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Park Accessibility in Atlanta

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PARK ACCESSIBILITY IN ATLANTA

by

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ABSTRACT

Urban green spaces, such as parks, provide urban residents with a multitude of environmental benefits and city residents should all have access to these benefits. This study examined the socioeconomic status of urban residents who live within one-mile distance to a public park in the city of Atlanta. Park accessibility was investigated with respect to distances to parks and park acreage using Euclidean distance and street-network distance. Socioeconomic status was examined using five variables: population density, median household income, percentage of population living below poverty, percentage of minority population and percentage of female population. A site suitability analysis was conducted to determine where additional park space could be most beneficial for the populations lacking access to the benefits of park space. Using Geographic Information Systems to analyze socioeconomic data from U.S. Census Bureau vis-à-vis Atlanta parks, this study discovered there is no statistically significant socioeconomic disparity among residents who currently have or do not have park access in Atlanta. The findings of this study showed some weak relationships of park distance and park size with population density and minority populations. The site suitability study suggested two sites that could be potentially used for future park development.

INDEX WORDS: Accessibility, Green space, GIS, Environmental justice

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DEDICATION

I dedicate this work to my parents for providing me with the education, opportunities and experiences that led me to explore this field and find my passions. I also dedicate this work to my fiancé, my Ann St. friends and again my parents who have spent hours listening, brainstorming and strategizing during these past two years allowing me to complete such an in depth and lengthy process.

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I would like to recognize all of the support, encouragement and guidance my committee members and classmates showed me during the many stages of this project and thank them immensely. The writing, editing, GIS and data collection assistance I received from them have made the completion of my degree possible.

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1 INTRODUCTION

Urban green spaces, such as parks, provide urban residents with a multitude of physical, emotional and societal benefits (Azwar & Ghani, 2009; Chiesura, 2004; Verheij, Maas, & Groenewegen, 2008). City residents should all have access to these benefits. This study examined the socioeconomic status of urban residents who live within walking distance to a public park in the city of Atlanta. Using GIS to analyze socioeconomic data from U.S. Census Bureau vis-à-vis Atlanta parks, this study explored whether there is a race or class-based disparity between residents who do or do not have access to parks in Atlanta. This study also conducted a site selection/suitability analysis to determine where additional park space could be most beneficial for the populations lacking access to the socio-environmental benefits of park space. This research may help to understand the environmental justice with regard to park accessibility.

2 LITERATURE REVIEW

2. 1 Green space

The majority of today's population lives in urban environments; planned, built and constructed by modern citizens. These settlements differ greatly from previous rural residential settings. The most important difference is the lack of a natural environment in urban places. Human beings have a biological need and connection with nature (Verheij et al., 2008). Urban green spaces, like public parks, have been incorporated into cities to fulfill this connection and create a higher quality of life for urban residents (Barbosa et al., 2007; Chiesura, 2004; Howard, 1898; Jim, 2004; Olmsted, 1996; Verheij et al., 2008; Wheeler, 1996; Whyte, 1998).

Definitions

Urban green spaces have been defined as environments ranging in scale, quality, size and attributes. Handley, Pauleit and Gill clarify the term "urban green space" as an umbrella term for any and all areas of lands that are mostly permeable, natural surfaces like trees, plants, grass and soil (Handley, Pauleit, & Gill, 2007). Baycan and his colleagues claim urban green spaces are "public and private open spaces in urban areas, primarily covered by vegetation, which are directly or indirectly available for users" (Baycan-Levent et al., 2002). The presence of green space in urban environments can come in the form of front/back personal yards, community gardens, greenfields, parks and urban forests (Barbosa et al., 2007; Bradley, 1995; Chicago Park District, 2009; Chiesura, 2004; Dorsey J. W, 2003; Olmsted, 1996). Urban forests can be considered as any urbanized place with vegetation, primarily as residential areas with trees as the dominant natural or common resource ("The Georgia Model Urban Forest Book," 2001). Trees first and foremost, have been used in urban environments for landscape purposes (Bradley, 1995). Community gardens are also components of green spaces, which are used by local residents to plant and cultivate vegetation for nutritional purposes. These gardens can develop a sense of community and empowerment, increase food security and provide a setting for urban citizens to experience urban green space (Blair-Lewis et al., 2005; Chicago Park District, 2009; Swanson, 2005). The examination and discussion of urban green space, for the purpose of this paper, will be referring to and focusing primarily on publically owned parks, these being city owned pieces of open space property that have a visible presence of vegetation and minimal built infrastructure.

2.2 Benefits of urban green space

Benefits on City Scale

Scholars have examined the positive effects of urban green space. The establishment and overall presence of green space fights against environmental and climatic derogation highly developed and congested settings can cause (Bullard, G. S. Johnson, & Torres, 2000; Giles-Corti et al., 2005; Wheeler, 1996). Urban parks create a safe and open public venue for community and relationship building among city residents (Balram & Dragicevic, 2005; Barbosa et al., 2007; Brett, 2009; Duany & Plater-Zyberk, 1998; Hankins & Powers, 2009). Natural environments have been proven to help urban society by fighting problems of crime, poverty, and poor health (Wolch, Wilson, & Fehrenbach, 2005). Urban economies benefit from increases in property values and investment attraction, which both result from green space (Anderson & West, 2006; Barrette, 2001; Harnik & Welle, 2009; Tajima, 2003).

Benefits on Individual Scale

The presence of open green space can provide psychological benefits for individuals. The absence of high density built environment combined with green vegetation, allows people to feel relaxed, calm, and healthy (Azwar & Ghani, 2009; Barbosa et al., 2007; Chiesura, 2004; Milgram, 1970; Verheij et al., 2008). Urban park visitors who participate in active pastimes (such as walking, jogging, biking, skating and team sports) gain personal health benefits from their physical activities (Chiesura, 2004). Even the view of a natural setting can provide physical benefits to an observer, such as hospital patients after surgery. In a study of forty-six cholecystectomy (removal of the gallbladder) patients, Ulrich found the twenty-three with window views of nature, as opposed to brick buildings, had a shorter and better recovery period

(Ulrich, 1984). Parks can provide economic benefits for individuals as well. In a study exploring the benefits of park space, Harnik and Welle quantified the economic value of park use activities (Harnik & Welle, 2009). Daily uses that were examined included $3.50 for playing on a playground and $4.00 for jogging, walking or skating. People who engage in these activities at a public park save money every time, as opposed to their alternative of paying to use a recreation facility (Harnik & Welle, 2009). Property values increase as the proximity to parks increases, providing residents a greater return on their property when/if they sell it (Anderson & West, 2006). Heynen has proven a positive correlation between income level and urban canopy cover, illustrating poor areas in the city have less canopy cover (Heynen, 2006).

2.3 Costs of urban green space

Availability of Land

Creating urban parks require time, money, planning, available land and local government attention, all of which can be fairly costly (Pincetl, 2003). Available land in urban environments can sometimes be difficult to locate. In these cases, cities have looked to redevelop neglected areas and remediate former industrial sites (also known as brownfields) into open green space (Bullard et al., 2000; De Sousa, 2003; Verheij et al., 2008; Wolch et al., 2005). The thesis of a Georgia Tech graduate student, titled "Beltline – Atlanta", describes one way to reestablish green space in the city. The Atlanta Beltline project, a twenty-five year plan for rails, trails and parks around Atlanta, illustrates the opportunity abandoned lots of land and rail can offer for a growing urban population (Gravel, 1999). This project will redevelop twenty-two miles of old railway lines into a new railway, create thirty-three miles of trails and 1,300 acres of parks and requires a great deal of land purchasing and transit planning and developing (Atlanta Beltline Inc., 2010).

Privately owned land donated to the city has also been an avenue for creating new parks in heavily developed cities. Lemuel P. Grant donated 100 acres of his land to the City of Atlanta, creating the Grant park that still exists today (Feldman, 2005; Jim, 2004).

Park Maintenance

Park maintenance is another cost of urban green space. The upkeep of overall conditions and features of a park can affect his or her use of the space. The presence of certain park amenities may facilitate some activities more than others, like picnic tables for passive use and walking paths for active use (Giles-Corti et al., 2005). Various groups of people perceive and experience park space differently, which makes it difficult to create a park that is inviting to all populations. Recent refugees or immigrants may have too many physical and psychological barriers to overcome before they can feel comfortable enjoying park space (Comber, Brunsdon, & Green, 2008). A previous study identified a variety of variables, including: quality, size, characteristics of users, personal preferences, surrounding local facilities, park maintenance and perceived safety that can affect the use of a public space (Giles-Corti et al., 2005). Whyte's "Street Life Project" examined the characteristics of "good green space", which are popular and highly visited parks (Whyte, 1998). He claimed the presence of women in a park would signify the park's safety level, if there were no women the park it was likely they feel uncomfortable or threatened in the public space. Unmaintained parks become useless or forgotten green spaces, which severely decreases their potential environmental benefits. Continuous park maintenance is important for the longevity of urban green space.

2.4 Accessibility

City residents are surrounded by high density population and development, which limits the areas of undeveloped or open land. Urban parks are possible where there is available open land, land to redevelop, or private property donations. The possibility of a public park location is determined by the availability of land. Urban residents who live by available or open land have easier access to the environmental benefits a park can bring, than citizens living farther away from the open space. Nicholls defines accessibility as, "the ease with which a site of service can be reached or obtained" (Nicholls, 2001). If a citizen can reach the site of environmental benefits with great ease, then they are considered to have good access; if the opposite is true the citizen will have bad access. In some cities it has been found that certain groups of residents (minorities, low socioeconomic groups, youth, elderly, etc.) have less access to urban parks than others (Babey et al.. 2008; Boone et al., 2009; Wolch et al., 2005). Some cities, in particular Baltimore, Maryland, may provide minorities with access to parks yet neglect to examine how much space is actually provided (Boone et al., 2009). Heynen argues there is less park space available in low-income neighborhoods in comparison to higher-income areas (Heynen, 2006). However, another study on Washington D.C.'s public parks and recreation facilities shows no correlation between access to recreation facilities and low-income and high-minority groups, illustrating there can be equal park access among urban residents (Abercrombie et al., 2008). Park accessibility in Atlanta has not yet been studied or explored within academic literature or by geographers.

Environmental Justice

Urban public parks provide a multitude of advantages for users including physical, social and psychological benefits (Chiesura, 2004). Environmental justice discourse examines the distribution of these benefits (and possible costs) within a society and identifies any presence of uneven distribution. Environmental justice integrates social, economical, and spatial concerns among populations. The historical development of environmental justice began with the siting of a landfill in Warren County, North Carolina; in which people started to recognize the discriminatory methods of locating hazardous waste facilities in poverty-stricken and poorly represented communities (Kurtz, 2005). Environmental justice discourse has mostly focused on the distribution of environmental costs (for example the effects of close proximity of populations to polluting facilities) rather than on the benefits for the past several decades (Boone et al., 2009). An increasing number of scholars are beginning to investigate the distribution of environmental benefits among urban residents (Abercrombie et al. 2008; Boone et al., 2009; Cutts et al., 2009; Heynen, 2006; Runfola & Hankins, 2009; Wolch et al., 2005)

Evaluating the presence of justice can play an important role concerning public resources, like parks. There are different conceptualizations of justice that have been identified and examined by scholars, such as distributional and procedural justice (Lake, 1996; Young, 1990). Procedural justice involves a deep discussion and understanding of structural and systematic phenomena. While distributive justice can be more related to a surface allocation of costs and benefits already created elsewhere. A population could obtain distributive justice by being granted access to resources and services that are already available to other populations. This study will seek to use a distributional view of justice when evaluating the equity of public park accessibility.

History of Atlanta's Public Parks

The history of public parks in Atlanta follows the same history as any other public space and service in Atlanta. It began with the creation and growth of a southern rail settlement into a large metropolitan area, complete with an established working government. Residents began to desire public services and resources from the government, like infrastructure for transit and recreation. Several parks were created in the late 1880s from private land donations, as well as the city buying up land lots. Over the next century land donation and land purchasing created many parks of various sizes, uses and placements (Kruse, 2005).

The 1960s brought change to Atlanta. The former mayor of 23 years, Mayor Hartsfield was replaced and the rise in the Civil Rights moment began, demanding equality for African Americans. The movement brought the fight for equality to the public realm. African Americans began to argue for equal access to the goods and services provided by the government, including public spaces like parks and recreational facilities (Keating, 2001).

Prior to the 1960s public parks had always been classified by race. African Americans were allowed to use three out of the one hundred thirty-two public parks (Kruse, 2005). African Americans had very limited, if any, access to other green spaces like golf courses and tennis courts. The public parks that were designated for African Americans were overcrowded, undersized, undermanaged and in some cases unsafe (Kruse, 2005). Eventually the local government ruled that African Americans were allowed to visit and use the public spaces free from the presence of discrimination. The white population in Atlanta was furious and for the most part began to withdraw from the public realm, which now included African Americans citizens. The withdrawal of white's economic activity in the public spaces and white voices in

decisions making, left the public realm somewhat empty. White residents now looked to find green space opportunities that were privately owned, where African Americans would be denied access.

The ratio of public parks in African American neighborhoods to parks in white neighborhoods remained untouched. The only difference now being African Americans who had had easy park access and the desire to use the facilities could use them. This still left the majority of African Americans with a severe lack of green space to access (Bayor, 2000; Keating, 2001; Kruse, 2005; Stone, 1989). African Americans were given the right to travel to a park located in a mostly white neighborhood, but never given their own parks and definitely never given parks of good quality (Kruse, 2005). This study examined the present day status of those who have access to the City's public park space, therefore investigating if African Americans are still being isolated from the environmental benefits of parks.

Standards and Recommendations for Distances to Green Space

In order to confront issues of urban park space accessibility, several organizations have established recommendations for the amount of park space each person in a city should be able to access. Natural England, an independent public advisor working to conserve, protect and improve England's natural environments, created the "Accessible Natural Green space Standards" declaring there should be about five acres for every one thousand people (Natural England, 2010). Their standards broke down the recommended acreage even further, claiming: everyone should have a 4.9 acre green space within 0.19 miles, a 50 acre green space with 1.24 miles, a 247 acre site within 3.11 miles and a 1,235 acre site within 6.21 miles. The National Recreation and Parks Association has established the only standards and guidelines for American

public parks. This Association used a needs-based equity model when creating the standards by giving a greater distribution of parks to low socioeconomic groups. Their guidelines, published in 1983, recommended 6.25-10.50 acres per every 1,000 people (Municipal Research & Services Center of Washington, 1994). American guidelines are lacking in comparison to European recommendations because there is no mentioned importance to the placement of park space. The European Environment Agency recommends that every resident should be within fifteen minutes of walking distance to a public green space. In order to fulfill the EEA's recommendations, green spaces must be accessible for the masses (Barbosa et al., 2007). The focus must become how much park space is available and where it is located in regards to the urban population (Babey et al., 2008; Boone et al., 2009; Comber et al., 2008; Wolch et al., 2005). Although these organizations have established park size to population guidelines there are no current organizations checking if they are being enforced.

2.5 GIS Studies

Green space accessibility in urban environments has been studied through the use of geographic information systems (GIS). The GIS software allows users to display, manipulate, examine and analyze the location of urban residents and public parks. GIS provides various ways to measure accessibility. Academic studies have shown residents and city visitors will typically walk no further than a quarter mile to enjoy a park space, therefore a quarter mile distance is the accepted maximum distance of accessing green space (Boone et al., 2009; Harnik & Simms, 2004; Wolch et al., 2005). This limits the environmental benefits of parks to those individuals who are within a quarter mile distance. Nicholls analyzed accessibility by comparing a street-network analysis to straight line analysis of Bryan, Texas, showing the variations that can occur

when using different methods (Nicholls, 2001). Straight line analysis does not take walking patterns into account, while street-network analysis does. Network analysis has also been used to examine park accessibility in Leicester, England, where it was discovered citizens have access to the recommended amount of open space (Comber et al., 2008). Quantitative and qualitative spatial analysis models have compared access to New York City park space and their physical activity usage (Maroko et al., 2009). Population densities and locations have been studied using buffers, kernel densities, centroids of census tracks, zip codes and land parcel populations (Biba, Curtin, & Manca, 2010; Comber et al., 2008; Maroko et al., 2009). Figures #13-17 in Appendix A, show and further explain the limitations some of these methods present. GIS has also been used to investigate the attributes and correlations between urban residents and public parks; detailed in Table 1 (Abercrombie et al., 2008; Anderson & West, 2006; Babey et al., 2008; Biba et al., 2010; Boone et al., 2009; Comber et al., 2008; Cutts et al., 2009; Giles-Corti et al., 2005; Harnik & Simms, 2004; Maroko et al., 2009; Nicholls, 2001; Wolch et al., 2005).

Table 1 Previous GIS Studies

Scholar	**Case study area**	**Focus of park study**
Abercrombie	Maryland	large population areas, high children populations and park placement
Anderson	Minneapolis, MN	property value in proximity to park placement
Babey	California	access to safe parks for physical activity opportunities
Biba	Dallas, TX	access to mass transit stations/stops for mobility
Boone	Baltimore, MD	populations in high need of park accessibility
Comber	Leicester, England	access to recommended park space acreage
Cutts	Phoenix, AZ	populations at risk for obesity and walkable park space
Giles-Corti	Perth, Australia	park attributes and park popularity
Harnik	Several	comparing walkable distance standards
Maroko	New York City	equity of park distribution
Nicholls	Bryan, TX	using GIS to measure accessibility and distribution of public parks
Wolch	Los Angeles, CA	equity of park distribution

Site Suitability Studies

GIS has also been used to plan and evaluate the creation of new green spaces. The software allows users to compile and compare attribute data from numerous spatial locations at once. This ability has been quite useful for site suitability studies where users create a criteria of desired characteristics for a particular development or land-use plan, after which the GIS uses the criteria to find the most potentially successful sites (Dai, Lee, & Zhang, 2001; Mahon & Miller, 2003; S. Sener et al., 2010). Mahon and Miller examined "open space" (used interchangeably with green space) in Stevens Point, Wisconsin that should be preserved in order to meet the area's long term community goals of "protecting water quality and critical natural areas, provide recreational opportunities for Stevens Point area residents and visitors, develop a green space network that preserves the community's natural character and guide future growth and development" (Mahon & Miller, 2003). Land parcels that met any of the four goals were identified, arranged into GIS maps, and assigned values based on the community goals. Parcels were ranked on a five-point scale, based on aesthetic, recreation, and ecological value. Land parcels with high associated values were then identified as sites that would benefit the City if preserved as green space (Mahon & Miller, 2003). Dai and his colleagues used GIS to identify important geo-environmental factors that should play into urban land-use planning in Lanzhou City of Northwest China (Dai et al., 2001). The authors focused on five land-categories, including a natural conservation classification, and examined the most beneficial topography, ground conditions, groundwater and geological hazards for each category. Natural conservation land-use was identified as being subject to factors of slope, elevation, distance to debris flow and land-sliding. Raster cells of natural conservation sites were assigned a value between 0 and 4 based on the selected attribute factors. The authors found the most beneficial location for natural

conservation sites would be along the area's mountains and narrow valleys (Dai et al., 2001). GIS provides great opportunities to analyze the urban environment and plan for its best use.

3 RESEARCH QUESTION

In view of the preceding background, this study aimed at answering the following questions, (1.) To what degree do Atlanta residents have equal access to the environmental benefits provided by urban green space? (2.) In the city, to what degree is there a socioeconomic disparity in park access? (3.) Where could additional park space be created to provide those Atlanta residents who have limited access to parks a greater opportunity to enjoy the benefits of parks? Examination and analysis of these inquiries were completed through use of U.S. Census data, parks and city land-use data in GIS ArcMap software.

Urban green space availability and development varies among city environments. Some cities allocate a great amount of land to park space, while others are lacking. The Trust for Public Land's 2009 City Park Facts reported Atlanta's percentage of city land dedicated to public green space as 4.5% (Shelton, 2009). Cities with similar land acreage to Atlanta (categorized as "intermediate-low") had an average of 8.3% city land dedicated to public green space. Atlanta has a population of about 519,145 and about 3,846 acres of park space, providing 7.4 acres per 1,000 residents (U.S. Census Bureau, 2010a). The average acreage per 1,000 residents for other cities with similar population density was 13.7 acres. Atlanta's low numbers illustrate insufficient amount of green space for residents living in this urban setting. If the City of Atlanta values the quality of life of its citizens, there must be urban green space for all citizens and visitors to benefit from and enjoy. However, to simply designate or create space within the city

as “green space” is not enough. The available green space designed and established by the City must be accessible to all.

Addressing these research questions is important. Exploring the populations who have the most access to Atlanta’s public parks will essentially determine if there is an equitable spatial distribution of environmental benefits throughout the city. If the populations living close to these parks are socioeconomically diverse, then the Atlanta public parks are displaying a case of environmental justice and are equally receiving the environmental benefits from parks. If the populations living close to Atlanta’s public parks are not socioeconomically diverse, then there is a case of environmental injustice for those people not receiving park benefits.

4 DATA AND METHODS

Methodology for this research included Geographic Information Systems and quantitative data collection. GIS provided visual representation of parks, surrounding populations, and existing land-use for analysis. Quantitative methods focus on Census data and City of Atlanta public parks characteristics. The mixed methodology provided a variety of data and analysis opportunities concerning green spaces.

GIS Data – Acquisition, Preparation and Initial Setup

Geographic Information Systems (GIS) was used in this study. ArcMap, the GIS software, provided a platform for spatial and attribute data to be gathered, joined and analyzed. GIS data was obtained from the Atlanta Regional Commission and City of Atlanta GIS Data Catalog. Data shapefiles obtained from the City of Atlanta Data Catalog included the future land

use plan and MARTA rail and bus lines. Other GIS shapefiles used included the City of Atlanta public parks, roads, highways, and census block group boundaries. Census data obtained at the U.S. Census Bureau was from the 2000 Census Summary Files 1 and 3 (U.S. Census Bureau, 2010b, 2010a). These summary files contained population, median household income, income level, sex by age, race and population below poverty. Although the 2010 Census data is the most current data, it was not available during the research period, therefore the 2000 Census data was used. Demographics from the Fulton and DeKalb county block groups were examined. These two counties were included because they combine to form the City of Atlanta, which is the desired focus area.

Scale in any study should be an important consideration prior to completing the work. The limits and scope of determining a scale can create positive and negative effects on the study's outcome. If a chosen scale is too large for the desired study, the researcher may miss a vital variable (which only occurs on a small scale) for their discussion and analysis. Scale can also be too small, where the researcher excludes a vital factor that greatly affects the studied element.

The scale for this study followed the City limits, therefore focusing on the populations and parks within the borders. However it is important to consider scale's edge effect, including people close to the city limits who use the parks just outside the City's actual borders. A study could miss vital information if it assumed a person would not choose to access the park just outside City limits because it's not a City of Atlanta park. This study included parks that are located within a one mile buffer of the city borders in hopes of capturing City residents who include non-Atlanta public parks as their own. These parks were obtained from Atlanta Regional Commission shapefiles.

Census data downloaded from the U.S. Census bureau was cleaned and formatted for the importation into the ArcMap software. Once brought into the software, the census data and the city of Atlanta data (parks, roads, etc.) were joined and simplified to show only the desired city of Atlanta. The parks used for analysis were all managed by the city of Atlanta and were all public parks, limiting the variables among the metropolitan parks. Parks of all sizes were included in the study and were used for analyzing distribution of park acreage.

Street Network of City Roads – Determining Distances to Park Space

A road network analysis was performed, establishing routes throughout the City that provide access to the public parks. These routes were used to show how and from where people can access the parks. Residents can use a variety of transportation options to access the parks; including cars, walking, mass transit, skating or biking. This study focused on those who can walk or bike to the parks, because it allows the inclusion of residents who are without a vehicle. The use of a vehicle for park accessibility brings in the issue of choice because those with access to vehicles can drive to whatever park they so desire at a distance they choose. Those citizens who must walk or bike in order to access a park will only travel so far to reach their destination. Accessibility and mass transit studies have agreed on and used a quarter mile distance for walkers and a mile distance for bikers (Abercrombie et al., 2008; Comber et al., 2008; Maroko et al., 2009). The network analysis was used to examine and identify routes of a quarter-mile and one mile from the parks (Figure 16). This analysis identified the population who could access a park on foot or bike.

