# Food Store Accessibility by Public Transportation in Ramsey County, Minnesota

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## Abstract

Public transportation plays an important role in connecting people to grocery stores where healthy, affordable food is available. Modeling the travel time necessary to reach a grocery store by public transportation provides an assessment of the grocery store accessibility in an area for people who cannot or choose not to drive. This study focuses on Ramsey County, Minnesota and compares results to other accessibility analyses whose data is available. The grocery store accessibility analysis by transit adds new information and will be of value to policymakers, community leaders, public health officials, public transportation planners, and advocates working to improve access to healthy food.

## Introduction

Access to affordable, healthy food is a fundamental need for all people. Previous efforts to spatially identify areas where access to food is limited, also known as food deserts, have often used simple proximity to grocery stores as a measure of food accessibility. However, for people who use public transportation, the amount of time necessary to reach a grocery store is determined not so much by distance but by the speed, frequency, and availability of transit services. Assessing transit accessibility to grocery stores throughout the day can better inform both community development and public health efforts on how to ensure residents without cars can still reach healthy and affordable food.

Accessibility to food stores can also be useful for evaluating the utility of a public transportation network for daily life. Many public transit systems are oriented around central business district commuters working a typical 9-5 schedule. While this is a promising demographic for many transit agencies, this emphasis can leave significant service gaps during evenings and weekends and in neighborhoods outside of the downtown area. People without cars in particular need to have transportation options throughout the week and to all their destinations. Grocery accessibility measures can help transit planners ensure that the transit network is serving all of their passengers' needs.

### *Healthy Food and Food Deserts*

The concepts of both health and food are entangled in larger questions such as culture, values, and personal choice. Much of the research on community access to food has revolved around the notion of a food desert. Food deserts are "low-income areas in which healthy foods are expensive, of poor quality, or inaccessible" based on a definition of "healthy foods" from white, middle class

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norms (Shannon, 2014). Shannon critiques the common concept of a food desert as too simple because the researchers ignore most of the factors that contribute to an individual's nutritional choices beyond proximity. They instead attempt to draw definite boundaries around food areas rather than measuring the degree to which food is available (Shannon, 2014). Shannon recommends approaches that go beyond delimiting food desert areas by assessing additional food access factors such as available transportation. Hillier, Smith, Cannuscio, Karpyn, and Glanz (2015) concur with this critique and in their research emphasize "individual-level, household-level, and neighborhood-level attributes" and their effect on food store access and choices.

### *Accessibility*

Definition

O'Sullivan, Morrison, and Shearer (2000) describe accessibility in relationship to mobility. Mobility is the capacity for people to traverse a distance while accessibility is the ease of arriving at a destination from an origin (O'Sullivan *et al.*, 2000). Accessibility measures transportation as a means to an end rather than as an inherent good (O'Sullivan *et al.*, 2000). This same definition is used by Tenkanen, Saarsalmi, Järv, Salonen, and Toivonen (2016).

Lovett, Haynes, Sünnenburg, and Gale (2002) are careful to situate "physical accessibility" as one component in the broader picture of social, cultural, and economic factors that shape individuals' overall access to health. Fransen, Neutens, Farber, De Maeyer, Deruyter, and Witlox (2015) note identifying areas or destinations reachable from an origin point within a certain period of time as one of four general methods for public transportation accessibility models.

Modeling Challenges

O'Sullivan *et al.* (2000) note modeling travel on public transportation is more complex than modeling walking or driving because the passenger must navigate the scheduled trips rather than departing spontaneously. It is also necessary to model the walking component to and from the transit stop and transfers between different services (O'Sullivan *et al.*, 2000).

Fransen *et al.* (2015) emphasize the time variability of public transportation service in their study of service gaps and also construct an index of public transit need based on demographics for comparison. Calculating accessibility at time intervals and averaging the results better captures the typical convenience of service for a spontaneous trip because any one specific time may not be representative of the typical passenger experience (Fransen *et al.*, 2015). Farber, Morang, and Widener (2014) map what percentage of the day at least one grocery store is accessible within 10 and 20 minutes by transit for census blocks in their study area. While they employ this method to assess the variability in transit service throughout the day, they note that walking access figures prominently into all day transit access to grocery stores (Farber *et al.*, 2014).

