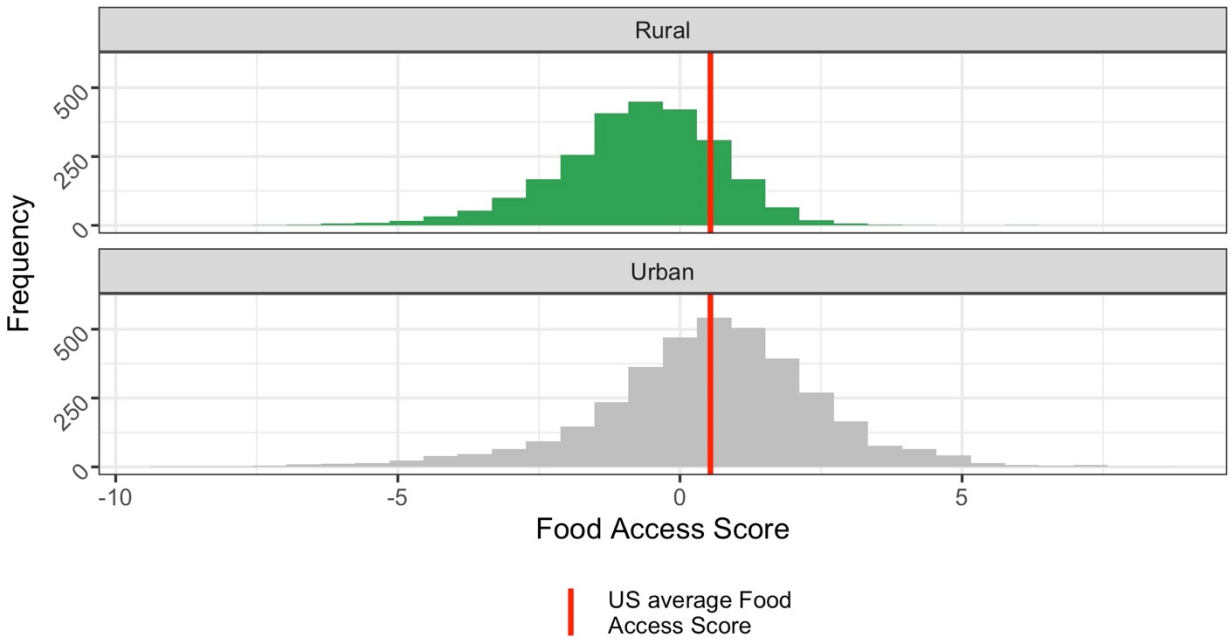

Figure 2: FAS distribution for large grocery stores alone. Showing distribution of rural (green) and urban tracts (grey) in Appalachia. US average FAS (red) calculated using average values for each of the indicators of access.

rural and urban classification reveals a dichotomy in food access. The distribution of rural FAS is skewed lower than the distribution of urban FAS. Less than 2% of the rural population lives in a census tract with a high or extremely high FAS, compared to over 25% of the urban population with higher FAS (Table 5). On the other hand, over 15% of the rural population lives in a tract with a low or extremely low FAS, compared to only 5% of the urban population with lower FAS. Food access demonstrates yet another disparity between the rural and the urban populations in Appalachia, adding on to discrepancies in economic well-being (Pollard & Jacobsen, 2021).

Underlying the larger rural-urban dichotomy in food access, the several spatial patterns emerge. Although census tracts with lower FAS are found across Appalachia, there is a notable concentration in the central portion, between eastern Kentucky and central West Virginia (Figure 3). Median household incomes in this central region tend to be lower, while the distance to the nearest store and percent of households with no vehicles tend to be higher. Conversely, census tracts with higher FAS show more distinct concentration around urban areas, largely within the boundaries of Metropolitan Statistical Areas (Census Bureau, 2020a). These coincide with areas in which census tracts tend to have smaller distance-to-stores values. Major concentrations are visible around urban areas such as Huntsville and Birmingham, Alabama, Atlanta, Georgia, Chattanooga and Knoxville, Tennessee, and Pittsburgh, Pennsylvania. For example, several tracts with extremely high FAS are located in and around Pittsburgh. These are census tracts in

Table 5: FAS Distribution in rural and urban portions of Appalachia. Table shows the number of census tracts and percent of population that occurred in each food access grouping (defined by number of standard deviations above and below the mean).

Food Access Score Groupings		Rural tracts (n = 2494)	Urban tracts (n = 3618)	Rural population (n = 10418692)	Urban population (n = 14824764)
Extremely Low	**< -2 SD**	75	117	2.11%	1.88%
Low	**-2 SD**	392	245	13.50%	4.80%
Average/Low	**-1 SD**	1249	922	51.36%	22.66%
Average/High	**+1 SD**	730	1545	31.08%	45.25%
High	**+2 SD**	44	639	1.79%	20.88%
Extremely High	**> +2 SD**	4	150	0.16%	4.53%

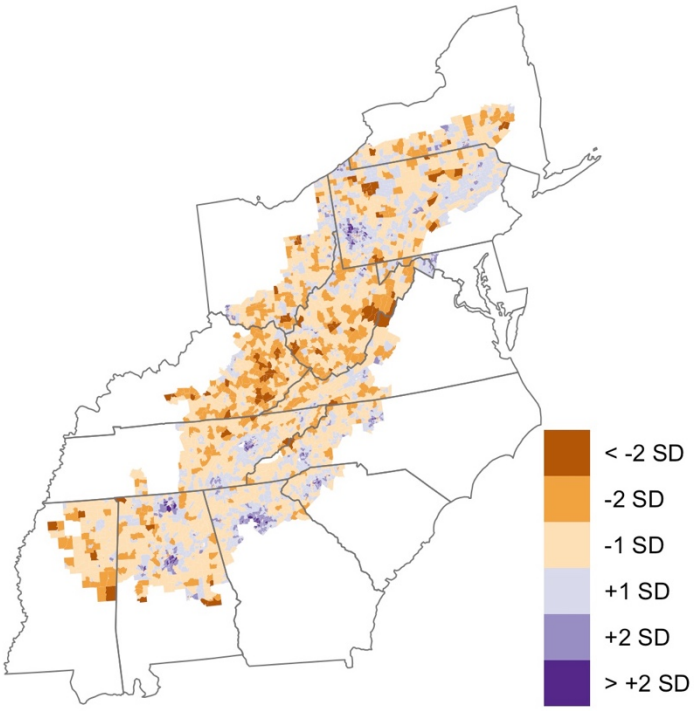

Figure 3: Spatial patterns of food access in Appalachia. Orange shades (light to dark) indicate decreasing access to food, purple shades (light to dark) indicate increasing access to food. Shades correspond to standard deviations from mean. Figure shown in greater detail in Appendix.

which people tend to live closer to stores and have higher incomes, and more households have access to vehicles. However, several tracts with extremely low FAS are also located in this same area. In these urban tracts, although the distance-to-store values are low, low median household income proportions and a high percentage of households with no vehicles yield low FAS. Localized geographic variability in food access is present to a lesser extent in other cities in Appalachia, such as Birmingham, Alabama. As such, both the highest and the lowest FAS within Appalachia are found in urban census tracts, and while rural census tracts tend to have lower FAS values than their urban counterparts, these do not reach the greatest extremes.

