

The Move for Food: Food Desert Alleviation for the Greater Madison, WI Area

University of Wisconsin at Madison

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I) INTRODUCTION

As communities in the United States focus on a national initiative for improving quality of life, the complexity to provide healthy, affordable food for households becomes more apparent. Our objective is to identify potential market locations to alleviate food deserts in communities of the Greater Madison, WI area. The evaluation for site suitability is based on the conditions of food deserts and the distances to potential allowable market locations by alternative transportation mode choices (walk, bicycle, and public transportation). The definition of a food desert varies (Coombs, et al. 2010, page 3); we will be using the United States Department of Agriculture's definition of which is low-income residential areas where a population of 500 and up, or 33% of the total population, are farther than one mile from a grocery store (American Nutrition Association 2016).

The first set of maps will outline current areas for food deserts with different transportation buffers placed around grocery stores and supermarkets in Madison, WI. The project will take into account the distance shoppers are willing to travel by walking, bicycling, and public transportation to assess how current food deserts change with respect to transportation mode choice. Maps were created for food deserts focusing on the distance pedestrians will walk for errands, bus routes that reach grocery stores without transferring buses, and the distance bicyclists will ride. The prospective locations for new grocery stores will take into account the distanced traveled and the definition of food deserts as defined by the U.S. Department of Agriculture (USDA). The second stage of the project created a map of potential sites for food markets based on available commercial zoned locations in Madison, WI that are within our identified current food deserts and accessible by alternative transportation mode choices.

II) BACKGROUND AND SITE SETTING

BACKGROUND

In 2010, a national initiative was launched by the Obama Administration, known as the Healthy Food Financing Initiative (HFFI) (Office of Community Services 2016). The purpose of the initiative is to increase opportunities in the United States to bring healthy food to underserved

communities, known as “food deserts”. Food deserts, as defined according to the United States Department of Agriculture (USDA), are “low-income communities without ready access to health and affordable food.” (American Nutrition Association 2016). As a result, the course of action across the United States has been to place grocery stores and other healthy food retailers in underserved communities to alleviate the on-going phenomenon. The HFFI, along with the Let’s Move! Campaign (Let’s Move! 2016), serve as opportunities for communities to not only improve food accessibility and affordability but improve the well-being for all in communities.

The challenge to understanding food deserts often becomes more complex as communities strive to not only to grow but provide accessible and affordable food market options. One of the main challenges correlated with food deserts is food accessibility by transportation mode choice. While the automobile is a predominant mode choice in the United States, access to a vehicle is not always available. Therefore, the need to address alternative transportation mode choices such as walking, public transportation, and bicycling becomes even greater.

The other challenge with food deserts is affordability for healthy food options. The development of the Supplemental Nutrition Assistance Program (SNAP) helps communities address domestic food hunger issues affecting community public health. SNAP and other food stamp programs also help lessen the burden that low-income households are faced with when making an important decision regarding necessities versus luxuries. The variance in food prices throughout different communities often impacts the quantity and the quality of food purchases. As a result, fast food options at times are considered more economical over healthier alternatives.

The objectives of the report will be looking to identify potential food market locations to alleviate food deserts as well as investigate the correlation between food deserts and alternative transportation mode choice in the Madison, WI area.

PROJECT AREA

The Madison, WI area consists of a population of 239,848 according to the 2014 U.S. Census which ranks 2nd in Wisconsin only to Milwaukee. Since 2010, the Madison, WI area has experienced a population increase of 10,612, or 4.6%, (US Census 2014) and is projected to

increase to a population around 290,500 by 2035 according to the 2035 Regional Transportation Plan by the Madison Area Transportation Planning Board (MATPB 2012). The median income in the Madison area has not drastically fluctuated since 2010, with the 2014 median income around \$53,933 (US Census 2014). Since the 2010 launch of the national initiative, however, the Madison area has experienced an increase in population in poverty and households receiving food stamps in the Tables 1 and 2 shown below from 2010 to 2014 U.S. Census Data.

Table 1: Madison, WI 2010-2014 Median Income and Household Poverty

Year	Median Income	Households Below Poverty Line	% Households In Poverty	% Population in Poverty
2010	\$52,550.00	4535	9.2%	17.9%
2011	\$54,093.00	5940	11.7%	18.4%
2012	\$53,958.00	5265	10.7%	18.5%
2013	\$53,464.00	4084	8.4%	19.4%
2014	\$53,933.00	5274	10.2%	19.6%

Source: 2010-2014 U.S. Census Household Characteristics (DP03) & Ratio of Income to Poverty (C17026). Accessed March 3, 2016. <http://www.census.gov>.

Table 2: Madison, WI 2010-2014 Food Stamps Use by Households

Year	Total Households	Households Receiving Food Stamps	Below Poverty Line (%)
2010	100,903	10,795	57.0%
2011	99,839	10,096	59.3%
2012	101,379	11,829	49.0%
2013	107,424	10,599	51.5%
2014	103,771	12,417	45.4%

Source: 2010-2014 U.S. Census Food Stamp Usage (S2201). Accessed March 3, 2016. <http://www.census.gov>.

Therefore, the question of interest is how population changes will affect the Madison community to provide accessible and affordable healthy food options. The decreasing percentage of households using food stamps below the poverty line from 2010 to 2014 also raises the

question as to the reasoning behind the phenomenon between the increasing number of households receiving food stamps and the decreasing percentage of the same households that have median income levels below the poverty level.

The project area for the report is based upon the Madison Metro Public Transit system which consists of 61 regular fixed routes that serve different parts of the Madison area (Madison Area Transportation Planning Board 2013), which is shown below in Figure 1.

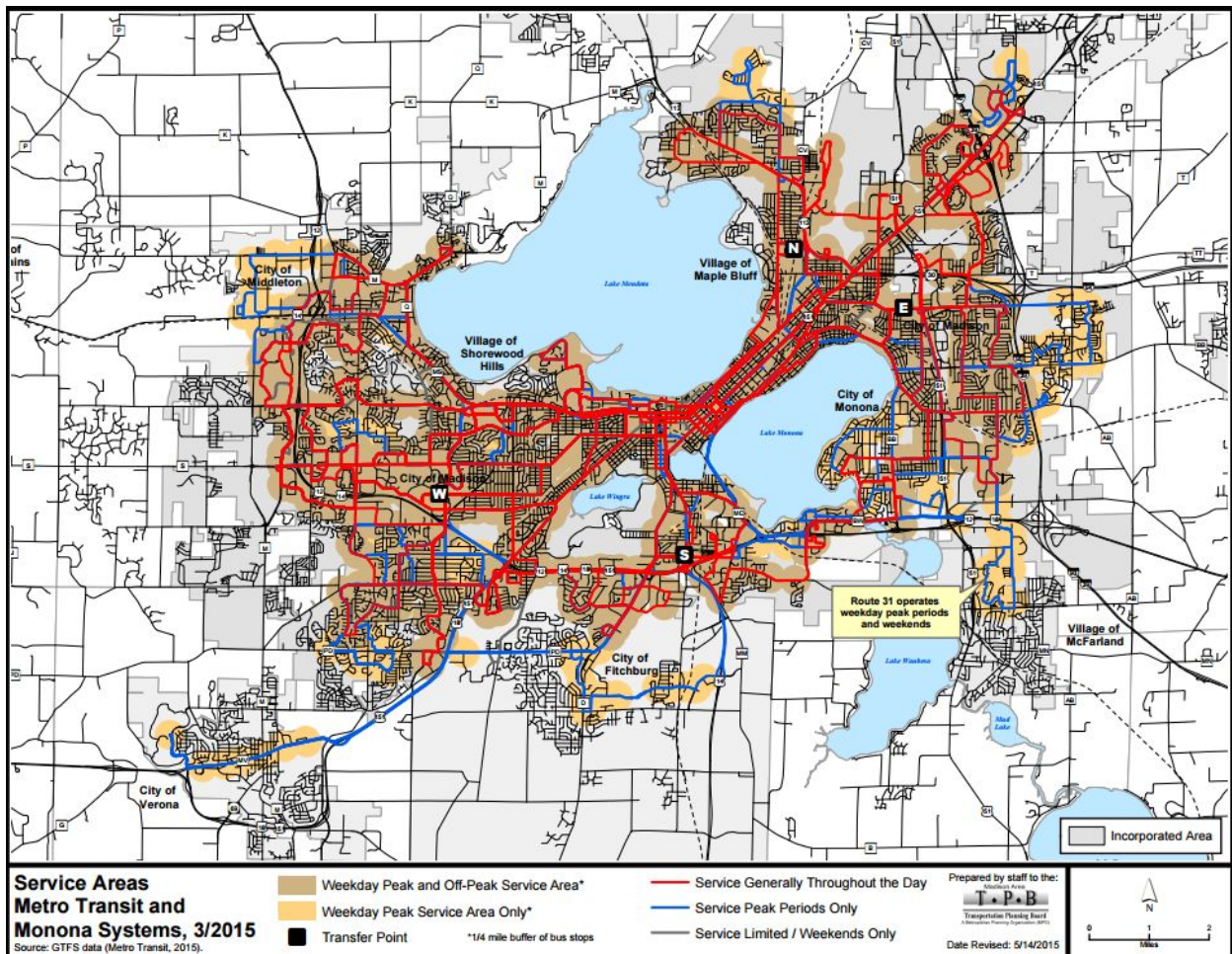


Figure 1: 2015 Madison Metro Transit Service Map
Source: Madison Area Transportation Planning Board Transit Maps. Accessed February 18, 2016.
<http://www.madisonareampo.org/maps/list.cfm#Transit>

The majority of the Madison Metro bus services run through the downtown area with specific routes assigned to different areas of Madison. The public transportation system operates from 6AM to 12AM during the weekdays and 6:30AM to 11PM on the weekends. Some of the

challenges with the bus services include fewer routes operate during the weekend and reliability during peak service times, which impacts the service area.

In addition to the Madison Metro system, the project area incorporates the 2015 Madison Bicycle Map and the Madison roads to account for bicycle and pedestrian movements in the Madison area. Madison, WI is one of five communities in the United States to hold platinum status for bicycle friendly communities as of 2015 (League of American Bicyclists 2015). The status takes into consideration for creating a bicycle infrastructure that encourages bicycling as a safe and viable transportation mode choice. As a result, bicycling becomes more of a viable alternative mode choice for the people in the Madison community. The current pedestrian infrastructure, however, has become more concerning for different reasons. Outside of the downtown area, deteriorating sidewalks to a lack of sidewalks in different parts of Madison have raised safety concerns with the walking environment which has resulted in the use of other transportation mode choices. The project not only looks into walkability in the Madison area but also walkability with respect to public transportation.

III) METHODOLOGY

The project primarily focused on identifying how the current food deserts in the Madison Area change with respect to alternative transportation mode choices and then finding potential new food market locations to alleviate the newly found food deserts. The first layers were an overlay of the Madison Metro Area, bike paths and bike routes in the Madison Area, a zoning layer focused on residential areas, grocery stores and supermarkets in our area of study, and Census Bureau information for food stamp use, demographics, car access, and population density.

The project scope for the report focused on how low-income residents, in accordance with Food Stamp Use, are able to reach grocery stores using alternative transportation mode choices. Therefore, the project study area is based on the current Madison Metro service area. A recent paper, “Food Deserts: Evaluating Grocery Stores and Bus Accessibility using GIS in Madison, Wisconsin”, (Omri, Resch, & Gundlach 2013) also looked at bus availability as a

means to access grocery stores in the Madison Area. In their research, and in the bus stop optimization project by the Maryland Transportation Authority (MTA 2014, page 7) it is discussed that residents will not use public transportation if the bus stop location is more than a quarter mile from their origin or to their destination. Omri, et al., 2013, also looked at how far people will travel while on a bus, showing that people are less likely to use it if there is a transfer involved. Based on this, bus routes were limited to routes that directly access grocery stores and supermarkets, with the focus only on buses without transfers. Research showed limited information on how far people will walk for errands. Without specific information about this walking distance, a buffer of a quarter mile was used for those traveling to grocery stores on foot. This distance is assumed based on the statement from the Maryland Transportation Authority on bus stop optimum distances. This limiting factor is not necessarily taken into account in the one-mile radius to grocery stores in the food deserts USDA definition. Our project started with a created layer of grocery stores and supermarkets in the Madison Metro Area and placed a one-mile radius buffer around these stores as seen in Figure 2. The initial one-mile buffer shows where the USDA food desert definition exists in Madison.

