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A GIS Analysis of Sidewalk Infrastructure in Starkville, MS

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By

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Sidewalks provide many community services, yet not much geospatial research exists regarding sidewalks, especially in Mississippi. The purpose of this thesis was to use geographic information systems to inventory and map sidewalks for Starkville, MS and to compare sidewalk availability and quality to 2010 US census block demographics. In Starkville, sidewalks served 28% of the census block population, which classifies the city as "Car-Dependent" according to a Walk Score criteria. Majority minority census blocks and majority white census blocks had similar proportions of sidewalks. However, 97% of "Excellent" quality and 64 more sections of ADA compliant sidewalks were within majority white census blocks or commercial census blocks. Residential census blocks, especially majority minority blocks, have 26% less connectivity and an overall less dense sidewalk network. Starkville sidewalks have greatly improved since initial construction, but it seems that the current sidewalk infrastructure still reflects historical settlement and zoning patterns.

DEDICATION

I would like to dedicate this research to my wife Courtney, my parents, Penny and Carter, and my sister, Kelty. I could not have made it this far without their unwavering love and support.

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CHAPTER I

INTRODUCTION

Sidewalk infrastructure is important to the communities that host them because sidewalks provide numerous benefits. The presence of sidewalks encourages physical activity, such as walking, and the use of sidewalks has been shown to improve community health (Lopez & Hynes, 2006). In addition, sidewalks provide an avenue of connectivity between origins and destinations that encourages pedestrians to interact with their neighborhoods and thus increases the sense of community and decreases the sense of isolation (Collins & Frantz, 1999). This sense of community encourages members of the neighborhood to interact. A tightly knit community is less likely to sit by while suspicious activity occurs (Collins & Frantz, 1999). This discourages crime and makes the neighborhood safer for the residents. Therefore, sidewalks are a vital component of a community's infrastructure.

Unfortunately, many communities in the United States do not have adequate sidewalk infrastructure. What was once considered adequate years ago may no longer work for the modern era of pedestrianism considering how populations fluctuate and how frequently city zoning ordinances change. Surprisingly, given their importance to the communities, there have been very few scholarly articles about the relationship between sidewalks and the needs of the community. Studying this relationship is especially

important in areas that have witnessed considerable growth and that have experienced major societal changes during the last several decades, such as in the state of Mississippi.

Starkville, MS is a city located in the northeastern portion of Mississippi. In 2010, Starkville's population was 23,888. The white population of Starkville make up 59.6% of the total population and minorities make up the other 40.4%. Starkville has been a city focusing on improving the Walk Score for almost ten years (Daniels, 2010). This, along with the cultural history of a racially divided Mississippi, makes Starkville a worthwhile city to investigate the effectiveness of the sidewalk infrastructure in regards to different populations. Through the introduction of a sidewalk ordinance (Ord. No. 2012-05, § 4, 6-5-12) that orders the construction of sidewalks with any new commercial development within city limits, Starkville attempted to improve the sidewalk infrastructure. Not everyone welcomed this ordinance and it became a topic of debate (Daniels, 2010) between residents, contractors, developers and the city. Some residents and developers saw the new ordinance's requirement for sidewalk construction as an unnecessary financial addition that could push businesses out of the area (Gines, 2014) by scaring off developers.

This thesis will study the composition of the Starkville, MS sidewalk network, the locations of certain community amenities within the city, and the availability of sidewalks to the population of the city. The objectives of this study are:

1. To use geospatial techniques to map the existing sidewalk network,
2. To compare the sidewalk network to amenities and attractors within the community,

3. And to explore the accessibility of sidewalks within neighborhoods dominated by different ethnic groups.

The hypotheses entering the study are that the sidewalk infrastructure of Starkville, MS may not adequately and evenly serve the population of the city.

The significance of this research is that there has not been much reported in the academic literature about the use of geospatial sidewalk networks to compare existing infrastructure to the needs of the people. Furthermore, this study may help identify locations that are in need of revitalization or addition of new sidewalk networks. The study will aid in the planning of new sidewalk infrastructure and the improvement of existing sidewalks.

CHAPTER II

LITERATURE REVIEW

This thesis focuses on comparing existing sidewalk infrastructure within Starkville, MS to the needs of the community. This research question addresses three main topics, including sidewalks as transportation networks, the use of Geographic Information Systems (GIS) to study sidewalks, and societal changes within the Deep South region. The following section provides a review of the recent literature for each of these topics. The purpose of this section is to underscore the importance of studying sidewalks and to provide an evaluation of the most appropriate methods to investigate the quality of sidewalk networks within a community.

Transportation

Transportation between and within neighborhoods is not restricted to a single mode. Whether it be by automobile or on foot, neighborhood inhabitants interact with their surroundings and each other. Transportation is defined as the movement of matter from an origin point to a destination point (Cooley, 1894). This term is a mechanical term, but can be widely applied to any form of transportation. For our purposes, the definition of transportation is simply movement from place to place.

Transportation is a function of the background of the person who uses it. People with higher incomes use private transportation whereas those with lower incomes tend to

use public transportation (Yago, 1983). Whether or not a city has public transportation can dictate which mode of transportation are used by members of lower income neighborhoods Public transit can help alleviate the cost of owning and maintaining a personal automobile for members of the lower class (Criden, 2008).

Sidewalks and GIS

A geographic information system is a useful tool in taking sidewalk inventories. A GIS is a framework of tools used to display and analyze geographic data. In Cucamonga, CA, the city used a contractor and GIS to take an inventory of existing sidewalk infrastructure. Using digital aerial orthophotos, sidewalk locations were digitized. For the areas that were hidden in the orthophoto, onsite spot checks were carried out (Isaacs, 2011). GIS can be a real asset when recording sidewalk locations and attributes, as well as modeling population flow and interaction.

There are two different types of approaches for modeling flow and capacity in street networks. These approaches can be useful for thinking of sidewalk networks as potential models. One approach is the geographic approach that uses nodes to represent junctions and edges to represent street segments. The topological approach is an approach that focuses on connectivity of the street segments, which are considered nodes, to other street segments, or edges (Jiang, 2008). By building a topological relationship from sidewalk networks, it is possible for researchers to model flow using mathematical models. The geographic model is best suited for simple network analysis while the topological approach better captures the cognitive recognition of route selection (Jiang, 2008).

Demographic studies lack a spatial perspective (Chi & Zhu, 2008). Examining problems from a geographical mindset allows for a fresh perspective and the utilization of geographers' tools, such as GIS. GIS is great for geovisualization of demographic data in relation to the variables of interest; in this case, the sidewalks of Starkville, MS and locations of attractors throughout the city that would draw pedestrians inward.

An important spatial statistic that can be calculated within GIS software is a hot spot analysis. A hot spot analysis is used to find spatial associations of data values within a dataset. Spatially proximal, similar values are considered a hot spot or a cold spot depending on the data's value (Páez & Scott, 2004). Tools such as this allow for the demographic study of the population as well as the populations of the persons under 18 years old (Mitchell, 2011). The results of these analyses can be mapped alongside the locations of the sidewalk network. High concentrations of minorities or people under 18 should be seen along the existing sidewalk infrastructure. These populations are the most likely to take advantage of the sidewalk infrastructure due to the lack of public transportation and the necessity to walk to school.

According to the Americans with Disabilities Act (ADA), new sidewalks shall be a surface that is both firm and stable, and at least 96 inches in length and 60 inches in width (Americans with Disabilities Act, 1994). This newly built sidewalk must be connected to a street, another sidewalk, or a pedestrian path either directly or by an access pad. For drainage, these sidewalks must have a maximum slope of 2% (Americans with Disabilities Act, 1994). The ADA considers a sidewalk a "path of travel." By definition, a "path of travel" is a continuous and unobstructed avenue by which pedestrians may be connected to other paths, or allows exiting and entering paths

(Americans with Disabilities Act, 2010). This definition could possibly exclude many of Starkville's existing sidewalk infrastructure. Therefore, the definition of a sidewalk will be broadened to include any path that is parallel to the street network and allows pedestrian transportation to occur outside the bounds of vehicle-only routes.

Walk Score®

Walk Score is a measurement of how walkable a city is based on nearby amenities, population, block length, and intersection density (Walk Score, 2010). Parks and Schofer also recognize these variables in a 2006 study (Parks & Schofer, 2006). The Walk Score of a location is an indicator of how easily errands can be completed by a pedestrian and what mode of transportation the population is likely to use. Walk Scores are lumped into five categories: Walker's Paradise, Very Walkable, Somewhat Walkable, Car-Dependent, Car-Dependent (Walk Score, 2014).

Walker's Paradise is the best range of scores a city can achieve. These Walk Scores range from 90-100 where everyday trips for errands do not necessitate the use of a car. The second best category is Very Walkable with scores ranging from 70-89. A city with this score has infrastructure in place that allows most trips taken for errands to be completed without the use of a vehicle. The Somewhat Walkable category Walk Scores range from 50-69 indicating that only some errands can be completed without a vehicle. The second-to-last category has Walk Scores from 25-49 indicating a Car-Dependent city where most trips for errands cannot be completed on foot, but require a car. Finally, Walk Scores from 0-24 fall into the Car-Dependent category where almost every trip requires a car and cannot be completed on foot (Walk Score, 2010). These categories are

the basis for interpreting Walk Scores for cities and addresses. Starkville's Walk Score is listed as a 26 indicating a Car-Dependent city.

History of Segregation in America and the South

Because of a turbulent past, the possibility of sidewalks serving one population adequately while not serving another is a real concern. Segregation may be helpful in explaining the differences in the locations of sidewalk infrastructure throughout the South and examining the history of race in America and the South can be useful in the analysis of sidewalk locations. The following section will focus on providing a brief overview of racial history in America.

A large part of the history of America's South is tied to racial turbulence. While many studies have focused on examining how that racial past has affected modern day settlements and economics, the question of how that past has influenced infrastructure at a neighborhood scale is sparse.

In the South, after the Civil War and the freeing of slaves, the settlement of freedmen began. The post-Civil War South was by no means a utopia and changes were still coming. Fast-forwarding to the civil rights era of the South, blacks were separated from whites in all parts of life. The popularity of a "separate but equal" society kept a region divided for much of the 20th century thanks to a federal government that could not enforce anti-segregation legislation and thanks to Jim Crow laws (Grose, 2003). Mississippi was the state with the greatest racial divides and oppression during this period of segregation (Hoelscher, 2003). Though Mississippi had a lesser number of Jim Crow laws than some other states in the South, there was a large amount of resistance to racial integration (Hoelscher, 2003). The written Jim Crow laws were only a piece of the

deep racial trenches that divided Mississippians. Interracial cohabitation or marrying was illegal in the state of Mississippi starting in 1865 (Bringing History Home, 2005) and was not overturned until 1967 with the case of *Loving v. Virginia* which prevented states from taking away this basic civil right for Americans (Dobson, 2010). In 1890 and 1891, Mississippi passed laws making education in integrated schoolhouses unconstitutional and passed laws closing voting locations to blacks (Hoelscher, 2003). The society was separate, but by no means was it equal.

Legislation was passed to try and bring equality to the races. The 1968 Fair Housing Act and the Equal Credit Opportunity Act of 1974 prevented race from being taken into account when buying or renting a home. Before then, it was legal for renters and homebuyers to be turned away or discriminated against based on their race and contributed to segregation in neighborhoods (Boustan, 2013).

Neighborhoods and Neighborhood Segregation

Neighborhoods are the spatial outline of a small community within a larger community, be it a city or town. The technical definition for neighborhoods that will be used for this thesis comes from the United States Census Bureau's definition of a census tract. Census tracts are "designed to be relatively homogeneous units with respect to population characteristics" (United States Census Bureau, n.d.). America's history of racial inequality and turbulence has had a significant effect on who comprises modern day neighborhoods. Racial residential segregation occurs when spatial rifts occur between racial groups in a given area (Boustan, 2013). Black self-segregation, white collective action, and white individual action are all contributing factors to this segregation (Boustan, 2013).

In the case of black self-segregation, the personal preference of blacks to settle in primarily black neighborhoods creates clusters of majority black neighborhoods. This segregation is not malicious, but due to a preferential settling pattern by blacks. Contributing factors for segregation isolate one race from the other. This creates the possibility of transportation infrastructure inequality between black neighborhoods and white neighborhoods. This is not always the case, some segregated neighborhoods are a result of migration patterns and things like preferential placement of housing projects and intentional locating of lower income housing and housing projects (Bayor, 1988). Still more bodies of work suggest that segregation is due primarily to socioeconomics and lifestyle differences or suburbanization (Chi & Zhu, 2008).

Obesity, Built Environments, and Sidewalks

Urban environment has an effect on rates of obesity in the population. Urban sprawl has been associated with obesity (Lopez & Hynes, 2006). If pedestrians are connected to the rest of the street/sidewalk network and to "pedestrian amenities" (Lopez & Hynes, 2006), then they are more likely to be physically active. Studies show that physical activity and high levels of accessibility are positively associated and that "walking is positively correlated with presence of sidewalks" (Handy S., 2004). Other factors that influence walking is safety and the built environment. Safety is more important to suburban residents than to their traditional neighborhood counterparts. Infrastructure that promotes means of transportation other than driving, such as sidewalks, bike paths, and public transit, can be a predictor of an increase in walking (Handy & Mokhtarian, 2005). The attractiveness of a built environment can also influence physical activity. Cao from the University of Minnesota analyzed

neighborhoods in Northern California and found that the physical attractiveness of the built environment actually is the largest of the factors that influence physical activity (Handy, et al., 2008). Pedestrian travel can be broken down into two general types of trips: strolling trips and utilitarian trips. As the names imply, strolling trips are characterized as the casual activity of walking for enjoyment or without a specific destination in mind. Utilitarian trips, on the other hand, are classified as trips that are undertaken with a specific purpose in mind, like walking to the store. Strolling trips are most heavily influenced by the pedestrian environment of the starting point, or the origin. For utilitarian trip, the environment at the destination can be as important as the environment at the starting point. In addition to these environments, travel distance, street layout, and land use along the route can all influence physical activity. Not designing neighborhoods and cities with the pedestrian in mind, having longer than ideal distances, as well as having infrequent or poorly connected sidewalks, can all have a negative influence on rates of physical activity (Cao, et al., 2006).

