GREEN SPACE DISTRIBUTION AND ENVIRONMENTAL JUSTICE IN OKLAHOMA CITY

By

DAISHA DELANO

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Oklahoma State University

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GREEN SPACE DISTRIBUTION AND ENVIRONMENTAL JUSTICE IN OKLAHOMA CITY

Thesis Approved:

Dr. Beth Caniglia

Thesis Adviser

Dr. Andrew Fullerton

Dr. Adam Mathews

Dr. Riley Dunlap

Name: DAISHA DELANO

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Environmental justice has long focused on the distribution of harmful environmental facilities that disproportionately affect low income and minority communities; however, recent work has begun to look at the distribution and access to environmental goods as well. Having access to green spaces can have a significant positive effect on individuals and communities. In urban areas where these spaces are often limited, it has been found that poor and minority communities are further from green spaces, and that the green spaces they do have access to are smaller and more run down. Green spaces and nature have positive impacts on individuals and communities ranging from physical environmental benefits, benefits to community and social cohesion, and benefits to individual's physical and mental health. Because of the wide range of benefits that green spaces provide, this has come to be considered an environmental justice issue. The aim of this study is to examine road based access to green spaces in the Oklahoma City area. ArcGIS was used to perform a network analysis of access to green spaces around the city from the centroid of each census block group within the city. Census block groups are organized to be as demographically homogenous as possible; therefore, these block groups were compared to determine differences in access based on percent racial minority, median income, and average level of education. Demographic data and census block group data were gathered from the U.S. census website, and shapefiles of Oklahoma City green space distribution, and Oklahoma City road network data were obtained from the Oklahoma City GIS (geographic information systems) department. Our findings indicate that census block groups with lower median income and higher percent minority are actually have closer road based access to green spaces in Oklahoma City. However, the green spaces that these census block groups have access to are smaller than the green spaces near census block groups with higher median income and smaller minority population. Future research should look at the quality and type of green spaces that are available to more clearly understand how they can affect the communities that live near them.

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CHAPTER I

INTRODUCTION

The human relationship with nature and the natural world is vastly complex, and has long been a topic of interest to researchers across disciplines. In recent decades several key scholars within the sub-discipline of environmental sociology have expanded upon this idea, and pushed sociological research into a new era of focus on this relationship. The New Ecological Paradigm has been a vital tool in bringing about new and compelling research that highlights issues with past interpretations of the human-nature dialectic and the benefits of applying a new framework (Dunlap et al. 2000). Much of the work in sociology prior to this paradigm shift subscribed to the common understanding of the relationship between humans and nature which has long assumed; that humans can and should be placed above or separate from the rest of the natural world. This has led to a disconnect between reality; which involves a world of highly interconnected and mutually impactful socio-ecological systems, and the more common but flawed view of the world which emphasizes the superiority and domination of humans over nature. While it is becoming increasingly obvious that humankind has the ability to cause significant harm to the surrounding environment at both the small scale (through pollution, poor farming practices etc.) and at the global scale with the threat of climate change, the impact that nature has on society (both good and bad) is more often ignored in research.

Though somewhat uncommon, there have been scholars, often in the fields of urban planning and health, that have studied and discussed the importance of access to and interaction with nature (Xiaolu and Rana 2012; Gidlof-Gunnarsson and Ohrstrom 2007; Barbosa et al. 2007). According to these studies, the benefits of frequent interactions with nature include positive impacts on psychological well-being, increased health and increased physical activity, and greater social cohesion and place meaning (Wolch et al 2014; Jackson 2003; Bird 2012; Tzoulas et al 2007; Chiesura 2004; Evans 2003; Heidt and Neef 2008; Bolund and Hunhammar 1999). These benefits are likely to increase the overall human security of the individuals who have access to them, and therefore the resilience of the neighborhoods and communities in which they live. Unfortunately the benefits provided by access to green spaces and nature are not equally available to all. Within urban areas especially, the dispersion of parks, community gardens, and other publicly accessible green spaces is not equitable, and some neighborhoods are left without easy access to any of these environmental goods (Heckert 2013; Eckerd and Keeler 2012; Dillon 2014; Barbosa et al 2007; McConnachie and Shackleton 2010). Urbanization continues to increase, with around half of the world's population now living in cities; this growth has caused urban environmental inequalities to be an increasingly critical injustice with rising adverse consequences for more and more individuals.

Environmental justice has been an important subfield within environmental sociology for several decades, with researchers studying many forms of injustices related to the environment. Most commonly discussed in this literature are injustices which occur due to the unequal distribution of human created, negative environmental impacts. Throughout its early years, research in environmental justice primarily focused on injustice issues relating to the proximity to, and harm from, environmental bads such as waste facilities, and pollution causing industries (Bullard 1990). However, issues of environmental justice are diverse, and can include many forms of injustice such as the unequal siting of hazardous facilities, the location of urban and rural food deserts, and unequal access to green spaces and nature. Recent literature in environmental justice has bolstered these new and expanding definitions of what constitutes an environmental injustice and several researchers have begun to focus on the unequal distribution of environmental goods. These researchers have discussed new measures of environmental justice which emphasize positive environmental characteristics such as access to natural resources and natural spaces. Studies done in this area of research have supported the claim that access to natural areas, parks, and other green spaces can have a significant impact on various aspects of a person's life including an individual's physical and mental health (Wolch et al 2014; Jackson 2003; Bird 2012; Tzoulas et al 2007; Chiesura 2004; Evans 2003), their perceptions and concern for the environment, and feelings toward their communities (Picket et al. 2001; Wu 2014; Heidt and Neef 2008; Bolund and Hunhammar 1999; Evans 2003). In urban areas, environmental goods such as parks and public recreation spots are often disproportionately located near neighborhoods comprised of higher income individuals, and farther from neighborhoods that are predominantly composed of minority group members (Jennings et al. 2012; Iverson and Cook 2000; Hope et al. 2003; Kinzig et al 2005; Heynen et al 2006; Wolch et al. 2014;

Byrne et al. 2009). Because of this inequality and the benefits that these natural areas provide, access to green spaces has begun to be seen by many as an environmental justice issue. This differential access only adds to the broader environmental injustice problem within urban areas which includes the distribution of both environmental goods, and environmental bads.

For this research project I have gathered data relating to ecological diversity and green spaces including: lakes, parks, and community gardens in the Oklahoma City area, in order to observe whether these previously found patterns of inequality characterize the distribution of green space access in OKC. Specifically, I have used the Oklahoma City GIS land use data and road map data to observe the spatial location and characteristics of green spaces and parks in Oklahoma City. These maps were then joined with United States Census data in order to examine the proximity and access to parks that are experienced by different census block groups. My research questions focus specifically on the Oklahoma City area and how green spaces are dispersed within the city's limits. The overarching research question for this project is: Are green spaces distributed equitably within the Oklahoma City area? However this question will be broken down to more specifically understand the relationship between the average socio-economic status of a census block group, the road based access to green spaces, and the size of green spaces these groups have access to. I have examined the relationship between the average income of the census block group and the road based access to the nearest green space, as well as the size of the nearest green space to each census block group. These same dependent variables were observed in relation to the percentage minority group members of the census block group and the average years of schooling of the census block group.

The goal of this research is to add to and expand on previous literature focusing on the subject of environmental justice relating to environmental goods. Because this is a topic that has been overlooked for much of the history of environmental justice research there is a great potential to expand the field and strengthen our understanding of these inequalities; consequently, more research needs to be done to ensure the accuracy of previous studies, and to see if the trend replicates itself across time and space.

This study specifically examines access to parks and green spaces in the Oklahoma City area to see if similar patterns of inequality emerge as have been found in previous studies done in urban areas around the world. Oklahoma City is listed as the third largest city in the United States in terms of area (US Census 2000), but as of the 2010 Census is only the 31st most populous city in the United States (US Census 2010), leading to the potential to have a better ratio of green spaces available to the population. The environmental situation in Oklahoma City mirrors the sustainability challenges of other mid-sized large cities in the mid-western part of the United States. Cities in this part of the country often grew out of rural areas and have an industrial base that is predominantly reliant on one industry, such as the oil and gas industry in the case of Oklahoma City. A lack of economic diversity is one aspect of a city which decreases resilience and increases the vulnerability of the system (Walker and Salt 2006). Oklahoma City and other cities of its kind were not planned around a goal of ecological resilience or sustainability; this includes less planning early on in terms of green spaces, parks, and other natural resources. Furthermore, this has limited the research done in any cities of this kind relating to resilience and sustainability, making Oklahoma City a unique location to emphasize these topics. This is one of the reasons it was chosen as a focus point for the Oklahoma EPSCoR project which aims to study and improve resilience across Oklahoma (OKEPSCoR). The EPSCoR project informed my decision for focusing on the Oklahoma City area (National Science Foundation under Grant No. IIA-1301789).

Furthermore, Oklahoma City has been listed as one of the fastest growing cities in the United States by Forbes, and CNN (Forbes 2013; CNNmoney 2014) with new industries and jobs being moved to the Oklahoma City area. This urban growth appears to be on a trajectory to continue, leading to an increased need to provide reasonable access to green spaces for all residents. The creation of new green spaces is a goal in progress for Oklahoma City. From 1993 until 2004 Oklahoma City significantly revitalized certain parts of the city through the Metropolitan Area Projects (MAPS) which worked to improve and upgrade "sports, recreation, entertainment, cultural, and convention facilities" (okc.gov). These improvements involved changes and additions to some of Oklahoma City's parks and green spaces including the Bricktown Canal which is lined with biking and hiking paths and small park areas, and the Oklahoma River which is lined with hiking trails, landscaped park areas, and other recreation facilities (okc.gov). Since 2010 the MAPS 3 has been in progress in Oklahoma City which further aims to revitalize parts of the Oklahoma City area, again including significant additions to green spaces and parks. This includes an eight mile multi-use trail stretching from Lake Hefner to the Oklahoma River, as well as a park area consisting of 40 acres of land north of I-40 and 30 acres between I-40 and the Oklahoma River. This vast park area will include gardens, fountains, and a lake (okc.gov).

In this paper I begin by reviewing the relevant literature relating to resilience, vulnerability and human security which provide a theoretical background for the importance of access to green spaces and nature. I then review important literature from traditional environmental justice, as well as more specific studies which focus on environmental justice in terms of access to green spaces and nature. Finally, I review relevant literature and studies which aim to understand and describe the various benefits that can be provided by having access to green spaces and nature, and the consequences that can occur when access is limited or not available. In the following section of this paper I discuss the research methods which I employ for this study. I first provide a brief literature overview of research that has been done using geographic information systems to study proximity and access to green spaces and parks in urban areas. I discuss the methods used in these similar studies, and how these methods will influence my own. Furthermore, I overview some of the commonly used GIS methods in earlier environmental justice research and how the methods have changed and improved with newer technology over time. I then discuss the GIS vector-based style network analysis method that I used for this project, and specifically discuss the necessary steps to be taken when conducting this GIS method, based on previous research and my own experiences. Finally I discuss the statistical methods used to analyze the network analysis results. Lastly, I will discuss the results of this research project, how they compare to other similar studies, and what they mean for future research and the future of Oklahoma City. In the final section of this paper I review the possible limitations of this research project, and how these limitations might affect similar research moving forward. I discuss the important contributions that this research can provide for the field of environmental sociology, and how the findings might fit in to the broader understanding of resilience and human security. Finally, I elaborate on future directions that research could take based on my understanding from this project, and how research could best further our knowledge of the inequalities of access to green spaces in Oklahoma City.

CHAPTER II

REVIEW OF LITERATURE

In the following sections I review the relevant literature relating to the various aspects of this project. First I will provide an overview of literature relating to resilience, vulnerability, and human security. These ideas will be used as a theoretical starting point for why access to green spaces and nature in urban areas is an important environmental issue, and provide a description of the desired equitable access to environmental goods in urban areas. Though separate, these three literatures have many similarities in their primary concepts and definitions which allow for an overlapping discussion. I will then review important literature from traditional environmental justice research to provide a background of the topic. This section will discuss early research in environmental justice, how the topic was initially approached, and how the focus and research within the discipline have changed over time. I will then review research examining the various social, psychological, and physical benefits provided by green spaces and access to nature. Most of this research comes from urban geography literature rather than sociology. Finally, I will review a smaller subset of environmental justice literature which focuses specifically on the differences in access to environmental goods and proximity to green spaces and nature within urban areas.