3.2 Farmers markets and small grocery stores in the Food Access Score

Incorporating local food retailers—small grocery stores and farmers markets—into the distance-to-store analysis has the potential to drastically increase FAS. However, this impact is not uniformly experienced across Appalachian census tracts. Almost two-thirds of census tracts

do not experience an increase in FAS when incorporating small grocery stores, and 30% of tracts experience no change when incorporating small grocery stores and farmers markets. Two-thirds of tracts with no change when including small grocery stores are urban, which rises to over 70% when adding farmers markets as well. This suggests that in urban areas, which tend to have a greater number of grocery stores, alternative retailers have a smaller impact on the FAS.

On the other hand, in communities with worse food access, alternative food options can play a greater role in providing access to food. Many of the census tracts that experience the greatest increase in access when adding small grocery stores and farmers markets are rural, and these tend have fewer grocery stores. Of the 10% of census tracts in Appalachia that experience the largest increase when incorporating small grocery stores, over 70% are rural. The same is true of the 10% of tracts that experience the greatest increase due to small groceries and farmers markets, where over 80% are rural. These differences are even more pronounced among the 5% of census tracts that experience an increase in the FAS. Furthermore, the majority of the census tracts that experience the greatest increases when accounting for small grocery stores and farmers markets have extremely low FAS. These tracts account for only a small percentage of the Appalachian population, but this demonstrates the ability of small grocery stores and farmers markets to have a major impact on community-level food access.

Similar trends are visible when examining the distribution of each replication of the FAS across Appalachia as a whole. Overall, differences between the FAS for large grocery stores alone, all grocery stores, and all grocery stores and farmers markets are negligible (Figure 4). The average FAS for rural areas is lower than for urban areas in all three replications. The majority of changes are visible among the lower outliers of the rural FAS. Adding additional food options—first small grocery stores and then farmers markets—shifts the range of rural FAS. Differences occur between the negative outliers in the urban FAS as well, but the shift towards

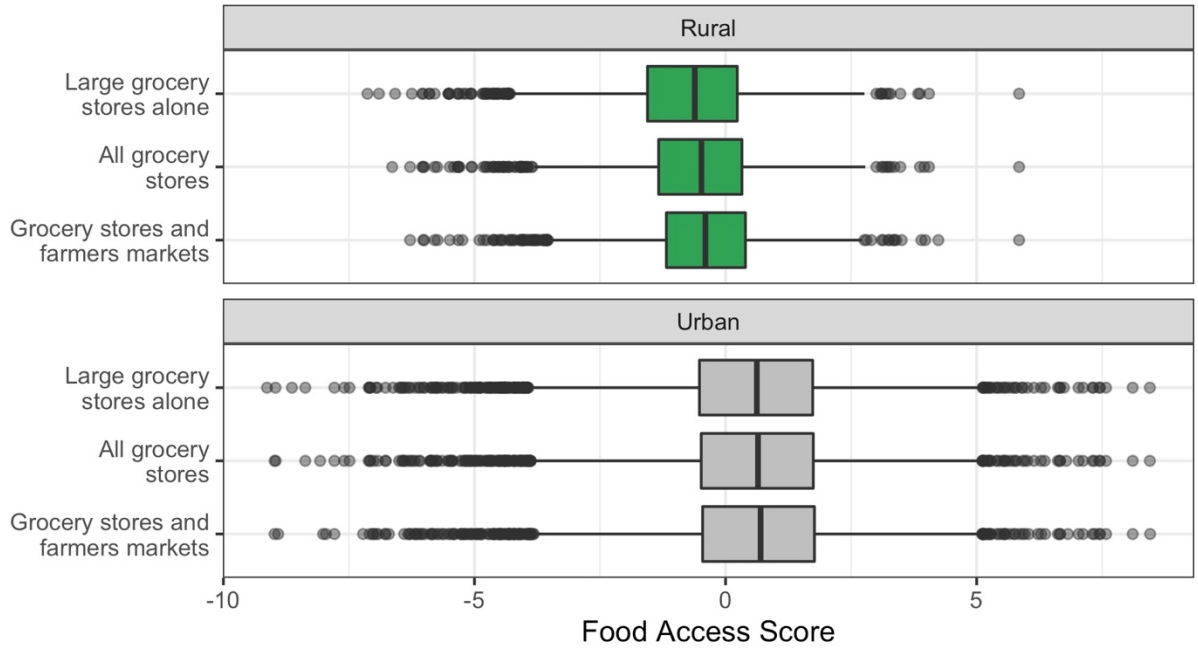

Figure 4: FAS replications for rural (green) and urban (grey) areas in Appalachia: large grocery stores alone, all grocery stores, and all grocery stores and farmers markets. Boxes show the 1st to 3rd quartiles of each replication, whiskers show 1.5 * the interquartile range (distance between the 1st and 3rd quartiles), points are outliers.

increased FAS is not as clear. Despite the fact that some urban census tracts have the lowest FAS calculated for Appalachia, this group of tracts is not the area of greatest change in the distribution of rural and urban FAS across the three replications. Rural tracts with low FAS see the most change when incorporating alternative food retailers.

3.3 Appalachian FAS compared to National FAS and Food Desert Classifications

Appalachia has worse food access than the US as a whole. The US average FAS is 0.54, higher than the mean FAS for Appalachia, although still within the range of average FAS values (within one standard deviation of the mean). The distribution of FAS for all census tracts shows that scores in Appalachia are skewed negative relative to the US average score. This skew is most noticeable among rural census tracts, the majority of which have an FAS lower than the US average (Figure 2). On the other hand, urban tracts are more evenly distributed around the US average. The overall distribution of the FAS in Appalachia supports the FDM classifications for

this region relative to the US as a whole. The FDM finds that 21.6% of Appalachian census tracts are classified as food deserts, higher than the 14.0% of US tracts that are food deserts (Economic Research Service, 2021a).