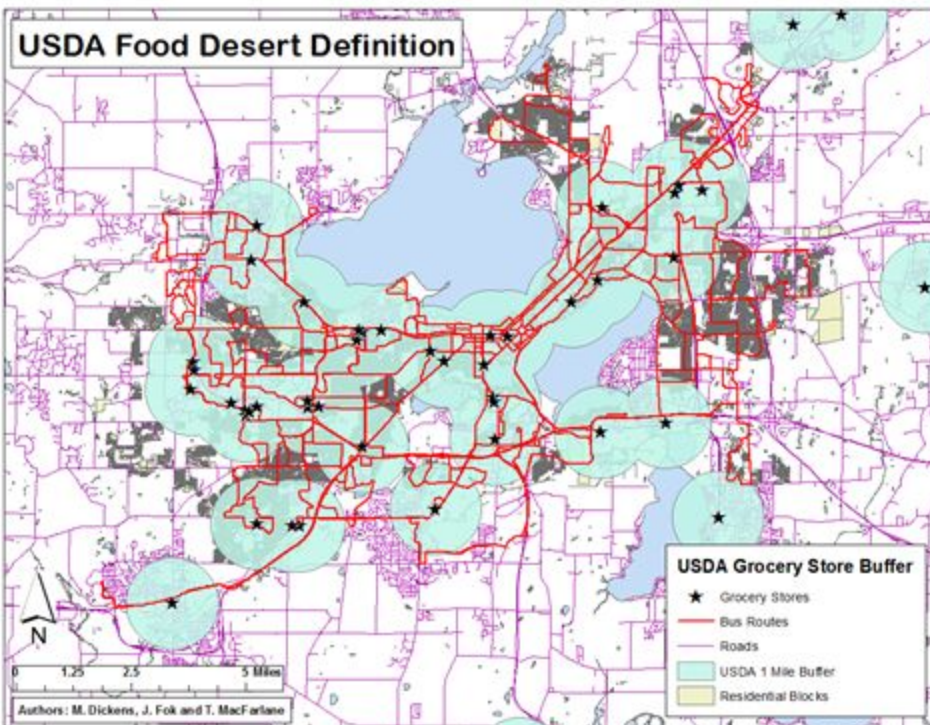


Figure 2: Food Desert Areas by USDA Definition for Madison, WI

To account for the 0.25 miles that we have determined people will walk, we have put a buffer of a quarter mile around these grocery stores. This quarter mile buffer was used for both our analyses of bus and pedestrian access, as residents will need to walk to and from stops to reach the stores. While bicycling for leisure and commuting has increased in recent years, (Longhurst 2015, page 13) there is limited research focusing on how far one will bike for errands. With the assumption that biking allows shoppers greater flexibility and access to grocery stores and supermarkets (Gatersleben, Appleton 2007, page 205), we expanded the area of access from one mile around the grocery stores. Some research has shown that those biking for errands will go as far as 6.2 miles to their destination (Icono, Krizek, El-Geneidy 2008), so this will become the new furthest extent of the bike buffer rings.

The second objective was to further extend the research and identify potential locations that would have a positive impact on limiting food deserts. Using the layers created from the previous overlays, polygons were created showing areas currently without access to healthy food and within the demographics defined as susceptible populations. To maximize the number of residents that benefit from an added grocery store, we found the centroids of these polygons. Current available commercial spaces, found by correlating real estate data and City of Madison zoning data, were used to locate potential locations for building grocery stores. Location suitability was determined by access to bike routes within 6.2 miles of accessibility, the number of buses that serve the areas within 0.25 miles, and the number of households served within .25 miles walking distance from them. This is similar to the method used in “A Spatial and Social Analysis of Food Deserts and Community Gardens in Madison, Wisconsin” (Coombs, Panther, Beye, & Fehrenbach 2010) to analyze how community gardens could decrease the size of food deserts in Madison. It was shown in one Canadian study (Larsen & Gilliland 2009, page 2) that adding farmer’s markets to current food deserts were also an effective way of increasing access to healthy food. Our goal is that highlighted areas will benefit from closer access to healthy food by locating viable commercial locations. The focus on alternative transportation for the project will take into consideration low-income households that are able to access healthy food options without having access to a vehicle.

We used the analysis of prior literature as a guideline to construct our conceptualization and implementation flowcharts. The conceptualization and implementation flowcharts highlight the process that we used to address the project objectives. These flowcharts, along with our pseudocoding, can be seen in the appendix, Figures 14 , 15, 16, and 17.

GROCERY STORE IDENTIFICATION LAYER

The capstone project consists of creating two original map data layers. The first original data layer is based on current grocery store and supermarket locations using the Google Maps online tool and exporting the data to a KML file. Google Maps is updated regularly and provides the most accurate source for finding stores in the greater Madison area. Depending on data availability, aerial and satellite images are updated every two weeks (“11 Fascinating Facts About Google Maps” 2016).

In gathering the data for these grocery points, we made the distinction of what would be considered a grocery store. A variety of fresh produce outside staple foods at the location was our primary criteria for an individual to live in a healthy manner (Coombs et al 2010 p 12). While Coombs et al omits ethnic food stores on the basis that the “livability” of their stock cannot be evaluated, we decided to include ethnic grocery stores because they do often include fresh produce along with a variety of food products of which an individual can live healthily (Coombs et al 2010 pp 12-13). This criterion would exclude convenience stores since they primarily carry “high-convenience items” of which consumers use in a short period of time (Payne 2011, n.p). Using the Google search engine, we first searched using the keywords “grocery”, “market”, and “supermarket” to get results for the larger, popular grocery stores like Target and Copps. To get some of the locations that our keywords missed, we also searched using more generic terms like “food”, “co-op”, “ethnic food”. Once we felt like we had all of the grocery stores that matched our criteria, we exported the points into a KML file, then converted that KML into a shapefile compatible with GIS software.

TRANSPORTATION AND ZONING LAYERS

Beyond our original data layer of Grocery and Supermarkets, our data layers came from a variety of sources. Most prominently we were able to use data from the City of Madison's GIS portal. Another prominent source for data came directly from the Madison Metropolitan Planning Organization (MPO). We also used a streets layer provided by the Wisconsin Department of Transportation for our network analysis.

For the zoning layers, we started with one that contained all of Madison's property zoning. We were interested in only the residential blocks and the blocks that are both grocery zoned and vacant. To break down this zoning layer into the layers we need, we used SQL queries to select and extract the features that fit our criteria. The first set of layers we extracted were the residential blocks, so we could see where people were concentrated within an area and a combination of the vacant and commercial blocks. Since the commercial zoning includes much more than grocery stores we used another SQL query to find vacant blocks that are classified as a grocery zone. This vacant and grocery layer allowed us to find lots to place potential grocery stores once we found our areas of interest.

We made buffers surrounding each grocery location to determine where the food deserts are for people reliant on walking as their primary form of transportation. The threshold we used for our buffers was based on people's willingness to walk to bus stops, which is defined by the Maryland Transit Association as a quarter-mile radius around the bus stop (Maryland Transit Authority 2014). We also considered that people tend not to or are unable to walk in a straight line from their house to the grocery store as they would need to cut through private property and buildings. More likely, pedestrians will follow along the road network where there are sidewalks and clear paths. To adjust for this we applied network analysis to Madison's roads, creating a quarter-mile radius following the most likely path for an individual. We overlaid the grocery store data, this new buffer, and the residential block data to create a visual representation of Madison's walking food deserts.

The Madison Metro Bus service area bus layer provided the furthest extent of our study area. We were only interested in, at most, the extent of the public transportation service areas because the focus of the project is on alternative transportation. This layer consists of bus transit routes as well as bus stop locations. As demonstrated by the Maryland Transit Authority, every bus rider is also a pedestrian for some part of their trip walking to and from their bus stops (Maryland Transit Authority 2014) therefore we placed a 0.25-mile buffer around each stop. We were able to use the Madison streets network analysis layer to determine where these bus stops reach into residential neighborhoods. Our next step was to determine which buses have direct access to our grocery stores. As found by Omri, et al. 2013, bus transfers add time and difficulty to a rider's trip so we only looked at buses that would access the groceries stores directly. We used select by location to find the bus stops within our grocery store 0.25-mile buffers. From these buses, shoppers will have access to a grocery within walking distance. The bus routes that used these stops were found in the attribute table. These routes were then assumed to have direct access to a grocery or supermarket. On the bus route layer, we selected by attribute to separate the routes with direct access. Overlaying these routes, the bus stops with buffers, the grocery stores with bus stops, and our populations of interest created a map of new areas without access to public transit and easy access to a grocery store.

Bike paths and bike routes were two separate designations. Paths are separate off-street trails meant for bicycle riders and pedestrians only. Routes are streets either with separate bike lanes designated with a stripe from car lanes or bike boulevards where bicycles are able to use the whole lane with cars. We performed a merge to turn the entire bike network into one unified bike layer as we were interested in the whole network for the Madison area. This layer, however, did not take into account higher priority towards protected paths or right of way access. This determination would have required a bicycle layer created to follow network analysis similar to the streets network we used when analyzing the pedestrian access. Without a layer specifically set up to run a network analysis, we were unable to pick which routes would be optimal for bicyclists to travel when biking to the grocery. To work around this limitation, we created buffers around our grocery and supermarket layer. These buffers reached as far as 6.2 miles, which we designated in concentric 1-mile rings. The farther from a grocery store, the

more difficult access to it is presumed to be. Based on age, ability, and comfort level biking 6.2 miles might be far for the average bicyclist to travel. Groceries beyond 4 miles may be beyond the average user's reach via bicycle. We used an overlay of the bicycle buffers, the bicycle network, and the grocery store location layer to demonstrate the extent that biking in Madison can be used to reduce food deserts in the city and greater Madison area.

DEMOGRAPHIC LAYERS

The demographics layers consisted of four characteristics that were evaluated to create the layers: census tract population, household median income, SNAP usage and vehicle availability. The demographic layers were consistent with the USDA food desert definition and were created using the American Community Survey (ACS) from 2010-2014 from the U.S. Census. The five-year period takes into consideration of the start of the national initiative in 2010 to the most recent U.S. Census data in 2014.

The objective for the demographic layers was to identify census tracts with high population levels, high percentage of households using food stamp and households with no vehicle availability as well as household median income levels below the poverty level.

We used a different dataset for each demographics characteristics layer. The census tract population layer was created using the 2010-2014 Total Population (B01003) dataset. The food deserts definition defined by the USDA considers such areas with a population of 500 or more, however, all of the census tracts in the Madison area have populations greater than 500 after analyzing the dataset. The vehicle availability layer highlights the percentage of households with no vehicle availability in which was from the 2010-2014 Household Characteristics (DP03) dataset (U.S. Census, 2016). The SNAP layer consists of the percentage of households that receive food stamps, which was made using the ACS 2010-2014 Food Stamps Usage (S2201) dataset (U.S. Census, 2016). The median household layer was created using the ACS 2010-2014 Household Median Income (B19019) dataset (U.S. Census, 2016). The median household income layer was broken down into seven parts to address median household income by household size. We conducted an SQL query to highlight the census tracts with median household incomes below the poverty level according to the 2016 Wisconsin Department of

Health Services, which ranged from \$11,880 to \$36,730 depending on the household size (Wisconsin Department of Health Services, 2016). The SQL queries can be seen in the pseudo-coding section in Figure 17 of the appendix.