Resilience and Vulnerability

Resilience, vulnerability, and human security, are interrelated and expanding literatures which contain research topics and discussions relevant to social ecological systems. Resilience literature is the most developed of the three with a background stemming from the field of ecology when the concept was first put forth by C.S. Holling in 1973 (Caniglia et al. 2014). In ecology literature, resilience has generally been defined as a system's ability to absorb a shock or disturbance while maintaining its primary functions and basic structure (Barr and Devine-Wright, 2012; Brand and Jax, 2007; Holling, 1973; Lopez et al., 2013; Webb, 2007; Walker and Salt 2006). However, in more recent work the social sciences have adopted the concept of resilience and applied the same idea to coupled human and natural systems in order to understand and describe what mechanisms can cause a system to be more or less resilient both to sudden shocks and large scale gradual changes (Walker and Salt 2006). The concept of resilience has in some ways replaced the end goal of sustainability as it is more versatile for understanding and benefitting complex and ever changing systems.

Walker and Salt (2006) discuss nine features they believe would be important in a resilient world. These features are related to both human and natural systems and are relevant for observing and building resilient systems as well as a resilient world. These features are important indicators of resilience at the local level and useful for examining the mechanisms or features of an urban area which contribute to its resilience or vulnerability. The nine features are: 1) increased diversity (economic, social, biological etc.) (Walker and Salt 2006: 145), 2) embraced ecological variability, 3) some degree of modularity of components, 4) acknowledgement of slow moving variables associated with system thresholds, 5) tight enough feedbacks that the results and consequences of behaviors would remain obvious to those participating in them (Walker and Salt 2006: 146), 6) strong social capital in the form of trust, social networks, and positive leadership, 7) innovation achieved through an emphasis on learning and experimentation (Walker and Salt 2006: 147), 8) overlap in governance which includes having systems and institutions with redundancy built into their structure, and 9) ecosystem services which include the acknowledgement of the value and uses of the ecosystems variables (Walker and Salt 2006: 147). The presence of green spaces and areas of diverse ecological resources within urban landscapes is a fitting component of several of these features of a resilient system. I therefore argue that the benefits of green spaces in urban areas (such as having increased biological diversity, strong social capital and social cohesion, increased physical and mental health) and the presence and acknowledgement of the benefits of ecosystem services could all be strengthened by the presence of natural spaces within cities, and might in turn increase the resilience of the overall urban system.

Human Security

Related to the concepts of resilience and vulnerability is the idea of human security. In their chapter "Human Security, Vulnerability, and Global Environmental Change" Brklacich, Chasan and Bohle (2010), discuss the mechanisms needed for a system to achieve human security, which they describe as "the capacity to overcome vulnerability" (2010: 37). This concept can more broadly be described as the presence of various features and mechanisms that coalesce to create an environment in which individuals face greater resilience or vulnerability to both social and environmental changes (Caniglia et al. 2014). The United Nations Human Development Report (1994) identifies seven primary components of human security which include: political, economic, food, health, community/cultural, personal, and environmental insecurity (UNDP, 1994). Within urban areas, these insecurity threats are common, and the benefits of natural and green spaces could play a part in their alleviation. Brklacich, Chazan, and Bohle (2010) argue that in order to be secure a system needs to 1) possess options that allow the elimination, mitigation, and adaptation of threats posed to the human, environmental, and social rights of the system, that it must 2) have the ability and freedom to exercise the options necessary to allow the elimination, adaptation, and mitigation of these threats, and that 3) the system must allow actors the opportunity to "actively participate in obtaining these options" (Brklacich, Chazan, and Bohle 2010: 37). These characteristics of a system with human security require that environmental factors do not interfere in the human ability to utilize opportunities to reduce or eliminate risks. These requirements for a system characterized by human security all imply that the system is in a state of either security or vulnerability.

Environmental security is one important dimension of human security which is a fundamental topic in research relating to environmental justice and green spaces. Research relating to this dimension of human security aims to more fully understand the intersection between human security issues and the environment. This research looks at the ways in which human security and environmental change intersect to create issues of vulnerability and insecurity of coupled human-natural systems. Barnett, Mathew and O'Brien (2010) argue that there are various social processes which impact the level of insecurity to environmental change by causing human systems to be more sensitive, and less able to respond to or cope with environmental shocks and changes (2010: 17). The ideas of resilience, vulnerability, and human security within coupled human natural systems are highly interconnected concepts which help inform important environmental issues within the field of sociology. Environmental justice is fundamentally related to the resilience and human security present within a socio-ecological system. Increased resilience of the system as a whole will have an impact on the overall human security of individuals within the socio-ecological system. Because environmental security is one of the primary dimensions of human security, the environmental justice and environmental equality within the system are considered a fundamental piece of the creation of a secure system (Caniglia et al. forthcoming).

Environmental Justice

Within the field of environmental sociology, the subject of environmental justice is an important topic of research when examining the mutually impactful relationship between humans and the rest of the natural environment. Environmental justice is defined by the EPA (www.epa.gov/environmentaljustice) as

> The fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies. Fair treatment means that no population, due to policy or economic disempowerment, is forced to bear a disproportionate share of the negative human health or environmental impacts of pollution or environmental consequences resulting from industrial, municipal, and commercial operations or the execution of federal, state, local and tribal programs and policies.

Over the last few decades a vast amount of research has been conducted within this subfield of environmental sociology regarding the existence and persistence of environmental injustices, environmental racism, and environmental inequality. These concepts refer to the processes by which racial minorities, low income individuals, and other marginalized groups are more likely to be exposed to environmental hazards. Numerous studies across time and location, and using various methods and units of analysis have consistently supported the existence of these inequalities. Common hazards facing these groups include, among other environmental stressors, the unequal siting of waste facilities, mining practices, paper mills, and numerous other industries which contribute to air, soil, and water pollution (Mohai 1996; Mohai et al. 2009; Bullard 1990; Pastor et al. 2001; Downy 2003, 2007; Downy et al. 2008 Shlosberg 2013; Mix and Shriver 2007; Pellow 2000; Pellow 2004; Brulle and Pellow 2006; Taquino et al. 2003). The research into these problems has also lead to the creation of environmental policies which attempt to eliminate or at least mitigate the inequalities present and to protect poor and minority residents who are often less equipped to fight against the placement of these types of hazards on their own (Bullard 1990). The 1970's and 1980's were a time of highly publicized, landmark cases of environmental injustice, including such cases as Love Canal in New York and Times Beach in Missouri. This time period also brought about the increasingly obvious inability of the government to regulate environmental pollutants and equally protect citizens. These events pushed forward the burgeoning topic in the field of sociology, and began to influence the creation of grassroots organizations and community groups which would participate in the environmental justice movement (Cable and Benson 1993).

The term environmental racism specifically was first coined in 1982 by Benjamin Chavis, and was defined as:

> Racial discrimination in environmental policy making, the enforcement of regulations and laws, the deliberate targeting of communities of color for toxic waste facilities, the official sanctioning of the life-threatening presence of poisons and pollutants in our communities, and the history of excluding people of color from leadership of the ecological movements (Mohai et al. 2009).

Despite the consistent studies finding support for the presence of these environmental inequalities, environmental justice remains a contentious topic (Mohai et al. 2009). Environmental justice scholars have long debated the importance of certain indicators of environmental justice; most notably whether race or income is a stronger predictor of the likelihood of an individual to be plagued by an environmental injustice. However, most current researchers in the field acknowledge that both race and income are significant in determining who will experience environmental injustices, and that the overlap between these two categorizations cause them to be far from mutually exclusive (Downy 1998; Mohai and Saha 2006). Though copious support has been found regarding the unequal exposure to environmental hazards of poor and minority groups, there is further debate amongst environmental justice researchers regarding how these inequalities were established. It is still debated as to whether environmental hazards and locally unwanted land uses are placed in locations already occupied by poor and minority residents, or whether these hazards lower the cost of living, causing poor and minority individuals to move in. Though both occur and add to the disproportionate exposure to environmental harms that minority group members face, research in the field of environmental justice has consistently found that the racial makeup and the socio-economic status of a neighborhood will affect the likelihood that it becomes a site for a waste facility or a polluting industry (Mohai et. al. 2009). For example, it was found that in Los Angeles County, unequal siting was a greater contributor to the problem than was minority move in (Pastor et al. 2001). Recent research has also found that these demographic variables are important in determining the likelihood that residents have access to green spaces such as parks and walking paths (Comber et. al; 2008), the likelihood that they have fresh and healthy food options (Powel et. al. 2006), and in determining the likelihood that individuals spend time visiting natural settings such as parks, and spend time participating in common outdoor activities such as hiking, camping, and sports (Comber et al. 2008; Shinew et. al. 2004). Because of the numerous benefits that green spaces provide, this has begun to be seen as an environmental justice issue in its own right. To fully understand how this has become an issue of injustice, it is important to understand the positive impacts and implications that access to green spaces can have.

Green Spaces

Urban ecology has developed in recent decades with a growing interest in the relationship between humans and the environment in urban and suburban areas. Because over half of the world's population now resides in urban areas, and the trend toward urbanization continues, this area of study has become increasingly important for understanding the changes that are occurring in cities which are uniquely human dominated ecosystems (Young 2009). Researchers in urban ecology and urban planning aim to understand how natural processes are embedded within cities and urban spaces, and more specifically how the dialectic between the human or built environment and the natural system and processes affect the economy, health, and human community (Picket et al. 2001). Though no comprehensive definition of urban areas has been fully agreed upon, there are several general characteristics of urban areas that researchers in the field acknowledge: “high population density, abundant built structures, extensive impervious surfaces, altered climatic and hydrological conditions, air pollution, and modified ecosystem function and services” (Wu 2014). These characteristics all impact the ecosystem functioning and biodiversity within the urban area which subsequently impacts the benefits and consequences experienced by the human population. The findings within this literature are directly related to issues of environmental justice, and are especially relevant for research focusing on access to green spaces and biodiversity within cities. Urban green spaces can be defined as

> an integrated area comprising natural, semi-natural, or artificial green land, providing manifold benefits to different groups of people within the city extent…an open space situated within the city limits with a good vegetation cover planted deliberately or inherited from pre-urbanization vegetation and left by design or by default” (Xiaolu and Rana 2012).

Studies within urban ecology and urban planning generally examine the benefits of green spaces and nature within cities in order to improve urban sustainability and increase the benefits that spaces of nature provide. Researchers have predominantly focused on the positive effects urban green spaces have on the human population including benefits for human health, physical activity, social cohesion, and psychological well-being (Wu 2014). The benefits provided by urban green spaces are ecosystem services, which are defined by the Millennium Ecosystem Assessment (2005) as “the benefits people obtain from ecosystems including 1) provisioning services, 2) regulating services, 3) cultural services, and 4) supporting services.”

The positive impacts of urban green spaces are diverse and can include important physical environmental benefits, benefits for community perception and social cohesion, psychological benefits, and health benefits. Environmental benefits include air purification which is provided by tree and plant cover, less impervious surfaces allowing for improved rainwater drainage which can be created through soil and groundcover, noise pollution reduction when nearby green spaces without traffic are available, micro-climate regulation and the reduction or elimination of urban heat islands which can be provided by tree and plant cover and green roofs, and sewage treatment through less impervious surfaces (Bolund and Hunhammar 1999; Tratalos et al. 2007; Gidlof-Gunnarsson and Ohrstrom 2007; Escobedo et al 2011; Groenewegen et al. 2006; Heidt and Neef 2008).