Categorizing the FAS for large grocery stores alone indicates that nearly half of the population of Appalachia has poor access to food. The FDM criteria yield a FAS of 0.16, slightly higher than the average FAS for Appalachia. Using this value and the US average FAS to define thresholds for categorizing good and poor food access, census tracts with FAS lower than 0.16 have poor food access, while those with scores higher than 0.92 have good food access. Based on these categorizations, 12.3 million people out of the 25 million living in Appalachia have poor food access, while only 8.3 million people have good food access. Examining the breakdown of good and poor food access among the rural and urban populations again highlights the dichotomy in food access (Table 6). Among urban census tracts, 48.3% of the population has good food access and 32.7% has poor food access. In contrast, rural census tracts primarily fall into the poor access category, with over 70% of the rural population having poor food access, compared to only 10.9% with good food access. Despite the rural population making up just over 40% of the total population of Appalachia, 60.6% of the population that has poor food access

Table 6: Percentage of tracts and populations in categories of good and poor access, according to the FAS and the FDM. The summaries were calculated for all tracts in Appalachia, as well as for urban and rural tracts. The FDM methodology does not classify tracts with good food access.

	Food Desert Model		**Food Access Score**	
	Tracts	**Population**	**Tracts**	**Population**
All tracts (n = 6112)				
Poor Access	21.58%	21.78%	52.90%	48.75%
Good Access	*N/A*	*N/A*	29.55%	32.87%
Rural tracts (n = 2494)				
Poor Access	17.48%	19.59%	73.26%	71.58%
Good Access	*N/A*	*N/A*	10.59%	10.86%
Urban tracts (n = 3618)				
Poor Access	24.41%	23.32%	38.86%	32.71%
Good Access	*N/A*	*N/A*	42.62%	48.34%

lives in rural census tracts, while only 13.6% of the population with good food access lives in these same tracts. Whether assessed using the continuous FAS or the discrete categories, poor access to food is a greater issue for the rural population of Appalachia than for the urban population.

The FDM indicates that poor food access is more common in urban areas of Appalachia than in rural areas, contradicting the findings of this investigation. 19.6% of the rural population and 23.3% of the urban population of Appalachia live in a food desert, and less than half the tracts that are categorized as poor food access by the FAS are food deserts (Economic Research Service, 2021a).[12] 73.3% of rural census tracts and 38.9% of urban tracts have poor food access, whereas only 17.5% of rural tracts and 24.4% of urban tracts are classified as food deserts. Of the population living in food deserts, 37.1% live in rural census tracts, compared to over 60% of tracts categorized as poor food access by the FAS (Economic Research Service, 2021a). The distribution of poor access according to the FAS is the reverse of the rural and urban breakdown of FDM classifications, and it may downplay the prevalence of poor access within this region.

Differences in classification between the FAS and the FDM are largely due to the models of food access on which these classifications are based. The number of tracts meeting the FDM indicator of access criteria using both the FAS and FDM methodologies are roughly the same (Figure 5).[13] Despite these similar tract counts, far more tracts are categorized as poor food access based on the FAS than are classified as food deserts. The FDM finds that nearly a third of Appalachian census tracts meet the combined distance-to-store and vehicle criteria for food deserts and almost half meet the economic criteria (Economic Research Service, 2021a). When

[12] Percentages based on the rural-urban designations used in this investigation, for direct comparison. These numbers change slightly when using ERS classifications of rural and urban census tracts. 20.4% of the rural population and 23.1% of the urban population live in food deserts based on ERS rural-urban designations.
[13] For the distance-to-store indicator of access, the two methodologies largely agree on the population counts at multiple distance thresholds, not just the half-mile criteria of the FDM, as is shown in Table 3.

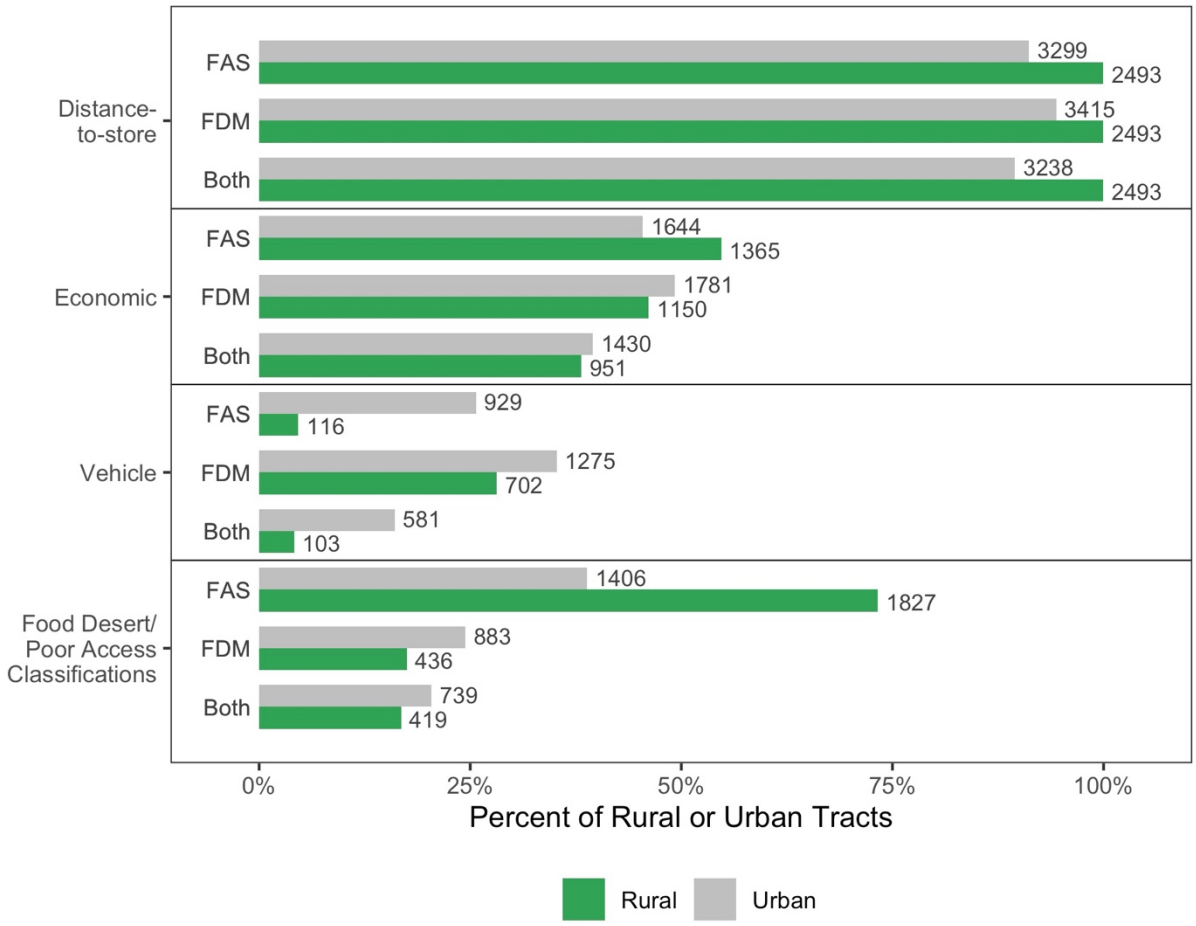

Figure 5: Indicators of access and census tract poor access classifications for the FAS and the FDM. Grouped according to rural (green) and urban (grey) designations. Numbers on each column indicate the total number of tracts that meet the indicator criteria/classification. "Both" indicates the number of census tracts that meet both FAS and FDM criteria. FDM data from the Food Access Research Atlas (Economic Research Service, 2021a).

these criteria are combined in the FDM, however, less than one-quarter of tracts meet both sets of criteria and are classified as food deserts (Figure 5). The additive model of the FAS avoids a scenario where tracts are not considered to have poor food access simply because an absolute threshold for *one* of the indicators is not met. Instead, census tracts with higher values for one of the indicators can be categorized as poor food access due to the combined influences of *all* of the indicators of access.