Equity of Park Access Study – Origin-Destination Matrix

After the road network identified the pathways to and from parks and the surrounding populations, an OD matrix was preformed. The origins were census block group centroids and the destinations were park centroids. This matrix allowed the software to establish routes leading to and from the parks from the various populations. The OD matrix produced a layer of data that identified the distance from each census block group centroid to each City of Atlanta park. A query was performed to identify census block groups that are within a ¼ mile and/or a one-mile distance from a park centroid. Census block groups traveling longer distances were considered the most in-need of a park development. The high-need block groups were used later in the site suitability study to evaluate possible locations for new parks. This analysis was similar to the Wolch and his colleagues' analysis of populations in Los Angeles lacking park access (Wolch et al., 2005).

The resulting distances for each census block group were categorized into three classes: 0-0.25 miles residents could access a public park by walking along the streets, 0.26-1.00 miles residents could access a public park by bike riding along the streets, and block groups with a travel distance above 1.01 miles were considered not to have access to a public park.

Traffic direction in the street-network was only considered a contributing factor in regards to the individuals whom bike to and from the parks. Walkers have the ability to walk with or against traffic on one-way or two-way roads, while by law bikers are to follow the direction of traffic. Therefore the ¼ mile OD matrix would disregard traffic direction for walkers, but include it in the 1 mile OD matrix for bikers. Census data will provide information about the surrounding residents of the parks. Examination of the economic status, household

medium income, gender and race were used to identify who had present-day accessibility to Atlanta's public parks.

Spatial Analysis – Spatial Autocorrelation of Census Data

Groups of people who share similar characteristics or values have a tendency to stick together, sometimes these groups will even live in the same neighborhoods. Their shared values and/or decisions illustrate the presence of an interdependence of one group of citizens on another, referred to as spatial autocorrelation. Spatial autocorrelation can also occur among populations who do not have a choice of where they live. Residential areas commonly have residents who earn similar income levels, locating these individuals or families in the same spatial placement.

In order to successfully analyze the spatial distribution of park accessibility, this study accounted for the effects of spatial autocorrelation among census block groups. To eliminate any of these effects among Atlanta's populations, a spatial regression model was performed. Spatial regression models consider the effects of spatial autocorrelation, by assuming the independence of the variables. A spatial lag regression model was used to evaluate the park inequity in this study. This model explored the independent population variables (percentage of minority populations, median household income levels, populations living below poverty, female populations, and population density) and their effects on a population's proximity to park space. Spatial analysis, including examination of possible correlations between distances to parks, park size and various census data was performed through the creation of scatter plot charts and use of Geoda software.

Site Suitability Study

The study's next goal was to provide suggestions on how to increase the equity among Atlanta residents. These suggestions aimed to provide greater access to the environmental benefits of urban green space. This was accomplished by identifying possible sites within the City of Atlanta where a park could be created. Site selection criteria examined City's future land use, which signify where open land and/or workable zoning district were located.

The desired goal was to identify parcels of land that would be most beneficial (to the Atlanta residents lacking access to green space) if converted to a public park. Sites that have good potential to become future parks were analyzed against the following criteria.

1 – Identify open land
- Land that is already zoned as open space would be more readily available and easier to development a future park without requiring the rezoning process to occur.
- Extraction - Open space polygons were extracted from the City of Atlanta's current zoning shapefile.

2 – Proximity to residential areas
- Possible park sites should be close to residential areas because residents would be more likely to use the parks close to their homes.
- Extraction – Residentially zoned areas were extracted from the zoning shapefile.
- Buffer – A 0.25 mile buffer was established around residentially zoned areas, in order to identify if any of the open spaces fell within a walking distance of a residential population.

3 – Proximity to park deprived population
- Proposed park sites should increase the equity of access to park space, therefore locations near populations lacking in access would be the first to have a new park.
- OD Matrix – Completed OD matrix in ArcMap that calculated the distances between open space sites and census block groups of park deprived populations (which have previously been identified as the census block groups with the closest park more than one mile away). Open space sites that were within one mile to a census block group centroid (which originally did not have park access) were designated as meeting this criterion and were given a higher ranking.

4 – Proximity to high density populations
- Potential park locations should be in a highly populated area (people per square mile), in hopes of providing green space access for as many people as possible.
- OD Matrix – Completed another OD matrix in ArcMap, which calculated the distance between open space sites and 25% of census block groups with the highest population densities. Open spaces with a closer proximity to areas of high population densities were given a higher ranking.

5 – Proximity to MARTA

- If the new park is close to a MARTA bus stop or rail station there would be a greater connectivity throughout the city for all residents to enjoy the new location.
- Buffer - Potential parks sites should have a MARTA bus stop or rail station within a 0.01 mile buffer in order to increase city connectivity via public transportation.

6 – Distance to existing park

- Potential park sites should be far from existing parks because those surrounding populations already have access to a park.
- OD Matrix – This ArcMap matrix examined distances between existing City parks and the proposed new park sites. Open space sites further away from existing parks were ranked higher than those sites with existing parks in close proximity.

High ranking open space sites from the GIS site suitability study were then analyzed through a visual audit using Google Earth, Maps and Street View, and then through a driving audit in order to see current physical standings. Sites were given additional rankings for the final recommendations. If certain parks appeared to be improbable for park creation, their site suitability ranking was adjusted. The final results were used to make recommendations for new park sites to various city entities and departments. The visual audit examined the following criteria:

1 – Minimal abandoned buildings and structures

- Lots should have minimal abandoned buildings to lessen the amount of clean up and renovation or debris removal required for before potential park construction.

2 – Current infrastructure

- Potential sites should have safety infrastructure in place, such as sidewalks and streetlights to increase the safety of park users.

3 – Presence of vegetation

- Potential park development sites should have a presence of vegetation, such as trees, shrubs, or grasses, to provide residents with some of the emotional and physical benefits green space can provide (as discussed in the literature review).

4 – Availability

- Polygon boundaries of each open space site were compared to the real-world locations through Google Earth and the driving audit to verify the site is available.

New Equity of Park Access Study – Including New Proposed Park Locations

After the site suitability analysis, a brief equity study was conducted again to establish whether and how the proposed sites would increase the equality. Another OD-matrix was performed, with block group centroids as the origins and the centroids of existing parks and proposed park as the destinations. The census block groups formerly without park access were compared to those block groups currently without park access, in hopes that the population size or number of block groups would have decreased.

Accessible Parks – Considering Park Size

Previous methodology steps examined accessibility to parks focusing on travel distance, however it is important to recognize what type of park residents are able to access. The parks in the study area come in a wide range of size, from less than a square mile to 240 square miles. Accessibility and the equitability of that accessibility were once again explored but this time park acreage was assigned a heavier weight. The simplified gravity model "$f = d^{-\beta} \times s$" was used in order to assign each park with a value, which was determined by the required travel distance and the size of the park site. This model represents: f = weighted size, d = distance to park, s = park size, and β = travel friction, with the assumption $\beta = 1$. Each park's new size-weighted score was used to examine park distances, providing insight into what size of parks certain populations could access.

5 RESULTS

5.1 Equity of current park access study

Identifying Accessibility

The initial OD matrix identified that the vast majority, 91% of block groups, was found to be able to walk or bike to close park, thus classifying these block groups as having public park access. Leaving 9% of the block groups recognized as being without park access. Those 27 block groups contained 50,535 residents. Further analysis of the minimum travel distance to a park is summarized in Table 2.

Table 2 Distance to closest park (miles)

	On foot access		Bike access		Access requires vehicle		
	0-0.25	0.26-0.50	0.51-0.75	0.76-1.00	1.01-1.25	1.26-1.50	1.51-2.26
# of block groups	74	100	56	37	13	10	4
% of total block groups	25%	34%	19%	13%	4%	3%	1%

Demographics of Populations without Access

The demographics of residents without access to public green space were then analyzed based off of several 2000 Census data categories. This population contained a wide range of median household income levels and minority populations. A more detailed account is below in Table 3 and 4.

Table 3 Demographics of block groups without park access

Median Household Income	\$0 - \$200,000
Female Population	4% - 59%
Population Living Below Poverty	0% - 77%
African American Population	0% - 100%
Asian Population	0% - 7.78%
Minority (non-white) Population	0% - 100%

Table 4 Block groups without access classified by distance to nearest park

	25% closest	2nd 25% closest	3rd 25% closest	25% farthest
Distance to Park (miles)				
average	1.023	1.111	1.321	1.621
min	1.002	1.054	1.252	1.418
max	1.046	1.243	1.417	2.257
Percentage of Minority Population				
average	0.792	0.356	0.600	0.562
min	0.443	0	0.025	0.091
max	1	1	0.1	0.986
Percentage of Female Population				
average	0.492	0.51	0.523	0.5
min	0.395	0.480	0.491	0.406
max	0.575	0.589	0.578	0.549
Population Living Below Poverty				
average	0.200	0.093	0.125	0.110
min	0	0.007	0.028	0.012
max	0.412	0.245	0.362	0.334
Median Household Income				
average	35483.667	96637.286	61634.429	67721.286
min	16439	28793	16408	25491
max	61146	200001	166772	184998
Population Density				
average	4967.109	2557.620	2673.630	1731.714
min	313.709	613.577	1043.301	383.108
max	15670.415	6873.416	7307.663	6157.185

Note: Census block groups without access were classified into four quartile groups based on their distance to parks.

5.2 Evaluating the inequity - spatial regression

Scatter plots (in Excel), Ordinary Least Square Model (OLS) and Spatial Lag Model (implemented in Geoda095i) were used to evaluate correlation between census block group demographics and distances to parks. This procedure was conducted in hopes of examining the correlation between the park distances and one of the several demographic variables listed above. The scatter plots and spatial lag model results showed no statistically significance correlation between any of the independent variables and distance to parks (Appendix C). There were weak

positive correlations found between distance to parks and median household income, as well as percentage of minority population. Distance to parks also had weak negative relationships with population density, percentage of female population and population below poverty.

5.3 Site suitability

This section of the study was aimed toward alleviating the limited park accessibility that affects some 50,000 residents in the City of Atlanta. The City's Future Land Use Plan was used to identify potential locations for public park space development. Land lots that were identified as open space were scored against six different criteria, eventually providing a ranking of the sites with the most potential for future park development. There were 382 open sites used in this suitability study, ranging from 0.01 – 706 acres and averaging at 17 acres.

Table 5 Site suitability criteria

Criteria used to score potential park sites	**# of sites that met this criteria**	**Percentage of total sites**
#1 – Open Space	382	100%
#2 – near Residential Area	373	98%
#3 – near Park Deprived Population	96	25%
#4 – near High Density Population	72	19%
#5 – near MARTA stop or station	92	24%
#6 – far from existing park space	96	25%

Table 6 Site suitability final ranking

Potential park sites final rank	**# of sites that received this score**	**Additional site data**
1 Lowest Suitability	1	0.075 acres
2 Very Unlikely Suitable	127	Mean: 4.29 acres Range: 0.025 – 57.72 acres
3 Unlikely Suitable	172	Mean 17.30 acres Range: 0.01 – 331.96 acres
4 Suitable	70	Mean: 35.93 acres Range: 0.03 – 706.04 acres

5 Highly Suitable	12	Mean: 52.29 acres Range: 0.53 – 243.56 acres
6 Very Highly Suitable	0	N/A

The 12 sites that received the highest score of five points were then further evaluated for potential park suitability. The sites were mostly located in the Southwest area within the City of Atlanta's borders, with some scattered in the Northwest section as well.

5.4 Visual audit of proposed parks

The final evaluation of the proposed park sites was completed using Google Earth and a driving audit to view the current conditions of each site. Location description, current conditions, additional notes, and a potential park score are detailed in Table 7. There were six resulting sites that still held high park development potential after a visual audit. However it appeared that three of these six sites were already park sites or were already partially designated as a park. The driving audit explored the three final sites, Sites ID #9, Site #38 and #59 and determined that only two of them still held park development potential, Site ID #9 and #59 (Appendix B).

Table 7 Highly suitable site attributes

Site ID	Location description	Acreage	Conditions	Park possibility (1=no; 4=yes)	Notes
9	**Triangle shape on the edge of tree-covered lot**	**1.33**	**Covered with trees**	**4**	**Next to an Elementary School, sidewalk along the road**
17	Linear shape between developments	18.43	Mostly covered in trees but crosses already used field	3	Partially Greenbriar Park
22	Linear and widens out	24.63	Mostly already developed into a park	1	Partially Pitman Park

23	Rectangular, includes a roadside lot and a median	4.63	Some trees but also concrete streets	1	
38	Rectangular, some streets and sidewalks	152.21	Vegetation of trees and fields	3	Partially Crestlawn Cemetery
59	**Rectangular**	**0.53**	**Covered in trees**	**4**	Sidewalk along road, creek running through it, neighboring residential area
89	Rectangular, site divided by streets	10.96	Some trees, mostly grass and some roads	3	
96	Rectangular with a linear portion	153.98	Covered in trees	3	Partially Cascade Natural Springs Preserve
106	Linear, some development	8.98	Half covered in trees, half open field with sidewalk	2	
325	Winding linear, with rectangular portion	243.56	Trees and sidewalks	3	Partially Freedom Park extensions and Candler Park
335	Linear, neighborhood median	0.77	Concrete street and a few trees	1	
377	Rectangular	7.72	Grass field and trees, tennis and baseball field	3	Partially West End Park

Note: The rows in bold identify the two sites with the most potential for park development.

5.5 Equity of park access with proposed parks

Another OD matrix was completed, including the twelve potential park sites in the original 382 destination locations (being the existing parks). When compared to the original equity study OD matrix results, there were no changes present (Figure 1 and Figure 2). The same census block groups that were previously without park access were still without access, even with potentially developing the top ranking open space sites into new parks. The inability to provide better park accessibility can be understood on account of the limits of a street network

layout. The OD matrices categorized any block group that could not reach a park within one mile via city streets, as a block group without access.

A Euclidean (straight-line) distance analysis was performed in ArcMap, to identify the proximity from block groups, formerly labeled with no access, to nearby parks. These provided opportunity to compare accessibility methods. The Euclidean distance results showed a public park within a one mile radius of almost every census block group (Figure 2). Of the previous 27 block groups that did not have park access, 25 showed having access using Euclidean distances. Six block groups gained walkable access and 19 block groups gained biking access. This left only two block groups that had their closest park more than a mile away, leaving these block group residents without access.

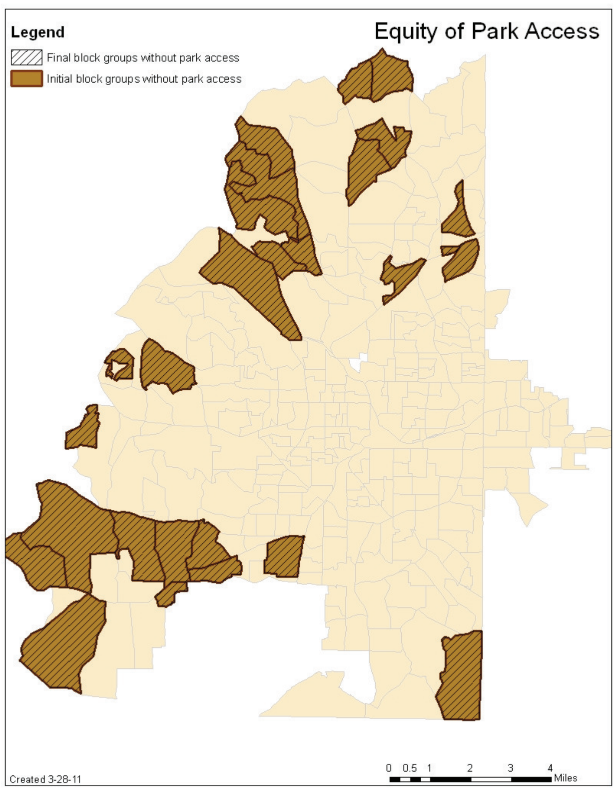

Figure 1 A map of the study area showing census block groups that were initially classified as having no park access within a one mile distance, compared to block group accessibility findings with the proposed parks included.

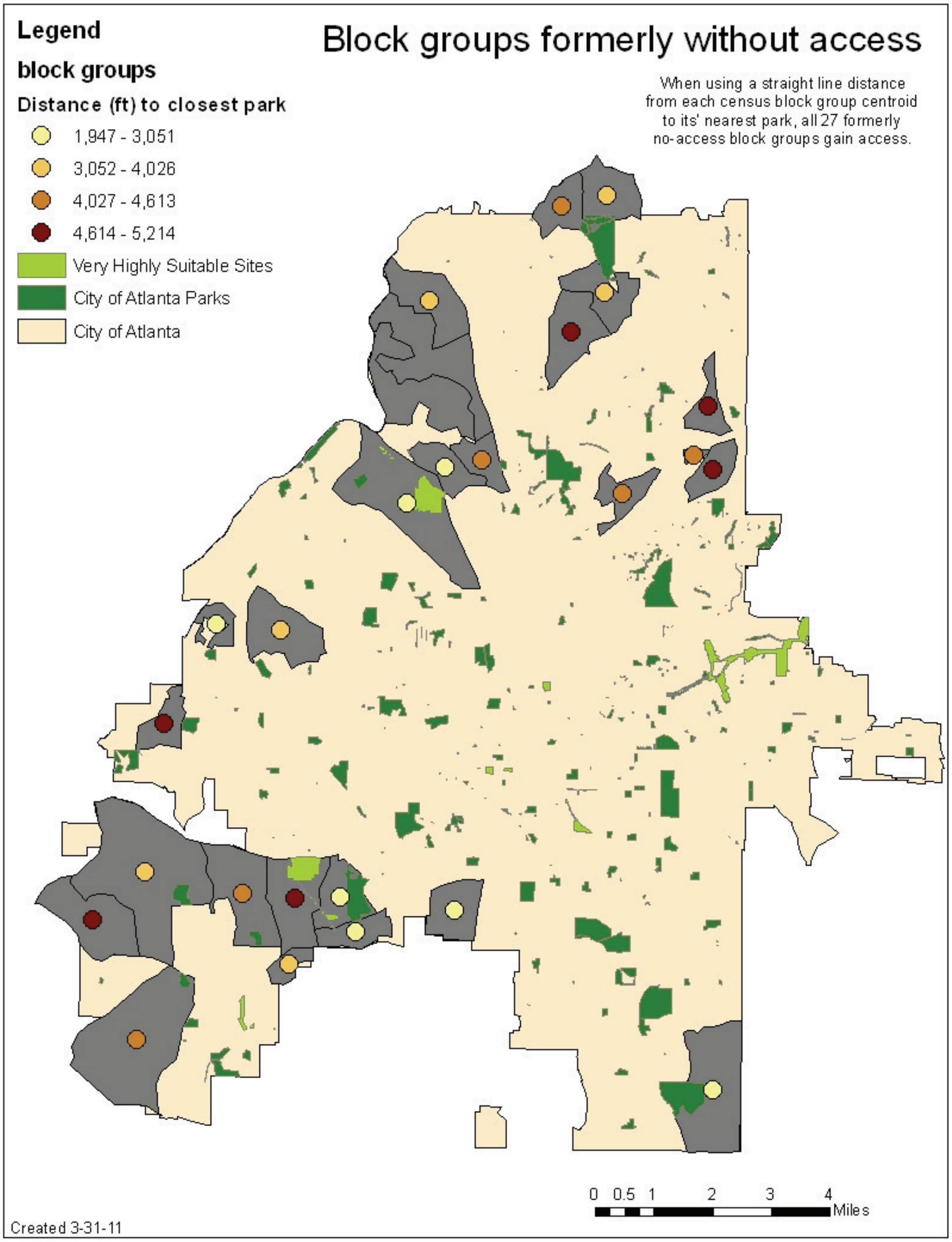

Figure 2 A map depicting the distances block groups have to travel to reach the closest park via street-network, as well as park locations.

5.6 Equity of park access – considering park size

Distances from the initial street-network OD matrix (which identified the minimal required travel distance from each census block group to its closest park) were again evaluated in regards to block group demographics, yet this time assigning park size additional weighting with the use of a simplified gravity model. Park acreage and block group park accessibility were further analyzed using Euclidean distance in conjunction with assigning park size an additional weight.

Spatial lag results analyzing park size and block group demographics again found no statistically significant correlations. Park size had a weak negative relationship with minority population percentage, population below poverty and population density. Park size and median household income showed a weak positive correlation. Spatial analysis results when using park distance as the dependent variable agreed with spatial analysis results when using park size as the dependent variable (Appendix C).

6 DISCUSSION

6.1 Park accessibility and minority populations

Statistically speaking none of the specified block group variables were significantly related to the required travel distance to a park. However the spatial distribution of minority groups within census block groups without access, when visualized on a map, illustrated a clear patterning phenomenon. Statistical analysis was not able to identify the spatial clustering of particular ethnic groups in Atlanta, which was highly visible when depicted spatially on a map

(Figure 3). Block groups without access in the north are almost entirely made up of white residents, while block groups without access in the south consist of a large African American dominance.

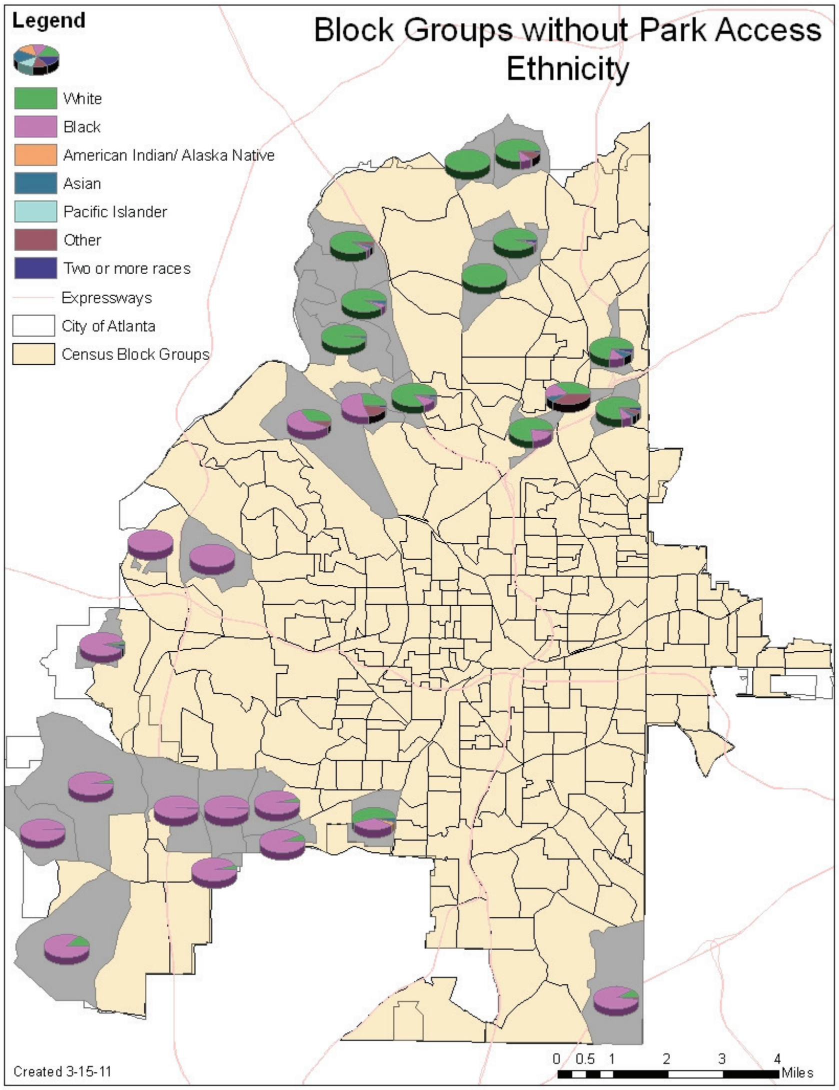

Figure 3 A map displaying the percentage of major ethnicities within the block groups classified in this study as having no park access.

This spatial phenomena occurring in Atlanta's contemporary landscape can be traced back to the desegregation of the city. Atlanta's public spaces, including public parks, had to go through a desegregation process that took many decades and the hard work of a multitude of

groups and leaders (Kruse, 2005). When the Civil Rights movement reached the national scale, laws were passed to begin the legal desegregation of public places. African Americans did not see any changes in their city until local government began to enforce the federal rulings and protect them against discriminatory actions, allowing them to actually visit and use these so-called "public" spaces. The white business elites who had worked with Mayor Hartsfield had always supported the African American equality movement because it allowed Atlanta to maintain a positive city image. However when African American citizens actually began to use the public spaces, including parks, it was the middle and lower socioeconomic status (SES) white residents who would be intermingling with the newly allowed residents. The white business elites never had a use for public spaces because they could afford their own services and facilities. The lower and middle SES whites rejected the notion of sharing these spaces with the African American community, thus they began to seek means of isolating themselves and retreating from the public places (Bayor, 2000; Keating, 2001; Kruse, 2005).