Sidewalks in the Golden Triangle (Starkville, West Point, Columbus, and Mississippi State)

According to Dr. Ronald E. Cossman, President of Starkville in Motion, the original sidewalk network of Starkville, MS dates back to World War II (Dr. Ron Cossman, personal communication March 6, 2015). Improvements to this network have occurred over the years. For example, Starkville, MS passed a city ordinance in 2009 requiring the owner of any new properties within a specified geographic area, within the downtown area of Starkville (Sims, 2011) with some exceptions, to construct sidewalks alongside the new property. If properties owners refuse to construct a sidewalk within

the first two years after the city accepted plans for new construction, the city will complete the construction of the sidewalk and tax the property owner based on an assessment "in accordance with state statute" (Starkville Code of Ordinances, 2012). Starkville's definition of a sidewalk is "a hard-surface, all-weather area designed for the convenience of pedestrian access, which is normally located immediately within the public right-of-way" (Starkville Code of Ordinances, 2012). According to this ordinance, sidewalks are required to be ADA compliant by being at least 1.5 m (five feet) wide with 0.9 m (3 feet) of clearance in the path. It is the city's responsibility to repair and maintain sidewalks, but it is proximal property owner's responsibility to request an evaluation of the sidewalk infrastructure in front of their properties (Starkville Code of Ordinances, 2012).

Starkville participated in the Federal Safe Routes to School Program, henceforth referred to as SRSP, in 2007. SRSP is a grant that allows cities to apply for money to create and repair sidewalk infrastructure for students to utilize in their walk to school (National Center for Safe Routes to School, 2012).

West Point, MS is located approximately 21 miles northeast of Starkville, MS and is within the geographic region called the "Golden Triangle" that includes the cities of Starkville and Columbus. These three cities are close together and are being compared to each other because they have three different takes, from the city's perspective, on sidewalks. West Point sidewalks are more loosely defined and regulated than Starkville's. West Point's code of ordinances refers to a sidewalk as a "portion of a street between the curb line and the adjacent property line, intended for the use of pedestrians, excluding parkways" (Code of Ordinances for the City of West Point, Mississippi, 1978).

Unlike Starkville, the slope of the sidewalk is determined by the city engineer and if none has been set, the grade is decided by a special ordinance. This city's definition of a sidewalk, as well as its specifications are much more loosely defined than Starkville's.

Columbus, MS is located approximately 26 miles east of Starkville, MS. Columbus' sidewalks are more strictly defined than the sidewalks in West Point. Columbus sidewalks are constructed only where necessary and only if they are approved by the city's mayor and city council. Two sets of sidewalk dimensions are given in the Columbus code of ordinances. Residential sidewalks are to be built 1.2 m (four feet) wide and four inches thick, but 2.1 m (seven feet) wide in business areas (Charter and General Ordinances of the City of Columbus, Mississippi, 1973).

Mississippi State, MS is the home of Mississippi State University. Mississippi State is considered its own city, technically, but it is housed within Starkville, MS. The sidewalk network of Mississippi State has proposed updates included in an overall "master plan" for the university. This master plan includes new buildings, updated gateways to campus, and new signage to benefit pedestrians, cyclists, and automobilists (LPK Architects; Sasaki Associates, 2010). The updates to the sidewalks will be completed with the goal of increasing pedestrian and bicyclist connectivity between the Mississippi State University campus and Starkville.

Out of the cases listed above, Starkville and Mississippi State University are the most progressive cases of sidewalk infrastructure updating, building, and connectivity. In both cases, improvements have been planned or ordinances have been passed to improve the pedestrian infrastructure. Starkville passed the sidewalk ordinance in their city in 2009 (Starkville Code of Ordinances, 2012) and made subsequent changes to allow for a

narrowing of the area in which developments are required to build sidewalks, while Mississippi State unveiled their master plans for campus the following year, 2010 (LPK Architects; Sasaki Associates, 2010).

The effects of sidewalks on health and pedestrian behavior is known and widely studied, but there is still much to be studied on sidewalk infrastructure, especially in northeast Mississippi. This thesis will look at whether or not the sidewalk infrastructure and sidewalk ordinances are adequate for the population in this region and will use geospatial technologies and approaches to analyze infrastructure and transportation.

CHAPTER III

DATA AND METHODS

The methods in this thesis proposal revolve around the collection, comparison, and visualization of spatial and qualitative data. The following section describes the research plan for acquiring sidewalk and community data and explains how the data will be analyzed.

Data Collection

Census block data representing ethnic composition and persons under 18 were collected for Oktibbeha County from the United States Census Bureau website. The census data are from the year 2010 because it is the most recent year in which block level data are available. In addition to the census data, sidewalk location data are collected. These data were collected by driving the street network of Starkville, MS with a paper map, marking sidewalk locations. These data will allow for the creation of a sidewalk dataset and map for Starkville, MS and for the assessment of how the sidewalks serve certain populations within Starkville.

Starkville's sidewalks were mapped in the field in March 2014 by drawing the location and the quality of sidewalks on a paper map. After collection, the sidewalk data were digitized using a GIS. The road and sidewalk lengths were measured differently. If a street had sidewalks on both sides, those sidewalks are considered two separate

sidewalks and their lengths are added together in the analysis of sidewalk length. For roads, regardless of the number of lanes, the roadway was considered a single entity. If a two lane road that was one mile long had sidewalks on both sides of the road throughout that one mile, the total road length would be one mile and the sidewalk length would be two miles. Areas of sidewalks were evaluated in the field with notes being taken on the general geographic area in relation to the streets, overall connectivity to the sidewalk infrastructure, presence of road cuts, sidewalk construction quality, and notes. Sidewalk connectivity was rated as being either Poor (very little or no connectivity to the rest of the sidewalk infrastructure), Fair (little connectivity to the rest of the sidewalk infrastructure but some is present), Good (connectivity occurs but not to an extent where improvements can't be made), or Excellent (high level of connectivity with little room for improvement; fully connected to surrounding area by multiple outlets). ADA compliance does not address the connectivity of sidewalk infrastructure. For this study, sidewalk connectivity was addressed separately from ADA compliance. Sidewalk construction quality was recorded on a similar scale to the aforementioned category of connectivity; Very Poor (Not ADA compliant; Obstructed), Poor (Not ADA compliant, but able to be used by most pedestrians; too narrow or broken sidewalks); Fair (ADA compliant, but may need repair; easily used by most pedestrians; few obstructions); Good (ADA compliant; no obstructions; no or very little breaking of surface); Excellent (ADA compliant; more than 1.8 m (six feet) wide; very few or no noticeable damage to surface; no obstructions; road cuts are present; easily used by all pedestrians without exception). Surprisingly the academic literature is scant regarding studies on sidewalk GIS analyses and sidewalk accessibility, therefore methodologies were developed. To do this, a geospatial file of the

Starkville street network was edited with lines representing existing sidewalk infrastructure. Sidewalks were offset one meter from the street layer on the appropriate side(s) of the street. The distance of one meter from the street was used based on research indicating that pedestrians prefer to be between 0.3 meters to 1.2 meters from the closest building or obstruction (Boodlal, 2006). This zone is called the "shy zone" and the one meter offset from the closest obstruction, the road that pedestrians would want to avoid fell within this range. Additionally, Starkville's medical establishments, fast food establishments, restaurants, farmer's markets, supermarkets, gyms, schools, banks, and parks were collected using Google's "My Business" results which is a free service Google provides to businesses or professionals where they can add their addresses, websites, business/profession information and other information (Google, Inc., n.d.). The attractors were chosen as a cross-section of different places that attract pedestrians for potential errands to be run. For the community, these categories represent a set of possible destinations for trips taken by residents of a city. Once the addresses for each attractor category were collected, the addresses were geocoded into the GIS alongside the sidewalk infrastructure. When geocoding in a GIS, the physical address of each location is entered into an address locator. This tool matches the user's input with physical addresses associated with the street layer inside the GIS. When the attractors were geocoded into the GIS, there was a match rate of 100%. This means that no address failed to be located along the street network.

Data Formatting

Because of a significant component of this research involves creating a GIS database, the following section details how the database were constructed. In a

spreadsheet, the data were formatted for importing into a geodatabase. Formatting these data included inputting short, descriptive column headings that were devoid of spaces. Then, all columns representing minority, persons other than non-Hispanic whites, or mixed race data were combined into a single column representing the minority population in each census block. Finally, columns were created to separate each entry's state FIPS code, county FIPS code, census tract, census block group, and census block. Using the census tract and census block number, unique IDs were generated for each entry. These unique IDs were used later to join the census data table to the census block geospatial files. The populations of persons under 18 were added into the database in their own column. The population of minors in each census block was included in the study because persons under the age of 18 are expected to utilize the sidewalk infrastructure to reach schools. Connecting minors to their schools is an important use of the sidewalk infrastructure. The collected and formatted data were imported into a geodatabase before analysis.

Data Analysis: Join

The data in the geodatabase were added into a GIS for visualization and analysis. First, the database table that holds the ethnic census information were joined to the census block feature class based on the unique ID that matches feature class entry to the database table entry. Once the join was verified and processed, the census block feature class were exported to the geodatabase so the joined attributes are permanently kept within the new feature class.

Data Analysis: Density and Connectivity

The density of sidewalks was determined by using a line density function in the GIS. For this analysis, the minimum search radius was set to 268 m which represents an area large enough to encompass significant portions of different census blocks but not so small that it counted small pieces of sidewalk infrastructure as a high density area. The output density grid was set to 33 m, which was appropriate to investigate sidewalk clusters as a citywide scale. The number of nodes that connected sidewalks determined sidewalk connectivity. For example, a segment of sidewalk without any connecting nodes would have a connectivity equal to 0. A sidewalk that connected to another sidewalk on one end but not the other had a connectivity of 1.

Data Analysis: Spatial Statistics

In a previous study, spatial autocorrelation was used to map the Hot Spots of minority and low income populations (Guerrero & Kao, 2013). No specific analysis was mentioned for studying special distributions of ethnicity, but a Hot Spot Analysis is ideal for this thesis. A Hot Spot Analysis creates a new shapefile containing the results when the analysis is complete and the results are interpreted based on the output Z-Scores. A Hot Spot Analysis was run on the newly created geospatial data in the GIS to determine the spatial autocorrelation of the data. The Hot Spot Analysis operates on data in a vector format that have attributes that can be examined quantitatively (Parks & Schofer, 2006). The output of this analysis is a geospatial file with Z-values that represent the significance of clustering with a high Z-score, greater than 1.75, representing statistically significant clustering of high values and a negative Z-score that is far from 0, -1.75 or less, representing a statistically significant clustering of low values. If the Z-score is

closer to 0, there is no significant clustering at that location (Scott & Warmerdam, 2005). The Hot Spot Analysis used the field in the geospatial data that represents the minority population total for each block, the Fixed Distance Band as the Conceptualization of Spatial Relationships and the Euclidean Distance as the distance method. The Fixed Distance Band was used as the Conceptualization of Spatial Relationships because it designates a Euclidean Distance from a neighborhood that makes anything within that distance a neighbor. The Euclidean Distance was used as a distance measurement from point to point to find the nearest neighbor in an area where interaction does not occur only on the street network. The output of this analysis was saved to the working geodatabase. The Hot Spot Analysis was run again on the feature class using the field that represents the population of persons under 18 years of age in each census block as well as the Euclidean Distance as the distance method. In addition to the hot spot analysis, a spatial statistical regression was run. This will allow the associated factors, or factors that may influence the surrounding population, such as the distance to the sidewalk infrastructure, to be explained as well as mapped.

An ordinary least squares regression (OLS) was run to determine the relationship between different demographic and geographic variables and the distance to the closest sidewalk. OLS creates a model based on the variables and tries to fit the best line to the data. The chosen line would be the line with the smallest residuals (difference between predicted and observed values) that best fits the data (Chumney & Simpson, 2006).

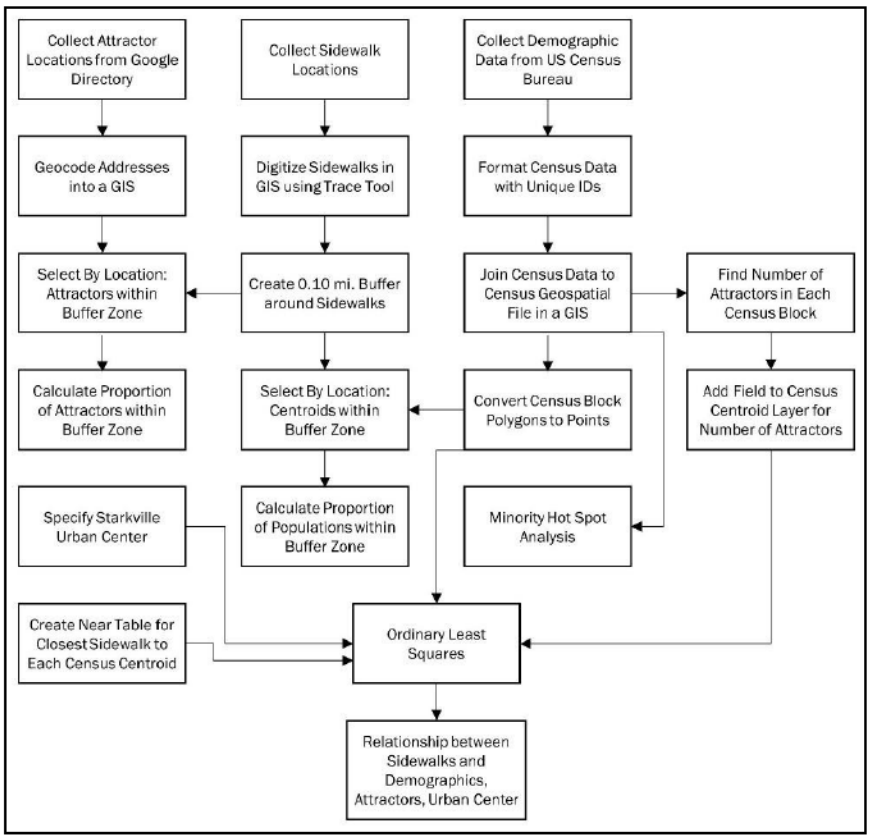

Figure 1 Study Methods

To determine whether or not the sidewalk infrastructure of Starkville adequately served the community, a set of guidelines were created to analyze the infrastructure. Sidewalks adequately serve residents of the area if the residents are within 161 m (1/10 mi.) of the sidewalk infrastructure. If 70% of Starkville's residents are within 161 m (1/10 mi.) of the sidewalk infrastructure, the community is considered adequately served by the sidewalk infrastructure. This threshold of 70% is taken from the Walk Score® (Walk Score, 2014) threshold for a "Very Walkable" city. If Starkville is considered "Very Walkable" in terms of the sidewalk infrastructure, then the population is adequately served by sidewalks. After evaluating the proportion of Starkville's

population that is served by the sidewalks, a similar assessment was run on the population, broken down by race and the population under 18, as well as the attractors. These assessments help determine whether Starkville serves these characteristics of the city adequately.