4. Discussion

This investigation finds that food access in Appalachia tends to be worse in rural areas than in urban ones and is highly context-dependent. Some places lack access to food because

there simply are not stores at which food can be purchased, while in others the lack of access to food is driven by lower incomes. Communities that lack access to food for multiple reasons—such as places that have low incomes, are far from stores, and have a greater percentage of households without vehicles—have very poor access to food. The results for the analyses including farmers markets and small grocery stores show that alternative food retailers can increase food access dramatically in rural communities with poor food access. However, these retailers do not have the same impact everywhere: in urban areas, where there are a greater number of large grocery stores, the addition of alternative food retailers has a negligible impact on food access. Small groceries and farmers markets have the greatest ability to provide access to food in places where they are filling a void in local food systems. Finally, the results of this investigation and the USDA food desert classifications both find that food access in Appalachia is worse than in the US as a whole. However, where the FAS finds poor food access to be more prevalent among rural census tracts, the FDM finds that food deserts are more often urban.

4.1 Patterns of access in Appalachia

This investigation finds that food access is a significant problem for the rural population of Appalachia. This aligns with other measures of access and well-being in Appalachia, including health outcomes, economics, and infrastructure (EBP US, Inc., 2020; Piontak & Schulman, 2014; Pollard & Jacobsen, 2021). The largely rural nature of this region of the US increases the friction of distance and makes access and transportation within the region difficult. Rural communities tend to be farther from stores, and where these communities also experience low incomes and a lack of vehicles, the effects on access to food are amplified. Low income individuals and households in rural areas tend to be farther from the nearest grocery, making access to food more difficult (Rhone et al., 2019). Limited access to vehicles is part of a larger trend in the lack of transportation infrastructure in rural places, making it even more difficult for

those who are far from stores to access food (EBP US, Inc., 2020; Piontak & Schulman, 2014). Further exacerbating problems with food access in rural communities is a discrepancy in food costs between rural and urban areas. A case study of food costs across rural and urban counties in Kentucky found that the cost of foods in rural counties is higher than in urban counties, and that the cost in counties with a higher poverty rate is also higher (Hardin-Fanning & Rayens, 2015). These trends in rural food access suggest that greater attention needs to be paid to the specific problems of access that afflict rural communities in the US.

4.2 The role of small grocery stores and farmers markets

Incorporating locations of small grocery stores and farmers markets—rather than assuming food can only be purchased at large grocery stores—can have a major impact on food access metrics. This contribution to assessing food access is context-specific and varies across Appalachia. While farmers markets and small groceries can be found across a diverse range of communities, the biggest increases in FAS are predominantly experienced in rural census tracts. Farmers markets and small grocery stores fill a niche in communities in which large grocery stores are scarce, and it is in these communities that alternative food retailers have the greatest potential to improve food access. Moreover, farmers markets can have community-level impacts beyond simply providing food. Local food production and integration with community institutions are two aspects of healthy food systems (Hamm, 2009), both of which can be fulfilled by farmers markets. In addition to having a positive impact on local food access, they serve as keystones of local food systems, promoting economic and social growth within rural communities while also providing a market for locally produced foods (Gillespie et. al., 2007). These food sources matter for rural communities.

Being able to incorporate local modes of food access into this model is a first step towards measuring the ways in which people can get access to food besides large grocery stores.

Beyond the stores considered in this investigation are other means of food access that are less visible. Grocery stores and farmers markets are food options that are open to the public, but other options exist outside of grocery store-based food systems. Social networks can provide access to food for those lacking other means, while local foodways, such as foraging and household gardening, can be particularly important for supplementing food access in rural areas (Kroll, 2017). These informal means of getting access to food are unlikely to show up in data and are difficult to incorporate into a generalized model of food access. Understanding the greater range of options that provide access to food in rural communities would be a step towards understanding rural food systems beyond what can be measured strictly through data approaches.

In terms of providing access to food, farmers markets cannot be assumed to have the same impact on food access as grocery stores. This methodology does not take into account the more limited hours of farmers markets as compared to groceries, nor does it consider that farmers markets have a greater seasonality, both in terms of the goods offered and in terms of when they operate. Future work should investigate the variable access provided by farmers markets as compared to the large grocery store, and it is likely that other food retailers could function similarly. Combining this means of measuring food access with an assessment of the type and quality of food provided by other food retailers beyond the grocery store could yield a composite measure of food access that assesses a greater range of food options.

4.3 Relative and absolute measures of food access

This investigation focused specifically on food access in Appalachia to better understand the variability in food access across a largely rural area of the US. The methodology produces a relative measure of food access within Appalachia, standardized using only the data for the region rather than for the US as a whole. As demonstrated by the comparison with the US average FAS, the scores computed in this investigation would likely change if this methodology

was applied to all US census tracts. A criticism of relative measures of food access is that it is difficult to connect these findings with concrete designations of adequate (average and good) or inadequate (poor) food access (Ver Ploeg, Dutko, et al., 2015). To an extent, this investigation addresses this critique by collapsing the FAS to a discrete set of food access categories based on the FDM criteria and comparing it to existing food desert classifications. The total number of census tracts within Appalachia that are categorized as good or poor access would change if this methodology were applied to the entire US, but the general distribution of the FAS in Appalachia would remain the same. As such, the trends observed—both in terms of spatial patterns and the rural and urban dichotomy of food access—would likely persist.

This investigation suggests that food access within a defined region is best understood through a relative measure of access that is contextualized using absolute measures. It is possible to collapse the spectrum of relative food access to discrete categories, but it is not possible to extract relative degrees of food access from a discrete classification. The binary FDM classifications erase distinctions between places with varying degrees of poor food access. It implies that there is a measurable point beyond which a place has poor access to food, and all places that do not meet the criteria do not have poor access. The ability to determine the places that have worse access to food when compared to others within the region is a strength of the FAS methodology. Conversely, the investigation also determines that there are census tracts that stand out for having better access to food relative to the rest of Appalachia, which is a major contribution to the understanding of food access in Appalachia. Identifying places that have worse food access could be used as a basis for targeting initiatives to best improve access to food in Appalachia, while understanding characteristics of places that have better food access could serve as a model for improving food access.