The withdrawal of white citizens from public spaces allowed a place for African Americans in the public sphere (Kruse, 2005). This retracting of the white Atlanta residents from the public sphere has allowed populations of a variety of ethnicities, family-structures, and income levels to come into areas, like public parks.

6.2 Effects of population density on park accessibility

Although the spatial analyses performed (scatter plots, ordinary least square regression model, and spatial regression lag model) did not find any statistically significance relationships, several slight correlations were found. In particular the spatial analysis performed highlighted a slight negative correlation between high population density and park distance, as well as park

size. This study uses the assumption that areas of high density will also have areas of high traffic density, therefore requiring a well-built street network to transport the populations. When the street-network dataset was used to identify distances to parks, populations living in close proximity to a well built street system would be classified as have the best park access. Areas of less population densities do not have the same amount of need for a thorough street system because there would be less people traveling on it. With a less-developed street grid the OD matrix would assign these populations with less park access.

The slight negative correlation between park size and population density can be understood because areas of high densities are usually highly developed as well, in order to meet the needs of the surrounding residential populations. An increase in need and desire for development would provide grounds for creating smaller land lots to sell off. As the high density areas are continuously divided up and built upon the availability of large pieces of land dwindles. Therefore when land becomes purchased or designated as park space there is a greater chance it is a smaller sized land lot.

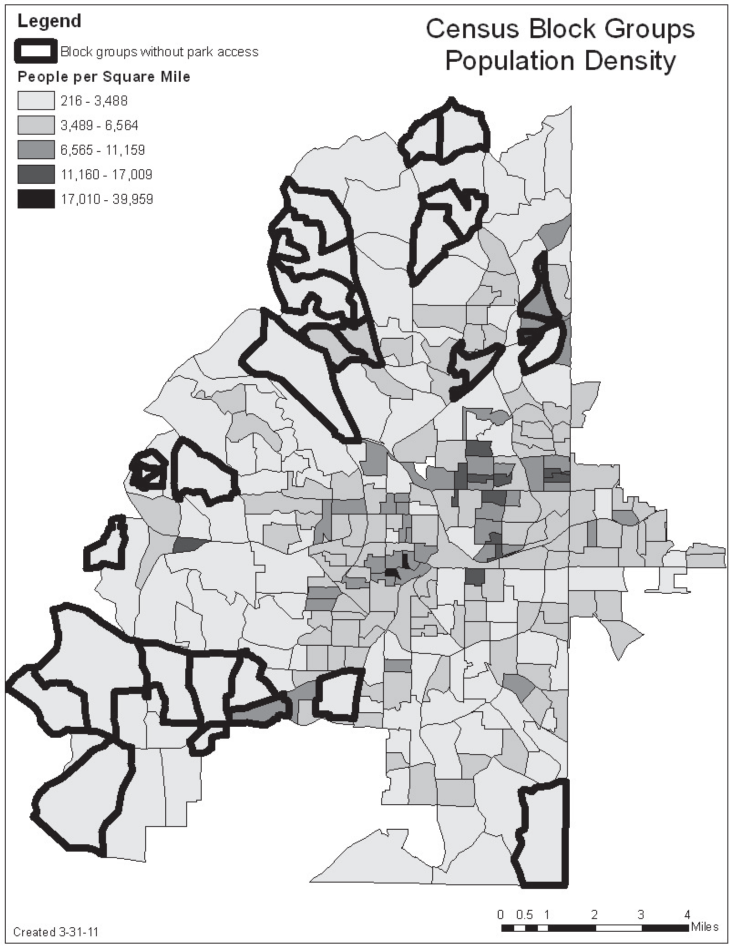

Figure 4 A map of the study area showing the population density in each census block group in the year of 2000 (U.S. Census Bureau, 2010a).

High population density in Atlanta is located around areas like Downtown and Midtown. These locations provide many opportunities for residents, including close proximity to jobs, schooling options, leisure activities and mass transit, as well has governmental services and resources. Populations residing in these areas may have easier access to parks because the City could easily recognize the environmental needs all of these people would be requiring. Green spaces provide a great amount of environmental benefits and when located in an area of high population density, the benefits can be mass distributed. Population density seems to have the most importance when analyzing park accessibility, compared to the other variables used in this

study. Although no statistically significance was found between population density and accessibility, it is this study's belief that the negative correlation does identify an important phenomena.

6.3 Site suitability recommendations

The resulting scores for the site suitability study demonstrated that the Open Space sites in the City's Future Land Use Plan did not easily meet the six criteria. No sites met all six criteria, requiring this study to only use Open Space sites that met five of the criteria (Figure 5). Criteria #1 and #2 were easily met because the initial shapefile was completely of open space sites and much of Atlanta is zoned for some sort of residential use. Criteria #3, #5 and #6 were met by a quarter of the open space sites. Criteria #4, close proximity to areas of high population density, was met by the fewest number of sites. The City would not want to have a lot of open space sites near areas of high population density because that land would hold great value in terms of development and potential profit. The City and the government must have financial resources to use in order run and be sustainable. It is within the City's best financial interest to find a way to profit off of all land near areas of high population density. Land further away from the majority of the population would be more likely designated or left as open space, in hopes of future development. This explains the occurrence of more open space sites further away from the downtown areas.

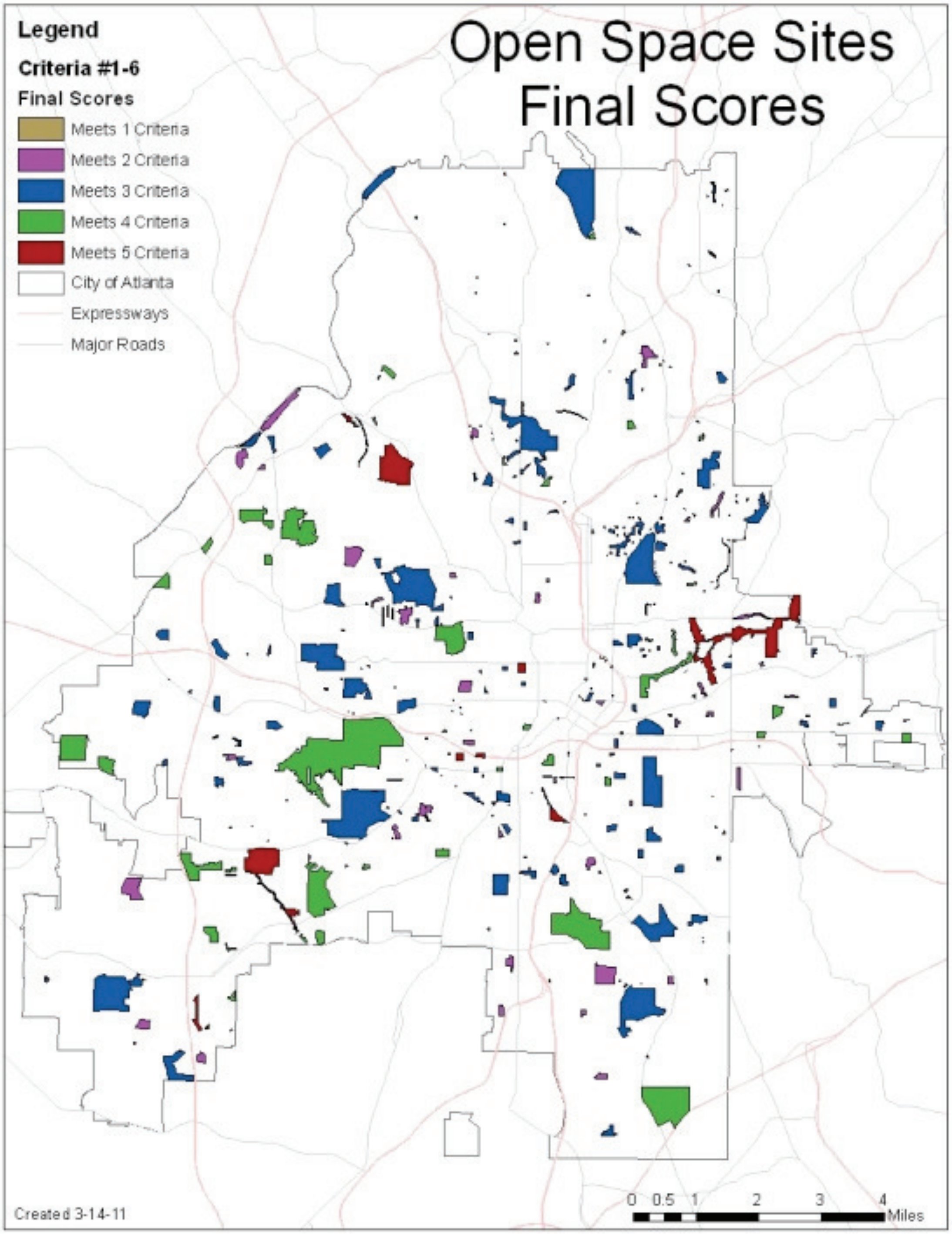

Figure 5 A map of the study area showing the final scores of each site that was analyzed for possible park development.

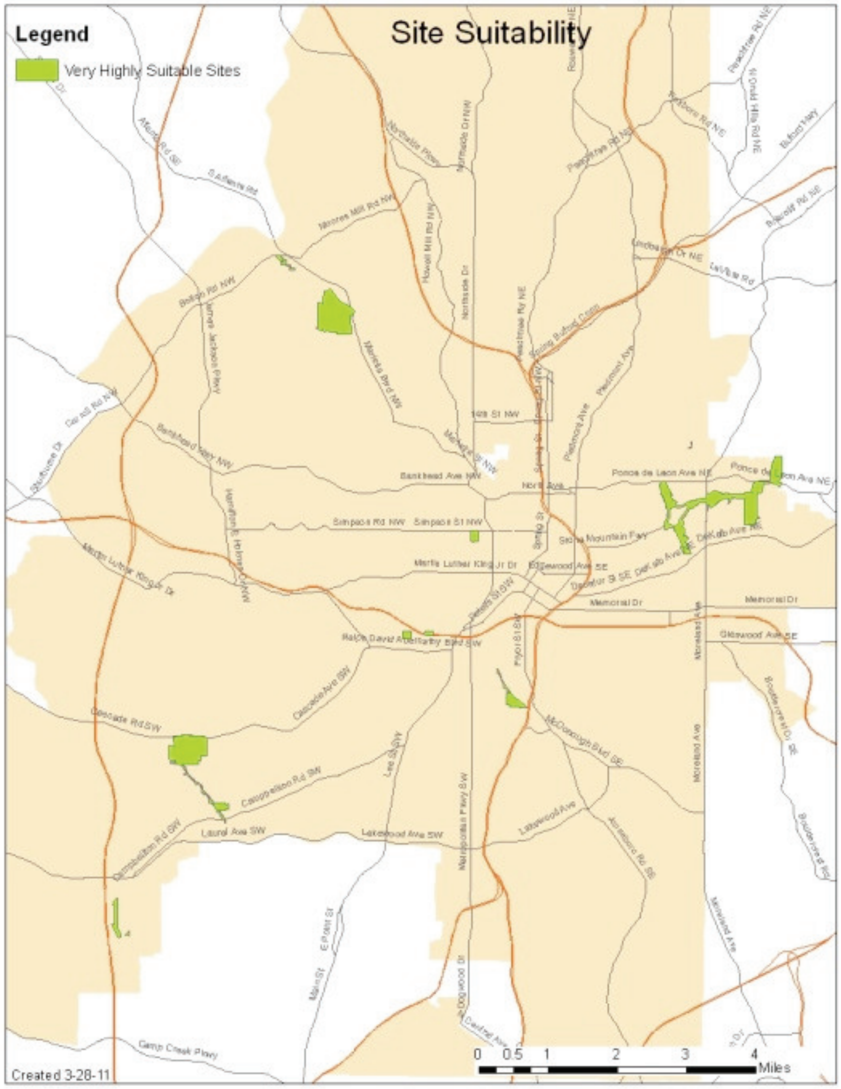

Figure 6 A map of the study area showing the sites that were selected as highly suitable for park development based on the methodology developed in this study.

6.4 Visual audit of proposed parks

The Google Earth visual audit allowed for a straight-forward illustration of what these potential park sides currently look like. A limitation of using GIS and shapefile data emerges when taking the information and applying it to its real world location. Boundary line locations are distinct and clear when viewing sites in Google Earth, as opposed to the absence of site boundaries in the real world. Utilizing the abilities of Google Earth also allowed for an overhead

view and image collection of the site and its conditions. A street view of each site allowed questionable shapes from above to be identified and classified. The final sites for potential park development are illustrated below.

Figure 7 A Google Earth image of site #9, one of the sites recommended for park development. The site is located west of an Elementary school.

Figure 8 A Google Earth image of site #59 from the site suitability study. The site surrounded by an undeveloped lot of trees.

The driving audit was able to provide a more real world present day understanding of the potential park sites. Site #9 was surrounded by an undeveloped lot of trees and is close proximity to an Elementary school. Students and the surrounding residents would be able to easily access this park. Site #59 had the most potential for park development because it is located next to an already established park, requiring the minimal amount of City work and resources. Both sites had sidewalks along the adjacent roads, a presence of high density vegetation and no siting of any buildings or structures (Figure 9 and Figure 10).

Figure 9 A photograph taken at site #9, one of the proposed park sites from the site suitability study, during the driving audit.

Figure 10 A photograph of Site #59 taken during driving audit, another recommended site for park development.

6.5 Equity of park access – considering park size

The identical nature of the initial and the final park access equity studies was not foreseen (Figure 11). However after reviewing the results and analyzing the methodology, it becomes understandable how the results could be the same. It was discovered that there were parks in close proximity and even within the block group borders that were previously declared having have no access. The problem remained that using the streets to access the parks required residents to walk/bike further than a mile, when realistically they could use sidewalks or cut across on alternative paths to reach the park well within a mile’s distance. Park accessibility was measured by using a street dataset that was made out of the City’s street network. Residents were assumed to walk or bike along the streets in order to find their way to a public park, however there are most likely many other ways pedestrians and bikers could travel to their closest park. Sidewalks or short-cuts without designated pathways would be a simple solution to gain access to parks that may be close by but no streets easily leading to them. Figure 12 illustrates how close a park can actually be yet still be consider inaccessible via street routes. It would be an

enormous and probably impossible task to compile and map possible alternative paths and sidewalks routes because everyone is capable of creating or taking their own path.

The Euclidean distance measurements identified that 98.6% block groups in the City of Atlanta can access a park without using a car. Distances produced by street-network analysis should be used in the future during initial park accessibility studies and straight-line distances should then be used to incorporate more real-world travel patterns. Only after using both accessibility methods was this study able to recognize that the great majority of Atlanta residents do have park access.

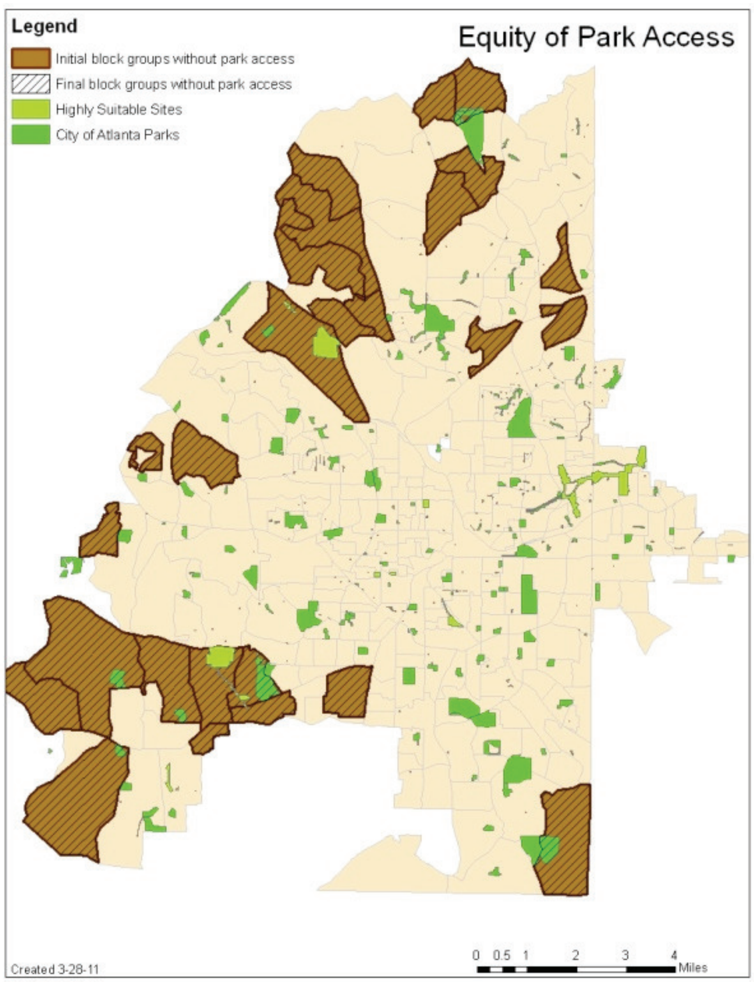

Figure 11 A map of the study area showing the locations of proposed parks relative to the existing parks and populations without park access.

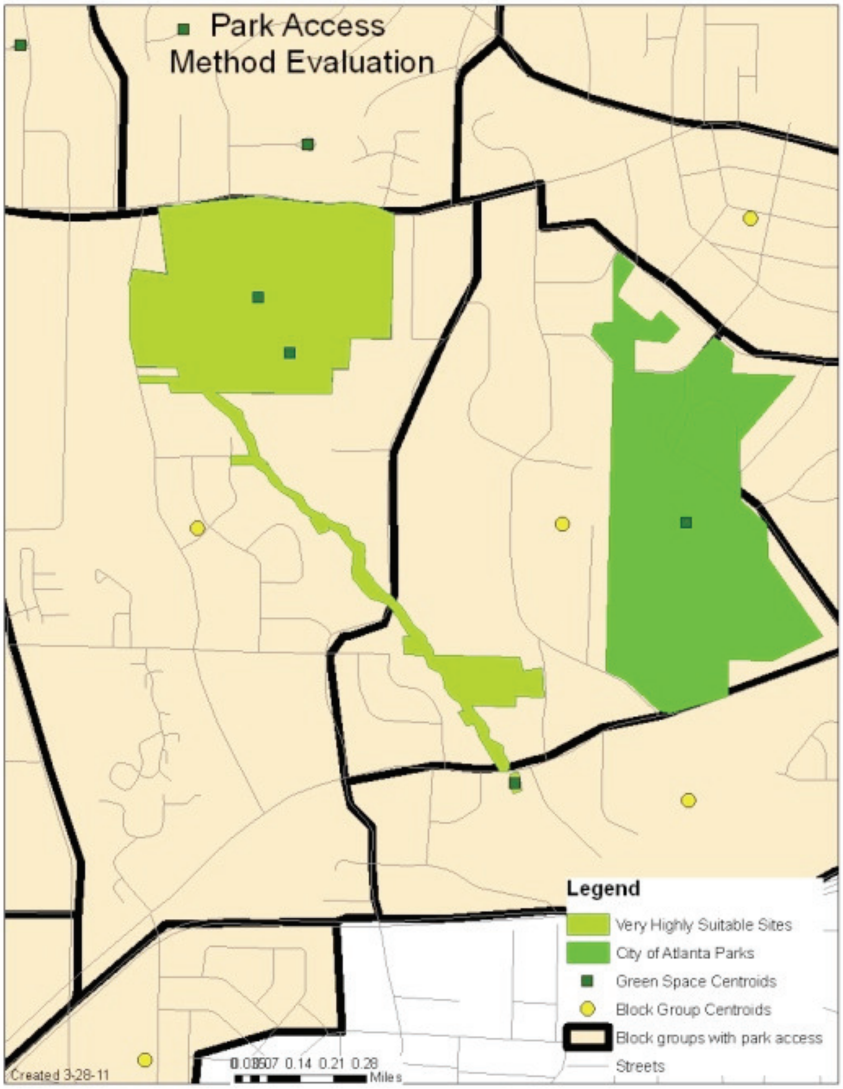

Figure 12 A spatial depiction of the proximity between parks (existing and proposed) and block groups formerly labeled as lacking park access.

6.6 Limitations

The limitations of this study vary throughout the many research steps and processes. The 2000 census data, road and park data may be out of date and therefore show previous cases of accessibility. Park GIS data was represented as polygons, with no indication of their established entrance or exit areas. Fences, walls or other barriers along park boundaries may limit a person's

access into a park site. This study used the assumption that people will always choose to access the closest park, however it is quite possible residents visit a preferred park that is further away. The accessibility considering park size might be sensitive to the choice of the simplified gravity model and the specific travel friction value. Street network distances were measured from census block group centroids to park centroids, which can only provide a general idea of the required travel distance. Measuring each the distance from each land lot to its closest park would have been more accurate, however census data is not available on that level in order to protect individuals' privacy. The large-scale study area may have affected the accuracy of measuring true park accessibility on an individual citizen's level.

6.7 Significance

The significance of the park accessibility results would be beneficial to a variety of possible stakeholders. These groups include: neighborhood residents, urban planners, real estate developers, educational institutions, politicians, city officials, Atlanta's Parks department and MARTA officials. Some could argue for more mass transit connectivity to public park space. Others could campaign for more accessibility for particular neighborhoods found lacking opportunities. The City of Atlanta and organizations like Atlanta Beltline Inc. could use the results for future park planning.

The City of Atlanta's Mayor Kasim Reed holds the existence of green space in Atlanta in high regards. This year's Sustainability Plan specified a desire for "providing a minimum of 10 acres of green space per 1,000 residents" (Mahoney, Bennett, & Grushack, n.d.). In order to reach this goal Atlanta would have to add 2.6 acres per person. Although this study does not

promise to add that particular acreage, the acreage suggested from the site suitable analysis could help Atlanta to work toward their green space goal.

The statistical analysis within this study found neither park distance nor park size are significantly correlated with block group population density, minority percentage, female percentage, median household income or population below poverty. However there were slight correlations between the dependent and independent variables (Appendix C).

These slight correlations may still be able to account for some aspect of present day accessibility distribution. This study could be used to provide support for exploring other factors or population characteristics that may be the statistically significant concerning park accessibility.

7 CONCLUSIONS

The first goal of the study was to identify if all Atlanta citizens have equal access to the environmental benefits provided by urban green space. The initial study of park access equity answered this inquiry by performing an Origin-Destination (OD) matrix measuring the distance (via the street network) from each census block group's centroid to the closest park centroid. The result showed that 91% of Atlanta's Block groups have a public park within traveling one mile on the nearby roads. Although this is a very high percentage of the population, there are still 9% of the block groups that do not have park access. The 27 block groups without access are comprised of 50,535 citizens who still deserve the opportunity to access the environmental benefits of urban green space. Therefore it can be concluded that not all Atlanta citizens have equal access to public parks.

The second research objective was to decide if there is a socioeconomic disparity in city park access. This study found there is not a statistically significant socioeconomic disparity between people with and people without park access when measuring for park access in regards to distance. The populations of both groups were made up of a wide range of median household income levels, as well as wide ranges of the percentage of people living below poverty, female population, population density, and minority populations. However when considering the size of accessible parks an important factor, a disparity among Atlanta populations does arise. Small correlations found low density, high socioeconomic status, white populations have better access to larger park spaces. Citizens of these groups can obtain greater environmental benefits from their green spaces because there is more space to use and enjoy. The high density, low socioeconomic, minority populations may have short distances to travel to reach a park, but the park will be of a smaller size, limiting the environmental benefits each person receives. In response to the second objective: a slight socioeconomic disparity among Atlanta populations can be found when assessing park accessibility with the consideration of park size.

The third goal was to determine where additional park space could be created to provide those Atlanta residents who have limited access to parks, a greater opportunity to enjoy the benefits of parks. The chosen methodology was to use the City of Atlanta's Future Land Use Plan to determine sites they classified as open spaces. It was this study's belief that these sites would be the most feasible for the City to turn into public parks. Results from the OD matrix between block groups without access and parks (existing and proposed parks) showed no increase of accessibility. However if this study was to argue for park development on these open sites, the Euclidean distance accessibility results did show an increase in park access for those formerly without. The Euclidean results showed several block groups would gain park access

within walking distance and several other block groups would gain park access within a biking distance, when using straight line measuring methods. Stakeholders would need to have a clear goal in mind when using these sites for future park development.