All of the census data was exported as shapefiles into ArcMap. Each demographic characteristic was broken down into quintiles as natural breaks to better represent the data. We especially focused the natural breaks for no vehicle availability to emphasize the use of alternative transportation mode choices. As such, we looked into census tracts where the percentage of households with no vehicle availability was above 19% for the Madison area demographics as defined by the natural break. The demographics layers were overlaid over each other to determine the census tracts with populations of interest.

FUTURE GROCERY LAYER - FOOD DESERT ALLEVIATION

To better visualize the extent of the food deserts and the amount of people potentially affected by each food desert for each mode of transportation, we took the buffers and removed the coverage from the area of interest. This created a clear image of how current forms of transportation combat the food deserts. We also extracted the residential blocks within each modified area to see if these transportation methods actually help Madison residents or do they serve empty space such as the Dane County Airport to the north or the Capital Springs State Recreation Area to the southeast.

With our food deserts and areas of interest clearly defined we were able to locate where a grocery store could be placed to reduce the food desert in these areas. We first applied spatial analysis, selecting by location to extract both the vacant grocery lots within the census blocks, then created a centroid point feature for each area of interest. Using the near tool we took the centroid and the vacant grocery blocks to find the closest one within our areas. This gave us the most central potential grocery location, which would best alleviate the problems caused by food deserts.

IV) RESULTS AND DISCUSSION

We were able to identify different trends from the analyzing all of the original data layers. After our analysis of the census demographic layers, we came to notice different trends

for each of the demographic characteristics. The populations for the census tracts increased as the distance from the downtown area increased, which was expected. Many of census tracts in close proximity to grocery stores have populations in the second highest quintile (5,558 to 7,229), particularly around major arterials such as Park Street and East Washington Avenue. The areas where zero vehicle availability households are high are predominantly in the northern and southern parts of Madison. The specific areas for high levels of no vehicle availability include the census tracts around the Madison Beltline by South Park Street and Packers Avenue in the north. The SNAP layer showed census tracts in the highest quintile for households receiving food stamps (560+) located in the southern part of Madison around the Madison Beltline. The southeast part of Madison consisted of census tracts that had household median income levels below the poverty level for household sizes four persons or less. The census tracts in the north and the southwest were for household median income levels below the poverty level of five persons or more. SNAP and no vehicle availability. Once we overlaid all of the demographic layers, we identified the populations of interest to be located in the north, southeast, and southwest areas of Madison. All of the specific maps for the census demographics can be found in the appendix under the data layers section in Figures 18-21.

The food desert outputs for the three transportation mode choices (walking, bicycling, public transportation) showed differences with respect to mode choice. The new food deserts were the most prominent in the pedestrian map Figure 3 below. There is extremely limited access to grocery stores within walking distance for some of the most vulnerable populations, especially those reliant on walking. The areas of interest were the least covered amongst the three transportation mode choices. The darkest red areas are the populations with the least access to cars, the highest population below poverty level, and the highest use of food stamps. While a grocery every 0.25 miles to assure pedestrian access may not be practical, the lack of many grocery stores in some of the worst areas, such as the northeast, east, southeast, and southwest sections of the greater Madison area does bear some further consideration. The full extent of the areas without easy access can be seen in Figure 4 where the residential blocks have been highlighted in yellow to show households in census tracts for the areas of interest.

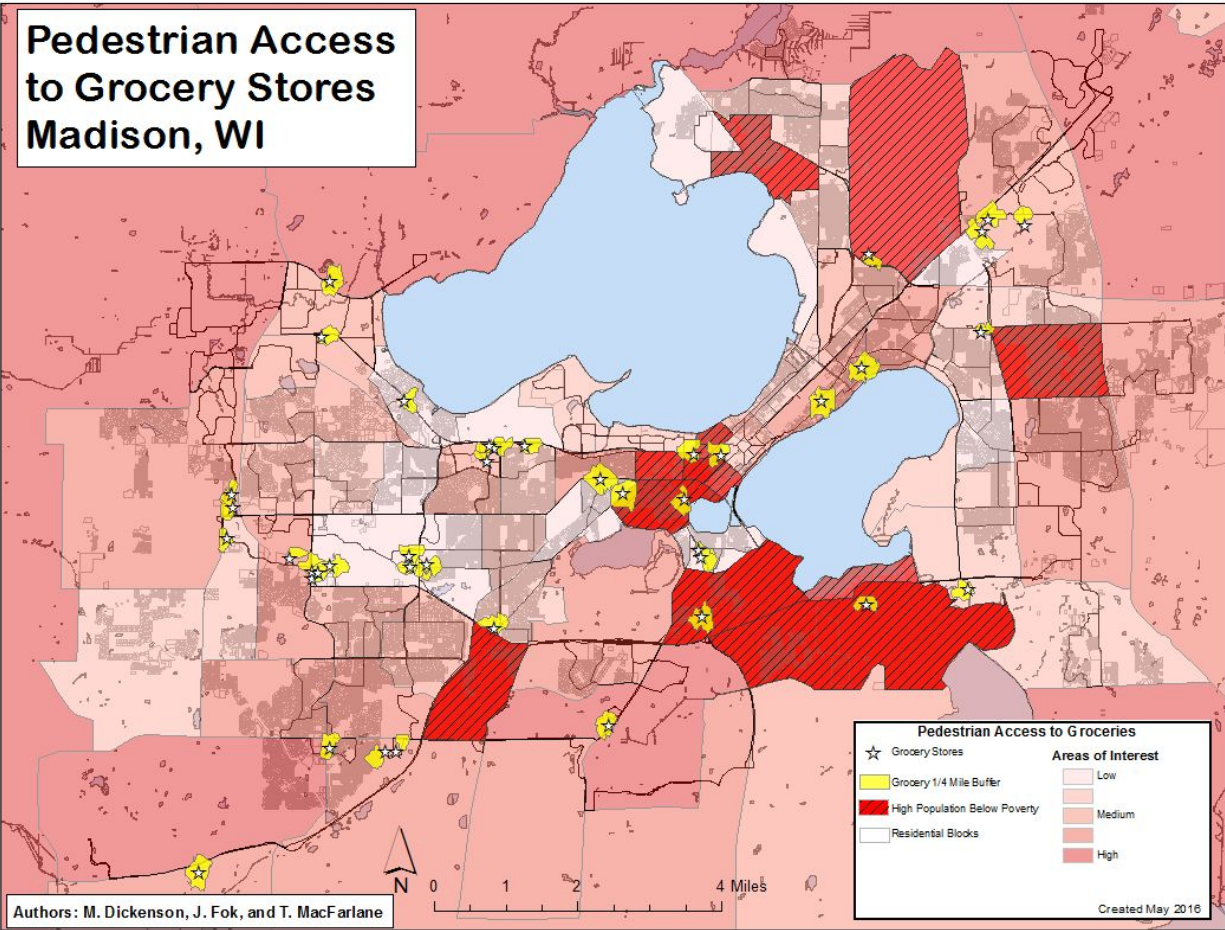


Figure 3: Pedestrian Accessibility to Grocery Stores in Madison, WI

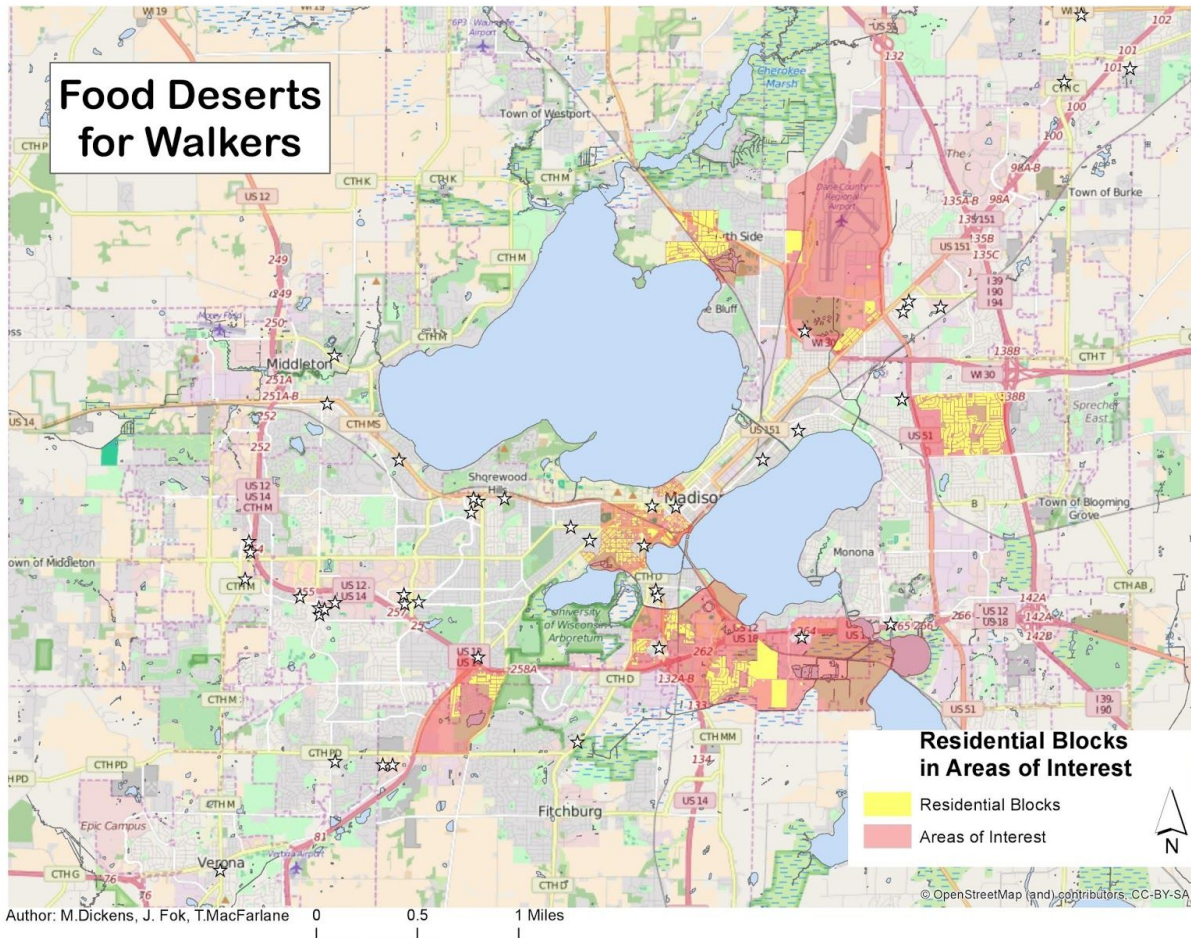


Figure 4: Food Desert Areas in Madison, WI by Walking

Public transportation allowed for greater accessibility and smaller areas without ready access to a grocery as seen in Figure 5 The bus routes with direct access to a grocery store are represented by the green routes along the maps. Bus routes that do not stop at a grocery store or supermarket are in red. Some routes overlap each other, so a bus rider would have to know which route does travel to a grocery store before boarding. From looking at the routes alone, much more of the Madison area is accessible to reach a grocery store. There is at least one major route through each of the areas of interest, except for the far north section which has a route that just skirts around the outside of it. The true coverage can be seen in Figure 6, below, where the 0.25-mile buffer is placed around each bus stop, showing where people would be most comfortable accessing the stops without having to walk too far. This distance is mapped along a network analysis, again to follow the most likely paths pedestrians will walk.