5. Conclusion

Food access in Appalachia is worse than average access in the US as a whole. This lack of access is more prevalent in rural communities than it is in urban ones, whether measured by the FAS or by good and poor food access classifications. The degree of food access varies widely, with some tracts having markedly better or worse food access than others within the study region. Areas with better food access are clustered around major urban centers. Central Appalachia, through southern West Virginia and eastern Kentucky, is an area of worse food access. This area of central Appalachia is a largely rural region, and the increased physical separation between communities in this part of Appalachia is tied to questions of health outcomes, economics, and infrastructure. These findings contribute to a larger body of literature about rural well-being and Appalachia. Future research into the variability of rural food access in the US would better contextualize Appalachia relative to other rural regions of the US.

Policies to improve infrastructure and public transportation options, as well as other food support programs for rural areas could address some of the outstanding issues that are endemic to rural communities. Increasing the number of food options that are open to residents of rural communities could also work to create stronger food systems. These programs should be targeted to census tracts that have particularly poor food access, especially relative to neighboring tracts or those with similar demographic or socio-economic characteristics. On the other hand, census tracts with particularly good food access, especially relative to similar or neighboring tracts, should be investigated in more depth to understand some of the measures that can be taken to improve food access. Overall, it is necessary to develop strategies for mitigating the lack of access to food in rural communities, as has already been done for specific urban contexts.

While it is important to consider local means of food access, like small grocery stores and farmers markets, these food options cannot provide food access everywhere equally. These

alternative means of food access are of greater importance in rural communities, primarily in areas with few large grocery stores. Urban areas, with a greater number of large grocery stores, show a small change in food access, if any, when these options are included in the model of food access. When examining food access on a community level, these local food organizations should be evaluated on a case-by-case basis to determine the impact that they can have on their specific communities. Other means of food access that are not visible in data on food retailers likely form a part of local food systems in areas with few grocery store options, but these access points are more difficult to investigate in a data-driven approach to food access. Future research on the context-specific role that additional food options play in rural communities would advance the understanding of rural food systems.

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Census Bureau. (2019h). *TIGER/Line Shapefile, 2019, 2019 state, Ohio, 2019 Census Census Tract State-based* [Shapefile]. U.S. Department of Commerce, U.S. Census Bureau, Geography Division, Geographic Products Branch. https://www2.census.gov/geo/tiger/TIGER2019/TRACT/tl_2019_39_tract.zip

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Census Bureau. (2019j). *TIGER/Line Shapefile, 2019, 2019 state, South Carolina, 2019 Census Census Tract State-based* [Shapefile]. U.S. Department of Commerce, U.S. Census Bureau, Geography Division, Geographic Products Branch. https://www2.census.gov/geo/tiger/TIGER2019/TRACT/tl_2019_45_tract.zip

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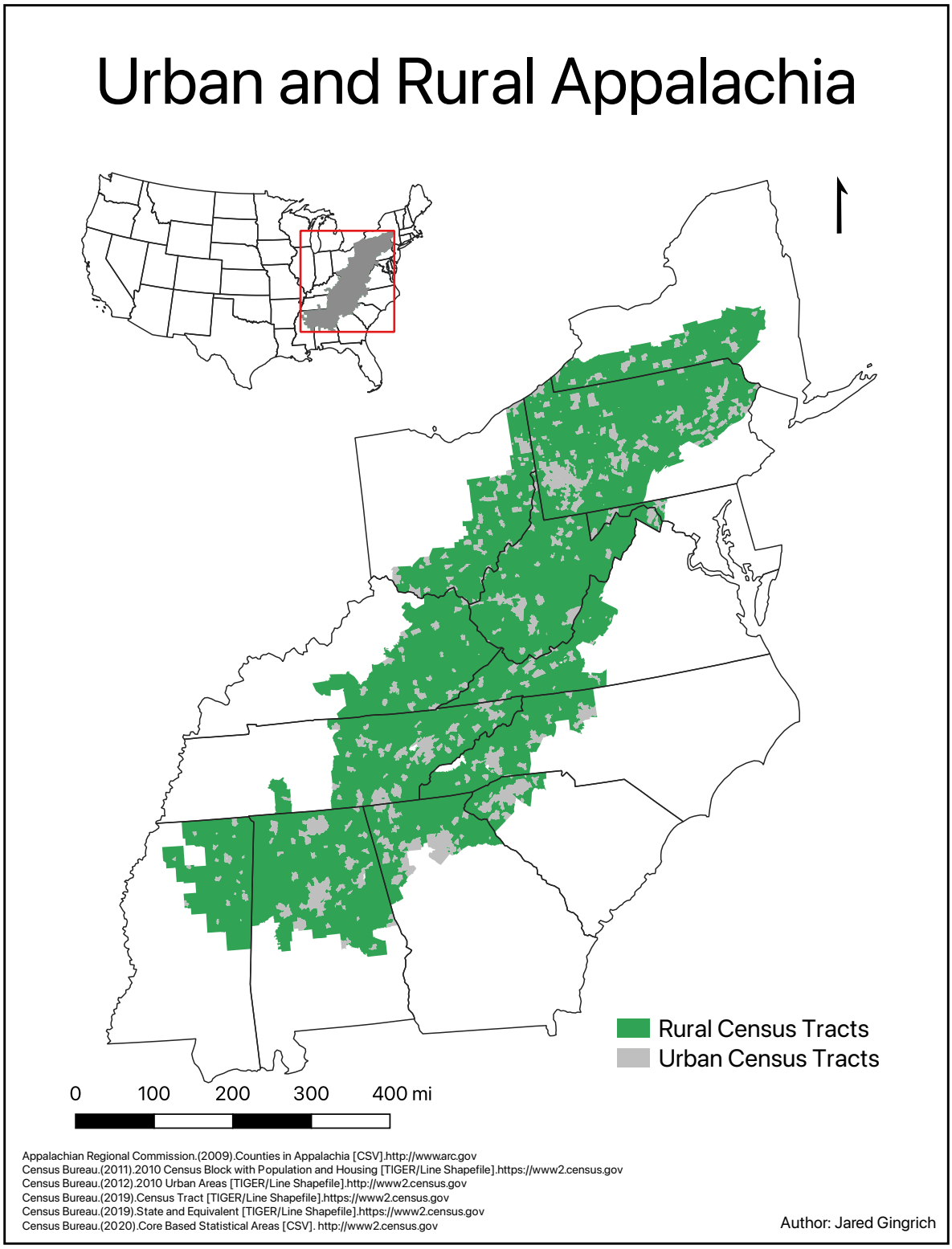
Appendix: Supplementary Maps