### *Existing Access Data*

Grocery Access

The United States Department of Agriculture (USDA) and the Reinvestment Fund, a non-profit, have both developed methodologies for spatially identifying food deserts. The USDA (2017) Food

Research Atlas defined their "low access census tracts" as tracts where at least either 33% of the population or 500 people were more than one mile from a supermarket in urban tracts, using a population grid derived by areal allocation. An alternative method defined the supermarket distance as half of a mile, but both distances are Euclidean (*i.e.*, as the crow flies), not network-based (USDA, 2017).

The Reinvestment Fund's (2015) Limited Supermarket Access (LSA) data identify census block groups where supermarkets are farther away than a benchmark distance for the population. This benchmark distance, calculated along the street network, varies according to the population density and vehicle ownership of the block group (The Reinvestment Fund, 2015). This method is more granular and context-sensitive than the USDA method described above, but it does not account for multiple modes of transportation.

Job Accessibility by Transit

Owen, Murphy, and Levinson (2015) produce a measurement of accessibility to jobs by transit at the census block level. From the center point of each block, they calculate travel time to job locations by transit for each minute between 7 and 9 a.m. on a weekday (Owen *et al.*, 2015). They weight the number of jobs accessible within different commute durations by the number of workers in the block (Owen *et al.*, 2015). This evaluation accounts for both the total number of jobs nearby and the travel time cost to reach those jobs on public transportation (Owen *et al.*, 2015).

The results of their analysis are published by the University of Minnesota's Accessibility Observatory for metropolitan areas in the United States. While not directly applicable to the question of food access, these methods and results do provide an interesting point of comparison for how to assess transit accessibility to various destinations for people's everyday needs. Notably, having access to many grocery stores likely does not matter as much as having very convenient access to at least one store.

### *Study Area*

The study area for this analysis is Ramsey County, Minnesota, shown in Figure 1.

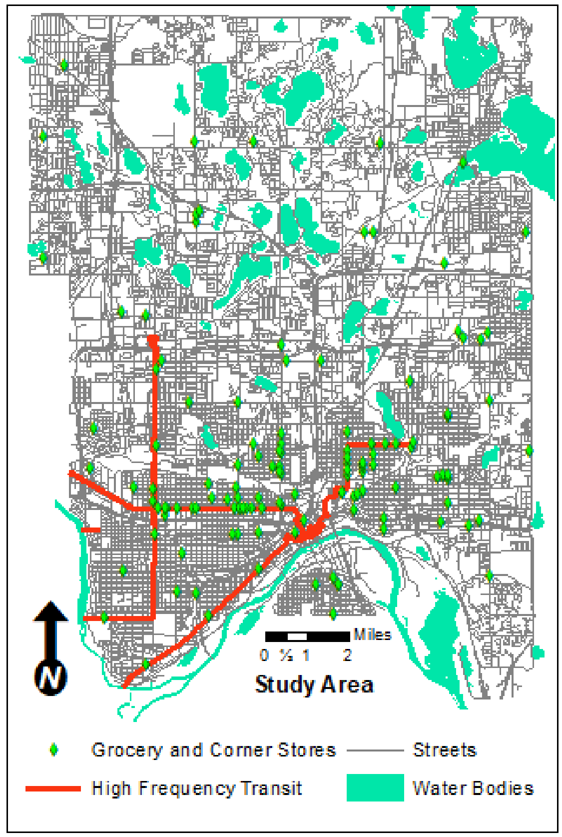


Figure 1. Study area featuring Ramsey County, MN.

The county comprises the city of Saint Paul and several suburbs within the Twin Cities metropolitan area. While the county is fully developed, intensity and density of development ranges from the skyscrapers of Saint Paul to large lots in the northern suburbs. Figure 1 depicts Ramsey

County's street grid, water bodies, corner and grocery stores, and high-frequency transit network. The high-frequency transit network offers passengers the most flexibility because of the relatively short waiting time between vehicles, but transit service in the county extend well beyond these routes.