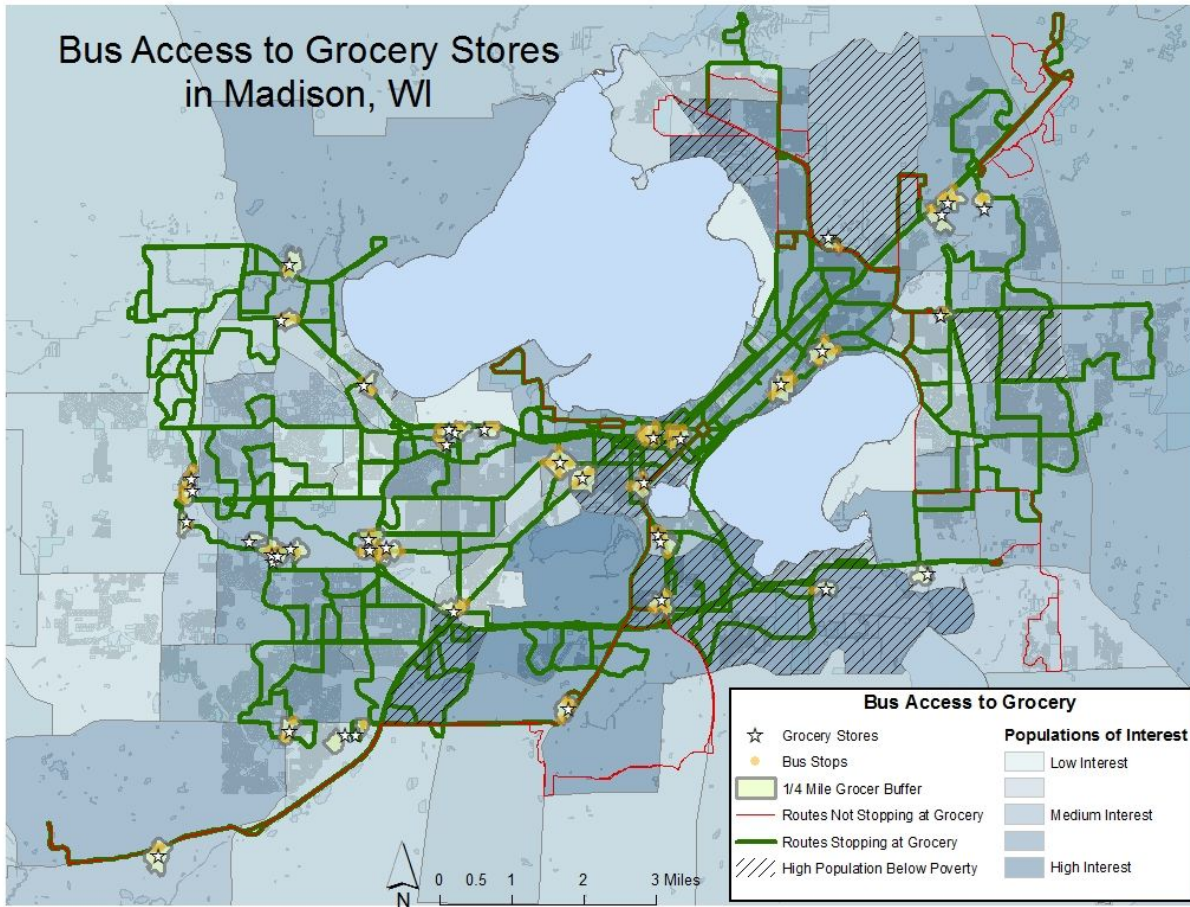


Figure 5: Public Transportation Routes to Grocery Stores in Madison, WI

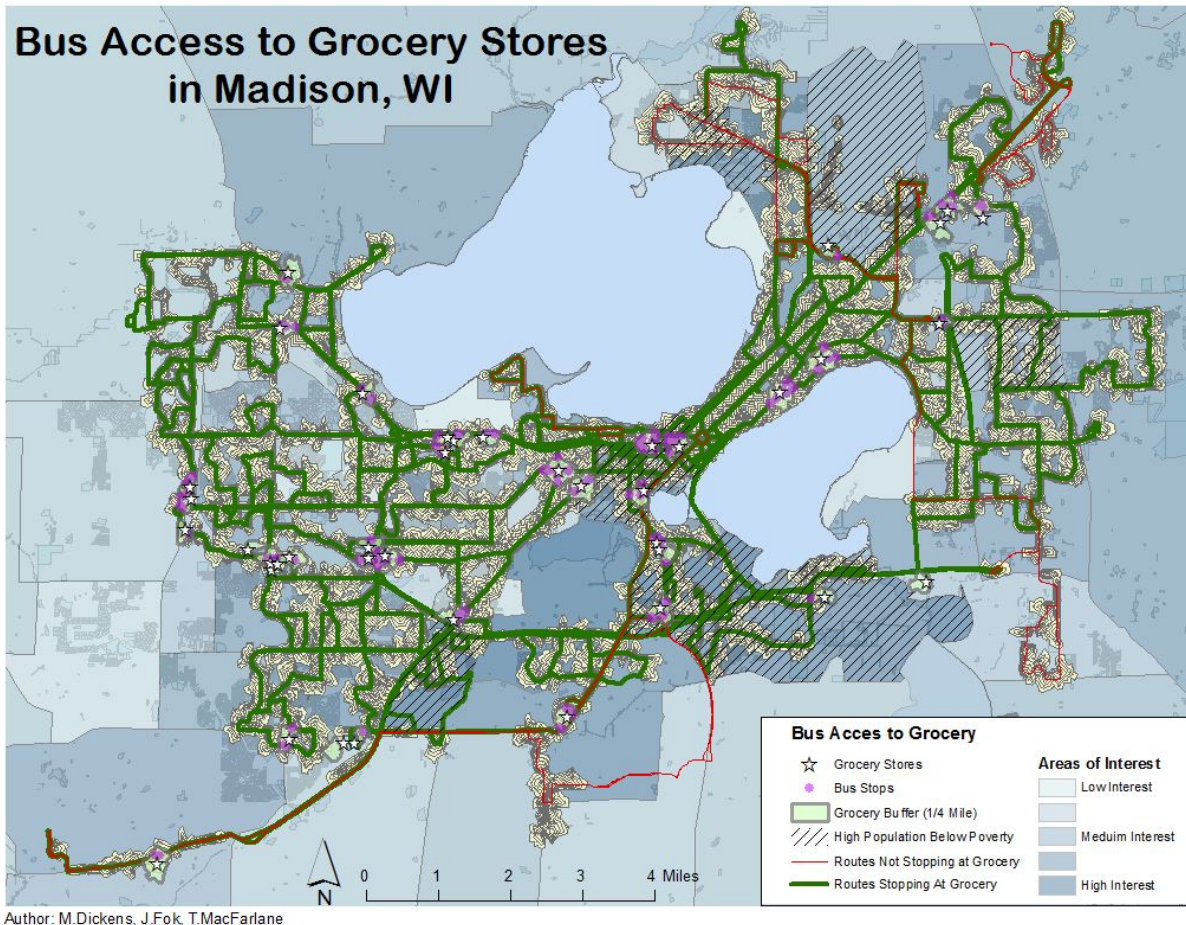


Figure 6: Public Transportation Routes to Grocery Stores in Madison, WI with Bus Stop Buffers

We identified the residential areas within our areas of interest in Figure 7 below that do not have access to a bus stop and a direct bus route to a grocery store or supermarket. The number of homes without access is greatly reduced in this analysis. The city of Madison’s transit system does encompass almost all of the Greater Madison Area, which was why we selected the Madison Metro service area as our study area. The routes in red, which have no access to a grocery, are still concerning and could be potential areas to place a new market, or in future route changes, perhaps Metro could adjust the routes to stop at a grocery or supermarket.

There are some concerns that do limit the validity of the results. The first is the network analysis for public transportation. The network analysis only took into consideration of proximity to bus stops and not travel times, which would play a major role in the use of public transportation. The use of transfer points would also be a factor in the time spent grocery

shopping. As stated by Omri, et al. 2014, the cost of riding the bus, while less expensive than owning a vehicle, could still be prohibitive to those with less income. Another concern is with the network analysis itself. The streets layer used is from 2004 and does not fully reflect current construction, such as Fitchrona Road on the south side of Madison.

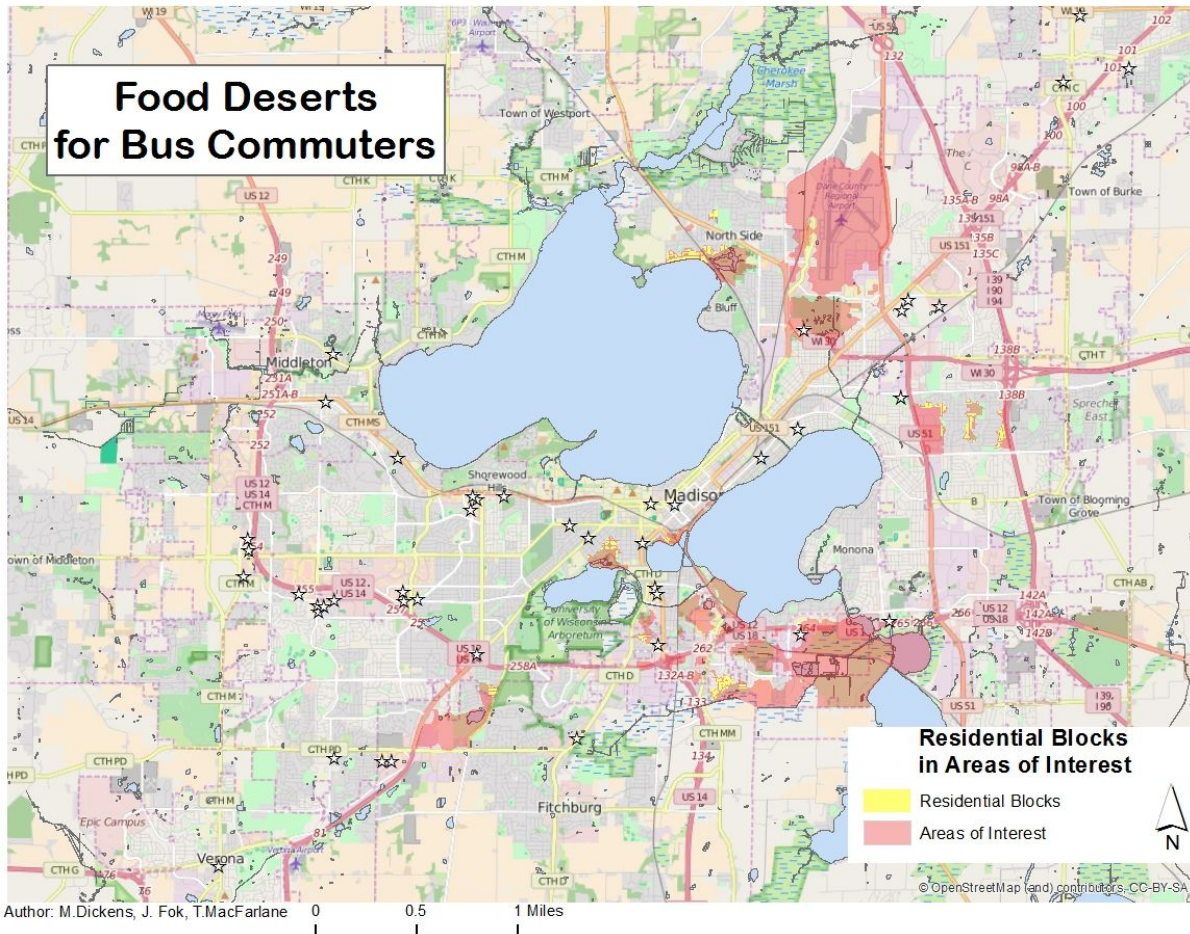


Figure 7: Food Desert Areas to Grocery Stores in Madison, WI by Public Transportation

The analysis of bikeable areas shows the greatest coverage out of the three alternative mode choices (Figure 8). The 6.2 mile range around each grocery store and supermarket encompasses the majority of our study area. As shown in Figure 8, all neighborhoods are within the range and most are within three miles of a grocery store. As the distances from the grocery stores increases, people are less likely to bike to those areas, so we also took into account a reduced range of 3 miles to accommodate those who are not able to bike the full 6.2 miles (Figure 9). Even with the reduced range, the majority of Madison is covered save for a few small

neighborhoods. These maps further prove that Madison is a great city for people who choose to commute by bike. One concern, however, is that we did not have a network for the bike paths, so we could not apply network analysis in our evaluation of bike transportation in Madison. This could greatly reduce the range for bike commuting, but looking at the amount of bike infrastructure in the city, it would seem that biking would still be extremely viable.