Green spaces have also been shown to provide overall human health benefits. Lower levels of air pollution are linked to general reduction in health problems, and as previously stated, some forms of green spaces act as spaces of air purification (Honold et al. 2012). Furthermore, those living within closer proximity or with greater access to public green spaces report a greater inclination to exercise (Wolch et al 2014; Jackson 2003; Bird 2012; Tzoulas et al 2007). Respondents in one study indicated that footage of a natural green environment was significantly more walkable than footage of a built urban environment, and walking while in a natural setting has greater psychological benefits than walking while in an urban setting (Kinnafick and Thogersen-Ntoumani 2014). Urban planning attempts to design environments that are beneficial to the public health; however, this is not usually the outcome in urban areas, with inactivity and obesity becoming increasingly common in most urban areas (Wells et al. 2007).

Access to green spaces and spending time in natural settings provide psychological benefits as well. Residents living in neighborhoods with more green areas report increased happiness and reduced stress (Chiesura 2004; Evans 2003). People living near areas with ample tree and grass cover also report less procrastination for major issues, rate these issues as less severe, more solvable, and shorter term (Kuo 2001). Furthermore, the density of tree cover in urban areas is related to higher reports of stress recovery (Jiang et al. 2014). Studies have found that even short term exposure to nature can reduce an individual's perceived stress (Tyrvainen et al. 2014). Short term and even virtual exposure to nature are able to increase respondents' reports of happiness and positive emotions, attention and focus, and ability to reflect on life events and problems (Mayer et al. 2009).

The quality of the green spaces available to individuals has been found to affect the degree to which the spaces benefit residents as well. One study found that the higher rated the quality of the public space, the fewer respondents reported psychological distress (Francis et al. 2012). For older individuals the pleasantness, safety, and distance to open spaces has been found to be related to life satisfaction (Sugiyama 2009). Green spaces have been shown to benefit children in poor urban neighborhoods as well; one study found that following a move, children who relocated to the most improved areas in terms of green space showed the highest cognitive functioning of participants in the study (Wells 2000). Children who have greater access to and use parks, gardens, and playgrounds are reported to have fewer emotional and behavioral problems than their peers with less green space access (Flouri et al. 2014). Urban blue spaces have been considered less in the literature than green spaces; however, a few studies have expressed the benefits that these areas can have for people as well. Blue spaces are areas where there is visible water, and are often connected to public green spaces (fountains or ponds in parks, rivers or lakes with walking paths around them). Public blue spaces have been shown to provide stress relief, influence positive perceptions of urban areas, and increase an individual's reports of emotional attachment to a place (Volker and Kistemann 2011; 2013). Some studies have even found natural and built blue spaces to be rated higher in terms of having a positive effect on the visitor, and being perceived as restorative than are green spaces (White et al. 2010).

Physical and aesthetic benefits are not the only effect that public green spaces have on an area. These spaces can also offer socio-cultural benefits such as providing places of leisure, and locations for social interaction and community integration (Heidt and Neef 2008; Bolund and Hunhammar 1999; Evans 2003). Research has shown that the social interactions that public green spaces provide are important for creating a stronger sense of community and social cohesion, generally providing relief from stress and daily life, and raising spirits. The use of these outdoor spaces in inner city areas is linked both to stronger social ties within ones neighborhood, and a greater sense of community (Kweon et al. 1998) and the chance to participate in social events and activities raise people's overall sense of well-being (Cattell et al. 2008).When residents have the opportunity to visit shared public green spaces in their neighborhoods, and when they have views of nature from their homes, they report significantly greater neighborhood satisfaction (Kearney 2006). For children in inner-city areas this access can be important as well, in neighborhoods with greater tree and grass cover children were more likely to participate in creative play and have adult supervision than were children in neighborhoods with more barren landscapes (Taylor et al. 1998). Even simply the amount of tree canopy cover in a neighborhood in an urban area has been found to be related to the degree of social capital individuals report (Holtan et al. 2014), and the presence of grass and trees in an urban public are is linked to how often the space is used for social and community activities (Sullivan et al. 2004). The perceived quality of these public spaces is important in determining whether they result in a greater sense of community cohesion. Having a public open space that is perceived as being of higher quality, is associated with reports of a greater sense of community (Francis et al. 2012). While residents who visit public parks in inner-city areas report greater social ties within their neighborhoods, it appears that these differences are strongly influenced by the quality of the parks being visited. Parks are more likely to provide the benefits of neighborhood based social ties if they are well maintained and have recreational facilities that the visitors can utilize (Kazmierczak 2013). This sense of community is also associated with higher reported feelings of safety and security, volunteering, community engagement (Sense of Community Partners 2004), and greater well-being (Davidson and Cotter 1991). Residents in inner-city neighborhoods reported finding pictures of areas with higher tree density and greater grass maintenance as being safer than pictures of areas with less green cover (Kuo et al. 1998). Feelings of safety and security correlating with green space is not entirely perception; both violent and property crime rates were compared for apartment buildings in inner city neighborhoods with varying levels of surrounding vegetation. The findings of the study indicate that the greener the area around the apartment building was, the fewer property and violent crimes were reported (Kuo and Sullivan 2001). In one study researchers looked at neighborhoods with low versus high environmental burdens which they listed as traffic noise, air pollution and lack of public green space. All of these burdens can be alleviated by the inclusion of public green spaces. The researchers found that residents living in the lower burden neighborhoods reported being more satisfied with their neighborhoods, participating in better health behavior, and finding their neighborhood conditions less stressful (Honold et al. 2012).

Furthermore, some studies have begun to address how these benefits are distributed in urban areas and how this differentially affects the health and well-being of residents. Researchers within urban ecology have used various methods to examine the spatial distribution of green spaces within urban areas including the use of GIS mapping. GIS can be used to examine the patterns of differential access and spatial distribution of urban green spaces and neighborhoods and the corresponding benefits green spaces provide. Some research in this area has focused on the effect that humans have on the natural environment in terms of the creation of vacant green spaces and abandoned areas. Urban areas are human dominated ecosystems which provide little in the way of natural resources and environmental benefits to residents. However, green spaces and natural areas are important within cities as they provide ecosystem services and environmental benefits such as reducing urban heat islands and flooding, human health benefits, and psychological and social benefits. The unequal distribution of these benefits constitutes an environmental injustice and should be further examined through research.

Environmental Justice: Proximity to Goods

Unlike the placement of environmental hazards which can be immediately obvious and directly harmful to those in close proximity, the lack of environmental goods is a more subtle and slowly harmful problem. Because of this, environmental justice scholars have not been as quick to study the unequal access to environmental benefits. Furthermore, individuals who are experiencing these differences are less likely to form grassroots organizations or coalitions to combat the inequalities. However, in more recent years the scope of environmental justice research has expanded to include a greater diversity of definitions of environmental justice including an emphasis on access and proximity to environmental goods such as green spaces and community gardens as well as other natural resources (Heckert 2013; Eckerd and Keeler 2012; Dillon 2014; Jennings et al. 2012). This change in focus has been important in building a more comprehensive understanding of how the environment has the ability to both positively and negatively affect groups of people, and how human actions can manipulate the environment to unequally distribute these outcomes. Research in this area has built both upon previous environmental justice research as well as literature from urban ecology and urban planning which have looked at the changes and benefits of biodiversity in urban areas.

Though far less research has been done in this specific area of environmental justice, various studies have found support for the existence of inequalities in terms of access to environmental goods with poor and minority neighborhoods being farther from and having less ease of access to these benefits both in the United States (Jennings et al. 2012; Iverson and Cook 2000; Hope et al. 2003; Kinzig et al 2005; Heynen et al 2006; Wolch et al. 2014; Byrne et al. 2009; Landry & Chakraborty, 2009; Abercrombie et al., 2008; Heynen Perkins and Roy 2006; Dai 2011; Davis et al. 2012; Comber et al. 2008) and internationally (Barbosa et al 2007; McConnachie and Shackleton 2010; Leslie, Cerin, & Kremer, 2010). Furthermore, research has shown that poor and minority group members are less likely to visit parks and green spaces for a variety of reasons. This includes the barriers to access, cultural factors that lead them to feel discriminated against or unwanted in certain spaces, and feeling that the parks and green spaces they do have access to are not safe, are overcrowded, are poorly maintained, and have fewer amenities (Wolch et al. 2005; byrne wolch and zhang 2009; Jennings et al. 2012; Byrne 2012; Byrne and Wolch 2009; Dahmann et al., 2010; Leslie, Cerin, & Kremer, 2010; Sister et al., 2010; Floyd *et al*., 1993).

Iverson and Cook's (2000) study in Chicago observed the correlations between types and amount of vegetative land cover and household income and household density and found that they were strongly related (Iverson and Cook 2000). Similarly, in the Central Arizona—Phoenix region Hope et al. (2003) found that the spatial variation of plant diversity was predicted by human variables, and in a smaller study of the same area researchers found that overall biodiversity was greater in more affluent areas of the city (Kinzig et al. 2005). In Atlanta, poorer neighborhoods were found to have less access to green spaces than wealthier neighborhoods (Dai 2011). Furthermore researchers have found that urban forest cover was positively correlated with household income in Milwaukee (Heynen Perkins and Roy 2006), and that low income and rent neighborhoods have less tree cover than higher SES neighborhoods in Tampa FL (Landry and Chakraborty 2009). Parks are often scarcer in lower income neighborhoods due to ecological gentrification, the process of nicer green spaces and parks being created and poorer residents being displaced as property values increase (Byrne and Wolch 2009). Previously found inequalities in park and green space access based on income lead to the first and second hypotheses in this study:

> **Hypothesis 1**: The median income of census block groups will be positively correlated with proximity to a public green space.
>
> **Hypothesis 2**: The median income of census block groups will be positively correlated with size of nearest public green space.

Research has also focused on disparities in terms of race and access to green spaces. Using aerial imagery to examine urban canopy cover in the city of Milwaukee, Heynen et al. (2006) found that inner city neighborhoods and predominantly non-white and Hispanic neighborhoods were less likely to provide green spaces and urban forest areas for residents (Heynen et al. 2006). Unequal access to green spaces based on race as well as housing cost and density was also found in small town areas in South Africa (McConnachie and Shackleton 2010). Hispanic census tracts were found to be significantly farther from green spaces and lake Michigan, and had significantly less bird diversity and tree canopy cover in a study done in Chicago (Davis et al. 2012). Racial and ethnic disparities for access to green spaces, with minority neighborhoods having less access or being farther from green spaces and parks were also found in the UK (Comber et al. 2008), and in Atlanta GA (Dai 2011). Researchers have also found that tree cover and street trees were less commonly located in predominantly African American neighborhoods in Tampa FL (Landry & Chakraborty, 2009). Though these studies have used varying methods, and have found inequalities present to greater or lesser degrees, it is evident that green space access is an injustice issue that affects minority neighborhoods in various cities around the world. These previous findings lead to the third and fourth hypotheses:

> **Hypothesis 3**: The percent minority of census block groups will be negatively correlated with the proximity to public green spaces.
>
> **Hypothesis 4**: The percent minority of census block groups will be negatively correlated with the size of the nearest public green space.

This branch of research uses similar measures for social vulnerability to measures used in traditional environmental justice research which emphasize differences in proximity to environmental hazards based on neighborhood racial makeup, and average income. Though previous literature in this field has not used average level of education as a SES measure to examine differences in access to green spaces, this project will include this as an additional hypothesized factor contributing to these inequalities, which leads to the fifth and sixth hypotheses:

> **Hypothesis 5**: The average education of census block groups will be positively correlated with the proximity to public green spaces.
>
> **Hypothesis 6**: The average education of census block groups will be positively correlated with the size of the nearest public green space.

Measures of proximity are not always as simple as calculating a neighborhood's distance from a hazard. The implementation of GIS to measure distance has been used in both traditional environmental justice studies (Downey 2003) and more commonly in examining green space and urban land cover differences and urban planning for sustainable development (Dai et al. 2001; Poggio and Vrscaj 2009; Rosa 2014; Rahman et al. 2011; Lwin and Murayama 2011; Oh and Jeong 2007; Gupta et al. 2012).