### *Importance for Comprehensive Planning*

The Saint Paul – Ramsey County Public Health Department is working with the communities of Ramsey County to improve access to healthy food through their comprehensive plans. Comprehensive plans are official documents used by governments to guide policy, planning, and public investment. This research may be of use to the Public Health Department and their community partners to identify areas with relatively poor access to food stores, to illustrate the role of public transportation in helping people access food stores, and the limitations of public transportation schedules oriented toward work commuters.

## Methods

The objective of this analysis is to model the typical length of time to reach the closest grocery store by public transportation from the census blocks of Ramsey County.

### *Data Sources*

Transit Schedules

The Metropolitan Council publishes Generalized Transit Feed Specification (GTFS) data for all regular Metro Transit bus and rail services. This collection of files comprehensively documents the routes and schedules necessary to model trips on public transportation. These data cover all routes provided by Metro Transit, not just the high-frequency transit network mapped above.

Street Network

Ramsey County publishes line data for all the public roadways in the county with an attribute field to identify which roadways do not permit walking (*e.g.,* interstate highways). The roadways that do allow walking are necessary to model the starting and ending portions of transit trips.

Grocery Stores

Ramsey County published geographic point data for a variety of food retailers and distributors in Ramsey County in 2017. This dataset includes community gardens, corner stores, grocery stores, farmers markets, and food shelves. The scope of this analysis covers only stores as year-round destinations for buying food. To avoid prescribing a narrow definition of healthy food, both grocery stores and corners stores are included in this analysis.

Census Blocks

The level of this analysis is the census block to capture potentially fine-grained variations in accessibility. Ramsey County publishes polygons representing the blocks of the 2010 United States Census, the most recent census.

### *Travel Time Calculation*

Transit Journey Modeling

Modeling a trip via public transportation can be substantially more complicated than modeling a trip by automobile. A public transportation trip will typically require at least three distinct segments depending on the number of transfers required. These segments are illustrated in Figures 2-4 for a hypothetical journey between two points with one transfer. Each segment of this trip must be modeled to accurately measure the duration of the passenger's journey. The travel time for segments onboard transit vehicles is calculated from the transit agency's schedules, assuming that all services are operating on schedule. The walking times are calculated from the network distance multiplied by a constant walking speed of 3 miles per hour as suggested by Morang (2017).

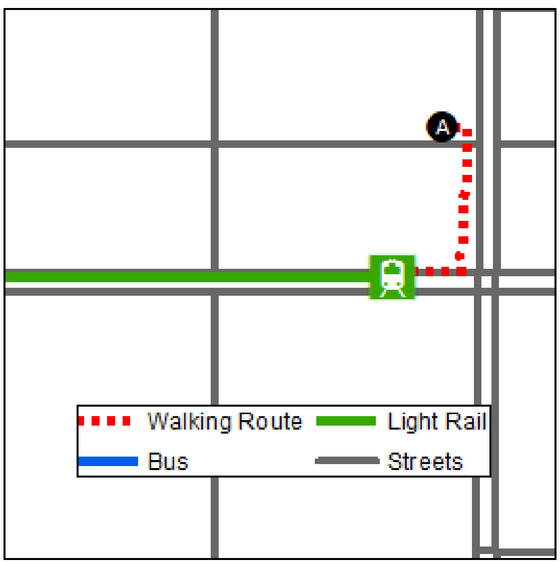


Figure 2. Traveler begins from origin point A, walks to a light rail platform, waits, and boards a scheduled westbound train.

In addition to its multiple segments, a public transportation journey is also more dependent on time-of-day than a journey by car. A difference of a minute in departure time could lead to a passenger arriving at a transit stop just as the vehicle is leaving, potentially adding many minutes to their journey as they wait for the next vehicle. This effect can be compounded by transfers. To handle this variation, it is necessary to calculate and average many modeled trips over a period of time rather than using a single point in time.