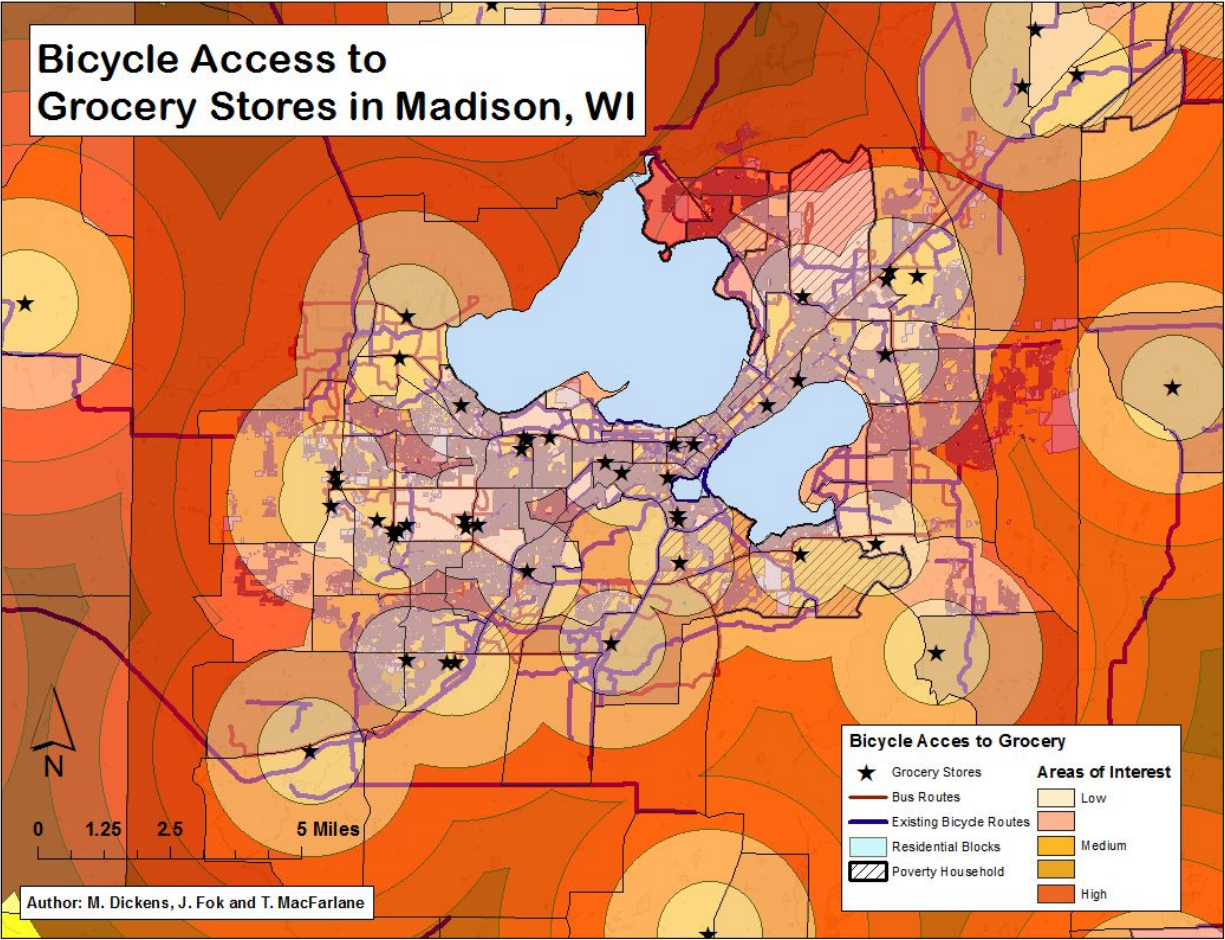


Figure 8: Bicycle Access to Grocery Stores in Madison, WI

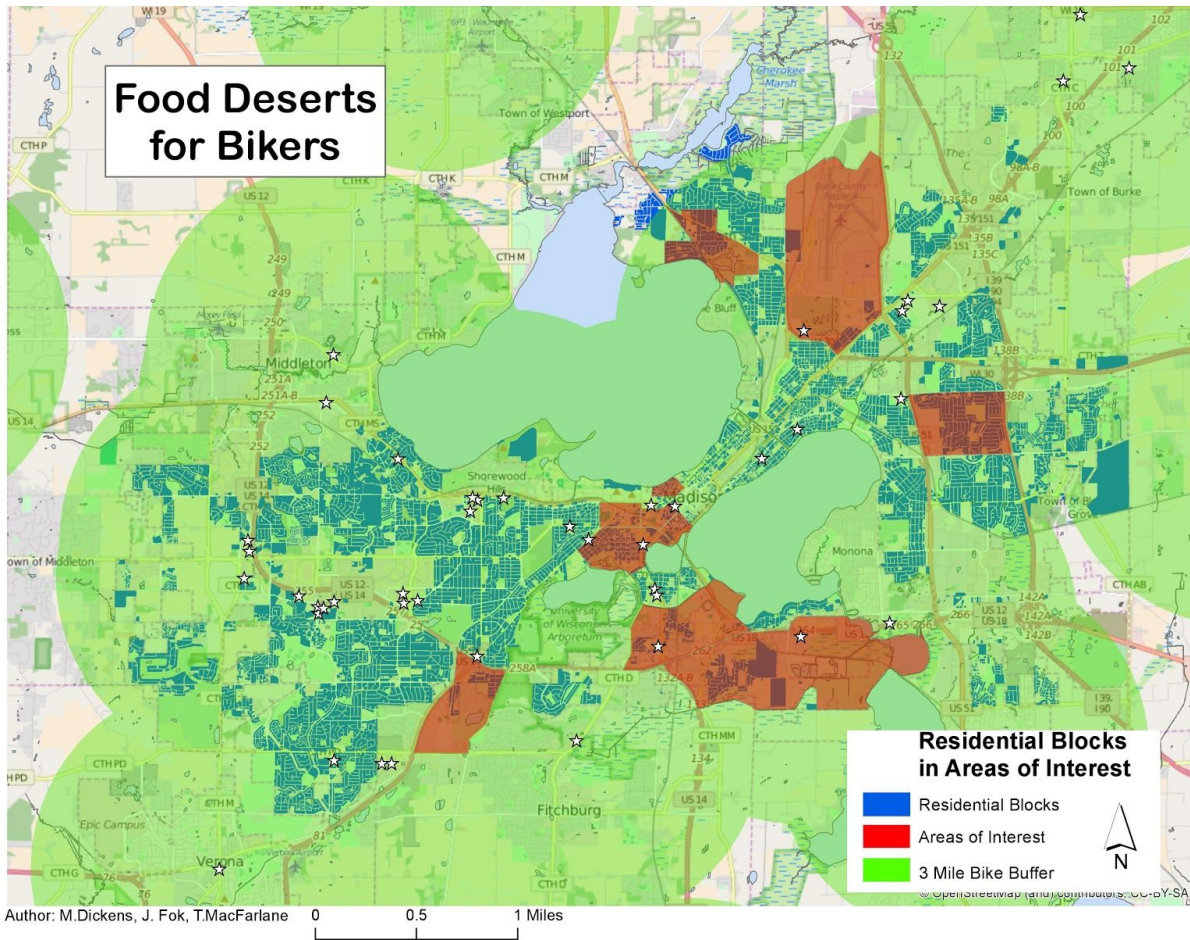


Figure 9: Food Desert Areas to Grocery Stores in Madison, WI by Biking 3-Mile Buffer

After evaluating the individual transportation mode choices, we were able to highlight overall areas of interest with respect to alternative transportation mode choices as shown in Figure 10.

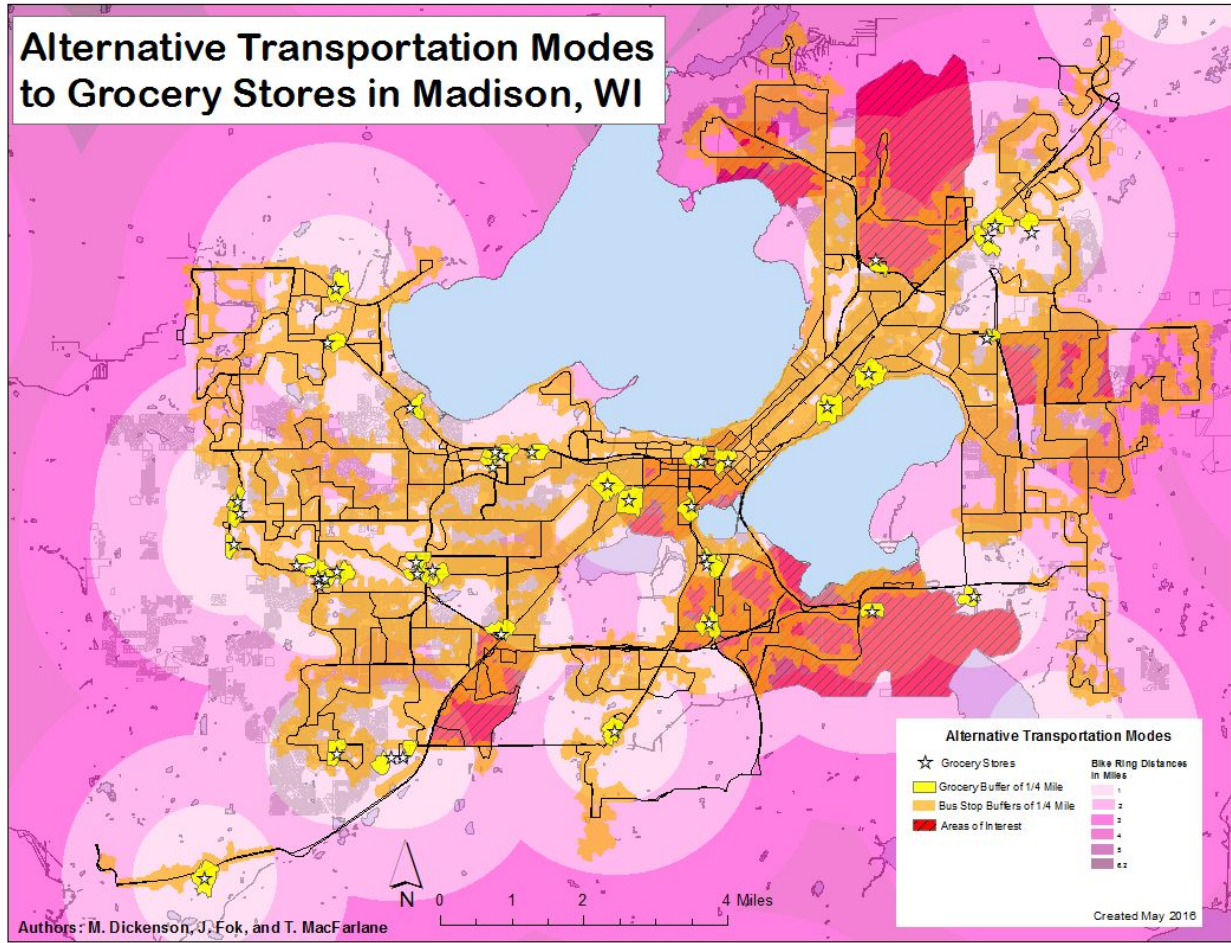


Figure 10: Food Desert Areas to Grocery Stores in Madison, WI by Across All Three Modes

The second part of the study was to analyze where we could place new supermarkets and grocery stores with respect to the populations of interest and the three alternative transportation mode choices. In our study, we were able to find commercial spaces that, if developed, would help alleviate food deserts in all areas of concern around the greater Madison area. Figure 11 shows our analysis of currently available commercial spaces in the greater Madison area as bright blue polygons. These spaces were found by filtering out commercial property in our original zoning layer, then seeing which of the properties were further zoned for grocery and small grocer buildings. There are properties available currently across the Madison area. By

looking at the centroids of each of our areas of interest, and then using a nearest neighbor analysis, we were able to find an available property for each of our areas of interest. In Figures 12 and 13 we show details of the north and the southeast areas of Madison to illustrate a few of the grocery locations we have found. The size of the parcel ranges from very large in the northeast of Figure 12 to a few small spots scattered in the rest of Figure 12 and Figure 13. A further look at the square footage required by a grocery or supermarket would help analyze the validity of each of these spaces.

