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This thesis examines the spatial distributions of bus stop amenities from the perspectives of transportation equity to determine whether they are being located in areas where they are needed the most as well as to analyze their amenities or lack thereof and the effect they might have on ridership. While much of the prior literature regarding bus ridership examined how the location of transit stops, scheduling, pollution and the urban built environment affect ridership, there is little to no research on how bus stop amenities can affect ridership. It can be expected that a bus stop with poor amenities will have less ridership than that of one with proper amenities. Bus stop amenities can consist of benches, shelter, proper signage, garbage cans, appropriate sidewalks and ramps, and proper lighting. However, bus stop amenities are not consistent throughout the service area, as some bus stops may have a shelter with a bench while others may have only a simple pole with sign. Greensboro, Kansas City and Seattle are used as case studies for this research. Data was collected from each city's regional transit authority, encompassing the amount of riders at each bus stop and their amenities over a one-year period. In addition, the socioeconomic characteristics of residents by block group are taken from census block group data. After the thorough examination of the spatial as well as the statistical analyses, this thesis suggest a fair distribution of bus stops and their associated amenities in areas of the transportation disadvantaged with few exceptions. This research concludes that better amenities increases ridership and the most important amenity that factors in with higher ridership is shelter.

BUS STOP AMENTIES AND THEIR RELATIONSHIP WITH RIDERSHIP: A TRANSPORTATION EQUITY APPROACH

By

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CHAPTER I

INTRODUCTION

1.1 Purpose

The purpose of this thesis is to examine the spatial distributions of bus stop amenities from the perspectives of transportation equity, to determine whether they are being located in areas where they are needed the most as well as to analyze their amenities, or lack thereof, and the effect they might have on ridership. An initial visual survey suggests that bus stop amenities consist of benches, shelter, proper signage, garbage cans, route maps, appropriate sidewalks and ramps (recommended by Americans with Disabilities Act guidelines of 1990), and proper lighting, etc. The idea of waiting at a bus stop for many people may cause trepidation of inconvenient and unsafe conditions, such as enduring detrimental weather and waiting in an unsafe environment. This is especially true given the fact that not all buses run on time which forces a rider to wait even longer in these conditions (TCRP, 1999). In my observations, bus stop amenities are not always dispersed in an even fashion. Some bus stops may lack the amenities of others possibly because of prior estimates in the fluctuation of ridership at each stop (Fitzpatrick et al, 1997). Some bus stops consist of a shelter with a bench while others may only consist of a simple pole and sign. Not only do bus stops need to be improved in order to increase and maintain ridership, they should also provide equal accessibility each

and every citizen (Fitzpatrick et al, 1997). However, there is no empirical evidence that suggests this.

This topic is critical for changing public transportation in the U.S. One can only assume, due to the increase in fuel prices and the ever popular idea of preserving the environment that ridership of public transit and alternative forms of transportation might increase. Most government officials, particularly Department of Transportation officials, encourage public transit or other forms of transportation. It not only can save the average citizen money, but can also provide for a lucrative asset for the government. If more citizens used public transit or other forms of transportation, such as biking or walking, government officials would have more funds to allot to other fields (Smart et al, 2000). With oil prices rising, fewer cars on the road would decrease infrastructure restoration in the future, especially since asphalt prices will rise because of oil. Therefore, it is imperative for government officials to realize the need for appropriate transit stops, especially bus stops. This thesis assumes that if every bus stop was appropriately delegated the same high level of amenities, there would be an expected increase in ridership.

Transportation equity (also known as social justice or fairness) issues have also been taken into consideration in this research to verify whether or not bus stop locations and amenities are accessible to all races, income levels, and the disabled. Since the early 1980s, transportation equity has been a concept to ensure transportation related impacts (benefits and costs) that are fairly distributed to all demographics (Litman, 2011), especially to the people of socio-economically disadvantaged groups who ride the bus

(Battelle, 2000). Many Americans live with some type of disability, such as sensory impairment. These citizens also ride transit systems and require special amenities to help them in the public transit system. The transportation equity topic will be further discussed in the literature review section. For an increase in ridership or even consistent ridership that is equally accessible to everyone, a bus system should be required to provide some if not all of the formerly mentioned amenities (Marston, 2000). This research will analyze these concepts to better understand bus stop amenities affecting ridership and the fair distribution of said amenities. One can only assume that a bus stop with poor amenities will have less ridership than one with full amenities; however, there is a lack of research to support this idea, and, therefore, it remains an untested hypothesis.

1.2 Research Questions

There is a copious amount of literature involving bus stops and ridership (e.g., TCRP 1999, Corfa et al., 2004), but there is little to no examination of how the bus stop design and location can affect ridership levels. Much of the literature regarding bus stops explores the issues of location of stops, how scheduling can affect ridership, how pollution can affect ridership, and how the urban environment can affect ridership (Bouzaiene-Ayari et al, 2001). There is also a dearth of literature regarding bus stops and amenities being evenly distributed to all demographic groups and to those who need them. Throughout many metro or regional transit systems, there is an inconsistent pattern of amenities per stop. Many transit stops may have a shelter and bench, while others may consist of only a sign (Figure 1.1 and 1.2). This thesis will, thus, examine following

questions to better understand the relationship between bus stop amenities and ridership: (1) Are the locations of bus stops and their associated amenities distributed evenly across the areas to serve everyone or are they located in areas and communities where the demographic trend leans towards a greater need for transit especially to the transportation disadvantaged such as lower income and minorities? (2) Are ADA approved bus stops proportional to areas where people with disabilities are located and is this population being served equally by the transit system? (3) Will the amenities of bus stops have an effect on overall ridership and if so, what amenities are the most important factors for predicting bus ridership? (4) Are bus stops with higher level of amenities associated with more ridership?

Figure 1.1: Bus Stop with Poor Amenities

Figure 1.2: Bus Stop with Good Amenities

Source: Both Photographs are taken by the Author, Matt Talbott, 2011

CHAPTER II

LITERATURE REVIEW

In order to thoroughly examine how amenities of bus stops can affect ridership, one must review existing research relating to this field. As mentioned in the introduction, prior research does not specifically tackle the idea of bus stop amenities and ridership. Instead, the literature that exists involves other factors and variables that may help or hinder transit ridership as a whole. These variables range from pollution, scheduling, and bus stop spacing, to crime rates, the urban environment, as well as urban form. Some literature examines the political forces that can make it difficult for the transit authorities to implement transit stops and stations with good amenities and connectivity, travel behavior of immigrants and minorities, and the transportation disadvantaged. The goal of this research is to examine each of these factors to provide a better idea of how different variables may or may not affect ridership as well as the transportation equity aspect of the locations of the bus stops.

2.1 Characteristics in Building Transit Ridership: What are Transit Amenities?

After investigating much literature regarding this topic, only one piece could be found that was directly related to the research being conducted about amenities and ridership. In 1999, the Transit Cooperative Research Program (TCRP) conducted a study. This study was sponsored by The Federal Transit Administration. The report is

titled *The Role of Transit Amenities and Vehicle Characteristics in Building Transit Ridership: Amenities for Transit Handbook and The Transit Design Game Workbook.* Although this report is titled as more of a handbook and workbook, there are case studies and empirical data which can be related to the findings in the research presented in this paper. The handbook part of this report attempts to identify amenities and express how they, as well as transit vehicle characteristics, attract ridership. It also investigates how amenities may affect ridership. The workbook section of this report incorporates information gathered from passenger surveys, discussion sessions, focus groups, and transit agency staff on the effect of recently implemented amenities on passengers. There is a growing interest in enhancing all stages of the transit experience by improving vehicle design characteristics and providing amenities. This is due to transit systems striving to maintain and increase ridership. The transit agencies need to maximize the effect of investments by focusing resources on those amenities that will have the greatest positive effect on ridership (TCRP, 1999).

This report states that one transit manager told them that "amenities would have to jump up to make it to the bottom of my priority list." Although this is one transit manger's opinion, there are more and more transit agencies that are trying to break out of the mold and change the way they provide service for their passengers. These transit agencies have shown that investing in amenities to increase ridership can be a cost-effective option instead of reducing service or eliminating amenities in order to cut costs-measures that can create a continuing downward spiral (TCRP, 1999). The report presents the findings and conclusions of a two year research effort analyzing the role

played by amenities and design features at transit stops and vehicles in building transit relationship. TCRP states that while all types of transit were considered in the work, there was a special emphasis placed on buses and bus stops. This is because the bus system carries the most transit riders in the U.S. (TCRP, 1999).

Before the findings and conclusions of this report are delved into, TCRP (1999) explains that there were key lessons learned in this project that are significant because they counter numerous misconceptions that transit agencies have about amenities. The counters of misconceptions are listed below:

- **Passengers actually react positively to amenities which are designed to improve their transit experience:** When amenities are well placed and well designed, passengers appreciate them. Amenities can help to infuse rider confidence in the transit agency. It can also increase passenger optimism in regards to the quality of future transit improvements and service.
- **Amenities can impact a wide range of passenger experience as well as the ridership decision of passengers:** One of the most targeted customers for increasing ridership, infrequent riders, showed significant interest in amenities in the case study surveys. Amenities do not only make transit passengers more comfortable, but safer and more efficient with lighting and security cameras. Amenities can also impact new rider perception of transit as a transportation option for themselves

- **Amenities are not as expensive as perceived:** When serving passengers with disabilities, amenities such as low floor buses can save money over wheelchair lifts and on-call van service. Also, means to pay for amenities can be quite diverse and can include options other than advertising. Developing public/private partnerships with local communities, businesses and governments and redefining the way transit agencies traditionally work with manufactures can offset the costs of providing amenities
- **Transit agencies that have applied improvement projects are more likely to have actively sought and attempted to address other customer concerns, as well:** This is apparent in some simple yet efficient steps that agencies are taking to assess customer concerns. These can be accomplished in focus groups, surveys, and other methods. These are critical in determining whether or not a particular amenity should be considered. Amenity projects can then become part of a total program geared toward providing customer-friendly service
- **To know which amenities passengers want most and to determine their willingness to pay for them can help the agency decide which amenities to offer and implement:** A design guideline by TRCP titled the *Transit Design Game,* plus passenger surveys developed in this report, can be of service to transit agencies in general and amenity program planners in particular. They state that the *Transit Design Game* is not a final set of guidelines. These guidelines are a planning tool for agencies

which can be used over time to facilitate ongoing passenger surveying activities to ascertain or predict rider preferences for particular amenities.

- **The agencies that have embarked on amenity programs tend to believe that the benefits to passengers, adjacent communities, people with disabilities, and the agency itself far outweigh the costs:** While the TCRP found agencies that would implement projects differently, almost all transit agencies contacted for this report felt that their investment in amenities was a worthwhile one, even if a direct ridership impact could not be immediately measured.

The TCRP, in this report, deal with the issues surrounding what exactly amenities are. They also discuss the idea of what works and how and whether or not amenities are a worthwhile investment. There exists no uniform procedure to guide decisions regarding amenities. There is no agreement upon how to define or interpret what an amenity is, therefore TCRP clarify the underlying assumptions regarding the meaning of the term "amenity" and explain the context in which the project was conducted. Some people associate amenity with "frill" or "extra" according to TCRP. This is a misunderstanding. Whereas some amenities can be a luxury, most amenities are practical features that passengers find attractive and which may have a positive effect on ridership. Amenities are often viewed as something that can be simply added to a vehicle or transit stop after the fact of implementation. Usually the design decisions are made by engineers and maintenance departments, but neither is usually trained to understand

passenger needs. Some transit agencies take an approach by incorporating new features that often cost no more to provide than the "basics." The Metro system in Seattle re-thought the transit vehicle's basic design and function to design a better bus that costs no more to build than existing ones, rather than adding amenities to an existing bus (TCRP, 1999).

In this report, the TCRP (1999) created an amenity checklist. This checklist was divided into amenities for the waiting environment and amenities for the vehicle environment. This checklist is listed below:

Waiting Environment: The waiting environment can include access to the station or stop, circulation within the area and movement into and out of the train or bus, the waiting space, and the amenities in these areas:

- Seating or places for people to lean
- Shelter from the weather
- Lighting of the shelter and adjacent areas
- Information systems (signs, maps, and schedules to electronic, updateable information about actual vehicle arrival times);
- Telephones and trashcans
- Special features for people with disabilities such as ramps, elevators, railings, bathrooms, signage, and accessible heights for services like ticket booths

- Proximity to retail and other civic activities and uses (libraries, art exhibits and recycling centers, etc.)

Vehicle Environment: the vehicle environment can include the space and facilities that are provided for people to board or leave the vehicle. This can also be the space where people stand and circulate on board, sit, get information and pay their fare. Among the features and approaches of the vehicle environments are:

- Circulation into and throughout the vehicle (arrangement of doors and seating)
- Types of seating (padding, height of the seat back, provision of armrest, type of fabric or material)
- On-vehicle passenger information displays (visual and audible information about route number and name; next stop, key destination, upcoming stops and connecting route announcements)
- Better vehicle access using low floor technology
- Lighting
- Climate control and ventilation
- Security cameras
- A quieter and smoother ride
- Multi-modal features (bike racks)
- Storage facilities (package racks)

- Driver courtesy and assistance

The TCRP (1999) used methods such as focus groups, on-site surveys, interviews with transit operating staff, and behavioral observations to conduct five different case studies for on-board vehicle and waiting environments. They concluded that buses and bus stops represent comparably modest investments on the part of a transit agency versus rail vehicle and facilities, which are much more costly to purchase and upgrade. The case studies demonstrate that much can be achieved given limited budgets for a transit agency. Quality amenity programs require a different way of doing business for a transit agency, one that will involve the customer in helping to make decisions about service and facilities. Also, the most successful amenity programs projects were those in which partnerships were created among transit agencies, other city agencies, state and deferral government, local merchant and community groups, and equipment manufacturers and designers to accomplish more than the transit agency could accomplish by itself (TCRP. 1999). This report includes very important information that about attitudes and opinions passengers and agencies have towards amenities that can be supplemented into the research done in this paper, but does not present actual data to determine any quantitative evidence that amenities and ridership can affect one another, therefore further research must be undertaken.

2.2 Bus Stop Design and Network Modeling

The focus of the most abundant literature is the idea of the modeling of bus systems and the overall design of the actual bus stops. There are several factors which need to be considered when selecting a bus stop location and design. Comprehensive guidelines are needed because reference material relating specifically to bus stop location and design is limited and not located in a single document. Transit agencies, cities, developers and other interested parties who have a stake in bus stops would benefit from having a single comprehensive reference document (Fitzpatrick et al, 1997).

The primary objective of Transit Cooperative Research Program Project A-10 (TCRP) of 1999 was the development of guidelines on locating and designing bus stops. The research performed during the project used several different techniques to develop the guideline materials. Written documents from transit agencies and literature on the American with Disabilities Act were reviewed. Information on transit agency practices were obtained from their manuals, a mail-out survey, a phone survey, face-to-face interviews and observations of existing bus stops. Pedestrian and vehicle behavior at existing bus stops were gathered during data collection efforts at 19 different bus stops. Computer simulation was used to investigate the effects of bus stop design on traffic operations of suburban arterials. The final report, which documents the research, creates guideline information on bus stop location and design (Fitzpatrick et al, 1997).

However, this paper did not focus on the aspect of bus stop amenities and their relationship with ridership, but it does give a good guideline as to how to properly design and locate bus stops. Before the research of Fitzpatrick, there was no single document

outlining how bus stops should be located and designed. With the help of the Institute of Transportation Engineers, there is now a single document that will help in the location and design decisions. This can be a helpful factor that will allow bus stops to appeal to more riders and hopefully increase ridership.

Another aspect discussed in prior literature about bus stops is the idea of modeling bus stops in a transit network. Passenger assignment problems in transit networks have been the subject of many studies in the last four decades. Various assignment models have been proposed to predict passenger behavior in such networks in order to analyze improved public transportation service in large cities and metropolitan areas. Among these are equilibrium assignment models which have been applied to real-life large scale problems (Bouzaiene-Ayari et al, 2001). Most recent studies on the subject assume that passengers use path selection strategies to get to their destinations rather than shortest single routes or itineraries. In Bouzaiene-Ayari et al's (2001) paper, they define a strategy as the choice of sets of (possibly divergent) attractive lines at reached bus stops that allow the passenger to reach his/her destination. The outcome of such a choice is a set of simple itineraries that can diverge, only at bus stops, along the attractive lines.

In this research, Bouzaiene-Ayari et al (2001) also undertook an extended and detailed study of the bus stop problem in transit networks in order to propose a bus stop model that can be used to predict the passenger global behavior in such networks. In general, the main existing stop models do not perform well especially when dealing with congested transit stops with multiple servers. If the line waiting time functions used are

well defined functions which are sensitive to all line parameters (frequencies, capacities, headway distributions, line congestion), then all these parameters will have an impact on both the passenger distribution between attractive lines and the net passenger waiting times. One conclusion they determined was that a more attractive bus line would increase ridership (Bouzaiene-Ayari et al, 2001). The only problem with this research is that they do not acknowledge the idea of the bus stops themselves with their amenities and how that can affect ridership. They focus only on the attractiveness of the line, the bus and the location rather than what is around the bus stop and what types of amenities are around.

Loukaitou-Sideris (2001) surveyed 474 riders waiting for the bus at ten bus stop sites in the South Bay area. The surveys were to gather a perception of the public's opinion of bus stop design and amenities. The surveys took place between 8:00 a.m. and 6:00 p.m. To obtain a representative sample of South Bay bus riders, all bus stop sites were surveyed during the early morning, mid-day, early and late afternoon hours on weekdays and Saturdays.The survey instrument was composed of twenty-four questions designed to identify 1) the socio-demographic characteristics of South Bay bus riders; 2) frequency, purpose, and time of bus trips; 3) level of satisfaction with the existing bus service and bus stop amenities; 4) desirable bus stop amenities; 5) perceived safety on the bus and at the bus stop; 6) problems encountered at the bus stop; and 7) suggested improvements that could also act as incentives for increased ridership. The overall purpose of the surveys was to get an idea of what types of people ride the buses and how they would improve the system (Loukaitou-Sideris, 2001).

Loukaitou-Sideris, (2001), however, did not find many complaints in regards to the transit amenities offered at the bus stops. Some complaints were context-specific (e.g. the presence of homeless and transients in South Bay Galleria; the placement of the bus stop very near the street and poor lighting at specific locations; the inadequacy of the shelter to protect from rain in South Bay Galleria; the lack of a shelter at certain areas. Bus shelters, benches, trashcans, and proper lighting were deemed as the most important amenities at the bus stop. Although this research is informative, it is only for that particular area. It can be assumed that shelters, benches, trashcans, and lighting would be the most important amenities people would want. What the authors failed to analyze is if the areas that lack these amenities suffer from a decrease in ridership or not. This should be the case if these amenities are important to those particular people.

Another topic involving bus stop amenities is the architectural design of the actual bus stops. Slessor (2002) reviewed new designs of bus stops in Bradford, England. The reason for this article is that bus travel is regarded as the cheapest and most marginalized form of transport, and structures and interchanges associated with it tend to be designed with an emphasis on economy rather than imagination. The author stated that waiting for a bus is rarely time spent in civilized or stimulating conditions.

In Bradford, England, however, the role of the bus stop has been seriously re-evaluated. Culture Company, an arts organization, assembled a team of architects, artists and engineers to re-examine and transform the smallest and often most neglected element of transport infrastructure. The outcome was a series of eye-catching shelters that enhance and dignify bus travel and make a strong statement in the urban environment. In

collaboration with artists, architect Bauman Lyons designed six new shelters. The shelters share a common language of contorted metal planes and vivid color. Two of the structures are topped with a wind charger that generates power to warm seats inside. Two of the shelters were designed with "songs of color," which reflects the hues worn by people passing by, creating an intriguing ephemeral sound environment. For another shelter a 24 hour text was devised that unfolds line by line on a digital display for passengers to contemplate as they wait for their buses. Although these ideas for designs are great and they probably do increase ridership, there needs to be empirical evidence to determine if designs like these will increase ridership (Slessor, 2002).

2.3 Air and Noise Pollution at Bus Stops

Other prior literature focuses on air pollution and noise pollution and how they can affect the bus system as a whole. The first literature to be discussed is by C.H. Chew (1998). It focuses on ways to reduce the ambient noise level of this type of bus station (an integrated bus/rail station), which is higher than the conventional open type bus station. Although the focus of this paper was coming up with different ways to reduce this ambient noise level, he also investigated bus/rail stations where the bus station is on top of the rail station (Chew, 1998).

To further encourage more people to use public transport so as to relieve the traffic congestion, the concept of an integrated bus/rail station is being promoted. The present concept is to build the bus station below the train station. The first integrated bus/rail station has been completed and is in operation presently. The strong point in

favor of the above system is the relative ease of commuters to transfer from bus to train and vice versa. Another advantage of the system is that commuters will not get wet when it rains. It also helps in optimizing the land use. Since its inception, the concept has been well received. However, the only drawback is the higher ambient noise level experienced in this bus station compared to the usual more open type of bus station. Therefore, Chew's (1998) study has been carried out to measure the noise levels in order to help reduce them; it gives a good perspective of new ways to improve bus stations to keep riders on the lines. The author did mention how these stations would keep riders out of bad weather and other unsafe environments, but the author was not able to measure the ridership levels in order to determine if these station increase or decrease ridership.

Another literature involves air pollution and how it can affect bus riders. Corfa et al. (2004) examine and analyze air pollution at railway and bus stations in order to determine if pollution is higher at these locations. The purpose of their research is to be able to model air pollution to determine if these stations produce more air pollution and, if so what can be done to hinder it? The authors express that because air quality issues concern an increasing part of the population, more answers are needed and, therefore modeling is needed. Although in their conclusion they did determine that air pollution was higher in rail and bus stations, they failed to examine was if the higher pollution at these stations results in lower ridership numbers (Corfa et al, 2004). One would assume that this would be the case, but there needs to be empirical evidence to prove it. The idea of pollution affecting ridership will not be discussed in this paper due to lack of data, but should be examined in future research.

2.4 Crime Rates and Child Safety at Bus Stops

Another area of literature focuses on crime rates and the safety of children around bus stops. R. Unger et al. (2001) study the injuries at bus or tram stops that were analyzed retrospectively by the authors in order to analyze and to create guidelines for prevention. The reason for this research is because in Austria the yearly mortality rate of child pedestrians is 0.66 out of 100,000 children aged between 0 and 14 years. Prompted by some severe child pedestrian accidents in the area of bus and tram stops, the authors decided to analyze this kind of child pedestrian injuries. Some studies describe the occurrence of these injuries but there are only few studies which examine the causes and of such injuries. It is the aim of this study to create guidelines for injury prevention by retrospective analysis of these injuries in order to highlight cause, mode and type of injury as well as physical injuries and post-traumatic behavioral disturbances of pedestrian injuries close to bus or tram stops (Unger et al, 2001).

Medical records were analyzed and questionnaires were sent to the parents in order to obtain detailed information about the mode and physical injury or post-traumatic behavioral disturbances of the injury. Crossing the road from behind a bus or a tram in the area of a bus/tram stop is extremely dangerous. It is mandatory to increase the safety at bus stops along crowded bus stops, which can cause severe injuries trying to get a free seat, even though there is only standing room for most passengers. Crossing the street from behind the bus or the tram in the area of the stop is one of the main causes of these injuries. (Unger et al. 2001) The authors' findings are well organized and interesting, but they failed to analyze the idea of child injuries at bus stops and how it could affect

ridership. Another aspect they could have focused on is if these accidents were occurring because of the lack of safety amenities at the bus stop. There might be a lack of shelters and benches that could lead a child to wander into traffic or behind a bus to sustain injuries. The idea of amenities installed to deter injuries at transit stops should be researched in the future. There are no studies as of yet to observe injuries at transit stops and if better amenities could deter them.

Crime rates can also have an effect on bus riders (Anastasia Loukaitou-Sideris 1998). The reason for this research is that crime and fear of crime affect many aspects of everyday life in our cities. It holds the elderly hostage in their own homes, prevents people from using public transportation, forces merchants to close their shops early, and discourages investment, thereby increasing the cost of living, working, or operating a business (Loukaitou-Sideris, 1998).

This study focused on bus stop crime and wanted to identify the environmental attributes that can affect the bus rider's security while at the bus stop. Following the argument of criminologists that certain place characteristics can affect the incidence of crime, the study used direct observation, mapping, interviews, and surveys to examine the physical and social environment around the 10 most crime-ridden bus stops in Los Angeles during 1994 and 1995. For methodology they used qualitative and ethnographic analysis. They chose this form of methodology because it has the advantage of describing street-level interactions at a bus stop and relating them to its spatial characteristics. Their empirical research indicates that environmental attributes and site characteristics have an effect on crime. This paper only focuses on how environmental factors around bus stops

will affect crime rates (Loukaitou-Sideris, 1998). The research was interesting and well thought out but they should also compare how the environmental factors will affect crime and how that crime will affect ridership. If a bus stop is located in an environment known for its crime, a bus commuter will more than likely not wait at that particular bus stop.

2.5 Space Optimizing and Proximity of Bus Stops

Some literature centers on the idea of space optimizing and proximity of bus stops. In a study by Mezyad M. Alterkawi, 2006, a computer simulation analysis for optimizing bus stops spacing was discussed. The aim of this research is to add to the development of public transport services for a heavily car-dependent society. This paper examines an optimal structure to improve the bus system and contribute to the sustainable development of the city of Riyadh, Saudi Arabia. The analysis is based on a computer program to simulate the optimum bus stop spacing based on the field-collected data. It concludes that many of the requirements of an adequate bus system might be provided by appropriate bus stops and that these should be incorporated as part of the bus priority measures.

The paper focuses mainly on the placement of bus stops and how they can improve accessibility and mobility (Alterkawi, 2006). The reason for this research is that the provision of adequate urban transportation is a challenge for most cities worldwide. Urban transportation in the large cities of developing countries generally consists of road traffic, automobiles and other private means. Very few utilize guided mass rapid transit systems. This paper discusses a computer model developed by the author in order to examine an allocation and deployment of

bus pick-up and drop-off points in order to provide a balance between the conflicting objectives of customer service (providing for a minimum walking distance to a ‘‘bus stop’’) and ‘‘bus weaving’’ (minimizing the number of allowable bus stops in order to minimize the number of bus occurrences that a bus will be required to enter, and exit, the flow of traffic) (Alterkawi, 2006). Although this paper does determine the most efficient way to locate bus stops in order to improve the urban environment, it does not determine if poorly located bus stops will negatively affect ridership. The obvious assumption would be that poorly located bus stops will deter ridership, but there is a need for empirical evidence to support this assumption.

In regards to the formerly motioned idea of bus stop spacing, proximity is also discussed in prior literature. A paper titled Impact Proximity to Light Rail Rapid Transit on Station-area Property Values in Buffalo, New York, was authored by Daniel Baldwin Hess and Tangerine Maria Almeida. Their research examines the impact of proximity to light rail transit stations on residential property values in Buffalo, NY. Light rail has been in service for twenty years in Buffalo, but population declining and ridership is decreasing. Because the relationship between a transit system, the location of transit stations and property values are fundamental to land markets and urban structure, the authors felt the need to research this topic (Hess, 2007).

The authors constructed hedonic models of assessed value for residential properties within half a mile of 14 light rail stations; independent variables are included that describe property characteristics, neighborhood characteristics and locational amenities. The model suggests that, for homes located in the study area, every foot closer to a light rail station increases average property values by $2.31 (using geographical

straight-lined distance) and $.99 (using network distance) (Hess, 2007). Overall the authors found that the closer a property is to a transit station, the higher that property value will likely be. The authors also suggest that based on their findings they cannot claim amid economic decline and population loss, light rail transit will unequivocally increase property values and revitalize depressed neighborhoods (Hess, 2007). This paper gives good insight as to how property values can fluctuate according to their proximity to transit stations. If they would have done the same study with bus stops, they might have found the same or a different result. They could have also examined the idea of higher property values near stations or stops and if it would ultimately affect ridership levels. If it is a high property value neighborhood, will ridership increase or decrease?

2.6 Urban Form and the Urban Environment Around Bus Stops

Other ideas on ridership have to do with urban form and/or the urban environment. Estupinan and Rodrıguez (2007) performed a study of this regard because the relationship between bus transit demand and urban form remains largely unexplored; these authors felt the need to examine this. By relying on primary and secondary data analyzed with a geographic information system, this paper examines the built environment characteristics related to stop-level ridership for Bogotá's successful bus rapid transit system (Rodrıguez, 2007).

The authors state that recent research has studied the relationship between the built environment and travel behavior with the aim of identifying environmental characteristics that support decreased auto use. Common outcomes examined include

distance traveled, travel mode choice, trip frequency and use of transit. Although there is an emerging understanding of the relevance of the built environment in supporting transit use, studies have focused almost exclusively on the relationship between rail transit as well as residential and employment density (Rodrıguez, 2007).

The study results suggest environmental supports for walking and that deterrents or barriers to car use were related to higher BRT use. Also, the factors measuring environmental supports for walking and barriers to car use had the strongest predictive power of the factors analyzed. The authors' results confirm the importance of the built environment in supporting non-automobile ways of traveling generally, and bus transit in particular. Their research identified environmental features, subjectively interpreted as walking supports, which successfully predict transit use, while controlling for other attributes (Rodrıguez, 2007). Although this paper did examine how the built environment will predict other forms of transportation, it did not investigate the idea of the amenities affecting the ridership. This could be an important factor in the fluctuation of transit ridership.

2.7 Transit Stops and Stations are Usually Controlled by Numerous Entities

As mentioned before, the data collection for this research was a strenuous task due to the fact that transit organizations collect their data in a non-uniformed manner. This can be attributed to the fact that transit stops and locations are often partially or fully controlled by other governmental agencies (most frequently, local governments that control sidewalks) who may have interests different than, and sometimes at odds with,

those of transit agencies (Smart et al. 2009). A transit agency may have certain ideas and incentives for certain locations and design of bus stop locations, but they often have to meet the needs of other government agencies such as a municipality's transportation planning division or a metropolitan planning organization.

In 2009, Smart et al. developed a study on how transit managers have to consider both the political and logistical factors intrinsic to transit operations, as well as the perspectives of customers they seek to attract and maintain. They state that passengers, transit managers, adjacent businesses and residents, and local governments can all have strong and sometimes differing ideas about what makes a good transit stop or station. This can make designing and implementing necessary amenities difficult for the transit agencies. Unlike other modes of transportation, (private vehicle, bike, or by foot) public transit passengers usually have to wait for and transfer between buses and trains. Therefore, the idea of the travel time spent outside of the transit vehicles comprises an imperative, and extremely understudied, part of transit travel. However, due to the many stakeholders who have a say in the location, design, and operation of the facilities, it is a very difficult task to plan a good transit stop or station. In many cases, it is a complex interaction of different stakeholders' requests and constraints that results in the final location and design of a stop or station (Smart et al, 2009).

Transit stops are not only places to wait for a bus or train, but a place to wait and transfer, which means a passenger could be waiting and transferring throughout their commute at different stops and stations. This being said, there is a need for better amenities and better connectivity at locations with higher wait times. Usually, when

transit connectivity is poor, waits and transfers become burdensome for transit users and can discourage transit use. According to the Metropolitan Transportation Commission in 2006, poor stop and station connectivity can result in trips that are frustrating, time consuming, and costly. This can produce lowering the quality of service for users and making transit unattractive for new customers. The range and degree of wait and transfer facilities (bus stops) vary considerably. They can range from thousands of simple bus stops around the U.S. marked by a simple sign on a pole to elaborate and architecturally significant multi-modal commercial hubs (Smart et al, 2009).

This literature also delves into the idea that perceptions of how the most important aspects of transit stops and stations can vary depending on the stakeholders involved. They state that the main factors include passengers, adjacent businesses and residents, local governments, and transit agencies. Passengers are the reason for the existence of transit travel; therefore their perspectives and needs are vital. Although passenger needs should be first, transit stops and stations must also meet operational objectives. Operational objectives can consist of the stipulation of vehicle queuing and staging areas, sufficient road/rail network access, adequate vehicle/passenger separation, driver break facilities, etc. If the transit organization directly owns or controls the property where the stop or station is to be located, it can largely control the attributes to accommodate operational requirements of the stop/station. In reality, more often than not, the property is partially or fully controlled by other governmental organizations. These other governmental agencies may have interests different from those of the transit agencies. Also, no stop or station is a stand-alone facility. It has to relate and interact with adjacent

businesses and residential properties. Therefore, the maintenance of providing access, as well as generating traffic, noise, emissions, and other negative externalities, are essential and sometimes rigorous (Smart et al., 2009). While this literature and research is imperative to understanding the process and problems of implementing successful transit stops or stations with sufficient amenities and connectivity, it fails to analyze if it would actually affect ridership in any way. It also does not touch on the subject of the process and design of locating stops and stations in areas where it is likely needed the most. The need for the research presented in this thesis is crucial and can then be tied to the literature mentioned above in order to realize the true analytical nature of this beast.

2.8 Transportation Equity

In order to better understand this research's spatial distribution of bus stop amenities from the perspectives of transportation equity, this term must be clarified. According to the USDOT (2006), transportation equity was enacted through law PL 105-178, the Transportation Equity Act for the 21st Century (TEA-21). TEA-21 authorized the Federal surface transportation programs for highways, highway safety, and transit for the 6-year period 1998-2003. Because Congress could not agree on funding levels, the Act was allowed to lapse. The transportation equity act requires several planning factors be included in regional transportation plans. Some factors include supporting the economic vitality of the metropolitan planning area, increasing transportation system's safety for motorized and non-motorized users, protecting and enhancing the environment, promoting energy conservation, and improving the quality of life. This definition for

transportation equity is defined through a governmental act, but there are other ideas and ways to define this term.

Equity can refer to the fairness with which impacts (benefits and costs) are distributed. Transportation decisions sometimes have significant equity impacts. Transport equity analysis can be difficult because there are several types of equity, numerous impacts to consider, various ways to categorize people for analysis, and many ways of measuring impacts (Litman, 2010). According to a report by the Victoria Transport Policy Institute in 2010, transportation equity is defined by three major categories:

1. Horizontal Equity: also called fairness and egalitarianism, is concerned with the distribution of impacts between individuals and groups considered equal in ability and need. Equal individuals and groups should receive equal shares of resources and be treated the same. It means that public policies should avoid favoring one individual or group over others, and that consumers should "get what they pay for and pay for what they get" from fees and taxes unless a subsidy is specifically justified.

2. Vertical Equity With Regard to Income and Social Class: also called social justice, environmental justice and social inclusion, is concerned with the distribution of impacts between individuals and groups that differ in abilities and needs by income or social class. Transport policies are equitable if they favor economically and socially disadvantaged groups, therefore compensating for overall inequities. Policies favoring disadvantaged groups are called progressive, while those that excessively burden disadvantaged people are called regressive. This definition is used to support affordable

modes, discounts and special services for economically and socially disadvantaged groups, as well as efforts to insure that disadvantaged groups do not bear an excessive share of external costs (pollution, accident risk, financial costs, etc.).

3. Vertical Equity With Regard to Mobility Need and Ability: This definition is concerned with the distribution of impacts between individuals and groups that differ in transportation ability and need and, therefore, the degree to which the transportation system meets the needs of travelers with special constraints. This definition is used to support universal design (also called accessible and inclusive design), which means that transport facilities and services accommodate people with disabilities and other special needs. This paper will look at these three transportation equity issues.

2.9 Using Technology to Help the Transportation Disadvantaged: Transportation Equality

Many disabled people use public transportation as much as non-disabled people, but sometimes this task can be a tedious and difficult one. According to the U.S. Census Bureau, 2005, there are over 54 million disabled people or about 19 percent of the United States population. Not all people reporting disabilities are severely disabled (needing help with everyday activities). Disabilities can range from eyesight disability, hearing disability, mobility disability, to cognitive disability. Many of these people work everyday and rely on public transit to get to their jobs. If the proper amenities are not located at each stop or station, getting there and waiting can be a burden. Not only do persons with disabilities have lower access to transportation or limited transportation, but

so do older adults and individuals with lower income. These populations are called the "transportation disadvantaged." These individuals need flexible and dependable routes and schedules, travel information that is easy to understand, fares that are low cost and easy to understand, as well as transportation that is safe and secure (U.S. DOT, 2006).

The report by the U.S. DOT (2006), "Improving Service for the Transportation Disadvantaged," highlights technologies such as the Intelligent Transportation System (ITS) that improve accessibility for the transportation disadvantaged. Akin to the study in the previous section, this report underlines that the challenges to implementing transit improvements and technologies is that of the coordination of goals and functions of multiple agencies. There are many obstacles to coordination, including different rules and standards among the various agencies, stakeholders, and limited guidance. This report focuses more on technological advances to improve transit for the transportation disadvantaged and not so much on the improvements of amenities. The technological improvements that are mentioned in this study will be reviewed because they can used to tie in with amenity improvements for future research.

The large population of transportation disadvantaged people are usually without access to private vehicles, which brings about concerns of how to find alternative forms of transportation, low fares that are easily understood and pay, security and safety, sufficient service coverage, reasonable journey times, and convenient schedules. These needs are sometimes coordinated by small agencies using phone, fax, pegboard, and so on; however, the demand for transportation services is on the rise across the country, which means the need for technological advances is becoming apparent. Managing

services among various transportation providers is a considerable test given the different goals, approaches, needs, and capabilities of the transportation disadvantaged population. Most of the transportation services for the transportation disadvantaged are funded by four different agencies. These include the Department of Transportation (DOT), Health and Human Services (HHS), the Department of Labor (DOL), and the Department of Education (DOE), (U.S. DOT, 2006).

Policy issues can be as important as the technology itself before an agency implements the Intelligent Transportation System (ITS). Another challenge is the rapid changes in technologies. It is a difficult task for the agencies to decide on the right time to implement new technologies, because each day a new technological feature is discovered. Other issues deal with the obstacle of meeting the wide range of needs within the transportation disadvantaged communities. The needs for a person with a cognitive disability or a person wheelchair bound greatly differ from a person with a sensory disability. Once these issues are addressed, the ITS technologies can be executed (U.S. DOT, 2006).