Urban ecology and urban planning have been integral to this research in their spatial measurement techniques as well as their definitions and conceptions of what constitutes urban green spaces. Another focus of research coming out of urban ecology and urban planning has examined the changes in population following the creation of green spaces in low income areas. This green space paradox often causes property values to increase significantly forcing low income residents to relocate following the creation of certain kinds of green spaces; this has been called among other things "ecological gentrification" (Wolch et al. 2014). Furthermore, all urban green spaces are not created equal, with some facing over-crowding, being seen as unsafe by residents, or being located near highways or other industry. Some researchers have focused on how these differences affect urban green space use and perceptions within cities. Poor and minority populations are more likely to have access to these less appealing or even dangerous green spaces as opposed to the types of spaces which would be more apt to provide benefits (Wolch et al. 2014). Providing access to clean and diverse green spaces including parks, community gardens, walking paths, and trails is difficult in densely populated urban areas; however, poor and minority areas continue to have even less access to these environmental benefits. Though some research has been done in this area, further research needs to be conducted for the problem to be accepted as significant and addressed in city planning and policy.

The current changes being made in Oklahoma City to the Myriad Garden area through the MAPS 3 project will increase the overall green space in the city. In recent years this area has already been drastically improved, and the Myriad Gardens park area is even currently one of six finalists worldwide for the Urban Land Institutes', Urban

Open Space Award, and award for the most improved green spaces in urban areas around the world. With Oklahoma City's changing landscape, one would expect to find overall increases in access to green spaces as well. This does not however mean that the increased overall access will change any inequalities that are present in terms of access to green spaces. The final hypothesis for this study is related to the possible changes in access to green spaces in Oklahoma City that could occur with the growing park area downtown:

> **Hypothesis 7**: The completion of the MAPS3 project will decrease inequality in access to green spaces in terms of education, income, and race.

Conclusion

Most of the history of environmental justice research has largely focused on the detrimental effects of proximity to environmental hazards and pollution that are disproportionately located near poor and minority communities. Copious support has been found in this area of research across time and place leading to some policy change and increased grassroots organization and success. The importance of this research is unquestionable; however, the current trend toward including the unequal access to environmental goods has begun to foster a more thorough understanding of the multitude of ways in which the environment can be used to create and perpetuate social inequality and subordination of certain groups. Some studies have begun to examine these inequalities in more detail and have found support for the claim that poor and minority dominated neighborhoods are less likely to have easy access to green spaces. However, because these inequalities are usually less blatant and the negative consequences are not as directly discernible, less has been done to combat these inequalities either in academia or in community organizing and policy making. The unequal distribution of these green spaces remains significant because of the ample benefits that green spaces and nature can provide in urban areas. Green spaces provide benefits for the physical environment including reduced noise pollution, reduction in the urban heat island effect, and decreased impervious ground area which reduces flooding (Bolund and Hunhammar 1999; Tratalos et al. 2007; Gidlof-Gunnarsson and Ohrstrom 2007; Escobedo et al 2011; Groenewegen et al. 2006; Heidt and Neef 2008). They also provide human health benefits and psychological and socio-cultural benefits by providing areas of recreation and relaxation and meeting places for community cohesion and social integration (Wolch et al 2014; Jackson 2003; Bird 2012; Tzoulas et al 2007; Chiesura 2004; Evans 2003; Heidt and Neef 2008; Bolund and Hunhammar 1999).

Geographic Information Systems

In recent years the use of GIS has become more common in the social sciences; especially in studies relating to urban environmental sociology. In the past, GIS analysis has been far more prevalent in research done in the field of geography, including work related to urban planning and design, and natural resource management; however, some sociologists have begun to adopt and utilize GIS methods. Social scientists have used analysis methods available through GIS for studying various social issues, including crime rates, immigration, and access to different social benefits (Garson and Vann 2001, Logan et al. 2011, McLafferty and Grady 2004). Specifically within environmental sociology, environmental justice scholars have quickly picked up these GIS methodologies (Fisher et al. 2006, Downey 2003). Because of the nature of environmental justice research as an area which focuses on the spatial relationships between neighborhoods and harmful facilities and sites, GIS has allowed the research to broaden its scope to add a quantitative element to what has traditionally been a more qualitative field. Different measurement techniques have been used in environmental justice with varying degrees of success and accuracy; the development of these new methods in environmental justice have also been vital in research relating to access to environmental goods (Comber et al. 2008; Davis et al. 2012; Wolch et al. 2005; Gupta et al. 2012; Oh and Jeong 2007; Lwin and Murayama 2011; Rosa 2013; Poggio and Vrscaj 2009; Dai et al. 2001; Germann-Chiari and Seeland 2002). Research aimed at understanding differences in access to urban green spaces and other natural resources has been significantly advanced by the GIS methods. GIS software packages have provided tools that allow for more specific measures of proximity and access that take into account spatial characteristics which have often been overlooked or avoided due to data limitations. There are numerous GIS software programs that allow researchers to analyze and observe geospatial data; however, currently ArcGIS is the most commonly used of these programs. I will be employing the use of ArcGIS for this current project focusing on the proximity and access to green spaces and parks in Oklahoma City.

My current research project and the specific GIS methods I have chosen to employ are informed by several previous studies which span internationally across different cities but focus on similar issues of accessibility of green spaces and environmental goods (Comber et al. 2008; Rosa 2014; Poggio and Vrscaj 2009; Zhang and Wang 2006). Specifically, previous research has used GIS to observe and analyze the patterns of green spaces and parks within urban areas with a focus on the characteristics of these urban environmental features. Researchers have used GIS techniques to examine urban sprawl and the growth patterns of growing cities (Rahman et al. 2011), to measure the number, distribution, size, and characteristics of green spaces and parks present in urban areas (Germann-Chiari and Seeland 2004; Gupta et al. 2012; Oh and Jeong 2007; Zhang and Wang 2006), to model the walkability of green spaces (Lwin and Murayama 2011), to analyze the actual accessibility of green spaces (Rosa 2014), to understand the linkages between human health and access to green spaces (Poggio and Vrscaj 2009), and most relevant to this research, to analyze the proximity and access to urban parks and green spaces (Comber et al. 2008). My method of analyzing the proximity and access to green spaces will be a vector-based network analysis. This method focuses on measuring the actual access to green spaces based on road network data. I will be measuring distance from the centroid of each census block group to the nearest road access point of the nearest green space based on available roads, taking into account obstacles.

Much of environmental justice research has relied on more descriptive qualitative methods such as case studies, ethnographies, and in-depth interviews with residents; however, over time more scholars have begun to focus on methods that examine or at least include quantitative aspects such as distance or proximity to waste facilities alongside the substantive qualitative research. Initially many researchers used more simplistic measures which looked at the census tracts or zip codes within which different facilities were located (also known as host units) and the adjacent or nearby tracts or zip codes that might be impacted as well. These methods have several accuracy issues that some researchers have observed and discussed (Mohai et al. 2009). Some of the simple spatial measurement methodologies require broad and often inaccurate assumptions to be made about the nature of census tracts or zip-codes, and the location and distribution of polluting facilities within these areas. Many studies look at the distribution of waste or polluting facilities by observing the number of facilities within a certain census tract or zip-code area and recording the number of minority or poor individuals within that area and in adjacent census tracts or zip-codes; this is done by either aggregating pollution data to correspond with census data or creating a dummy variable for the presence of environmental hazards in an area (Downy 2003). These methods ignore the spatial location of the facilities within each area, whether the facility is near the border of the area, how the facilities are distributed within the area, how the area is shaped, and how large the area is. Researchers are likely to make errors in their determination of how people are affected, for example by assuming that all individuals within a certain tract are affected equally, and that all those living in adjacent tracts are impacted less than those in tracts containing the pollutant. GIS spatial location methods are able to alleviate some of these issues so that researchers can more accurately observe the distance from polluting and waste facilities of certain groups or neighborhoods.

Distance based approaches using GIS have been compared to findings from approaches using only census tracts or zip code areas, and GIS distance based approaches generally indentify greater disparities between both racial and socioeconomic groups (Mohai et al. 2009, Ringquist 2005; Mohai and Saha 2006; Downey 2003). Furthermore, distance based approaches have been found to be more accurate, and allow researchers to overcome several issues that arise with traditional and commonly utilized "unit hazard coincidence approaches" (Mohai and Saha 2006). This is the classic method of examining environmental hazard distribution in which researchers break apart the study area into segments, and catalogue which segments contain hazards, and how many hazards are contained in each section.

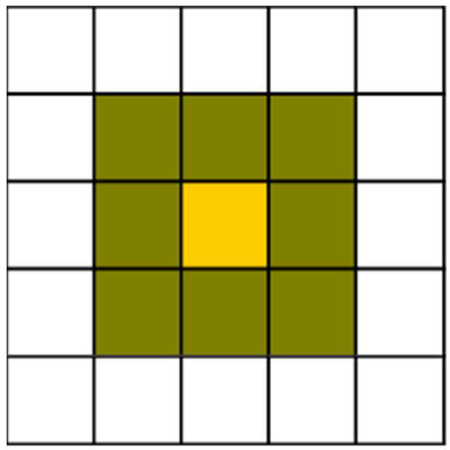

Figure 1: Classic Environmental Hazard Distribution

In a simplified version of this method a host unit would be the yellow tract with the presumed highest level of pollution, the surrounding tracts would be given a slightly lower score of pollution, and the tracts past these given a pollution score of zero (see Figure 1). The dominant demographic characteristics of each section are then compared to the number of hazards present to determine if environmental injustices are present (Mohai and Saha 2006). Downy (2003) discusses the benefits of adopting a GIS variable when observing segregation and environmental inequality in urban areas (Downy 2003). Though he did not use a vector GIS based network analysis method which allows the researcher to use specific points, lines and polygons to determine actual routes and obstacles; his use of local map data paired with census tract information was able to be transformed into raster data maps (rectangular grid maps composed of square cells) which was a beneficial starting point in improving the spatial measurement techniques used in environmental justice research. Raster data maps, while adequate for some research examining the location of pollutants or polluting facilities, are less informative when determining accessibility to green spaces. When looking at these kinds of issues it would be insufficient not to take into account the actual roads, paths, and obstacles that affect the possible routes from neighborhoods to green spaces.

Network Analysis

GIS methods have been used frequently in studies related to urban geography and landscape and urban planning. Urban planning for parks and other outdoor recreation areas have often included some elements which are applicable to environmental equality issues such as location of green spaces and the access, proximity, and expected use of green spaces and parks in different parts of urban areas. These studies do not specifically consider themselves to be environmental justice pieces; however, their observations and focus are often similar to that of environmental justice approaches that focus on access to environmental goods and natural resources. Within urban planning and urban geography, various studies have focused on the spatial location and accessibility of green spaces and parks in urban areas in order to most equitably locate them, or to place them based on what will allow for the greatest use (Comber et al. 2008; Davis et al. 2012; Wolch et al. 2005; Gupta et al. 2012; Oh and Jeong 2007; Lwin and Murayama 2011; Rosa 2013; Poggio and Vrscaj 2009; Dai et al. 2001; Germann-Chiari and Seeland 2002). A GIS-based network analysis is one of many tools which can be utilized when conducting this form of research, and it allows for researchers to more accurately and consistently measure the time and distance to green spaces from various neighborhoods. Comber et al. (2008) did a study which very heavily emphasized what sociologists would consider to be the environmental justice side of green space accessibility, though their field of study was more directly related to urban planning. This study used a network analysis method to examine the green space accessibility of different ethnic and religious groups in Leicester, UK. The researchers used census data to determine the ethnic and religious makeup of the different areas in the study, and performed a network analysis in order to quantify the access to green spaces these groups had. Measurements were taken from the central point of the census output areas (centroid) which, similar to census blocks in the US, is the smallest grouping of census data. Using smaller scale units of analysis allows the groups to be more socially homogenous than would be possible using larger groupings such as zip codes (Comber et al. 2008). Heckert (2013) performed a study in Philadelphia that looked at both the access to green spaces using a network analysis in ESRI's ArcGIS and at amount of green space nearby using raster grids. While the network analysis findings showed black residents of the city being within a closer walking distance to green spaces, the raster grid analysis examining amount of green space showed the opposite results (Heckert 2013).