Once the proportion of the populations that were served were calculated, a model was created using the Ordinary Least Squares (OLS) tool in the GIS. The output of the OLS is an equation representing the model that predicts the dependent variable, or distance to the nearest sidewalk. In this model, to explain the distance to the nearest sidewalk, demographics and presence of attractors in the census blocks were used as independent variables. The independent variables in each city block are the population of persons under 18 years of age, the population of Whites, the population of minorities, the number of attractors in the census block, and the distance from the city block to the urban center of Starkville, MS. The United States Census Bureau data contain the population information, such as the number of persons under 18 and racial statistics, but the other characteristics, number of attractors per census block and distance from urban center, had to be mined from the data on hand. To calculate the number of attractors in each census block, a "Sum" function was used within the borders of each census block to add the number of attractors that fell within each block. An urban center was defined within the center of Starkville's central business district at the intersection of Martin Luther King, Jr., Blvd. and North Montgomery St. (Figure 2). This location is in the heart of Starkville's central business district where major banks, businesses, and city government offices are located. Using the location of the urban center, a table that calculates the distance from the center of each census block to the urban center was created using the

Near Table tool. This tool measures the Euclidean distance between features chosen by the user and populates a table with these distance values. Once all of these were calculated, the census blocks were joined with the data and converted to centroids for each census block. This geospatial file contained all of the information about that census block's geographic and population characteristics making it ready to be used in the model.

The use of a GIS to digitize and visualize the sidewalk network of Starkville, the community attractors of Starkville, and the population in each census block achieved the objective of comparing the locations of these three facets of the community. To answer the last objective about how the sidewalks serve the community as well as different societal groups in the minority, the latter part of the methodology, Ordinary Least Squares Regression and the GIS processing model, addressed this objective based on the assumptions listed above.

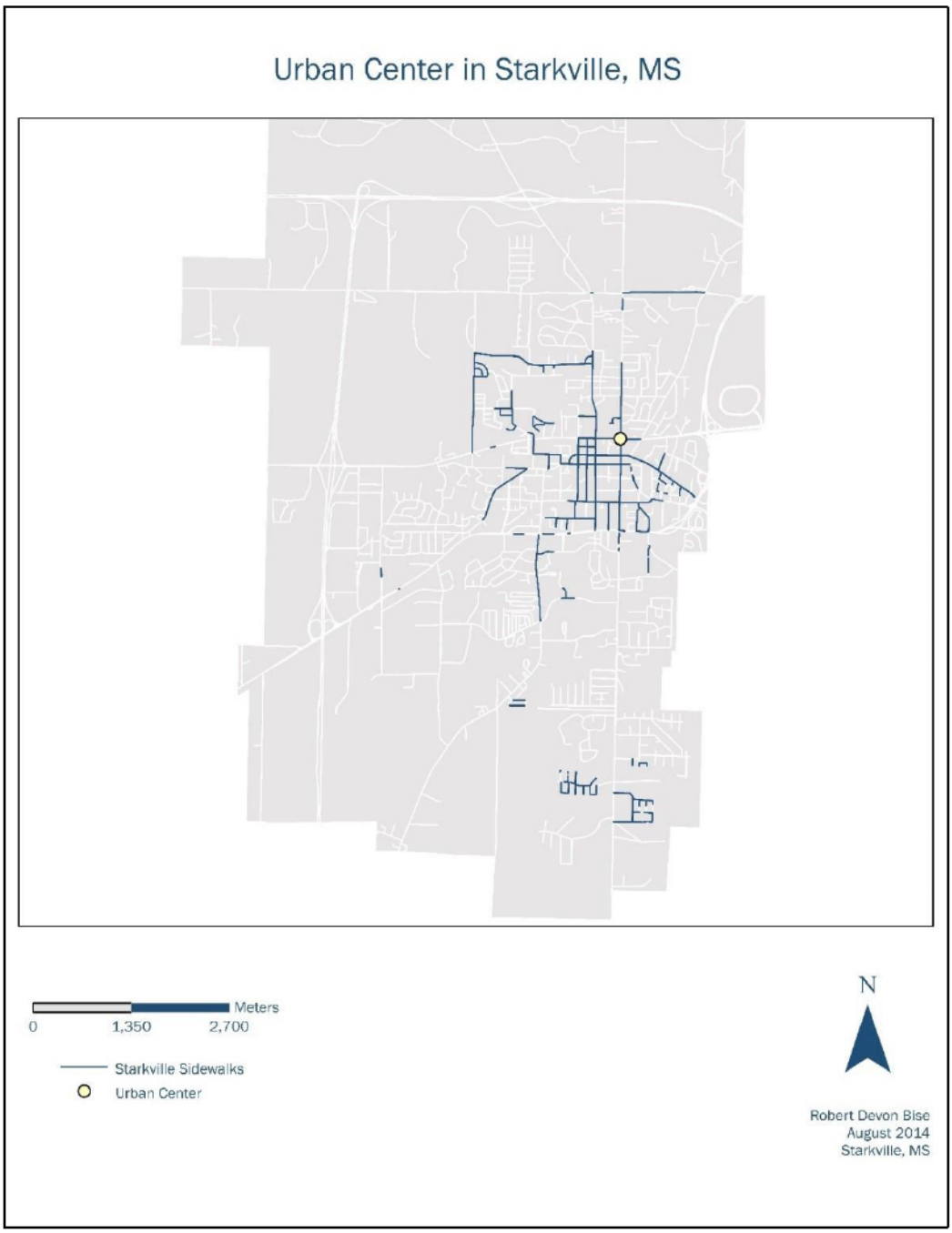

Figure 2 Location of Starkville, MS Urban Center

CHAPTER IV

RESULTS

Starkville Sidewalk Network

In Starkville, MS there are approximately 45 kilometers (28 miles) of sidewalk infrastructure compared to 326 kilometers (288 miles) of roads (Figure 3). This equates to 13.8% of the total road length being represented with sidewalk infrastructure.

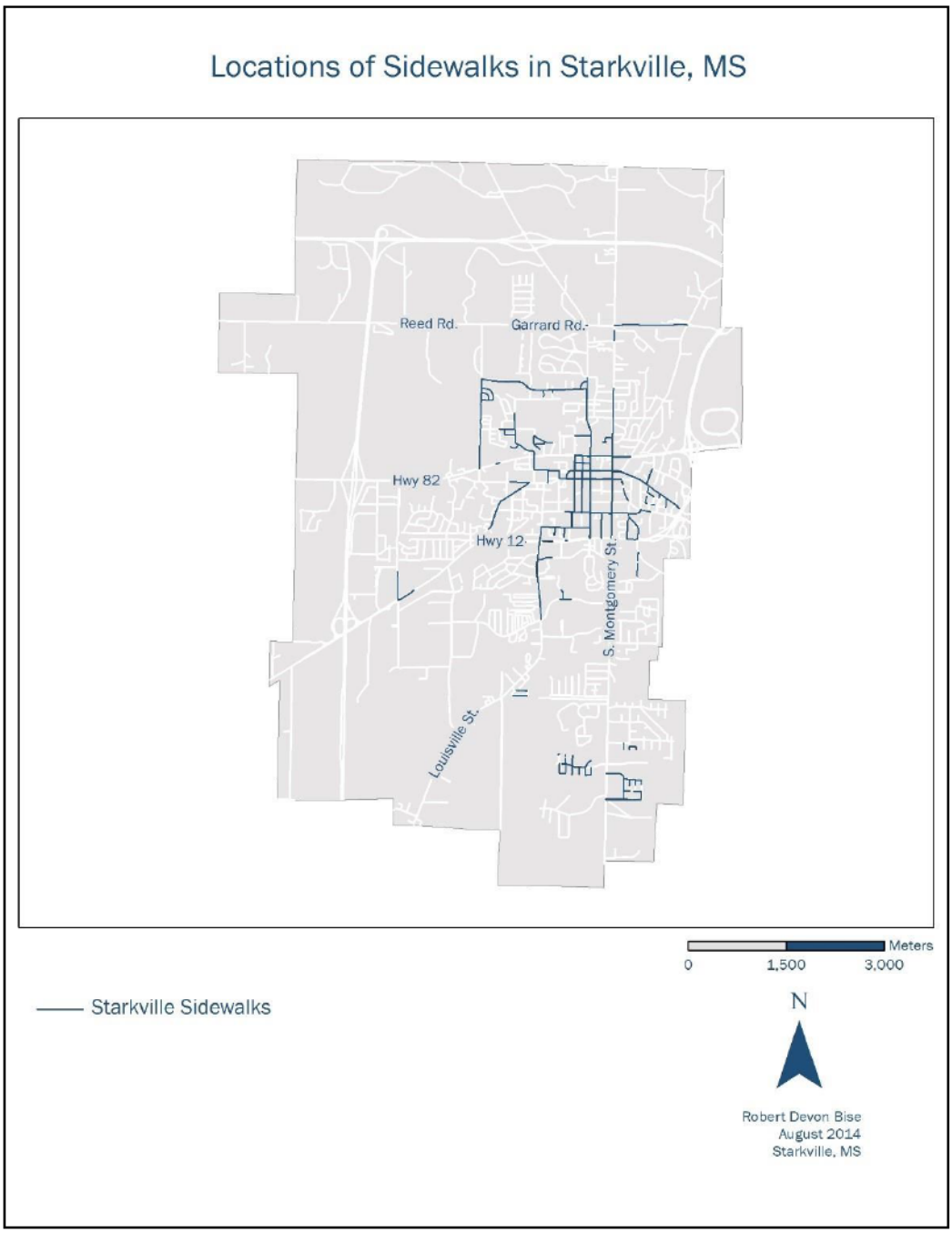

Figure 3 Starkville, MS Existing Sidewalk Infrastructure

Sidewalk Walk Score

Starkville, MS has a Walk Score of 26 (Table 1) on a scale of zero to 100. Considering the results from the study, this seems to be an accurate assessment of the walkability of the city. Starkville is indeed a town that is dependent on automobiles, but the Walk Score is higher than expected. With a score of 26, Starkville is considered as pedestrian-friendly as Jackson, MS and Gulfport, MS. Without considering connectivity, the Walk Score of Starkville is inflated. Starkville does not connect the east side of town to the west side of town with sidewalks. If attractors are located on a section of sidewalk infrastructure that does not connect to any other section of sidewalk infrastructure, then that area of attractors should hold very little weight on the Walk Score.

Table 1 Mississippi Cities and Walk Scores (Walk Score, 2014)

City Name	Population in 2010	Walk Score
Greenville, MS	34,400	34
Gulfport, MS	67,793	23
Jackson, MS	173,514	25
Mississippi State, MS	N/A	48
Oxford, MS	18,916	23
Southaven, MS	48,982	16
Starkville, MS	23,888	26
West Point, MS	11,307	78

Sidewalk Density

The highest density of sidewalks in Starkville is in the downtown area with the lowest density of sidewalks, occurring almost everywhere outside of this downtown/eastern central portion of the city (Figure 4). Sidewalk line density was found using the Line Density tool in ArcGIS with a default distance parameter.

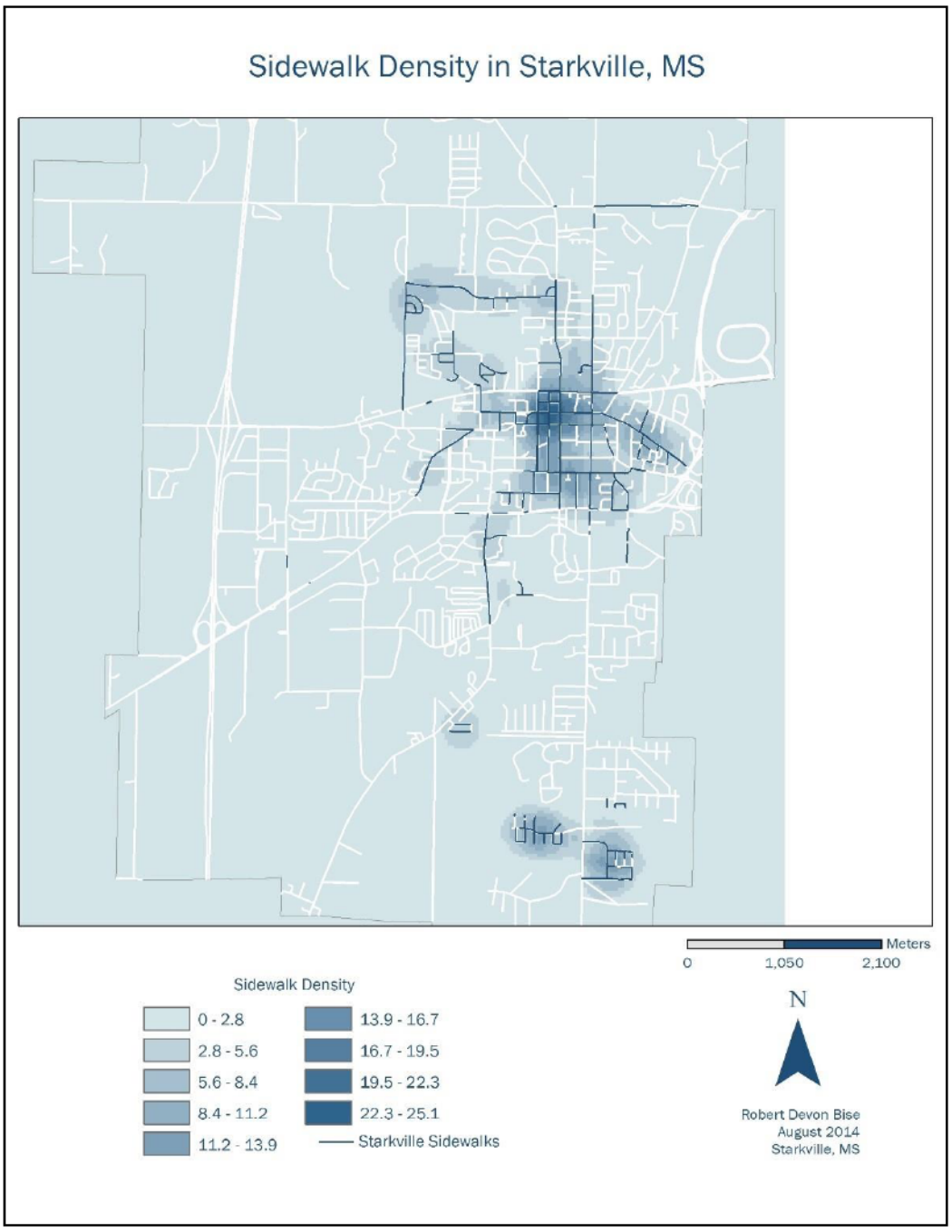

Figure 4 Sidewalk Line Density in Starkville, MS

Sidewalk Connectivity

Many sidewalks end and do not resume anywhere in sight. Sidewalks will change from one side of the street to another without notice or without crosswalks before ending. In some cases, the older sidewalks will connect to newly constructed, ADA compliant sidewalks. This is the case along Jackson Street when it reaches Hospital Road (Figure 5). On Hospital Road, newly constructed sidewalks connect to the older infrastructure in place on Jackson Street. Hospital Road is a prime example of well-constructed sidewalks that facilitate connectivity by connecting two major avenues of travel, Reed Road and Jackson Street.