Computers, electronics, and communications systems for improving the surface transportation system are all aspects of the Intelligent Transportation System. Specific computer software programs for improvement include location software and equipment (automatic vehicle location [AVL] and geographic information systems [GIS], computer-aided dispatch (CAD), mobile data terminals (MDTs) or mobile data computers (MCDs), and integration and coordination software. One of the goals of the U.S. DOT (2006) and the transportation industry is to utilize ITS to move people more efficiently and with

greater safety, although it does not seem to include the improvements of amenities in this process.

ITS is divided into passenger-related technologies and organization-related technologies. The first passenger-related technology discussed is traveler information. Traveler information includes websites, automated telephone systems, audible enunciators, kiosks, and transit stops with automated information. The purpose of the traveler information technology is to provide the customer with information electronically. The content might include schedules, fares, routes, transfers, arrival times, and so on. The information may be provided on the transit vehicle itself, at the transit stop, through the internet, or over the phone. The second passenger-related technology listed is electronic fare payment. This technology allows the rider to pay for transportation services using a smart card or magnetic stripe card. This simplifies billing and payment. The third and final passenger-related technology is surveillance and security systems. These include video surveillance, silent alarms and covert microphones on vehicles, and smart cards for driver identification. These can be provided at transit stops and stations as well as in the transit vehicles (U.S. DOT, 2006).

There are four organization-related technologies as well. The first technology listed is automatic vehicle location. Using GIS and global positioning systems (GPS), the agency can track its buses. By combining AVL with Automatic Terminal Information Service (ATIS), the agency can then alert riders with real-time information. The combination of AVL with CAD, the agency can reroute transit vehicles to provide flexible service. The second organization-related technology is computer-aided dispatch

(CAD). This is used to assist agencies in dispatching paratransit vehicles. The third technology listed is mobile data terminals and mobile data computers. MDT/MDC is small on-board computers and interfaces that links the transit driver to an agency's computer network through wireless connection. The fourth and final organization-related technology is coordination and integration software. This helps agencies with scheduling, routing, billing, and reporting. With the integration of both the passenger-related and organization-related technologies, the advancement in helping the transportation disadvantaged population moved more efficiently and with greater safety. Although better amenities such as making sure each stop is ADA (Americans with Disabilities Act) approved with low-tech factors like wheelchair ramps and shelters are not included in this report, the combination of the afore mentioned high-tech advancements would greatly improve this idea significantly and should be implemented in future research.

It is apparent from the literature review that the research of relating bus stop amenities to ridership levels is a new idea. Transit authorities are always trying to bring more passengers aboard their systems. If more people use public transportation, the less traffic congestion and road maintenance is a hindrance. It can also produce additional funds for the authorities to utilize. This is especially true in an age where more people are trying to be economically frugal and some want to be environmentally conscious.

CHAPTER III

RESEARCH DESIGN, STUDY AREAS, DATA, AND METHODOLOGY

3.1 Research Design, Data, and Study Areas

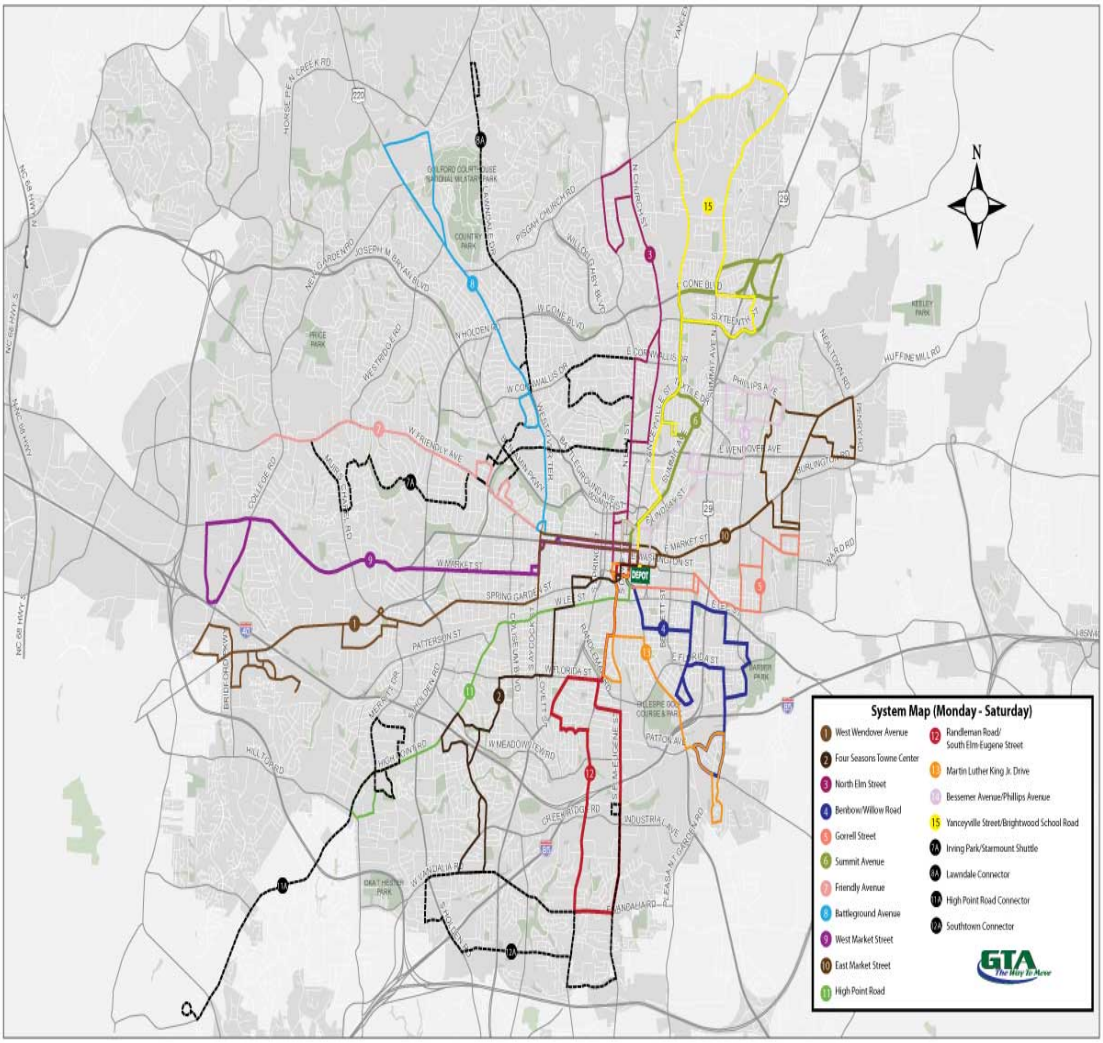
In researching literature, there were no mentions of a direct link between amenities and ridership. There were also few studies regarding transportation equity and locations of bus stops to meet the needs of all types of demographic groups. The empirical research on this matter is lacking; therefore, an extensive study on this idea through case studies needs to be carried out. For this purpose the following hypotheses are tested:

1) The location of bus stops and amenities are proportional to the areas of socio-economically disadvantaged group of people (e.g., areas with high proportion of minority, poverty, carless household, bus user commuters, and disabled people).
2) Bus stops with lower levels of amenities are placed in areas where socio-economically disadvantaged groups of people live, and bus stops with higher amenities are disproportionately found in the areas where socioeconomically advantaged groups are prevalent.
3) ADA approved bus stops (level 3 and 4) are facilitated in areas where these services are needed.

4) The lack or different level of amenities at each bus stop affects ridership levels in a significant way.

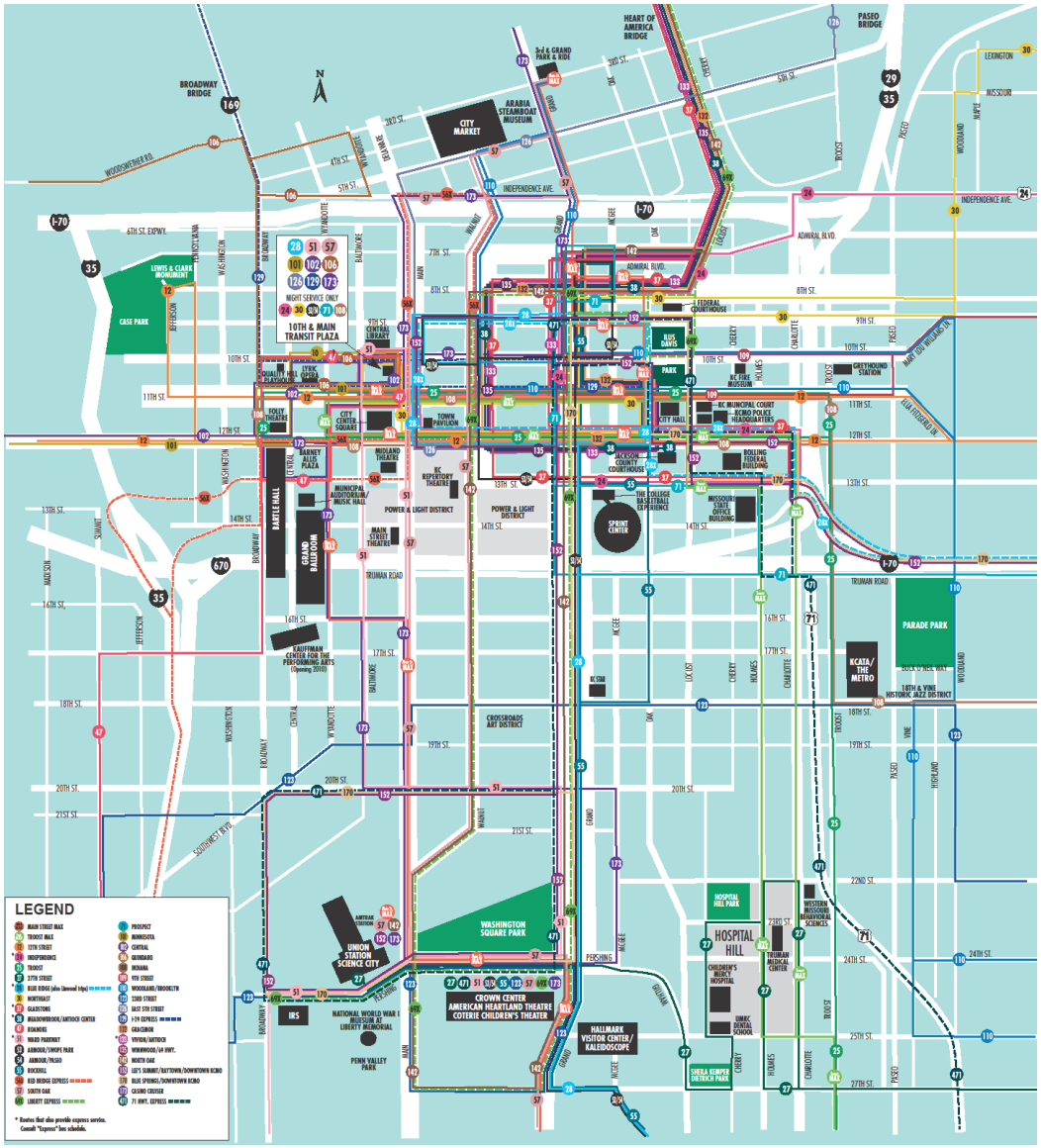
However, obtaining data for these investigations was not an easy task and explains why proposed research questions carried out in this thesis have not yet been investigated. Ridership data can sometimes be found through transit authority websites, although ridership levels at each stop is usually not available online. Initially these concepts were to be studied for the three larger cities of Charlotte, Raleigh and Greensboro in North Carolina (NC). The city authorities of Charlotte and Raleigh were contacted requesting data for this research. Although excited about this research topic, they failed to provide the ridership and amenity data. On the other hand, while the author was working with the City of Greensboro's Transportation Planning Division in 2009, I amenity and ridership data was able to be collected in person, although it was very time consuming. When obtaining the data from these cities in NC seemed unfeasible, different measures were taken. Emails and phone calls were sent to numerous, middle to large size metropolitan area transit authorities throughout the U.S. asking for available datasets for bus stop amenities and ridership at bus stop locations. Finally, a few responses were received. However, only three cities, Greensboro, NC, Kansas City, MO, and Seattle, WA, were able to provide datasets that were closest in format; therefore, they were chosen for investigation (Figure 3.1, 3.2 and 3.3). Even though the study areas are chosen based on the availability of data, these areas also represent a small, medium, and large metropolitan size for an excellent empirical analysis.

Figure 3.1: Greensboro Bus System



Source: Greensboro Transit Authority, 2010

Figure 3.2: Kansas City Bus System



Source: Kansas City Area Transportation Authority, 2011

Figure 3.3: Seattle Bus System

Source: King County Metro Transit, 2011

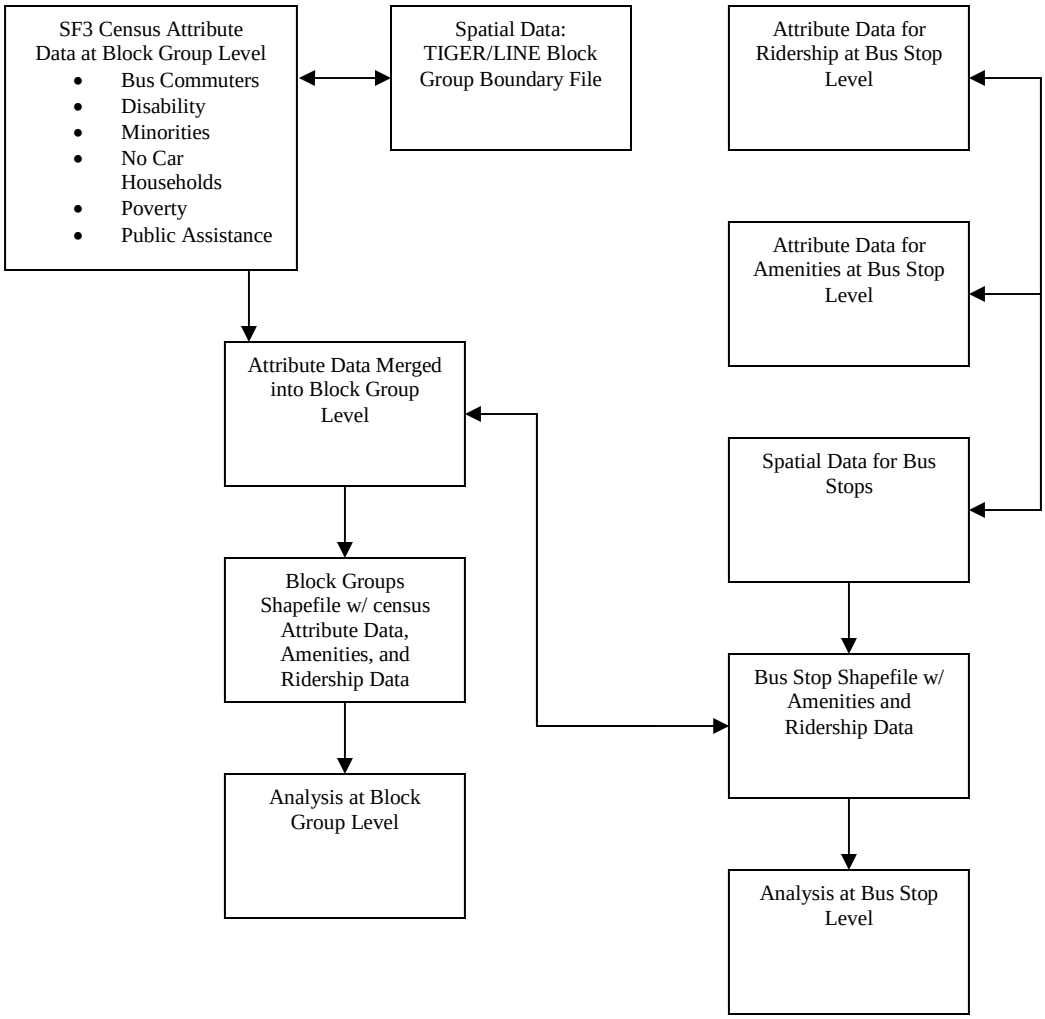
Greensboro's data was received via Greensboro Transit Authority (GTA). GTA serves the Greensboro metro area in Guilford County with 15 routes and five connector routes. GTA has partnership with seven local universities and colleges called Higher Education Area Transit (HEAT). There is also a system for riders who have a disability that prevents them from riding the fixed route service called Specialized Community Area Transportation (SCAT), (GDOT, 2011), (Figure 3.1.)

Kansas City's data was received via Kansas City Area Transportation Authority (KCATA). KCATA is a bi-state agency created by a compact between the States of Missouri and Kansas. This compact defines the KCATA district as the counties of Cass, Clay, Jackson, and Platte in Missouri, and Johnson, Leavenworth, and Wyandotte in Kansas. The KCATA operates the Metro bus service, the Metro Area Express (MAX) Bus Rapid Transit service, MetroFlex demand-response routes, and Share-A-Fare paratransit service for the elderly and persons with disabilities. KCATA runs a 61 bus route, 8 MetroFlex route, and 1 Bus Rapid Transit route system (KCATA, 2011), (Figure 3.2.)

Seattle data was obtained via King County Metro Transit (Metro). Metro is the public transit authority for King County, Washington, serving the greater Seattle metro area. It operates the transit bus system and Access Transportation for the elderly and persons with disabilities. KCMT operates a 223 route system. Also, Metro maintains a fleet of 159 electric trolley buses (ETBs) that serve 14 routes, (Figure 3.3.) These three transit authorities represent case studies for a small metro area (Greensboro), a medium

sized area (Kansas City), and a larger sized area (Seattle). The range in scale will serve for a better analysis in this research.

Figure 3.4: Methodology Design



Sources: US Census Bureau, 2000; GTA, 2009; KCATA, 2009; KCMT, 2009

3.2 Methodology

Since amenity data and ridership data are not combined and analyzed by the transit authorities, the data that was retrieved from each agency was not uniform and had to be re-categorized and processed into a new database. The ridership data for each transit authority was in a one year period. Greensboro had only recently implemented their automatic passenger count which was ridership levels for one year. Kansas City ridership data was for a one year period as well. Seattle sent data for two different years, but only one was used due to the one year periods of the other cities. Ridership data is represented by ONs (on boards), OFFs (off boards), and TOTAL for each bus stop. One problem in the data given was due to the fact that ridership data and amenity data were cataloged in separate databases. In order to properly match these two variables at each location, a linking system was undertaken through Microsoft Excel. The amenities for each bus stop location's address had to be linked one by one to the location address of each bus stop ridership cell. This had to be done for each city and it was tedious.

All three transit authorities collected and reported their amenities in different ways. Seattle listed more amenities where as Kansas City listed the least. Amenities can range from a sign, bench, trash can, shelter, lighting, to Americans with Disability Act functions. The amenity listed as Americans with Disability Act (ADA) represents if the location is equipped with wheelchair ramps, raised bumps in the sidewalk (for visually impaired people), and so on. Greensboro's amenities that were listed are the following: sign, bench, trash can, lighting, shelter, ADA. Kansas City amenities listed were benches, trash cans, and shelters. Seattle amenities listed were sign, sidewalk, bench,

shelter, awning, landing, bollards, news box, bike rack, and ADA. The amenity and ridership data were linked together and tabulated in an Excel spreadsheet by each bus stop location.

Since ridership data at bus stop locations did not come with demographic characteristics of riders, for further analysis of transportation equity issue, selected socio-economic variables were extracted. There were many demographics to choose from to study this topic. Because a high level of mobility is essential to the lifestyles and economic well-being of all people, and historically, minorities and the financially deprived have not enjoyed as high a level of mobility as others (Batelle, 2000), only certain socio-economic variables were chosen for this research. The socio-economic variables were chosen as: vehicles with no car, people who ride the bus, people with disabilities, total minorities, population below poverty, and population receiving public assistance (Census 2000 Summary File 3 (SF3) at the block group level, Dbase IV file). The variables chosen were used as percentages of the total population. Also Census 2000 TIGER/Line Data block groups shape files for each county of the three study areas were downloaded. The census Dbase IV files were then joined with the TIGER block groups files in ArcMap 9.3 to create a shapefile which presents block group socio-economic data. The bus stop locations files were collected in GIS shapefile format and amenities in Microsoft Excel format. These two files were linked in a database then merged into a new shapefile that contains the location of bus stops and their associated amenities and ridership. Then this shapefile, which includes the amenity level, is joined with the Census block group census demographic shapefile through a spatial join. The spatial join

summed the amount of bus stops and amenities that are located in each block group. This process was done for Greensboro, Kansas City, and Seattle. Before further discussion of bus stop amenities and their spatial analysis, the idea of amenity levels should be explained. After reviewing the literature about the functionality of amenities, the author's knowledge and judgment were used to create an amenity level structure to designate each bus stop. The amenity levels are broken down into 4 categories. They are designated amenity level 4, being the highest, to level 3, 2, and 1 (lowest). Each amenity level also has a different color assigned to it. The criteria for different amenities are listed in the following table to provide a better understanding. Based on the literature review, other variables such as crime rate, accident rates, and pollution at bus stops may affect ridership, but to the author's knowledge there are no such records at bus stop level, and it is impossible to include those variables in this analysis. This also makes it impossible to determine which came first; amenities or ridership. There is a cause and effect relationship that needs to be studied in the future by these transit agencies to determine the relationship if amenities create ridership or vice versa.

Table 1: Amenity Level Criteria

AMENITY LEVELS		
LEVEL 4	SHELTER, ADA, BENCH, AND ANY OTHERS FROM LEVELS 1, 2, OR 3	
LEVEL 3	BENCH, ADA, AND ANY OTHERS FROM LEVELS 1 OR 2	
LEVEL 2	SIGN, LIGHT, TRASHCAN	
LEVEL 1	SIGN ONLY	

CHAPTER IV

FINDINGS

One could assume that the more amenities at a bus stop, the more riders. Is this a fact or just an assumption? The research undertaken in this paper will attempt to clarify this question. Also, are amenities being distributed fairly to all communities and demographic groups? Are they being distributed to those who need and use public transit the most? These questions will be answered through a series of spatial and quantitative approaches.

4.1 The Spatial Distribution of Bus Stops and Amenities: Do they serve everyone fairly?

All demographics are at the block group level. The block groups on the maps are broken into 4 classifications. The darkest blue represents block groups with the highest percentage of each selected demographic. The selected demographics chosen are bus users, households with no car, disabled, minorities, those in poverty, and those who use public assistance. These demographic groups are represented as percentages of the total population on the maps. The reason for choosing these demographics is because these are the populations who tend to use public transit the most and also fall into the transportation equity equation. The following figures in this section show different maps for each case study. Each figure contains two maps. One map will represent the total

number of bus stops in each block group as graduated circles which are embedded in each block group. There are four classifications of circles, the largest having the most bus stops in that block group. They were classified by natural breaks. These maps representing total bus stops will serve to show spatially if more bus stops are located in areas to where there is the most use and of need transit. The second maps in each section show each individual bus stop designated with a different amenity level (noted by different colors.) Each figure will contain the same demographic, but one showing bus stops and the other showing amenity levels. The purpose of these maps is to determine if these demographics are being fairly served by the transportation authorities. Also each socio-economic variable represented in each map will be followed by a bar graph showing categorical analysis created through PASW 18 in relation to the specific variable and the amount of bus stops and amenities that fall in those block groups.

Table 2: Number of Bus Stops and Amenity Level Percentages

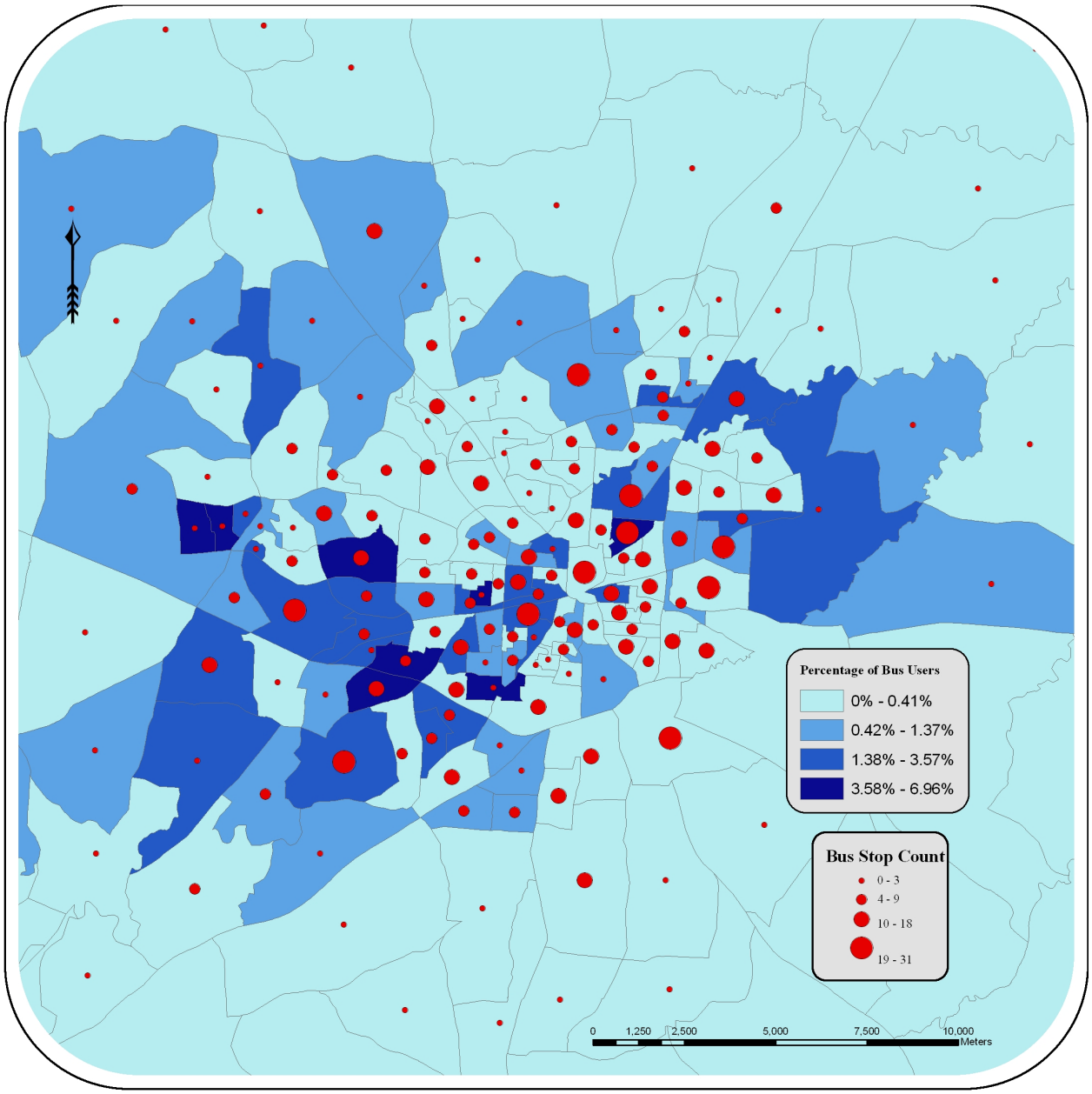
	GREENSBORO		KANSAS CITY		SEATTLE	
AMENITY LEVEL	NUMBER OF BUS STOPS AT EACH LEVEL	PERCENTAGE OF TOTAL BUS STOPS	NUMBER OF BUS STOPS AT EACH LEVEL	PERCENTAGE OF TOTAL BUS STOPS	NUMBER OF BUS STOPS AT EACH LEVEL	PERCENTAGE OF TOTAL BUS STOPS
LEVEL 4	13	1.2%	0	0%	1661	18.3%
LEVEL 3	10	.92%	158	3.4%	3145	34.8%
LEVEL 2	801	74.2%	668	14.5%	257	2.8%
LEVEL 1	255	23.6%	3764	82.0%	3971	43.9%
TOTAL	1079	100%	4590	100%	9043	100%

Sources: GTA, 2009; KCATA, 2009; KCMT, 2009

4.2 Greensboro, NC

Before analyzing the maps in this section, Table 2 shows the amount of bus stops of each amenity level and the percentage of total bus stops for Greensboro, Kansas City, and Seattle. One can already see that there are very few bus stops at levels 4 and 3. There is an overwhelming amount of bus stops at levels 2 and 1. The bus stops with high amenity levels will now be analyzed where they are located on the maps to ascertain if they are in areas where they are needed or used the most.

Figure 4.2.1: Bus Stop Counts and Percentage of Bus Users: Greensboro, NC

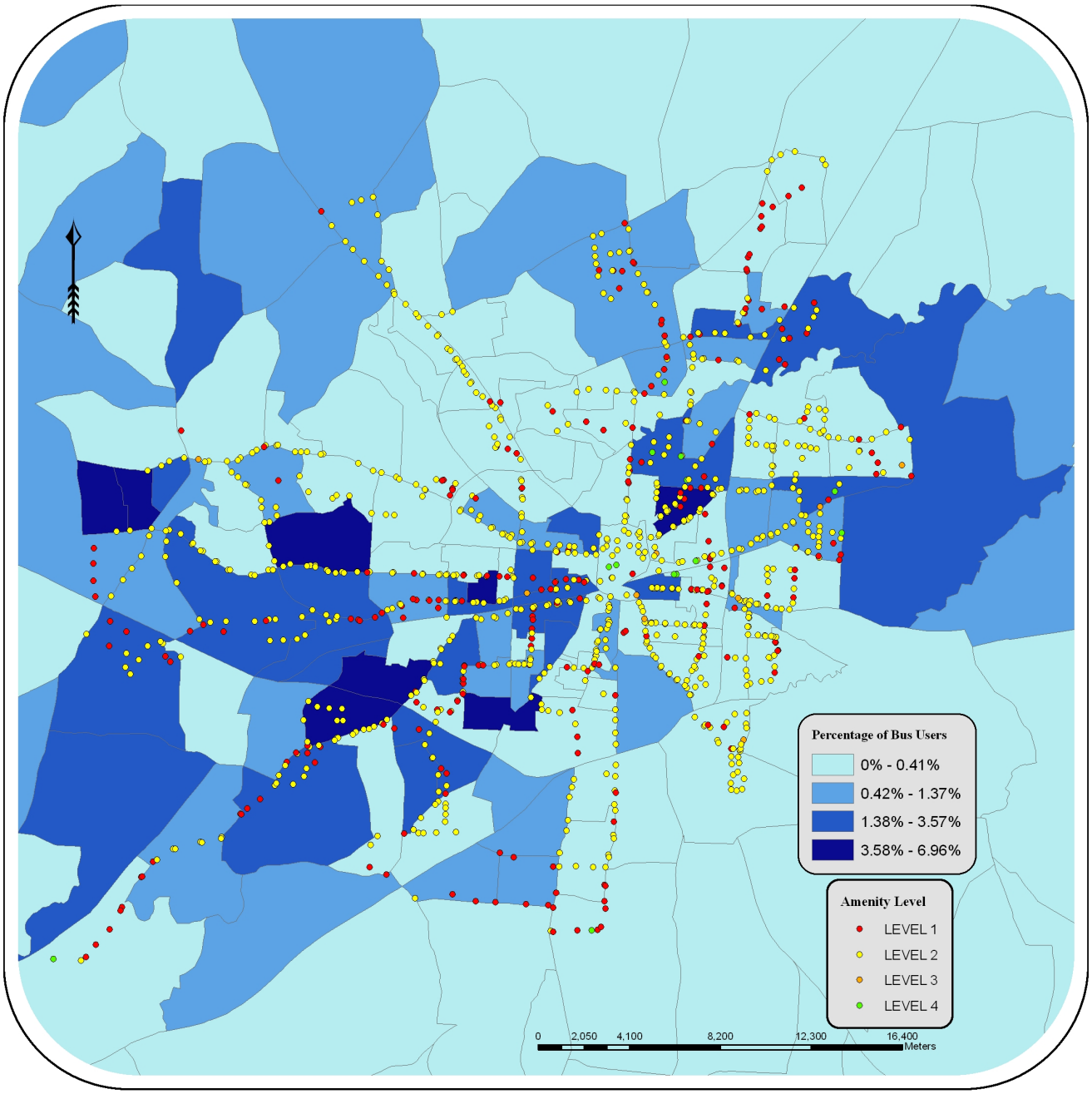


Sources: US Census Bureau, 2000; GTA, 2009

Figure 4.2.1 is a map showing bus stop counts and the percentage of commuters who use bus by block groups in Greensboro. The numbers in the bus stop count legend represents the total number of bus stops located in each block group. The first map which represents total bus stops by graduated circles has nine representing the highest amount of bus stops. None of these are located in block groups with the highest percentages of commuters use bus. Three of the highest bus stop counts are located in block groups with the least amount of bus user commuters. It seems as if overall concentrations of bus stops are not spatially located in areas where they are needed by people who actually use the bus system.

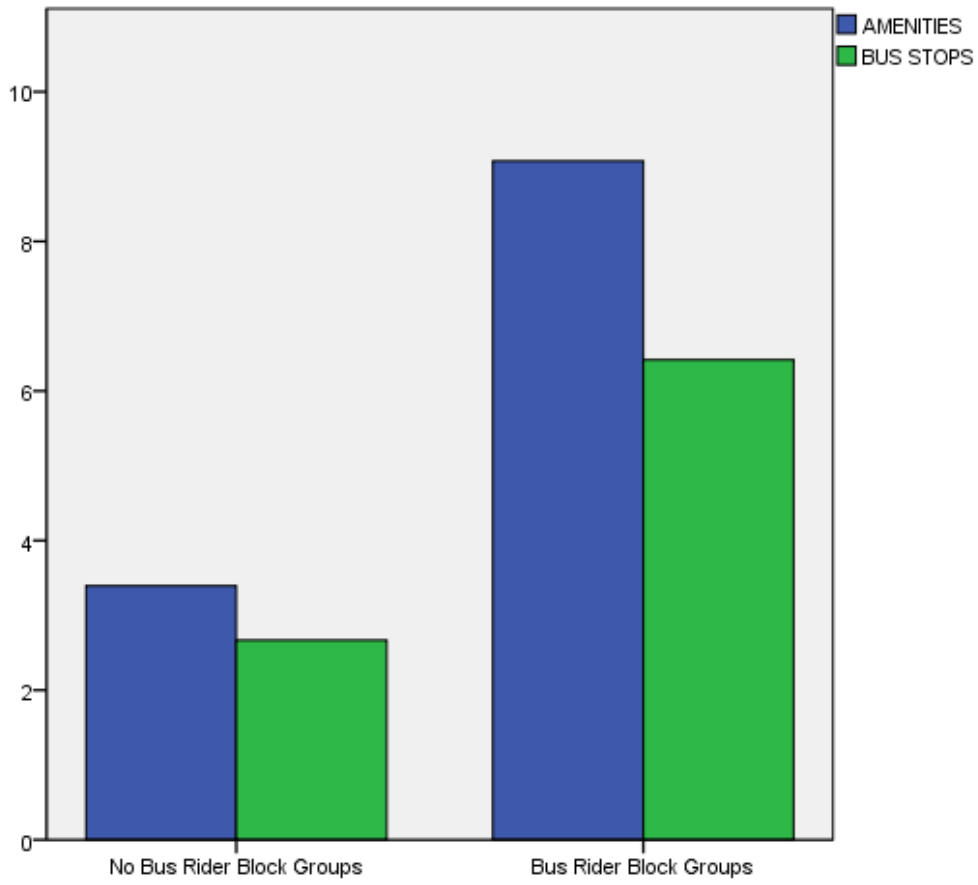
Figure 4.2.2 shows bus stop amenity levels and commuters who use bus by block groups. Of the block groups with the highest percentage of bus user commuters, there are no bus stops with amenity levels 4 or 3. Most of the bus stops in these areas are level 2 with three at level 1. There are only two bus stops with level 4 located in areas with the second highest amount of bus user commuters and only a few stops with level 3. The rest of the stops with level 4 are located in areas of the second fewest and fewest percentages commuters who use bus. Although, people who ride the bus more for their commuting and have to endure more wait and exchange times should be rewarded with more amenities for their safety and comfort, the spatial distributions of bus stop amenity level suggest an unfortunate trend. However, one can see this trend as a strategy by transit authorities to place more amenities in places with lower bus rider commuters to improve ridership

Figure 4.2.2: Amenity Levels and Percentage of Bus Users: Greensboro, NC



Sources: US Census Bureau, 2000; GTA, 2009

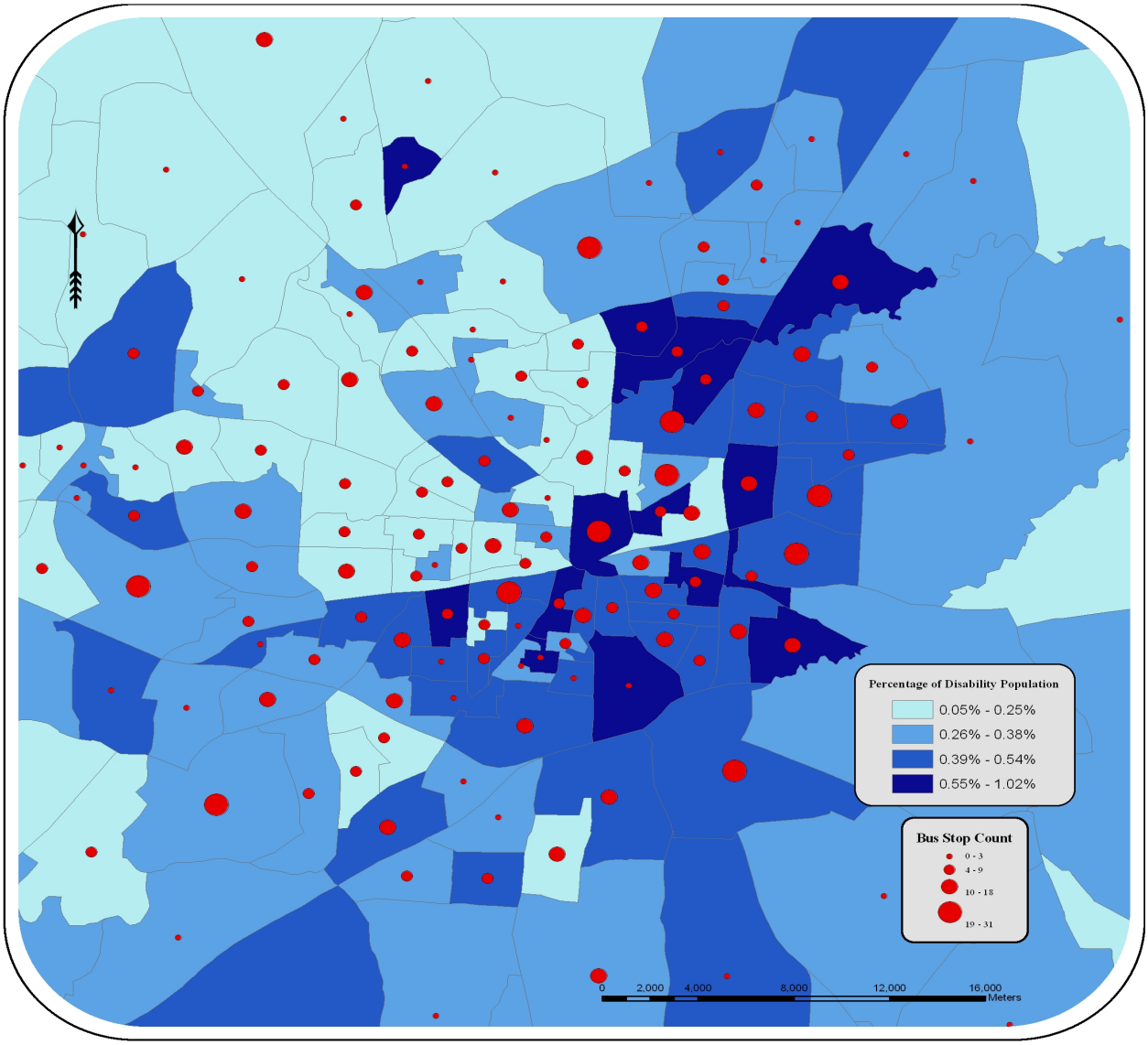
Figure 4.2.3: *Bus Users Block Groups in Relation to Bus Stop and Amenity Locations*



Sources: US Census Bureau, 2000; GTA, 2009

Figure 4.2.3 is a bar graph showing bus stop counts and total amenities found in block groups with no bus use commuters and block groups with bus user commuters. Although by examining Figure 4.2.2, it seems there are not enough high amenity levels in areas of more bus rider commuters, Figure 4.2.3 shows that there are more total amenities and bus stops in block groups with bus rider commuters versus those without bus rider commuters.