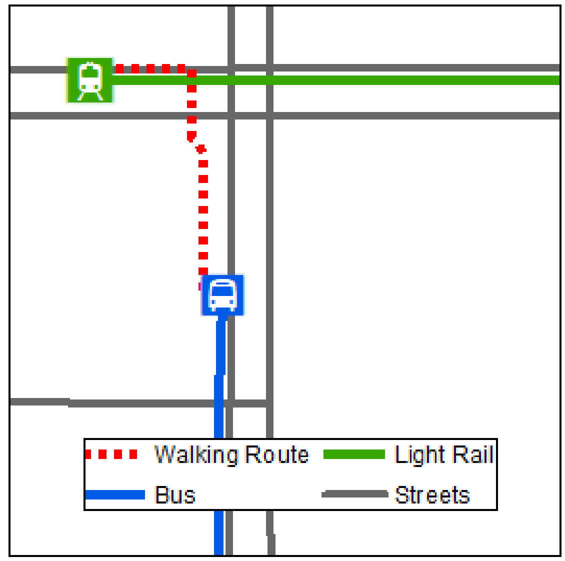


Figure 3. Traveler alights from the train, walks to a bus stop, waits, and boards a scheduled southbound bus.

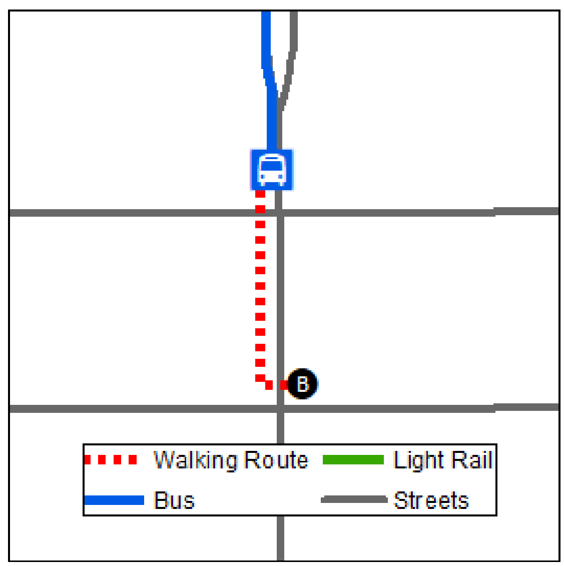


Figure 4. Traveler alights from the bus and walks to the destination point B.

Grocery Store Accessibility

Once the transit network model is implemented based upon the trip modeling principles described above, standard network analysis techniques can be performed for transit. A closest facilities analysis can identify the most easily accessed grocery store from a given origin location at a given time, using travel time as the cost of the journey.

This process works by algorithmically modeling trips to multiple possible destinations and returning the fastest possible travel time. For this analysis, the geometric center of each census block is used as the origin and each grocery store point as a potential destination.

As mentioned above, transit travel time can vary substantially minute-to-minute according to the schedule of transit services. To mitigate the effect of this variation on the results, the accessibility calculation is run for each minute of an hour (*e.g.*, 2:00, 2:01, 2:02, […], 2:58, 2:59). These minute-by-minute values are then averaged to yield a typical travel time for that hour of the day.

For the purposes of this analysis, the hours selected are 2:00 p.m., 5:00 p.m., and 8:00 p.m. to capture travel times at different times of a weekday when people might be visiting a grocery store. To reduce the processing time of the calculation, trips are limited to 60 minutes of travel time. Census blocks where a grocery store cannot be reached within 60 minutes are presented as "no data" in the results.

Software Implementation

The trip modeling process described above was completed using the ArcGIS Network Analyst. A network dataset was created from the Metro Transit GTFS data with the "Add GTFS to a Network Dataset" custom tool developed by Morang (2017).

**Results**

The results of the analysis for 2:00 p.m., 5:00 p.m., and 8:00 p.m. are displayed in Figures 5, 6, and 7 respectively. Descriptive statistics for the results are displayed in Table 1.