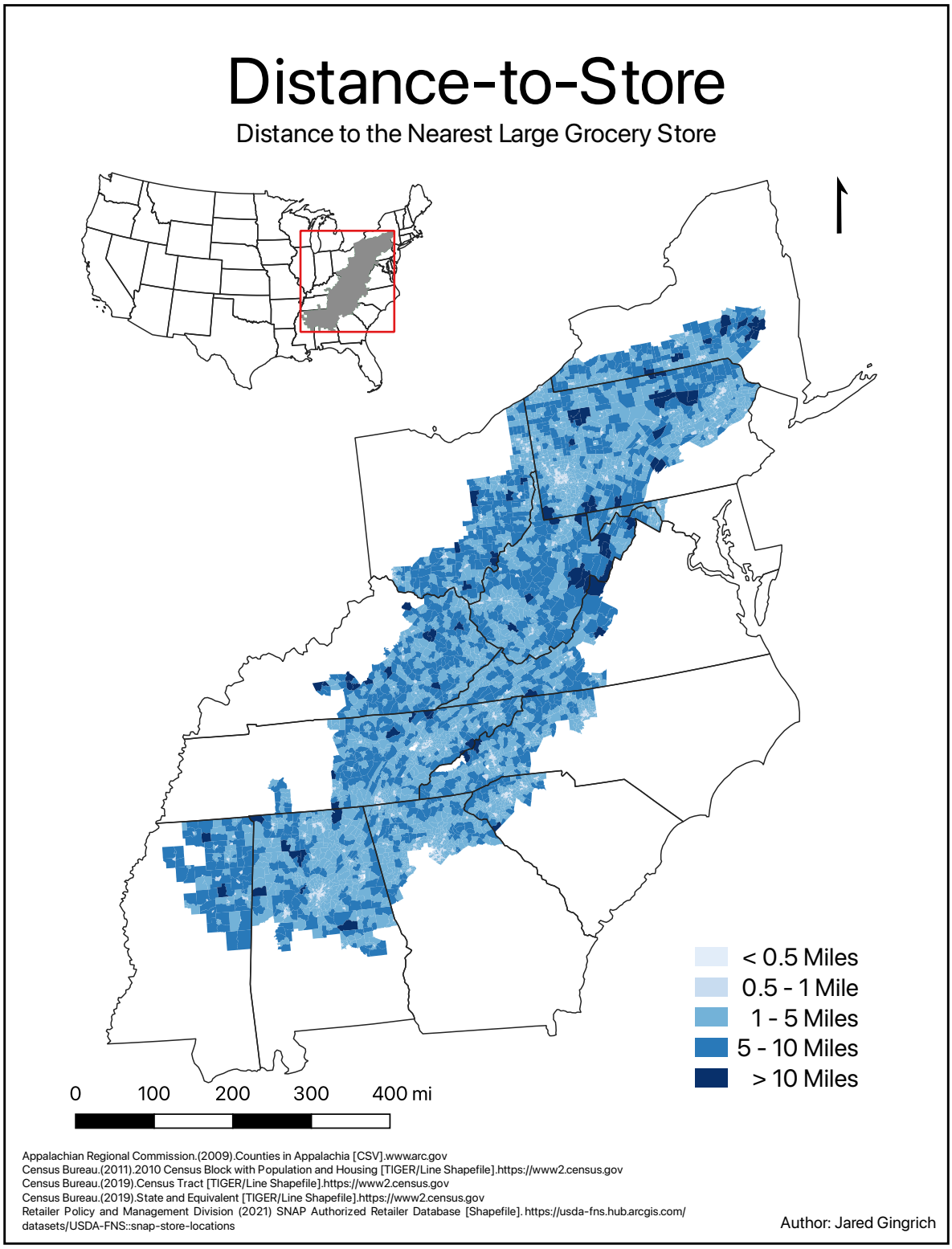
This section contains supplementary maps showing each of the indicators of access used to calculate the Food Access Score. It also contains enlarged versions of Figures 1 and 3.