The prime example of good connectivity within the network is in downtown Starkville on Main Street. Here, sidewalks follow alongside the roadways in every direction on both sides of the road for a few blocks providing the most comprehensive connectivity possible. The rest of Starkville is much different. In some areas, sidewalks are present but do not connect one neighborhood with another, as in southeastern Starkville. In other areas, sidewalks are notably absent. The worst case of connectivity in Starkville is in the western part of Starkville just off Highway 12 and Stark Rd. (Figure 6). A small section of sidewalk is located on the side of the highway. It connects to neither a building nor another sidewalk. The length of the segment does not exceed 15 meters. This is an example of the worst possible case of connectivity. This sidewalk is an island with no sidewalk within 305 meters of its location.

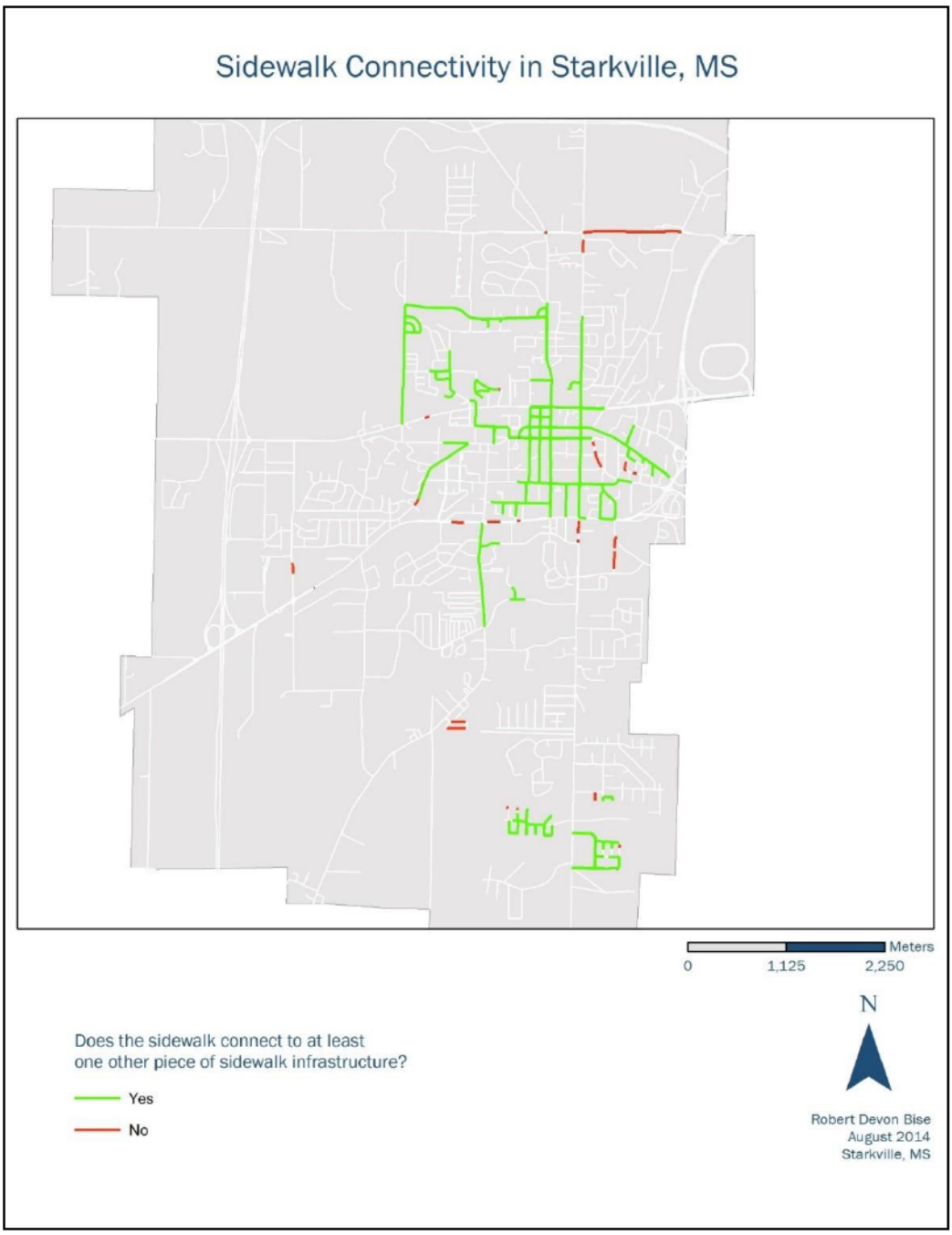

Figure 5 Starkville, MS Sidewalk Connectivity to Other Sidewalks

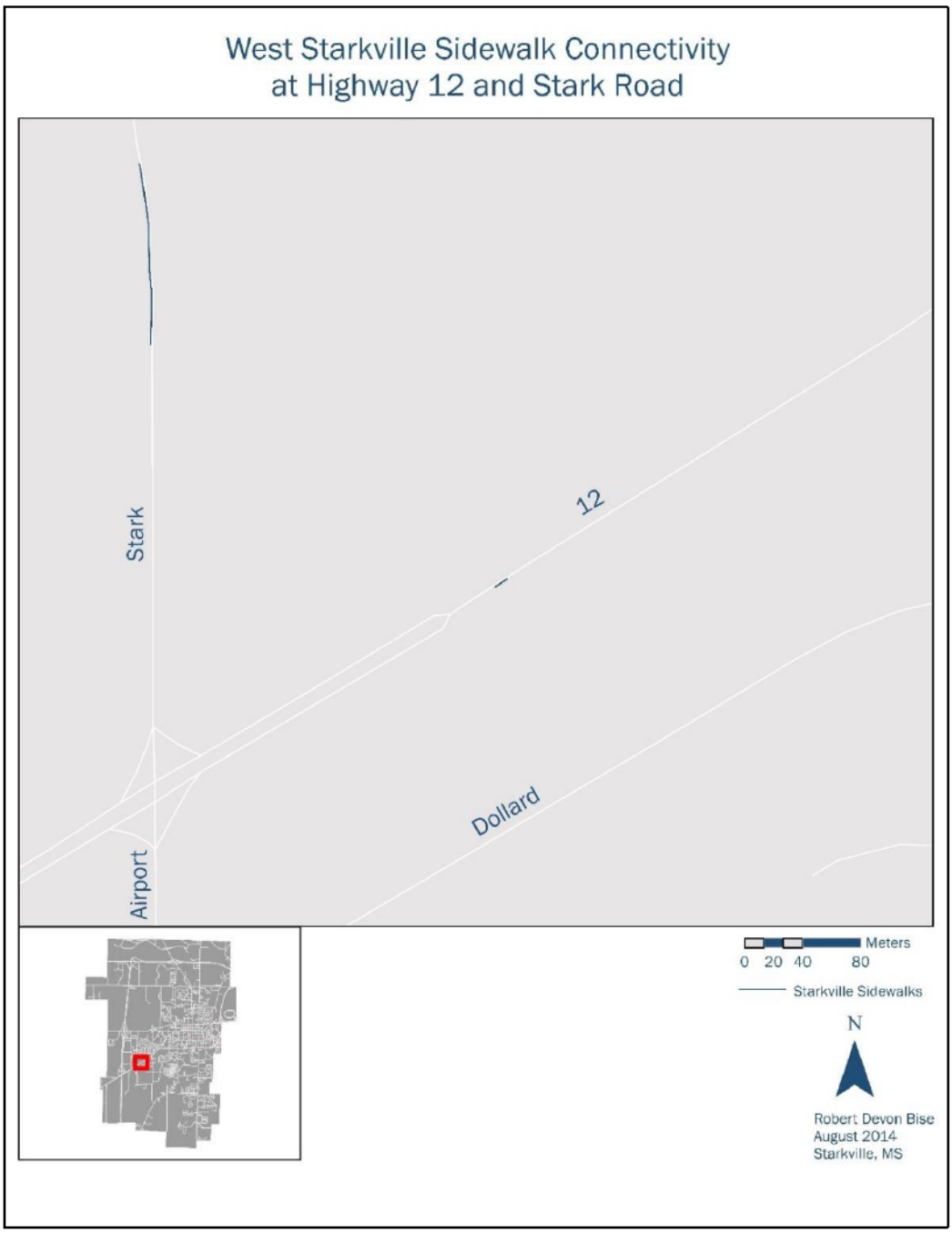

Figure 6 Location of Poor Sidewalk Connectivity in West Starkville

The most well connected sidewalks exist in government housing projects with a connectivity of 73.5%. These locations are neighbors to other neighborhoods or are

alongside roads with existing infrastructure, as with the housing project off Reed Road. Good connectivity, in general, does not extend to the newly constructed sidewalks of businesses or subdivisions. A newly constructed business on the corner of Garrard Road and North Montgomery Street has built sidewalks, per the city sidewalk ordinance. The issue with this construction is the lack of existing sidewalk infrastructure to which the new sidewalk can connect. This same problem occurs with new neighborhoods. Two of Starkville's new neighborhoods are located near the southern boundary of the city. Due to this location, the newly constructed sidewalks serve the community within the neighborhood, but does not provide an avenue of travel from the neighborhood to the rest of Starkville. Cases of internal connectivity do not support a pedestrian's travel outside of these small areas. This poor connectivity is an example of how urban sprawl can decrease connectivity. As businesses and residents move outward, the infrastructure must keep up and meet the needs of the community. However, sidewalks do provide a way for the residents of neighborhoods such as those located at the edge of cities to interact with the environment around them. Sidewalk presence encourages the act of walking and gives the neighborhood a potential for social interaction. The sidewalk ordinance is a good start in beginning this transition from a car-centric city to a city that serves pedestrians as well as cars.

Connectivity of sidewalks in Starkville is variable with individual connectivity percentages (number of connected sidewalks/number of roads along sidewalks) ranging from 0% to 100%. Depending on the region of Starkville, the connectivity can vary from being really good to poor. In eastern central Starkville, the sidewalk infrastructure has

52% connectivity. Sidewalk density is highest in this location and the sidewalks tend to connect to different branches of the network.

Sidewalk Quality

During the collection of sidewalk infrastructure locations, the quality of Starkville sidewalks became apparent. Sidewalks in Starkville are, in general, ADA compliant in the older parts of town. Starkville's central business district, being one of the most active and oldest parts of the city, represents one of the areas of highest connectivity (around 70% with 22 to 23 connected sidewalk nodes per km^2), fewest obstructions, and widest of the sidewalk infrastructure (Figure 5). Wide (3 m or greater), well-maintained sidewalks (no apparent disrepair of sidewalk surface) with high connectivity, around 70%, (many avenues connecting one piece of sidewalk infrastructure to another piece of the sidewalk infrastructure) to other sidewalks are present throughout much of downtown Starkville.

Radiating outward from this section are older sidewalks that connect downtown to parts of the surrounding neighborhoods. Within these neighborhoods, the sidewalk quality dichotomy begins to show. Around the boundary of Starkville's central business district, newer sidewalks connect to older sidewalks. These connections provide wide, 3 m or greater, and clear, no impediment of the sidewalk surface by abrasions or debris, paths of travel for pedestrians, but moving 500 – 700 m outward from the central business district, sidewalk quality and connectivity begin to drop.

Government housing projects, the central business district, new businesses, and new subdivisions have a majority of the best sidewalk locations based on sidewalk width (more than 3 m) and the quality of the sidewalk surface (no cracks or breaks) in the city

of Starkville. These locations, according to Starkville's sidewalk ordinance, must build sidewalks at new build sites.

The quality of Starkville's sidewalks varies by location (Figure 7). In some areas, such as newly built low-income housing and Hospital Rd., the sidewalks are well constructed (no visible signs of disrepair), wide (greater than 3 m), level, and clear with ample space for foot traffic. In other areas, such as on North Montgomery St. near Lampkin St., the sidewalk changes elevation by rising approximately one meter from the previously level sidewalk over a length of under 4 meters, is cracked, is narrow, and has a broken curb cut that would otherwise allow handicapped persons to enter the sidewalk path of travel. The overall quality of sidewalks in Starkville, MS are fair. Of the 27 areas of sidewalks in the study area, the worst classification of sidewalks occur only 15% of the time and are not common, whereas the best sidewalks occur more often at 40% of the areas. Forty-five percent of the sidewalks fall into a mid-quality rating due to the natural wear and tear either on the concrete or due to the width of the sidewalk. Having a sidewalk that is compliant with the Americans with Disabilities Act is important and without that compliance, it is hard to give that piece of sidewalk infrastructure of Starkville anything more than a mid-quality rating. Fourteen percent of Starkville's sidewalks are not ADA compliant (Figure 8). Three of the seven sections of the branch infrastructure that are classified as 'Poor' or 'Very Poor' are located in areas where 50% or more of the population identify as a race other than white. Of the six mid-quality branches of the sidewalk infrastructure two are located in majority white neighborhoods,, two are located in neighborhoods where the majority of residents identify as something other than white, and two are located in neighborhoods where the road divides a majority

white and a majority minority neighborhood. Of the fifteen highest quality sidewalks, 'Good' or 'Excellent' rating, seven of the branches are located in majority white neighborhoods, one of the branches is located in a neighborhood where the majority of the population identify as being a race other than white, and the last seven branches are located in areas that divide a majority white neighborhood from a majority minority neighborhood.