***Spatial Patterns***

Areas with better grocery store accessibility are more common in the urban, southern portion of the county where both grocery stores and transit services are more common. Grocery store access in the more suburban parts of the county is generally limited to the immediate vicinity of the stores themselves. Areas where results could not be calculated include part of the Mississippi River Valley in the southeast,

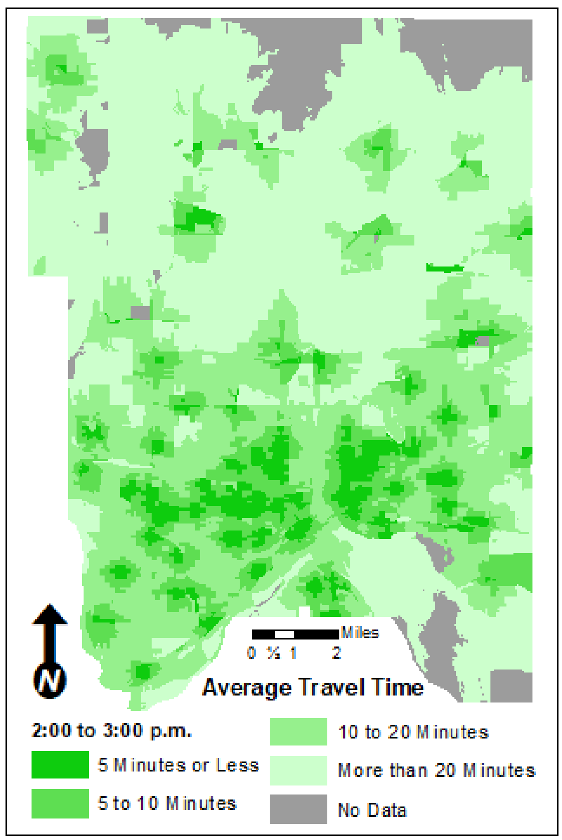


Figure 5. Results for 2:00 p.m.

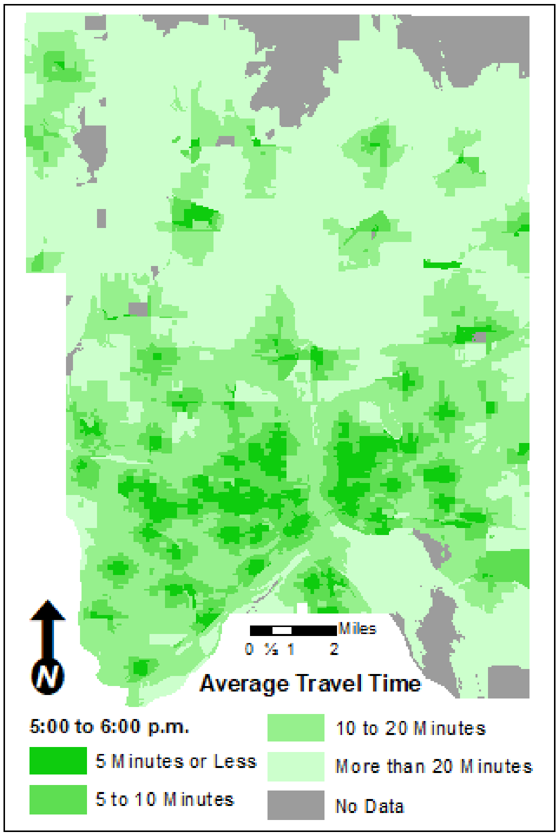

Figure 6. Results for 5:00 p.m.