A study done in Catania in south Italy by Rosa (2014) both the Euclidian distance (straight line distance between two points) and Manhattan distance (distance based on an existing network) were found using the network analysis method. This study as well found that fewer individuals have access to certain open spaces within a predetermined range (300 meters and 600 meters were both measured) when measuring based on access by available roads and paths than when measuring based on Euclidean distances (Rosa 2014). See Figure 2 for a visual example of the difference between Euclidian and Manhattan distance.

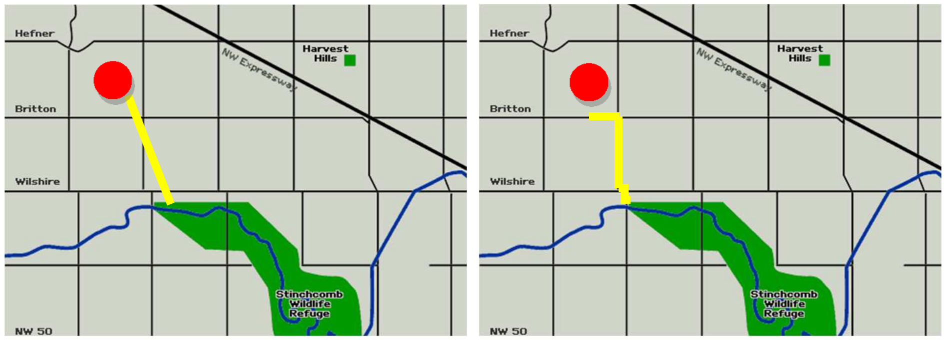

Figure 2: Euclidian Distance versus Manhattan Distance

Oh and Jeong (2007) used a network analysis using Manhattan distance to examine the distribution of green spaces throughout Seoul, South Korea. They observe the best routes available for pedestrians to access the urban parks, which are often located on the outskirts of the city. Oh and Jeong (2007) discuss their decision to use a network analysis method to measure these distances based on previous critiques of methods which focus exclusively on park area per capita, number of parks, or access to parks using a simple Euclidian model of distance. Calculating the walkability to open spaces in urban areas is another use of the network analysis method, this was done by Lwin and Murayama (2011) in their study based in Japan. This GIS based measure of distance is more useful in studies examining access to environmental goods than in more traditional environmental justice work looking at proximity to environmental bads and pollutants. This is because a vector-based network analysis, using Manhattan distance, allows the researcher to examine and answer questions relating to the spatial relationships of common linear networks such as roads, walking paths, rivers etc. Using this kind of a network analysis allows for a more accurate measure of access than a mere point-to-point Euclidean distance analysis because it allows the researcher to take into consideration the roads and paths which are actually available for use, and the obstacles that exist between the two points being analyzed instead of assuming the availability of traveling in a straight line.

CHAPTER III

METHODOLOGY

This study is focusing on the Oklahoma City area. As of the 2010 Census, Oklahoma City had a population of 580,005 with a current 2015 estimated population of 610,613 (census.gov). Oklahoma City has a land area of 606.41 square miles with 956 persons per square mile. In order to examine proximity and access to green spaces and parks in Oklahoma City I used shapefiles of land use information and road network data, both acquired from the Oklahoma City GIS department. Demographic data for the Oklahoma City population and census block groups, racial makeup and distribution, household income and education originates from the United States 2010 census data.

Network Analysis

These datasets were also uploaded into ArcGIS and joined to be analyzed together. The first step of this process was to: 1) download the geographic data (the 2010 TIGER/Line shapefile). To do this selected the layer type (census block groups), state (Oklahoma), and counties (Oklahoma County), and unzip the zip file to be uploaded into ArcGIS. The next step in the process was to 2) retrieve the attribute data. To do this I located the "American fact finder" on the census.gov website, selected the desired state (Oklahoma), and filtered it by layer (block groups) and county (Oklahoma). Next I chose the 2010 SF1 100% data, narrowed the data to the desired types (eg. race, income, education), downloaded these desired tables and unzipped the file. Next I 3) converted the file to a format that could be used in ArcGIS. This includes opening the attribute data in an excel workbook, limiting to one header row, formatting the GEOID2 cell as text, deleting unnecessary columns, and saving the file as a single excel workbook. Finally I 4) joined the excel attribute table and the geography shapefile in ArcGIS. To do this I added the census block group shape file data, and the excel attribute table and used the join function to adhere the tabular data to the census block group spatial data.

OBJECTID *	SHAPE *	STATEFP	COUNTYFP	TRACTCE	BLKGRPCE	GEOID	NAMELSAD	MTFCC	FUNCSTAT
2	Polygon	40	071	000201	1	400710002011	Block Group 1	G5030	S
7	Polygon	40	071	000202	1	400710002021	Block Group 1	G5030	S
13	Polygon	40	071	000300	1	400710003001	Block Group 1	G5030	S
15	Polygon	40	071	000500	1	400710005001	Block Group 1	G5030	S
16	Polygon	40	071	000600	1	400710006001	Block Group 1	G5030	S
17	Polygon	40	071	000100	1	400710001001	Block Group 1	G5030	S
21	Polygon	40	071	001200	1	400710012001	Block Group 1	G5030	S
22	Polygon	40	071	001100	1	400710011001	Block Group 1	G5030	S
31	Polygon	40	071	001301	1	400710013011	Block Group 1	G5030	S
33	Polygon	40	071	000400	1	400710004001	Block Group 1	G5030	S
36	Polygon	40	071	001302	1	400710013021	Block Group 1	G5030	S
40	Polygon	40	107	080700	1	401070807001	Block Group 1	G5030	S
41	Polygon	40	107	080600	1	401070806001	Block Group 1	G5030	S
46	Polygon	40	107	080900	1	401070809001	Block Group 1	G5030	S
48	Polygon	40	107	081000	1	401070810001	Block Group 1	G5030	S
51	Polygon	40	145	030402	1	401450304021	Block Group 1	G5030	S
54	Polygon	40	145	030509	1	401450305091	Block Group 1	G5030	S
55	Polygon	40	145	030502	1	401450305021	Block Group 1	G5030	S
57	Polygon	40	145	030510	1	401450305101	Block Group 1	G5030	S
58	Polygon	40	145	030511	1	401450305111	Block Group 1	G5030	S
59	Polygon	40	145	030505	1	401450305051	Block Group 1	G5030	S
61	Polygon	40	145	030601	1	401450306011	Block Group 1	G5030	S
65	Polygon	40	145	030800	1	401450308001	Block Group 1	G5030	S
67	Polygon	40	145	030602	1	401450306021	Block Group 1	G5030	S

Figure 3: ArcGIS Attribute Table

Figure 3 is an example of an attribute table in the ArcGIS format. To permanently save this join I exported the data as a new shapefile. As mentioned above, for this study the Oklahoma City area was broken into census block groups as the unit of analysis. I have a sample size of 491 as there are 491 census block groups in the Oklahoma City proper area.

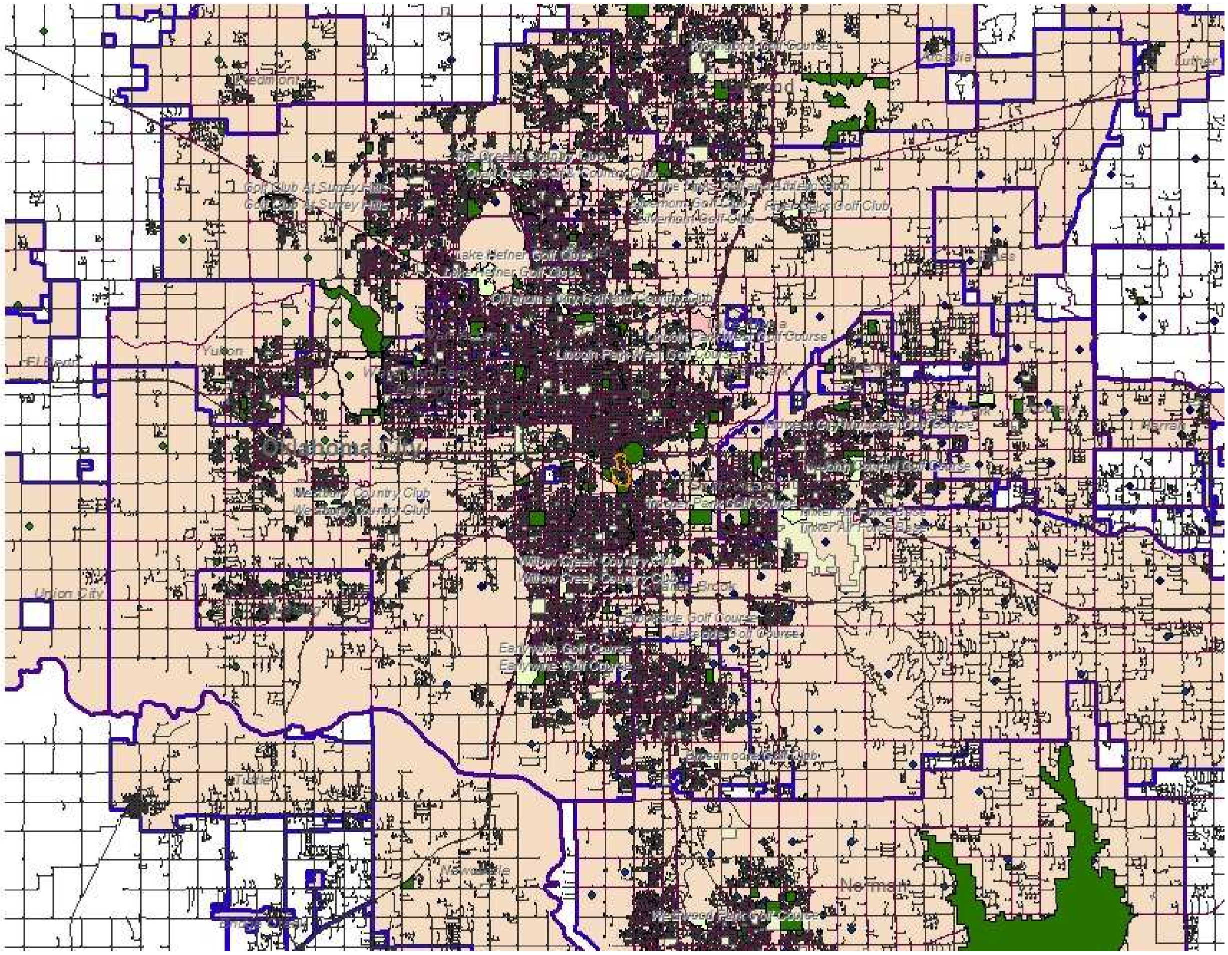

Figure 4: Oklahoma City Road Network, Block Group, and Green Space Map

Figure 4 shows the Oklahoma City area (outlined in light blue) was created in ArcGIS and shows the census block groups, the centroid of each census block group, the green spaces in Oklahoma City, and the road networks that will be used in the network analysis. Census block groups are the second smallest spatial unit of analysis provided and defined by the U.S. Census Bureau. Census block groups are small groupings of census blocks which are formed using boundaries such as “streets, roads, railroads, streams and other bodies of water, other visible physical and cultural features, and the legal boundaries shown on Census Bureau maps” (U.S. Census). Using census block groups as opposed to zip codes, census tracts, or other larger groupings, will allow the groups making up the unit of analysis to be a smaller and more homogenous group, but will be a more manageable sample size than the smaller census blocks. Census block groups have been used as the unit of analysis in similar research, and usually contain a relatively homogenous group of around 1,000 households and 2,000 people (Heckert 2013; Abercrombie et al. 2008). Having a manageably small unit of analysis is important for the current study because it will allow for a clearer and more accurate comparison of different groups in terms of their access to environmental goods.