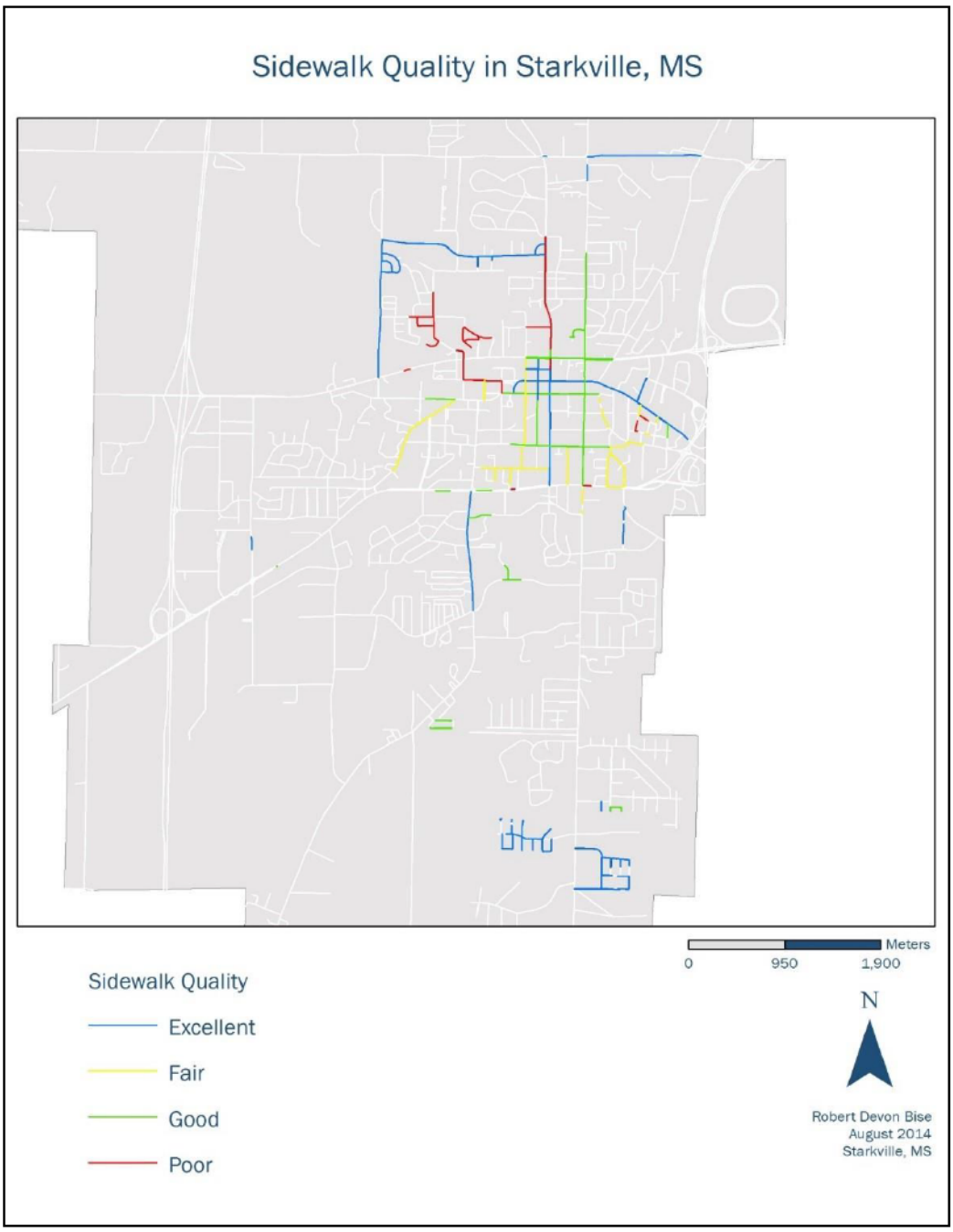

Figure 7 Starkville, MS Sidewalk Quality by Category

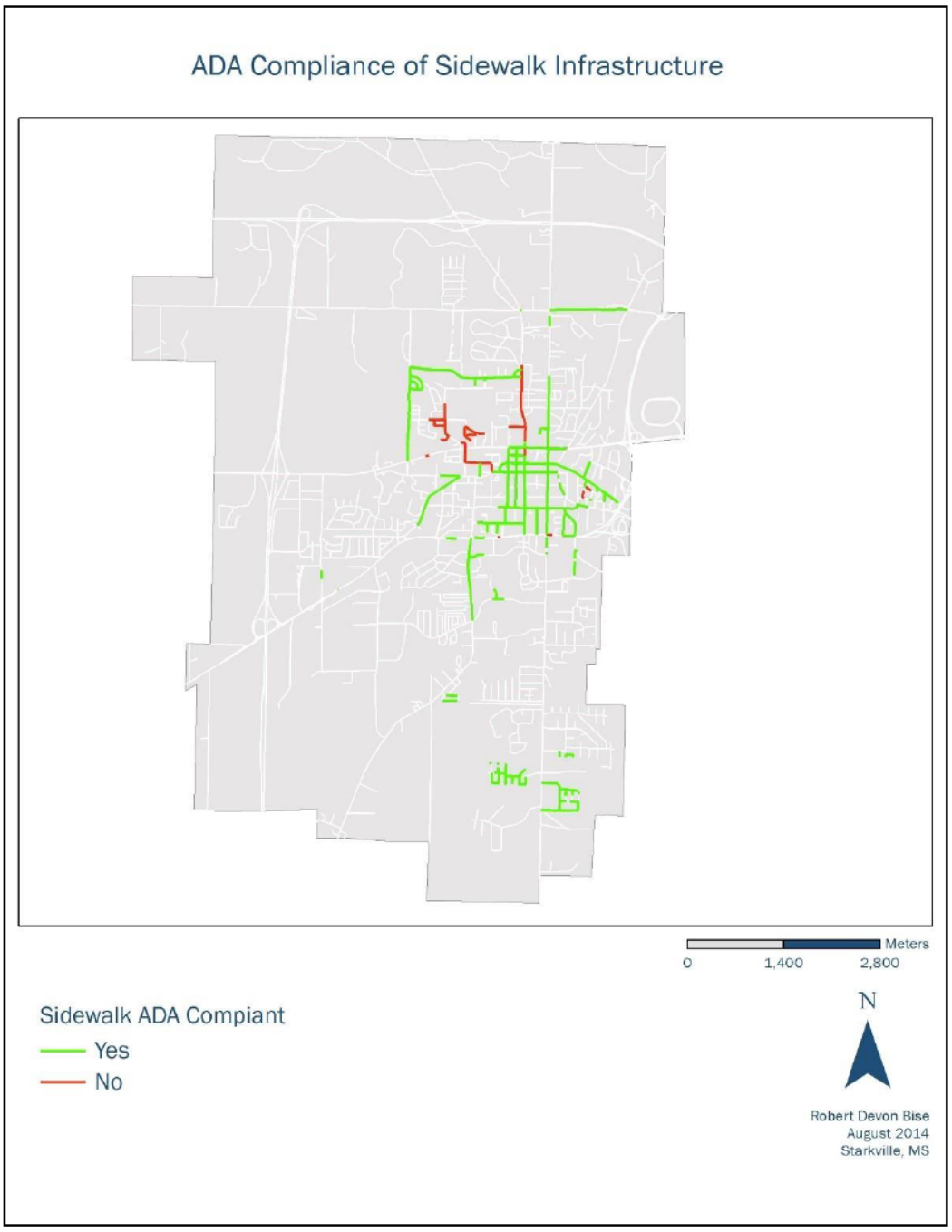

Figure 8 ADA Compliance of Starkville, MS Sidewalks

Accessibility of Sidewalks within Different Societal Groups

Based on the methods for this research, a sidewalk serves a census block if the centroid of the census block polygon is within 161 m (1/10 of a mile) of a sidewalk infrastructure. In Starkville, the total population, based on the 2010 census block data, is 25,697. The population of the census blocks whose centroid is within 161 m (1/10 of a mile) from the sidewalk infrastructure is 7,149 (28% of the total population).

Further breaking down this population by majority vs. minority yields similar results (Table 2). In the census blocks of Starkville, the white population is 14,817. Census blocks within 161 m (1/10 of a mile) of the sidewalk infrastructure have a white population of 4,100. The proportion of the white population served by the sidewalk infrastructure is 28% of the total white population. The minority population for Starkville is 10,880. The minority population within the census blocks that are 161 m (1/10 of a mile) or closer to the sidewalk infrastructure is 3,049 (Figure 9). The proportion of the minority population served is also 28 % of the total minority population. The minority hot-spots in Starkville are located northwest and southwest of the urban center (Figure 10). When considering the population based on the number above and below the age of 18, the results show just over 21% of the population of persons under the age of 18 being served by the sidewalk network in Starkville. The sidewalks in Starkville, MS, serve just under 30% of persons over the age of 18, which is less than the desired 70% specified in this study (Table 2).

Table 2 Percent of Population by Age Served by Sidewalks in Starkville, MS

Population	# Persons Served	Total	Percent Served
Persons Under 18 Years of Age	986	4,682	21.06
Persons Over 18 Years of Age	5,864	19600	30.07
Total	6,850	24,282	28.21

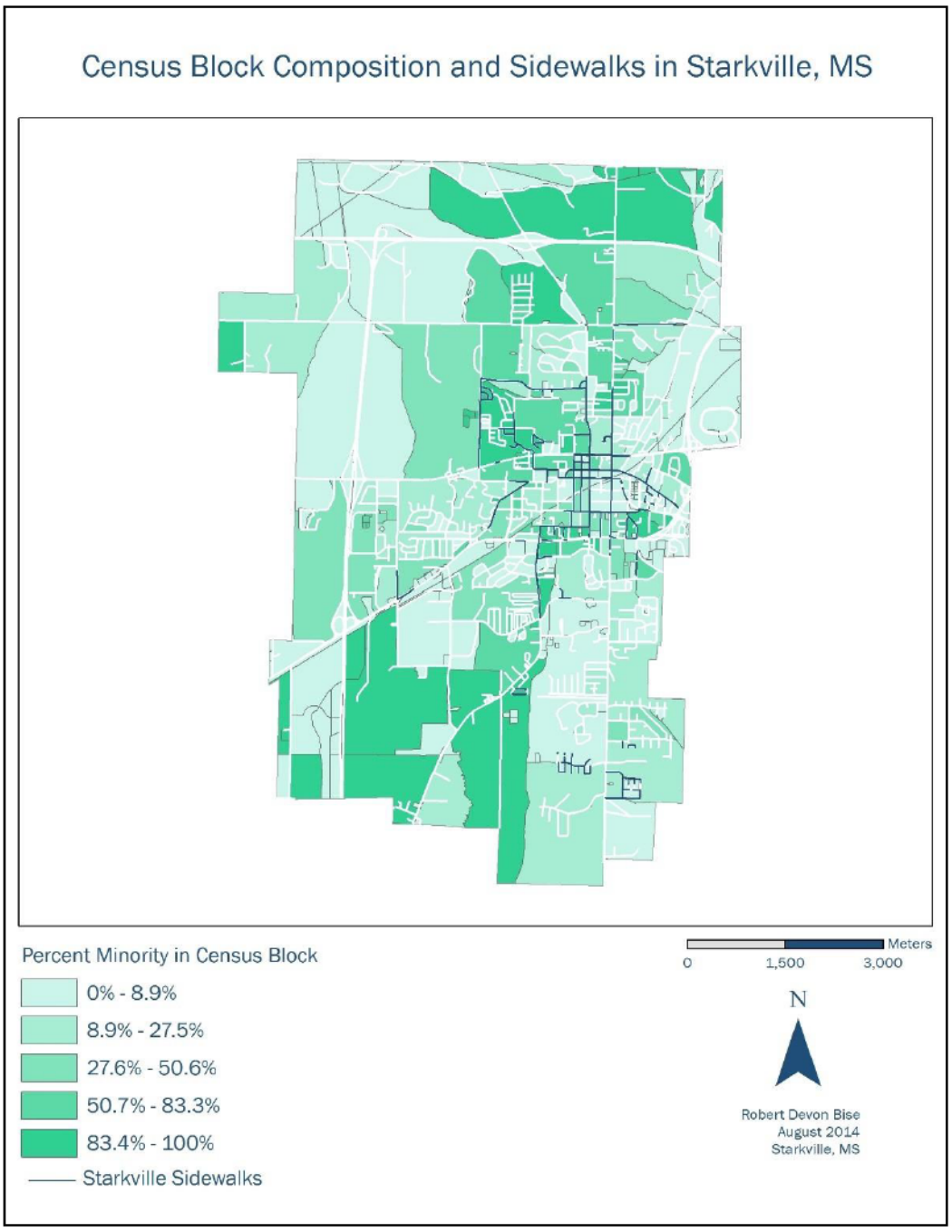

Figure 9 Percent Minority by Census Block and Sidewalks in Starkville, MS

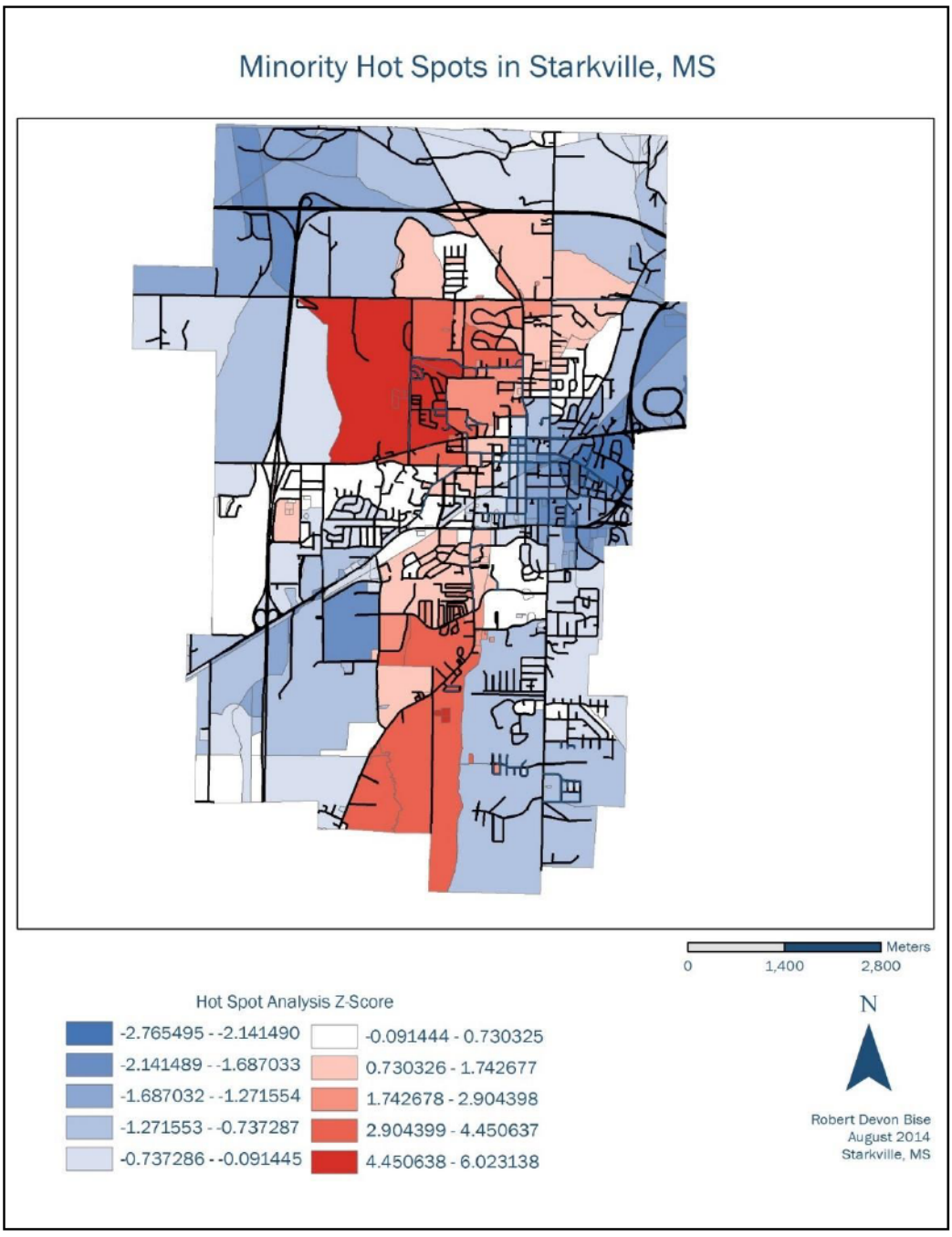

Figure 10 Minority Hot Spots in Starkville, MS

With approximately 28% of the total population, total white population, and total minority populations served, the sidewalk infrastructure does not preferentially serve one

societal group over another. Defined earlier, sidewalk infrastructure is considered to adequately serve a community if 70% of the population is served. With only 28% of the population being within 161 m (1/10 of a mile) of the closest sidewalk, it can be concluded that the sidewalk infrastructure of Starkville, MS does not adequately serve the community.