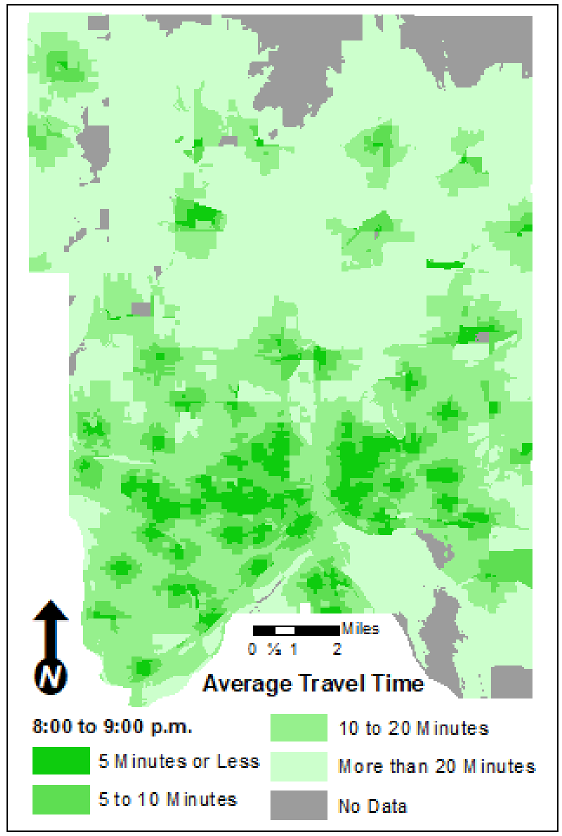

Figure 7. Results for 8:00 p.m.

sporadic freeway- or lake-adjacent areas, and in the most sparsely-developed areas of the county along the northern border. These patterns hold true across the different time periods.

***Descriptive Statistics***

The descriptive statistics for the results are displayed in Table 1, including measures of central tendency, distribution, and variation for the three different intervals individually and for all of them together.

Across all time periods, the minimum and maximum travel times remain the same. The median and the mode are highest for the 8:00 p.m. travel hour and lowest for the 5:00 p.m. hour. The standard deviation and 95th percentile travel time are also highest for the 8:00 p.m. hour and lowest for the 5:00 p.m. hour. These statistics indicate that that travel times are both faster and more reliable during the 5:00 p.m. hour than during the 8:00 p.m. hour.

Table 1. Descriptive statistics. All values in minutes.

| | 2:00 p.m. | 5:00 p.m. | 8:00 p.m. | All 3 Hours |
|---|---|---|---|---|
| **Minimum** | 0.045 | 0.045 | 0.045 | 0.045 |
| **5th Percentile** | 2.99 | 2.99 | 2.99 | 2.99 |
| **25th Percentile** | 7.89 | 7.88 | 7.93 | 7.90 |
| **Median** | 13.05 | 12.99 | 13.35 | 13.15 |
| **75th Percentile** | 21.13 | 20.69 | 21.83 | 21.27 |
| **95th Percentile** | 41.9 | 39.96 | 44.7 | 41.98 |
| **Maximum** | 59.96 | 59.96 | 59.96 | 59.96 |
| **Mean** | 16.23 | 15.9 | 16.81 | 16.32 |
| **Standard Deviation** | 11.7 | 11.35 | 12.38 | 11.77 |

## Discussion

### *Comparison to Other Food Access Data*

The USDA (2017) and the Reinvestment Fund (2015) data are illustrated for Ramsey County in Figures 8 and 9, respectively. The methodologies for these data are described in the introduction section above.

In Ramsey County, the USDA low access census tracts cover most of the county, including all but one suburban census tract at the ½ mile threshold. At the 1-mile threshold, some suburban tracts and most of Saint Paul qualify as having sufficient access.

The omission of transit in the analysis methodology is apparent, as tracts along Ramsey County's two rapid transit services, the Green Line and the A Line, both qualify as low access. The proximity analysis employed here makes the USDA methodology relatively easy to execute, an important factor for a national dataset, but the lack of consideration for the specific urban context and transportation choices limits its precision at a local or regional scale.

The Reinvestment Fund's LSA analysis identifies many fewer areas compared to the USDA data and low access areas tend more toward urban areas as a result of its context-sensitive methodology. There is some alignment between Figure 9's LSA map and the transit accessibility analysis in Figures 5, 6, and 7. Notably, the network analysis methods used for both datasets seem to have captured the effect of urban barriers like interstate highways on accessibility.