Although the City of Atlanta had been classified as a City with "intermediate-low" park acreage by the Trust for Public Land, park accessibility is relatively high for residents. It is important to recognize that while Atlanta may not have the recommended park acreage for its population, the city does provide accessible park space to 369,344 people. It is this study's belief that Atlanta does need to meet the park accessibility needs of those without easy access, however the current state of the City's park accessibility is not in a dire situation.

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APPENDICES

Appendix A - Maps

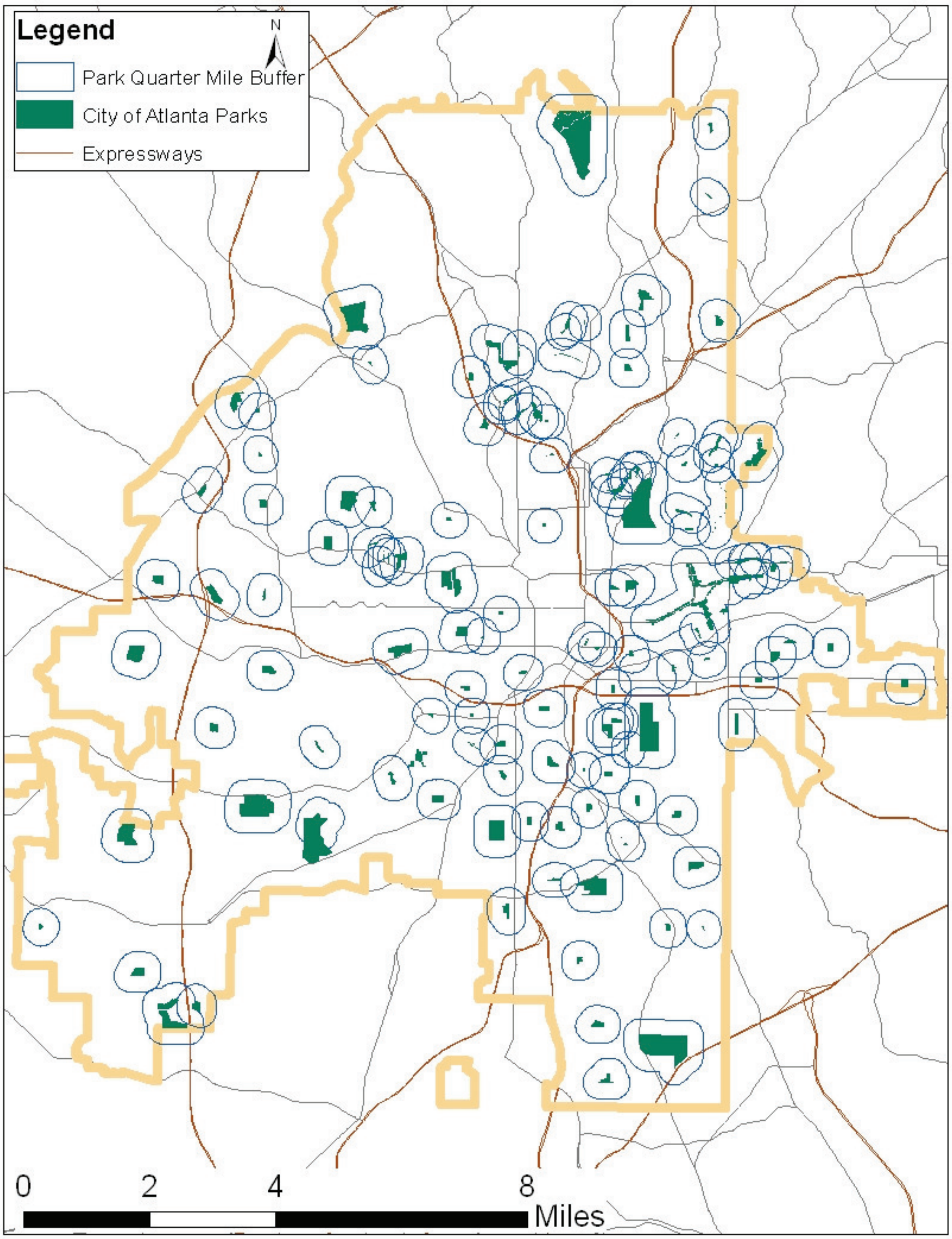

Figure 13 Quarter mile buffers

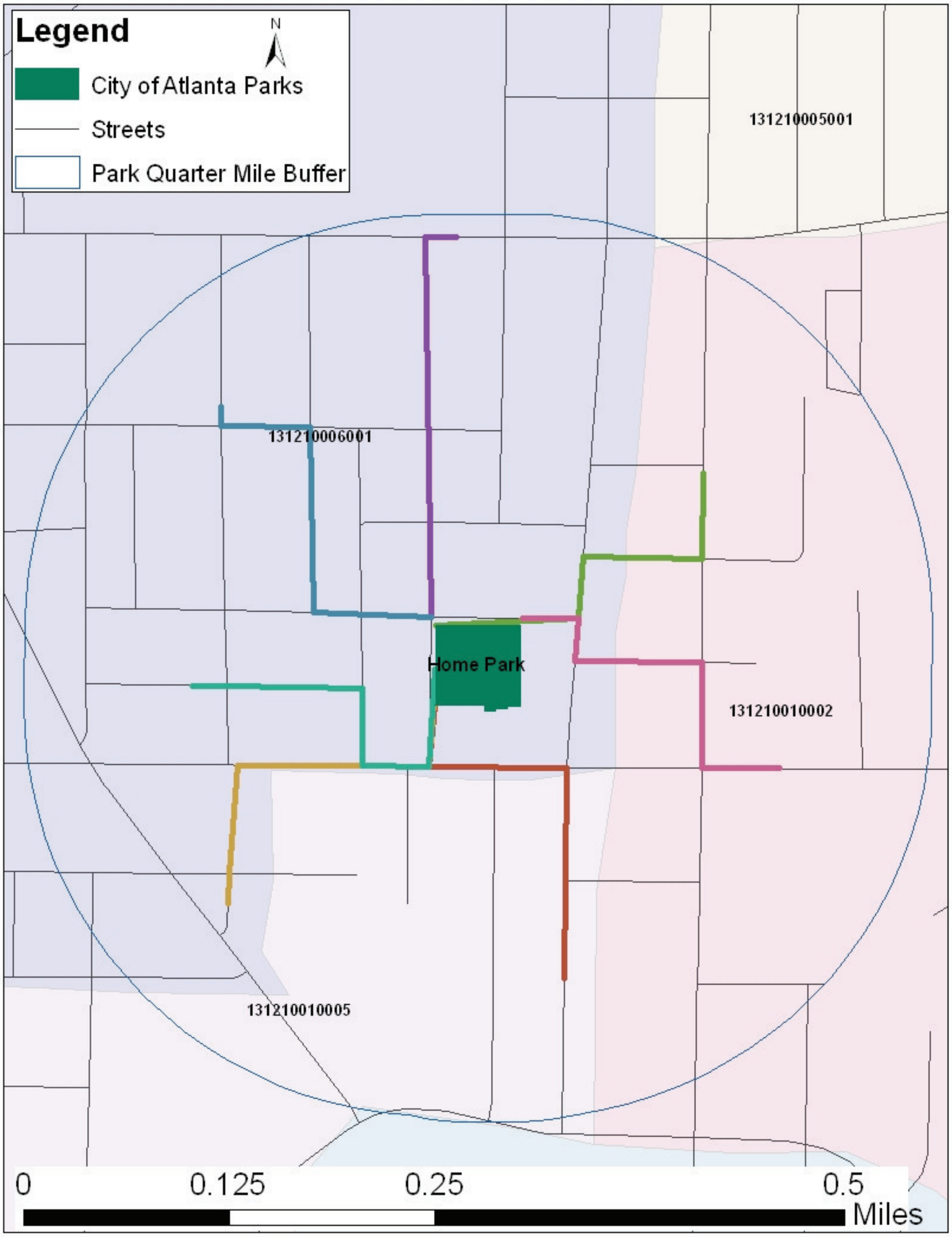

Figure 14 Road network

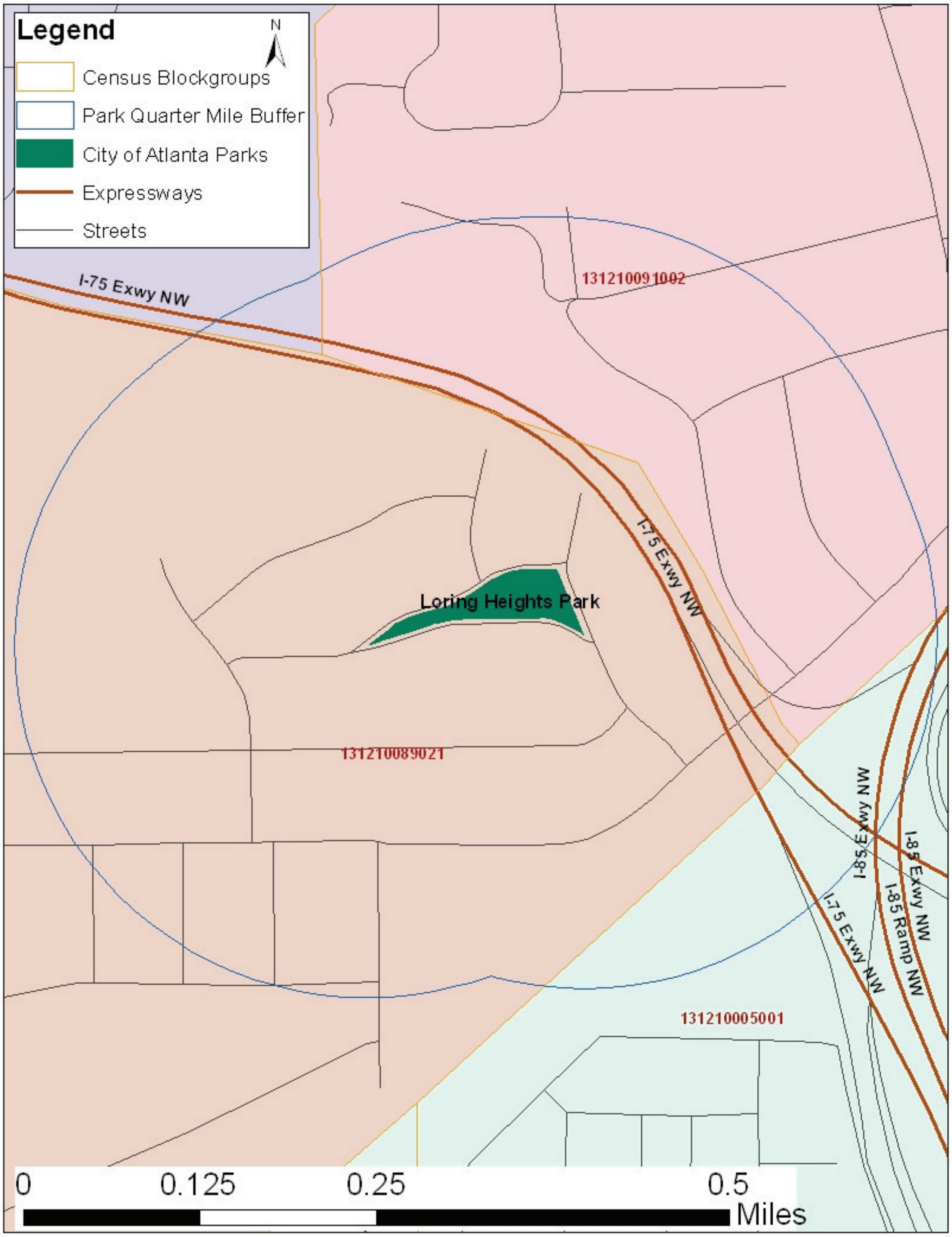

Figure 15 Buffer analysis

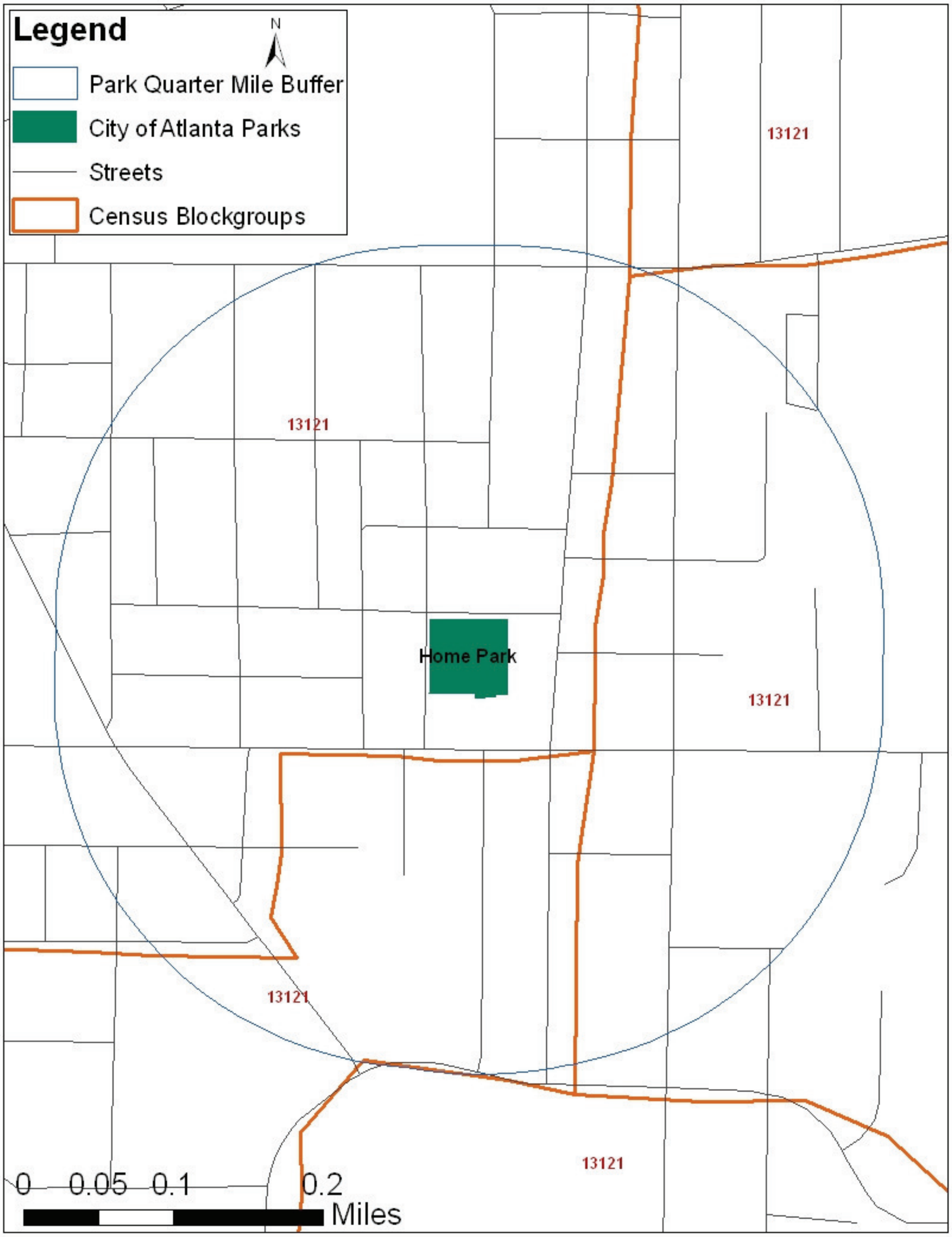

Figure 16 Quarter mile buffer analysis

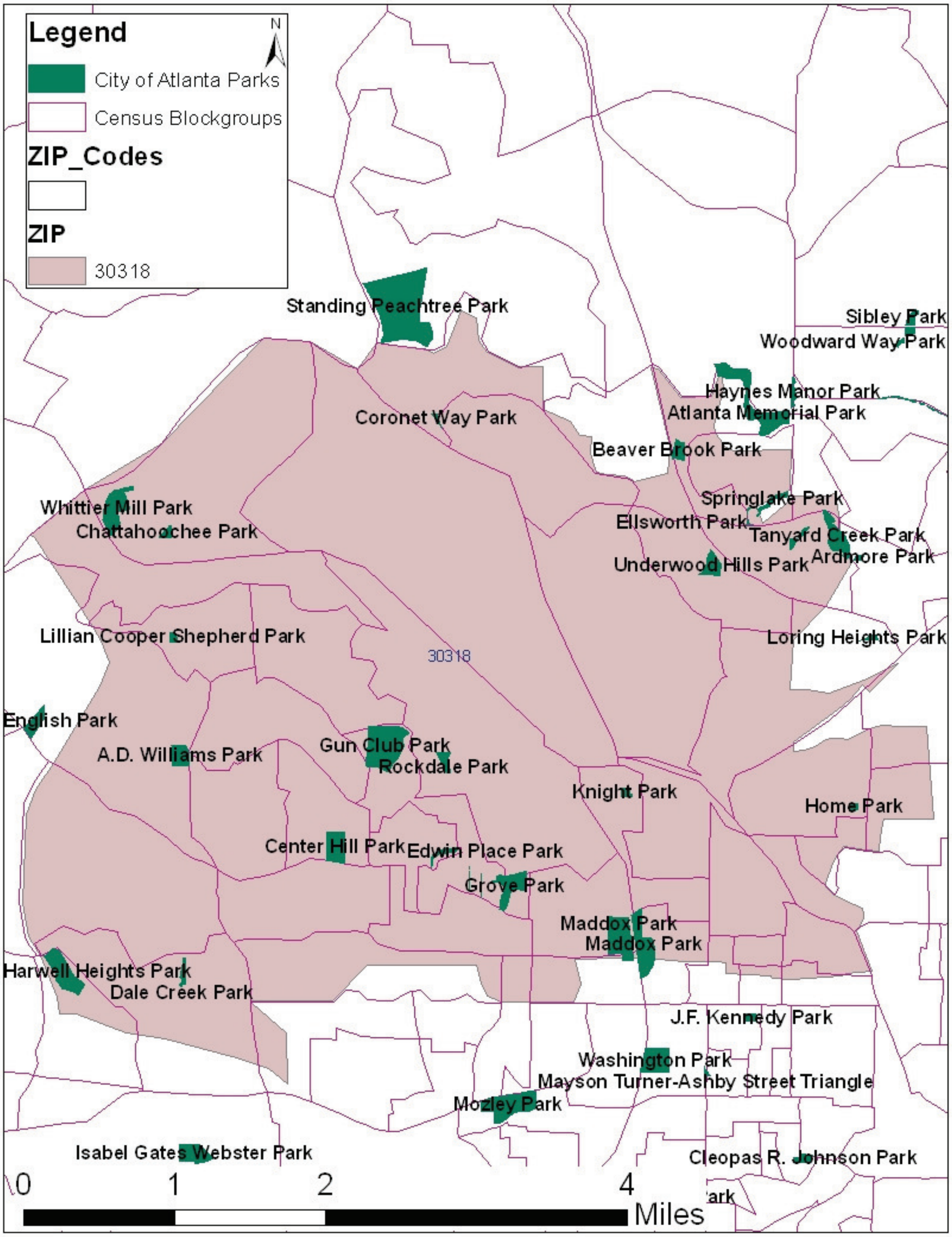

Figure 17 Zip Codes

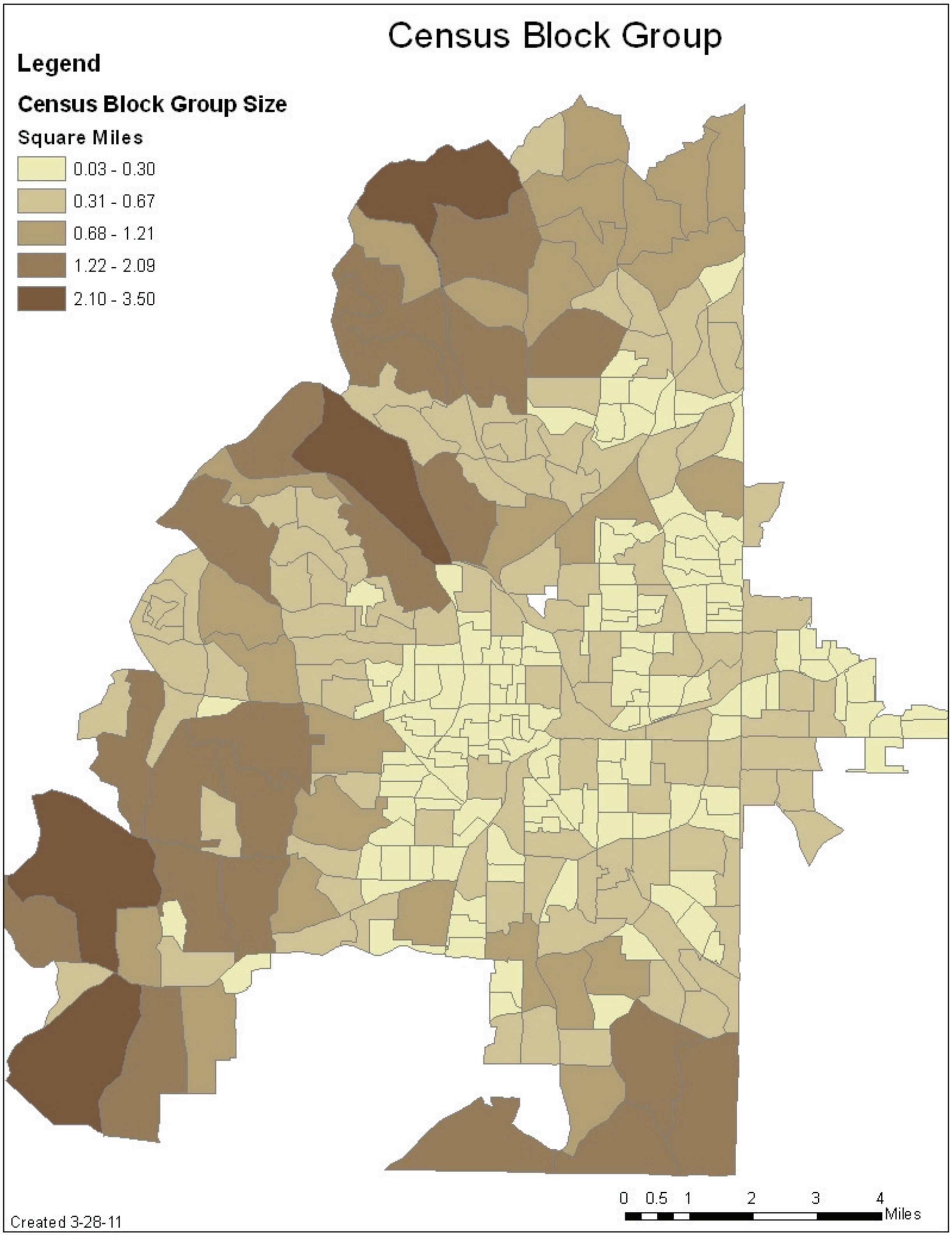

Figure 18 Census block group size

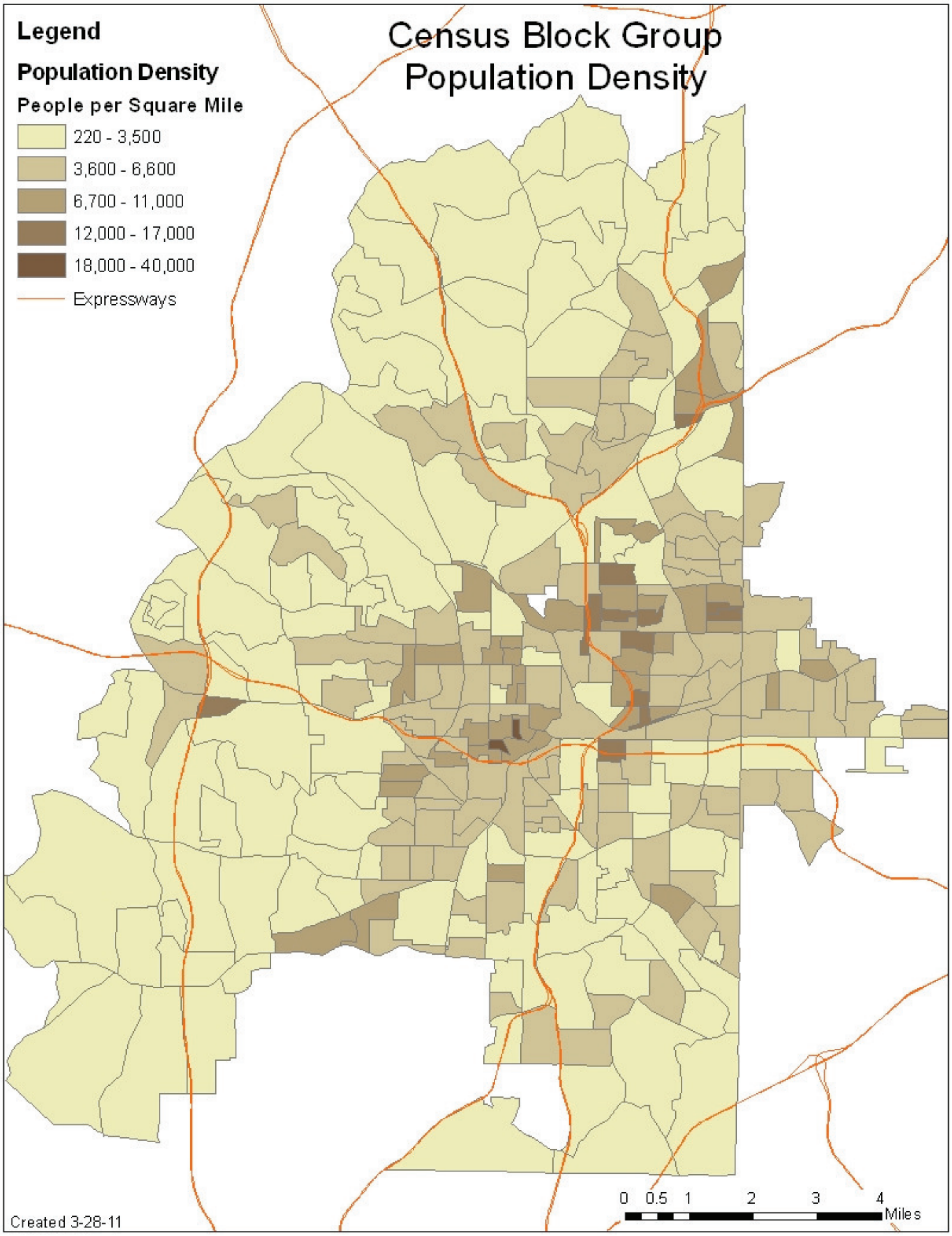

Figure 19 Census block group size

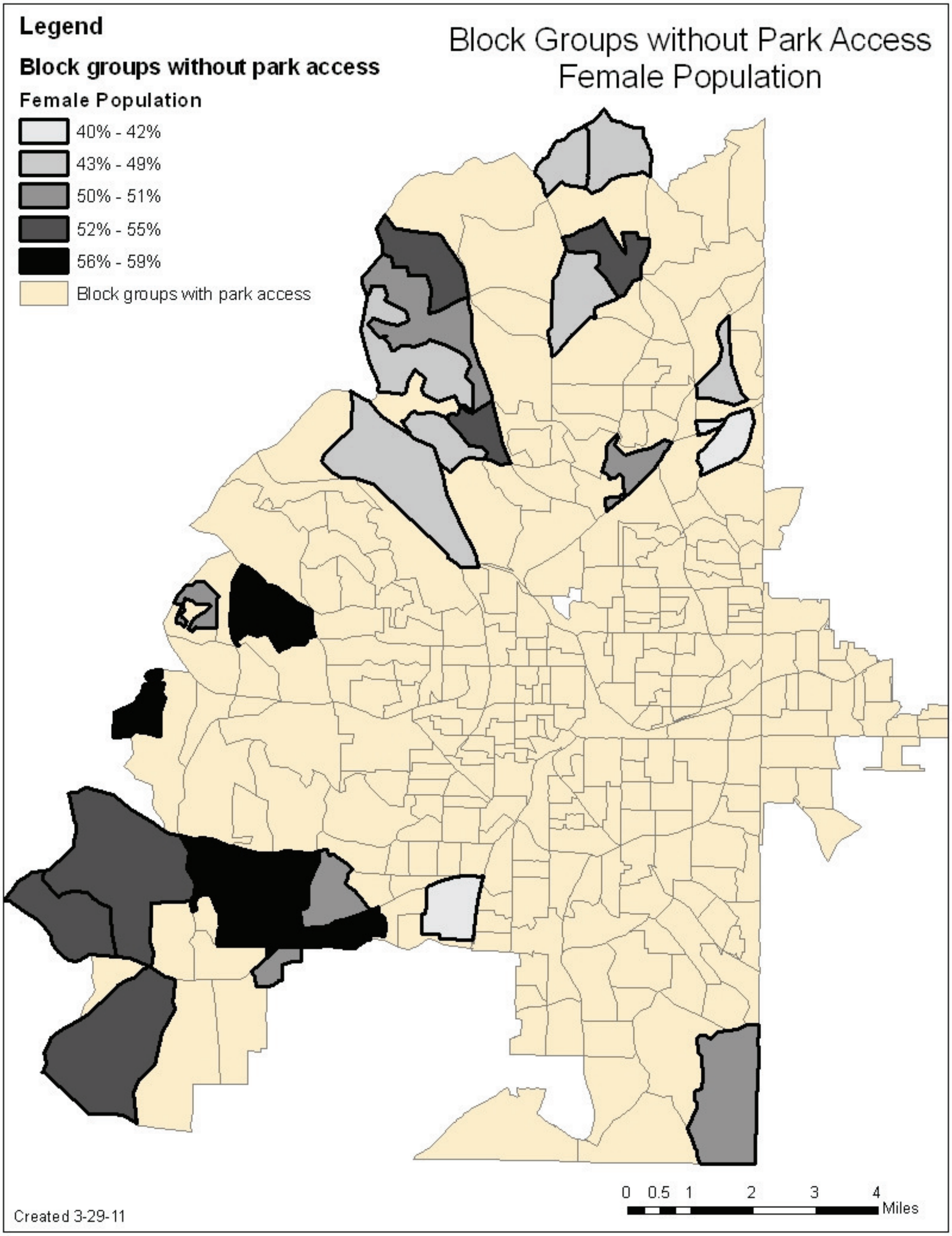

Figure 20 Female populations

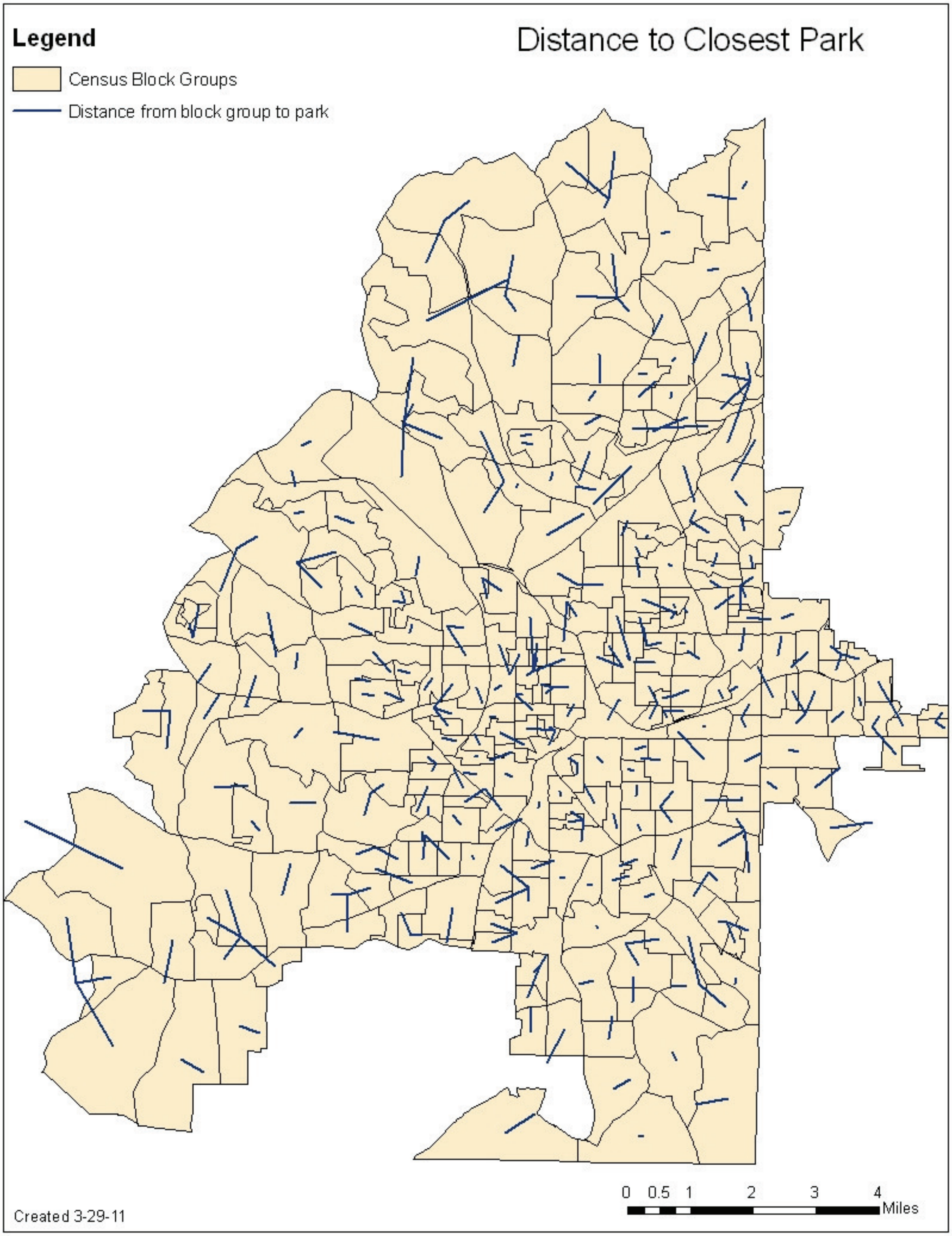

Figure 21 Euclidean distance to closest park

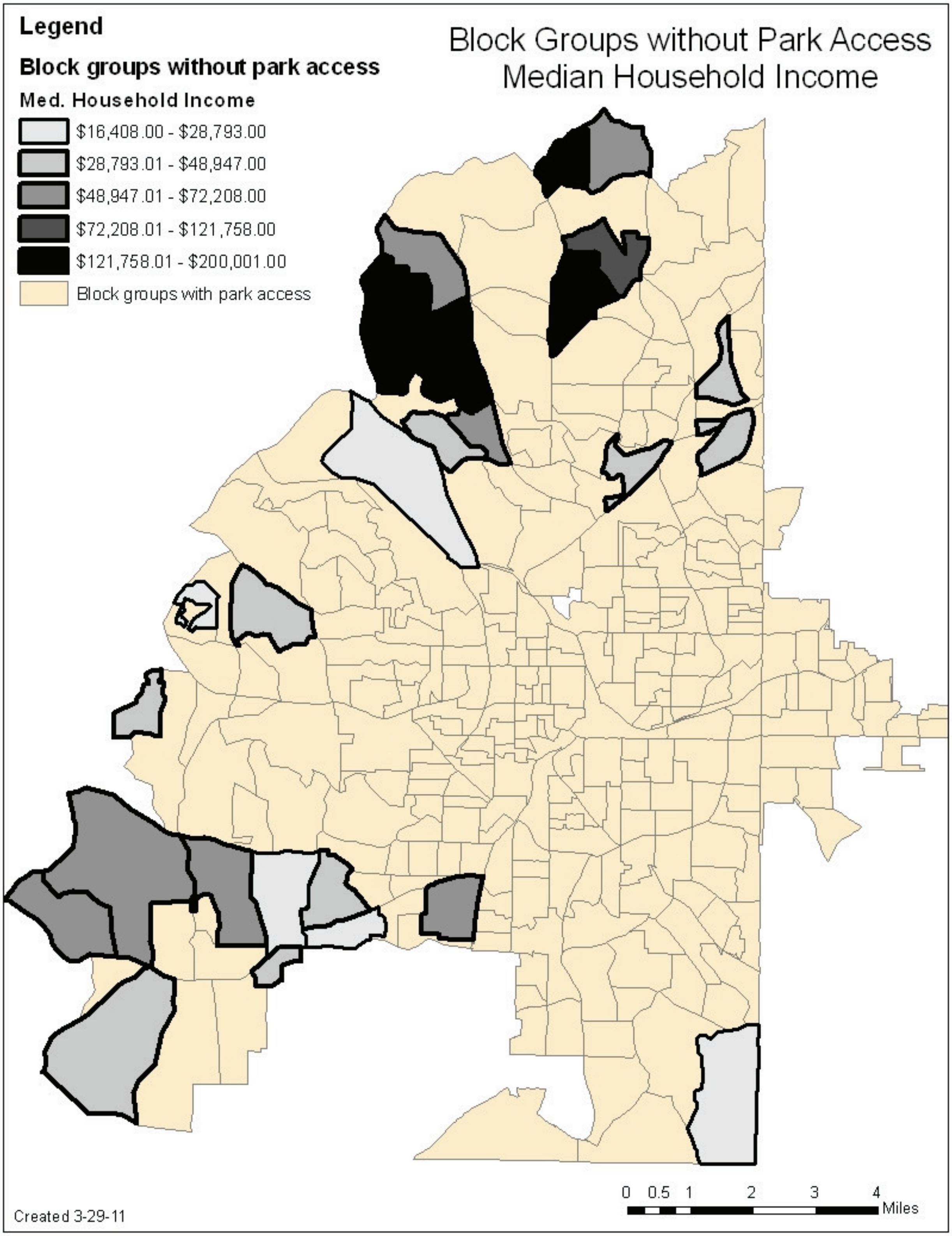

Figure 22 Median household income

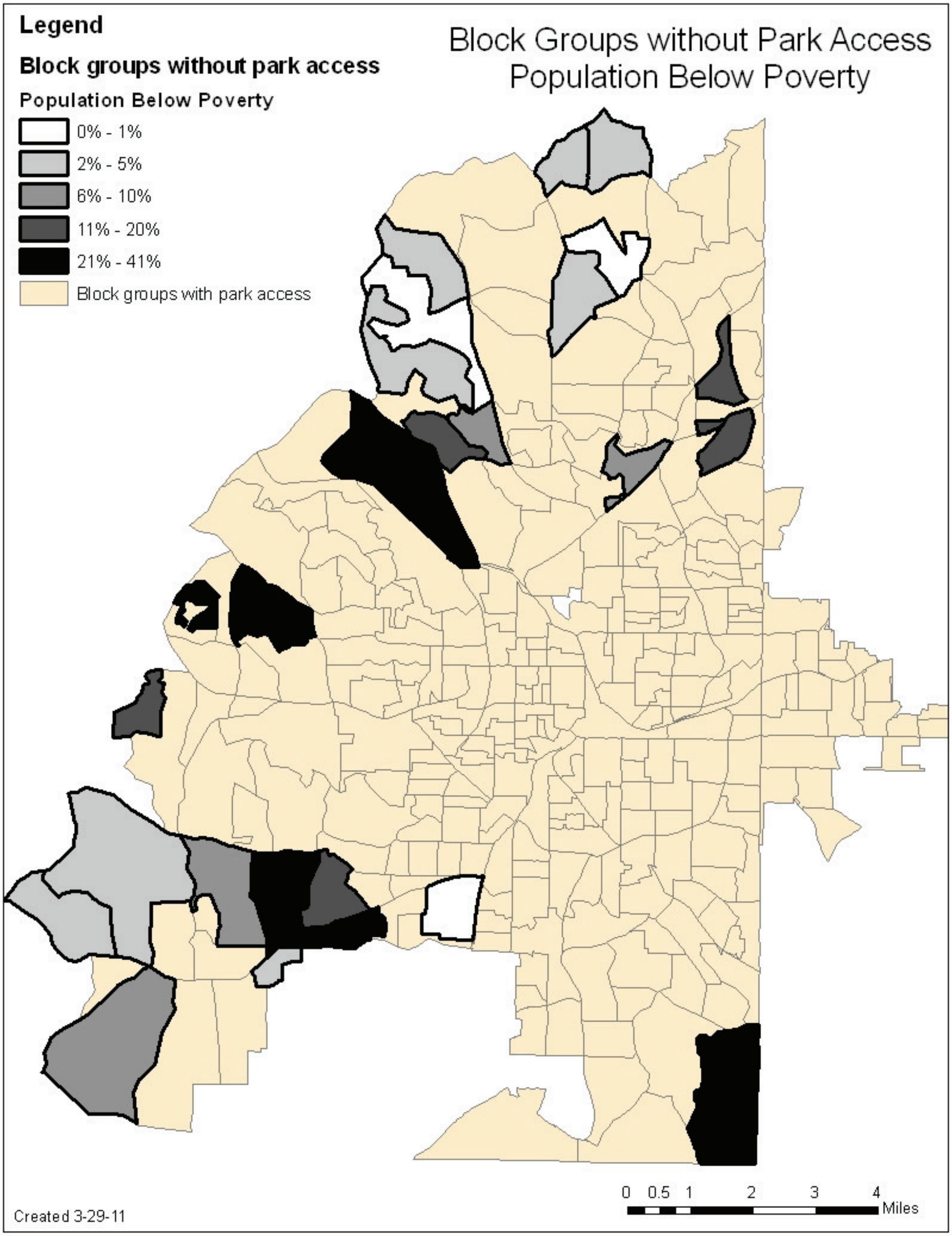

Figure 23 Population below poverty

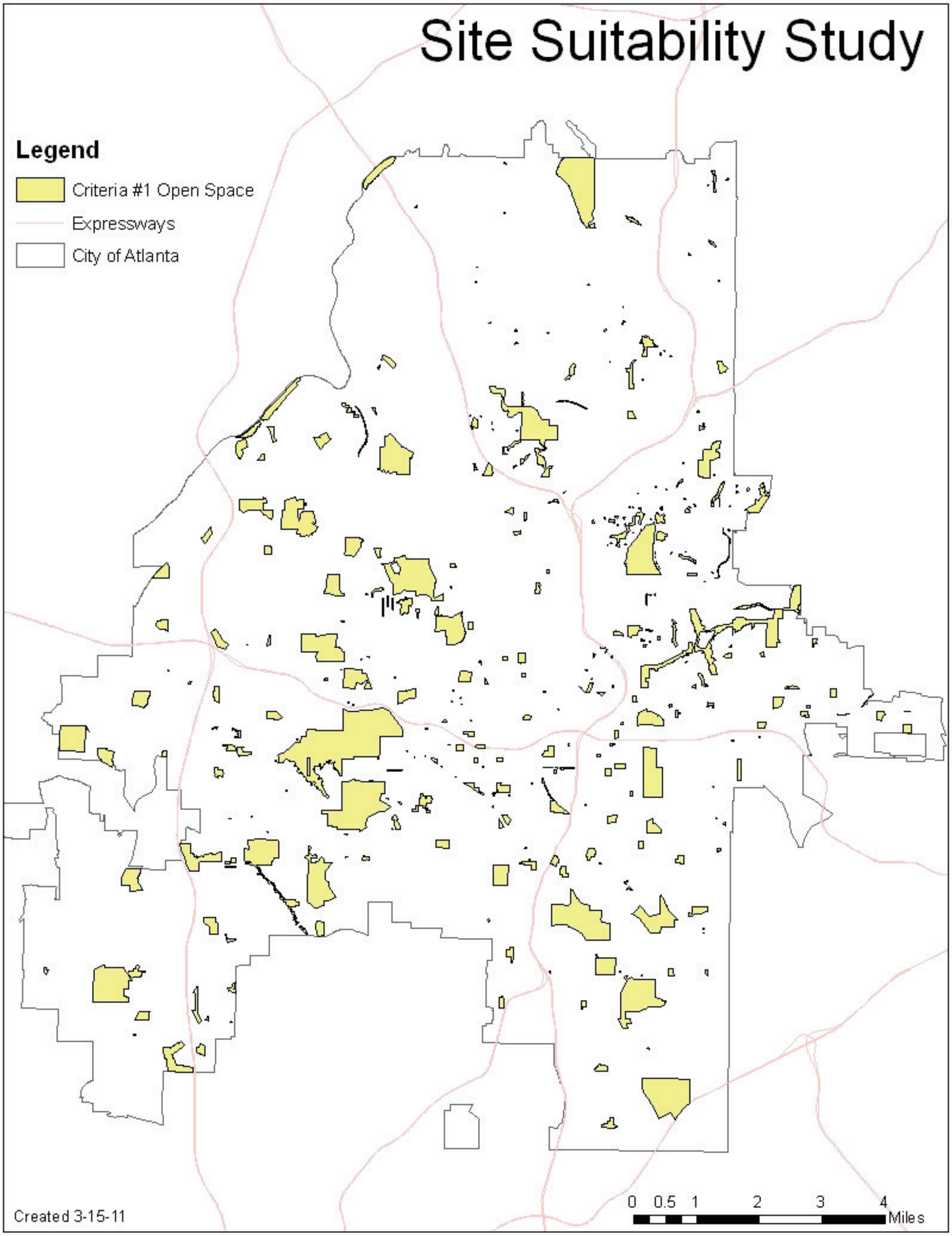

Figure 24 Site suitability criteria #1

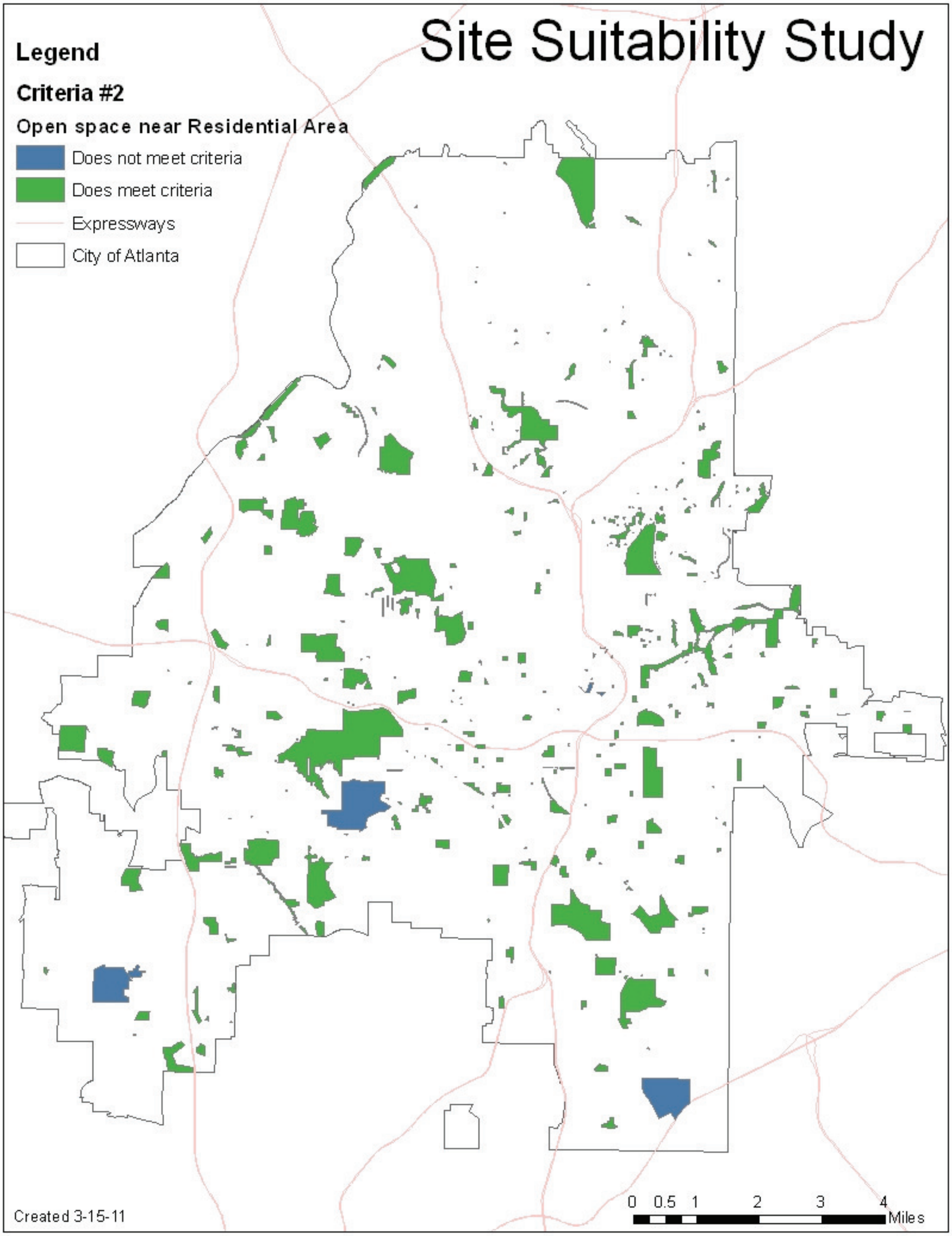

Figure 25 Site suitability criteria #2

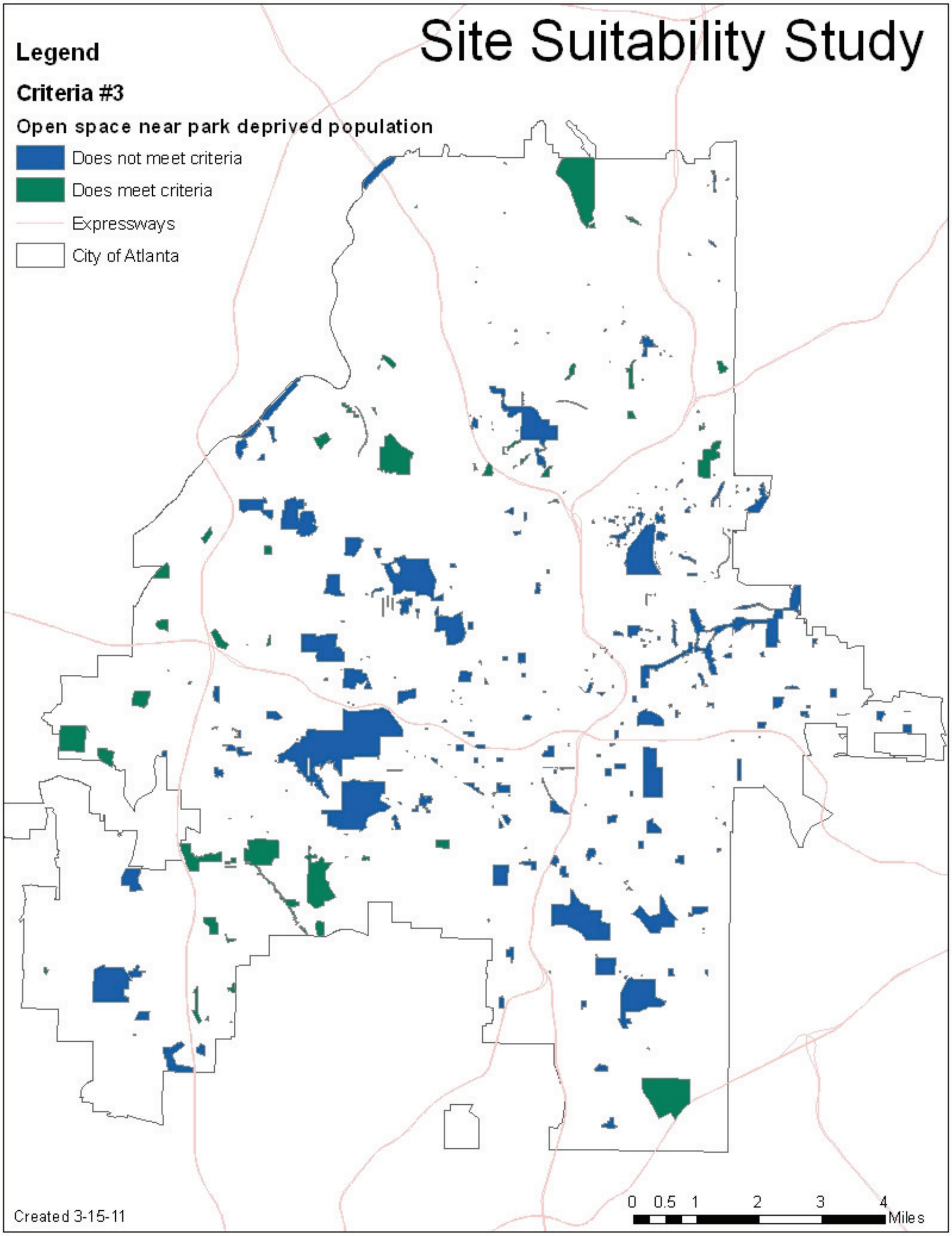

Figure 26 Site suitability criteria #3

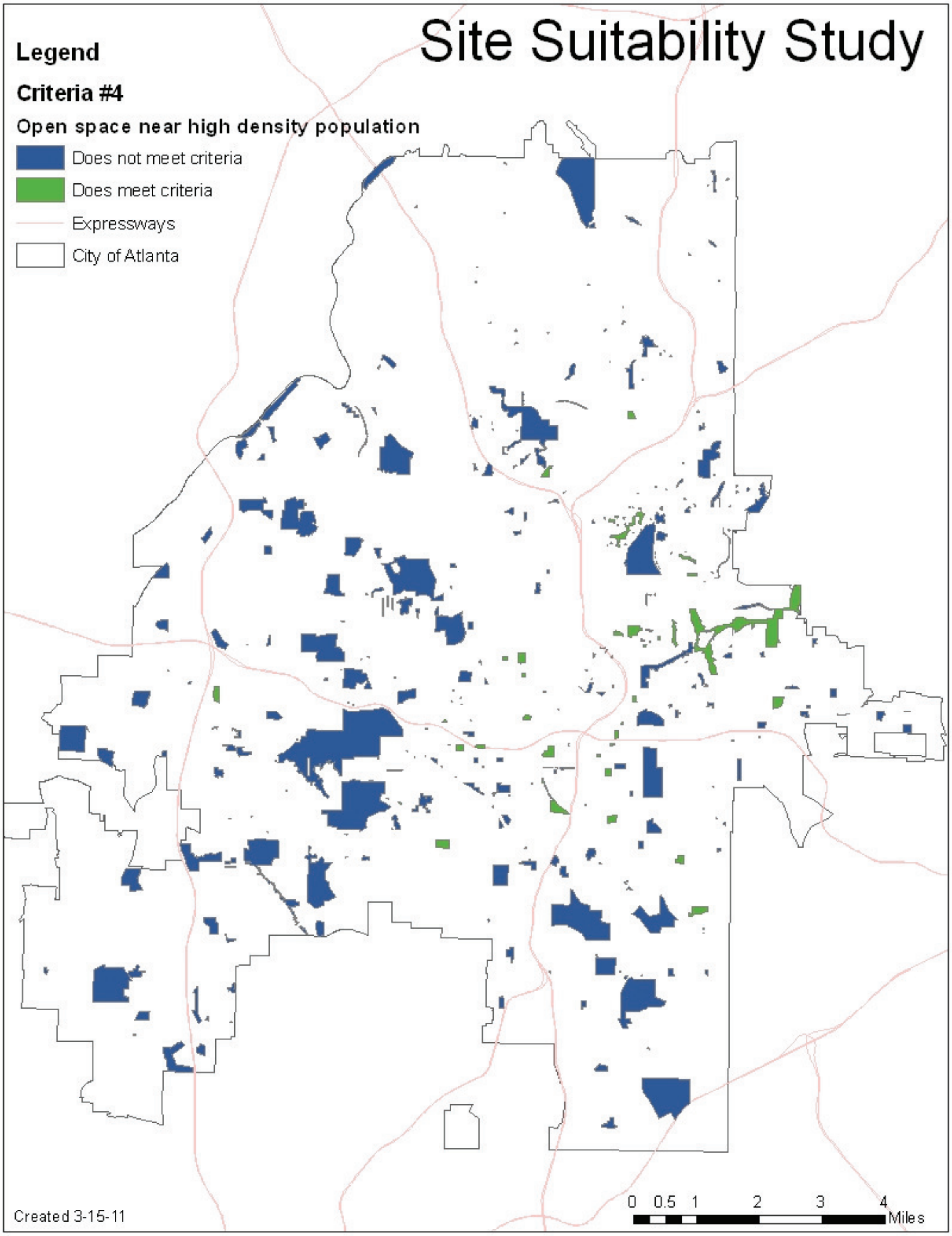

Figure 27 Site suitability criteria #4

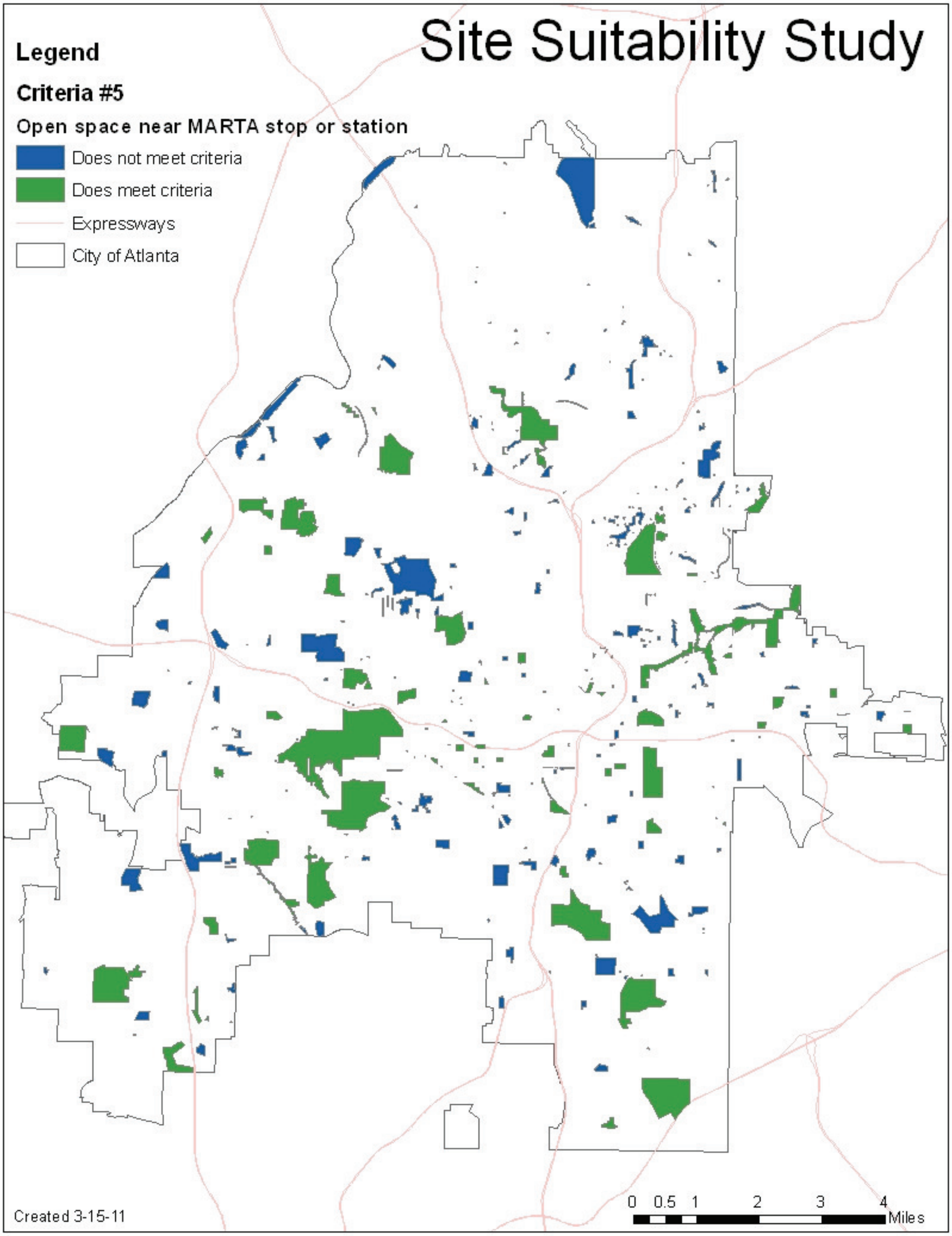

Figure 28 Site suitability criteria #5

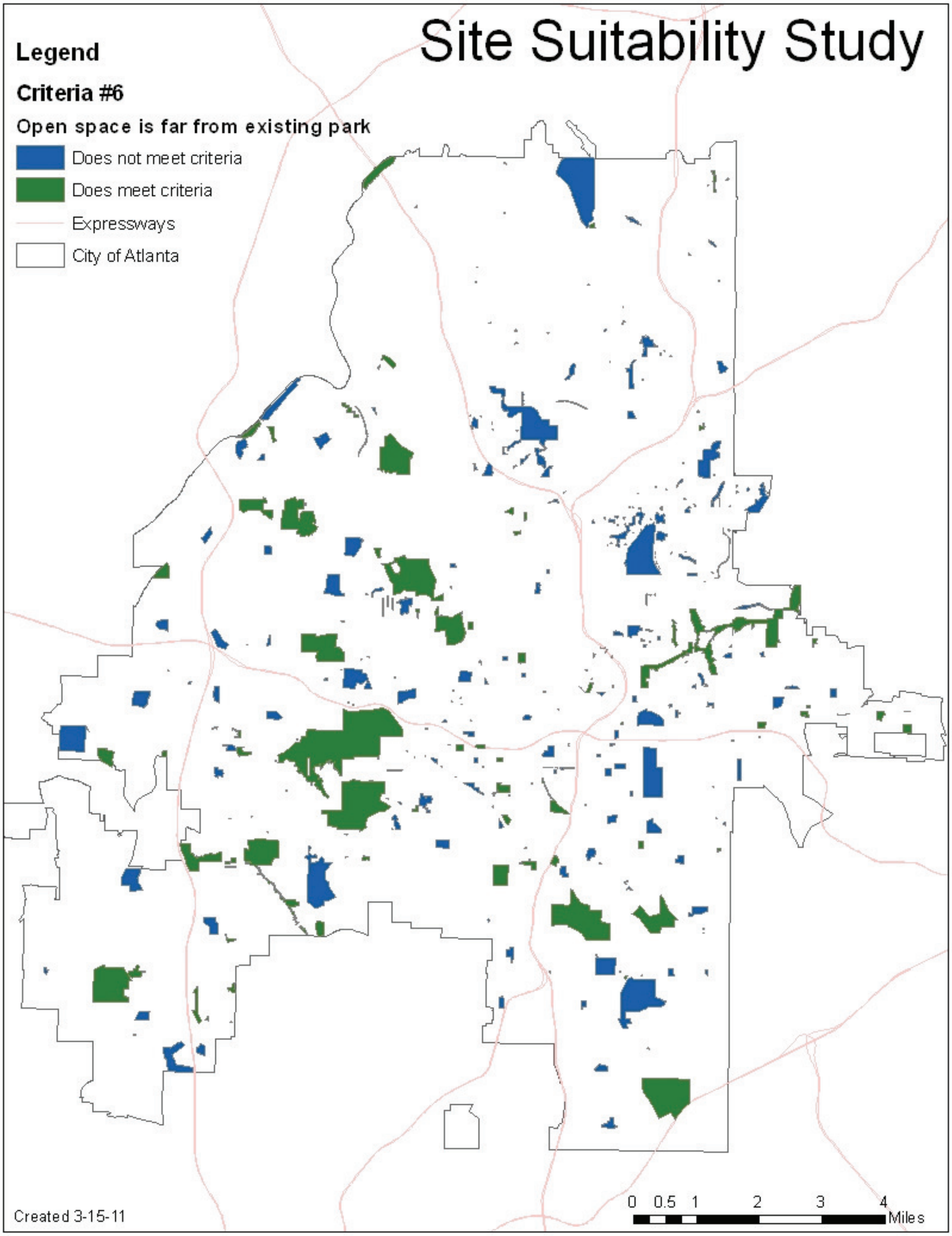

Figure 29 Site suitability criteria #6

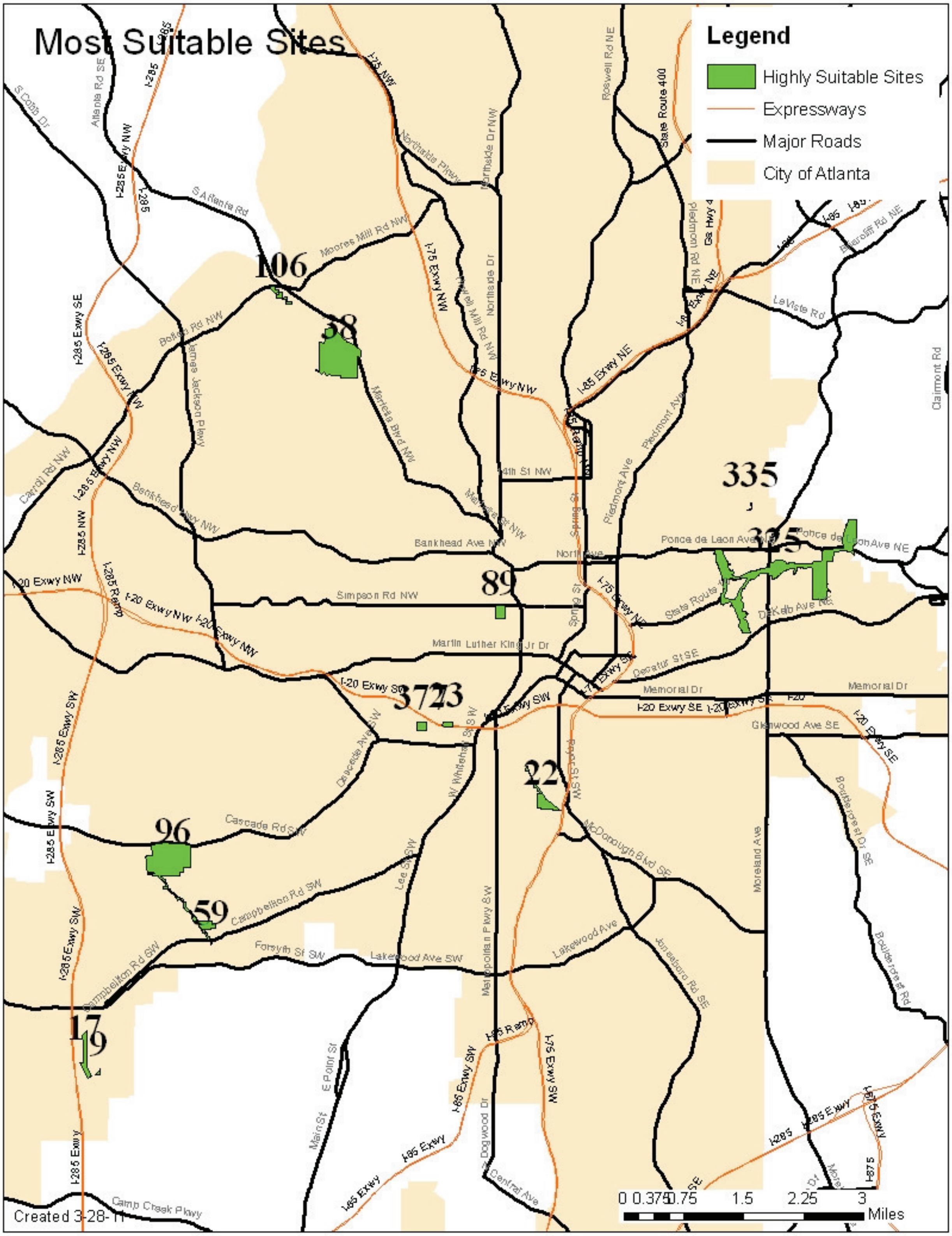

Figure 30 Highly suitable sites

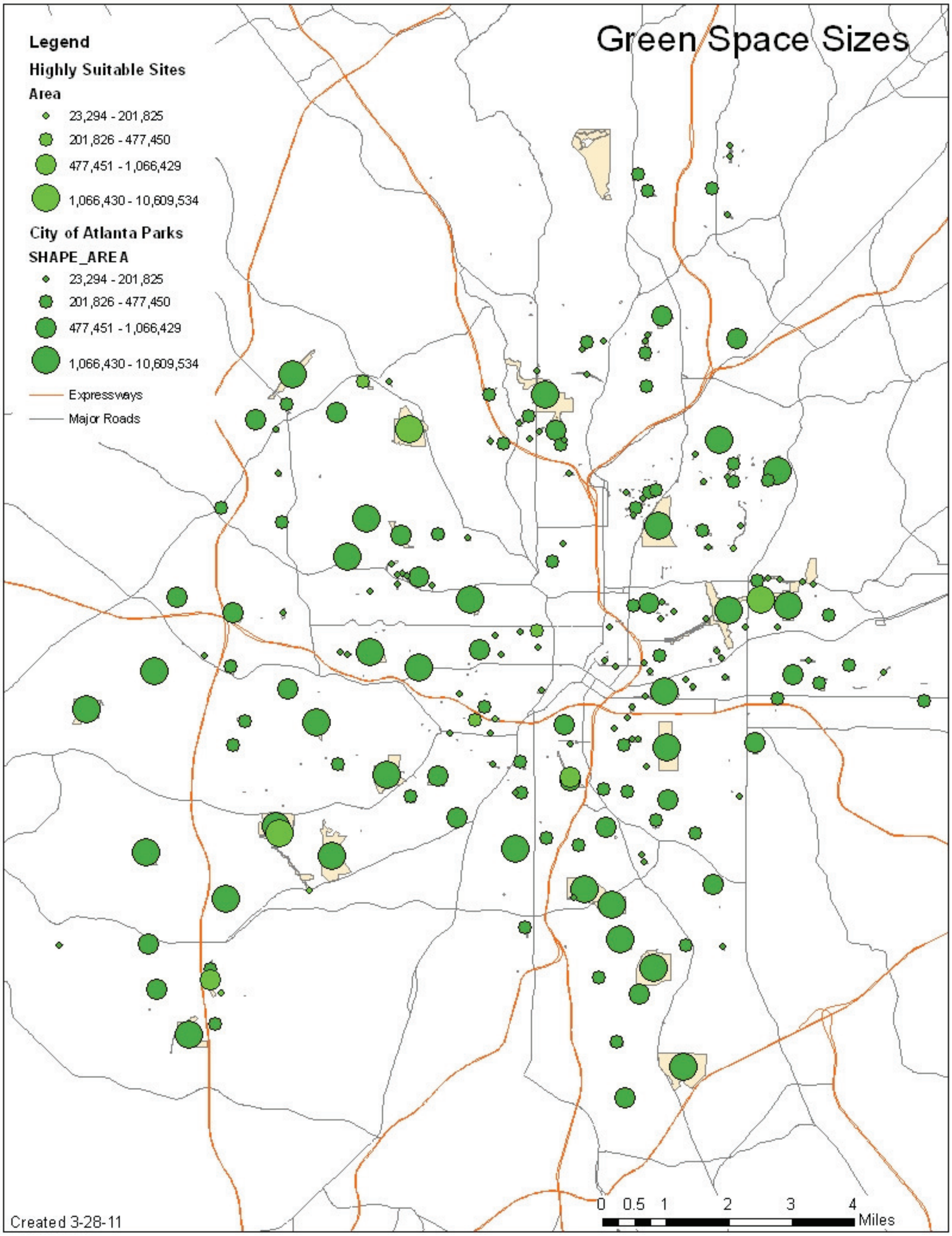

Figure 31 Green space sizes

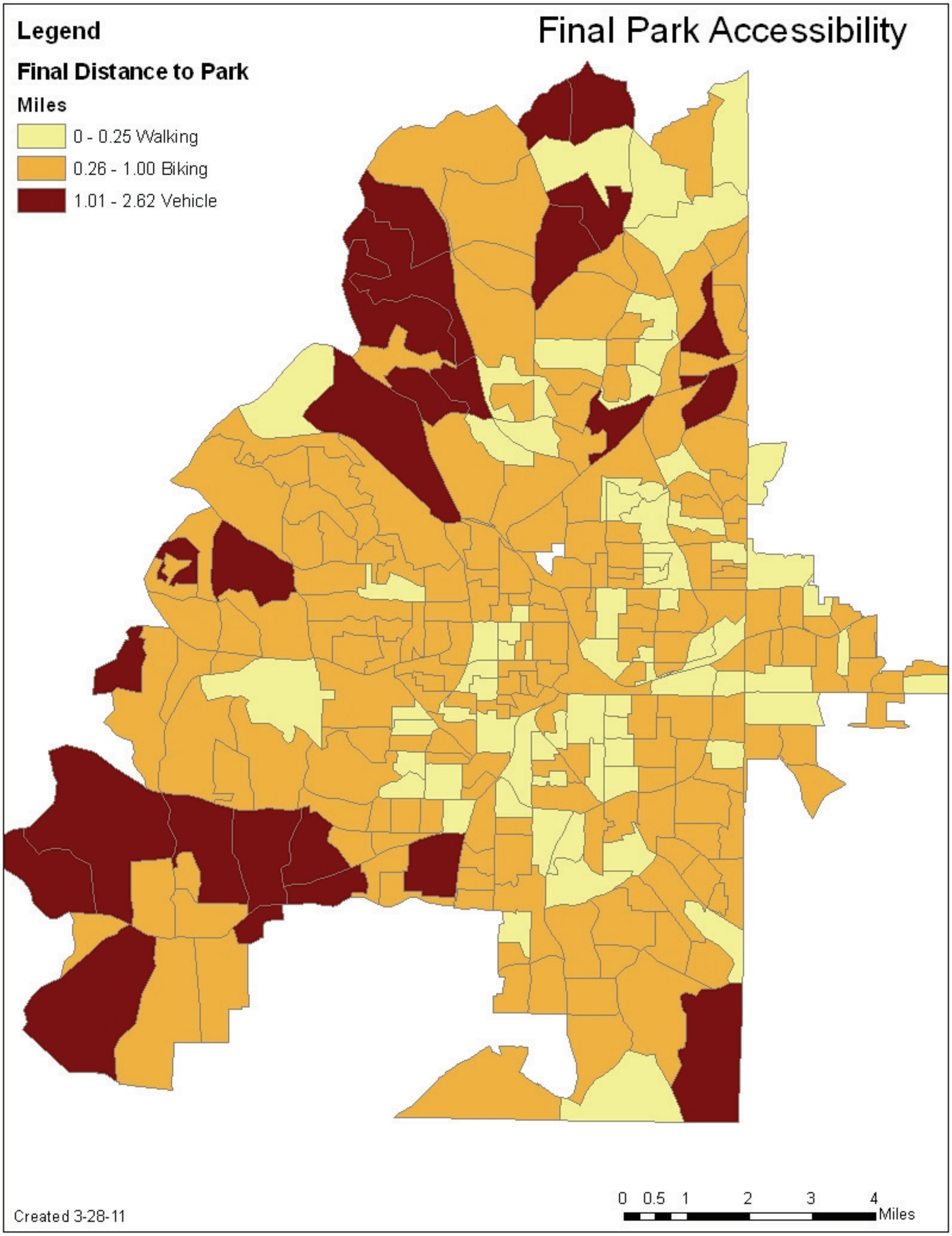

Figure 32 Final accessibility

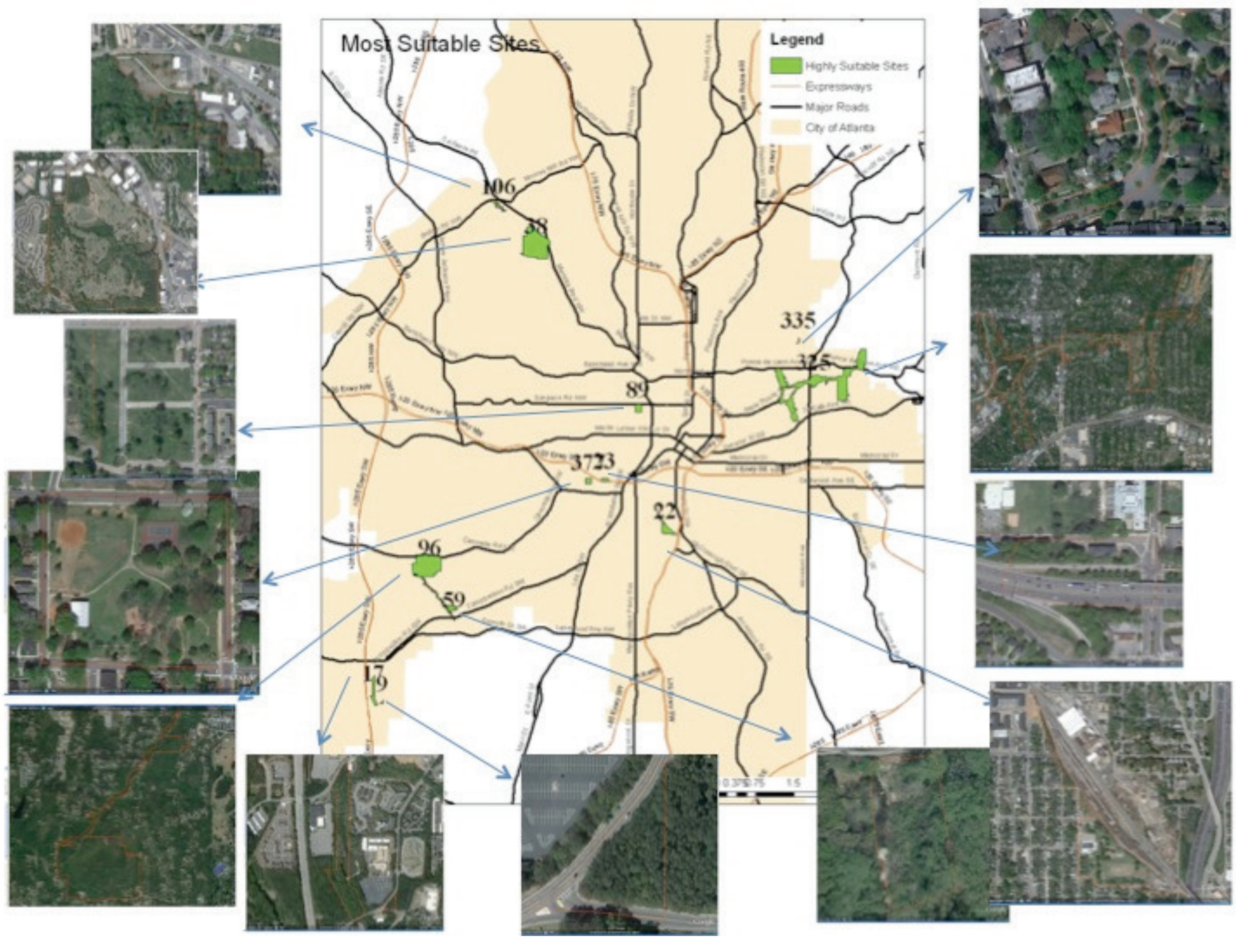

Figure 33 Highly suitable site locations

Appendix B – Driving Audit


Figure 34 Site #9 driving audit image 2


Figure 35 Site #9 driving audit image 3


Figure 36 Site #59 driving audit image 2


Figure 37 Site #59 driving audit image 3

Appendix C - Statistical Analysis

Regression Models Terminology

Dependent Variables	
WEIGSIZE	Census block groups were assigned a score based off of the size of their closest park (assigned by the simplified gravity model).
PARKDISTMI	Census block groups assigned a value based off of the distance to their closest park.
Independent Variables	
MINORITYTYPE	Minority population percentage
P053001	Median household income
PCTBELOWPO	Percentage of poverty living below poverty
POPDENSQMI	Population density (people per square mile)
FEMALEPERC	Female population percentage

Euclidean distance - Park Size as dependent variable

```
REGRESSION
SUMMARY OF OUTPUT: ORDINARY LEAST SQUARES ESTIMATION
Data set            : apr7_ecludDist_cbg_park_sizeweight_allData
Dependent Variable  :    WEIGSIZE  Number of Observations:  293
Mean dependent var  :   0.0146495  Number of Variables   :    2
S.D. dependent var  :   0.0533231  Degrees of Freedom    :  291

R-squared           :    0.009069  F-statistic           :     2.66338
Adjusted R-squared  :    0.005664  Prob(F-statistic)     :    0.103764
Sum squared residual:    0.825546  Log likelihood        :     444.482
Sigma-square        :  0.00283693  Akaike info criterion :    -884.964
S.E. of regression  :   0.0532628  Schwarz criterion     :    -877.603
Sigma-square ML     :  0.00281756
S.E of regression ML:   0.0530807
-----------------------------------------------------------------------
    Variable    Coefficient     Std.Error    t-Statistic   Probability
-----------------------------------------------------------------------
    CONSTANT    0.02387046    0.006450337      3.700653    0.0002571
  MINORITYPE   -0.01358176    0.008322223     -1.631986    0.1037637
-----------------------------------------------------------------------
REGRESSION DIAGNOSTICS
MULTICOLLINEARITY CONDITION NUMBER   3.88878
TEST ON NORMALITY OF ERRORS
TEST                 DF        VALUE          PROB
Jarque-Bera           2         39255.99       0.0000000

DIAGNOSTICS FOR HETEROSKEDASTICITY
RANDOM COEFFICIENTS
TEST                 DF        VALUE          PROB