If the maximum distance a person or attractor had to be from a sidewalk to be considered being served was increased from 161 m (0.10 miles) to 402 m (0.25 miles), how would the proportions of the population and attractors that are served by effected?

The expected result of this would be a higher proportion of both attractors and people would be served compared to the smaller threshold. By increasing the maximum distance threshold to 402 m (0.25 miles), the number of whites served boosts to 53%, the number of minority persons served increases to 56%, and the total population served by the sidewalks in Starkville increases to 55%. Though the proportions increased, they still fall short of the 70% needed to consider the community adequately served. With this increase, the proportion of persons served by age changes. Under the age of 18, 50% of the population are served. Over the age of 18, 56% of the population are served.

Sidewalk Accessibility and Quality

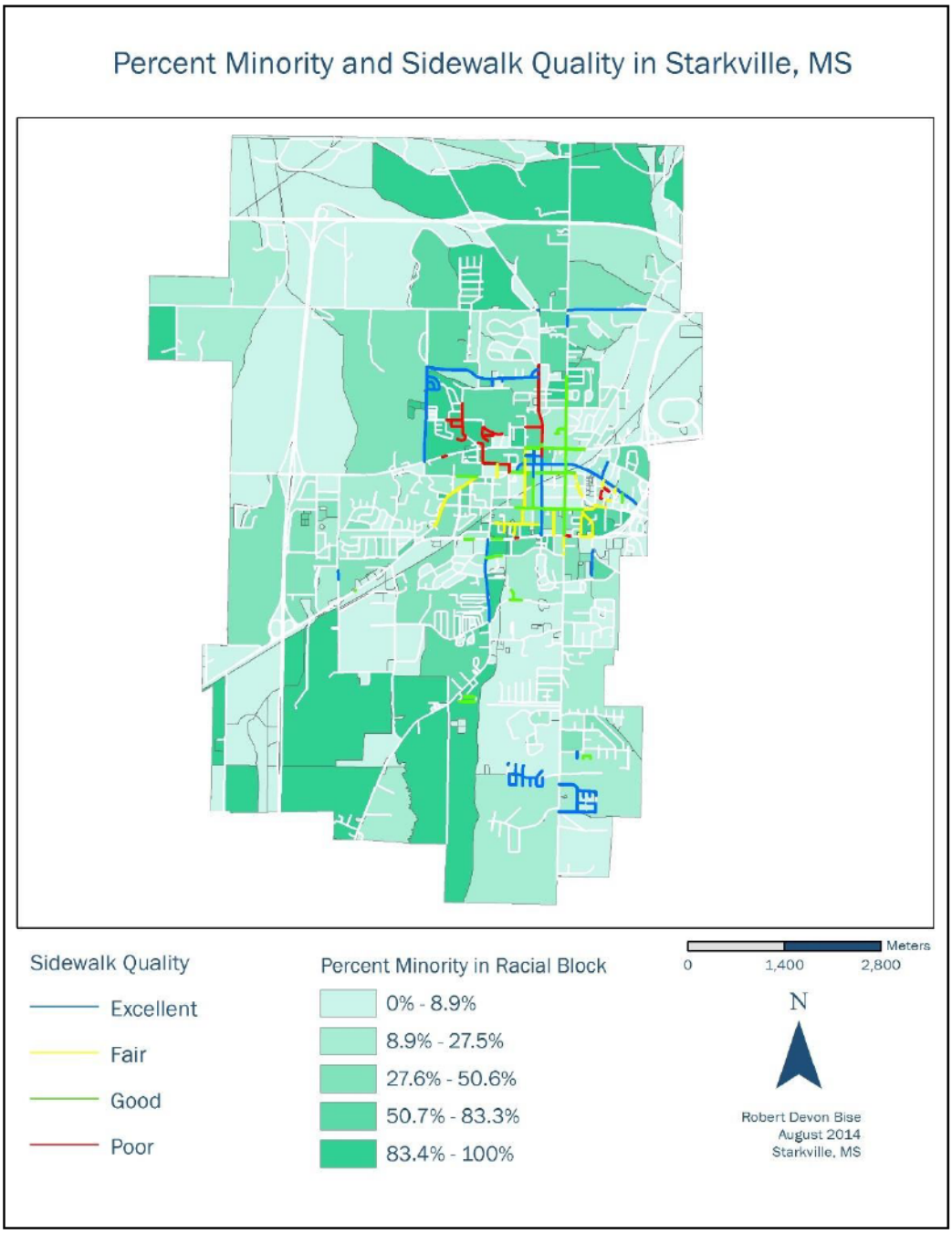

Figure 11 Percent Minority by Census Block and Sidewalk Quality in Starkville, MS

Though both the white and minority populations are served equally by the sidewalk infrastructure, the quality of sidewalks are not equal (Figure 11). Of the non-ADA compliant sidewalks, 48% of them are adjacent to census blocks that have a majority white population compared to 67% of the non-ADA compliant sidewalks that are adjacent to census blocks that are majority minority (Figure 12). Starkville has 67 pieces of sidewalk infrastructure that qualify as being of "Excellent" condition. Thirty-one percent of these sidewalks are adjacent to census blocks that are majority non-white. However, of the 67 sections of the sidewalk infrastructure that are "Excellent," 97% of these are adjacent to majority white census blocks. Predominantly white census blocks have 26% more connectivity than predominantly minority census blocks. White census blocks have 93 pieces of ADA compliant sidewalks while minority census blocks only have 29 ADA compliant pieces of sidewalk network.

Persons under the age of 18 are likely to utilize the sidewalk network to reach destinations such as schools or recreational parks. In Starkville, the sidewalk network coincides with high concentrations of persons under 18 and with lower than expected concentrations of persons under 18 (Figure 13). In central Starkville, there is both a high concentration of persons under 18 in the northern part of the central district and a lower than expected concentration of persons under 18 in the southern part of the central district. These two areas are connected by the sidewalk infrastructure with the central business district of Starkville located in the middle of these two areas. The high concentration of persons under 18 in central Starkville coincides with a high concentration of the minority population.

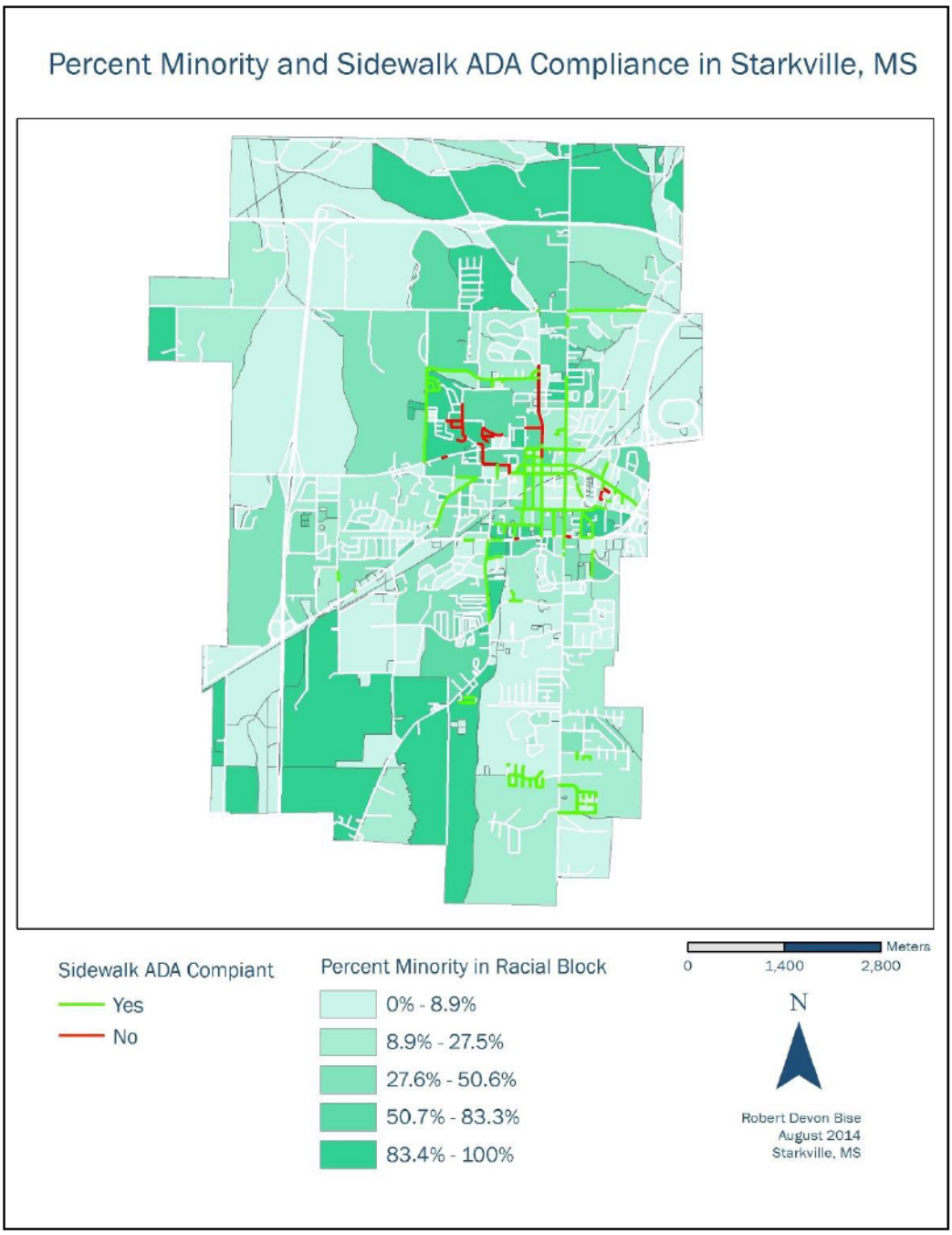

Figure 12 Percent Minority by Census Block and Sidewalk ADA Compliance

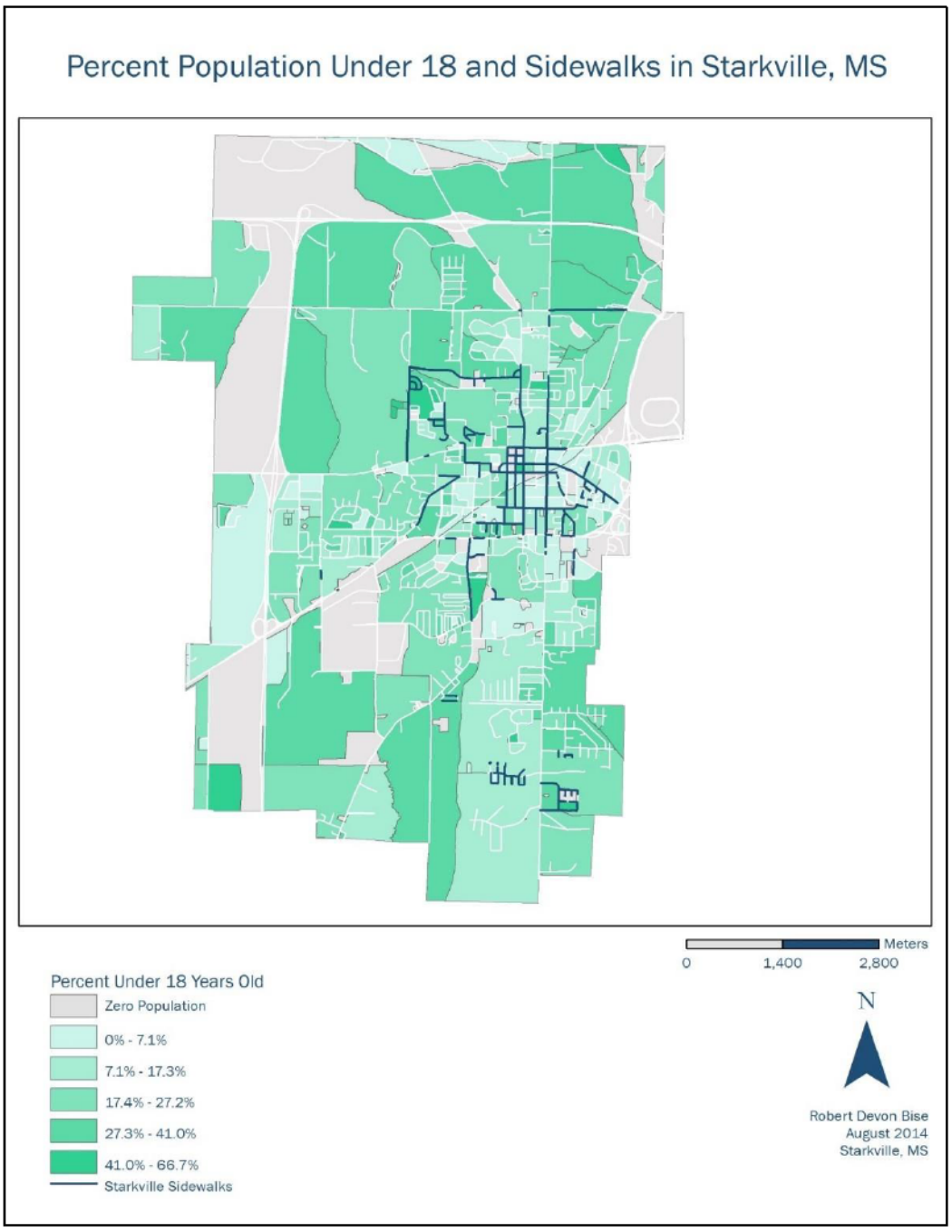

Figure 13 Percent under 18 by Census Block and Sidewalks in Starkville MS

Sidewalks and Attractors

In this study, 296 attractors fit into the various categories of attractors. As a whole, 201 of the 296 attractors (68%) of the attractors, are served by the sidewalk infrastructure of Starkville. Table 3 gives a further breakdown of the attractors served by category.