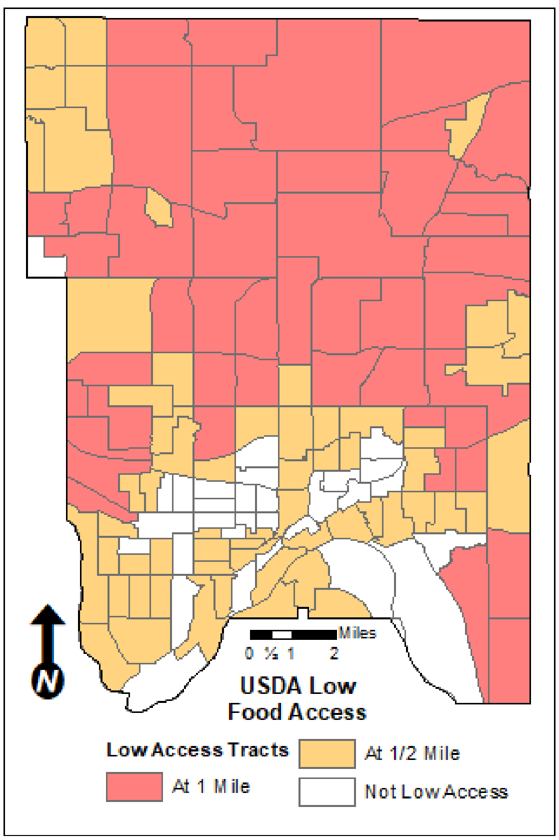


Figure 8. USDA low access census tracts.

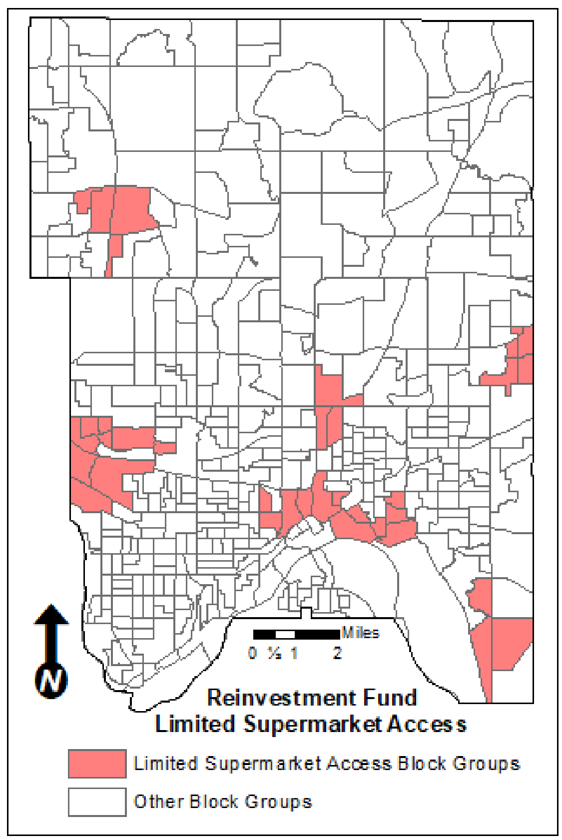


Figure 9. The Reinvestment Fund Limited Supermarket Access (LSA) census block groups.

There are LSA clusters around I-35E north of downtown Saint Paul, state highway 36 in North Saint Paul, and I-35W between New Brighton and Arden Hills. Where the two analyses notably differ is in areas with frequent transit service but no immediate supermarkets, such as the Saint Anthony Park neighborhood in western Saint Paul. The LSA analysis does not account for the possibility of taking the light rail to supermarkets further away than walking distance.

The demographic factors in the Reinvestment Fund's analysis prevent it from classifying most suburban areas as LSA's due to their lower population density and higher vehicle ownership. The USDA analysis and the transit accessibility analysis do not attempt to assess the relative need for food access in an area, and therefore many suburban areas are identified as having low access. It may be preferable for community members and policymakers to make their own judgments about where access improvements are most necessary in the county.