Figure 4.2.4: Bus Stop Counts and Percentage of Disability Population: Greensboro, NC



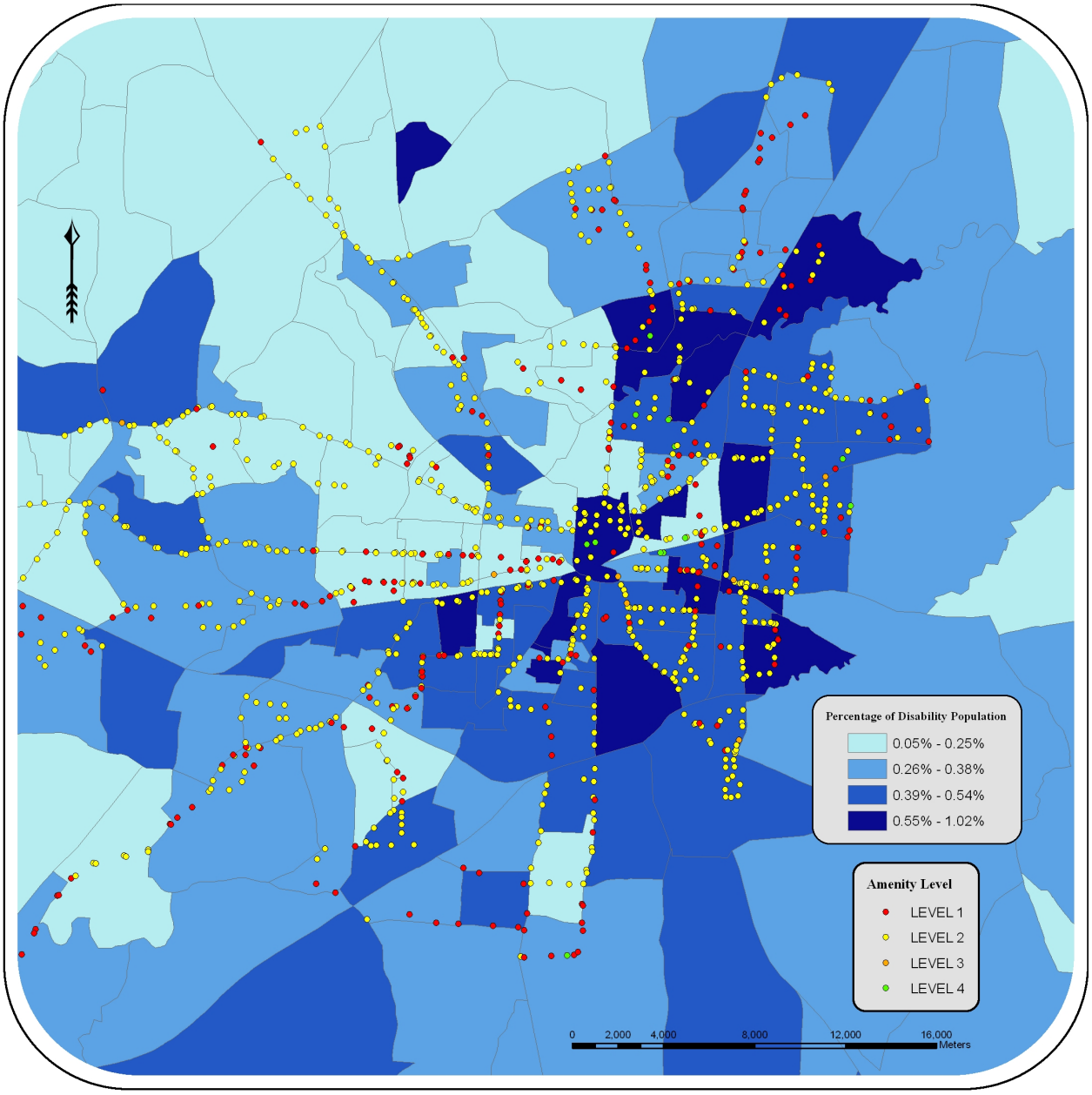
Sources: US Census Bureau, 2000; GTA, 2009

Figure 4.2.4 shows the bus stop counts and the percentage of disabled population by block groups in Greensboro. Figure 4.2.4 shows only one circle with the highest amount of bus stops falling inside a block group with the highest concentration of

disabled population. There are, however, five of the nine circles with the highest bus stops located in the areas of the second highest concentration of disabled population. Overall, from viewing the map, there seems to be a fairly even dispersal of bus stops in areas with the disabled population, and there are no circles of the highest level amenities located in areas with the lowest population of the disabled. However, there is a definite need for more bus stops in the block groups with the highest concentration of disabled people.

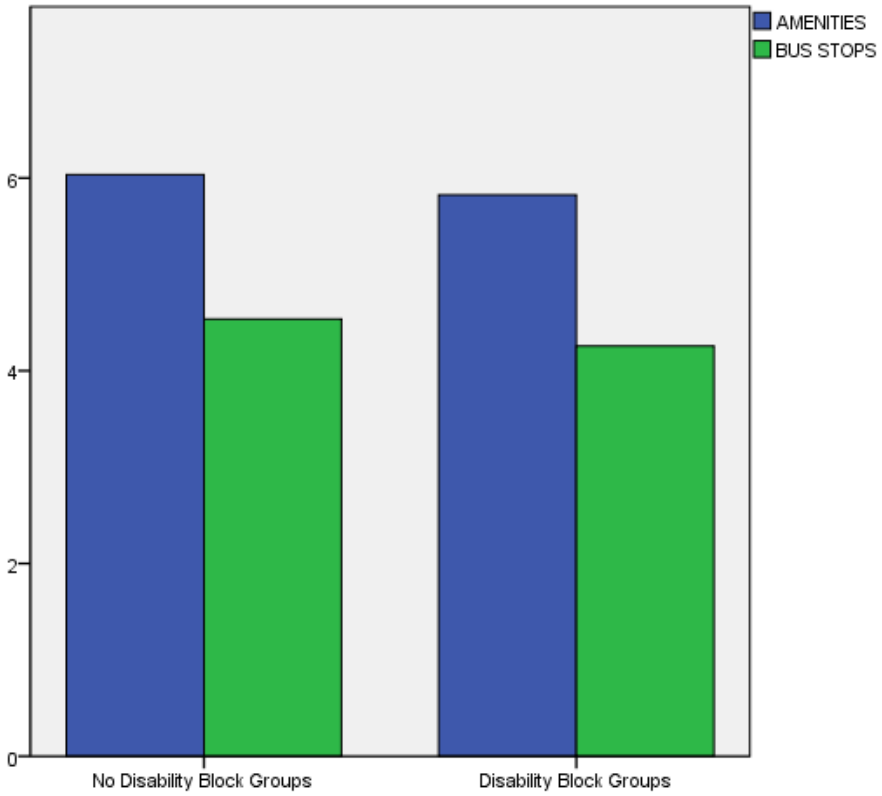
Figure 4.2.5 represents amenity levels and the percentage of disability population by block groups for Greensboro. The disability population should receive the same amount of amenities, if not better, than that of the population with no disabilities. As shown in Table 2, there are only 13 out of 1079 bus stops in Greensboro that are categorized as level 4. Of those thirteen level 4 bus stops, three fall inside block groups with the highest populations of the disabled. Seven of the thirteen level 4 bus stops fall inside areas with the second highest disabled population. The remaining three level 4 bus stops are located in areas of the lowest disabled populations. Although it is fortunate that the majority of the level 4 bus stops are located in areas of high disability populations, the problem is that there are very few bus stops with level 4 and level 3 designations in Greensboro as a whole. Of the ten level 3 bus stops, only two are located in block groups with the highest disabled populations.

Figure 4.2.5: Amenity Levels and Percentage of Disability Population: Greensboro, NC



Sources: US Census Bureau, 2000; GTA, 2009

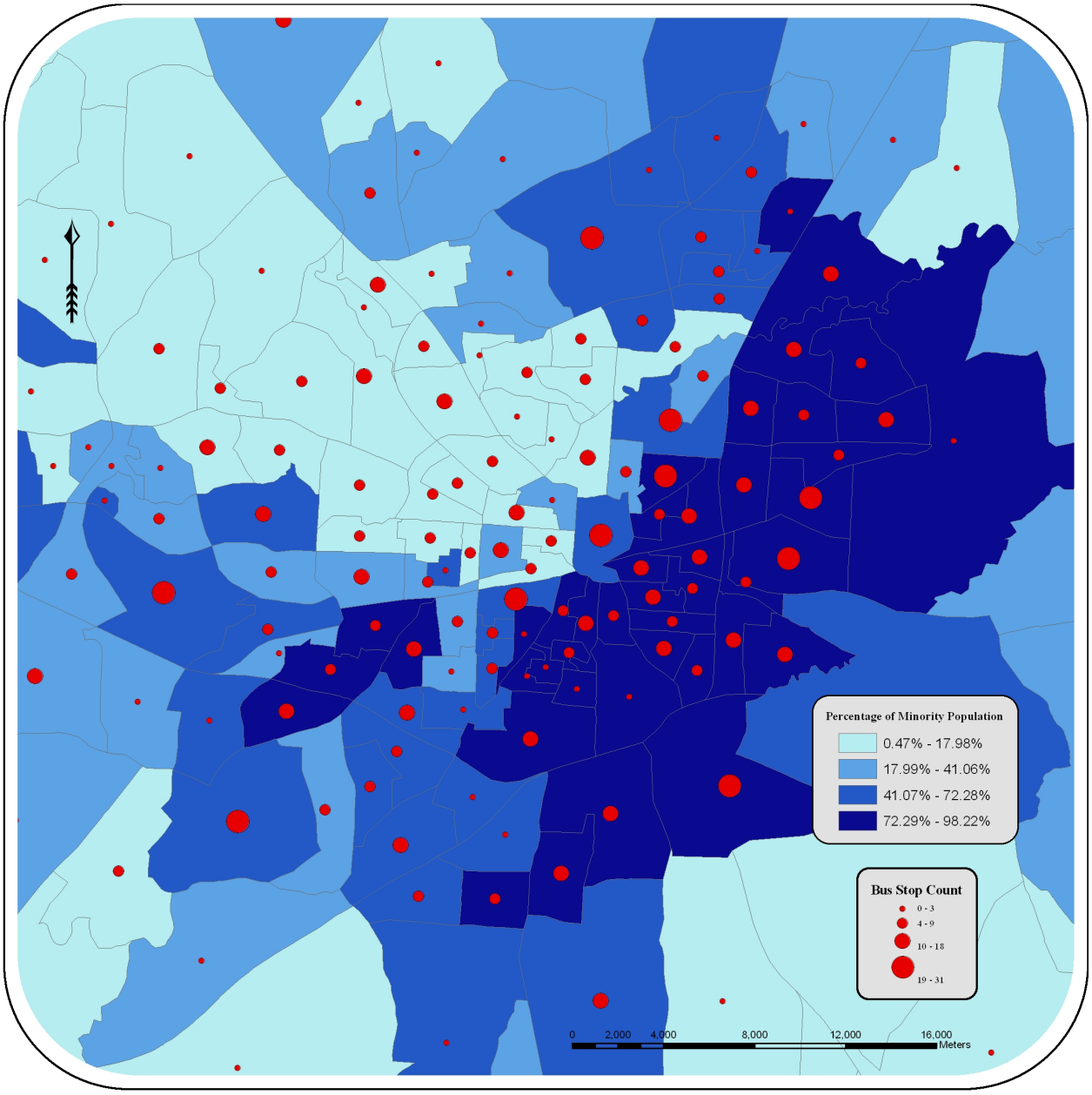
Figure 4.2.6: *Disability Block Groups in Relation to Bus Stop and Amenity Locations*



Sources: US Census Bureau, 2000; GTA, 2009

Figure 4.2.6 is a bar graph showing bus stop counts and total amenities found in block groups with no disabilities and block groups with disabilities. Although the maps show a somewhat fair distribution of bus stops and amenity levels, one can see in Figure 4.2.6 that there are slightly more bus stops and total amenities located in block groups with no disabilities.

Figure 4.2.7: Bus Stop Counts and Percentage of Minority Population: Greensboro, NC

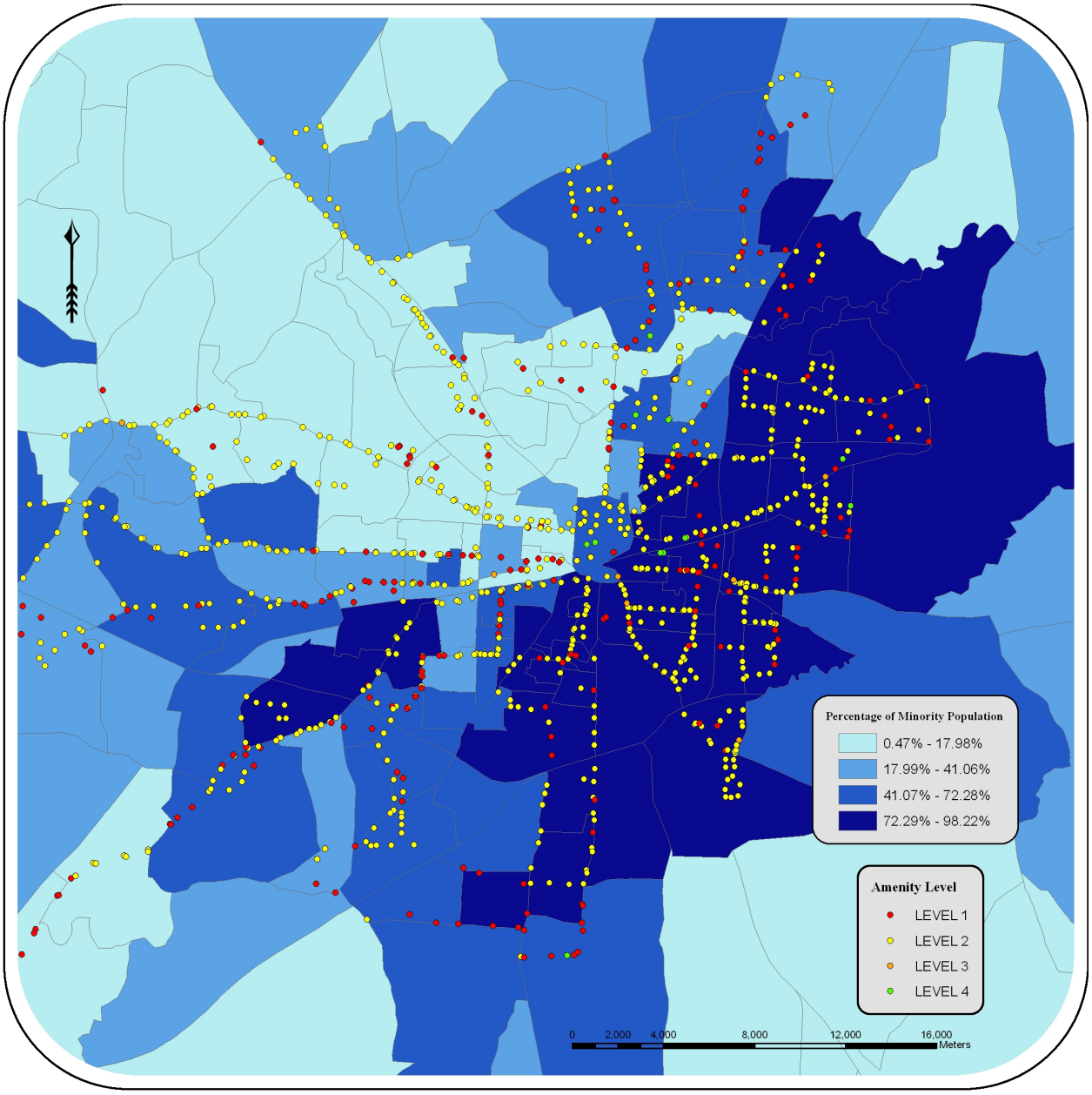


Sources: US Census Bureau, 2000; GTA, 2009

Figure 4.2.7 is a map showing the bus stop counts and the percentage of minority population by block group in Greensboro. Figure 4.2.7 has four block groups of the highest minority percentage containing the highest amount of bus stops. There are six block groups with the second highest minority population containing the highest amount of bus stops. As far as the location of bus stops in Greensboro, there seems to be a moderately even dispersal throughout the city. There are actually more bus stops located in areas of higher minority population. This trend is quite compatible with the idea of transportation equity.

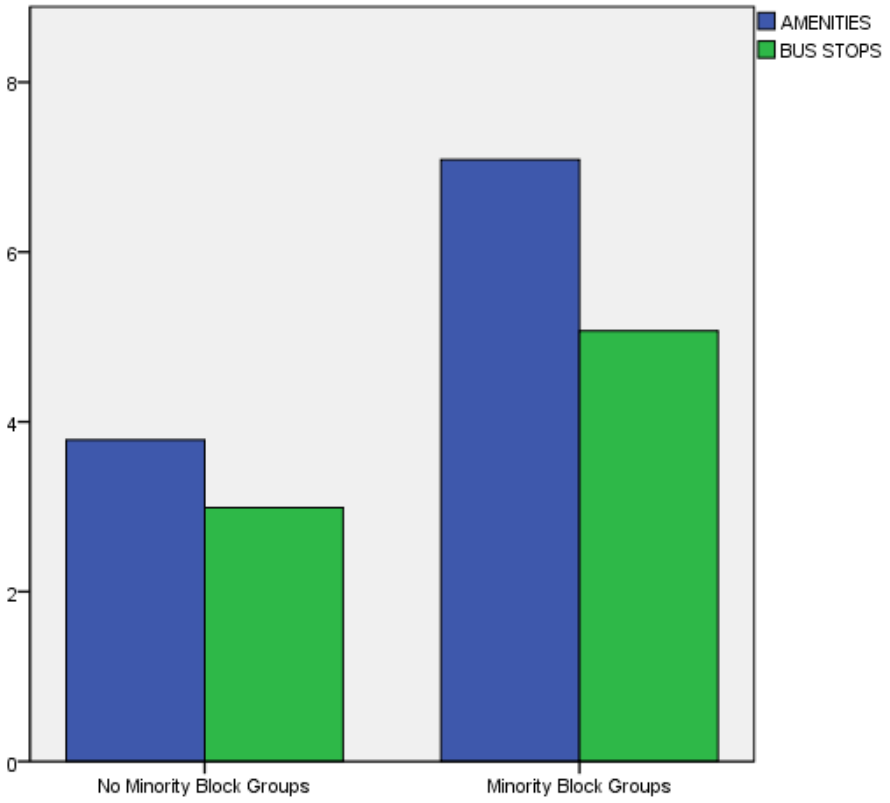
Figure 4.2.8 shows amenity levels and the percentage of minority population by block groups in Greensboro. Of the thirteen level 4 bus stops, five are located in block groups of the highest minority populations. Seven of the level 4 bus stops are located in block groups of the second highest minority population. Only one level 4 bus stop is located in a block group with the lowest minority population. Eight out of the ten level 3 bus stops are inside block groups of the highest minority population. The remaining two level 3 bus stops are in areas of the second highest minority population. The overall dispersal of amenities in Greensboro is definitely located in areas of higher minority populations which again is compatible to transportation equity, although the same problem remains: there are too few bus stops with high amenity levels throughout the city.

Figure 4.2.8: Amenity Levels and Percentage of Minority Population: Greensboro, NC



Sources: US Census Bureau, 2000; GTA, 2009

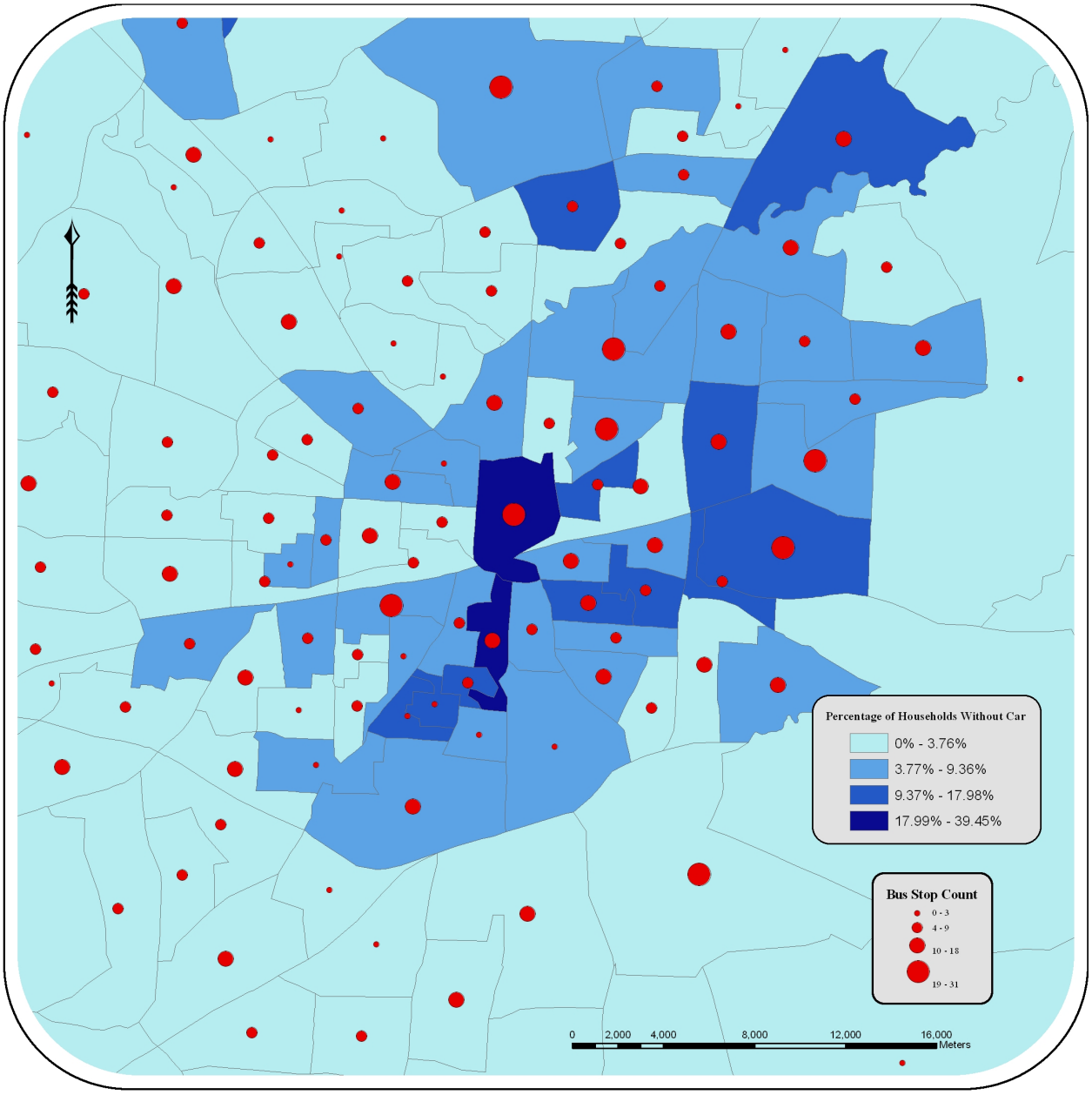
Figure 4.2.9: *Minority Block Groups in Relation to Bus Stop and Amenity Locations*



Sources: US Census Bureau, 2000; GTA, 2009

Figure 4.2.9 is a bar graph showing bus stop counts and total amenities found in block groups with no minorities and block groups with minorities. The results in Figure 4.2.9 are the same as those in the maps. There are definitely more bus stops and total amenities in areas of more minority populations.

Figure 4.2.10: Bus Stop Counts and Percentage of Households without Car: Greensboro, NC

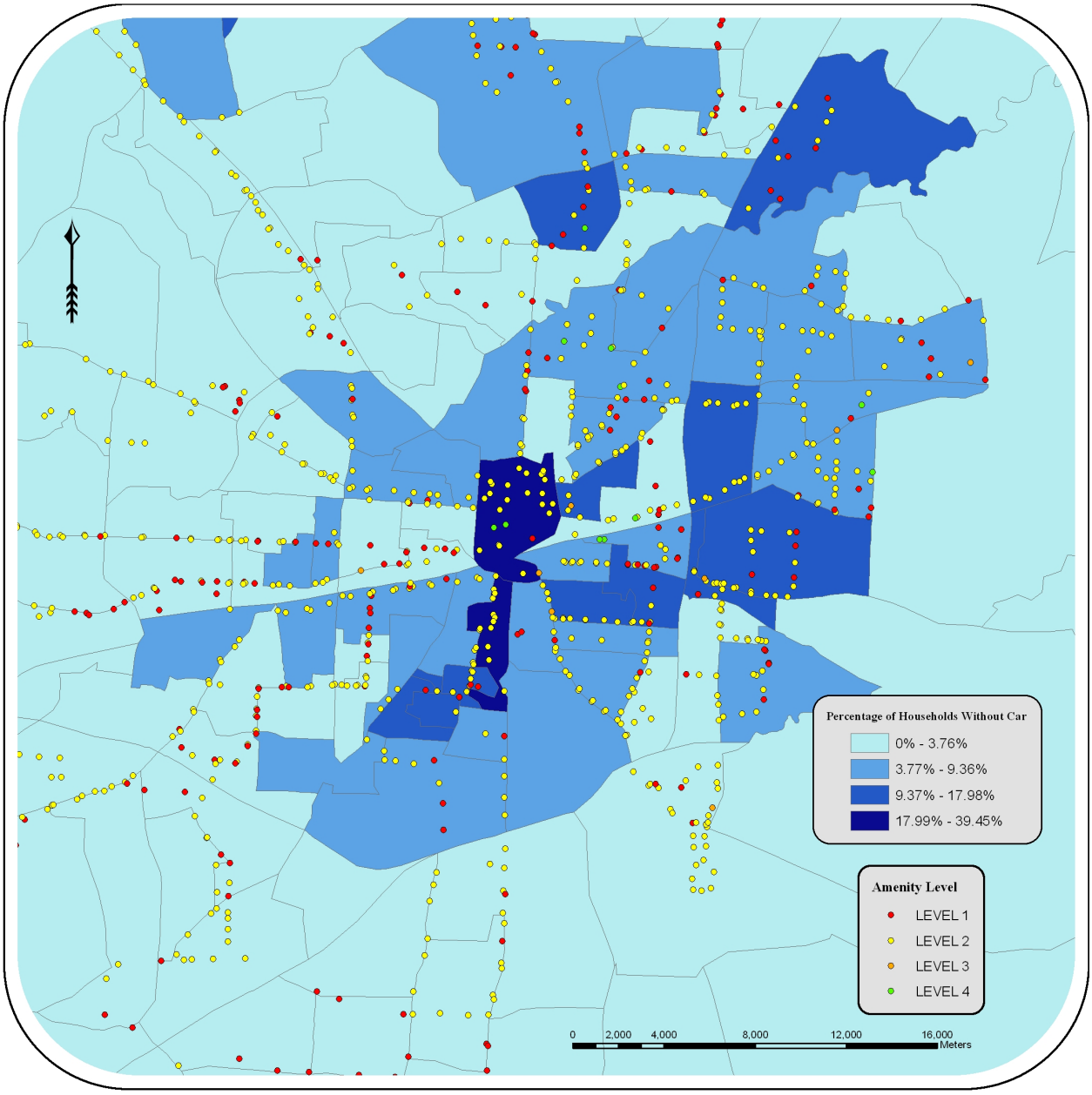


Sources: US Census Bureau, 2000; GTA, 2009

Figure 4.2.10 is a map representing the percentage of households with no car by block group in Greensboro. Figure 4.2.10 shows two block groups with the highest population with no car. In those two block groups, there is one with a circle representing the highest number of bus stops and the other with the second highest. The first block group is the block group of downtown, which most downtowns do contain higher populations without cars because they tend to work and live in a close proximity. The rest of the block groups with the second and third highest no car households are fairly evenly dispersed with bus stops throughout.

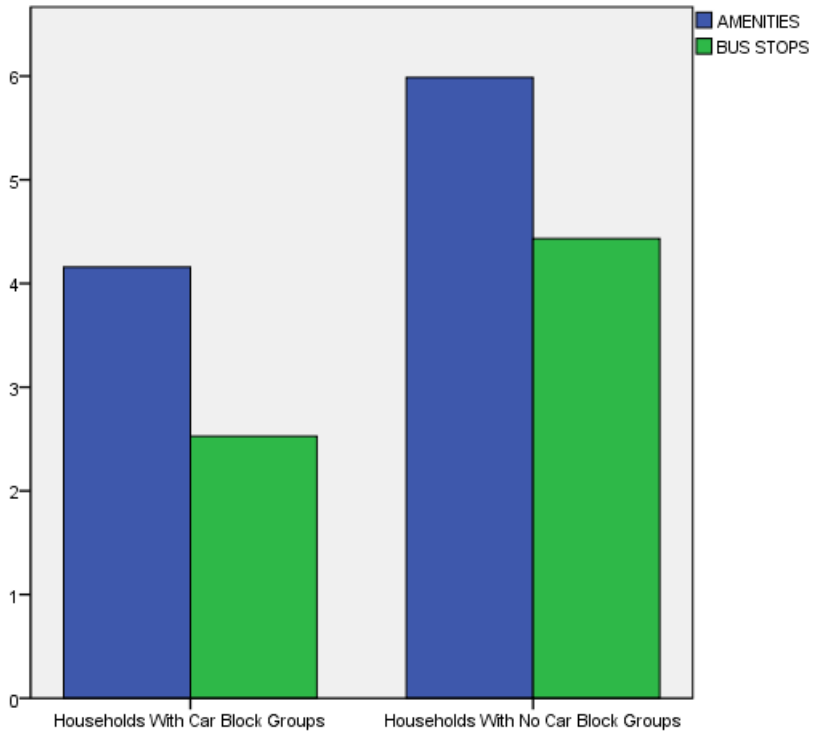
Figure 4.2.11 represents amenity levels and the percentage of households with no car. Of the two block groups with the highest population of no car households, there are two level 4 bus stops. The rest of the bus stops in these areas are level 2 with one level 1. There is only one level 4 and one level 3 bus stop in areas of the second highest population of no car households. The rest of the higher level bus stops fall inside areas of lower no car household populations. This is an adverse trend given the assumption that those without cars are more likely to need bus stops and deserve better amenities at those stops.

Figure 4.2.11: Amenity Levels and Percentage of Percentage of Households without Car: Greensboro, NC



Sources: US Census Bureau, 2000; GTA, 2009

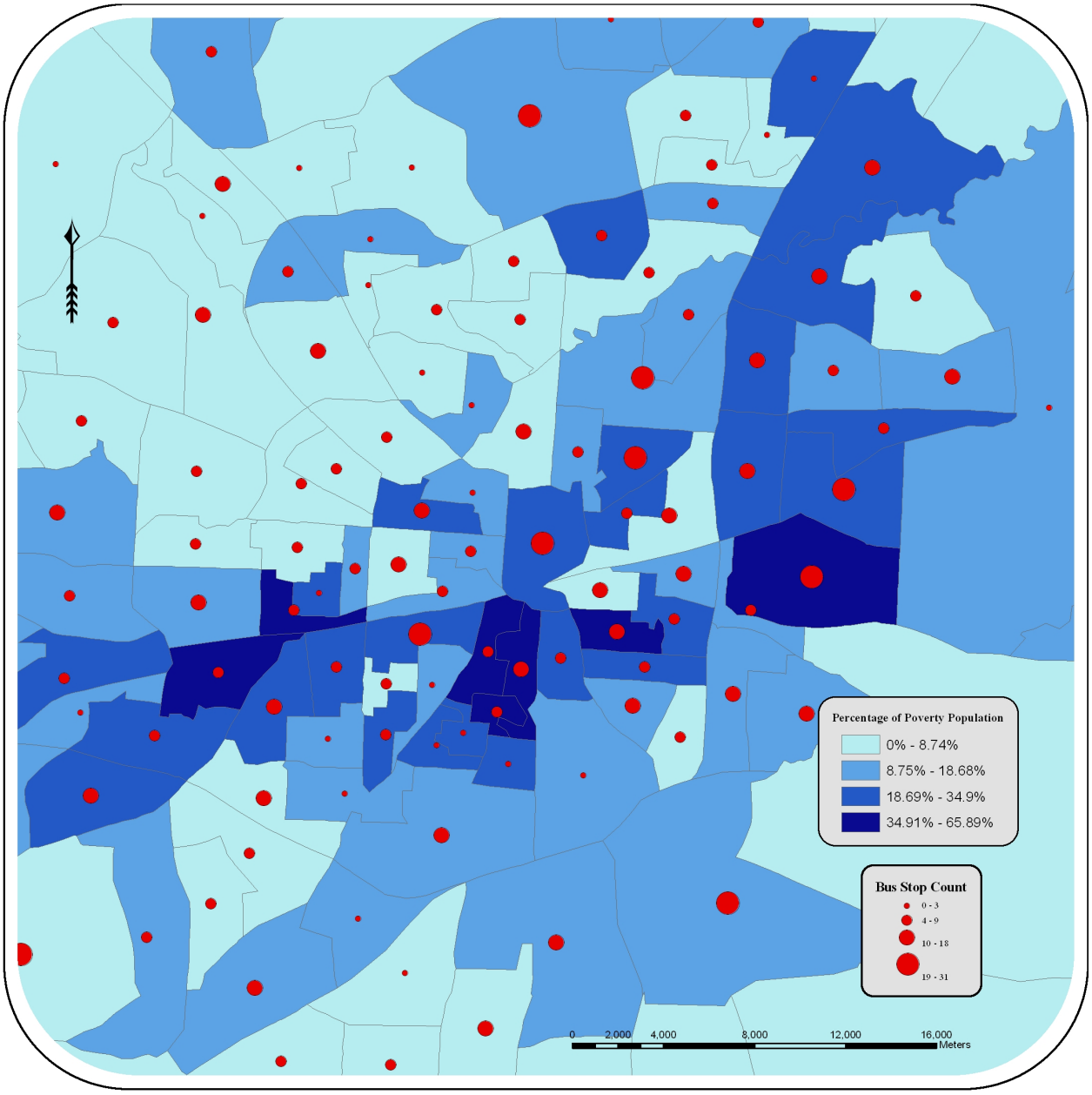
Figure 4.2.12: *No car Household Block Groups in Relation to Bus Stop and Amenity Locations*



Sources: US Census Bureau, 2000; GTA, 2009

Figure 4.2.12 is a bar graph showing bus stop counts and total amenities found in block groups with households with cars and block groups with households with no car. Although the maps show higher amenity levels in areas with cars, Figure 4.2.12 shows that there are more total amenities and bus stops in areas of households with no car.