```

Breusch-Pagan test 1 121.535 0.0000000
Koenker-Bassett test 1 4.268026 0.0388360
SPECIFICATION ROBUST TEST

TEST	DF	VALUE	PROB
White	2	4.26818	0.1183522

========================= END OF REPORT ==============================

<u>REGRESSION</u>
<u>SUMMARY OF OUTPUT: SPATIAL LAG MODEL - MAXIMUM LIKELIHOOD ESTIMATION</u>
Data set : apr7_ecludDist_cbg_park_sizeweight_allData
Spatial Weight : mar17_geoda_createdWeight.GWT
Dependent Variable : WEIGSIZE Number of Observations: 293
Mean dependent var : 0.0146495 Number of Variables : 3
S.D. dependent var : 0.0533231 Degrees of Freedom : 290
Lag coeff. (Rho) : 0.0047772

R-squared : 0.009076 Log likelihood : 444.482
Sq. Correlation : - Akaike info criterion : -882.965
Sigma-square : 0.00281755 Schwarz criterion : -871.924
S.E of regression : 0.0530806

Variable	Coefficient	Std.Error	z-value	Probability
W_WEIGSIZE	0.004777201	0.137372	0.03477567	0.9722585
CONSTANT	0.02376528	0.007091898	3.351046	0.0008052
MINORITYPE	-0.01353075	0.008421255	-1.606738	0.1081118

REGRESSION DIAGNOSTICS
DIAGNOSTICS FOR HETEROSKEDASTICITY
RANDOM COEFFICIENTS

TEST	DF	VALUE	PROB
Breusch-Pagan test	1	121.551	0.0000000

<u>DIAGNOSTICS FOR SPATIAL DEPENDENCE</u>
SPATIAL LAG DEPENDENCE FOR WEIGHT MATRIX :
mar17_geoda_createdWeight.GWT

TEST	DF	VALUE	PROB
Likelihood Ratio Test	1	0.00124459	0.9718575

========================= END OF REPORT ==============================

REGRESSION
SUMMARY OF OUTPUT: ORDINARY LEAST SQUARES ESTIMATION
Data set : apr7_ecludDist_cbg_park_sizeweight_allData
Dependent Variable : WEIGSIZE Number of Observations: 293
Mean dependent var : 0.0146495 Number of Variables : 2
S.D. dependent var : 0.0533231 Degrees of Freedom : 291

R-squared : 0.000227 F-statistic : 0.0660197
Adjusted R-squared : -0.003209 Prob(F-statistic) : 0.797415
Sum squared residual: 0.832913 Log likelihood : 443.18
Sigma-square : 0.00286224 Akaike info criterion : -882.361
S.E. of regression : 0.0534999 Schwarz criterion : -875
Sigma-square ML : 0.00284271
S.E of regression ML: 0.053317

Variable	Coefficient	Std.Error	t-Statistic	Probability
CONSTANT	0.01367033	0.004928471	2.773747	0.0058996
P053001	2.397781e-008	9.331959e-008	0.256943	0.7974151

REGRESSION DIAGNOSTICS
MULTICOLLINEARITY CONDITION NUMBER 2.796072
(Extreme Multicollinearity)
TEST ON NORMALITY OF ERRORS

TEST	DF	VALUE	PROB
Jarque-Bera	2	41462.44	0.0000000

DIAGNOSTICS FOR HETEROSKEDASTICITY
RANDOM COEFFICIENTS

TEST	DF	VALUE	PROB
Breusch-Pagan test	1	0.7246704	0.3946162
Koenker-Bassett test	1	0.02477548	0.8749278

SPECIFICATION ROBUST TEST

TEST	DF	VALUE	PROB
White	2	3.054144	0.2171706

======================== END OF REPORT
================================

REGRESSION
SUMMARY OF OUTPUT: SPATIAL LAG MODEL - MAXIMUM LIKELIHOOD ESTIMATION
Data set : apr7_ecludDist_cbg_park_sizeweight_allData
Spatial Weight : mar17_geoda_createdWeight.GWT
Dependent Variable : WEIGSIZE Number of Observations: 293

```
Mean dependent var  :   0.0146495  Number of Variables   :    3
S.D. dependent var  :   0.0533231  Degrees of Freedom    :  290
Lag coeff.   (Rho)  :   0.0381732

R-squared           :    0.000626  Log likelihood        :     443.221
Sq. Correlation     : -            Akaike info criterion :    -880.442
Sigma-square        :  0.00284157  Schwarz criterion     :    -869.401
S.E of regression   :   0.0533064

--------------------------------------------------------------------
    Variable    Coefficient     Std.Error    z-value      Probability
--------------------------------------------------------------------
  W_WEIGSIZE    0.03817322      0.1359881     0.2807101    0.7789329
    CONSTANT    0.01323696    0.005272613      2.510512    0.0120557
     P053001  2.078354e-008             0        1.#INF   -1.#IND000
--------------------------------------------------------------------

REGRESSION DIAGNOSTICS
DIAGNOSTICS FOR HETEROSKEDASTICITY
RANDOM COEFFICIENTS
TEST                             DF     VALUE        PROB
Breusch-Pagan test                1      0.7290005     0.3932074

DIAGNOSTICS FOR SPATIAL DEPENDENCE
SPATIAL LAG DEPENDENCE FOR WEIGHT MATRIX :
mar17_geoda_createdWeight.GWT
TEST                             DF     VALUE        PROB
Likelihood Ratio Test             1     0.08095741     0.7760041
========================== END OF REPORT
===============================
```

```
REGRESSION
SUMMARY OF OUTPUT: ORDINARY LEAST SQUARES ESTIMATION
Data set            : apr7_ecludDist_cbg_park_sizeweight_allData
Dependent Variable  :     WEIGSIZE  Number of Observations:  293
Mean dependent var  :   0.0146495  Number of Variables   :    2