### *Comparison to Job Accessibility*

Job accessibility presents an interesting comparison for food accessibility because transit services that prioritize rush hour service to the central business district or other job clusters may not be useful for trips to a neighborhood grocery store. The data from Owen *et al.* (2015), available from the University of Minnesota Accessibility Observatory, are depicted in Figure 10 for Ramsey County. The values are the number of jobs accessible by public transit from census blocks centroids during 7:00 to 9:00 a.m. weekday in 2015 (Owen *et al.*, 2015).

Compared to the food accessibility results, the job accessibility map paints a much starker picture, with downtown Saint Paul and the Green Line corridor seeing the highest job accessibility. It appears that jobs are more closely clustered than grocery stores with most suburban areas of Ramsey County falling into the least accessible class. A combined index considering accessibility to both grocery stores and jobs could assess where the transit system meets two of the most fundamental needs for residents.

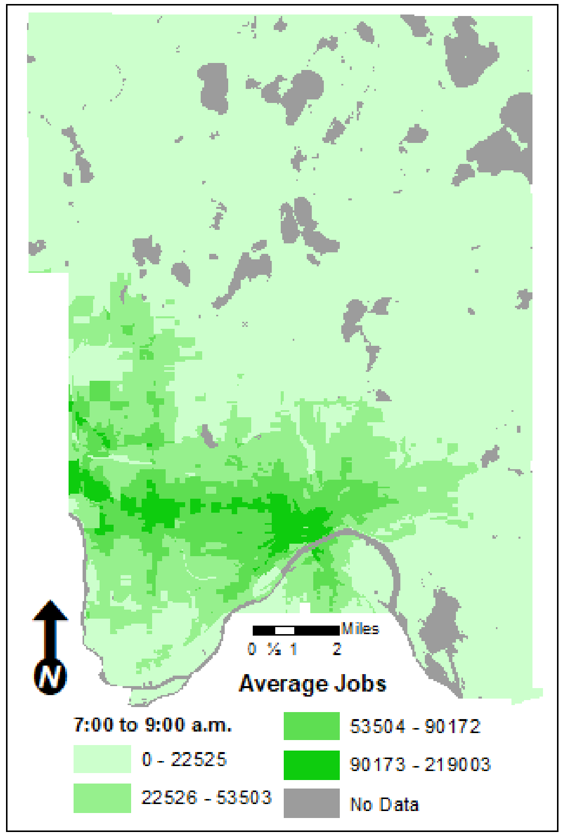


Figure 10. University of Minnesota Accessibility Observatory job accessibility by transit.

### *Limitations to this Analysis*

There are some notable limitations to the accessibility by public transportation analysis described here. This methodology assumes that the traveler chooses their departure time spontaneously rather than by consulting the transit schedule to avoid a long wait time. This assumption may understate the utility of lower-frequency transit services whose passengers plan their trips around the schedule. An alternative method could attempt to model the best-case scenario for a trip during an hour rather than average all travel times over an hour.

This analysis models pedestrian routes using the street network where pedestrian travel is permitted. There are additional paths and shortcuts available to pedestrians, and many streets which permit pedestrian travel are otherwise dangerous or unpleasant due to poor or missing sidewalks, poor lighting, heavy traffic, and crime concerns.

Lastly, by limiting the scope of this analysis to Ramsey County, grocery store accessibility is likely underestimated somewhat along the county borders. Turning to additional data sources for grocery stores near the county border could ameliorate this issue, though possibly introduce some inconsistency in data collection quality.

## Conclusion

Modeling accessibility to food stores by public transportation can help policymakers and advocates in both public health and public transportation better understand the role transit service plays in helping people reach grocery stores. Other analyses of grocery store access available for the United States do not account for public transportation as a means of travel. Considering job accessibility and food accessibility together can identify areas where public transportation holistically addresses residents' needs, where car-free and car-light living is likely to be most feasible.

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