Figure 4.2.13: Bus Stop Counts and Percentage of Poverty Population: Greensboro, NC

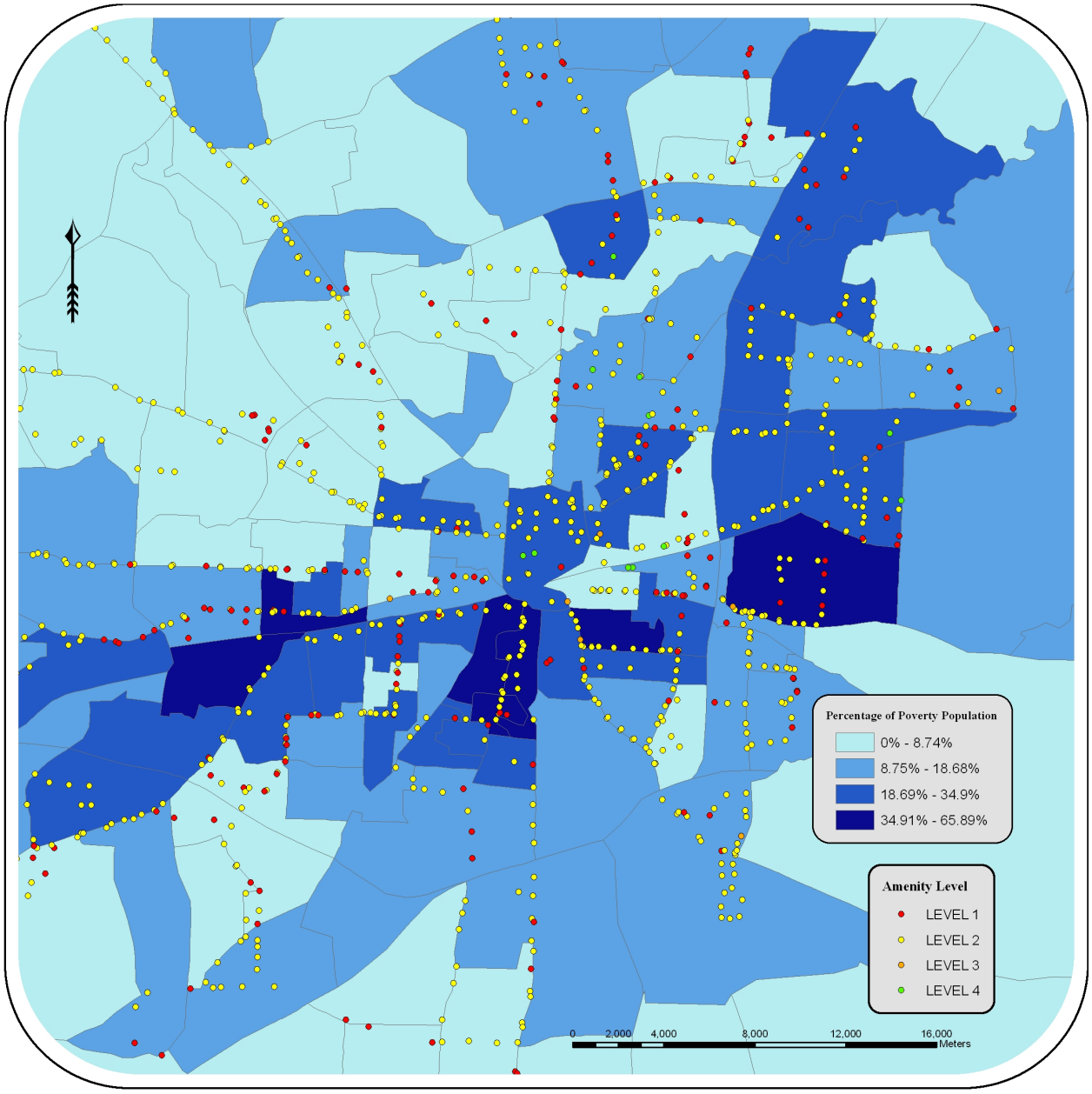


Sources: US Census Bureau, 2000; GTA, 2009

Figure 4.2.13 represents the percentage of poverty population by block groups. Figure 4.2.13 shows only one circle representing the highest amount of bus stops located in a block group with the highest percentage of poverty stricken, however, the rest of the block groups in these areas have the second to third highest amounts of bus stops. The areas of the second highest poverty populations have numerous block groups with high concentrations of bus stops. There are very few low concentrations of bus stops in areas of higher poverty populations. Most of the block groups with a low amount of bus stops are in areas with low poverty populations. This dispersal seems somewhat fair given the assumption that those in poverty will more likely have to use public transportation.

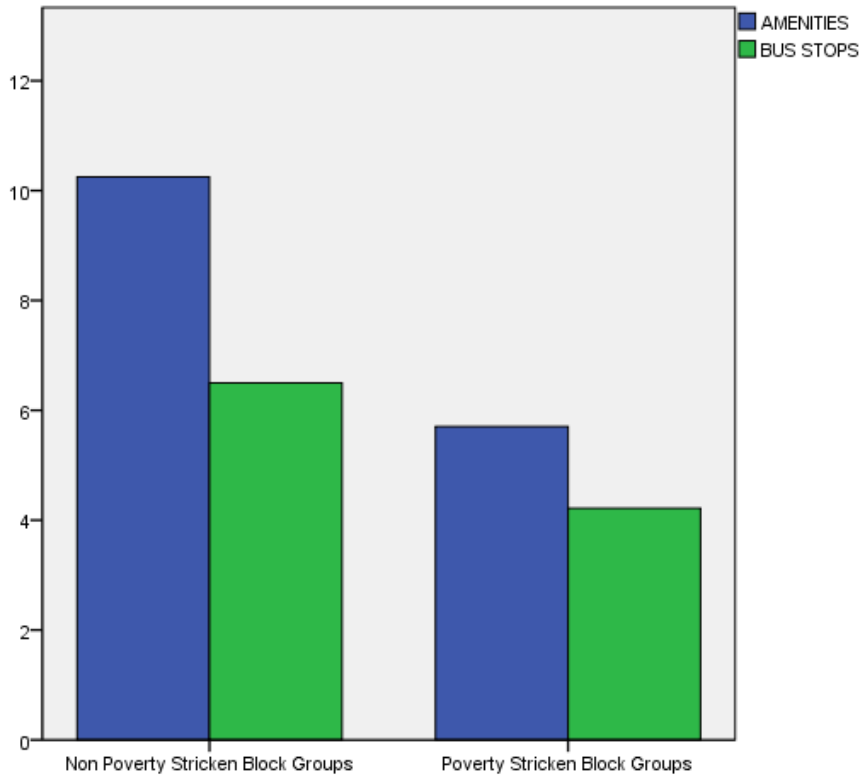
Figure 4.2.14 represents amenity levels and the percentage of poverty population by block group. Of the level 4 bus stops, there is not one located in areas of the highest concentration of those in poverty. And of the level 3 bus stops, there are only two located in these same areas. There are numerous level 1 and level 2 bus stops where the poverty population is high. There are, however, five level 4 bus stops and two level 3 bus stops in areas of the second highest poverty populations. The rest of the higher level bus stops are in areas of lower poverty populations. Although there are sufficient amounts of total bus stops in these areas, there is a lack of those with higher amenity levels. This is contradictory to the concept of transportation equity.

Figure 4.2.14: Amenity Levels and Percentage of Poverty Population: Greensboro, NC



Sources: US Census Bureau, 2000; GTA, 2009

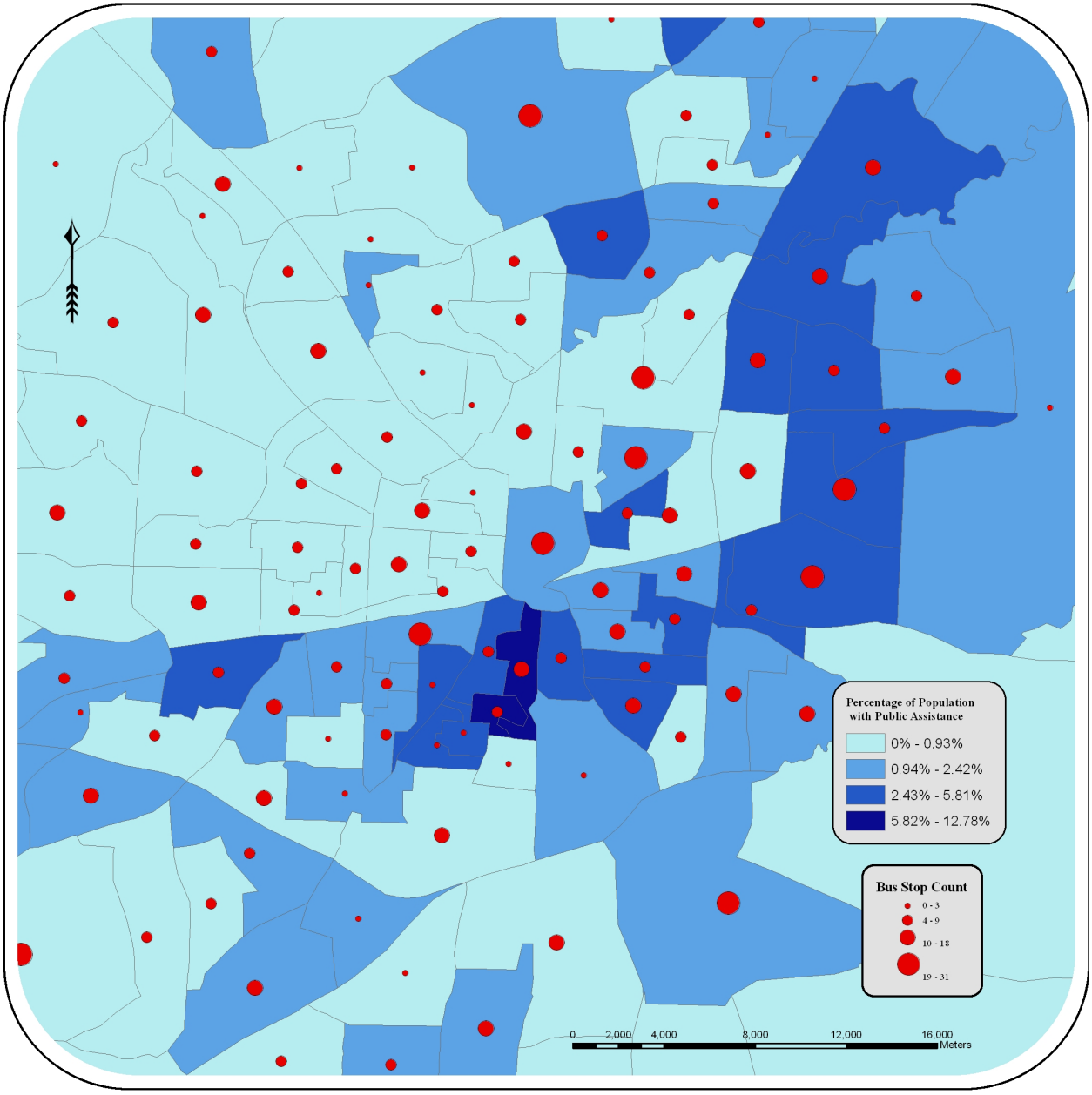
Figure 4.2.15: *Poverty Stricken Block Groups in Relation to Bus Stop and Amenity Locations*



Sources: US Census Bureau, 2000; GTA, 2009

Figure 4.2.15 is a bar graph showing bus stop counts and total amenities found in block groups with no poverty and block groups in poverty. This figure shows a clear uneven distribution to those in poverty versus not in poverty. There are far more bus stops located in block groups with no poverty, as well as more amenities in areas of no poverty.

Figure 4.2.16: Bus Stop Counts and Percentage of Population with Public Assistance: Greensboro, NC

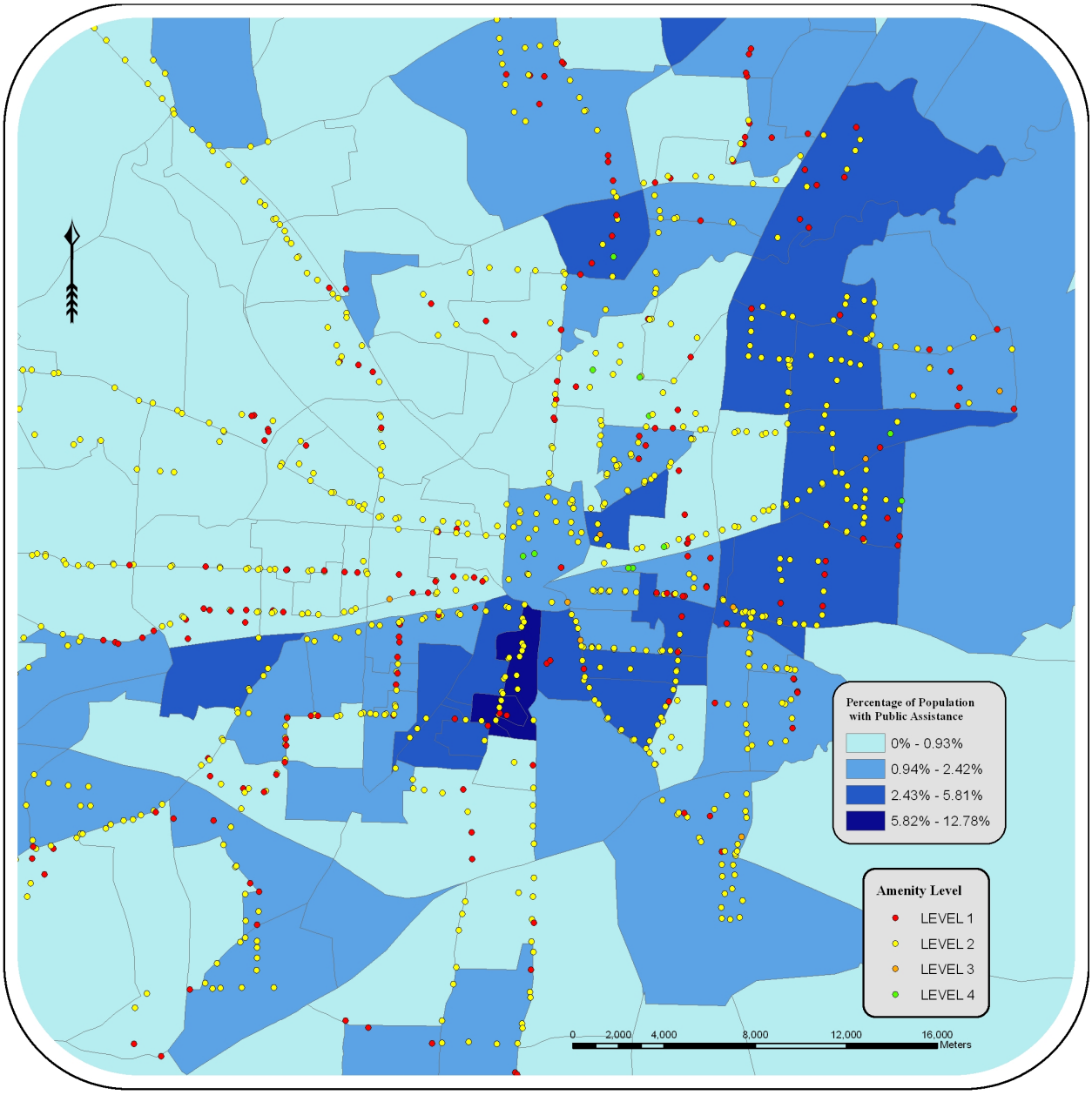


Sources: US Census Bureau, 2000; GTA, 2009

Figure 4.2.16 is a map representing the percentage of population receiving public assistance by block group. This map does not have a concentration of the highest amount of bus stops in block groups with the highest populations receiving public assistance, although they are not the lowest amounts of bus stops either. There is a fair amount of higher concentrations of bus stops in areas of the second highest public assistance populations. There are definitely more bus stops concentrated in areas of where the population receives public assistance versus those where they do not. Mentioned in the poverty section above, this is a good trend given the assumption that people living with public assistance, like those in poverty, might rely more on public transportation than those without public assistance.

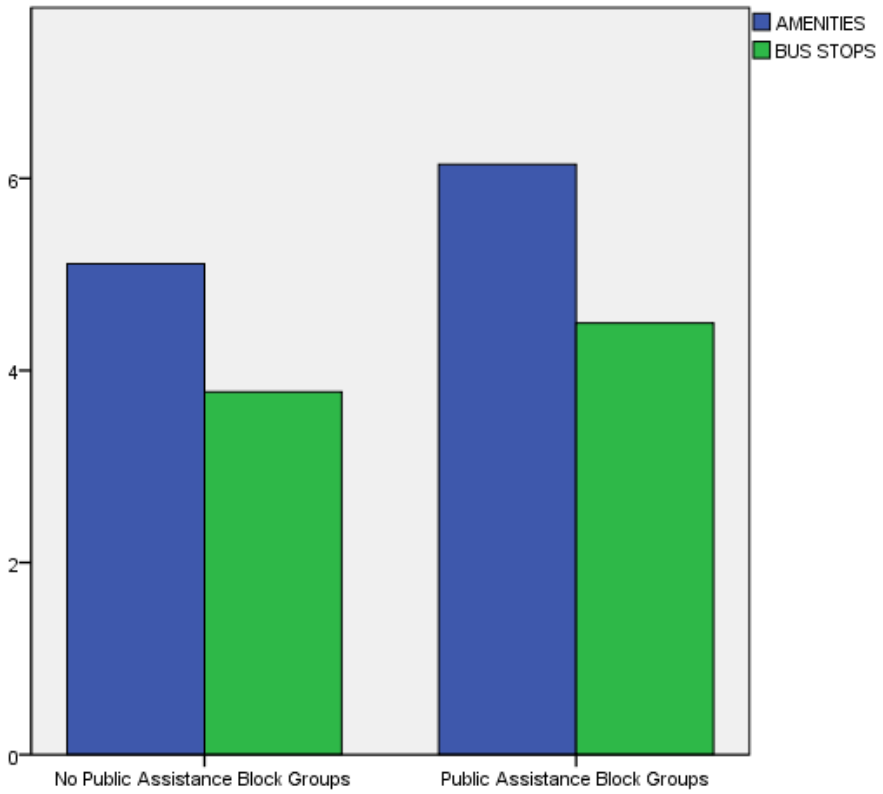
Figure 4.2.17 shows amenity levels and the percentage of population receiving public assistance by block groups. In the block groups with the highest public assistance population, there are no level 4 bus stops and only one level 3. In the areas with the second highest populations of public assistance aid, there are three level 4 bus stops and three level 3 bus stops. There is a significant amount of level 1 and level 2 bus stops in these areas. There are ten level 4 bus stops in areas of the lower to lowest populations of those receiving public assistance. This is also unfortunate, as in the case for the poverty population. Again, there are plenty of bus stops in these areas, but with lower amenities.

Figure 4.2.17: Amenity Levels and Percentage of Population with Public Assistance: Greensboro, NC



Sources: US Census Bureau, 2000; GTA, 2009

Figure 4.2.18: *Public Assistance Block Groups in Relation to Bus Stop and Amenity Locations*



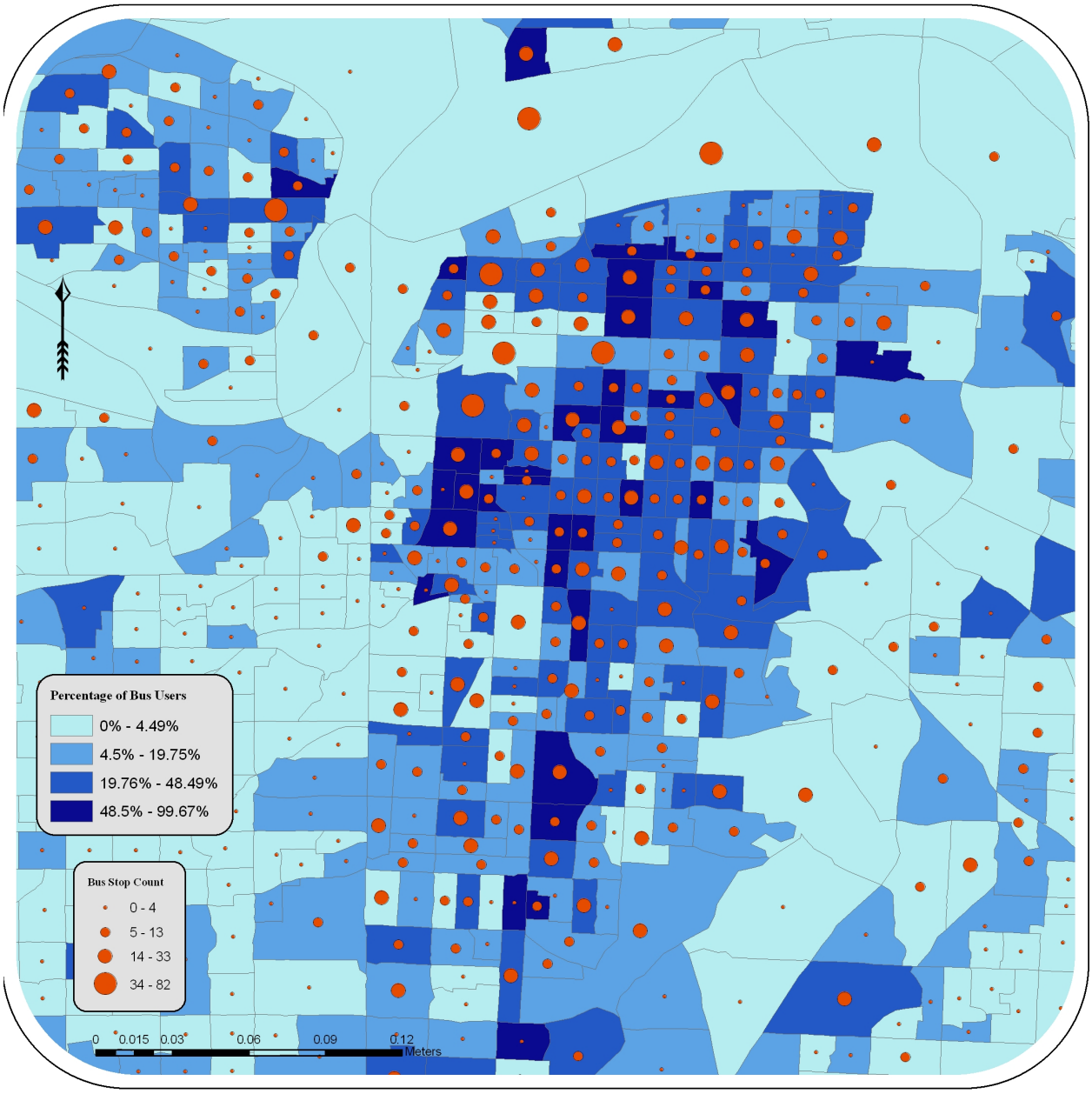
Sources: US Census Bureau, 2000; GTA, 2009

Figure 4.2.18 is a bar graph showing bus stop counts and total amenities found in block groups with no public assistance and block groups with public assistance. Although the maps show higher amenity levels in areas with less public assistance, Figure 4.2.18 shows more bus stops and total amenities in areas where people receive public assistance.

4.3 Kansas City, MO

Before analyzing the maps in this section, the Table 2 in the prior section is represented to show the number of bus stops of each amenity level for Kansas City, MO. After creating the amenity level system it was realized that no bus stops in Kansas City are at level 4 and only 158 out of 4590 bus stops have amenities at level 3. There are an overwhelming number of bus stops at level 2 and 1. The number of bus stops and those with higher amenity levels, with none of the highest level, will now be analyzed as to where they are located spatially on the maps and if they are in areas where they are needed or used the most.

Figure 4.3.1: Bus Stop Counts and Percentage of Commuters by Bus: Kansas City MO

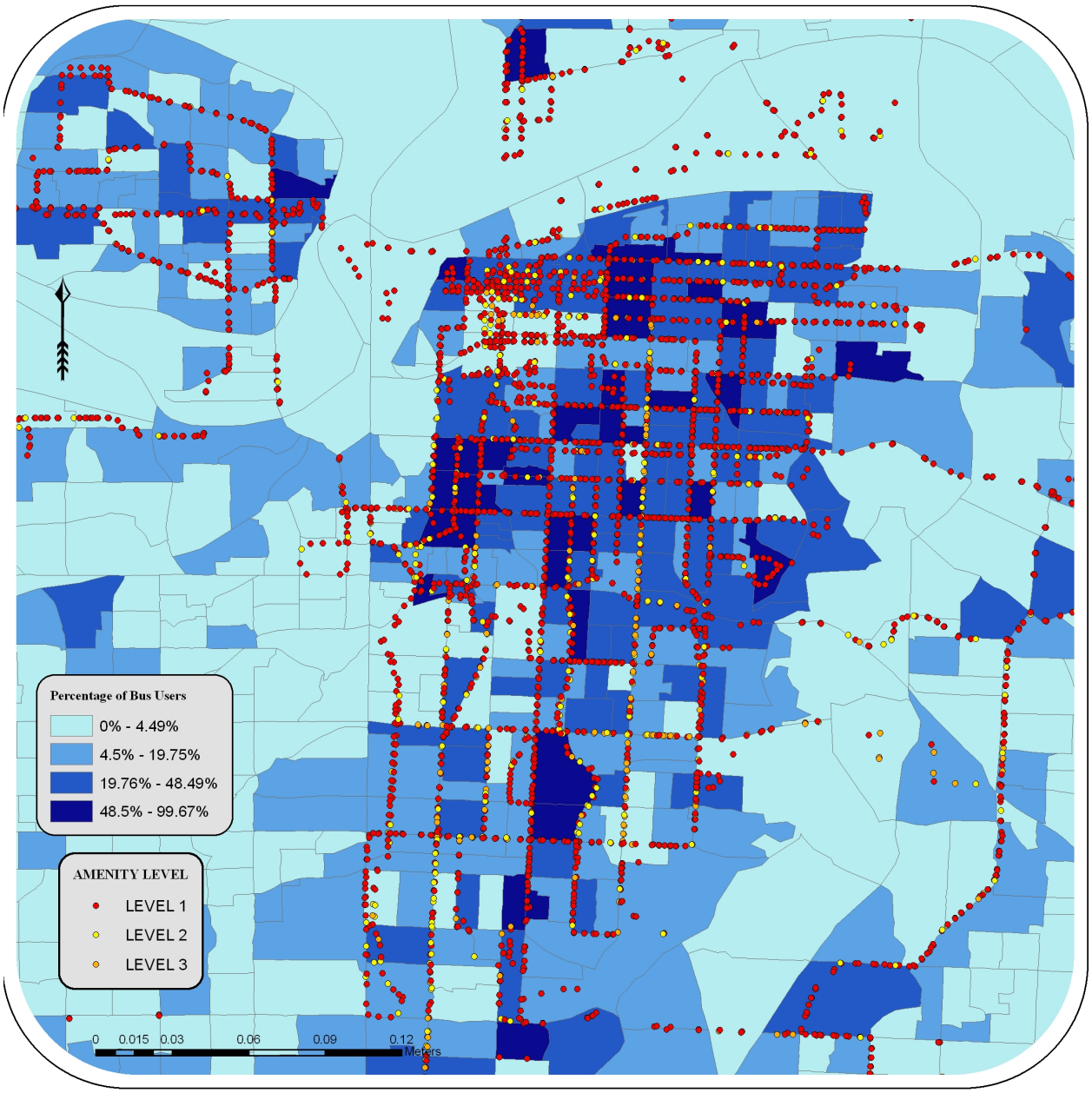


Sources: US Census Bureau, 2000; KCATA, 2009

Figure 4.3.1 represents the percentage of bus users by block group for Kansas City. We can see that there are no block groups with the highest population of public assistance containing the highest amount of bus stops. Of the areas with the second highest population of bus riders, there are two block groups containing the largest number of bus stops. There does seem to be an overall fair distribution throughout. In the areas of higher bus user populations, there are numerous block groups with medium to high bus stop counts the majority of low stop counts fall in block groups of low bus user populations.

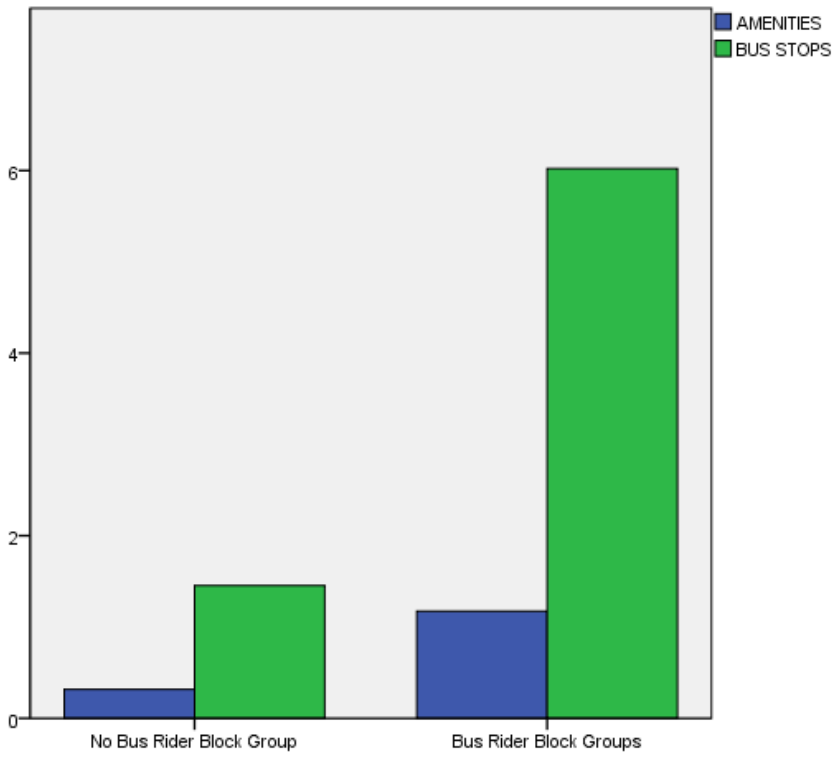
Figure 4.3.2 shows amenity levels and the percentage of bus user population by block group. The block group with the largest population of bus riders has bus stops only at amenity level 1. The areas with the second highest populations of bus riders contain numerous level 3 bus stops. The majority of the level 3 bus stops actually fall inside higher populations of bus riders, except of course the block group with the most bus riders. Although the level 3 bus stops are mostly located where more bus riders live, the overall concern for Kansas City is the overall lack of high amenity bus stops.

Figure 4.3.2: Amenity Levels and Percentage of Bus Users: Kansas City MO



Sources: US Census Bureau, 2000; KCATA, 2009

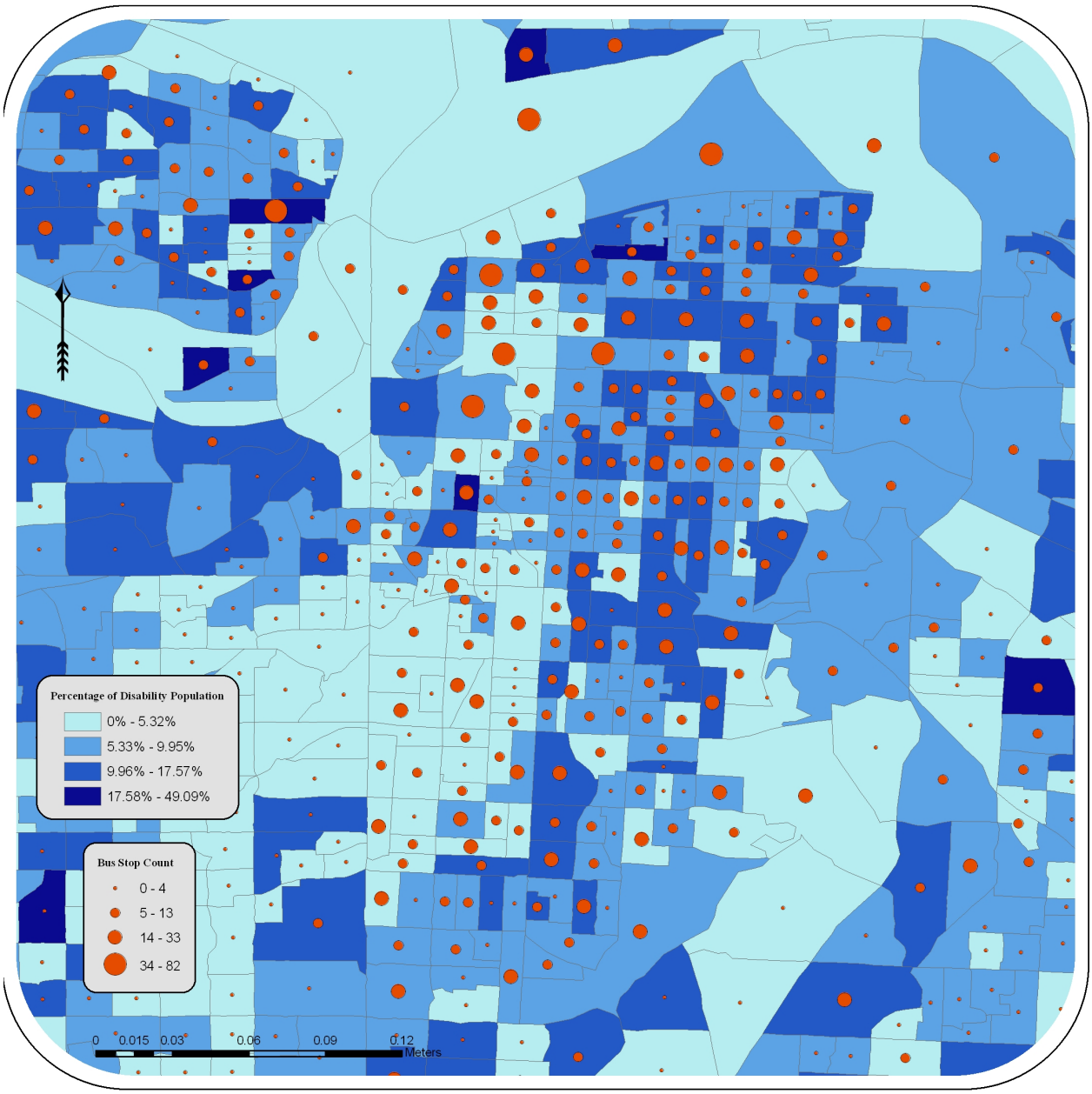
Figure 4.3.3: *Bus User Block Groups in Relation to Bus Stop and Amenity Locations*



Sources: US Census Bureau, 2000; KCATA, 2009

Figure 4.3.3 is a bar graph showing bus stop counts and total amenities found in block groups with no bus riders and block groups with bus riders. Although the maps show more bus stops in areas with lower bus rider populations, Figure 4.3.3 shows that there are significantly more bus stops in block groups with bus riders versus those with no bus riders, as well as more total amenities in these areas. Note that this graph represents block groups with absolutely no bus riders versus those with any number of bus riders where the maps show four different classifications of bus rider populations which could explain the contrasting results.

Figure 4.3.4: Bus Stop Counts and Percentage of Disability Population: Kansas City MO

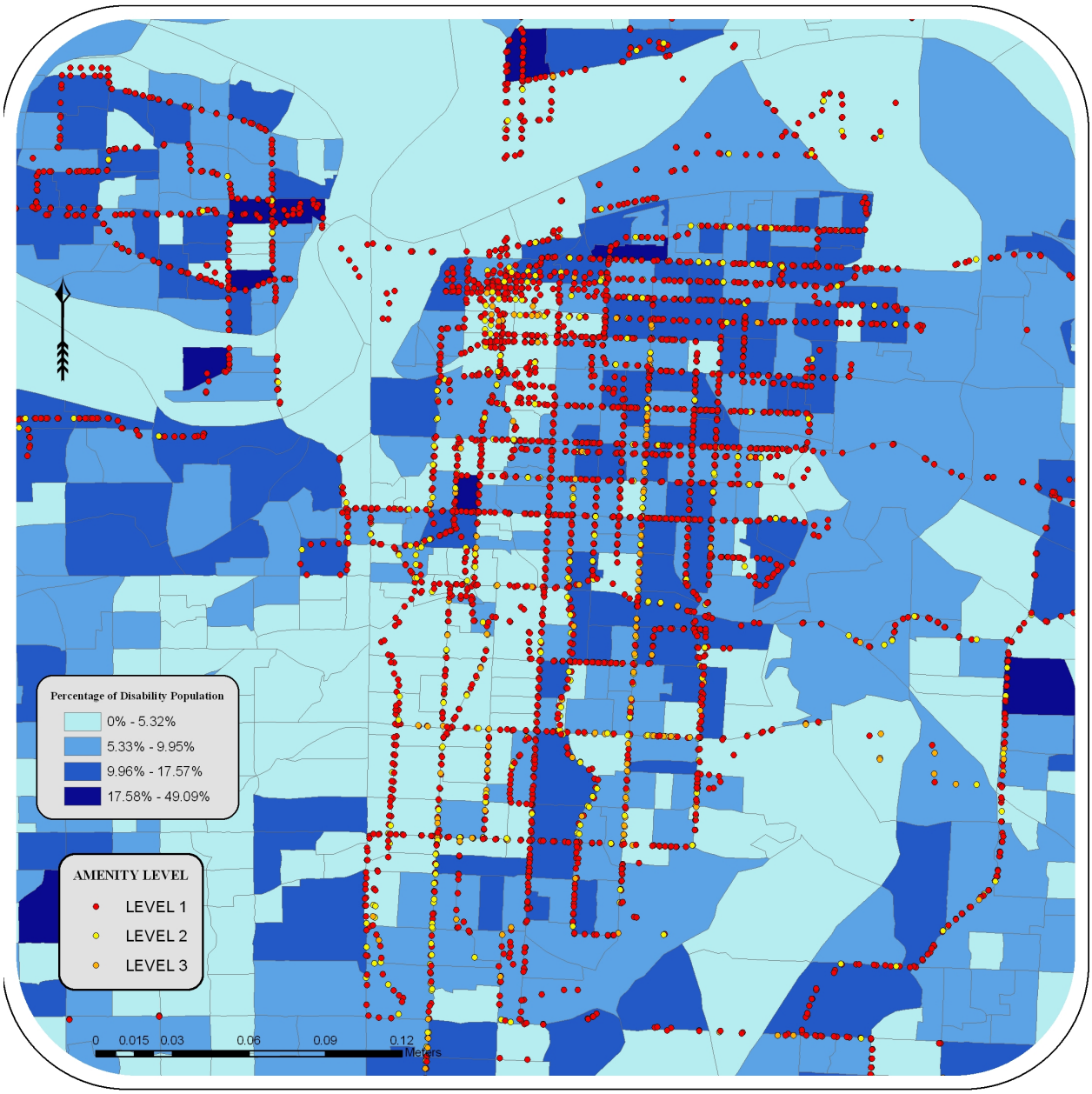


Sources: US Census Bureau, 2000; KCATA, 2009

Figure 4.3.4 represents bus stop counts and the percentage of disability population by block group. The map shows seven block groups containing the highest number of bus stops. Of those seven block groups, two are located in areas of the highest population of the disabled and two in areas of the second highest population. Over half of the other block groups of the highest disabled population contain concentrations of higher bus stops. Most of the block groups with the fewest bus stops fall inside areas of lower to lowest disability population. There seems to be an even distribution of bus stops to the disabled and non-disabled peoples.