My definition for open spaces or green spaces is be informed by previous studies done with a similar focus on themes of environmental justice and access to green spaces. Davis et al. (2012) defines open spaces as "publicly accessible outdoor space, including cemeteries, city parks, forest preserves, and public beaches." Comber et al. (2008) include in their analysis of green spaces "parks and public gardens, green corridors, local nature reserves, surviving urban commons, spinneys (or small areas of woodland with undergrowth), sites of importance for nature conservation, washland areas, cemeteries." Both of these studies exclude certain types of green spaces including golf courses, agricultural land, and school parks or playing areas because they are not publicly accessible. My study adhered to these definitions, categorizations and guidelines when determining what constitutes an open space or green space, and what types of green spaces are relevant to measure access to. The size of the green space was taken into account as this has been shown to be a relevant factor in previous studies (Heckert 2013; Comber et al. 2008; Abercrombie et al. 2008; McConnachie 2010; Sister et al. 2010). Parks and green spaces size can be found in the Oklahoma City land use data that I used. The park and green space characteristics are available including the size in square miles;

the exact size of the green space was catalogued so that this could be a continuous variable. Distance to open space was measured from the centroid (arithmetic center point) of each relevant census block groups. All of the public parks, cemeteries, and green space areas are visible in the land use map and are visible as polygons with accessible road access points being clear on the map. This allows me to measure to the actual nearest point that a car could use to access a park in the area.

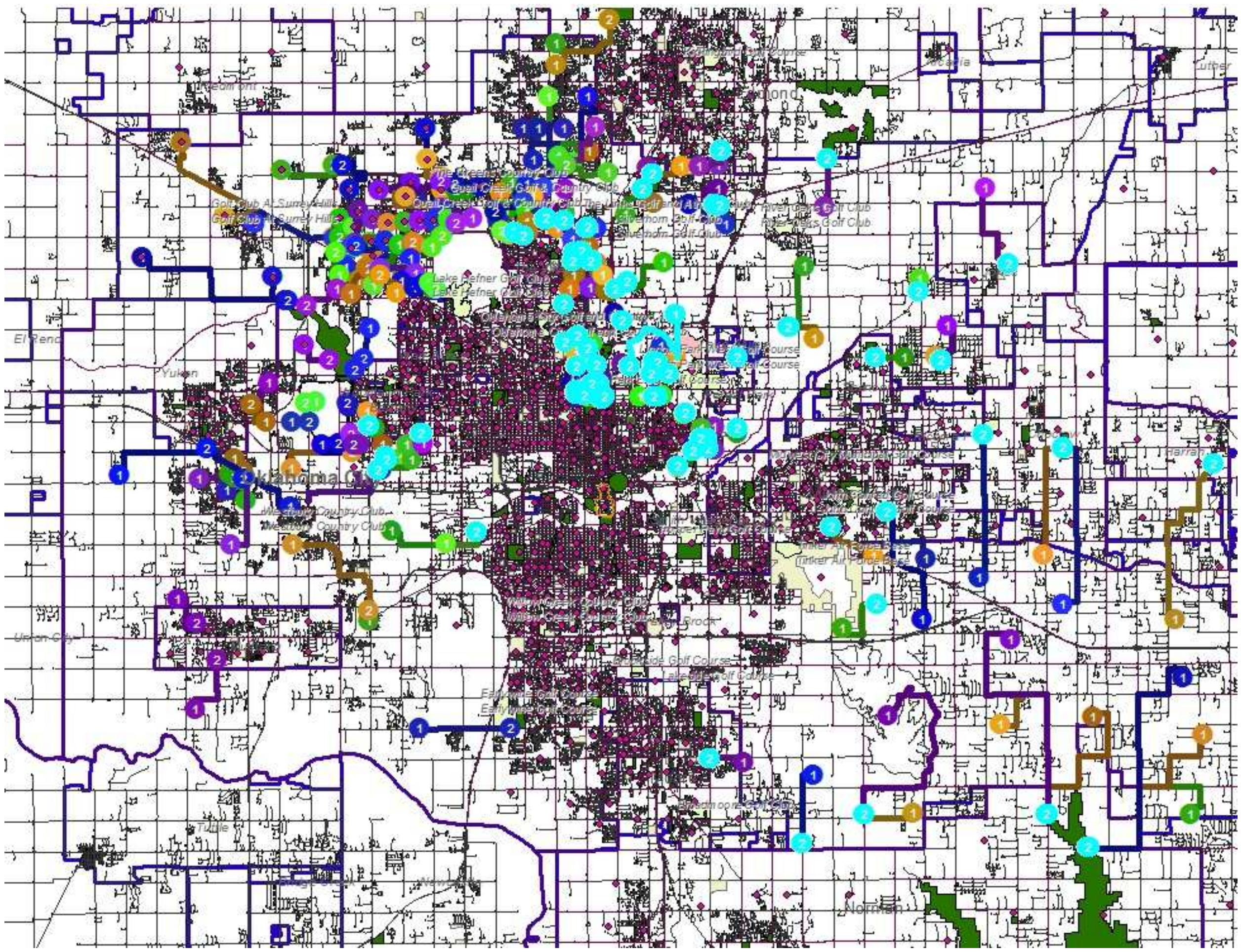

Figure 5: Network Analysis

Figure 5, shows the road network analysis. A GIS-based network analysis using Manhattan distance was be employed in order to measure not only proximity of these block groups to green spaces, but the accessibility based on physical characteristics such as roads, highways, one way streets, bridges, bodies of water, buildings, and other obstacles. Because these distances are still being measured using the centroid of each selected census block group area they are still only proxies of the distance each individual within the area would have to travel to get to the green space area; however, this limitation can be minimized because distance can be measured to the nearest street access point to each green space rather than to its centroid (Rosa 2014). Following the same steps for a network analysis as are outlined by Comber et al. (2008) this study will include a process of: digitizing the access points of the relevant green spaces, creating the output areas and their centroids from census data, calculating the distance between output centroids and access points, calculating the distance from each output area to each green space, and finally analyzing these results for access to green spaces in terms of the socio-economic and racial makeup of each output area. The first step in performing a network analysis in ArcGIS is 1) to use the street features in the map to create a network dataset. Though the street features will already be available in the existing map, this will not be enough to perform a network analysis. Creating a network dataset connects the streets into a network which allows the individual streets to recognize each other in the analysis. This can be done using the "new network dataset" wizard in ArcMap. Next I 2) used the network dataset properties dialogue box to add the desired network attributes (eg. distance, one-way roads, speed limits) and eliminate any unwanted or unnecessary attributes that have little or no impact on the route. Finally I 3) used the Network Analyst Toolbar to choose the type of network analysis to be performed which will create each network analysis layer. Also within the Network Analyst Toolbar are the "directions" function which opens the turn by turn navigation of available routes, and the "solve" function which is the final step that generates the results for the network analysis. This function gives the specific distance that would have to be traveled based on the road network from the two points selected for the network analysis. This process will be repeated for each of the 491 census block groups in the Oklahoma City proper area. For each analysis the census block group centroid and the nearest green space access point will be selected. Furthermore, the network analysis will be employed to look at access to green spaces once MAPS3 has been completed, to examine any possible differences in access or inequality once the MAPS3 core-to-shore park is complete.

Regression Model

My dependent variables are continuous; therefore, I will be using an OLS regression model to measure association between the independent and dependent variables. This method allows for hypothesis testing using continuous variables. STATA was used to run the regression analysis so that the impact of the independent variables on the dependent variable could be observed. I measured the significance of income, schooling, and minority population of a census block group on the distance to the nearest green space, and the size of the nearest green space. The unit of analysis in this project is a census block group. For the analysis all of the independent variables (percent minority, median income, and average years of schooling) were calculated based on the information from the census data. Percent minority is the percentage of individuals in the census block group who reported a race other than white. The median income variable was calculated by taking the median of the reported incomes of households in the census block groups. The census reports income in categories, so the midpoint of the category that the median case fell within was used. The variable for education is average years of schooling; this was calculated by taking the average of the highest reported years of schooling of each household. The three independent variables will be kept as continuous variables. The first dependent variable is the road based travel distance to the closest road access point of the nearest green space from the centroid of the census block group. These distances were calculated during the GIS network analysis, and are reported in miles. The second independent variable is the size of the nearest green space. The information for the size of each green space is available in the land use dataset, and is measured in square miles. Both distance to green space and size of green space were kept as continuous variables.

OLS has an assumption of no perfect multicollinearity or that no independent variable can be a perfect linear combination of the model's other independent variables; therefore, the model was tested for multicollinearity using the Variance Inflation Factor. None of the variables had a high degree of multicollinearity using the common threshold of a VIF of 4, with the highest (income) having a VIF of 2.21. OLS also requires an assumption of homoskedasticity or constant error variance, which was tested for using Whites General Heteroskedasticity Test. The obtained chi^2 value was 28.90 which was larger than the critical chi^2 value (df=9). The obtained P value was 0.0007; therefore, we reject the null hypothesis of homoskedasticity, and conclude that heteroskedasticity is a problem in the model. To correct for the problem of homoskedasticity in the model I used the Robust HC3 regression which inflates the variances and covariances to limit the influence of observations with larger variances. Using Cook's D we find that the estimates range from zero to 0.065. Generally any maximum below one suggests that none of the cases have a large degree of influence over the regression estimates. I observed the histograms and scatterplots for each of the variables in order to see if they were normally distributed. All of the independent variables were approximately normal in distribution. The dependent variables were both skewed and the sktest in STATA showed significance in skew and kurtosis; therefore, the ladder and gladder commands in STATA were used to observe the best method of correcting for these issues. The log of each of these variables was the best solution for increasing normality. The log of distance and the log of size were taken to correct for this issue. I will present the regression models using the log distance and log size variables as well as the regression models with the untransformed variables for comparison. After all of the tests were complete, a regression was run for the dependent variables.

CHAPTER IV

FINDINGS

As previously stated I used OLS regression to observe the influence of my independent variables (median income, average years of schooling, and percent of minority residents) on the dependent variables distance to the nearest green space, and size of the nearest green space. The unit of analysis for this study is the census block group; there are 490 census block groups in Oklahoma City proper, and all are included in the analysis.

Table 1:
Descriptive Statistics for Independent and Dependent Variables

Variable	Mean	SD	Min	Max	Description
Dependent					
Distance to GS	0.99	1.25	0	9.3	Road based distance to nearest green space in miles
Size of GS	0.34	2.33	0.001	21.18	Area of nearest green space in square miles
Independent					
Income	58.10	29.25	10.95	185.80	Median income of residents in census block group in thousands of dollars.
Percent Minority	35.51	22.99	0	100	Percent of non-white residents living within the census block group
Years Schooling	15.40	1.94	9.68	19.53	Average years of schooling of residents living within the census block group

Notes: Data from the 2010 US Census, N= 490.

Descriptive Statistics for Independent Variables

In Oklahoma City proper the average median income for a census block group is 58,100 dollars with a standard deviation of 29,250 dollars. In Table 1 these numbers are reported by thousands of dollars. The lowest median income for any census block group in the analysis is 10,950 while the highest median income of any census block group is 185,000. The average, average years of schooling for census block groups in Oklahoma City is 15.4 years (some college) with a standard deviation of 1.94 years. The lowest average years of schooling for a census block group is 9.68 (early high school), while the highest average years of schooling for any census block group is 19.53 (approximately master's degree or higher). The average percentage minority residents for census block groups in Oklahoma City is 35.51 percent with a standard deviation of 22.99. The census block groups range all the way from zero for the lowest percent minority a census block group has, to 100 for the highest percent minority a census block group has. These descriptive statistics show that all of the independent variables have a reasonably broad range.

Descriptive Statistics for Dependent Variables

As you can see from the maps in figures 4, 5, 6, and 7 the parks and green spaces in Oklahoma City appear to be fairly well dispersed, with small green spaces being more commonly located in the areas closer to the center of the city and more closely clustered together, and green spaces on the outskirts of the city being generally larger and more widely spread apart.