S.D. dependent var  :   0.0533231  Degrees of Freedom    :  291

R-squared           :    0.005602  F-statistic           :     1.63924
Adjusted R-squared  :    0.002184  Prob(F-statistic)     :    0.201449
Sum squared residual:    0.828435  Log likelihood        :      443.97
Sigma-square        :  0.00284686  Akaike info criterion :     -883.94
S.E. of regression  :   0.0533559  Schwarz criterion     :     -876.58
Sigma-square ML     :  0.00282742
S.E of regression ML:   0.0531735
```

```
----------------------------------------------------------------------
   Variable    Coefficient     Std.Error    t-Statistic   Probability
----------------------------------------------------------------------
   CONSTANT    0.02003697    0.005236687       3.826269    0.0001593
 PCTBELOWPO   -0.02177862     0.01701021      -1.280327    0.2014488
----------------------------------------------------------------------

REGRESSION DIAGNOSTICS
MULTICOLLINEARITY CONDITION NUMBER   3.029948
TEST ON NORMALITY OF ERRORS
TEST                  DF         VALUE           PROB
Jarque-Bera            2          40336.23        0.0000000

DIAGNOSTICS FOR HETEROSKEDASTICITY
RANDOM COEFFICIENTS
TEST                  DF         VALUE           PROB
Breusch-Pagan test     1          41.34768        0.0000000
Koenker-Bassett test   1          1.432823        0.2313043
SPECIFICATION ROBUST TEST
TEST                  DF         VALUE           PROB
White                  2          2.64088         0.2670178
========================= END OF REPORT
=================================
```

```
REGRESSION
SUMMARY OF OUTPUT: SPATIAL LAG MODEL - MAXIMUM LIKELIHOOD
ESTIMATION
Data set            : apr7_ecludDist_cbg_park_sizeweight_allData
Spatial Weight      : mar17_geoda_createdWeight.GWT
Dependent Variable  :    WEIGSIZE  Number of Observations:  293
Mean dependent var  :   0.0146495  Number of Variables   :    3
S.D. dependent var  :   0.0533231  Degrees of Freedom    :  290
Lag coeff.   (Rho)  :   0.0207382

R-squared           :    0.005718  Log likelihood        :     443.982
Sq. Correlation     : -            Akaike info criterion :    -881.964
Sigma-square        :  0.00282709  Schwarz criterion     :    -870.923
S.E of regression   :   0.0531704

----------------------------------------------------------------------
   Variable    Coefficient     Std.Error    z-value       Probability
----------------------------------------------------------------------
 W_WEIGSIZE    0.02073817      0.1364867      0.1519428    0.8792320
   CONSTANT    0.01964858    0.005716702       3.437049    0.0005882
 PCTBELOWPO   -0.02144678     0.01700921      -1.260892    0.2073479
```

```
-----------------------------------------------------------------------

REGRESSION DIAGNOSTICS
DIAGNOSTICS FOR HETEROSKEDASTICITY
RANDOM COEFFICIENTS
TEST                          DF    VALUE       PROB
Breusch-Pagan test             1      41.37671    0.0000000

DIAGNOSTICS FOR SPATIAL DEPENDENCE
SPATIAL LAG DEPENDENCE FOR WEIGHT MATRIX :
mar17_geoda_createdWeight.GWT
TEST                          DF    VALUE       PROB
Likelihood Ratio Test          1    0.02382691    0.8773261
========================= END OF REPORT
================================
```

```
REGRESSION
SUMMARY OF OUTPUT: SPATIAL LAG MODEL - MAXIMUM LIKELIHOOD
ESTIMATION
Data set          : apr7_ecludDist_cbg_park_sizeweight_allData
Spatial Weight      : mar17_geoda_createdWeight.GWT
Dependent Variable  :    WEIGSIZE  Number of Observations:  293
Mean dependent var  :   0.0146495  Number of Variables   :    3
S.D. dependent var  :   0.0533231  Degrees of Freedom    :  290
Lag coeff.   (Rho)  :   0.0454323

R-squared          :    0.005864  Log likelihood        :     443.983
Sq. Correlation    : -            Akaike info criterion :    -881.966
Sigma-square       :  0.00282668  Schwarz criterion     :    -870.926
S.E of regression  :   0.0531665

-----------------------------------------------------------------------
    Variable    Coefficient     Std.Error    z-value     Probability
-----------------------------------------------------------------------
  W_WEIGSIZE     0.0454323      0.1351821      0.3360823    0.7368089
    CONSTANT    0.01875136    0.005338627      3.512395    0.0004442
  POPDENSQMI  -9.757293e-007   7.770902e-007     -1.255619    0.2092543
-----------------------------------------------------------------------

REGRESSION DIAGNOSTICS
DIAGNOSTICS FOR HETEROSKEDASTICITY
RANDOM COEFFICIENTS
TEST                          DF    VALUE       PROB