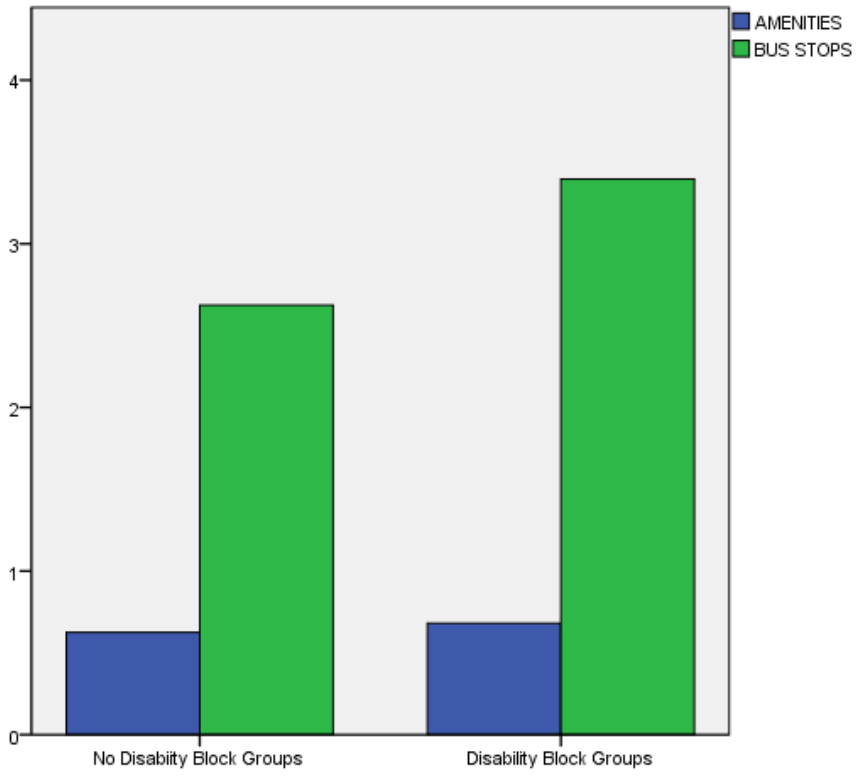
Figure 4.3.5 represents amenity levels and the percentage of disability population by block group. Of the 158 level 3 bus stops, 22 are located in areas with the highest disability population. In areas of the second highest disability populations, 39 contain level 3 bus stops. Almost half of all level 3 bus stops fall inside block groups with higher disability populations. Although this is a fair dispersal of higher amenity levels in these areas, there are still numerous level 1 and level 2 bus stops in these same areas because of the overall lack of stops with the highest amenity level throughout the city as a whole.

Figure 4.3.5: Amenity Levels and Percentage of Disability Population: Kansas City MO



Sources: US Census Bureau, 2000; KCATA, 2009

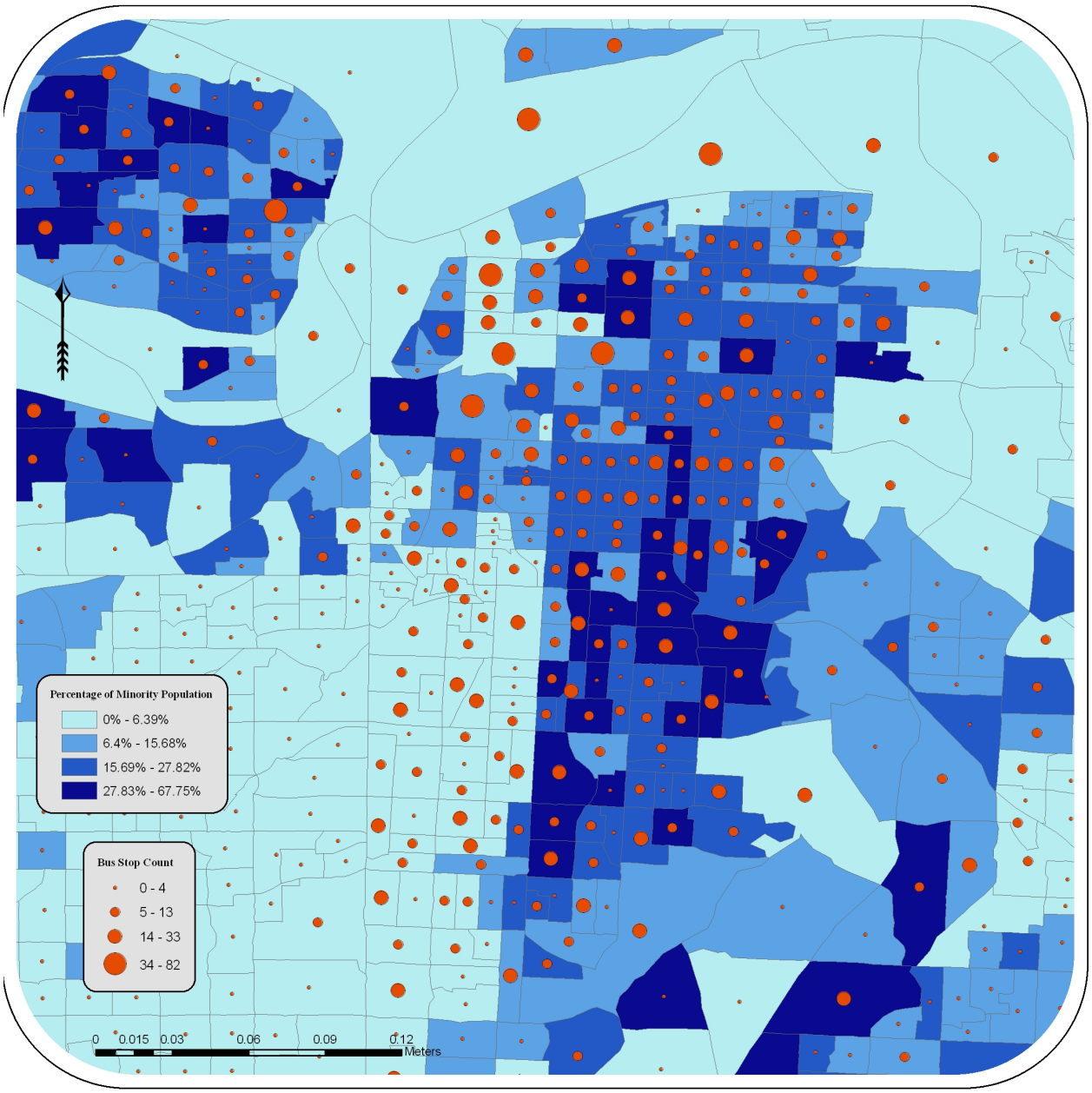
Figure 4.3.6: *Disability Block Groups in Relation to Bus Stop and Amenity Locations*



Sources: US Census Bureau, 2000; KCATA, 2009

Figure 4.3.6 is a bar graph showing bus stop counts and total amenities found in block groups with no disabilities and block groups with disabilities. Figure 4.3.6 results are very comparable to those found in the maps of Figure 4.3.5 and 4.3.4. There are slightly more amenities and much more bus stops in block groups with disabilities.

Figure 4.3.7: Bus Stop Counts and Percentage of Minority Population: Kansas City MO

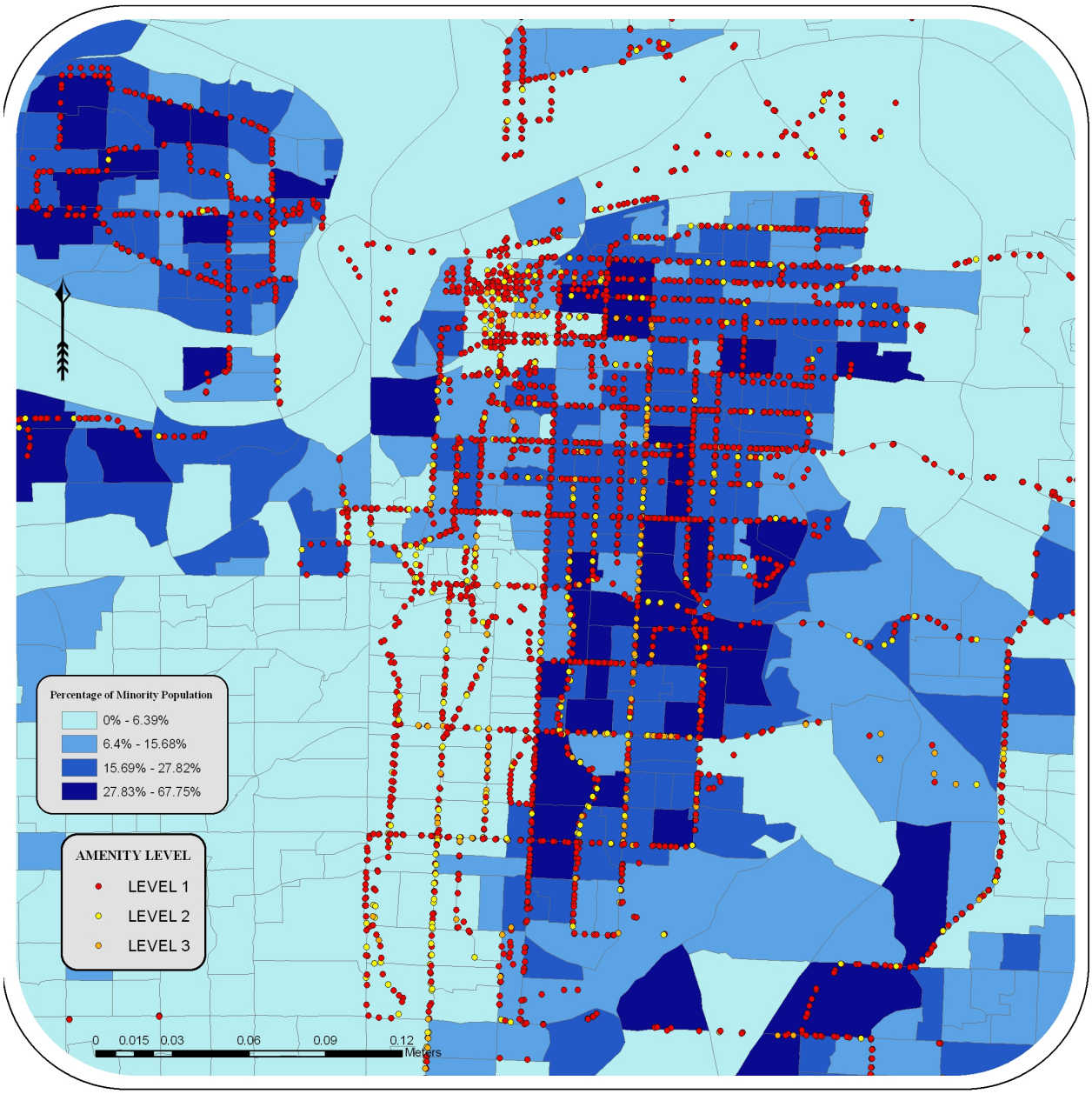


Sources: US Census Bureau, 2000; KCATA, 2009

Figure 4.3.7 represents bus stop counts and the percentage of minority population by block group. Of the seven block groups containing the largest number of bus stops, only one falls inside a block group with the most minorities. Two of these block groups with the most bus stops fall inside areas with the second largest minority populations. Of course, the remainder falls inside areas in the lower to lowest minority population categories. Although there are few higher minority population block groups with the largest number of bus stops, there are still rather high categories of bus stops in most of these block groups. Overall, there seems to be significantly more bus stops in areas of higher minority populations in Kansas City. This is much attuned to the transportation equity idea.

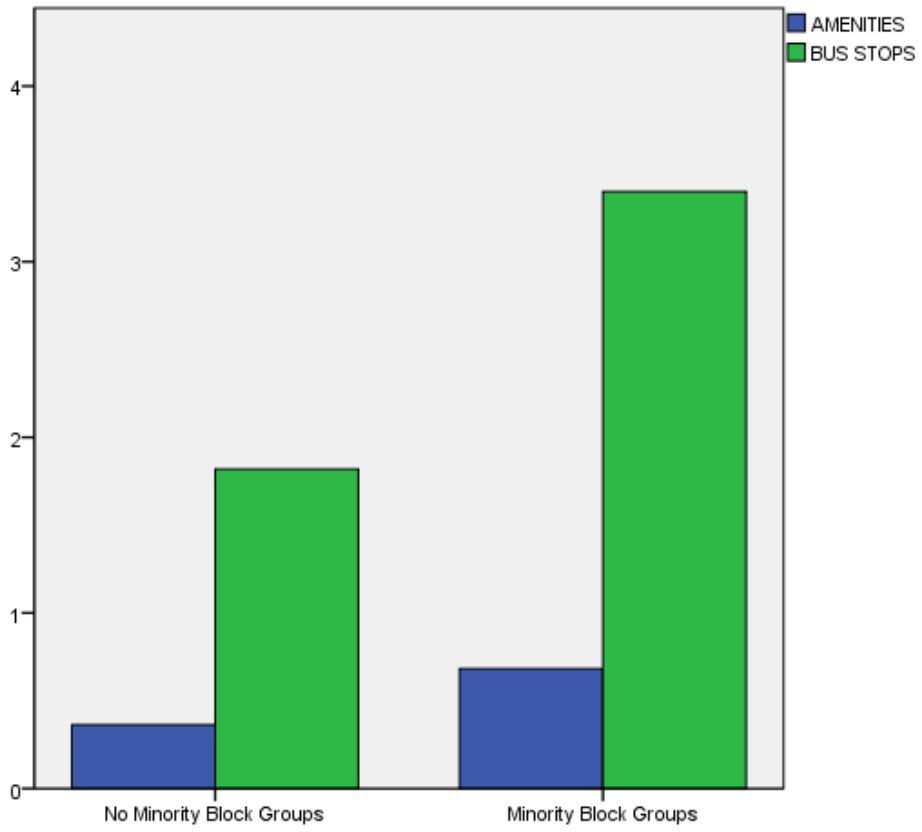
Figure 4.3.8 represents amenity levels and the percentage of minority population by block group. Of the 158 total level 3 bus stops, 92 are located in areas of the highest minority population. There are fifteen level 3 bus stops located in areas with the second highest minority population, with the rest falling in areas of lower to lowest minority populations. More than half of the level 3 amenity bus stops are located in areas of the highest minority populations; however, there are still an overwhelming number of bus stops in these same locations with level 1 and level 2 bus stops.

Figure 4.3.8: Amenity Levels and Percentage of Minority Population: Kansas City MO



Sources: US Census Bureau, 2000; KCATA, 2009

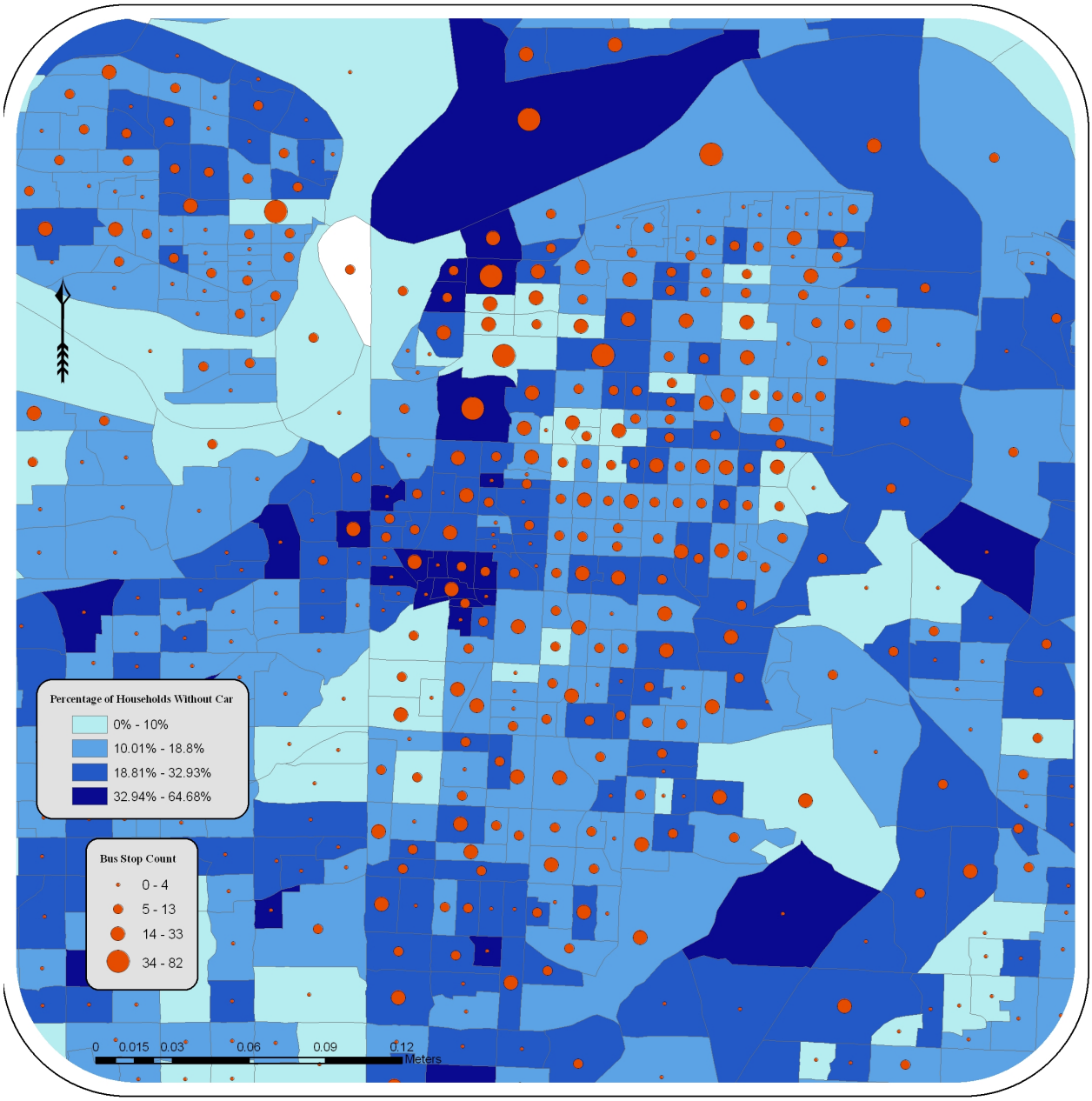
Figure 4.3.9: *Minority Block Groups in Relation to Bus Stop and Amenity Locations*



Sources: US Census Bureau, 2000; KCATA, 2009

Figure 4.3.9 is a bar graph showing bus stop counts and total amenities found in block groups with no minorities and block groups with minorities. Just like in the maps of Figure 4.3.7 and 4.3.8, the results shown in Figure 4.3.9 reveal a much higher bus stop count and total amenity count in areas of higher minority populations.

Figure 4.3.10: Bus Stop Counts and Percentage of Households without Car: Kansas City MO

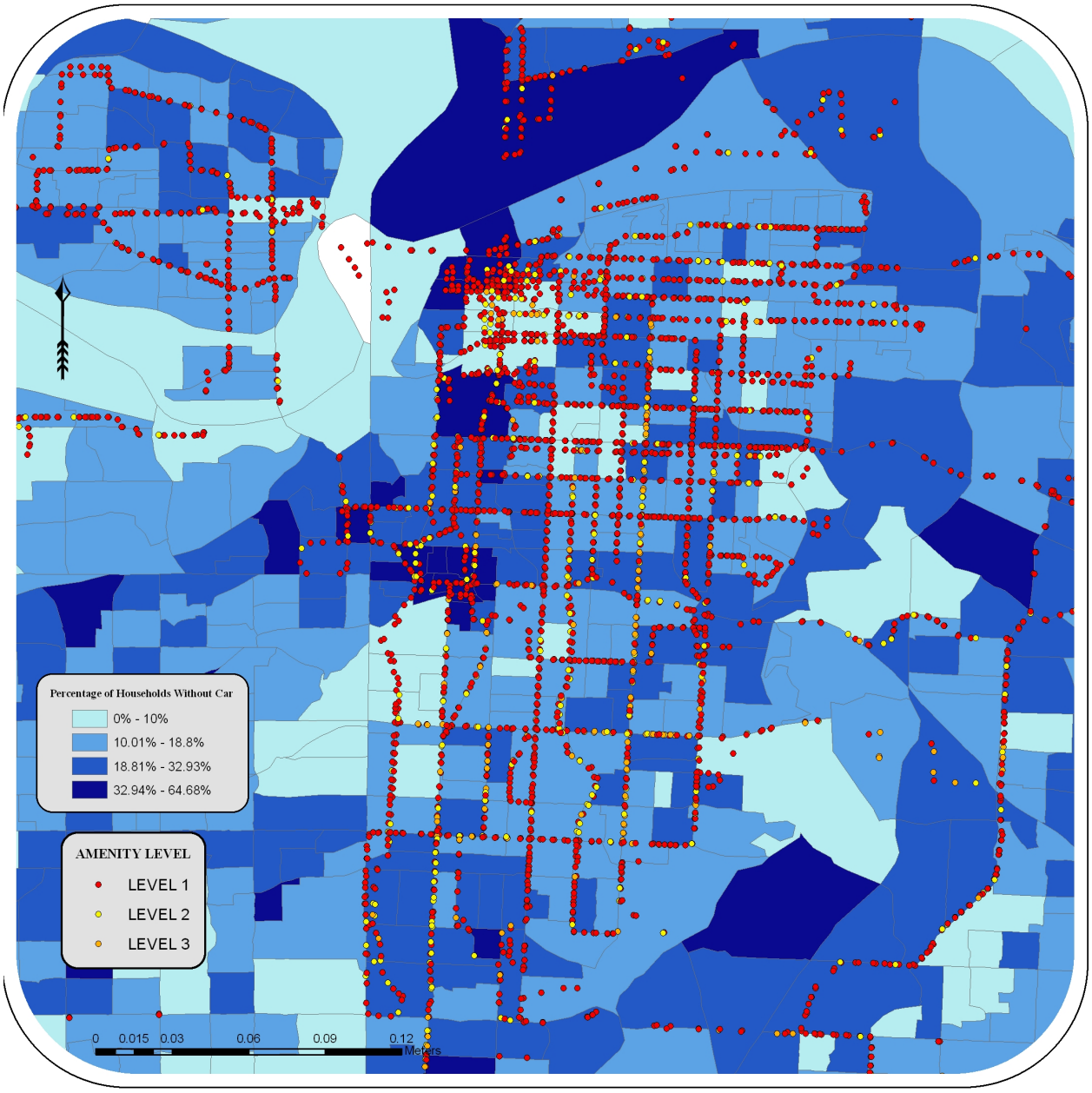


Sources: US Census Bureau, 2000; KCATA, 2009

Figure 4.3.10 represents bus stop counts and the percentage of households with no car by block group. The map shows three out of seven block groups with the most of bus stops located in areas with the highest population percentage of households with no car. The areas with the second highest percentage of households with no car have one with the highest bus stop count. In the other block groups with the highest no car populations there are many containing a medium to high number of bus stops. Although there are a few outliers, there seems to be overall medium to high bus stop counts located in areas with the high percentages of no car households throughout the city.

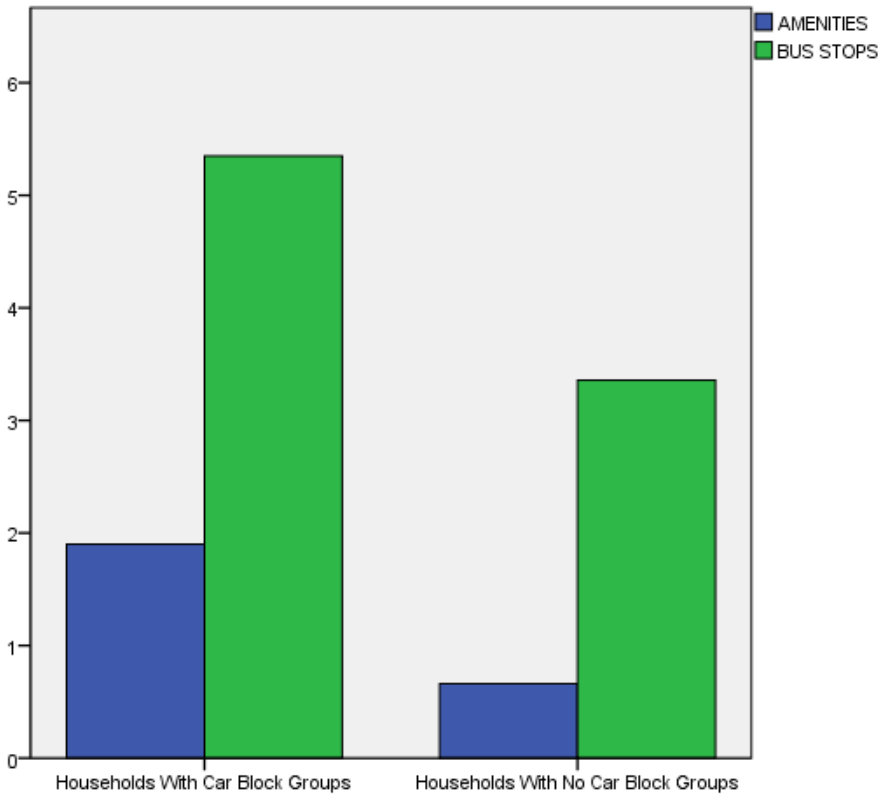
Figure 4.3.11 represents amenity levels and the percentage of households with no car by block group. In contrast to Figure 4.2.10 with the fair location of bus stops it is quite different with amenity levels. There are only nine of the 158 level 3 amenity bus stops located in areas of the highest no car household population, with numerous level 1 and level 2 bus stops in these same areas. There are, however, thirty-seven level 3 bus stops in the areas with the second highest no car population. At the same time, there are a plethora of level 1 and level 2 bus stops in these areas. The majority of the level 3 bus stops are located in areas of the lower to lowest populations of no car households. As mentioned before, assuming that one with no car might use public transportation more, there should be more bus stops and better amenities in these areas.

Figure 4.3.11: Amenity Levels and Percentage of Households without Car: Kansas City MO



Sources: US Census Bureau, 2000; KCATA, 2009

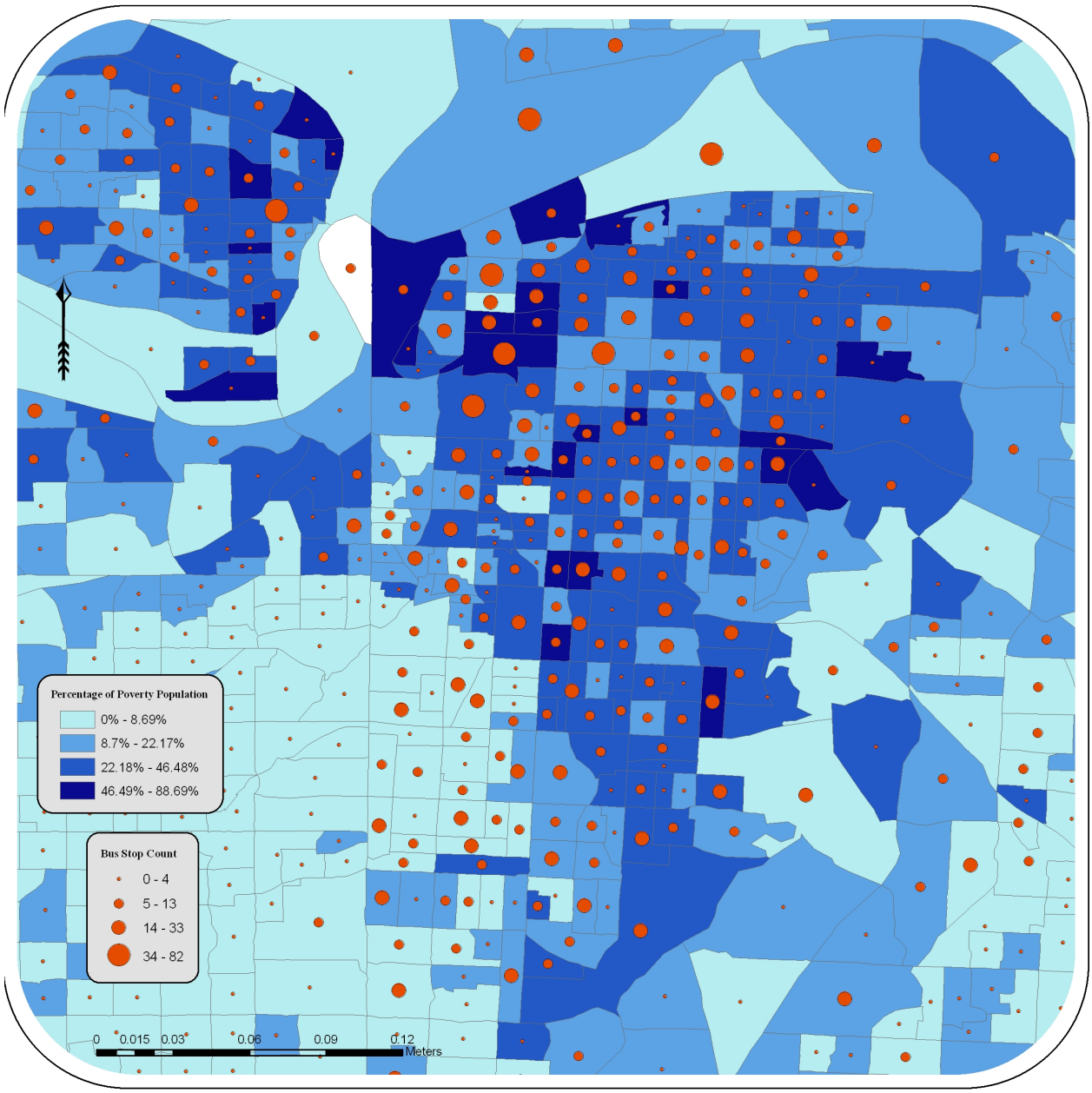
Figure 4.3.12: *No Car Household Block Groups in Relation to Bus Stop and Amenity Locations*



Sources: US Census Bureau, 2000; KCATA, 2009

Figure 4.3.12 is a bar graph showing bus stop counts and total amenities found in block groups with cars and block groups with no cars. Like the maps in Figure 4.3.10 and 4.3.11, the trend is the same in Figure 4.3.12, where there are far more bus stops and total amenities in areas of households who own cars versus areas with households who do not own cars.

Figure 4.3.13: Bus Stop Counts and Percentage of Poverty Population: Kansas City MO

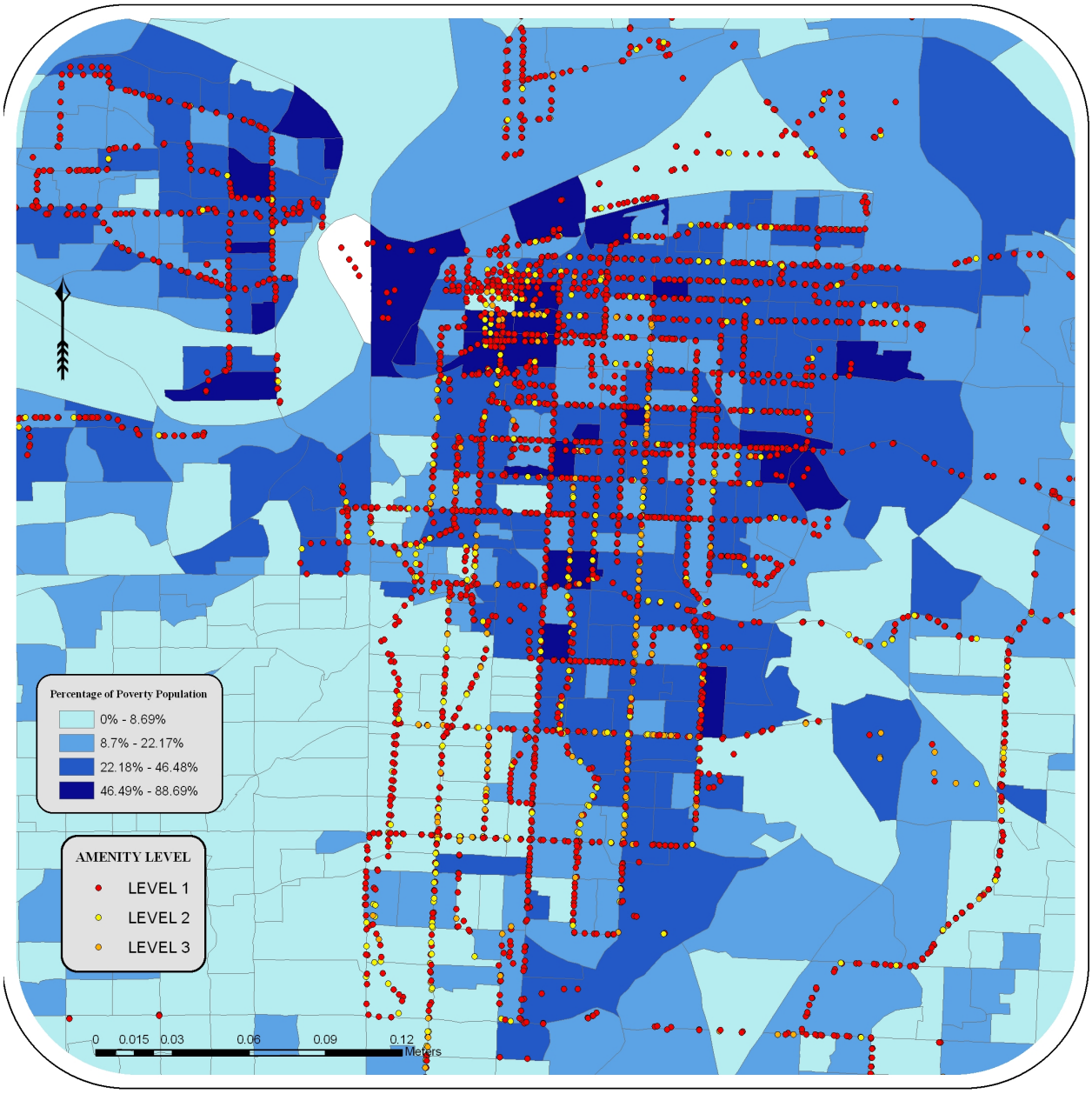


Sources: US Census Bureau, 2000; KCATA, 2009

Figure 4.3.13 represents bus stop counts and the parentage of poverty population by block group. Of the seven block groups containing the most bus stops, one is located in an area of the highest poverty population. Two of those are in areas of the second highest poverty population. The remaining four are in areas of lower to lowest populations of those living in poverty. Of the other areas of the highest poverty populations, many contain lower to lowest bus stop counts. As for the areas with the second highest poverty populations, there seems to be a larger number of bus stops in each block group. In the southwest region of the city, there is a very small population living in poverty and significantly fewer bus stops. Overall, there appears to be a fair dispersal of bus stops to those living in poverty that might use or need public transit more than others.

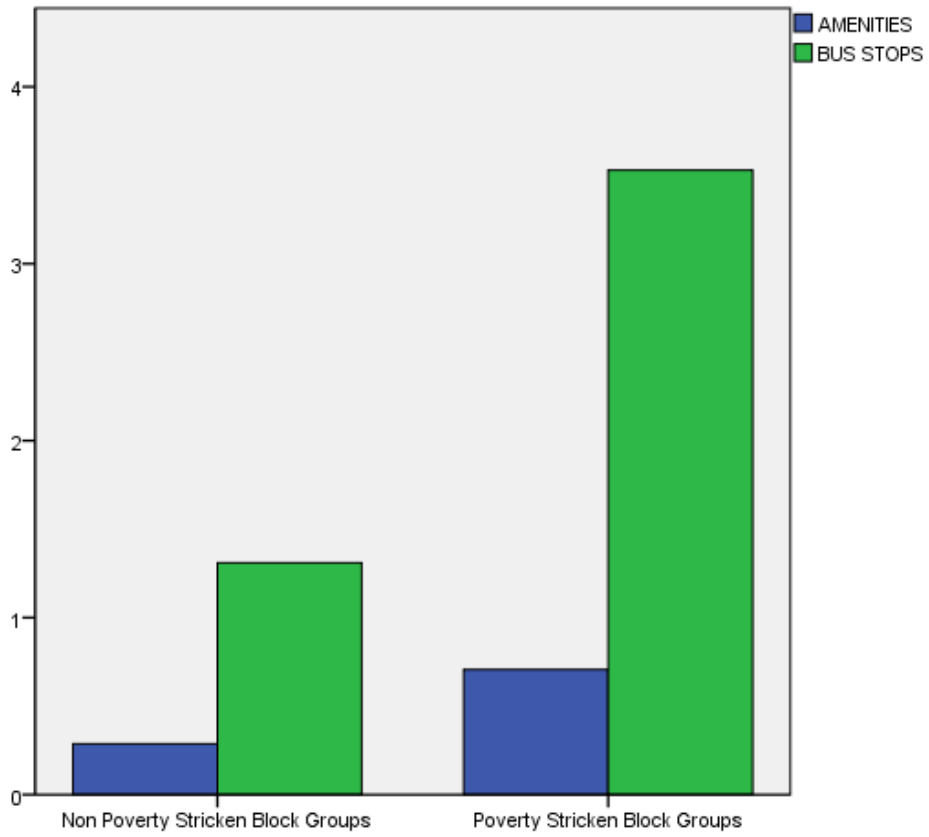
Figure 4.3.14 represents amenity levels the percentage of poverty population by block group. Fourteen out of the 158 level 3 bus stops fall inside block groups with the highest poverty population as do over one hundred of the 3764 level 1 amenity bus stops. There are 61 level 3 bus stops located in areas with the second highest poverty population. This number seems high, but it is well under half of the total number of level 3 bus stops in the city. Most of the level 3 bus stops are located in areas with the lower to lowest population living in poverty. Although there are numerous bus stop locations in the areas with more poverty, there is a dearth of high amenities at those bus stops.