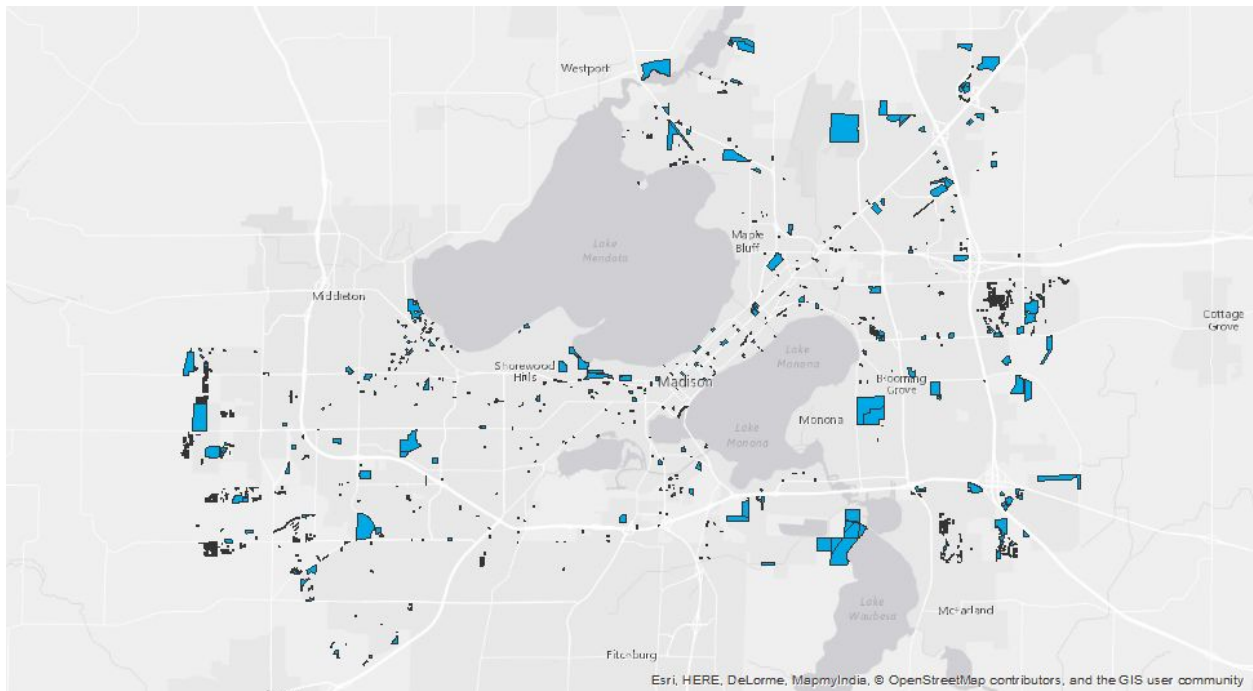


Figure 11: Vacant Grocery Zoned Lots for a Potential Grocery Store in Madison, WI

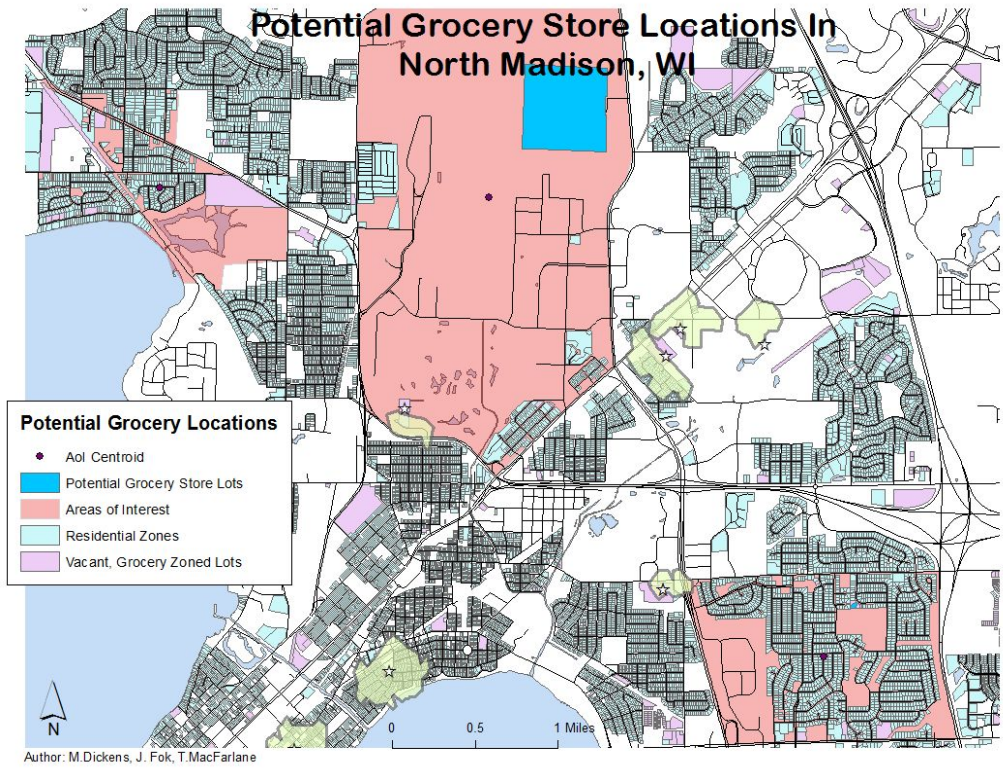


Figure 12: Potential Grocery Store Locations in Northern Madison, WI

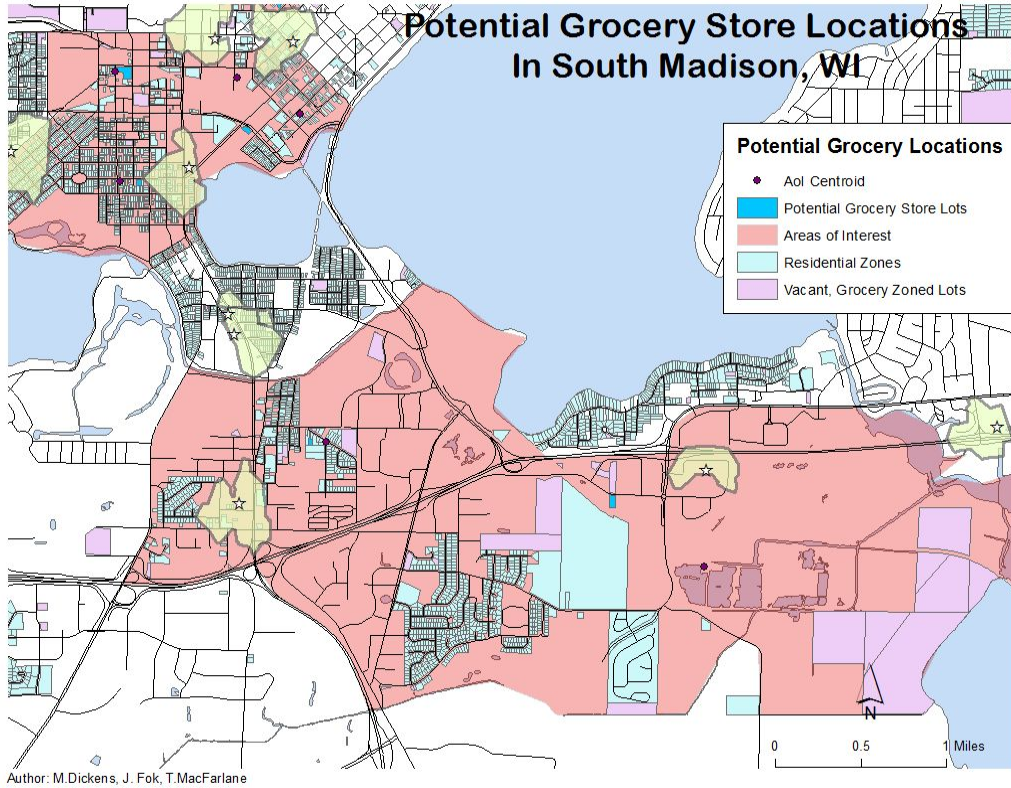


Figure 13: Potential Grocery Store Locations in Southeastern Madison, WI

V) CONCLUSIONS AND FURTHER RESEARCH

CONCLUSION

The projective objective was to identify potential locations for grocery stores to alleviate food deserts in the Greater Madison, WI Area. As a part of the national initiative to address strategies, the challenge for communities to provide healthy and affordable food options becomes more apparent. Therefore, the evaluation of site suitability takes into account both food desert conditions and distances to grocery stores using alternative transportation mode choices which are walking, bicycling and public transportation. Food deserts in accordance to the USDA describes such areas as “low-income communities that do not have ready access nor affordable food options”. We created the census demographics layers using the U.S. Census Bureau to identify food desert areas consistent with the USDA definition. The combination of the demographics and the transportation layers resulted in food desert areas in the Madison, WI area with respect to each alternative transportation mode choice (walking, bicycling and public transportation). After overlaying the food desert layers for each transportation mode choice with the vacant grocery store layer we identified potential locations for grocery stores in the Madison, WI area. The results from the analysis showed that the preferred transportation mode choice does change the areas that would be considered food desert. Walking generates the largest food desert areas because of the short range. Public transportation and bicycling create smaller to non-existent food deserts in the Madison area however travel times and network connectivity affect usage by both modes.

Despite our results, there are opportunities for future evaluation. One example is to conduct a network analysis using up-to-date maps which could highlight changes in the food desert areas found in our project. Conducting a network analysis for the bicycle system could provide a more accurate assessment of travel behavior and identify disconnected areas in the bicycle network that would affect bicycle travel. Another opportunity is to evaluate non-high-risk areas that are in food desert areas to determine whether another food market would be helpful. Other topics of interest include re-evaluating zoning ordinances and policies regarding SNAP eligibility and alternative transportation regulations. Changes in zoning

ordinances could influence the number of vacant grocery lots available to alleviate food deserts in the Madison area. Policies for SNAP eligibility and alternative transportation regulations would not only influence the grocery stores accepting food stamps, but also the households that are reliant on financial assistance for purchasing healthy food options and traveling to grocery stores. The issues significantly increase more so for households within our populations of interest. Lastly looking into mobile grocery alternatives such as grocery delivery and their impact on food desert alleviation. While the report focused on people using alternative transportation to travel to and from grocery stores, a future question of interest is the impact of grocery stores coming to the households. There are some grocery stores in the Madison area such as Woodman's and Fresh Madison Market that offer delivery services but in a limited range. The project sheds light that perhaps there is optimism for communities to work together to address food accessibility and insecurity issues and there is hope that the United States will continue to take steps in the right direction.