Table of Maps

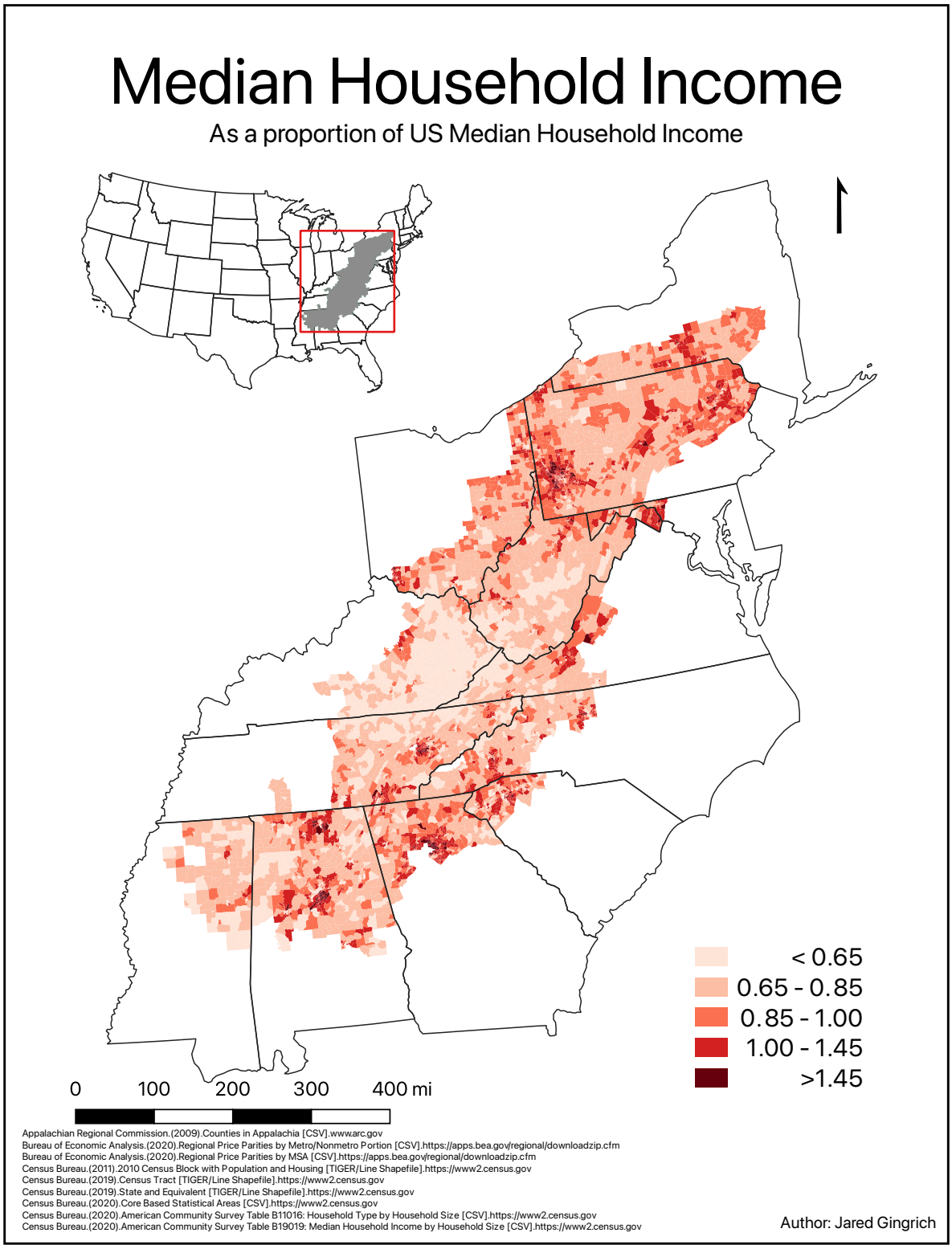
Map 1


Urban and Rural Appalachia
Rural Census Tracts
Urban Census Tracts
0
100
200
300
400 mi
Appalachian Regional Commission.(2009).Counties in Appalachia [CSV].http://wwwarc.gov
Census Bureau.(2011).2010 Census Block with Population and Housing [TIGER/Line Shapefile].https://www2.census.gov
Census Bureau.(2012).2010 Urban Areas [TIGER/Line Shapefile].http://www2.census.gov
Census Bureau.(2019).Census Tract [TIGER/Line Shapefile].https://www2.census.gov
Census Bureau.(2019).State and Equivalent [TIGER/Line Shapefile].https://www2.census.gov
Census Bureau.(2020).Core Based Statistical Areas [CSV]. http://www2.census.gov
Author: Jared Gingrich

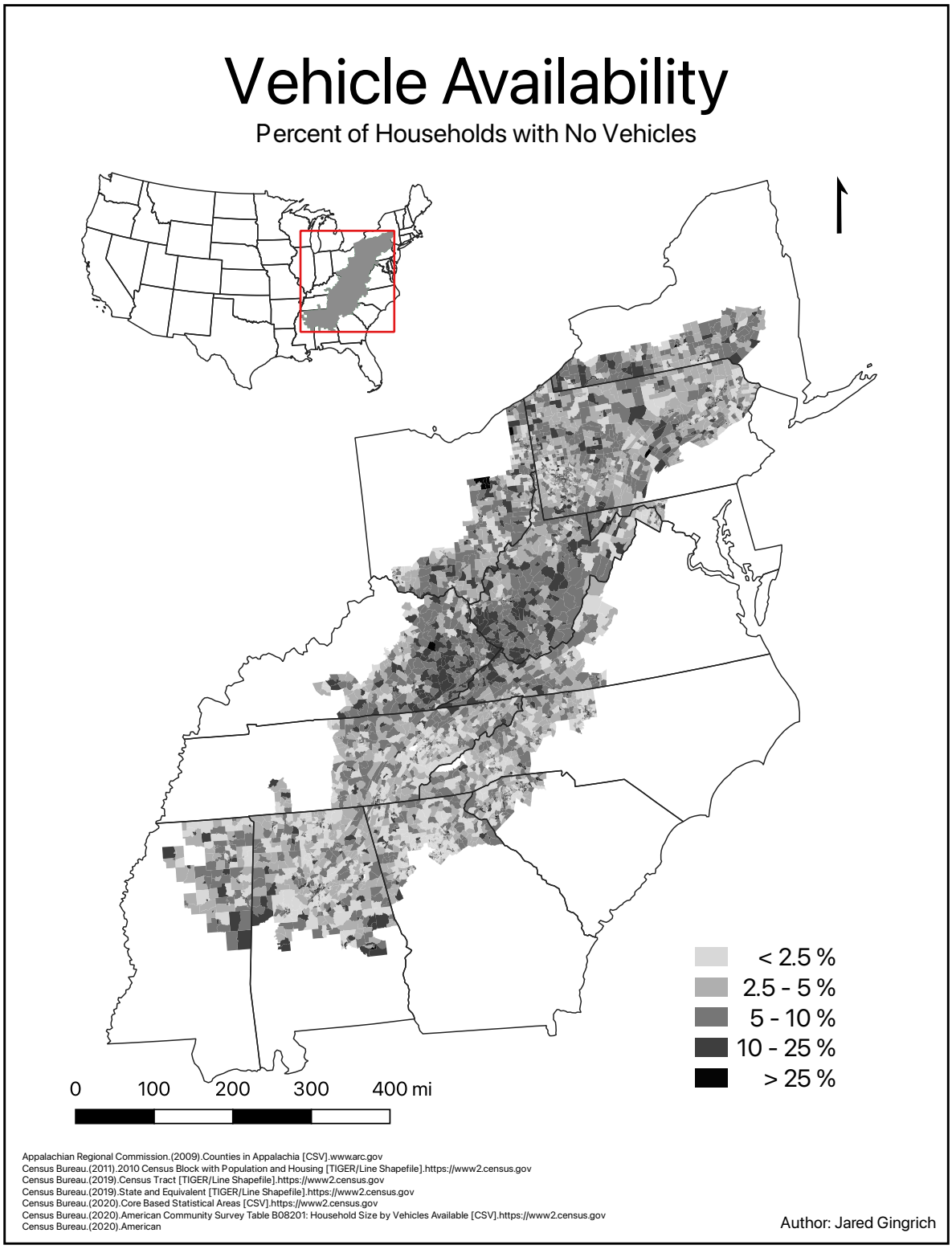
Map 2


Distance-to-Store
Distance to the Nearest Large Grocery Store
< 0.5 Miles
0.5 - 1 Mile
1 - 5 Miles
5 - 10 Miles
> 10 Miles
0
100
200
300
400 mi
Appalachian Regional Commission.(2009).Counties in Appalachia [CSV].wwwarc.gov
Census Bureau.(2011).2010 Census Block with Population and Housing [TIGER/Line Shapefile].https://www2.census.gov
Census Bureau.(2019).Census Tract [TIGER/Line Shapefile].https://www2.census.gov
Census Bureau.(2019).State and Equivalent [TIGER/Line Shapefile].https://www2.census.gov
Retailer Policy and Management Division (2021) SNAP Authorized Retailer Database [Shapefile]. https://usda-fns.hub.arcgis.com/datasets/USDA-FNS::snap-store-locations
Author: Jared Gingrich