Figure 4.3.14: Amenity Levels and Percentage of Poverty Population: Kansas City MO



Sources: US Census Bureau, 2000; KCATA, 2009

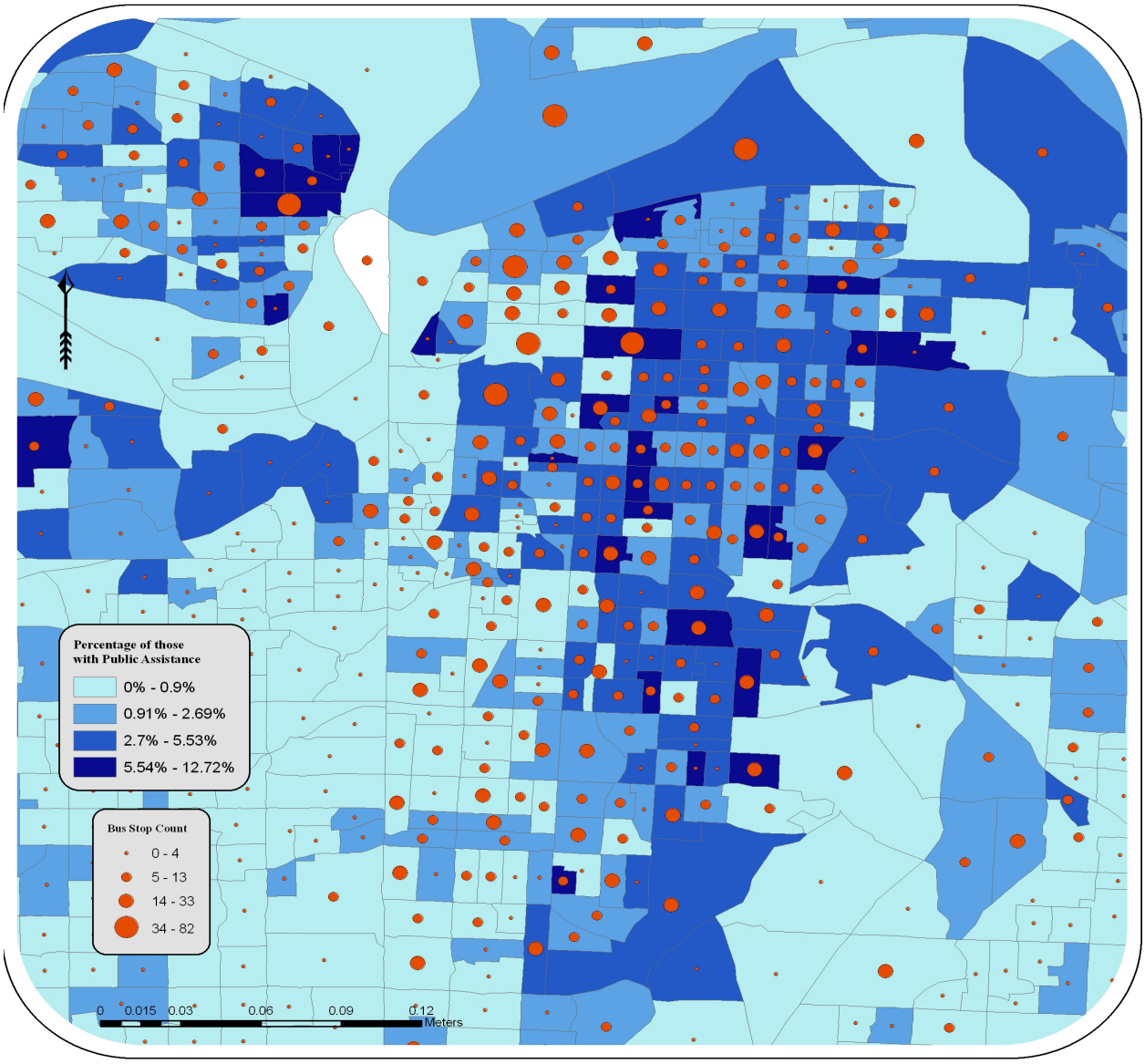
Figure 4.3.15: *Poverty Stricken Block Groups in Relation to Bus Stop and Amenity Locations*



Sources: US Census Bureau, 2000; KCATA, 2009

Figure 4.3.15 is a bar graph showing bus stop counts and total amenities found in block groups with no poverty and block groups with poverty. As shown in Figure 4.3.15, there are significantly more bus stops in block groups with poverty versus those without poverty. Figure 4.3.15 also shows that there are more total amenities in block groups with poverty, although according to Figure 2I, there is a lack of bus stops with high amenities in these areas.

Figure 4.3.16: Bus Stop Counts and Percentage of Population with Public Assistance: Kansas City MO

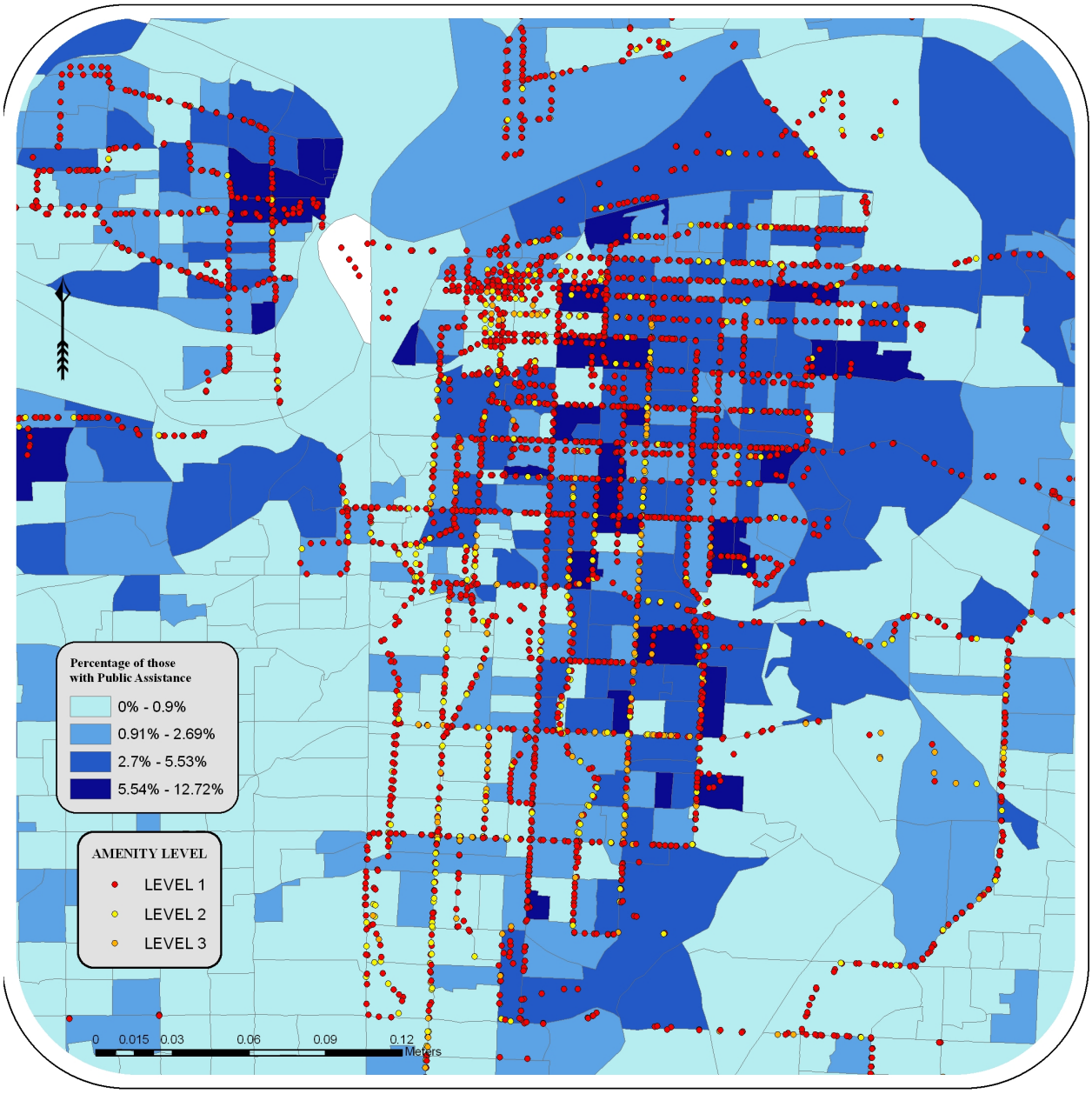


Sources: US Census Bureau, 2000; KCATA, 2009

Figure 4.3.16 represents bus stop counts and the percentage of population receiving public assistance by block group. Of the seven block groups with the highest bus stop count, two are found in block groups with the highest public assistance populations and two are found in block groups with the second highest public assistance population. There is only one of block group with the lowest public assistance population containing the highest bus stop count. For the remaining block groups with the largest population on public assistance, there are many with high to very high bus stop counts. The southwest region of the city which has a low population of those receiving public assistance, has significantly fewer bus stops. Overall, there seems to be a level and just distribution of bus stops for those in need.

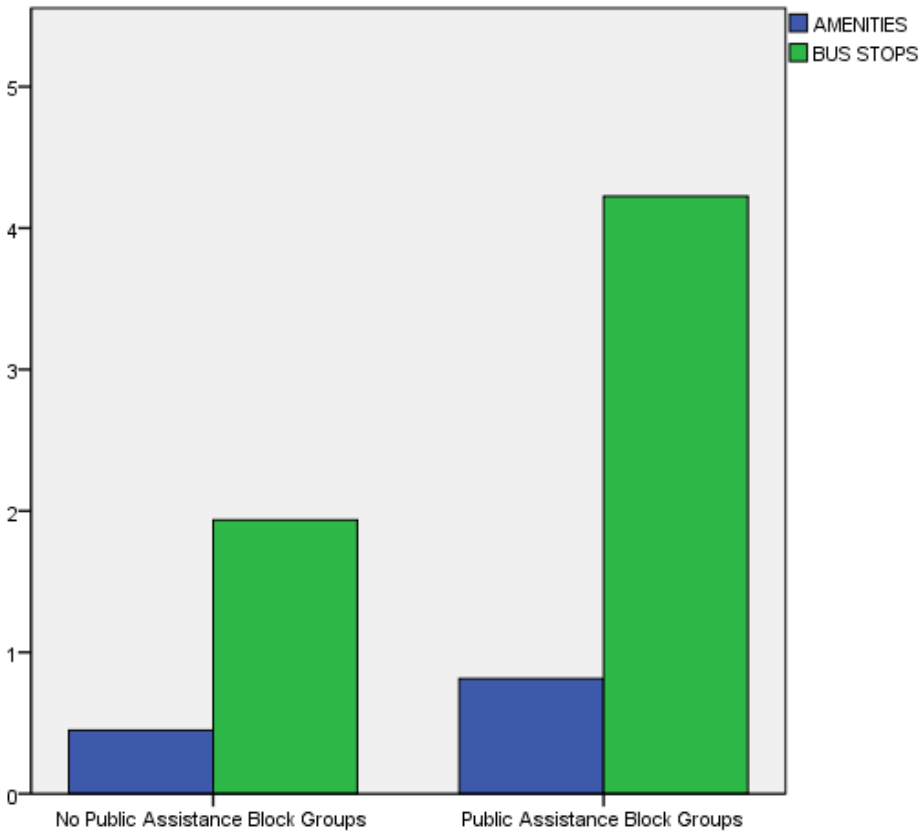
Figure 4.3.17 represents amenity levels and the percentage of population receiving public assistance by block group. Sixteen out of the 158 level 3 bus stops are located in block groups of the highest public assistance populations. There are well over one hundred out of 4432 level 2 and level 1 bus stops in these same areas. There are forty eight level 3 bus stops in areas with the second highest percentage of public assistance recipients, which is well under half of the total number of level 3 bus stops. The majority of level 3 bus stops are located in areas of lower to lowest populations of those receiving public assistance. This is the same trend as those living in poverty for Kansas City. Once again, although there are plenty of bus stops in these locations where they are needed more, there is a deficiency of higher amenities throughout.

Figure 4.3.17: Amenity Levels and Percentage of Population with Public Assistance: Kansas City MO



Sources: US Census Bureau, 2000; KCATA, 2009

Figure 4.3.18: *Public Assistance Block Groups in Relation to Bus Stop and Amenity Locations*



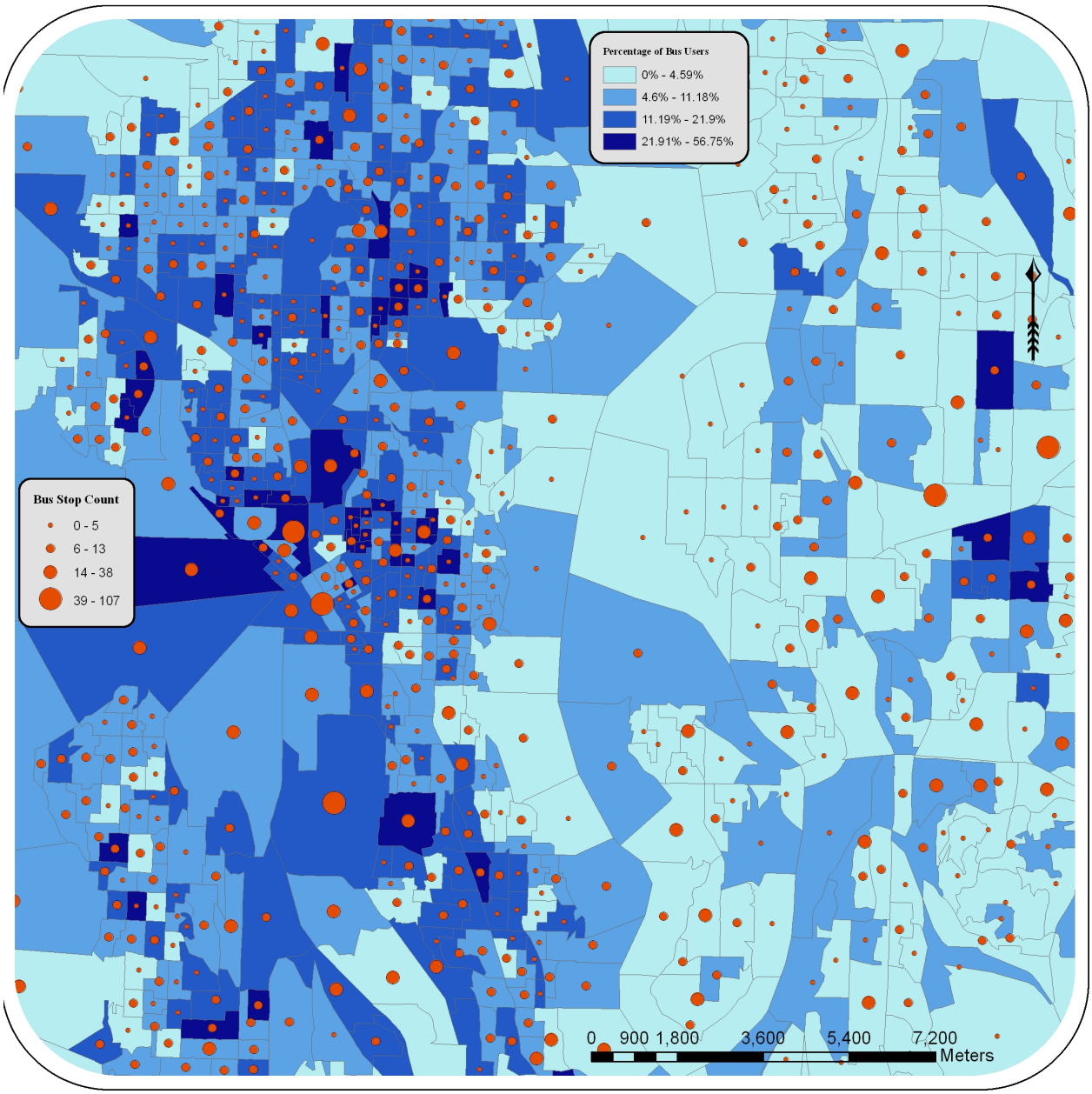
Sources: US Census Bureau, 2000; KCATA, 2009

Figure 4.3.18 is a bar graph showing bus stop counts and total amenities found in block groups with no public assistance and block groups with public assistance. The results in Figure 4.3.18 coincide with those in Figure 4.3.16; where there are definitely more bus stops located in block groups with higher public assistance populations. There are also more total amenities in these areas, although as shown in Figure 4.3.18; there is a lack of bus stops with high amenities.

4.4 Seattle, WA

Before analyzing the maps in this section, the Table 2 in section 4.1 is represented to show the number of bus stops of each amenity level for Seattle, WA. Seattle contrasted greatly in terms of higher amenity level with those of Greensboro and Kansas City. Although they have far more total bus stops, they have a much higher percentage of those stops with amenity levels 4 and 3. They have a total of 1661 level 4 bus stops compared to 0 in Kansas City. They also have 3154 level 3 bus stops compared to the dismal 10 in Greensboro. Although these numbers are higher, the question must be answered whether they are located in the places of greatest need. The number of bus stops and higher amenity levels will now be analyzed regarding where they are located spatially on the maps and if they are in areas where they are needed or used the most.

Figure 4.4.1: Bus Stop Counts and Percentage of Bus Users: Seattle, WA

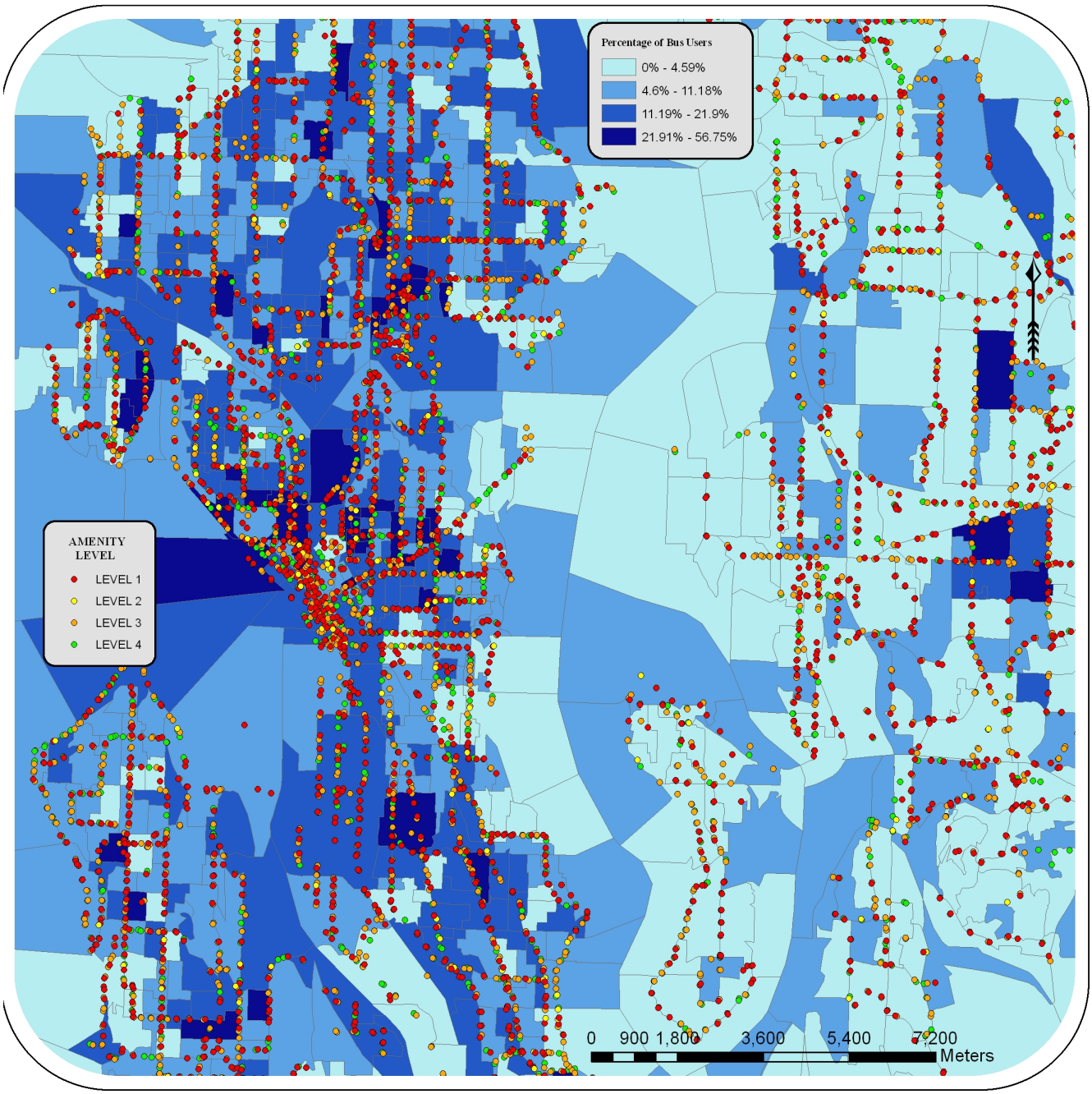


Source: US Census Bureau, 2000; KCMT, 2009

Figure 4.4.1 represents bus stop counts and the percentage of bus users by block groups for Seattle, WA. Of the seven block groups containing the highest bus stop count, none are found in areas of the highest populations of bus riders. Only one is found in the area of the second highest population of bus riders, while the others are in areas with the lower to lowest population of bus riders. In the areas of the second highest population of bus riders, however, many contain a moderate number of bus stops. Overall, while there could be more bus stops in these areas, there seems to be an overall fair distribution throughout.

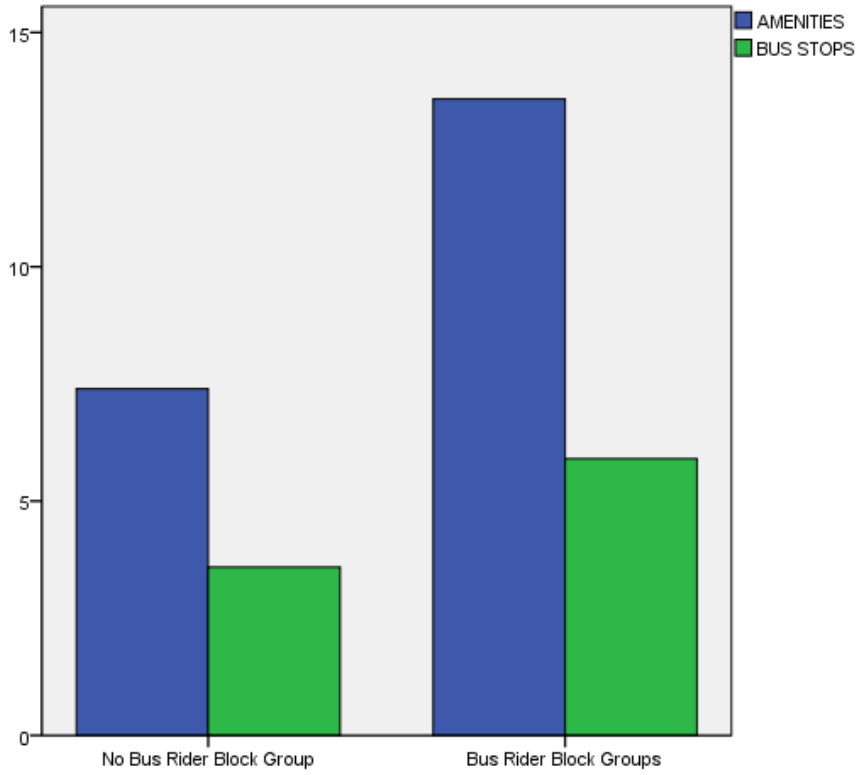
Figure 4.4.2 represents amenity levels and the percentage of population of bus users by block group. Of the two block groups with the highest population of bus riders, there are only four of 1661 level 4 bus stops. In these same block groups, there are five of 3154 amenity level 3 bus stops. In the block groups with the second highest bus rider population, there are thirty-six level 4 bus stops. This seems like a large number of high amenity bus stops, but there are over sixty of 4228 level 1 and level 2 bus stops in these same areas. The majority of level 4 bus stops are located in areas of low populations of bus riders. The location of high amenities should be more evenly dispersed in throughout the areas of higher populations of bus riders.

Figure 4.4.2: Amenity Levels and Percentage of Bus Users: Seattle, WA



Source: US Census Bureau, 2000; KCMT, 2009

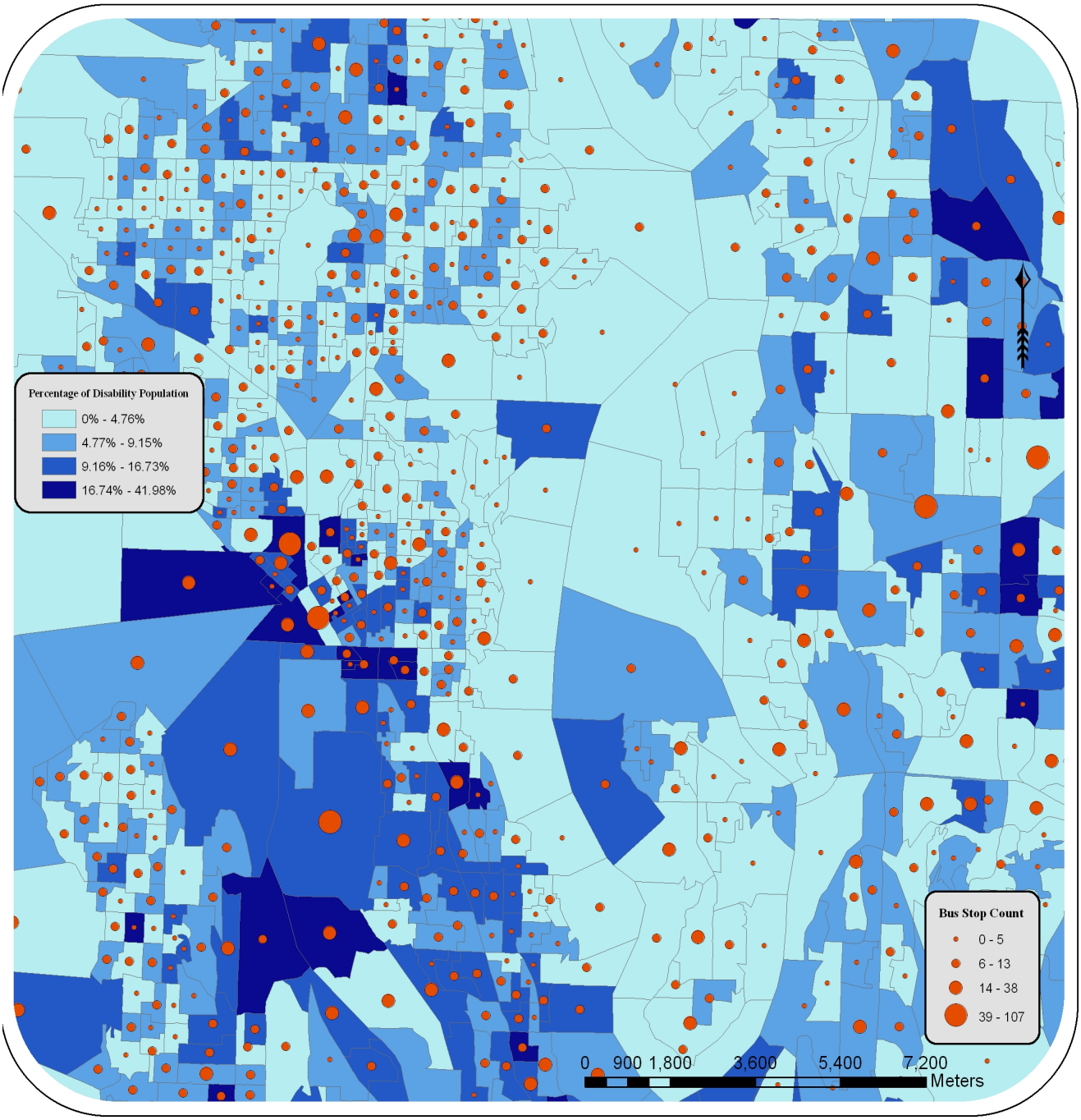
Figure 4.4.3: *Bus User Block Groups in Relation to Bus Stop and Amenity Locations*



Source: US Census Bureau, 2000; KCMT, 2009

Figure 4.4.3 is a bar graph showing bus stop counts and total amenities found in block groups with no bus riders and block groups with bus riders. Although 4.4.1 seems to have more bus stops located in areas of lower bus riders, Figure 4.4.3 shows otherwise. Figure 4.4.1 shows more bus stops are located in block groups with bus riders versus those without. Note, this graph represents block groups with completely no bus riders, versus those with any number of bus riders whereas the maps show four different classifications of bus rider populations which could explain the contrasting results.

Figure 4.4.4: Bus Stop Counts and Percentage of Disability Population: Seattle, WA

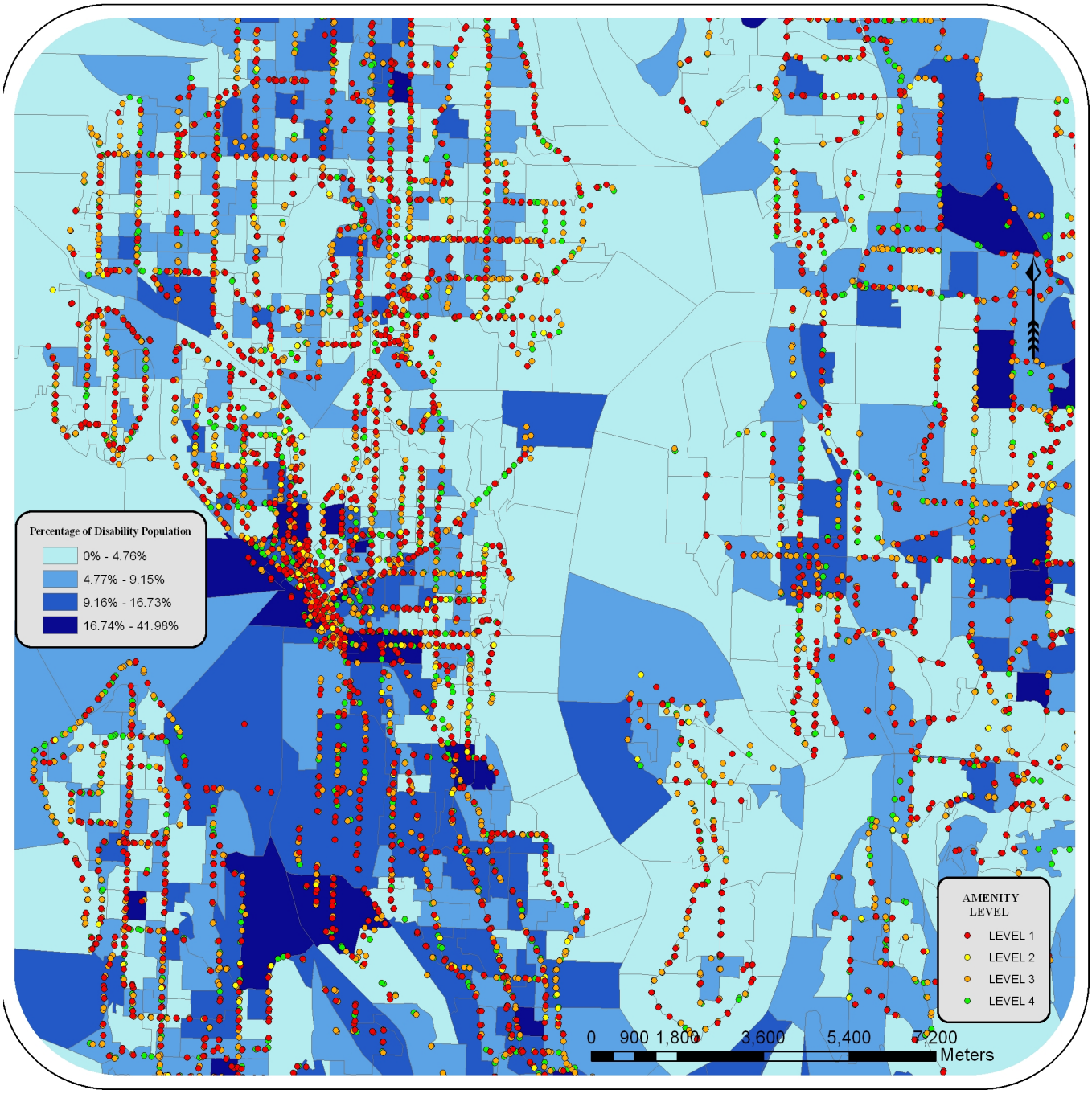


Source: US Census Bureau, 2000; KCMT, 2009

Figure 4.4.4 represents bus stop counts and the percentage of disability population by block group. Of the seven block groups containing the highest bus stop counts, none falls inside areas of the highest disabled populations and only one falls inside areas of the second highest disabled population. The bulk of the block groups with the highest disabled populations contain the lower to lowest number of bus stops with one exception. The majority of block groups with the highest bus stop counts fall within areas of lower disabled populations, contradicting the transportation equity initiative.

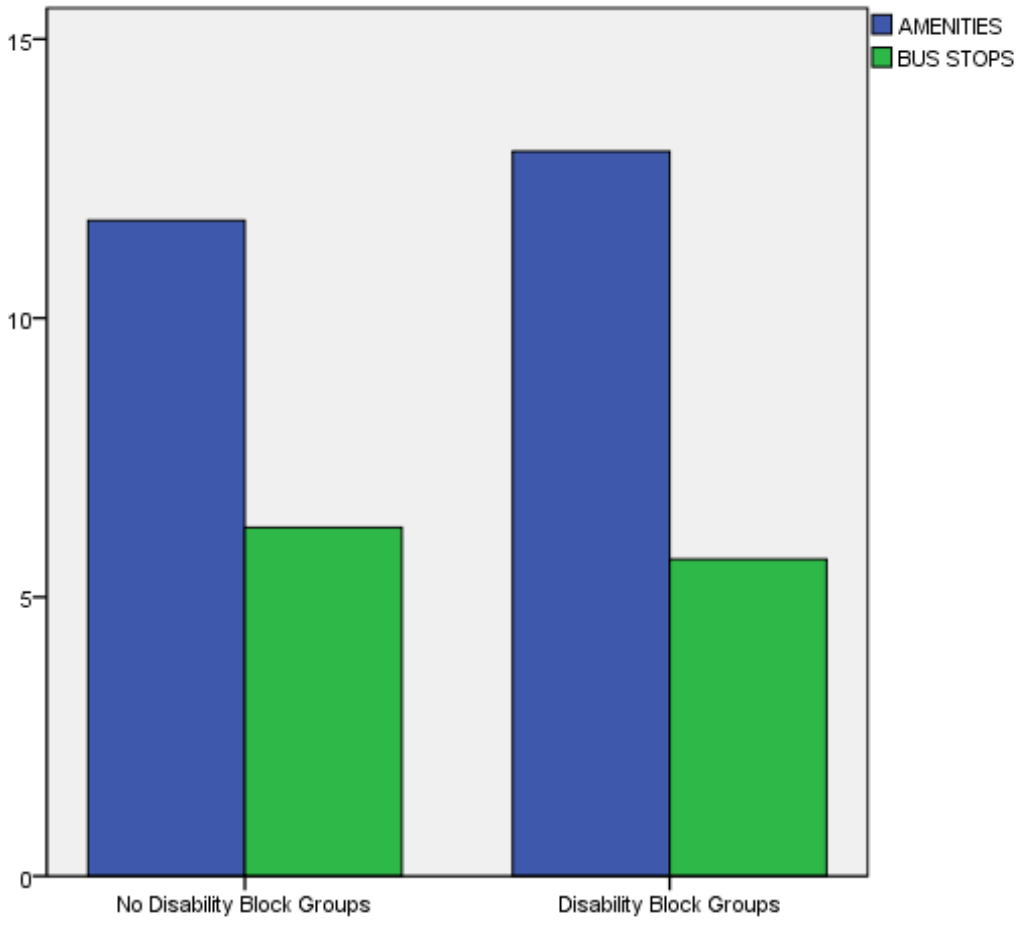
Figure 4.4.5 represents amenity levels and the percentage of disability population by block group. Of the 1661 total amenity level 4 bus stops, only sixteen are located in areas of the highest and second highest disability population. Of the 3154 total amenity level 3 bus stops, only 35 are located in these same areas, which contain over sixty of 4228 level 1 and level 2 bus stops. The number of level 1 and level 2 bus stops are almost double those of level 4 and level 3 in these areas. The bulk of high amenity level bus stops are located in areas where there are very few disability populations. This too is in contrast to transportation equity.