Breusch-Pagan test             1      8.030338    0.0046000
```

DIAGNOSTICS FOR SPATIAL DEPENDENCE
SPATIAL LAG DEPENDENCE FOR WEIGHT MATRIX :
mar17_geoda_createdWeight.GWT

TEST	DF	VALUE	PROB
Likelihood Ratio Test	1	0.1168343	0.7324937

======================== END OF REPORT
=================================

STREET NETWORK – PARK SIZE WEIGHTED

REGRESSION
SUMMARY OF OUTPUT: ORDINARY LEAST SQUARES ESTIMATION
Data set : apr6_cbg_park_weightedbysize
Dependent Variable : WEIGSIZE Number of Observations: 293
Mean dependent var : 0.0108167 Number of Variables : 2
S.D. dependent var : 0.0521561 Degrees of Freedom : 291

R-squared : 0.001992 F-statistic : 0.580699
Adjusted R-squared : -0.001438 Prob(F-statistic) : 0.446654
Sum squared residual: 0.795448 Log likelihood : 449.923
Sigma-square : 0.0027335 Akaike info criterion : -895.846
S.E. of regression : 0.0522829 Schwarz criterion : -888.485
Sigma-square ML : 0.00271484
S.E of regression ML: 0.0521041

Variable	Coefficient	Std.Error	t-Statistic	Probability
CONSTANT	0.007978885	0.004816353	1.656624	0.0986728
P053001	6.949513e-008	9.119665e-008	0.762036	0.4466539

REGRESSION DIAGNOSTICS
MULTICOLLINEARITY CONDITION NUMBER 2.796072
TEST ON NORMALITY OF ERRORS

TEST	DF	VALUE	PROB
Jarque-Bera	2	82245.34	0.0000000

DIAGNOSTICS FOR HETEROSKEDASTICITY
RANDOM COEFFICIENTS

TEST	DF	VALUE	PROB
Breusch-Pagan test	1	10.05334	0.0015207
Koenker-Bassett test	1	0.2445919	0.6209091

SPECIFICATION ROBUST TEST

TEST	DF	VALUE	PROB
White	2	3.454747	0.1777507

========================= END OF REPORT
================================

<u>REGRESSION</u>
<u>SUMMARY OF OUTPUT: SPATIAL LAG MODEL - MAXIMUM LIKELIHOOD ESTIMATION</u>
Data set : apr6_cbg_park_weightedbysize
Spatial Weight : mar17_geoda_createdWeight.GWT
Dependent Variable : WEIGSIZE Number of Observations: 293
Mean dependent var : 0.0108167 Number of Variables : 3
S.D. dependent var : 0.0521561 Degrees of Freedom : 290
Lag coeff. (Rho) : 0.0987539

R-squared : 0.005580 Log likelihood : 450.328
Sq. Correlation : - Akaike info criterion : -894.655
Sigma-square : 0.00270508 Schwarz criterion : -883.615
S.E of regression : 0.0520104

Variable	Coefficient	Std.Error	z-value	Probability
W_WEIGSIZE	0.09875392	0.1321283	0.7474094	0.4548163
CONSTANT	0.007503075	0.004947143	1.516648	0.1293556
P053001	5.486168e-008	0	1.#INF	-1.#IND000

REGRESSION DIAGNOSTICS
DIAGNOSTICS FOR HETEROSKEDASTICITY
RANDOM COEFFICIENTS

TEST	DF	VALUE	PROB
Breusch-Pagan test	1	9.509035	0.0020446

<u>DIAGNOSTICS FOR SPATIAL DEPENDENCE</u>
SPATIAL LAG DEPENDENCE FOR WEIGHT MATRIX :
mar17_geoda_createdWeight.GWT

TEST	DF	VALUE	PROB
Likelihood Ratio Test	1	0.8098383	0.3681681

========================= END OF REPORT
================================

<u>REGRESSION</u>
<u>SUMMARY OF OUTPUT: ORDINARY LEAST SQUARES ESTIMATION</u>
Data set : apr6_cbg_park_weightedbysize
Dependent Variable : WEIGSIZE Number of Observations: 293

```
Mean dependent var  :   0.0108167  Number of Variables   :    2
S.D. dependent var  :   0.0521561  Degrees of Freedom    :  291

R-squared           :    0.008080  F-statistic           :     2.37032
Adjusted R-squared  :    0.004671  Prob(F-statistic)     :    0.124748
Sum squared residual:    0.790596  Log likelihood        :     450.819
Sigma-square        :  0.00271682  Akaike info criterion :    -897.638
S.E. of regression  :   0.0521232  Schwarz criterion     :    -890.278
Sigma-square ML     :  0.00269828
S.E of regression ML:    0.051945
-----------------------------------------------------------------------
    Variable    Coefficient     Std.Error    t-Statistic   Probability
-----------------------------------------------------------------------
    CONSTANT    0.01932947    0.006312319      3.062183    0.0024027
  MINORITYPE   -0.01253861    0.008144152     -1.539585    0.1247476
-----------------------------------------------------------------------

REGRESSION DIAGNOSTICS
MULTICOLLINEARITY CONDITION NUMBER   3.88878
TEST ON NORMALITY OF ERRORS
TEST                  DF         VALUE          PROB
Jarque-Bera            2         79916.12       0.0000000

DIAGNOSTICS FOR HETEROSKEDASTICITY
RANDOM COEFFICIENTS
TEST                  DF         VALUE          PROB
Breusch-Pagan test     1         106.8924       0.0000000
Koenker-Bassett test   1         2.637834       0.1043457
SPECIFICATION ROBUST TEST
TEST                  DF         VALUE          PROB
White                  2         3.167622       0.2051916
========================== END OF REPORT
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```