Table 3 Attractors Served by Category at 0.10 mi. Threshold

Attractor Type	# Served	Total	Percent Served
Farmer's Markets	2	2	100.00
Financial	15	27	55.56
Food	52	67	77.61
Gyms	4	6	66.67
Medical	92	140	65.71
Parks	3	6	50.00
Pharmacies	8	10	80.00
Schools	9	13	69.23
Supermarkets	16	25	64.00
Total	201	296	67.91

If the maximum distance a person or attractor had to be from a sidewalk to be considered being served was increased from 161 m (0.10 miles) to 402 m (0.25 miles), how would the proportions of the population and attractors that are served by effected?

The expected result of this would be a higher proportion of both attractors and people would be served compared to the smaller threshold. By increasing the maximum distance threshold to 402 m (0.25 miles), the number of Whites served boosts to 53%, the number of minority persons served increases to 56%, and the total population served by the sidewalks in Starkville increases to 55%. Though the proportions increased, they still fall short of the 70% needed to consider the community adequately served. With this increase, the proportion of persons served by age changes. Under the age of 18, 50% of the population are served. Over the age of 18, 56% of the population are served.

The proportion of all attractors served by the sidewalks increases to 76% with this increase in the threshold. Table 4 breaks down the proportion served for each attractor with the new threshold.

Table 4 Breakdown of Attractors Served by Type at 0.25 mi. Threshold

Attractor Type	# Served	Total	Percent Served
Farmer's Markets	2	2	100.00
Financial	16	27	59.26
Food	59	67	88.06
Gyms	4	6	66.67
Medical	102	140	72.86
Parks	4	6	66.67
Pharmacies	8	10	80.00
Schools	10	13	76.92
Supermarkets	21	25	84.00
Total	226	296	76.35

As expected, there was an increase in the population and attractor proportions served with an increased threshold. The proportion of the population served increased from 28% to 55% served. The proportion of attractors served increased from 68% to 76% served.

The spatial distribution of sidewalks in relation to attractors is shown in Figure 14. There are two farmer's markets in Starkville and both of these are served by the sidewalk infrastructure. Farmer's markets are geared toward a personal, interactive experience with pedestrians as well as the population who must drive to reach the market.

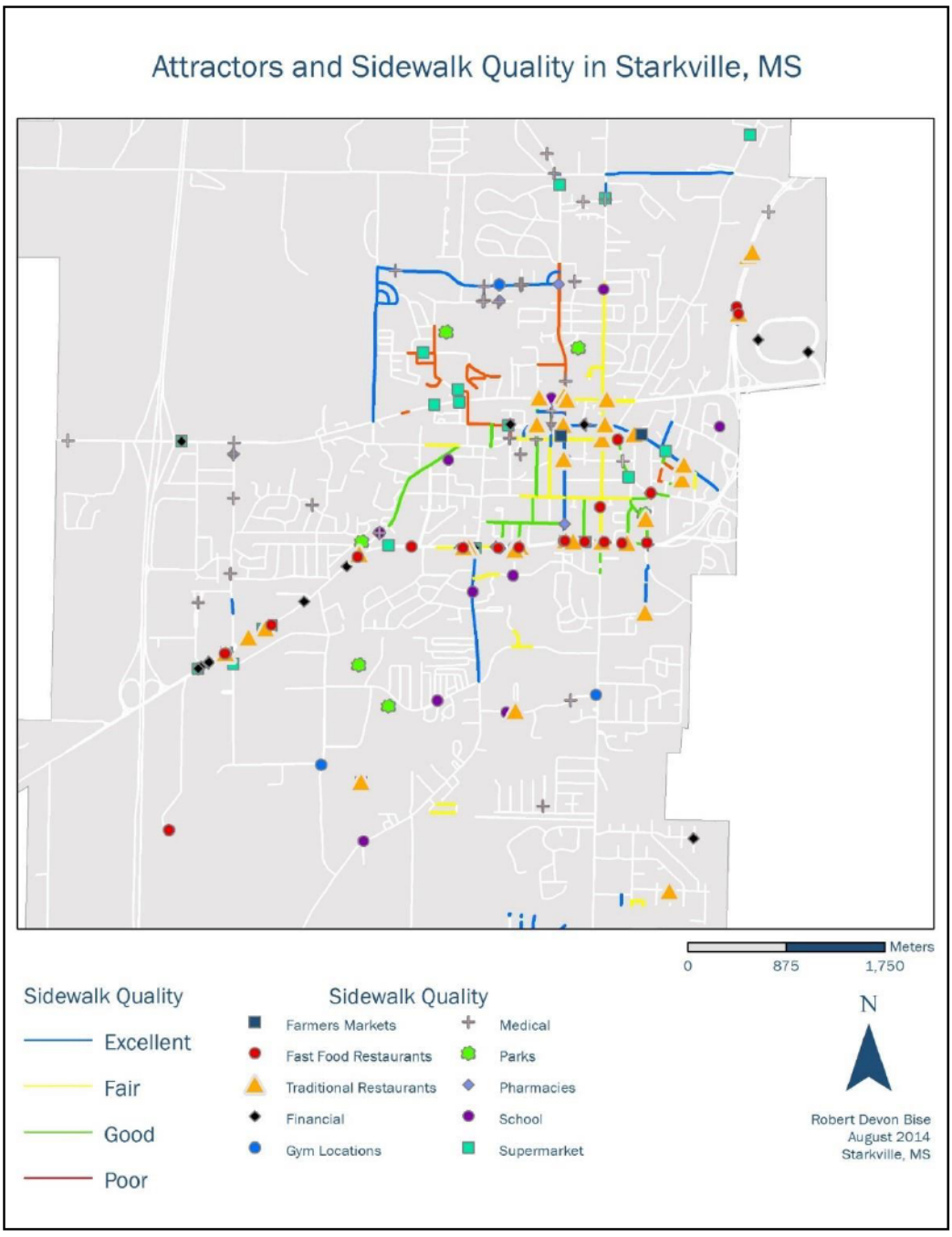

Figure 14 Attractors by Category and Sidewalk Quality in Starkville, MS

Persons under the age of 18 are likely to utilize the sidewalk network to reach destinations such as schools or recreational parks. In Starkville, the sidewalk network

coincides with high concentrations of persons under 18 and with lower than expected concentrations of persons under 18 (Figure 13). In central Starkville, there is both a high concentration of persons under 18 in the northern part of the central district and a lower than expected concentration of persons under 18 in the southern part of the central district. These two areas are connected by the sidewalk infrastructure with the central business district of Starkville located in the middle of these two areas. The high concentration of persons under 18 in central Starkville coincides with a high concentration of the minority population.

The sidewalk infrastructure serves 15 out of 27 of the attractors in the financial category. With over 50% of the financial attractors being located near a sidewalk, banks gain the benefit of opening themselves to foot traffic. Thirty-three percent of Starkville's financial attractors are located in portions of western Starkville where there is no sidewalk infrastructure. Financial amenities are accessible by both pedestrians and vehicles, but pedestrians can access a smaller proportion of the institutions. This disparity could be based on the institutions opting for areas of higher traffic flow, like a highway, compared to areas of steady foot traffic in the central business district, like in eastern central Starkville. The former location is more thoroughly developed with sidewalks than a highway setting.

There are a total of 67 food attractors and out of these, 52 are served by the sidewalk infrastructure. Access to food is a critical component to any community. With approximately 77% of this category's attractors served, the food attractors are considered adequately served by the sidewalk network. A majority of the food attractors are located in downtown Starkville and just off Highway 12, the main highway through Starkville.

In eastern Starkville, the downtown section of the city is well served by sidewalks with fewer sidewalks being located around Highway 12. As the highway extends westward, the sidewalks become fewer and fewer until they are nearly non-existent in the western part of town which is populated with single family homes, apartments, and areas of where population is over 300 persons per census block (Figure 3). The isolation of several food attractors as well as the location of more attractors on the western part of Highway 12 contributes to the last 23% of the attractors not being served. Of the food attractors, 22 food locations are fast food restaurants and 45 locations are traditional restaurants. Sixty-eight percent of the fast food restaurants are within 161 meters (0.10 miles) of the sidewalk infrastructure. Eighty-two percent of traditional restaurants are within the 161 meter distance of the sidewalk infrastructure. Only 18% of fast food restaurants are located somewhere other than a major roadway, such as a highway or interstate. The sidewalk infrastructure in Starkville is not located alongside the major roadways (highways and interstates) in Starkville. This causes the proportion of fast food restaurants served to be low. Of the traditional restaurants, 56% are located somewhere other than a major roadway. Because of this, the proportion served is expectedly higher than the fast food restaurant amenities.

Six gyms are located in the city of Starkville and only four are served. Several of the gyms are located just off the sidewalk network in central and eastern Starkville. Three of the six gyms are located in or around downtown Starkville or eastern Highway 12. These locations have some of the denser sidewalk infrastructure in the city and are well served. The gyms that are not served in Starkville are rather isolated from the main parts of the city or are located somewhere between the upper-class neighborhoods of

Starkville and the center of town. This could be a way to attract customers to stop by for a workout on the way to or from work just by offering a convenient location. The roads that connect the outlying neighborhoods, approximately 4.8 km (three miles) from the urban center, to the center of town do not have sidewalks and therefore do not serve the gyms there.

Medical attractors are a completely different case compared to the other attractors. Medical professionals are located in hospitals, private clinics, or other locations that can house many professionals at one address. This means one address may be associated with many medical professionals, drawing in more individuals who seek medical attention. There are 140 listed medical professionals in Starkville. Out of these, 92 of the medical professionals are housed in an office within the 161 m (1/10 mile) distance of the nearest sidewalk, meaning just over 65% of these offices are served by the sidewalk infrastructure. Many of the professionals in Starkville are located in the eastern central portion of Starkville where sidewalks are more prevalent. Within this portion of Starkville is the hospital that houses many doctors. Hospital Road in Starkville has a sidewalk running the length of the road and has decent connectivity to two other main sidewalks in the area. This allows patients who don't have access to cars to travel a larger distance on safe thoroughfares to reach the hospital for treatment and attention.

Parks benefit communities by offering a venue for physical activity, are linked with decreased rates of anxiety disorders in residents near large green spaces, help reduce the feeling of isolation that may come with living in a city, increases a sense of community, and improves the air quality of the surrounding area through the natural processes of pollution removal (National Recreation and Park Association, 2010). Only

three out of the six parks in Starkville are considered served by the sidewalk infrastructure. This low percentage served is due to the phenomena of more sidewalks being located in central and eastern Starkville. Three out of the six parks are located in this region of Starkville while three of the six parks are located in central or west central Starkville. These parks that are not served are located in older neighborhoods or areas that are mostly apartments or duplexes that have not been recently renovated. Because these neighborhoods have not undergone construction by commercial companies recently, they are not beholden to the sidewalk ordinance of Starkville.

Pharmacies are important to the population because they offer the prescription-based and over-the-counter medicine that many people require. Being able to reach these pharmacies safely encourages the population to interact with the locations. In Starkville, the sidewalks serve eight out of the ten pharmacies. Unfortunately, for one of these pharmacies in western central Starkville, there is no connectivity from their location to other sidewalks. Though technically this location is served, it is not well connected to the rest of the sidewalk infrastructure. For the two pharmacies that are not served, they are located in western Starkville and are located in areas just off main roads where no sidewalks have been constructed.

One of the most important attractors, are the schools. Schools, in general, draw in most of the people under the age of 18. This could be for pre-school, Elementary, Middle, or High schools. It is important that every child have the opportunity to reach their learning institution. According to the Safe Routes to School Program, there is a boundary that extends outward from the school within which children can be expected to walk or bicycle to the school (National Center for Safe Routes to School, 2012). For

Elementary School, this boundary is 0.8 km (0.5 miles). For Middle School, the boundary is (1.6 km) 1.0 mile. For High School, the Boundary is up to 2.4 km (1.5 miles) from the school. Having an adequately safe sidewalk to connect children to schools is important because within these boundaries, it is considered reasonable to expect students to walk or use their bicycle to reach school. In Starkville, there are 13 schools. Nine of the 13 schools are served by the sidewalk infrastructure. The schools that are not served are either in southern central Starkville or are located just off the Mississippi State University campus where the sidewalks from the university end before reaching the school.

The last type of attractor being considered in this study are supermarkets or places like supermarkets such as convenience stores. Access to supermarkets allow people to grab the essentials for cooking, cleaning, over-the-counter medicine, etc. that can help make life easier. Twenty-five supermarkets are present in Starkville, but only 16 of them are served by the sidewalks. Based on the spatial distribution of these attractors, several supermarkets are located in the western central part of Starkville, just off Highway 12. These supermarkets are not served by the sidewalk infrastructure. A couple of the supermarkets are served by a piece of sidewalk that does not connect to any other sidewalks. Technically, they are served, but the connectivity is practically non-existent.

Relationship between Distance to Sidewalks and Population Characteristics and Distance to Urban Center

When exploring the relationship between the distance from sidewalks to the centroid of census blocks, the independent variable of interest including the population of Whites in each census block, the population of minorities in each census block, the

number of attractors in each census block and the distance from the urban center. The results of the Ordinary Least Squares analysis (Table 5) show a positive relationship between the distance to the sidewalk and the population of minorities in each census block and the distance from the urban center. This means that as the distance from the sidewalk becomes shorter, the minority population total and the distance from the urban center decreases, as well. The population and attractors may not be the biggest influence on the sidewalks in Starkville. The zone (residential, commercial, etc.) may be the biggest predictor of sidewalks. The large magnitude of the Mean Squared Error (MSE) indicates a poor model fit.