Figure 4.4.5: Amenity Levels and Percentage of Disability Population: Seattle, WA



Source: US Census Bureau, 2000; KCMT, 2009

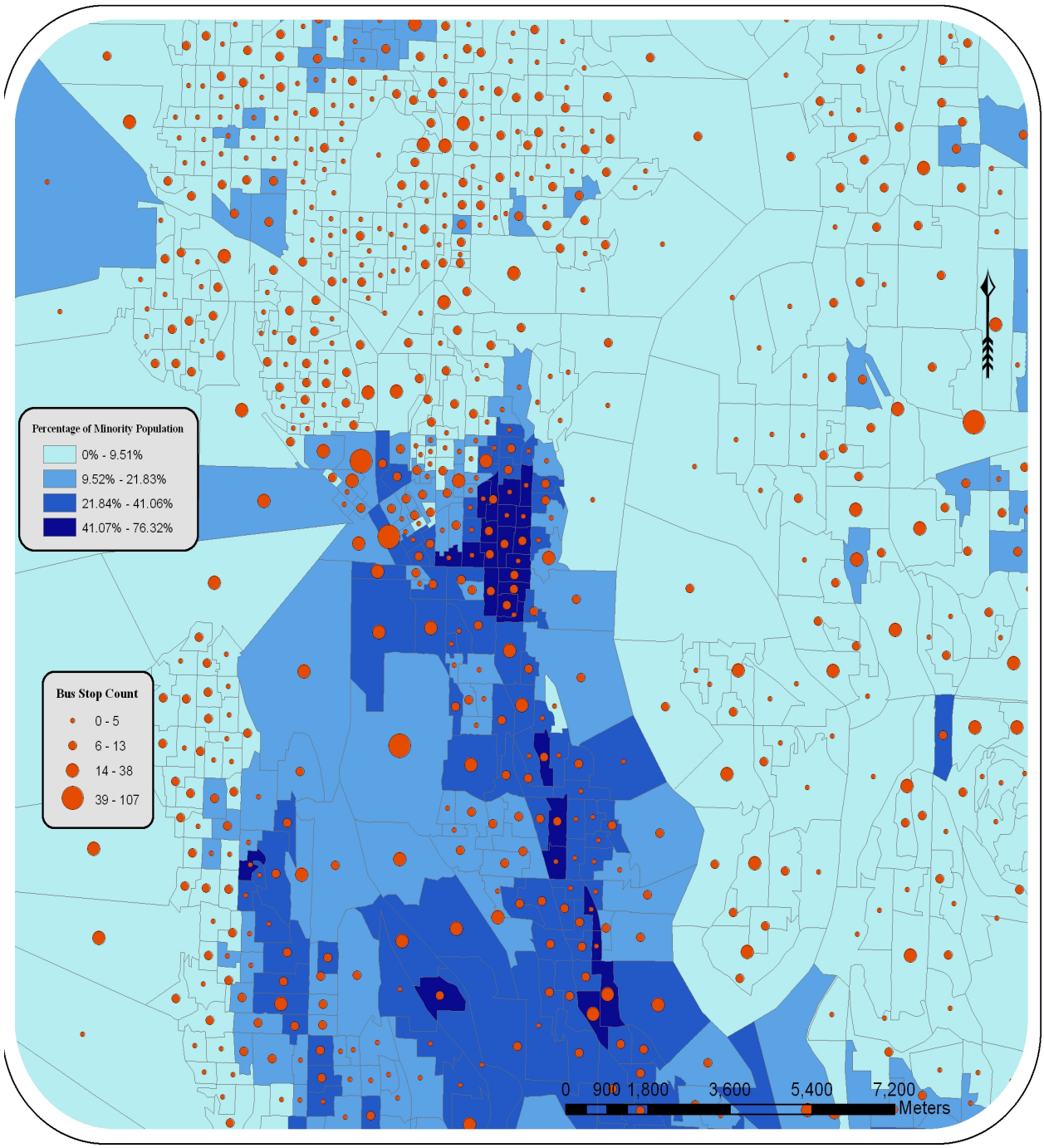
Figure 4.4.6: *Disability Block Groups in Relation to Bus Stop and Amenity Locations*



Source: US Census Bureau, 2000; KCMT, 2009

Figure 4.4.6 is a bar graph showing bus stop counts and total amenities found in block groups with no disabilities and block groups with disabilities. Figure 4.4.6 corresponds with the results in Figure 4.4.4. There are more bus stops located in areas of lower disability populations. However, Figure 4.4.6 does show more amenities are located in block groups with higher disability populations, though not by much.

Figure 4.4.7: Bus Stop Counts and Percentage of Minority Population: Seattle, WA

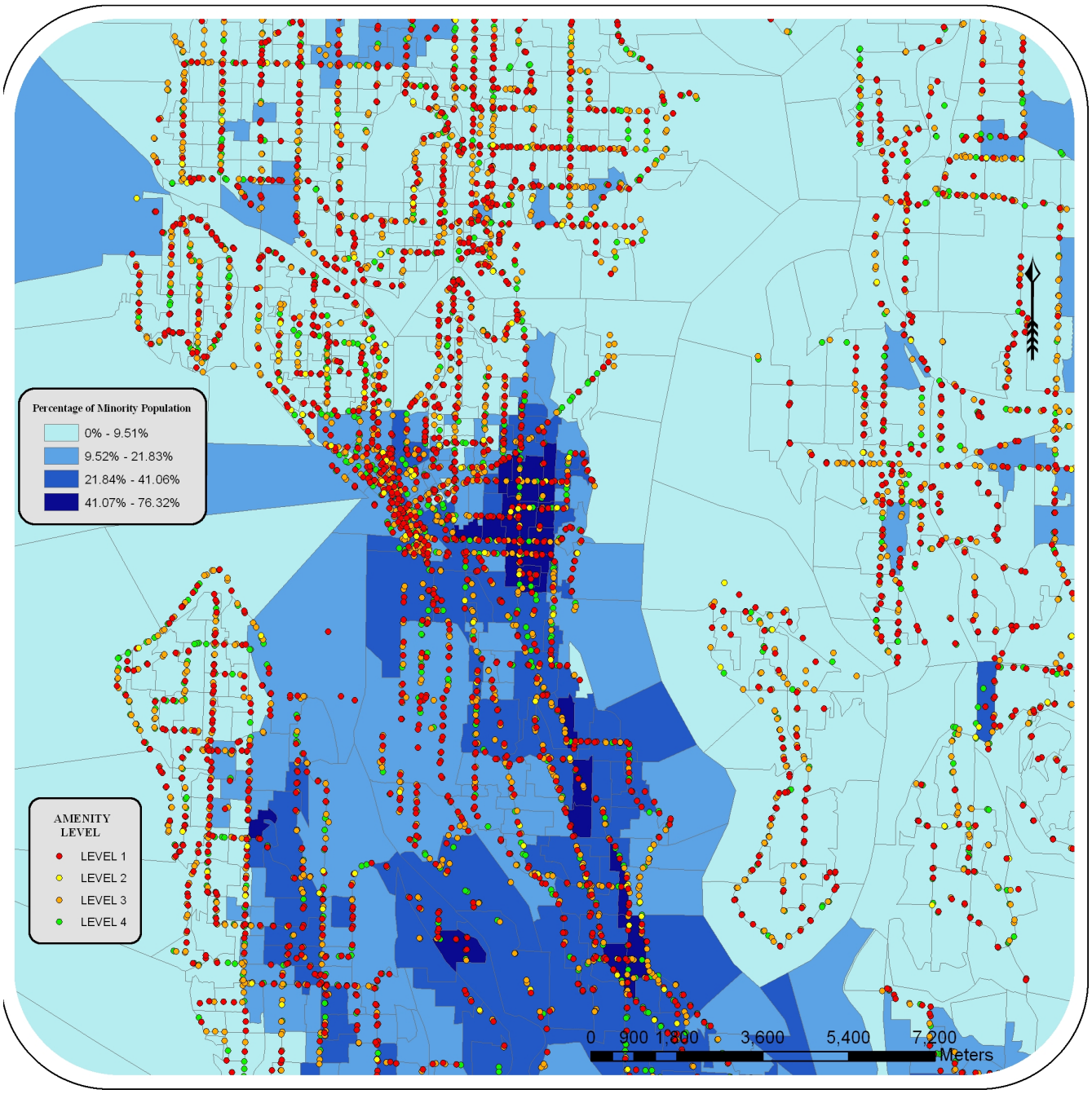


Source: US Census Bureau, 2000; KCMT, 2009

Figure 4.4.7 represents bus stop counts and the percentage of minority population by block group. Of the seven block groups with the highest bus stops counts, none are located in areas with the highest minority populations and one falls inside an area with the second highest minority populations. Although some block groups with low minority populations contain high bus stops counts, there is an overall fair distribution of bus stop counts throughout. As mentioned before, these are areas where more bus stops are needed more and this trend seems to meet that approach.

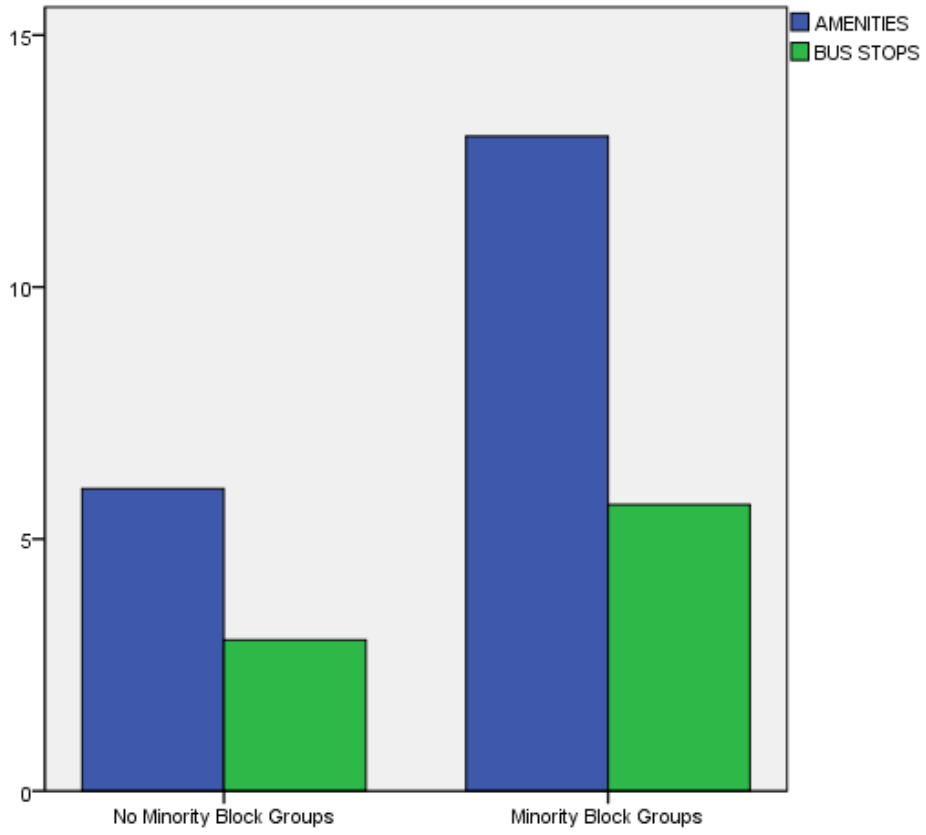
Figure 4.4.8 represents amenity levels and the percentage of minority population by block group. Of the 1661 total amenity level 4 bus stops, thirty-six are located in areas with the highest minority population. Of the 3154 total amenity level 3 bus stops, there are twenty-eight located in these same areas. There are a total of 198 bus stops in areas of the highest minority population, which means that less than half of those stops are at the amenity level 3 and 4. This again does not meet the needs of these people in terms of transportation equity. There should be more amenities at each stop assuming that this population will depend more on public transportation.

Figure 4.4.8: Amenity Levels and Percentage of Minority Population: Seattle, WA



Source: US Census Bureau, 2000; KCMT, 2009

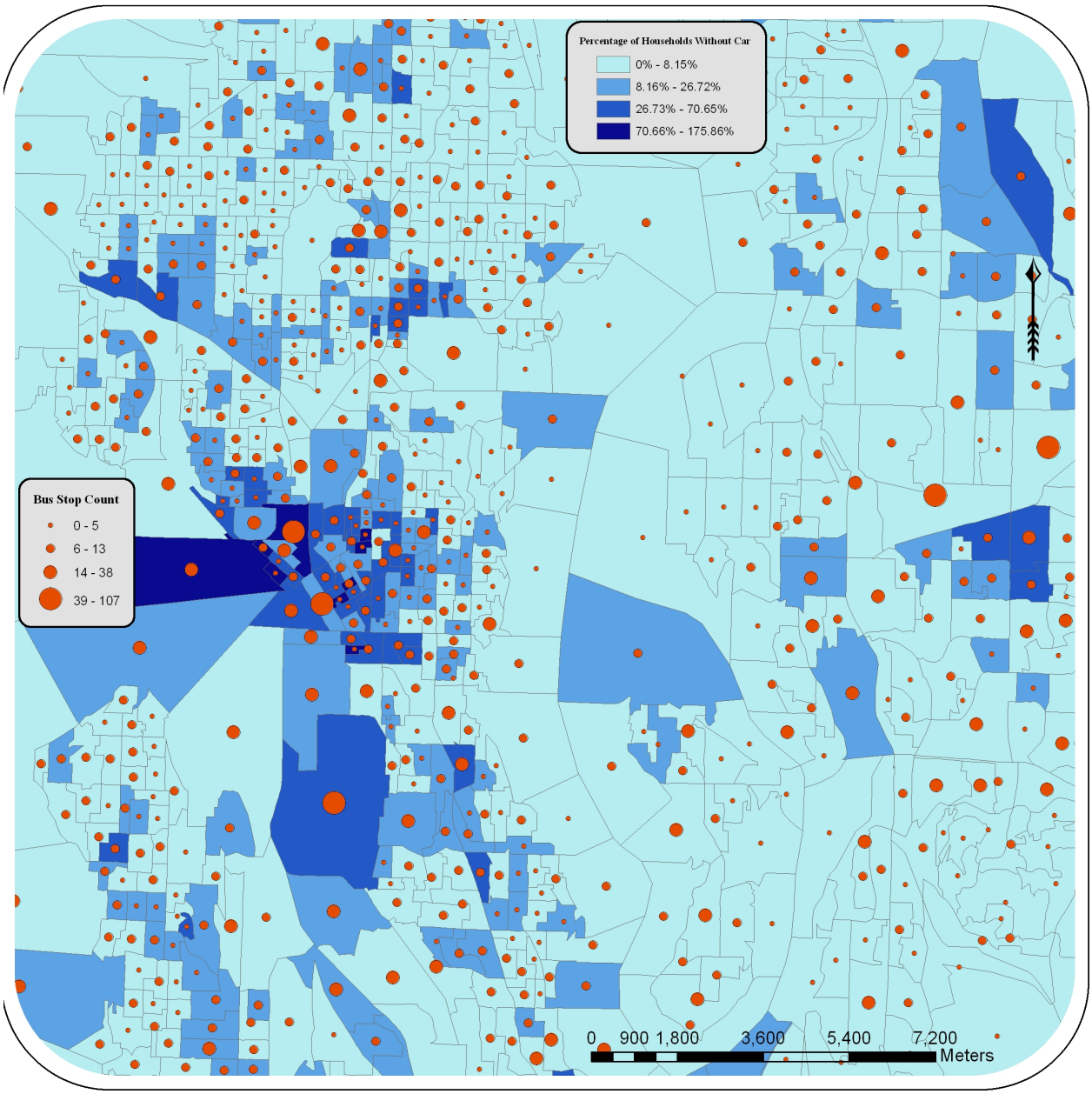
Figure 4.4.9: *Minority Block Groups in Relation to Bus Stop and Amenity Locations*



Source: US Census Bureau, 2000; KCMT, 2009

Figure 4.4.9 is a bar graph showing bus stop counts and total amenities found in block groups with no minorities and block groups with minorities. Figure 4.4.9 shows more bus stops are located in block groups with minorities versus those without any. Total amenities in block groups with minorities far outweigh those in block groups without minorities, although there are fewer bus stops with high amenities in these areas represented in Figure 4.4.9.

Figure 4.4.10: Bus Stop Counts and Percentage of Households without Car: Seattle, WA

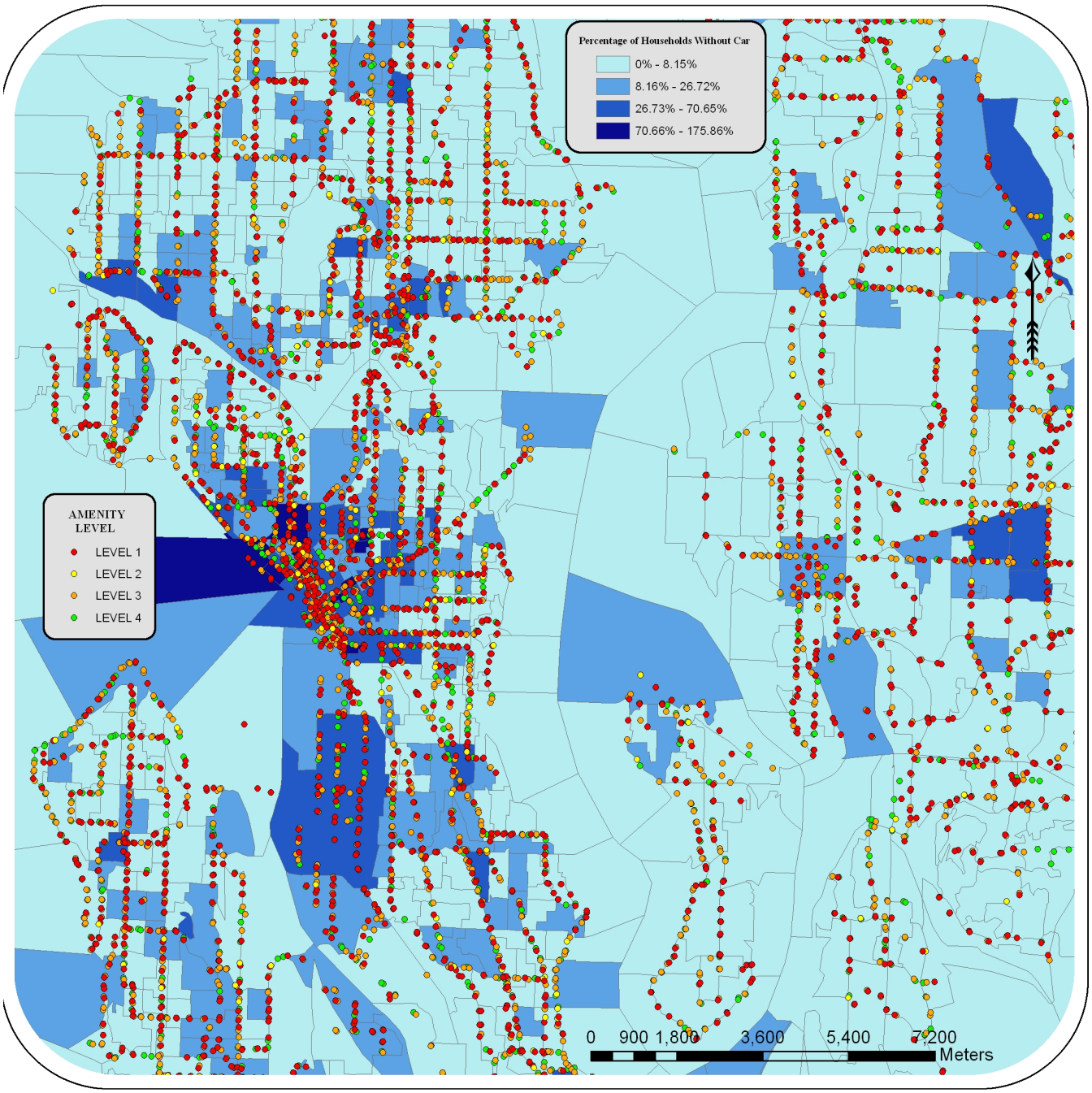


Source: US Census Bureau, 2000; KCMT, 2009

Figure 4.4.10 represents bus stop counts and the percentage of households with no car by block group. One of the block groups of the highest no car population contains the highest concentration of bus stops. Also the areas of the second highest no car population contains high bus stop counts. Overall there is an even distribution of bus stops throughout. As mentioned before, if we are to assume that those with no car will rely greater on public transportation, then the dispersal of bus stops in these areas is well placed.

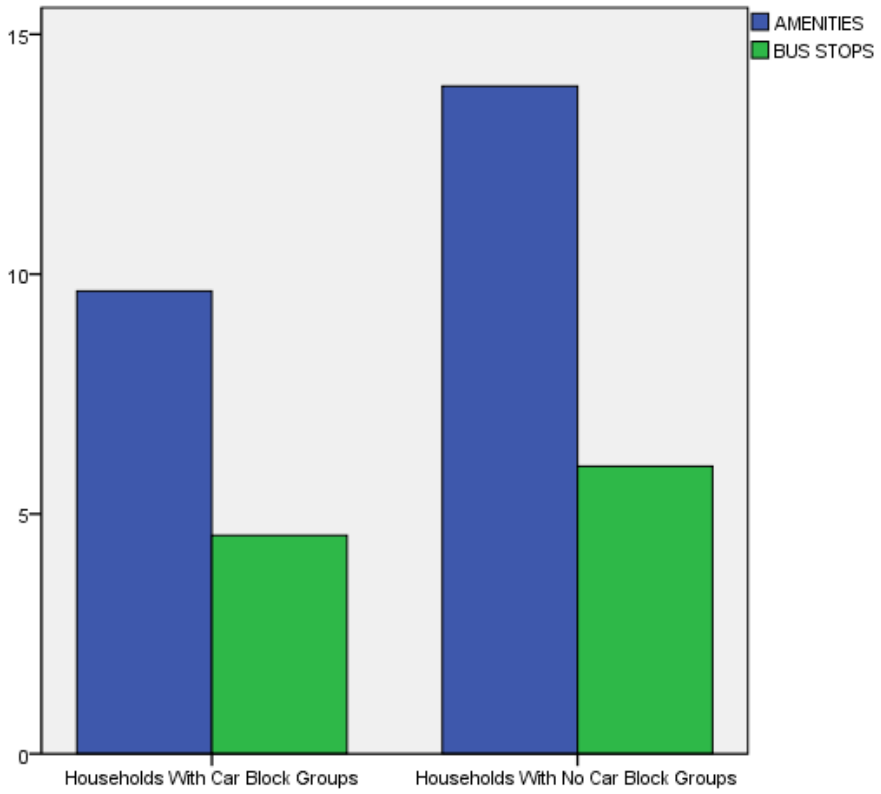
Figure 4.4.11 represents amenity levels and the percentage no car households by lock group. Of the 1661 total amenity level 4 bus stops, only six fall inside areas of the highest no car population as do only sixteen level 3 amenity level bus stops. There are a total of sixty-three total bus stops in these areas which means there are almost triple the number of lower amenity bus stops versus high amenity bus stops in these areas. The same goes for the areas of the second highest no car population. In the areas with the second highest no car population, there are a total of twenty three amenity level 4 bus stops and twenty-nine amenity level 3 bus stops. Presuming this population will depend more on public transit, there is a need for better amenities in these areas.

Figure 4.4.11: Amenity Levels and Percentage of Households without Car: Seattle, WA



Source: US Census Bureau, 2000; KCMT, 2009

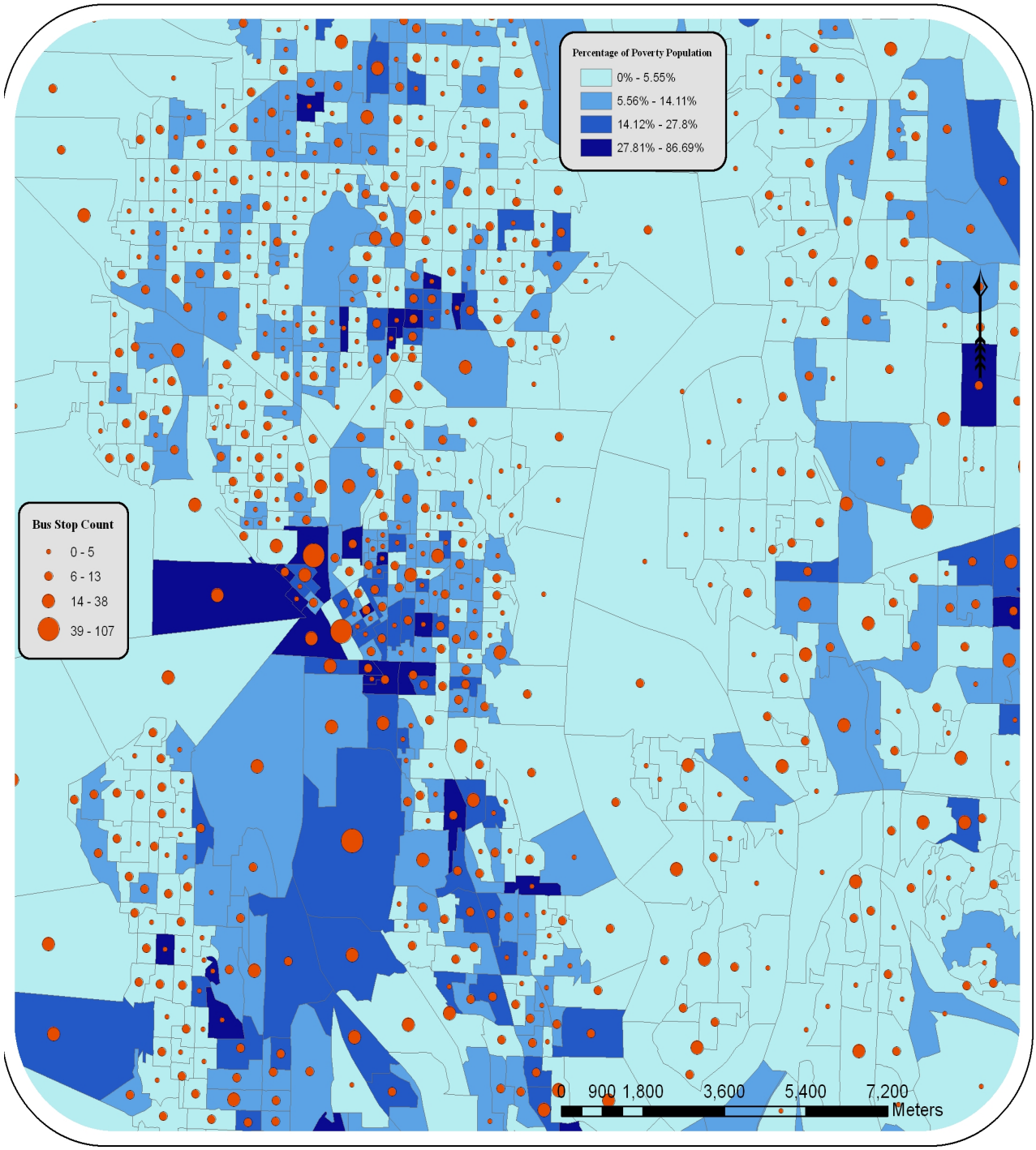
Figure 4.4.12: *No Car Household Block Groups in Relation to Bus Stop and Amenity Locations*



Source: US Census Bureau, 2000; KCMT, 2009

Figure 4.4.12 is a bar graph showing bus stop counts and total amenities found in block group households with cars and block groups households with no car. Figure 4.4.12 matches well with the results in Figure 4.4.10, where there are more bus stops in block groups where there are more households with no cars. Figure 4.4.11 shows more amenities in these same areas, although according to Figure 4.4.12, there are fewer high amenity bus stops in these block groups.

Figure 4.4.13: Bus Stop Counts and Percentage of Poverty Population: Seattle, WA

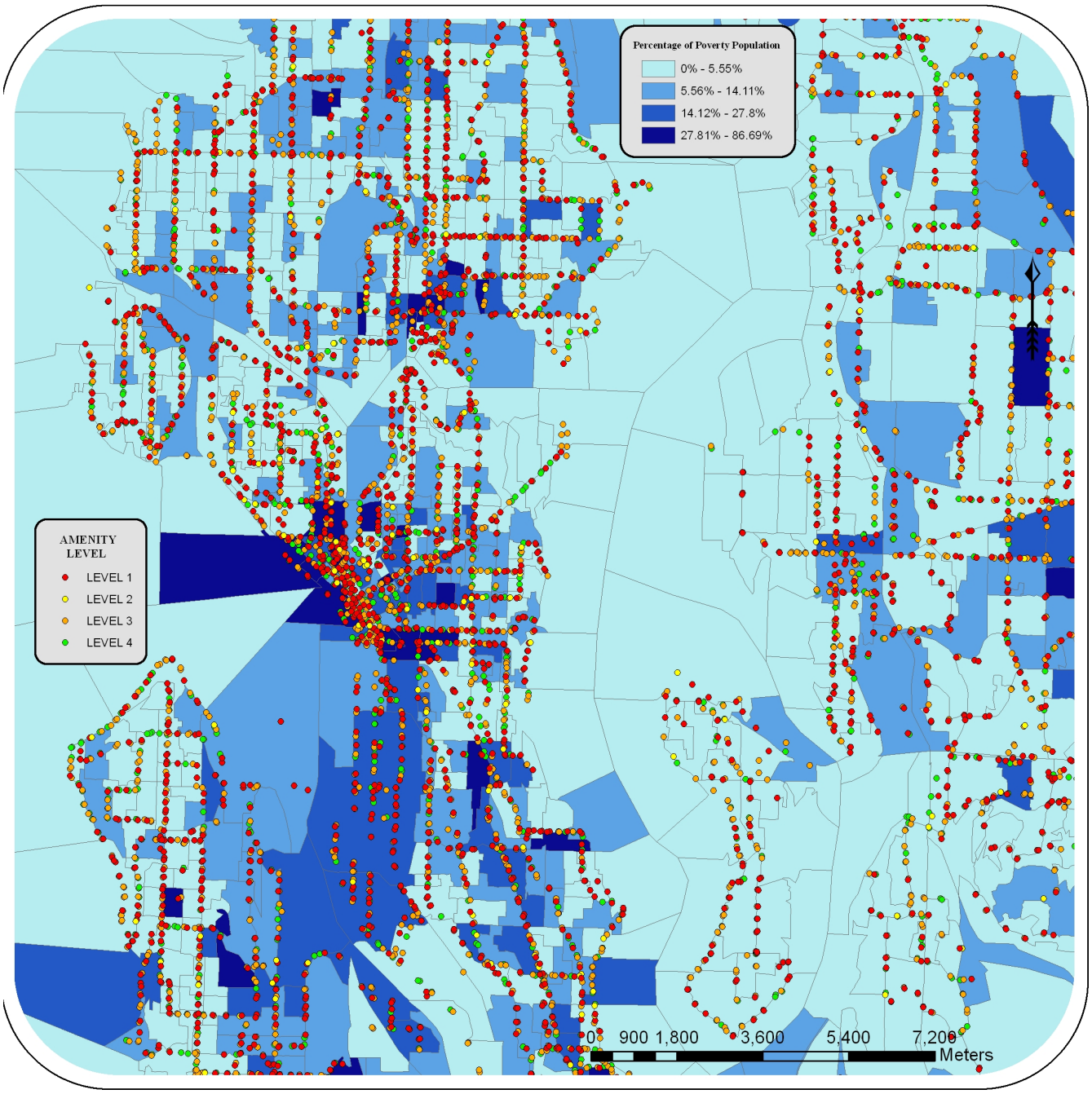


Source: US Census Bureau, 2000; KCMT, 2009

Figure 4.4.13 represents bus stop counts and the percentage of poverty population by block group. Of the seven block groups containing the highest bus stop count, one falls in areas with the highest poverty population and another falls inside areas of the second highest poverty population. There are also numerous medium to high bus stop counts in the other block groups with higher poverty populations. Overall, there appears to be more bus stops in areas of higher poverty populations. Again, if one were to assume that this population will rely more on public transit, there should be a greater number of bus stops in these areas.

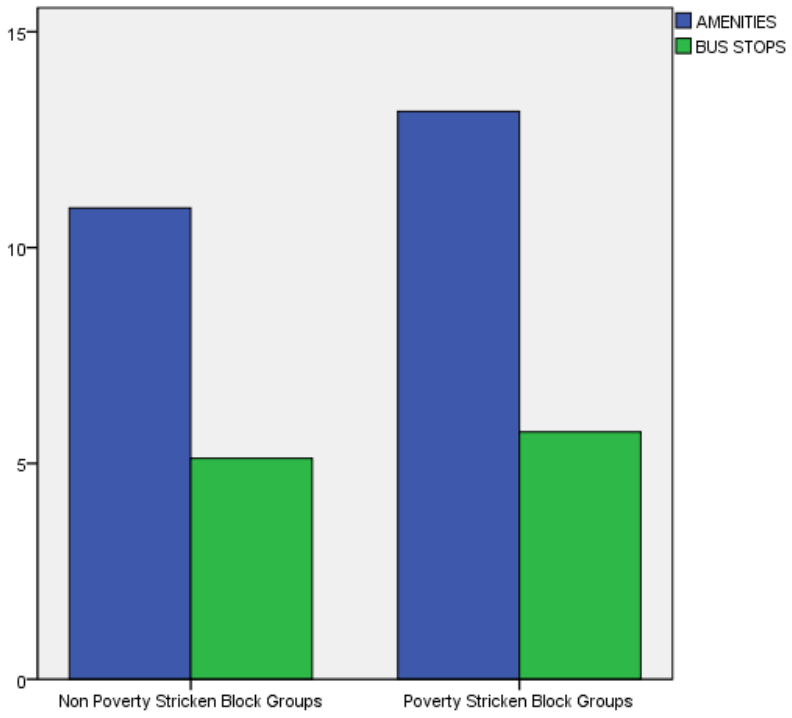
Figure 4.4.14 represents amenity levels and the percentage of poverty population by block group. In the areas of the highest and second highest poverty populations, there are only twenty-five amenity level 4 bus stops out of the total 1661 for the city. There are fifty-six amenity level 3 bus stops in these same areas out of the total 3154 for the city. There are a total of 189 bus stops in these same areas, which means less than half of these bus stops are amenity level 4 and amenity level 3. The majority of the bus stops with higher amenities are in areas with lower poverty populations. According to transportation equity, the minority population should be treated with the same amenities as the rest of the population and this is not the case here.

Figure 4.4.14: Amenity Levels and Percentage of Poverty Population: Seattle, WA



Source: US Census Bureau, 2000; KCMT, 2009

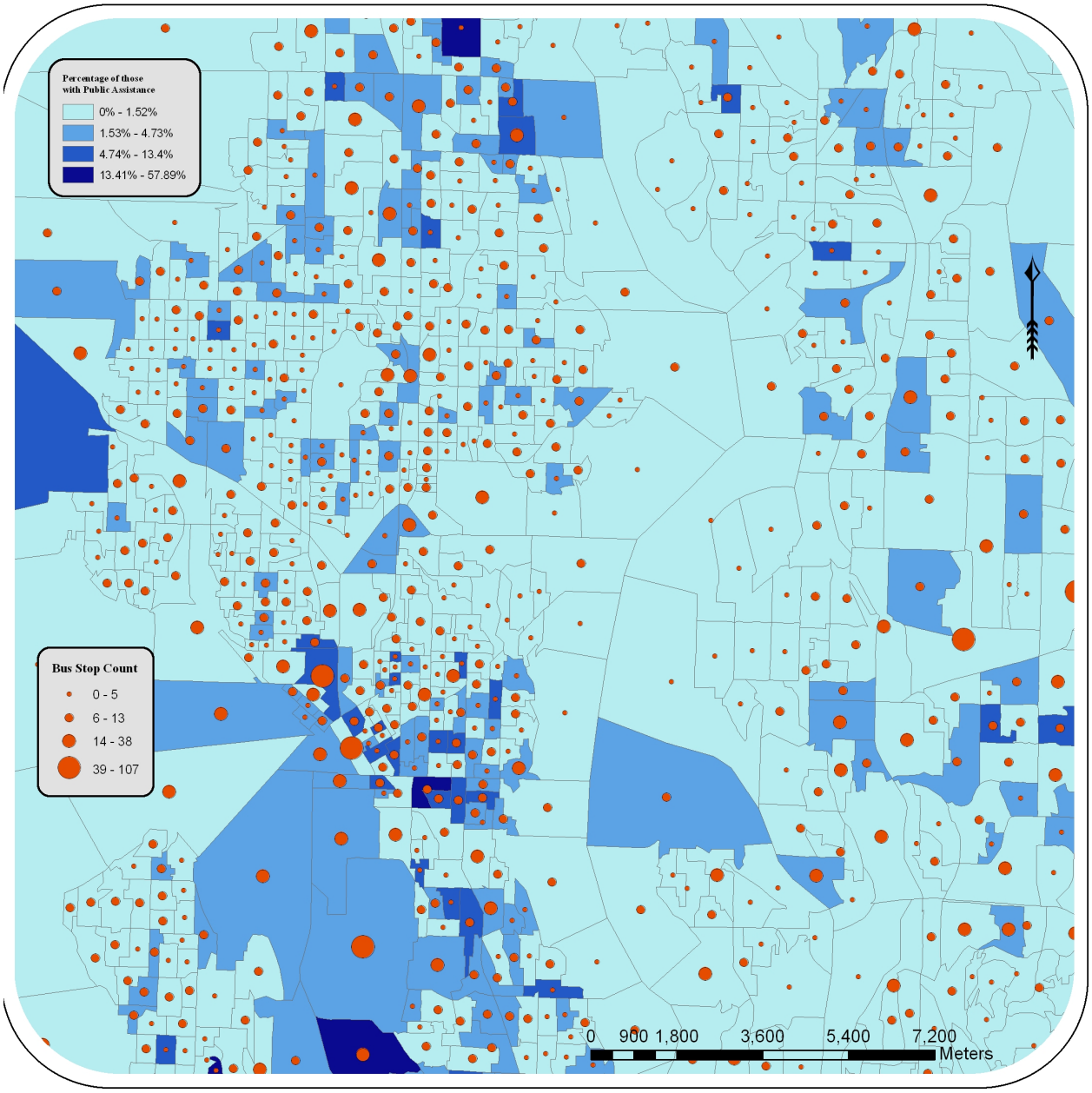
Figure 4.4.15: *Poverty Block Groups in Relation to Bus Stop and Amenity Locations*



Source: US Census Bureau, 2000; KCMT, 2009

Figure 4.4.15 is a bar graph showing bus stop counts and total amenities found in block groups without poverty and block groups with poverty. Figure 4.4.15 shows that there are more bus stops in block groups with poverty versus those without, although not by much. Figure 4.4.15 also shows more total amenities in block groups with poverty, although Figure 4.4.14 resulted in fewer bus stops with high amenity level in these locations.