REFERENCES

- “11 Fascinating Facts About Google Maps”. *Mashable*. Accessed March 13, 2016.
<http://mashable.com/2012/08/22/google-maps-facts/#p61tLUEm0kqT>
- City of Madison Datasets <https://data.cityofmadison.com/>
- Clifton, Morrissey, Ritter “Mode Choice and Consumer Spending: An Examination of Grocery Store Trips” (January 2012)
- Coombs, Panther, Beye, and Fehrenbach “A Spatial and Social Analysis of Food Deserts and Community Gardens in Madison, Wisconsin” (University of Wisconsin-Madison, 2010)
- Gatersleben and Appleton “Contemplating cycling to work: Attitudes and perceptions in different stages of change” *Transportation Research Part A* (2007) 302-312
- GeoData@UW-Madison. Accessed March 05, 2016. <http://maps.sco.wisc.edu/opengeoportal/>.
- “Healthy Communities” Accessed February 16, 2016.
<http://www.letsmove.gov/healthy-communities>
- Icono, Krizek, El-Geneidy “Access to Destinations: How Close is Close Enough? Estimating Accurate Distance Decay Functions for Multiple Modes and Different Purposes”
<http://www.lrrb.org/PDF/200811.pdf> *Report #4 in the series: Access to Destinations Study* (May 2008)
- Larsen and Gilliland “A farmers’ market in a food desert: Evaluating impacts on the price and availability of healthy food” *Health & Place* (2009) 1158–1162
- Larsen and Gilliland “Mapping the evolution of ‘food deserts’ in a Canadian city: Supermarket accessibility in London, Ontario, 1961–2005” *International Journal of Health Geographics* (2008) 1 - 16
- League of American Bicyclists. “New Platinum, New Gold Bicycle Friendly Communities.” *News From the League*. November 13, 2015.
<http://www.bikeleague.org/content/new-platinum-new-gold-bicycle-friendly-communities>
- Let’s Move!. Access March 05, 2016. <http://www.letsmove.gov/healthy-communities>
- Longhurst, *Bike Battles*, University of Washington Press, 2015
- Madison Area Transportation Planning Board. Accessed February 18, 2016.
<http://www.madisonareampo.org/>
- Madison Area Transportation Planning Board Transit Maps. Accessed February 18, 2016.
<http://www.madisonareampo.org/maps/list.cfm#Transit>

Madison Area Transportation Planning Board. *2035 Regional Transportation Plan Update* (2012) 13. Accessed March 1, 2016.

http://www.madisonareampo.org/planning/documents/RTPFINAL_Web.pdf

Maryland Transit Authority “Bus Stop Optimization Policy (Pilot) Bus Network Improvement Project - Phase One Plan” (2014)

Mentzer Morrison and Mancino “Most U.S. Households Do Their Main Grocery Shopping at Supermarkets and Supercenters Regardless of Income” *Amber Waves* (2015)

<http://www.ers.usda.gov/amber-waves/2015-august/most-us-households-do-their-main-grocery-shopping-at-supermarkets-and-supercenters-regardless-of-income.aspx#.VuCSuvkrKHs>

“New Platinum, New Gold Bicycle Friendly Communities” *League of American Bicyclists*.

Accessed March 1, 2016.

<http://www.bikeleague.org/content/new-platinum-new-gold-bicycle-friendly-communities>

Office of Community Services. Accessed February 16, 2016.

<http://www.acf.hhs.gov/programs/ocs/programs/community-economic-development/healthy-food-financing>

Omri, Resch, Gundlach, and Gartner “Food Deserts: Evaluating Grocery Stores and Bus Accessibility using GIS in Madison, Wisconsin” (University of Wisconsin-Madison, 2013)

Payne, Michelle. “Difference Between a Grocery Store and Convenience Store” (2011)

<http://smallbusiness.chron.com/difference-between-grocery-store-convenience-store-19023.html>

United States Census Bureau. Accessed March 1, 2016. <http://www.census.gov/en.html>

“USDA Defines Food Deserts”. *American Nutrition Association*. Accessed February 16, 2016.

<http://americannutritionassociation.org/newsletter/usda-defines-food-deserts>

USDA Supplemental Nutrition Assistance Program (SNAP), Last modified February 17, 2016.

<http://www.fns.usda.gov/pd/supplemental-nutrition-assistance-program-snap>

White, “Stranded: How America's Failing Public Transportation Increases Inequality.” *The Atlantic*. May 16, 2015.

<http://www.theatlantic.com/business/archive/2015/05/stranded-how-americas-failing-public-transportation-increases-inequality/393419/>

Wisconsin Department of Health Services Federal Poverty Level Guidelines. Last modified February 1, 2016. <https://www.dhs.wisconsin.gov/medicaid/fpl.htm>

APPENDIX

CONCEPTUALIZATION:

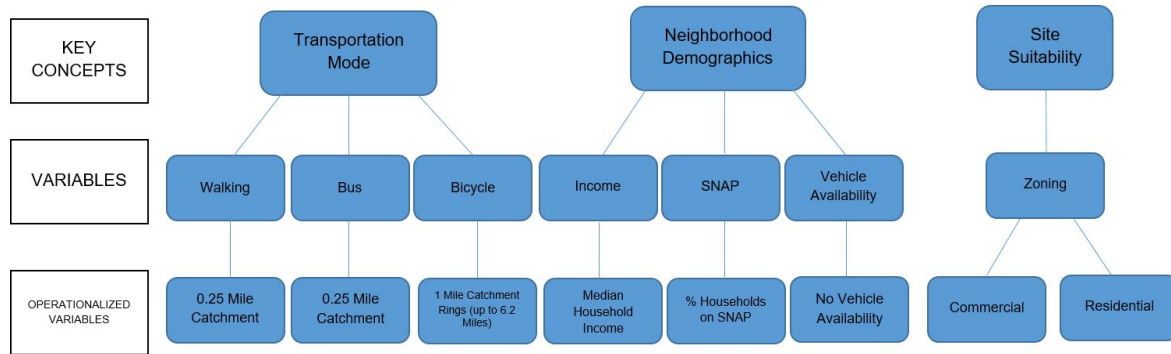


Figure 14: Conceptualization Diagram

IMPLEMENTATION:

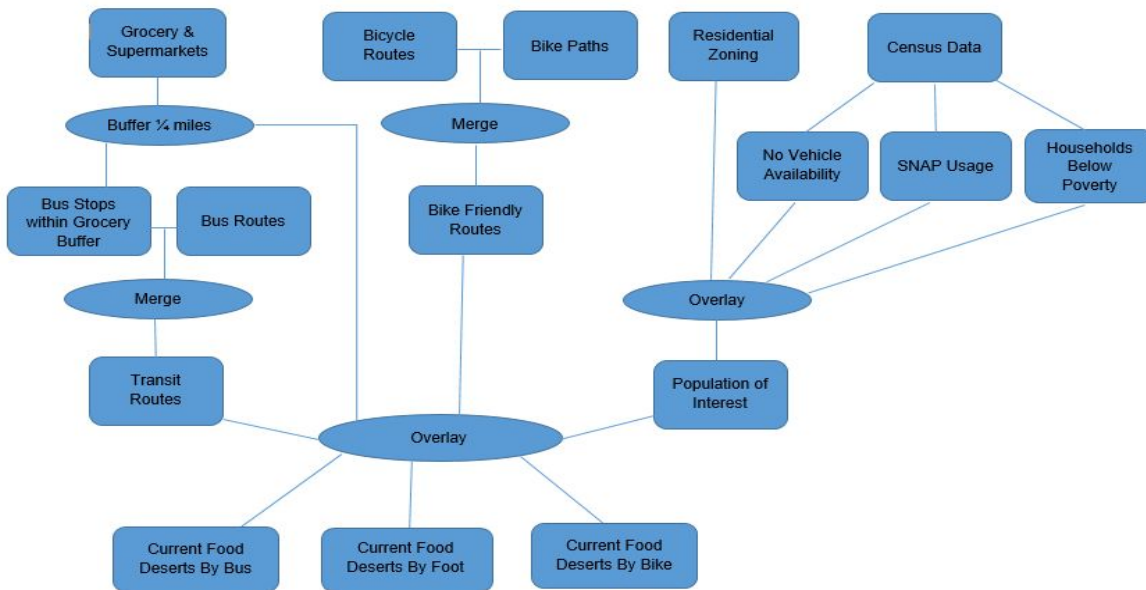


Figure 15: Implementation Diagram Part 1

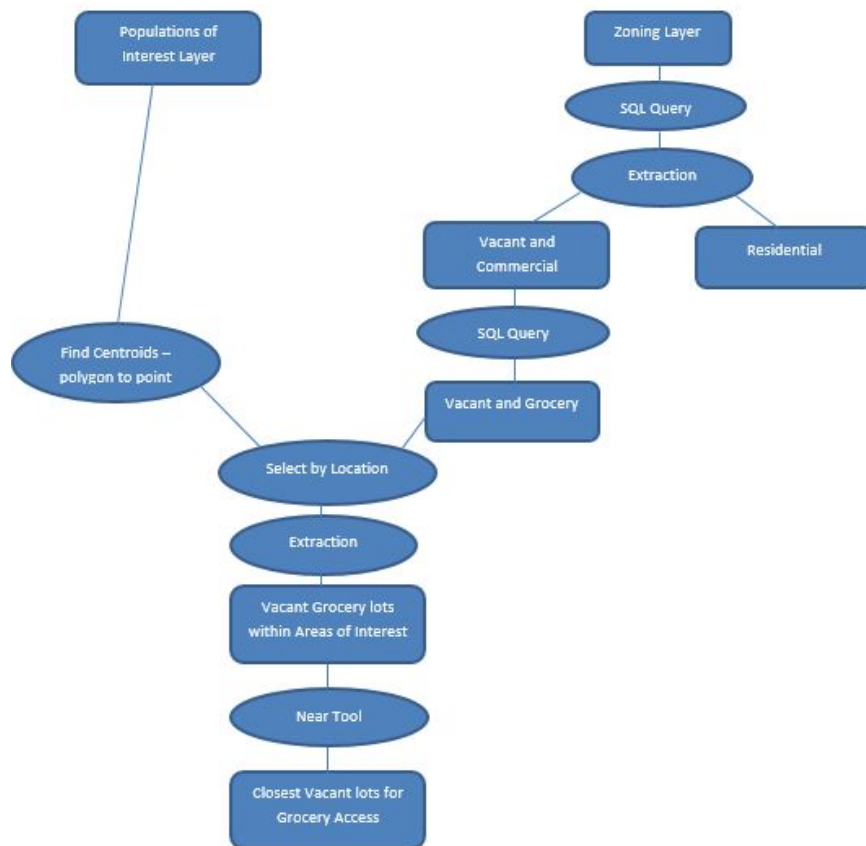


Figure 16: Implementation Diagram Part 2

PSEUDOCODING

- KML Import:
 - Import KML file from Google Maps
 - KML to Layer (Grocery.kml) = Grocery shapefile
- Buffers Possibly add network analysis here as well
 - Grocery Shapefile
 - Buffer 1 mile from Grocery location - show USDA food desert distance
 - Dissolve - create a cleaner image
 - Buffer ¼ mile from Grocery location - show walking distance
 - Dissolve - create a cleaner image
 - Bus Stops:
 - Buffer ¼ mile from Stop location - show walking distance
 - Dissolve - create a cleaner image
 - Select by Location: Select Bus Stops NOT within the Grocery ¼ mile buffer
 - Gets all bus stops within walking distance of grocery
 - Selecting specific Bus Routes
 - SELECT from Bus_Operation_WKD WHERE trips_ro_1 = ***
 - *** = specific bus route