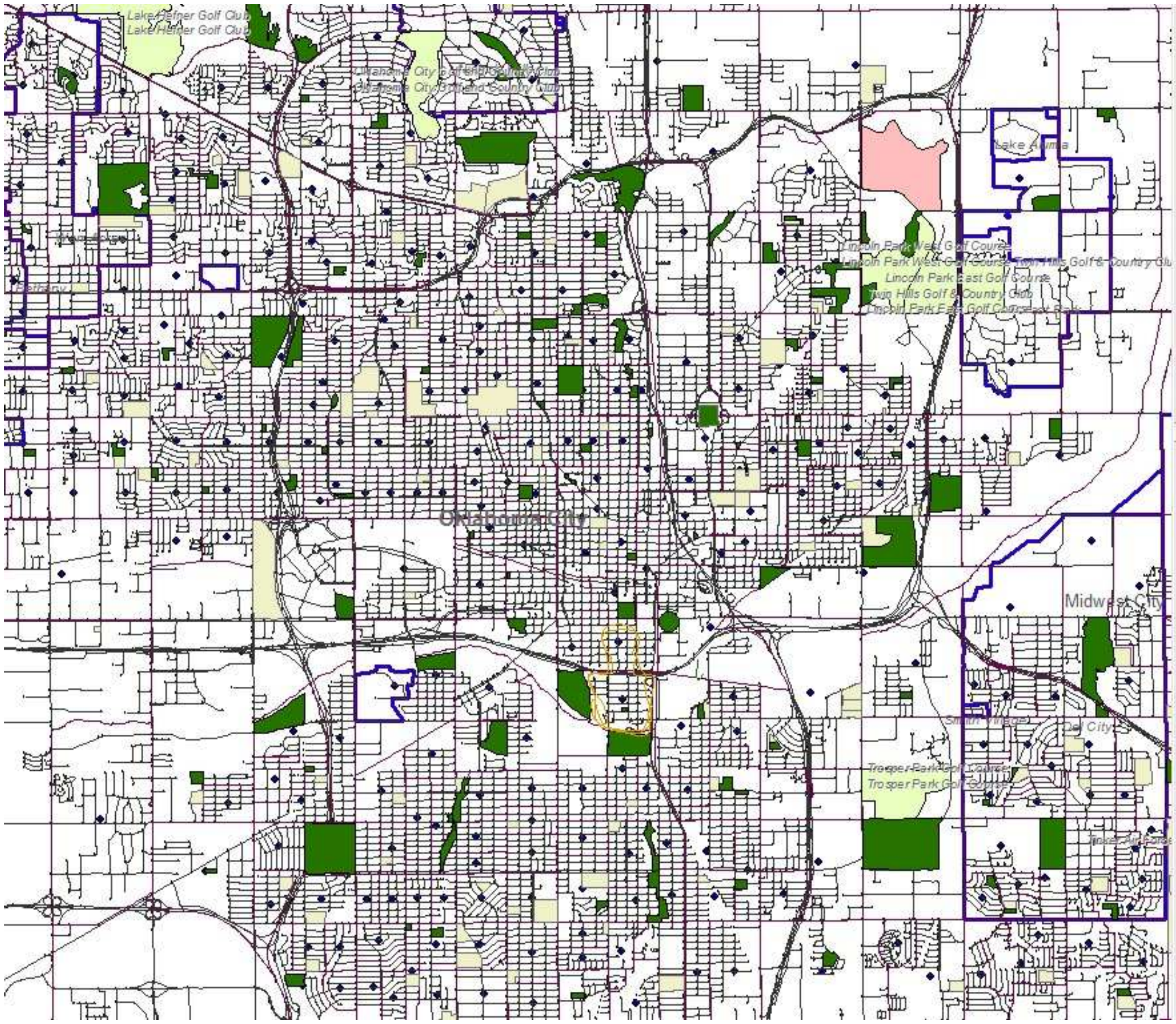

Figure 6: Smaller Green Spaces in the Inner City Area

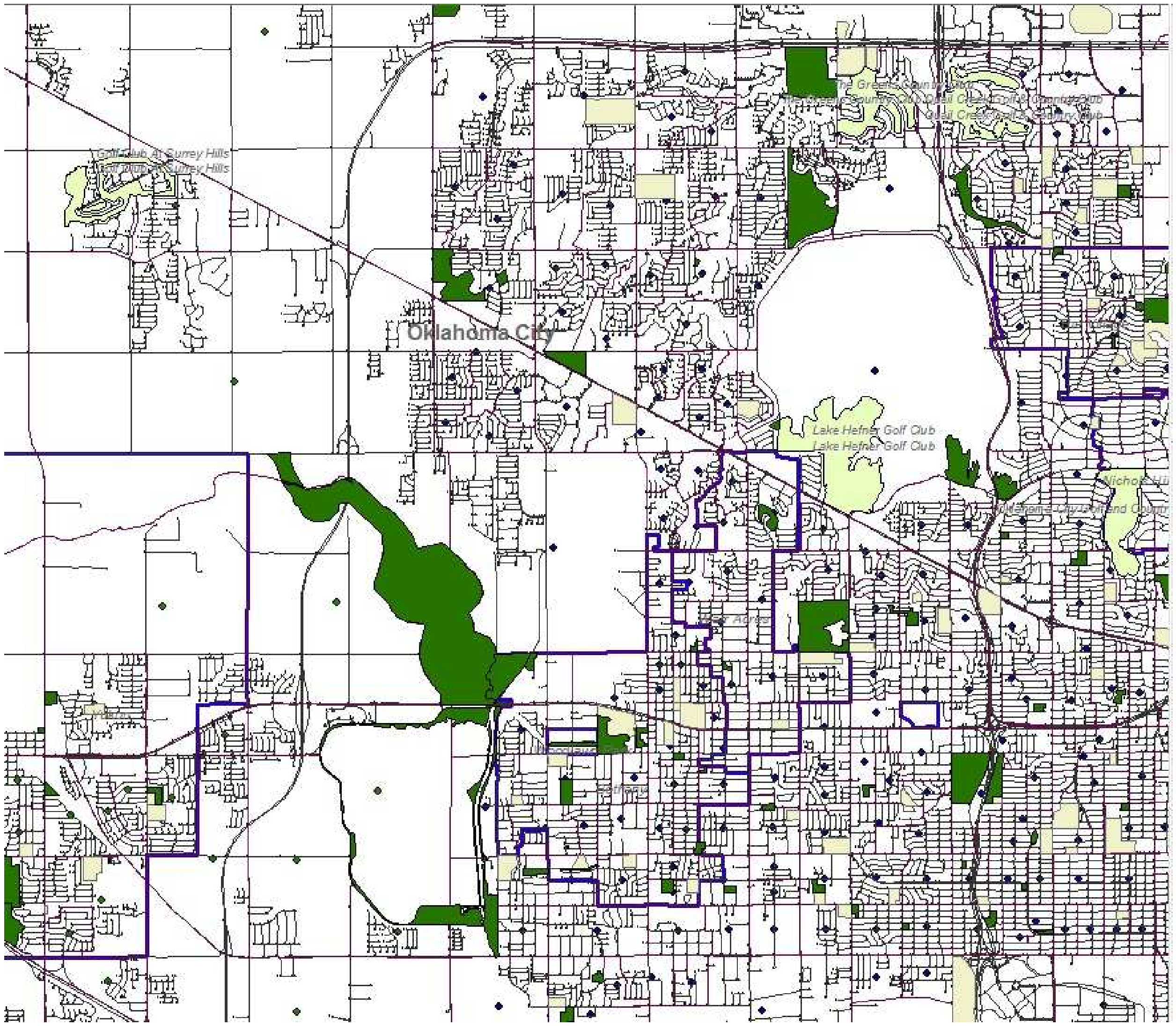

Figure 7: Green Spaces on the Outskirts of the City

In the Oklahoma City area the average distance to a green space from the centroid of a census block group was 0.99 miles with a standard deviation of 1.25 miles. As previously stated this distance is the Manhattan distance or road based access that would actually have to be traveled on roads and highways to get to a road based access point of the nearest green space. The distance that would have to be traveled from the centroid of a census block group to the nearest green space access point ranges from zero (when the centroid of a census block group actually fell within a green space) to the greatest travel distance 9.3 miles. The information for the size of each green space was available in the GIS data and is reported in square miles. The average size of a green space that the census block groups have access to is 0.34 square miles with a standard deviation of 2.33 square miles. The size of the green spaces in the analysis ranges from 0.001 square miles to 21.18 square miles. Both of the dependent variables had outliers that caused the distribution to be skewed; therefore, the log of each variable was taken and used in the regression. Two census block groups had to travel 9.3 miles to the nearest green space; however, approximately 90% of census block groups were within two miles of the nearest green space, and nearly 97% were within four. Six census block groups were nearest to the 21.18 square mile green space which was vastly larger than any of the other green spaces in the analysis. The second largest green space was 1.55 square miles, and over 97% of census block groups were near a green space that is less than 1 square mile. The numbers reported in Table 1 are for the distance to nearest green space, and size of nearest green space variables before the log was taken.

Regression for Distance to Nearest Green Space

Hypotheses 1, 3, and 5 were related to the travel distance from the centroid of the census block groups to the nearest green space access point. The network analysis allowed me to use GIS to measure the exact distance from the centroid of each census block group to the closest road access point of the nearest green space. It then automatically calculated the shortest travelable route by roads and highways and generated driving directions with the exact distance that would be traveled in miles. Using this information I was able to create OLS regression models to examine the association between median income, average years of schooling, percent minority and distance to nearest green space. Here I have the information from the model using the log distance variable to correct for skew in the distance variable, as well as the information from the model using the untransformed distance variable. The coefficients relating to hypotheses one, three, and five are located in Table 2 below.

Hypothesis 1 states that the median income of a census block group will be positively correlated with proximity to public green spaces. I did not find support for this hypothesis. In fact, the opposite appears to be true with a significant positive association between the two variables. For every thousand dollar increase in median income of the census block group, the distance to the nearest green space is expected to increase by 0.016 log miles. This interpretation is substantively meaningless because this model uses the log of the dependent variable to correct for skew in the distribution; however, what this means is that census block groups with a higher median income were actually significantly farther from the nearest green spaces than census block groups with lower median incomes. This holds true in the model using the untransformed distance variable, with census block groups with higher median income being farther from green spaces. This model shows that for every thousand dollar increase in median income of the census block group, there is an expected 0.013 mile increase in distance to the nearest green space. Though this finding is not in the expected direction based on most literature, some studies that had similar findings, and discuss various reasons that this pattern might appear (Wolch et al. 2005; Byrne et al. 2009; Jennings et al. 2012; Byrne 2012; Byrne and Wolch 2009; Dahmann et al., 2010; Leslie et al. 2010; Sister et al., 2010; Floyd et al., 1993). Possible reasons from the literature will be elaborated upon further in the discussion section.

Hypothesis 3 states that the percent minority of a census block group will be negatively correlated with the proximity to public green spaces. I did not find support for hypothesis three, and in fact the results show that the trend is in the opposite direction than what was expected. Using the log distance model, the percent of individuals that identify as a race other than white within a census block group was not significantly associated with the distance of the census block group to the nearest green space (with a P value of 0.405). This indicates that for every one percent increase in individuals identified as a racial minority in the census block group, there is a corresponding expected -0.004 log miles decrease in distance from the nearest green space. The regression model using the untransformed distance variable was significant in the opposite direction expected at the 0.001 alpha level, meaning that for every one percent increase in percent minority within the census block group, travel distance to the nearest green space is expected to decrease by 0.008 miles. Though this hypothesis was not significant using the log distance model, the direction of the results is interesting. Some studies have found similar discrepancies in what was expected and what was found when looking at minority access to green spaces (Kessel et al. 2009; Boone et al. 2009)., and there are various speculations for why this might be the case discussed in the literature (Wolch et al. 2005; byrne wolch and zhang 2009; Jennings et al. 2012; Byrne 2012; Byrne and Wolch 2009; Dahmann et al., 2010; Leslie, Cerin, & Kremer, 2010; Sister et al., 2010; Floyd *et al*., 1993).

Finally, **Hypothesis 5** states that the average education of a census block group will be positively correlated with the proximity to public green spaces. I did not find support for this hypothesis. Average years of schooling in a census block group was not significantly associated with distance to the nearest green space in either the log distance model, or the untransformed distance model. However, unlike income and percent minority, this variable was non-significant but in the expected direction. The log distance model shows that for every one year increase in average years of schooling of a census block group there is an expected 0.009 log miles decrease in distance to the nearest green space. The untransformed distance model shows that for every one year increase in average years of schooling of a census block group there is an expected 0.017 mile decrease in distance to the nearest green space. This variable was not previously considered in the literature and therefore there are no comparisons for what other researchers have found in relation to an association between years of schooling and distance to green spaces. Though I hypothesized that this variable would be significantly associated with distance to the nearest green space, the variable did at least prove to be in the expected direction.