```
REGRESSION
SUMMARY OF OUTPUT: SPATIAL LAG MODEL - MAXIMUM LIKELIHOOD
ESTIMATION
Data set            : apr6_cbg_park_weightedbysize
Spatial Weight      : mar17_geoda_createdWeight.GWT
Dependent Variable  :    WEIGSIZE  Number of Observations:  293
Mean dependent var  :   0.0108167  Number of Variables   :    3
S.D. dependent var  :   0.0521561  Degrees of Freedom    :  290
Lag coeff.   (Rho)  :    0.084942

R-squared           :    0.010726  Log likelihood        :      451.12
Sq. Correlation     : -            Akaike info criterion :     -896.24
```

```
Sigma-square       :  0.00269108  Schwarz criterion     :      -885.2
S.E of regression   :   0.0518756

--------------------------------------------------------------------
   Variable    Coefficient     Std.Error    z-value      Probability
--------------------------------------------------------------------
  W_WEIGSIZE    0.08494195      0.1327456      0.6398851    0.5222472
    CONSTANT    0.01767731    0.006692728       2.641271    0.0082596
  MINORITYPE   -0.01146496    0.008208375      -1.396739    0.1624922
--------------------------------------------------------------------

REGRESSION DIAGNOSTICS
DIAGNOSTICS FOR HETEROSKEDASTICITY
RANDOM COEFFICIENTS
TEST                              DF     VALUE        PROB
Breusch-Pagan test                 1       107.5468     0.0000000

DIAGNOSTICS FOR SPATIAL DEPENDENCE
SPATIAL LAG DEPENDENCE FOR WEIGHT MATRIX :
mar17_geoda_createdWeight.GWT
TEST                              DF     VALUE        PROB
Likelihood Ratio Test              1      0.6018082     0.4378890
========================== END OF REPORT
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```

```
REGRESSION
SUMMARY OF OUTPUT: ORDINARY LEAST SQUARES ESTIMATION
Data set           : apr6_cbg_park_weightedbysize
Dependent Variable  :    WEIGSIZE  Number of Observations:  293
Mean dependent var  :   0.0108167  Number of Variables   :    2
S.D. dependent var  :   0.0521561  Degrees of Freedom    :  291

R-squared           :    0.003043  F-statistic           :    0.888308
Adjusted R-squared  :   -0.000383  Prob(F-statistic)     :     0.34672
Sum squared residual:     0.79461  Log likelihood        :     450.077
Sigma-square       :  0.00273062  Akaike info criterion :    -896.155
S.E. of regression  :   0.0522553  Schwarz criterion     :    -888.794
Sigma-square ML     :  0.00271198
S.E of regression ML:   0.0520767
--------------------------------------------------------------------
   Variable    Coefficient     Std.Error    t-Statistic   Probability
--------------------------------------------------------------------
    CONSTANT    0.01470084    0.005128664       2.866408    0.0044545
  PCTBELOWPO   -0.01570142     0.01665932      -0.942501    0.3467198
--------------------------------------------------------------------
```

REGRESSION DIAGNOSTICS
MULTICOLLINEARITY CONDITION NUMBER 3.029948
TEST ON NORMALITY OF ERRORS

TEST	DF	VALUE	PROB
Jarque-Bera	2	81871.08	0.0000000

DIAGNOSTICS FOR HETEROSKEDASTICITY
RANDOM COEFFICIENTS

TEST	DF	VALUE	PROB
Breusch-Pagan test	1	31.67799	0.0000000
Koenker-Bassett test	1	0.7724575	0.3794579

SPECIFICATION ROBUST TEST

TEST	DF	VALUE	PROB
White	2	1.84709	0.3971088

======================== END OF REPORT
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<u>REGRESSION</u>
<u>SUMMARY OF OUTPUT: SPATIAL LAG MODEL - MAXIMUM LIKELIHOOD ESTIMATION</u>
Data set : apr6_cbg_park_weightedbysize
Spatial Weight : mar17_geoda_createdWeight.GWT
Dependent Variable : WEIGSIZE Number of Observations: 293
Mean dependent var : 0.0108167 Number of Variables : 3
S.D. dependent var : 0.0521561 Degrees of Freedom : 290
Lag coeff. (Rho) : 0.0991509

R-squared : 0.006704 Log likelihood : 450.492
Sq. Correlation : - Akaike info criterion : -894.985
Sigma-square : 0.00270202 Schwarz criterion : -883.944
S.E of regression : 0.051981

Variable	Coefficient	Std.Error	z-value	Probability
W_WEIGSIZE	0.0991509	0.1319955	0.7511686	0.4525511
CONSTANT	0.01315642	0.005362728	2.453308	0.0141549
PCTBELOWPO	-0.01381463	0.01659896	-0.8322585	0.4052629

REGRESSION DIAGNOSTICS
DIAGNOSTICS FOR HETEROSKEDASTICITY
RANDOM COEFFICIENTS
TEST DF VALUE PROB

```
Breusch-Pagan test                  1       31.95871     0.0000000

DIAGNOSTICS FOR SPATIAL DEPENDENCE
SPATIAL LAG DEPENDENCE FOR WEIGHT MATRIX :
mar17_geoda_createdWeight.GWT
TEST                            DF     VALUE        PROB
Likelihood Ratio Test                1      0.8302937     0.3621876
========================== END OF REPORT
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```

```
REGRESSION
SUMMARY OF OUTPUT: ORDINARY LEAST SQUARES ESTIMATION
Data set           : apr6_cbg_park_weightedbysize
Dependent Variable  :    WEIGSIZE  Number of Observations:  293
Mean dependent var  :   0.0108167  Number of Variables   :    2
S.D. dependent var  :   0.0521561  Degrees of Freedom    :  291

R-squared          :    0.006839  F-statistic           :     2.00371
Adjusted R-squared  :    0.003426  Prob(F-statistic)     :    0.157984
Sum squared residual:    0.791585  Log likelihood        :     450.636
Sigma-square       :  0.00272022  Akaike info criterion :    -897.272
S.E. of regression  :   0.0521558  Schwarz criterion     :    -889.912
Sigma-square ML     :  0.00270165
S.E of regression ML:   0.0519774
-----------------------------------------------------------------------
   Variable    Coefficient     Std.Error    t-Statistic   Probability
-----------------------------------------------------------------------
   CONSTANT    0.01609148    0.004813527      3.342971    0.0009373
 POPDENSQMI  -1.078326e-006   7.61785e-007     -1.415525    0.1579845
-----------------------------------------------------------------------

REGRESSION DIAGNOSTICS
MULTICOLLINEARITY CONDITION NUMBER   2.802757
TEST ON NORMALITY OF ERRORS
TEST                DF         VALUE          PROB
Jarque-Bera           2           82213.2       0.0000000

DIAGNOSTICS FOR HETEROSKEDASTICITY
RANDOM COEFFICIENTS
TEST                DF         VALUE          PROB
Breusch-Pagan test     1          10.99734       0.0009124
Koenker-Bassett test   1         0.2675977       0.6049478
SPECIFICATION ROBUST TEST
TEST                DF         VALUE          PROB
White                2         2.182475       0.3358007
========================== END OF REPORT
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```

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REGRESSION
SUMMARY OF OUTPUT: SPATIAL LAG MODEL - MAXIMUM LIKELIHOOD
ESTIMATION
Data set            : apr6_cbg_park_weightedbysize
Spatial Weight      : mar17_geoda_createdWeight.GWT
Dependent Variable  :    WEIGSIZE  Number of Observations:  293
Mean dependent var  :   0.0108167  Number of Variables   :    3
S.D. dependent var  :   0.0521561  Degrees of Freedom    :  290
Lag coeff.   (Rho)  :    0.104537

R-squared           :    0.010948  Log likelihood        :    451.106
Sq. Correlation     : -            Akaike info criterion :   -896.211
Sigma-square        :  0.00269047  Schwarz criterion     :   -885.171
S.E of regression   :   0.0518698

---------------------------------------------------------------------
    Variable    Coefficient     Std.Error    z-value     Probability
---------------------------------------------------------------------
  W_WEIGSIZE     0.1045371      0.1313795      0.795688    0.4262133
    CONSTANT    0.01481465    0.005034211      2.942795    0.0032528
  POPDENSQMI  -1.04958e-006   7.583024e-007     -1.384118    0.1663225
---------------------------------------------------------------------

REGRESSION DIAGNOSTICS
DIAGNOSTICS FOR HETEROSKEDASTICITY
RANDOM COEFFICIENTS
TEST                             DF     VALUE        PROB
Breusch-Pagan test                1       11.0001     0.0009111

DIAGNOSTICS FOR SPATIAL DEPENDENCE
SPATIAL LAG DEPENDENCE FOR WEIGHT MATRIX :
mar17_geoda_createdWeight.GWT
TEST                             DF     VALUE        PROB
Likelihood Ratio Test             1      0.9394219     0.3324266
========================== END OF REPORT
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```

Street Network – Park distance as dependent variable

REGRESSION P053001
SUMMARY OF OUTPUT: ORDINARY LEAST SQUARES ESTIMATION
Data set : CBG_display_basic_data
Dependent Variable : PARKDISTMI Number of Observations: 293
Mean dependent var : 0.50626 Number of Variables : 2
S.D. dependent var : 0.348981 Degrees of Freedom : 291

R-squared : 0.027634 F-statistic : 8.26994
Adjusted R-squared : 0.024292 Prob(F-statistic) : 0.00432839
Sum squared residual : 34.6977 Log likelihood : -103.191
Sigma-square : 0.119236 Akaike info criterion : 210.383
S.E. of regression : 0.345306 Schwarz criterion : 217.743
Sigma-square ML : 0.118422
S.E of regression ML : 0.344125

Variable	Coefficient	Std.Error	t-Statistic	Probability
CONSTANT	0.4355302	0.03180992	13.69165	0.0000000
P053001	1.732106e-006	6.023143e-007	2.875751	0.0043284

REGRESSION DIAGNOSTICS
MULTICOLLINEARITY CONDITION NUMBER 2.796072
TEST ON NORMALITY OF ERRORS

TEST	DF	VALUE	PROB
Jarque-Bera	2	121.9653	0.0000000

DIAGNOSTICS FOR HETEROSKEDASTICITY
RANDOM COEFFICIENTS

TEST	DF	VALUE	PROB
Breusch-Pagan test	1	4.901304	0.0268364
Koenker-Bassett test	1	2.380116	0.1228884

SPECIFICATION ROBUST TEST

TEST	DF	VALUE	PROB
White	2	6.259832	0.0437215

======================== END OF REPORT
==============================

SPATIAL LAG
REGRESSION
SUMMARY OF OUTPUT: SPATIAL LAG MODEL - MAXIMUM LIKELIHOOD ESTIMATI

SUMMARY OF OUTPUT: SPATIAL LAG MODEL - MAXIMUM LIKELIHOOD ESTIMATION
Data set : CBG_display_basic_data
Spatial Weight : mar17_geoda_createdWeight.GWT
Dependent Variable : PARKDISTMI Number of Observations: 293
Mean dependent var : 0.50626 Number of Variables : 3
S.D. dependent var : 0.348981 Degrees of Freedom : 290
Lag coeff. (Rho) : 0.639273

R-squared : 0.242910 Log likelihood : -73.2106
Sq. Correlation : - Akaike info criterion : 152.421
Sigma-square : 0.0922042 Schwarz criterion : 163.462
S.E of regression : 0.303651

Variable	Coefficient	Std.Error	z-value	Probability
W_PARKDISTMI	0.6392729	0.0781684	8.178151	0.0000000
CONSTANT	0.1625132	0.04703665	3.455034	0.0005503
P053001	6.942657e-007	5.359337e-007	1.295432	0.1951714

REGRESSION DIAGNOSTICS
DIAGNOSTICS FOR HETEROSKEDASTICITY
RANDOM COEFFICIENTS

TEST	DF	VALUE	PROB
Breusch-Pagan test	1	4.728073	0.0296741

DIAGNOSTICS FOR SPATIAL DEPENDENCE
SPATIAL LAG DEPENDENCE FOR WEIGHT MATRIX : mar17_geoda_createdWeight.GWT

TEST	DF	VALUE	PROB
Likelihood Ratio Test	1	59.96135	0.0000000

========================= END OF REPORT ===============================

REGRESSION
SUMMARY OF OUTPUT: SPATIAL LAG MODEL - MAXIMUM LIKELIHOOD ESTIMATION
Data set : CBG_display_basic_data
Spatial Weight : mar17_geoda_createdWeight.GWT
Dependent Variable : PARKDISTMI Number of Observations: 293
Mean dependent var : 0.50626 Number of Variables : 3
S.D. dependent var : 0.348981 Degrees of Freedom : 290
Lag coeff. (Rho) : 0.65793

R-squared : 0.241272 Log likelihood : -74.0246
Sq. Correlation : - Akaike info criterion : 154.049
Sigma-square : 0.0924037 Schwarz criterion : 165.09
S.E of regression : 0.30398

Variable	Coefficient	Std.Error	z-value	Probability
W_PARKDISTMI	0.6579303	0.07615487	8.639373	0.0000000
CONSTANT	0.177924	0.05425026	3.279689	0.0010393
MINORITYPE	0.005500194	0.04750457	0.1157824	0.9078249

REGRESSION DIAGNOSTICS
DIAGNOSTICS FOR HETEROSKEDASTICITY
RANDOM COEFFICIENTS

TEST	DF	VALUE	PROB
Breusch-Pagan test	1	5.114836	0.0237221

DIAGNOSTICS FOR SPATIAL DEPENDENCE
SPATIAL LAG DEPENDENCE FOR WEIGHT MATRIX : mar17_geoda_createdWeight.GWT

TEST	DF	VALUE	PROB
Likelihood Ratio Test	1	66.54383	0.0000000

========================== END OF REPORT
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REGRESSION
SUMMARY OF OUTPUT: ORDINARY LEAST SQUARES ESTIMATION
Data set : CBG_display_basic_data
Dependent Variable : PARKDISTMI Number of Observations: 293
Mean dependent var : 0.50626 Number of Variables : 2
S.D. dependent var : 0.348981 Degrees of Freedom : 291

R-squared : 0.039918 F-statistic : 12.0991
Adjusted R-squared : 0.036619 Prob(F-statistic) : 0.000581569
Sum squared residual: 34.2593 Log likelihood : -101.329
Sigma-square : 0.11773 Akaike info criterion : 206.657
S.E. of regression : 0.343118 Schwarz criterion : 214.018
Sigma-square ML : 0.116926
S.E of regression ML: 0.341944

Variable	Coefficient	Std.Error	t-Statistic	Probability
CONSTANT	0.5915317	0.03166679	18.67987	0.0000000
POPDENSQMI	-1.743211e-005	5.011562e-006	-3.478378	0.0005816

REGRESSION DIAGNOSTICS
MULTICOLLINEARITY CONDITION NUMBER 2.802757
(Extreme Multicollinearity)
TEST ON NORMALITY OF ERRORS

TEST	DF	VALUE	PROB
Jarque-Bera	2	106.1968	0.0000000

DIAGNOSTICS FOR HETEROSKEDASTICITY
RANDOM COEFFICIENTS

TEST	DF	VALUE	PROB
Breusch-Pagan test	1	0.4451563	0.5046442
Koenker-Bassett test	1	0.2283158	0.6327755

SPECIFICATION ROBUST TEST

TEST	DF	VALUE	PROB
White	2	15.69172	0.0003914

========================= END OF REPORT
================================

REGRESSION
SUMMARY OF OUTPUT: SPATIAL LAG MODEL - MAXIMUM LIKELIHOOD ESTIMATION
Data set : CBG_display_basic_data
Spatial Weight : mar17_geoda_createdWeight.GWT
Dependent Variable : PARKDISTMI Number of Observations: 293
Mean dependent var : 0.50626 Number of Variables : 3
S.D. dependent var : 0.348981 Degrees of Freedom : 290
Lag coeff. (Rho) : 0.630302

R-squared : 0.243728 Log likelihood : -72.8228
Sq. Correlation : - Akaike info criterion : 151.646
Sigma-square : 0.0921045 Schwarz criterion : 162.686
S.E of regression : 0.303487

Variable	Coefficient	Std.Error	z-value	Probability
W_PARKDISTMI	0.6303022	0.07931776	7.946546	0.0000000

```
CONSTANT            0.2301537          0.05130359        4.486113      0.0000073
POPDENSQMI         -7.127372e-006      4.442907e-006     -1.604214      0.1086670
-----------------------------------------------------------------------

REGRESSION DIAGNOSTICS
DIAGNOSTICS FOR HETEROSKEDASTICITY
RANDOM COEFFICIENTS
TEST                              DF     VALUE        PROB
Breusch-Pagan test                 1      2.247945     0.1337920

DIAGNOSTICS FOR SPATIAL DEPENDENCE
SPATIAL LAG DEPENDENCE FOR WEIGHT MATRIX : mar17_geoda_createdWeight.GWT
TEST                              DF     VALUE        PROB
Likelihood Ratio Test              1      57.01177     0.0000000
========================== END OF REPORT
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```

```
REGRESSION
SUMMARY OF OUTPUT: ORDINARY LEAST SQUARES ESTIMATION
Data set           : CBG_display_basic_data
Dependent Variable  :  PARKDISTMI          Number of Observations:  293
Mean dependent var  :     0.50626          Number of Variables   :    2
S.D. dependent var  :    0.348981          Degrees of Freedom    :  291

R-squared           :    0.023700          F-statistic           :     7.0642
Adjusted R-squared  :    0.020345          Prob(F-statistic)     :   0.0082986
Sum squared residual:      34.838          Log likelihood        :   -103.783
Sigma-square        :    0.119718          Akaike info criterion :    211.565
S.E. of regression  :    0.346003          Schwarz criterion     :    218.926
Sigma-square ML     :    0.118901
S.E of regression ML:     0.34482
-----------------------------------------------------------------------
   Variable           Coefficient           Std.Error          t-Statistic              Probability
-----------------------------------------------------------------------
CONSTANT            0.5787864           0.03395894        17.04371                0.0000000
PCTBELOWPO     -0.293183             0.110308           -2.657857                0.0082986
-----------------------------------------------------------------------

REGRESSION DIAGNOSTICS
MULTICOLLINEARITY CONDITION NUMBER   3.029948
TEST ON NORMALITY OF ERRORS
TEST               DF         VALUE          PROB
Jarque-Bera          2          109.2165       0.0000000

DIAGNOSTICS FOR HETEROSKEDASTICITY
```

```
RANDOM COEFFICIENTS
TEST              DF        VALUE          PROB
Breusch-Pagan test    1          11.6162       0.0006538
Koenker-Bassett test   1         5.933852       0.0148527
SPECIFICATION ROBUST TEST
TEST              DF        VALUE          PROB
White             2          10.3694       0.0056016
========================= END OF REPORT
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```

```
REGRESSION
SUMMARY OF OUTPUT: ORDINARY LEAST SQUARES ESTIMATION
Data set           : CBG_display_basic_data
Dependent Variable  :  PARKDISTMI            Number of Observations:  293
Mean dependent var  :     0.50626             Number of Variables   :    2
S.D. dependent var  :    0.348981             Degrees of Freedom    :  291

R-squared           :    0.023700             F-statistic           :      7.0642
Adjusted R-squared  :    0.020345             Prob(F-statistic)     :  0.0082986
Sum squared residual:      34.838             Log likelihood        :   -103.783
Sigma-square        :    0.119718             Akaike info criterion :    211.565
S.E. of regression  :    0.346003             Schwarz criterion     :    218.926
Sigma-square ML     :    0.118901
S.E of regression ML:     0.34482
--------------------------------------------------------------------
   Variable            Coefficient    Std.Error        t-Statistic      Probability
--------------------------------------------------------------------
CONSTANT            0.5787864     0.03395894      17.04371        0.0000000
PCTBELOWPO     -0.293183       0.110308        -2.657857       0.0082986
--------------------------------------------------------------------

REGRESSION DIAGNOSTICS
MULTICOLLINEARITY CONDITION NUMBER   3.029948
TEST ON NORMALITY OF ERRORS
TEST              DF        VALUE          PROB
Jarque-Bera          2          109.2165       0.0000000

DIAGNOSTICS FOR HETEROSKEDASTICITY
RANDOM COEFFICIENTS
TEST              DF        VALUE          PROB
Breusch-Pagan test    1          11.6162       0.0006538
Koenker-Bassett test   1         5.933852       0.0148527
SPECIFICATION ROBUST TEST
TEST              DF        VALUE          PROB
White             2          10.3694       0.0056016
```

```
========================= END OF REPORT
================================
```

```
REGRESSION
SUMMARY OF OUTPUT: ORDINARY LEAST SQUARES ESTIMATION
Data set           : CBG_display_basic_data
Dependent Variable  :  PARKDISTMI         Number of Observations:  293
Mean dependent var  :     0.50626            Number of Variables   :    2
S.D. dependent var  :    0.348981            Degrees of Freedom    :  291

R-squared           :    0.000012              F-statistic           :   0.0034306
Adjusted R-squared  :   -0.003425             Prob(F-statistic)     :    0.953308
Sum squared residual:     35.6833              Log likelihood        :    -107.295
Sigma-square        :    0.122623              Akaike info criterion :      218.59
S.E. of regression  :    0.350176             Schwarz criterion     :      225.95
Sigma-square ML     :    0.121786
S.E of regression ML:    0.348979
---------------------------------------------------------------------
   Variable            Coefficient           Std.Error      t-Statistic          Probability
---------------------------------------------------------------------
CONSTANT              0.5134309       0.1241307         4.136211          0.0000463
FEMALEPERC          -0.01417145     0.2419521       -0.05857129       0.9533083
---------------------------------------------------------------------

REGRESSION DIAGNOSTICS
MULTICOLLINEARITY CONDITION NUMBER   12.05251
                              (Extreme Multicollinearity)
TEST ON NORMALITY OF ERRORS
TEST                DF         VALUE          PROB
Jarque-Bera           2          140.7967       0.0000000

DIAGNOSTICS FOR HETEROSKEDASTICITY
RANDOM COEFFICIENTS
TEST                DF         VALUE          PROB
Breusch-Pagan test    1        0.0009874916       0.9749311
Koenker-Bassett test   1       0.0004626936       0.9828386
SPECIFICATION ROBUST TEST
TEST                DF         VALUE          PROB
White               2          1.775222       0.4116380
========================= END OF REPORT
================================
```

```
REGRESSION
```

```
SUMMARY OF OUTPUT: SPATIAL LAG MODEL - MAXIMUM LIKELIHOOD
ESTIMATION
Data set            : CBG_display_basic_data
Spatial Weight      : mar17_geoda_createdWeight.GWT
Dependent Variable  :  PARKDISTMI             Number of Observations:  293
Mean dependent var  :     0.50626             Number of Variables   :    3
S.D. dependent var  :    0.348981             Degrees of Freedom    :  290
Lag coeff.   (Rho)  :    0.661739

R-squared           :    0.243233             Log likelihood        :   -73.7506
Sq. Correlation     : -                       Akaike info criterion :    153.501
Sigma-square        :   0.0921648             Schwarz criterion     :    164.542
S.E of regression   :    0.303587

-----------------------------------------------------------------------
   Variable          Coefficient    Std.Error      z-value        Probability
-----------------------------------------------------------------------
W_PARKDISTMI     0.6617393     0.0755229      8.762101     0.0000000
   CONSTANT       0.2595819     0.1157711      2.242199     0.0249484
 FEMALEPERC     -0.157706      0.2098202     -0.7516247    0.4522766
-----------------------------------------------------------------------

REGRESSION DIAGNOSTICS
DIAGNOSTICS FOR HETEROSKEDASTICITY
RANDOM COEFFICIENTS
TEST                              DF     VALUE        PROB
Breusch-Pagan test                 1     0.09149028     0.7622911

DIAGNOSTICS FOR SPATIAL DEPENDENCE
SPATIAL LAG DEPENDENCE FOR WEIGHT MATRIX : mar17_geoda_createdWeight.GWT
TEST                              DF     VALUE        PROB
Likelihood Ratio Test              1      67.08854     0.0000000
========================== END OF REPORT
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```