Figure 4.4.16: Bus Stop Counts and Percentage of Population with Public Assistance: Seattle, WA

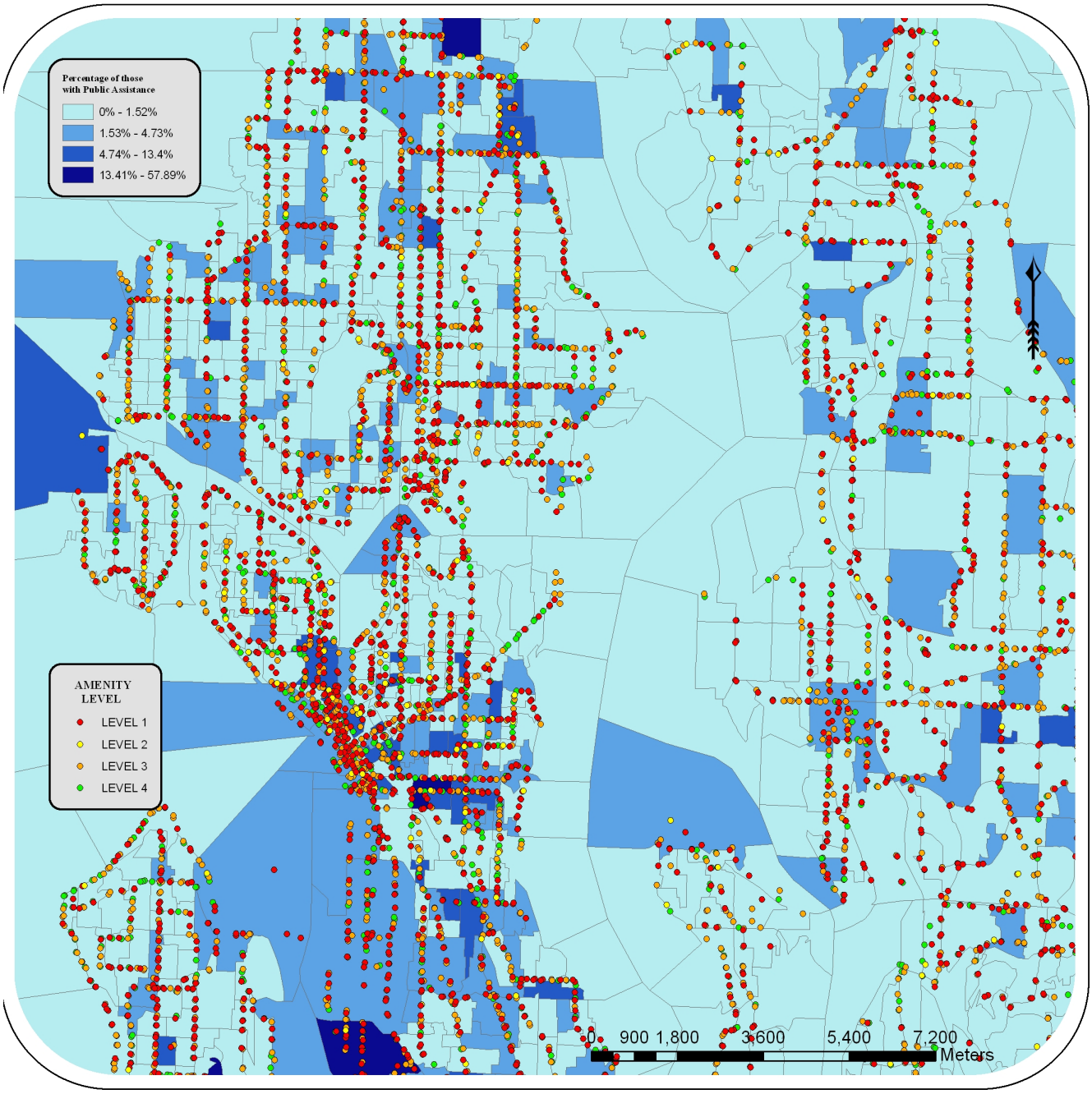


Source: US Census Bureau, 2000; KCMT, 2009

Figure 4.4.16 represents bus stop counts and the percentage population receiving public assistance by block group. Of the seven block groups containing the highest bus stop counts, none fall inside areas of the highest public assistance population, although two are in areas of the second highest public assistance population. For the rest of the areas with the highest population with public assistance, there several moderately to high bus stop counts. This is the same for areas with the second highest population of those receiving public assistance. Although there are a couple of areas with the lowest public assistance population containing high bus stop counts, there seems to be an overall unfair dispersal of bus stops throughout considering this is a population who may use or need public transit more.

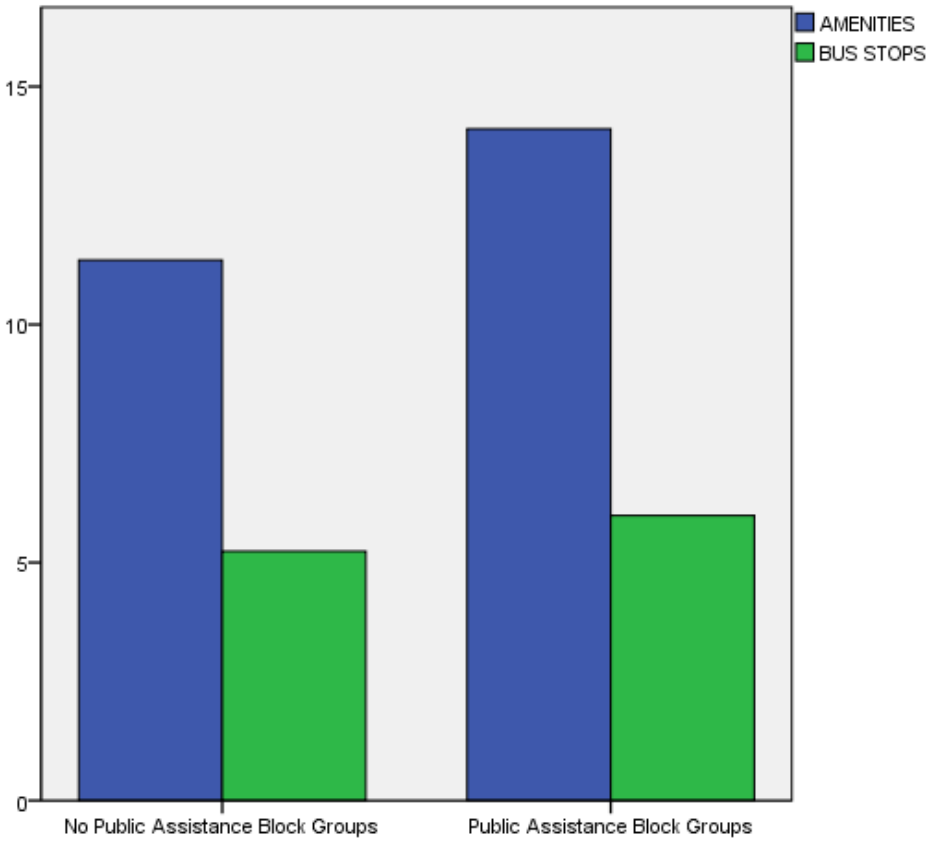
Figure 4.4.17 represents amenity levels the percentage of population receiving public assistance by block group. In the areas with the highest population on public assistance, there are only nine amenity level 4 bus stops and twenty-three amenity level 3 bus stops. There are a total of fifty-seven bus stops in these areas which means that over half of the bus stops are level 4 and level 3. Of all the demographics shown for Seattle, persons on public assistance is the only one with more than half of the bus stops in the highest category to have high amenity levels. The same goes for the areas with the second highest populations of public assistance. Over half of the bus stops there are of high amenity levels. Although the majority of amenity level 4 bus stops fall inside areas of lower to lowest public assistance populations, at least the bus stops that are in the areas of need have seem to have a fair distribution of high amenity level bus stops.

Figure 4.4.17: Amenity Levels and Percentage of Population with Public Assistance: Seattle, WA



Source: US Census Bureau, 2000; KCMT, 2009

Figure 4.4.18: *Poverty Block Groups in Relation to Bus Stop and Amenity Locations*



Source: US Census Bureau, 2000; KCMT, 2009

Figure 4.4.18 is a bar graph showing bus stop counts and total amenities found in block groups without public assistance and block groups with public assistance. The results in Figure 4.4.18 coincide with those in Figures 4.4.16 and 4.4.17 where more bus stops and total amenities fall inside than outside block groups with higher public assistance populations.

4.5 Amenities and Bus Stops in Relation to Transportation Equity: Are they associated with the areas of socio-economically disadvantaged group of people?

Now that we have analyzed the transportation equity aspect of the spatial relationship of bus stop locations and amenities, a statistical technique is needed to test the hypotheses that are stated in the methodology section. The Pearson's correlation coefficient is used to determine whether there is any association between number of bus stops and amenities with selected socio-economic variables, bus rider commuters, disabled, minorities, no car households, poverty stricken, and those on public assistance at block group levels. PASW 18 software is used to run spearman correlation coefficient for this analysis. Table 3 shows the results by each city.

Table 3: Correlations between Socio-Economic Variables, Ridership, Amenities, and Bus Stop Counts

		AMENITIES	BUS STOPS
GREENSBORO	MINORITY	.363**	.389**
	DISABILITY	.119*	.142*
	POVERTY	.255**	.284**
	PUBLIC ASSISTANCE	.204**	.215**
	NO CAR HH	.373**	.359**
	BUS RIDER COMMUTERS	.303**	.306**
KANSAS CITY	MINORITY	.227**	.339**
	DISABILITY	.100**	.212**
	POVERTY	-.010	.105**
	PUBLIC ASSTANCE	.133**	.254**
	NO CAR HH	.043	.078**
	BUS RIDER COMMUTERS	.278**	.440**
SEATTLE	MINORITY	.170**	.123**
	DISABILITY	.129**	.101**
	POVERTY	.144**	.103**
	PUBLIC ASSISTANCE	.093**	.077**
	NO CAR HH	.214**	.180**
	BUS RIDER COMMUTERS	.197**	.168**

***Significant at P=.01; * Significant at P=.05*

Sources: US Census Bureau; GTA, 2009; KCATA, 2009; KCMT, 2009

First, Greensboro will be examined to find any relationships between the number of bus stops and their total amenities with the selected socio-economic variables. We can see that there is a positive correlation between all demographics and amenities for Greensboro with the highest between no car households at .373 and minorities at .363. The rest of the demographics all have positive relationships with amenities as well. The next examination is between bus stop counts and the demographics. Just like with amenities, there is a positive relationship between all variables. The highest relationship is with minorities at .389 and no car households at .359. The results do not exactly seem to correspond to the spatial relationship on the maps of amenity levels; although, most of the bus stop counts on the maps do seem to relate to the findings in Table 3. One reason these amenity results don't quite match with those on the maps is because the maps looked at amenity levels where these results summed total amenities in each block group. Overall there seems to be a high relationship between the demographics and bus stop counts for Greensboro according to Pearson's correlation coefficient. This could possibly mean that there are many bus stops in these demographic areas, but not enough amenities.

Next, Kansas City is examined to find any relationship between bus stop amenities and socio-economic variables. The correlations between amenities and the socio-economic variables is quite lower than those of Greensboro which does match with the map results given Kansas City has a fewer amenities and lower amenity levels. In general there seems to be a high relationship between the socio-economic variables and bus stop counts for Kansas City according to Pearson's correlation coefficient. Each variable has a much higher relationship with bus stops than amenities. As was the case in

Greensboro, this could possibly mean that there are many bus stops in these disadvantage group areas, but not enough amenities.

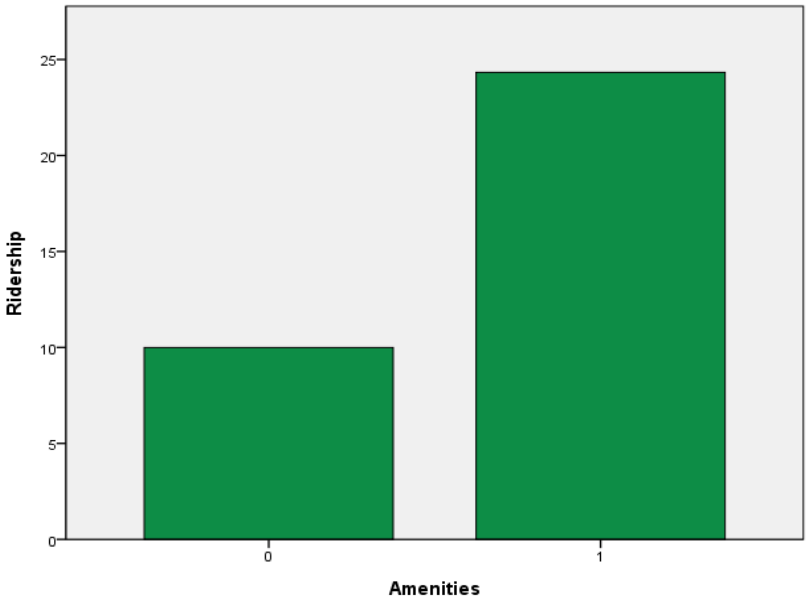
Lastly, Seattle is examined to find whether there is any relationship between bus stops and amenities and the selected socio-economic variables. In the category of bus stop counts and the socio-economic variables, just like in Greensboro and Kansas City, they all have positive relationships. The highest relationship is with no car households at .180 and second highest with commuters who ride bus at .168. Seattle's results are much different than those of Greensboro and Kansas City. This could be because overall they have more amenities and more concentrated amounts of bus stops in each block group. This can be a trend to pattern a transit implementation after for up and coming metro areas trying to expand their transit systems.

After analyzing the results of Table 3 in comparison to the results found in the maps, there were definite trends. There does seem to be a fair distribution of bus stops and amenities in the populations of the transportation disadvantaged. There is statistical significance that high bus stop counts and amenity counts are related to the socio-economic and disabled communities. Although these results signify a fair and even allocation of said bus stops and total amenities, there is still a lack of bus stops with high amenity levels in these same areas. If we assume that these populations need the bus system as much if not more than others, they should be served with bus stops with higher amenity levels

4.6 Do Amenities Increase Ridership and if so, what amenities are the most important factors associated with predicting bus ridership?

Now that this research has analyzed the transportation equity aspect of amenities and bus stop locations, a series of tables and graphs will answer the question asked: Do amenities increase ridership? An examination of amenity levels in relation to ridership, as well as each individual amenity in relation to ridership will be analyzed in this section to determine if these two variables affect each other positively. This analysis is being conducted at the bus stop location data, not blockgoups level.

Figure 4.5.1: Amenities and Ridership: Greensboro, NC



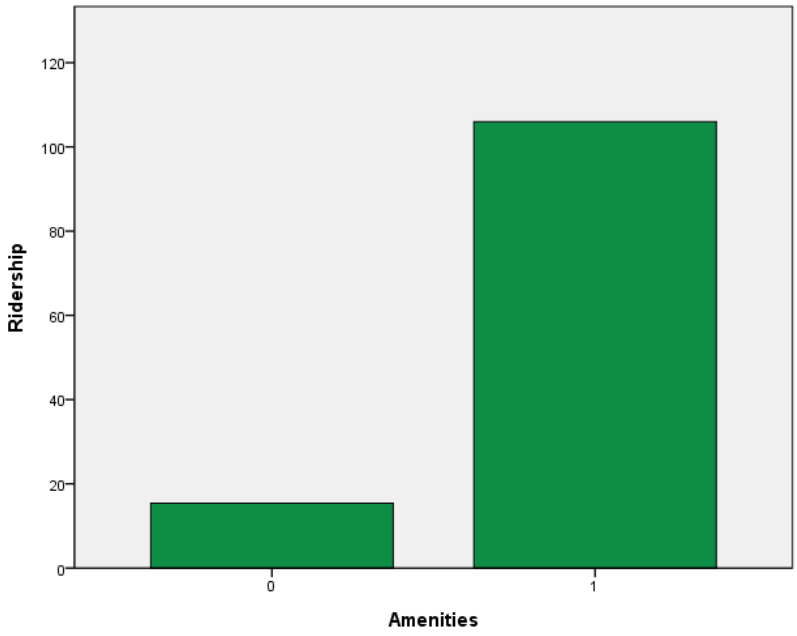
0 = No Amenities

1 = One or more amenities

Source: GTA, 2009

Figures 4.5.1 through 4.5.3, were created through PASW Statistics 18 software and shows ridership by amenities for each city. Figure 4.5.1shows Greensboro ridership data by bus stop locations with either no amenities (0) or one to numerous amenities (1). Here no amenities means with a sign only. There is a significant increase in ridership (more than double) at bus stops with amenities compared to those without amenities.

Figure 4.5.2: Amenities and Ridership: Kansas City, MO



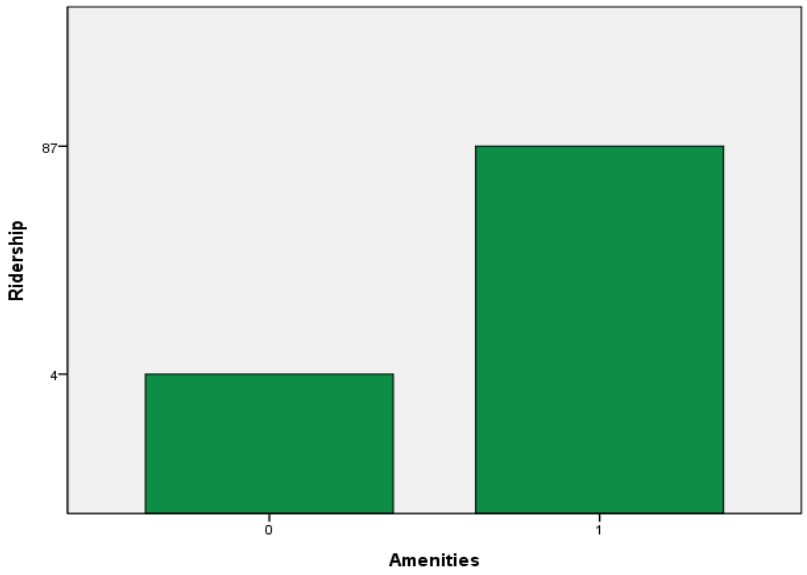
0 = No Amenities

1 = One or more amenities

Source: KCATA, 2009

Next, like in the Greensboro case study, Figure 4.5.2 is shows ridership data by bus stop locations with either no amenities (0) or one to numerous amenities (1). There is a significant increase in ridership (quadruple) at bus stops with amenities compared to those without amenities. This is evidence that more amenities at bus stops produce higher ridership.

Figure 4.5.3: Amenities and Ridership: Seattle, WA



0 = No Amenities

1 = One or more amenities

Source: KCMT, 2009

Figure 4.5.3 shows ridership levels by the amenities for Seattle. Just like in the Greensboro and Kansas City case studies, Figure 4.5.3 is a graph showing ridership data by bus stop locations with either no amenities (0) or one to numerous amenities (1). There is a significant increase in ridership (more than double) at bus stops with amenities compared to those without amenities. This is more evidence that more amenities at bus stops produce higher ridership

Next, an examination of relationships between ridership and each individual amenity, as well as total amenities, is observed in Table 4, representing a one-tailed bivariate correlation table using Pearson's correlation coefficient. Each city listed different numbers of individual amenities. For Greensboro, there are numerous significant correlations. There is a positive relationship between total amenities and bus riders at the .121 level. Of bus riders and individual amenities, the two highest positive relationships are lighting at .247 and shelter at .251. All other amenities have positive relationships as well: benches at .188, trashcans at .098 and ADA at .067. This is more confirmation that more amenities and increased ridership affect each other.

Just as in Greensboro, there are significant positive correlations in each category for Kansas City. Total amenities have the highest positive correlation at .406 (the highest relationship for any category in Table 4). The individual amenities have positive correlations as well: trashcans at .359, shelters at .345, and benches at .124. Again, these relationships help support the case that more amenities and increased ridership affect each other.

In Seattle, there is a significant correlation between bus riders and amenities at the .266 level, although not as high as for Kansas City. The highest positive correlation between individual amenities and bus riders were shelters at .373 and awnings at .128. There is also a small correlation with signs at .055 and ADA at .050. Although there were not as many individual high positive correlations as those in Greensboro and Kansas City, it still provides confirmation that overall, more amenities provide more riders. Of

all the individual amenities, shelter had a very high relationship with ridership for all three cities.

Table 4: Correlations between Amenities and Ridership

		RIDERSHIP
GREENSBORO	AMENITIES	.121**
	TRASH	.098*
	LIGHTING	.247**
	ADA	.067*
	BENCH	.188**
	SHELTER	.251**
KANSAS CITY	AMENITIES	.406**
	TRASH	.359**
	SHELTER	.345**
	BENCH	.124**
SEATTLE	AMENITIES	.266**
	BOLLARDS	.004
	NEWS BOX	.023*
	BIKE RACK	-.002
	ADA	.050**
	SIGN	.055**
	SHELTER	.373**
	SIDEWALK	-.001
	LANDING	.007
	AWNING	.128**

***Significant at P=.01; * Significant at P=.05*

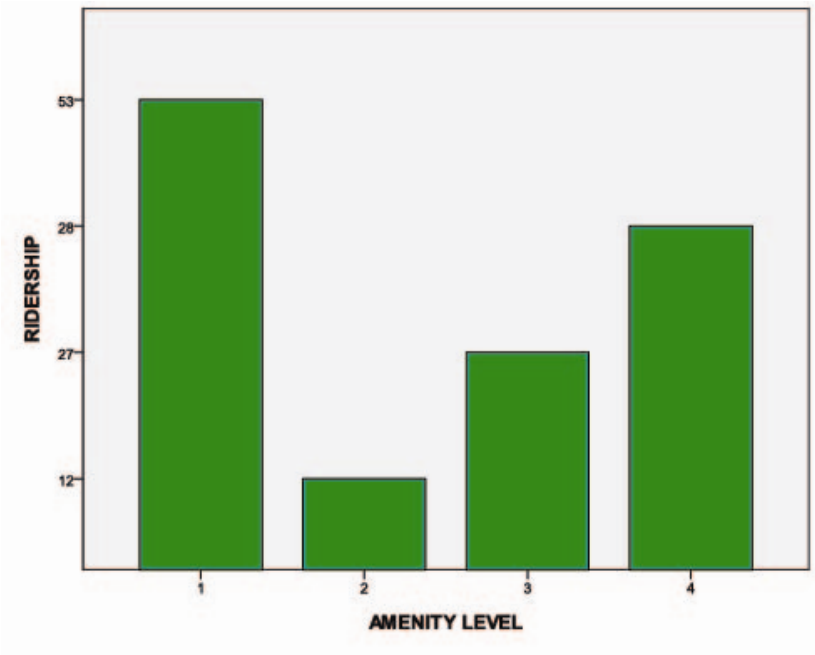
Sources: GTA, 2009; KCATA, 2009; KCMT, 2009

4.7 Does the lack or different level of amenities at each bus stop affect ridership levels in a significant way?

Now, relationships between amenity levels and ridership will be examined through a series of graphs, with a categorical analysis. There is already evidence in the prior figures that bus stops with one to numerous amenities greatly increase ridership versus bus stops with no amenities. Now bar graphs (Figures 4.5.4 through 4.5.6) will examine if different amenity levels will influence ridership accordingly. The amenity levels used here are the same criteria as those in the map section and explained in Table 1. Once again, this analysis is being conducted at the bus stop location data, not blockgoups level.

Figure 4.5.4 shows Greensboro's amenity levels and ridership. There is greater ridership with amenity level 1 than level 4. This could be due to the fact that the majority of bus stops in Greensboro have amenity level 1 and people have to use them regardless. On the other hand, ridership is the lowest at amenity level 2 and doubles at level 3 which also doubles with level 4. Although there is an anomaly with level 1, ridership otherwise increases greatly as the amenity level increases.

Figure 4.5.4: Amenity Levels and Ridership: Greensboro, NC



1 = Amenity Level 1

2 = Amenity Level 2

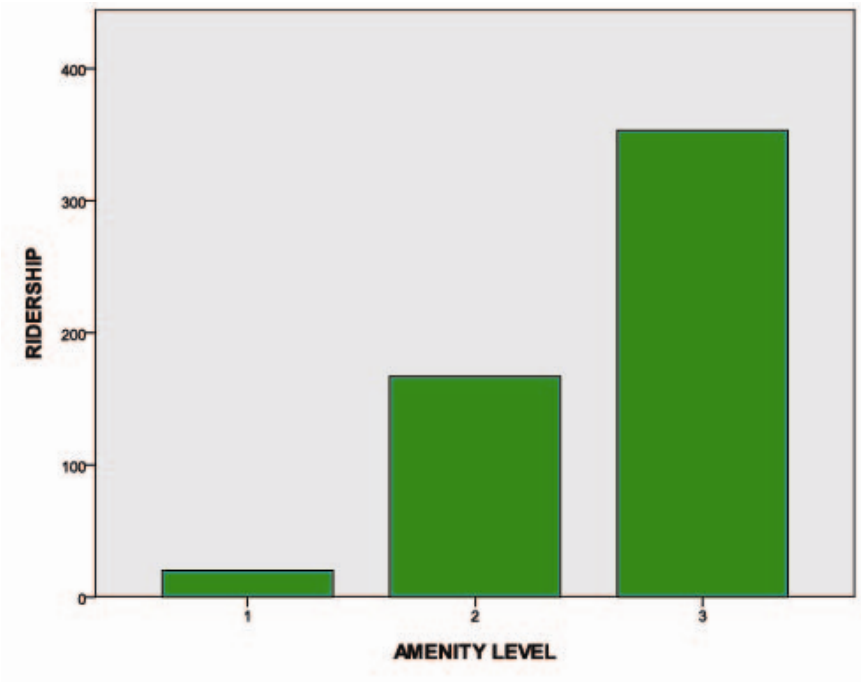
3 = Amenity Level 3

4 = Amenity Level 4

Source: GTA, 2009

Figure 4.5.5 shows Kansas City's amenity levels and ridership. Although Kansas City had no level 4 bus stops, the ridership for each amenity level increases as the level increases, which goes to show if they had any level 4 bus stops, the ridership would likely increase for those stops as well. Level 1 has the lowest ridership and quadruples with amenity level 2 and quadruples again with amenity level 3. This is more evidence that the better the amenities, the more ridership will increase.

Figure 4.5.5: Amenity Levels and Ridership: Kansas City, MO



1 = Amenity Level 1

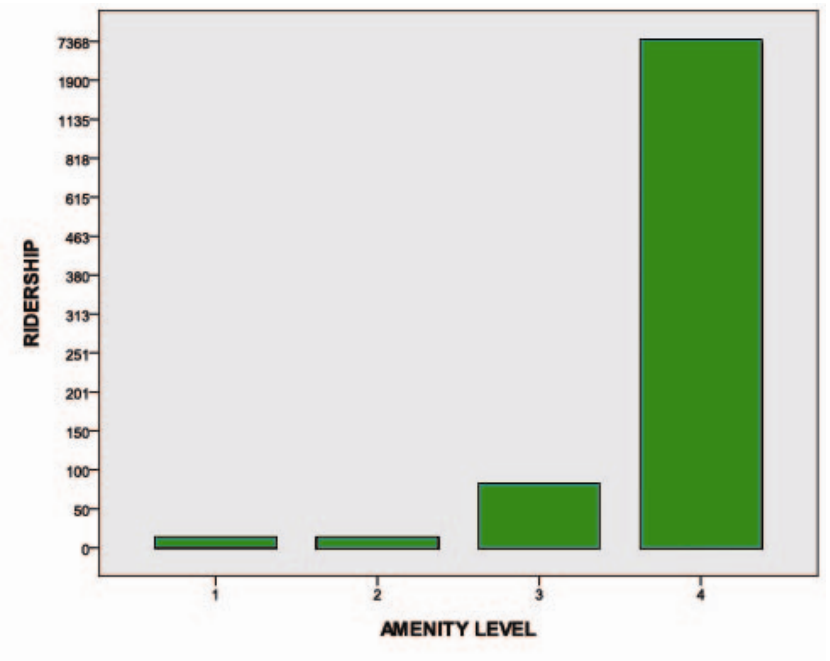
2 = Amenity Level 2

3 = Amenity Level 3

Source: KCATA, 2009

Figure 4.5.6 shows Seattle's amenity levels and ridership. The evidence in this graph is overwhelming. Ridership at amenity levels 1, level 2, and level 3are minute in comparison to the ridership at level 4. The ridership at level 4 is almost six times the ridership at level 3. Again, this is only more confirmation that better and more amenities at a bus stop will certainly increase ridership.

Figure 4.5.6: Amenity Levels and Ridership: Seattle, WA



1 = Amenity Level 1

2 = Amenity Level 2

3 = Amenity Level 3

4 = Amenity Level 4

Source: KCMT, 2009

One-Way ANOVA Post Hoc Analysis was performed to test whether each level of bus stop amenities generates different level of ridership and whether these differences are statistically significant. The assumption of equal group of variance is required to run ANOVA. Therefore, the Levene test was performed to test the assumption of equal group of variance and Tamhane test was performed when Leven test was significant or the assumption of equal variance were not met. Table 5 shows the One-way ANOVA Post Hoc Analysis for three cities that this study is conducted.

Table 5: One-Way ANOVA Post Hoc Analysis

	Greensboro	Kansas	Seattle
Amenity level comparisons at bus stops	Mean Differences in Ridership		
Level 1 and Level 2	40.2975905	-146.890*	-.893*
Level 1 and Level 3	25.6587172	-332.851*	-33.499*
Level 1 and Level 4	25.2267162	NA	-387.725*
Level 2 and Level 3	-14.6388733	-185.960*	-32.605*
Level 2 and Level 4	-15.0708743	NA	-386.832*
Level 3 and Level 4	-.4320010	NA	-354.227*

**Significant at p=.01*

Sources: GTA, 2009; KCATA, 2009; KCMT, 2009

In Greensboro, ridership is higher for bus stops with level 1 amenities compared with higher level of amenity service. Level 2 has the lower ridership than level 3 and there is a difference between level 3 and 4 amenity level. However, all these differences are not statistically significant. Therefore, even though it appears that bus stops with lower amenity levels have higher ridership in Greensboro, this is not conclusive that lower level of amenities bus stops is positively associated with more ridership.

However, Kansas and Seattle have different outcomes as expected. In Kansas, Bus stops with level 1 amenities have average 147 less ridership than bus stops with level 2 amenities, and level 1 amenity bus stops have average 333 less riders compared to bus stops with level 3 amenities. Similarly, Level 2 amenity bus stops have average 186 riders compared to level 4 amenity bus stops. All these differences in ridership are statistically significant in Kansas City. Seattle has the similar patterns: bus stops with level 4 have average 354 more riders than bus stops with level 3 amenity services and level 2 generate average 387 riders compared to the bus stops at level 2 services. Although there is not much difference in ridership between bus stops with level 1 and 2 amenity services, bus stops with level 1 amenities has average 34 ridership compared to bus stops with level 3 amenities, and has 388 less riders to bus stops with level 4 amenities. All these differences are statistically significant in Seattle as well. Based on Kansas City and Seattle's One-Way ANOVA Post Hoc analyses, it can be generalized that bus stops with higher level amenity services have average higher level of ridership. In other way of saying is that different level of amenities at each bus stop affects ridership levels in significant way.

Although Kansas City and Seattle proved a significant increase in ridership with higher amenity levels, Greensboro seemed to fail in this regard. There could be varying reasons for this outcome. The first and obvious explanation could be the size of each city. In general, the larger the metro population is, the more expansive the bus system will be. Greensboro, being a smaller metro area has significantly less bus stops and a much smaller bus system than Kansas City and Seattle, therefore, the ridership numbers are far less as a whole and prove to be not as significant. Another factor could be the geographical location of each area. Each metro area is not only geographically different, but culturally as well. Greensboro is a smaller southern city, Kansas City a larger Midwestern city, and Seattle a large west coast city. The trend towards better public transit usually tends to start in places with larger populations and better economies.

CHAPTER V

SUMMARY, DISCUSSION, AND CONCLUSION

This thesis examines the spatial distributions of bus stop amenities from the perspective of transportation equity to determine whether they are being located in areas where they are needed the most as well as to analyze their amenities or lack thereof and the effect they might have on ridership. Several questions are examined. The first question was whether the locations of bus stops and their amenities were distributed evenly across areas to serve everyone and if they are located in areas and communities where the demographic trend leans towards a greater need for transit, especially the transportation disadvantaged such as lower income and minorities. The other question being discussed is whether disabled people being served equally by the transit system. After the thorough examination of the spatial aspect as well as the statistical analysis to answer these questions, a conclusion was met.

The maps as well as the statistical analysis show a fair distribution of bus stops in areas of the transportation disadvantaged with few exceptions. Groups such as minorities, poverty, bus users, no car households, and people with public assistance, were met with a higher number of bus stops than areas of low populations of these variables. Overall, the total amenities were also located in these places of need. Although there is a fair distribution of total amenities, there is a lack of bus stops with high amenity levels in these same areas. In most cases, few of these bus stops had more than one amenity,

giving it a lower amenity level. There seems to be higher amenity bus stops found in areas where fewer commuters ride the bus, no poverty zones, or in areas with the lowest minority population. This may happen because neighborhood associations or other types of entities that can use their power and sway to receive better amenities only for aesthetic purposes. These areas might look more appealing but in some cases they are not practical. This can also be the case for areas near a new high-end, mixed-use development that wants aesthetically appealing bus stops, but in reality the residents might not use the bus, as least based on mode of commuting data. In prior observations in Greensboro, the author has seen more people waiting at bus stops in low income areas, and most of the time these people aren't sitting on a bench under a shelter but rather standing under a light pole with a sign. There were block groups shown in the maps with high amenity levels in areas where they are needed, but there were also many other low amenity block groups in the same areas.

The same goes for areas of the disabled population. There is a fair distribution of bus stops where the disabled live, but high amenity levels are lacking. This is unfortunate since high amenity levels (level 4 and level 3) are the only two level containing ADA approved but stops. There were some exceptions, but too few. Seattle has significantly more amenity level 4 bus stops where Kansas City had no level 4 bus stops. For most cities, it is not too late to rethink their transit system plan to meet the needs of transportation equity so all populations can be served equally especially those in need of more and better transit options.

The other questions examined in this research are related to ridership: whether the amenities of bus stops have an effect on overall ridership and if so, which amenities are the most important factors for predicting bus ridership and whether bus stops with higher level of amenities associated with more ridership. In each case study, there is overwhelmingly higher ridership where there are more amenities. There is also a high statistical relationship with total amenities and ridership. The most important amenity that factors in with higher ridership is shelter. Bus stops with shelter have a higher statistical relationship throughout. Amenity levels also factor in to ridership levels. In Kansas City and Seattle, ridership increases with the amenity levels. Amenity levels and ridership were statistically significant for these two cities. Greensboro had the most ridership at level 1 amenities, but level 3 and level 4 had much higher ridership than level 2. This could be due to Greensboro having the majority of their bus stops at level 1 and being a smaller city. Greensboro's bus system is not as expansive and is not used as much as Kansas City or Seattle. Greensboro's expansive urban sprawl may also have an effect on this aspect as well. Since higher amenity levels do increase ridership, there is a definite need for more amenities at more bus stops. Each city had significantly more of their total bus stops designated with lower amenity levels.

The findings in this research suggest that it is worth the time and funding for agencies to undertake studies to implement amenities because amenities do affect ridership. In each case study, there was a significant relationship and an increase in ridership at bus stops with more amenities. It is overwhelming how much ridership increases when more amenities are present. Although the findings do suggest the

relationship is significant, there is still a need for more research to determine if the ridership or the amenities came first. Many agencies did not keep automated passenger counts decades ago when the first amenities were implemented. There needs to be a continuous study by the transit agencies to monitor ridership before and after a new amenity is installed. Also, other factors need to be researched in the future that could have effects on ridership such as pollution, crime rates, route factors etc. This needs to be a continuous study so that eventually all transit agencies can strive for a more fluid, accessible, comfortable, and safe bus system.

So, what are the policy implications for this research? There is renewed interest in transit systems striving to maintain and increase ridership by enhancing all stages of the transit experiences by improving vehicle design characteristics and providing amenities (Adelson, 2008). These findings will not only help the transit authorities to recognize that more and better amenities are a driving force for equality, but it can also help them understand that better amenities will unquestionably produce more ridership which can produce more revenue for the transit agency. If transit agencies were aware of these finding, they may have more incentive to implement more amenities which may end up helping the cause of transportation equity, if it is done correctly and justly.

The transit agencies need to maximize the effect of investments by focusing resources on those amenities that will have the greatest positive effect on ridership (TCRP, 1999). A transit agency may have certain ideas and incentives for certain locations and designs of bus stops, but they often have to meet the needs of other government agencies and organizations (Smart et al, 2009). An ideal map (hopefully

available in the future) would have equal amenities and bus stops throughout all areas. Amenities not only reward those who already use the bus, but can also help recruit those who don't.

Usually the design decisions are made by engineers and maintenance departments in which neither is usually trained to understand passenger needs (TCRP, 1999). That is one reason it was such a burden to obtain data from transit agencies. There is no uniform that ridership and amenity data has been kept and maintained. Each agency kept records in a much unorganized and unsystematic manner. Instead of dividing local Departments of Transportation into transportation engineers and transportation planners, the author suggests combining the two so that sensible decisions can be made and funding is not wasted on amenities in areas where they are not appreciated or used.

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