- Grocery/Bus Network:
 - Extract all Bus Stops within ¼ mile walking distance:
 - SELECT all Bus Stops within ¼ mi network Grocery Buffer
- Bike NA
 - Time, 30 min limit for BCycle
 - 5 km buffer (3 miles)
- Merges:
 - Merge Bike Paths and Bike Routes - create one complete shapefile with all of the bike infrastructure to support bikes
- Joins / Relates
 - JOIN Census tracts with SNAP data.
- SQL Statements
 - Extract Commercial layer from Tax parcels
 - SELECT * FROM Tax_Parcel_Land_Use WHERE LU3_1_DESC = 'Commercial' OR LU3_1_DESC = 'Undeveloped Land'
 - Extract the vacant and Grocer zoning parcels from Commercial layer:
 - SELECT * FROM Commercial_Undev WHERE PropertyUs = 'Grocer, large' OR PropertyUs = 'Grocer, small' OR PropertyUs = 'Vacant' OR PropertyUs = 'C-1 vacant' OR PropertyUs = 'C-2 vacant' OR PropertyUs = 'C-3 vacant'
 - Extract the Census Tracts with Household Median Income Below Poverty Level from Household Median Income layer:
 - SELECT * FROM Poverty_Household1 WHERE Poverty_Household1 =< '11,880'
 - SELECT * FROM Poverty_Household2 WHERE Poverty_Household2 =< '16,020'
 - SELECT * FROM Poverty_Household3 WHERE Poverty_Household3 =< '20,160'
 - SELECT * FROM Poverty_Household4 WHERE Poverty_Household4 =< '24,300'
 - SELECT * FROM Poverty_Household5 WHERE Poverty_Household5 =< '28,440'
 - SELECT * FROM Poverty_Household6 WHERE Poverty_Household6 =< '32,580'
 - SELECT * FROM Poverty_Household7 WHERE Poverty_Household7 =< '36,730'

Figure 17: Pseudocoding

DATA LAYER SOURCES

Table 3: Data Layer Sources

<u>Grouping</u>	<u>Layers Included</u>	<u>Source</u>
Facilities	Bus Stops, Bike Facilities, BCycle, Grocery Stores	City of Madison - Metropolitan Planning Organization (MPO), Google Maps to KML Original Layer (Grocery Stores)
Streets	Streets network analysis	WisDOT
Roads and Paths	Bike Routes, Dane_MPO_Roads, Bus Routes	City of Madison MPO
Buffers	Grocery_buffers ¼ mile and 1 mile (USDA Food Desert Definition) , Bus Stop buffer	Original based off of Facilities
Madison City	Tax Parcel Land Use, Urban Areas, Zoning Districts, FoodStamp	Dane County Land Information Office USDA - SNAP
Census	Census Block Data	US Census Bureau
Ungrouped	Dane Hydro-Poly	Dane County Land Information Office

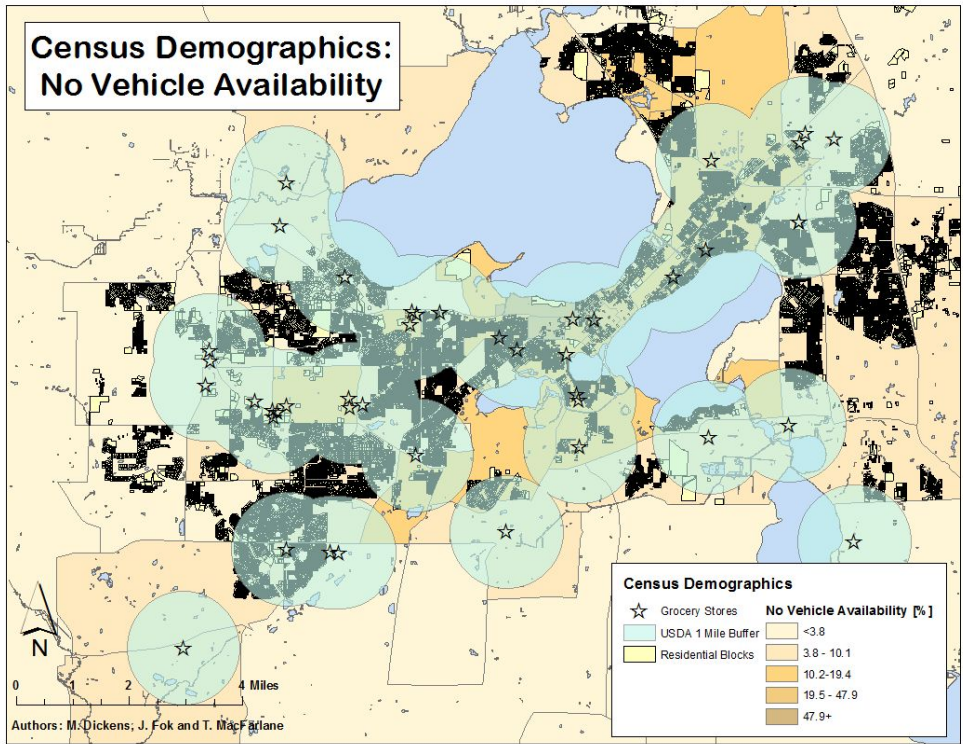


Figure 18: Census Demographics: No Vehicle Availability

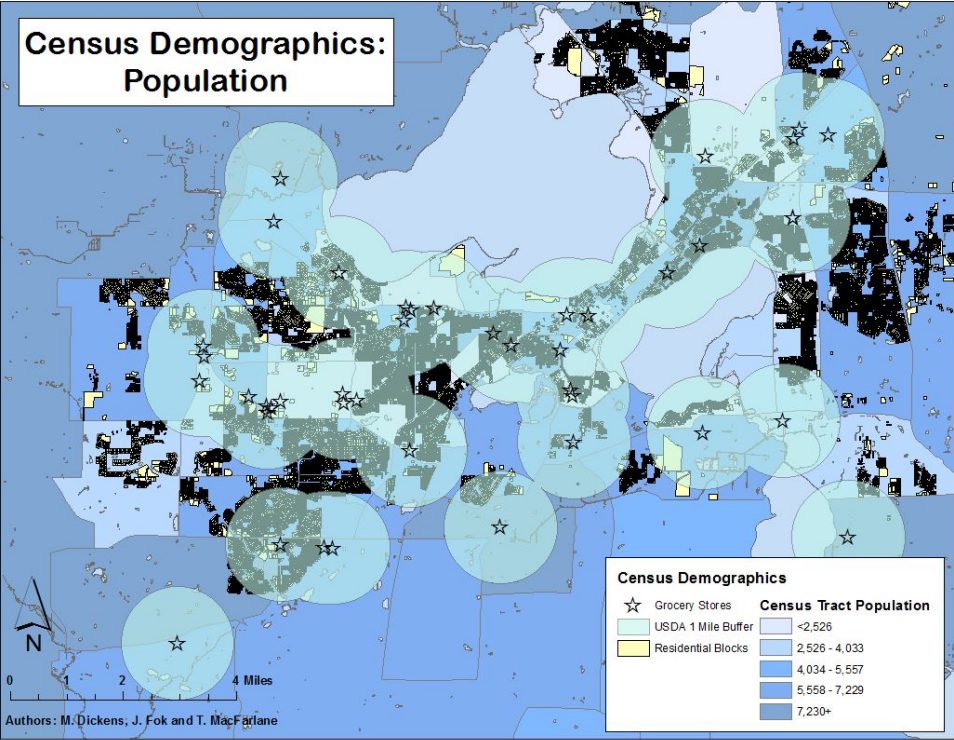


Figure 19: Census Demographics: Population

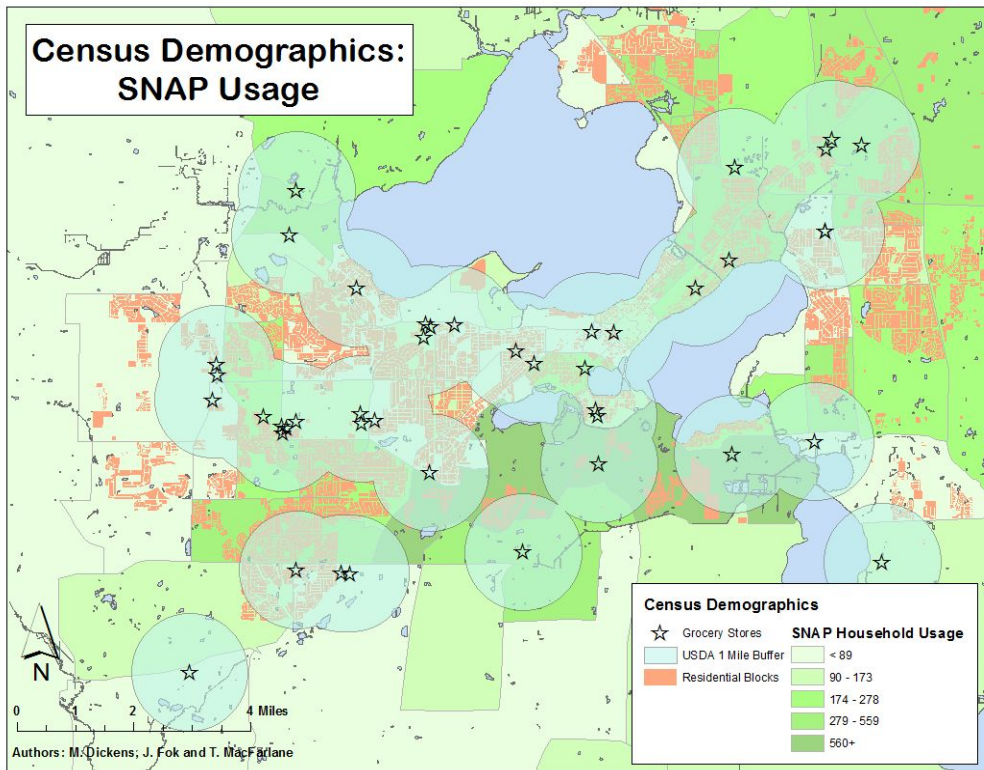


Figure 20: Census Demographics: SNAP Usage

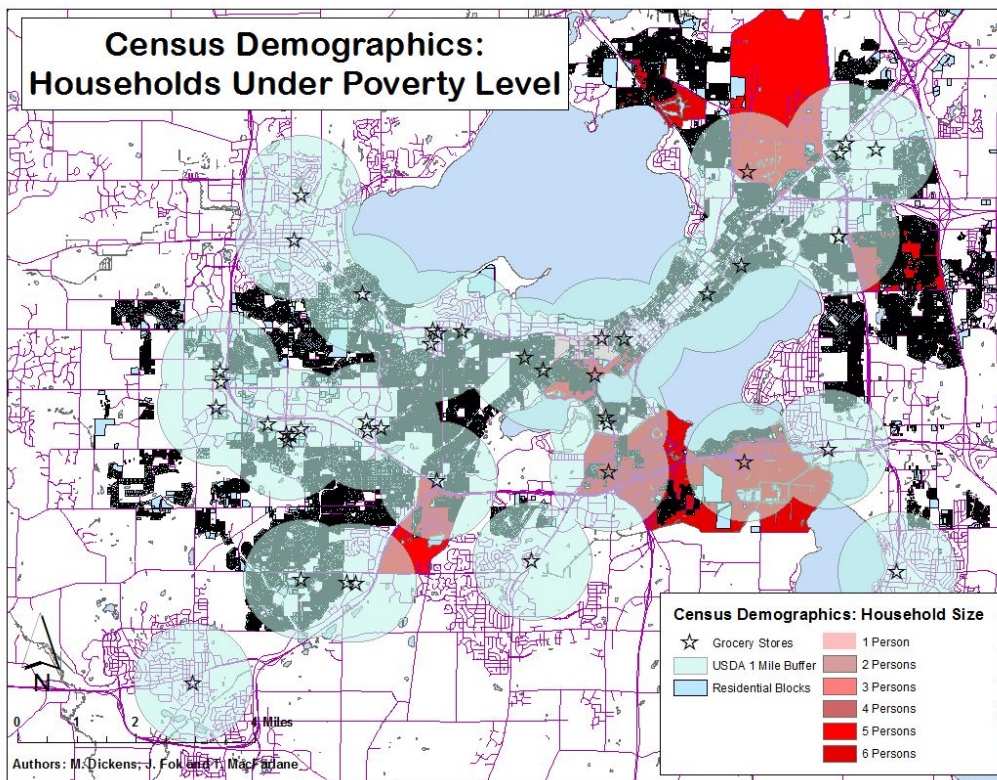


Figure 21: Census Demographics: Households Under Poverty Level