Table 5 Relationship between Distance to Sidewalks and Environmental Variables

Variable	Coefficient	Probability
Intercept	-349.792007	0.000000
Population of Persons Under 18 Years Old	-6.718652	0.017292
Population of Whites in Census Block	-0.474696	0.345983
Population of Minorities in Census Block	1.155802	0.246419
Number of Attractors in Census Block	-13.099042	0.220686
Distance from Urban Center	0.441666	0.000000
Multiple R-Squared	0.641096	
Adjusted R-Squared	0.638604	
Mean Squared Error	331628.8	

The Adjusted R^2 statistic of 0.63 indicates that the model explains approximately 63% of the variability in the data. This model indicates that at least part of the sidewalk locations can be predicted using anthropogenic characteristics as well as the locations of attractors.

CHAPTER V

DISCUSSION

Starkville, MS Sidewalk Network

With only 28% of Starkville's population being within 161 m of the closest sidewalk network, the Starkville sidewalk does not seem to adequately serve the community as a whole as well as it probably could. The results of this thesis corroborate the "Walk Score" that generated a value for Starkville of 26% (Table 1). Collectively, the results of this thesis and the Walk Score suggest that even for mid-sized Mississippi cities, Starkville has a lower proportion of sidewalks to roads. Further, with less than 1/3 of the population within this distance of the sidewalk network, the lack of connectivity further reduces the effectiveness of the sidewalks. The most heavily developed sidewalk infrastructure in Starkville is in the eastern portion of the city, nearest Mississippi State University. Even here, the sidewalk connectivity is 52% on average, meaning that just over half of the possible avenues for connectivity have sidewalk infrastructure that connect.

Based on criteria of Walk Score, Starkville would be classified as "Car-Dependent". This designation has societal and environmental implications. First, the lower connectivity between residential and commercial areas and the low degree of connectivity suggests that the communal benefits of sidewalks (Collins and Frantz, 1999, Lopez and Hynes, 2006) are not being as met as well as they could be. Although there is

a recently developed public transportation network (e.g. Starkville MSU Area Rapid Transit), walking helps reduce obesity, encourages social interaction and lowers the probability of crime (Lopez and Hynes, 2006). Thus even though residents have increased public opportunities to travel within the city, the car-dependency status may still be restricting the societal benefits of sidewalks. Environmentally, the dependency of fossil fuels for transportation, including public transit systems, conceptually increases carbon emissions and potentially elevates particulates in the city. Increasing the number of sidewalks in Starkville would help to create an environment that promotes physical activity as reported in Lopez & Hynes (2006). Having the existing paths of travel encourages the population to participate in physical activity by providing safe routes for exercise and travel.

Sidewalk Accessibility

As previously stated, most of the sidewalks in Starkville were established post-WWII, and this predates the ADA by nearly 50 years. The city has made significant strides to comply with ADA. The results of this analysis suggest that many of the ADA segments are more proximal to commercial districts, as evidenced by the high number of attractors served, and they are notably not as abundant within majority minority residential census blocks. Eventually with new development, the Starkville Ordinance will result in a more complete ADA sidewalk coverage for all residents. This is the intended goal of the ordinance.

During the 1940's and early 1950's when much of the sidewalk network was being established, Starkville was a segregated city. Some of the disparity between the abundance of high quality and ADA compliant sidewalks within census blocks that were

majority minority were likely a result of this legacy. Minority Hot Spots in Starkville, especially in the southern area off Louisville Street and east/northeast of the central business district had fewer 'Excellent' sidewalks, less ADA sidewalks, less connectivity, and lower density of sidewalks. An explanation for the pattern might be that these are residential areas. Most of the 'Excellent', ADA compliant, connecting, and denser sidewalks are likely associated with the commercial districts. These are the locations that would be the most likely to be under the jurisdiction of the sidewalk ordinance. Thus it is expected that the better sidewalks would be within these areas. Nevertheless, there have been much improvements in the Starkville sidewalk network over time, but the results during the time of the thesis suggest that the sidewalk infrastructure in many ways still reflects the social history of the community.

Sidewalks and Zoning

One clear pattern that evolved from this study is that the sidewalk network, its quality, and its ADA compliance are disproportional among zoning types. From this research it appears that most of the attractors in the city were adequately served by sidewalks. Many of these are located in the commercial and financial districts. Residential neighborhoods, however, were not as adequately served and did not generally connect well to the commercial sidewalk networks. Thus it appears that a major driving variable to explain sidewalk distribution is land use or zone type. This is perhaps one of the reasons to explain the sub-par performance of the OLS model. In addition to the demographics, the analysis may have been improved by incorporating zone type as a principle variable.

Suggestions for Future Sidewalk Development

The sidewalk infrastructure of Starkville should continue to be developed and updated. Having a functional, well-connected sidewalk infrastructure will allow pedestrians to traverse Starkville safely to reach whatever destination they wish. Once Starkville has the sidewalk infrastructure in place, upkeep is imperative to prevent sidewalks from cracking and becoming impassable by those who are wheelchair bound or have limited physical abilities.

A good starting point for the development of Starkville's sidewalk infrastructure would be trying to address the disparity in good quality sidewalks between minority and white neighborhoods. Furthering the infrastructure's reach from downtown Starkville to the western and outer boundaries of the city would boost connectivity and provide more of Starkville's residents with access to sidewalks. For example, south Louisville Street has a high minority population and indicated by the Hot Spot Analysis, but this location has no suitable sidewalk network to connect with commercial or other residential areas.

Site-specific development could be a way to enhance connectivity between Mississippi State University and Starkville. One large population attractor is Mississippi State University's athletic events. By providing safe avenues of travel to students, alumni, fans, visitors, and locals, traffic congestion could be reduced and foot traffic flow could be made safer. The enhancement of Starkville's sidewalk infrastructure would be a way to set the city apart from the rest of the state by becoming a model of connectivity and harmony between the vehicular and pedestrian modes of transportation.

Increasing the proportion of attractors that are served by the sidewalk network is an important step in connecting pedestrians to amenities. Developing the sidewalk

network alongside attractors and residential neighborhoods alike will increase the proportion of both amenities and populations served by the infrastructure.

Nodes for connectivity could be centered on transit stops in Starkville. By providing pedestrians the ability to utilize either the sidewalk infrastructure or the bus system would provide pedestrians with an easy way to travel longer distances and pick up their trip on another safe path of travel.

Limitations of Study

This study's limitations came mainly in the data. The United States Census Bureau's population data for Starkville, MS in 2010 is the basis for this project's reliability. Any sort of error in the census data can skew the study's numbers leading to errors. The timeline of the study was another limitation. Data in the study are as recent as late March 2014. Starkville is a city that is continuing to update and add onto the sidewalk infrastructure meaning that as this study was written, it is possible that more sidewalks have been constructed in the area. All data were calculated and recorded in late March 2014. The census data, sidewalk data, and amenities came together to provide a very interesting look at the city of Starkville, MS and gave a unique insight to the sidewalk infrastructure.

Additional study limitations come from the parameters for the study. By changing the distance threshold of the maximum distance a person or attractor can be from a sidewalk, the results can change. By increasing the maximum distance, more of the population and more attractors would be considered served. Conversely, decreasing the distance from which a person or attractor can be from a sidewalk to be considered served would decrease the number served by the sidewalk infrastructure. The two

distances used for the maximum distance threshold (161 m and 402 m) yielded similar results ultimately leading to the conclusion that the sidewalk infrastructure did not adequately serve the city of Starkville, MS.

CHAPTER VI

CONCLUSIONS

The goal of this study was to evaluate the sidewalk infrastructure in Starkville, MS and to use geospatial techniques to map the sidewalks and pedestrian attractors within the city. In this evaluation, it would be determined whether or not the sidewalk infrastructure of Starkville adequately served the population of Starkville, whether the sidewalk infrastructure served a certain race over another, and whether the sidewalk infrastructure served one age group over another. This research was done to fill a gap in the existing literature on how geospatial techniques can be used to determine how well sidewalks serve the communities in which they are located and how geospatial techniques can be used to show where sidewalks are needed within the communities. The main questions asked in this study are:

1. Does the sidewalk infrastructure of Starkville, MS adequately serve the community by being accessible by 70% or more of the resident population?
2. Does the sidewalk infrastructure serve one racial group over another?
3. Does the sidewalk infrastructure serve the population of persons under the age of 18 adequately?

Does the Sidewalk Infrastructure Adequately Serve the Community? All Races? Minors?

Starkville's sidewalk infrastructure is within 161 meters (0.10 miles) of 27.82% of the city's residents. The threshold for an "adequately" served population was set at 70% indicating that Starkville's population is not served adequately. When breaking the population down into minority and white populations, only 27.67% of the total white population is served the infrastructure. Comparably, 28.02% of the minority population is served by the infrastructure indicating that both races are equally served. When considering the population of persons who are under the age of 18, only 21.06% are served by the infrastructure. The number of people served by the sidewalk infrastructure leaves much to be desired. The proportions served are far below the 70% threshold leaving much room for improvement in the infrastructure.

When expanding the distance threshold to 402 meters (0.25 miles), 55% of the city's population would be considered served by the sidewalk infrastructure. The number of whites served by the sidewalks increases to 53% while the number of minority persons served increases to 56%. Fifty percent of the population of persons under 18 are served when the distance threshold is expanded. Over the age of 18, 56% of the population are served. The increase in the populations served still falls short of the 70% threshold, which is based on the Walk Score® threshold for a pedestrian friendly city.

Impacts of the Study

This study shows the lack of infrastructure in Starkville, MS. This research and its methods may be used for further development of the sidewalks in Starkville and analysis of potential infrastructure placement in the future. The sidewalk ordinance in

Starkville is a good start in bolstering the sidewalk infrastructure, but the connectivity of pieces of sidewalks will also need to be addressed. Without adequate connectivity, sidewalks cannot reach their full potential in aiding the pedestrian community. Theoretically, this study has contributed an empirical evaluation method for sidewalk infrastructure, which can be a valuable tool in the development and building of sidewalks.

Recommendations for Future Research

The tailoring of these methods for evaluation should be on a case-by-case basis. In the future, different thresholds may be used to determine the adequate number of the population served by the sidewalks. This could be tied to the amount of urban sprawl, rurality of an area, average income of an area, etc. Every city is different and the addition of variables into the determination of a threshold can evolve these methods of evaluation.

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APPENDIX A

SIDEWALK SURVEY TABLE

Table 6 Sidewalk Survey Table

Area	Overall Connectivity	Road Cuts	Sidewalk Quality
Turnberry Lane Development	Poor	Yes	Excellent
Huntington Drive	Poor	Yes	Excellent
Laurel Hill	Poor	Yes	Excellent
Southern Louisville near Azalea	Poor	Sporadic	Good
Louisville Near Academy	Fair	Yes	Excellent
Lynn Lane East of Louisville	Poor	Yes	Good
Yellow Jacket and Louisville	Good	Yes	Good
Lincoln Green	Poor	Yes	Excellent
Spring Street and Hwy 12	Excellent	Yes	Fair
Russell and East Gillespie	Excellent	Yes	Fair
S. Montgomery from Gillespie to Mae	Excellent	Sporadic	Fair
Gillespie	Excellent	Yes	Good
Vine Street	Good	Yes	Fair
Pecan Acres	Fair	Sporadic	Fair

Table 6 (Continued)

Whitfield St.	Good	Sporadic	Fair
W. Main St. and Long	Good	Sporadic	Poor
Reed	E	Yes	Excellent
Peoples/Sadye Weir	G	Yes	Excellent
Hospital Rd.	E	Yes	Excellent
Long St.	P	Sporadic	Poor
Hilliard	P	Sporadic	Poor
Downtown	E	Yes	Excellent
Jackson St. North of MLK Blvd.	E	Sporadic	Very Poor
Martin Luther King Jr. Blvd.	E	Yes	Good
Garrard St.	P	Yes	Excellent
Garrard and Hwy 389	P	Yes	Very Poor
Stark Rd.	P	No	Very Poor
Hwy 12 and Stark Rd.	p	No	Very Poor

APPENDIX B

SIDEWALK CONNECTIVITY SURVEY

Table 7 Sidewalk Connectivity Survey

Sidewalk Location	Percent Connectivity	Percent of Road Covering Sidewalk
Highway 12	75%	4%
Lynn Ln.	100%	6%
Laurel Hill Dr.	50%	6%
Stark Rd.	0%	7%
Parking Lot	100%	8%
Greensboro St.	100%	17%
Lumus St.	0%	17%
Yellow Jacket Dr.	67%	20%
Louisville St.	7%	20%
Strange Rd.	100%	21%
Maxwell St.	100%	21%
Reed Rd.	57%	21%
Russell St.	14%	26%
Westside St.	40%	30%

Table 7 (Continued)

N. Montgomery St.	37%	36%
Garrard Rd.	0%	37%
Pecan Acres	44%	37%
Pinehurst Rd.	100%	45%
Cushman St.	25%	46%
Huntington Dr.	100%	46%
Cypress Point Rd.	50%	47%
Hancock St.	40%	50%
Curry St.	50%	51%
Colonel Muldrow St.	50%	52%
Henderson St.	67%	52%
Pebble Beach Rd.	100%	53%
Lincoln Green	0%	55%
Lafayette St.	73%	58%
Vine St.	50%	58%

Table 7 (Continued)

Nash St.	44%	60%
Whitfield St.	8%	62%
Kingwood	100%	63%
Brandon Rd.	100%	65%
Lampkin St.	63%	66%
Long St.	29%	66%
Gillespie St.	59%	67%
Spring St.	57%	72%
Hospital Rd.	50%	73%
Washington St.	71%	75%
Pilcher St.	100%	82%
University/Main St.	57%	87%
Jackson St.	54%	91%
Wood St.	50%	91%
Peoples St.	100%	100%

Table 7 (Continued)

Sadye Weir St.	100%	100%
Alfred Perkins St	50%	100%
Hiliard St.	67%	100%
Raymond St.	60%	100%
Dover Ct.	40%	100%
Kenswick Ct.	100%	100%
Chelsea Way	100%	100%
Kingston St.	50%	100%
Autumn Woods	100%	100%
Lake Pointe Ln.	67%	100%
Turnberry Ln.	40%	100%
Oakmont Rd.	71%	100%
Sawgrass Rd.	80%	100%
Laurel West Cove	0%	100%
Laurel East Cove	50%	100%

Table 7 (Continued)

Jefferson St.	100%	100%
Average Percentage	58%	34%