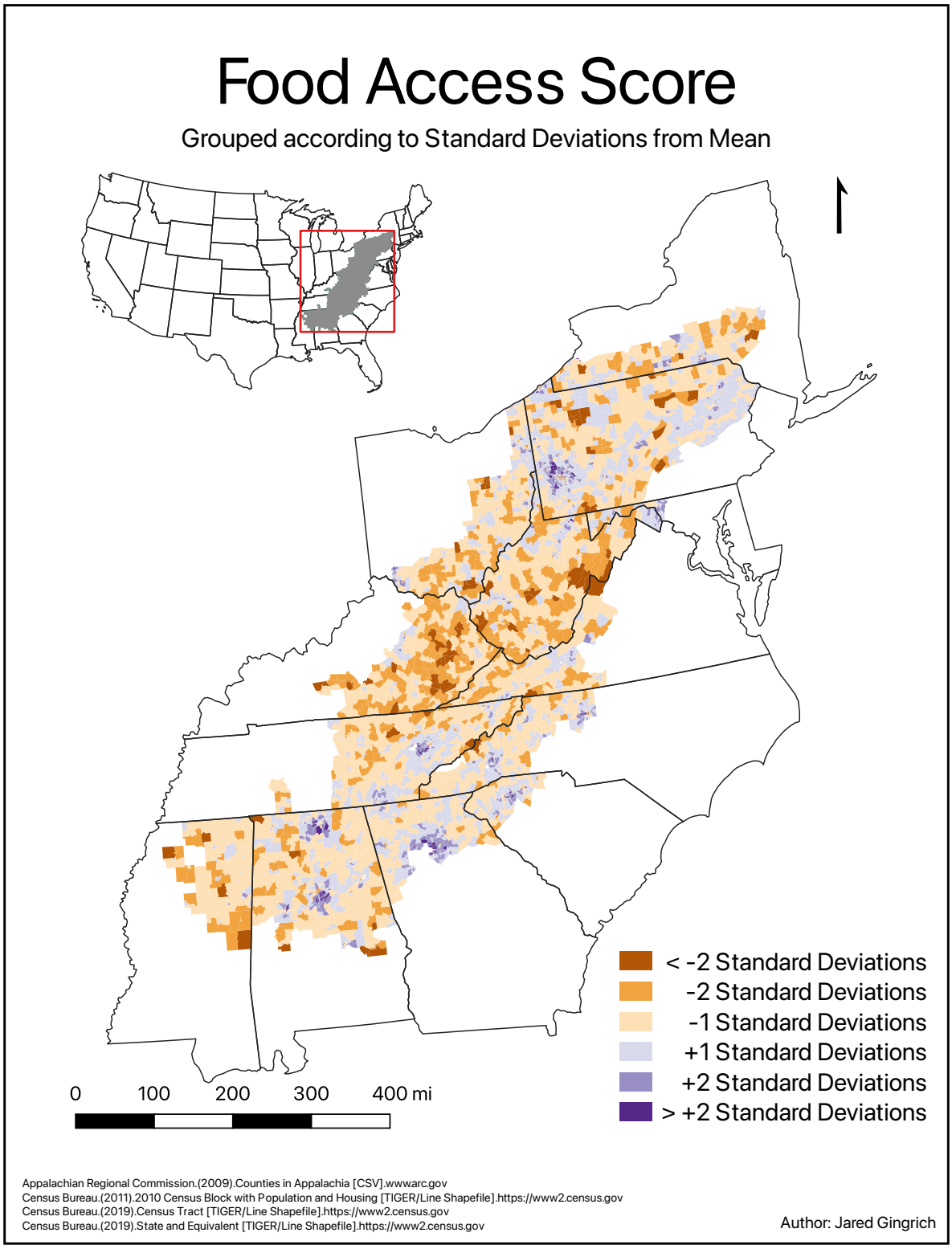
Map 3


Median Household Income
As a proportion of US Median Household Income
< 0.65
0.65 - 0.85
0.85 - 1.00
1.00 - 1.45
>1.45
0
100
200
300
400 mi
Appalachian Regional Commission.(2009).Counties in Appalachia [CSV].www.arc.gov
Bureau of Economic Analysis.(2020).Regional Price Parities by Metro/Nonmetro Portion [CSV].https://apps.bea.gov/regional/downloadzip.cfm
Bureau of Economic Analysis.(2020).Regional Price Parities by MSA [CSV].https://apps.bea.gov/regional/downloadzip.cfm
Census Bureau.(2011).2010 Census Block with Population and Housing [TIGER/Line Shapefile].https://www2.census.gov
Census Bureau.(2019).Census Tract [TIGER/Line Shapefile].https://www2.census.gov
Census Bureau.(2019).State and Equivalent [TIGER/Line Shapefile].https://www2.census.gov
Census Bureau.(2020).Core Based Statistical Areas [CSV].https://www2.census.gov
Census Bureau.(2020).American Community Survey Table B11016: Household Type by Household Size [CSV].https://www2.census.gov
Census Bureau.(2020).American Community Survey Table B19019: Median Household Income by Household Size [CSV].https://www2.census.gov
Author: Jared Gingrich

Map 4


Vehicle Availability
Percent of Households with No Vehicles
< 2.5 %
2.5 - 5 %
5 - 10 %
10 - 25 %
> 25 %
0
100
200
300
400 mi
Appalachian Regional Commission.(2009).Counties in Appalachia [CSV].www.arc.gov
Census Bureau.(2011).2010 Census Block with Population and Housing [TIGER/Line Shapefile].https://www2.census.gov
Census Bureau.(2019).Census Tract [TIGER/Line Shapefile].https://www2.census.gov
Census Bureau.(2019).State and Equivalent [TIGER/Line Shapefile].https://www2.census.gov
Census Bureau.(2020).Core Based Statistical Areas [CSV].https://www2.census.gov
Census Bureau.(2020).American Community Survey Table B08201: Household Size by Vehicles Available [CSV].https://www2.census.gov
Census Bureau.(2020).American
Author: Jared Gingrich

Map 5


Food Access Score
Grouped according to Standard Deviations from Mean
< -2 Standard Deviations
-2 Standard Deviations
-1 Standard Deviations
+1 Standard Deviations
+2 Standard Deviations
> +2 Standard Deviations
0
100
200
300
400 mi
Appalachian Regional Commission.(2009).Counties in Appalachia [CSV].www.arc.gov
Census Bureau.(2011).2010 Census Block with Population and Housing [TIGER/Line Shapefile].https://www2.census.gov
Census Bureau.(2019).Census Tract [TIGER/Line Shapefile].https://www2.census.gov
Census Bureau.(2019).State and Equivalent [TIGER/Line Shapefile].https://www2.census.gov
Author: Jared Gingrich