Table 2:
Coefficients from an OLS Regression Model of Distance to Nearest Green Space

	Log Distance Model		Untransformed Distance Model	
Variable Name	**b**	**SE**	**b**	**SE**
Income	0.016***	0.004	0.013***	0.003
Percent Minority	-0.004	0.004	-0.008***	0.002
Years Schooling	-0.009	0.057	-0.017	0.025

Notes: Data from the 2010 US Census, N= 490. *p<.05, **p<.01, ***p<.001

The R^2 for the model using the log of distance is 0.081. This means that knowing the median income, percent minority, and average years of schooling of census block groups can explain about 8.1% of the variation in the log distance to green spaces. The R^2 for the model using the untransformed distance variable is 0.145, meaning that median income, percent minority, and average years of schooling of a census block group can explain about 14.5% of the variation in distance to nearest green space. Future research could include more variables that might be important in explaining more of the variation in distance to green space along with the three used in this study.

Regression for Size of Nearest Green Space

Hypotheses 2, 4, and 6 were related to the size of the nearest green space to each census block group. Based on the network analysis results for travel distance to the nearest green space of each census block group I was able to determine exactly which public green space was the closest to the census block group. Each of these public green spaces had information available for the size of the entire green space in square miles, so for each census block group the size of the nearest green space was catalogued. Using this information I was able to create an OLS regression model to examine the association between median income, average years of schooling, percent minority and size of nearest green space. This section reports information both from the regression model using the log size variable which was taken to correct for skew in the size variable, as well as the information from the regression model using the untransformed size variable.

Hypothesis 2 states that the median income of census block groups will be positively correlated with the size of the nearest public green space. I found support for hypothesis two when using the log size regression model. Using this model higher median income and larger size of nearest green space were significantly associated (with a P value of 0.001). For every thousand dollar increase in median income there is an expected 0.013 log square mile increase in size of nearest green space. However, the regression model using the untransformed size variable does not support the hypothesis.

Though this model still shows a trend in the expected direction the variables are no longer significantly associated (with a P value of 0.074). This model does however allow for a more substantive interpretation. For every thousand dollar increase in median income there is an expected 0.005 square mile increase in size of nearest green space. These findings fit with the expected trend based on previous literature looking at income and size of nearest green space (Iverson and Cook 2000; Hope et al. 2003; Kinzig et al. 2005; Dai 2011; Heynen Perkins and Roy 2006; Landry and Chakraborty 2009).

Hypothesis 4 states that the percent minority of census block groups will be negatively correlated with the size of the nearest public green space. I did not find support for this hypothesis using the log size regression model. The model shows a clear but not significant trend in the expected direction with a P value of 0.057. This model shows that for every one percent increase in percent minority population in a census block group, there is an expected 0.007 log square miles decrease in the size of the nearest green space. The model using the untransformed size variable was significant and therefore supported the hypothesis (with a P value of 0.013). This model shows that for every one percent increase in percent minority of the census block group, there is an expected 0.011 square mile decrease in the size of the nearest green space. Though only the untransformed size model showed a significant association between percent minority of the census block group and size of the nearest green space, the log size model was very close to being significant and was in the expected direction. These results tentatively provide support for the hypothesis and are similar to findings in previous literature looking at the relationship between these variables (Heynen et al. 2006; McConnachie and Shackleton 2010; Davis et al. 2012; Comber et al. 2008; Dai 2011; Landry & Chakraborty, 2009).

Hypothesis 6 states that the average education of census block groups will be positively correlated with the size of the nearest public green space. I did not find support for this hypothesis, and in fact the models show a trend in the opposite direction than was expected. The log size model was not close to significant with a P value of 0.594. This model showed that for every one year increase in average years of schooling of the census block group, there is an expected 0.027 log square mile decrease in size of the nearest green space. The model using the untransformed size variable was close to being significant (with a P value of 0.054) and therefore showed a trend in the opposite direction expected. This model showed that for every one year increase in average years of schooling in the census block group, there was an expected 0.06 square mile decrease in the size of the nearest green space. Though neither of these models showed a significant association between average years of schooling of the census block group and size of the nearest green space, the untransformed size model showed a trend in the opposite direction expected. This is of interest, especially because years of schooling has henceforth not been looked at in relation to green spaces, and these findings might indicate a need for further research to understand any association between the two.

Table 3:
Coefficients from an OLS Regression Model of Size of Nearest Green Space

	Log Size Model		Untransformed Size Model	
Variable Name	**b**	**SE**	**b**	**SE**
Income	0.013***	0.004	0.005	0.003
Percent Minority	-0.007	0.004	-0.011*	0.004
Years Schooling	-0.027	0.051	-0.055	0.029

Notes: Data from the 2010 US Census, N= 490. *p<.05, **p<.01, ***p<.001

The R^2 for the model using the log of size variable is 0.065. This means that taking into account the median income, percent minority, and average years of schooling of census block groups we can explain approximately 6.5% of the variation in the log size of nearest green space. The model using the untransformed green space size variable has an R^2 is 0.017, meaning that median income, percent minority, and average years of schooling explain about 1.7% of the variation in size of nearest green space.

Summary

I did not find support for any of the hypotheses examining differences in census block group distance to the nearest green space. These models used log distance and untransformed distance to test hypotheses one, three and five. While I did not find significant support for my hypotheses in the expected direction, the results of these models were interesting because of the direction of the findings. Both median income of the census block group and percent minority of the census block group were significant in the opposite direction expected. This means that on average higher income census block groups were farther from green spaces than those with a lower median income, and higher percent minority census block groups were closer to green spaces than those with a lower percent minority. Some other studies have found similar patterns in cities, but most have not. Other researchers have discussed reasons that their results might have shown significance in the opposite direction expected, and I will elaborate on this further in the discussion section.

I did find support for two of the hypotheses looking at inequality in proximity to larger green spaces. The two models for these hypotheses, two, four, and six, used log size and untransformed size respectively. Using these two models I found support for hypothesis two and hypothesis four. I found support for hypothesis two in the log size model. Income showed significance in the expected direction with the nearest green space to census block groups with higher median income being, on average, larger than the nearest green space to census block groups with lower median income. Based on previous related literature, this was the expected relationship between income and nearest green space size. I also found support for hypothesis four in the untransformed size model. The percent of reported minority members in the census block group was found to be negatively associated with size of the nearest green space. On average census block groups with a higher percent minority had smaller green spaces nearest to them than census block groups with lower percent minority. This was expected based on previous literature looking at similar trends. As previously stated, these findings are interesting because in terms of distance to green space both of these variables were found to be significant in the opposite direction expected, while in terms of nearest green space size, both of these variables were significant in the expected direction. Further analysis of the Oklahoma City area and the types of smaller green spaces that are located nearer to lower income and higher percent minority census block groups could shed light on the nature of these inequalities. Literature and studies on vacant lots and brown fields have found that poorly maintained and unkempt green spaces can sometimes have the opposite health, safety, and community support effects than well kept and landscaped green spaces (Nemeth and Langhorst 2014; McPhearson et al. 2013; Garvin et al. 2012). A qualitative field analysis of the types and quality of the green spaces and parks in this study would be able to shed more light on the quantitative findings of this study.

Regression Models Including MAPS 3 Changes

Hypothesis 7 states that the completion of the MAPS 3 project will decrease inequality in access to green spaces. In order to test this hypothesis, I ran a second network analysis for all of the census block groups that would be closest to the MAPS 3 Central park area instead of the park that they were currently closest to. I then changed the size of the closest park for these census block group to the projected size of the MAPS 3 Central Park. The regression models for log distance and distance to nearest green space, and log size and size of nearest green space were run again with the six altered cases to see if any of the variables would change in significance. None of the R^2 values changed for any of the models.

The significance of income did not change at all in either the log distance or the untransformed distance model. Income remained significant at the 0.001 alpha level in the opposite direction expected in both models. Meaning that higher median income for a census block group remained significantly associated with the census block group being farther from the nearest green space. The significance of percent minority of a census block group on distance from nearest green space also remained the same in the two models. In the log distance model, percent minority was still not found to be significant. In the untransformed distance model, percent minority was still significant at the 0.001 alpha level. This was still in the opposite direction expected, with a higher percent of individuals indentifying as minority in the census block group being associated with a shorter distance to the nearest green space. Finally, the significance of average years of schooling did not change at all, with years of schooling showing no significance in either the log distance model or in the untransformed distance model.

Table 4:
Coefficients from an OLS Regression Model of Distance to Nearest Green Space

	Log Distance Model		Untransformed Distance Model	
Variable Name	**b**	**SE**	**b**	**SE**
Income	0.017***	0.004	0.013***	0.003
Percent Minority	-0.003	0.005	-0.007***	0.002
Years Schooling	-0.000	0.058	-0.016	0.025

Notes: Data from the 2010 US Census, N= 490. *p<.05, **p<.01, ***p<.001

In the models using log size and untransformed size with the new MAPS 3 changes, one of the variables showed a change in significance in one of the models. Income remained significant at the 0.001 alpha level in the expected direction in the log size model with higher income being associated with being nearest to larger green spaces. The untransformed model also remained the same with income not showing significance at all. Percent minority showed a change in significance in the log size model. Before the MAPS 3 data was added to the model, percent minority only showed significance in the expected direction in the untransformed size model with census block groups with a higher percentage minority being associated with having nearest access to smaller green spaces. After the MAPS 3 data was added to the model, the percent minority variable showed significance at the 0.05 alpha level in the log size model as well. This could indicate that the addition of the MAPS 3 Central Park actually increased inequality in terms of percent minority access to larger green spaces. Finally, average years of schooling remained insignificant in both the log size model and untransformed size model after the MAPS 3 data was added. In the untransformed size model years of schooling was still nearly significant (with a P value of 0.054) in the opposite direction than was expected.

Table 5:
Coefficients from an OLS Regression Model of Size of Nearest Green Space

	Log Size Model		Untransformed Size Model	
Variable Name	**b**	**SE**	**b**	**SE**
Income	0.013***	0.004	0.005	0.003
Percent Minority	-0.008*	0.004	-0.011*	0.004
Years Schooling	-0.034	0.051	-0.055	0.029

Notes: Data from the 2010 US Census, N= 490. *p<.05, **p<.01, ***p<.001

This portion of my thesis was a comparison between the first set of models that included the actual and current park and green space access of all census block groups, and the second set of models which ran the same analysis but included the future MAPS 3 Central Park. The results of this comparison indicate that there will be very little difference in access to green spaces once the MAPS 3 Central Park is in place, and does not find support for hypothesis seven which states that inequality will decrease when MAPS 3 is complete. The models looking at distance to green spaces showed no notable changes at all after the MAPS 3 Park was included. In the models looking at size of nearest green space, only percent minority changed slightly in significance. Census block group percent minority showed significance in one of the models that did not show significance before the MAPS 3 Park was added. This indicates that inequality in size of nearest green space actually increased in terms of percent minority of census block groups. Overall the MAPS 3 Park changes do not significantly reduce the inequalities that were present. While the increases in green space that the MAPS projects have been vast and are steps in the right direction for the city, future ideas regarding how to increase overall access to green spaces, to larger green spaces, and to higher quality green spaces should be considered.

Table 6:
Overview of Findings

Hypothesis	Log Model	Untransformed
<u>Hypothesis 1</u>: The median income of census block groups will be positively correlated with proximity to public green spaces.	No: Significant in opposite direction	No: Significant in opposite direction
<u>Hypothesis 2</u>: The median income of census block groups will be positively correlated with the size of the nearest public green space.	Yes: Found support	No: No significance
<u>Hypothesis 3</u>: The percent minority of census block groups will be negatively correlated with proximity to public green spaces.	No: No significance	No: Significant in opposite direction
<u>Hypothesis 4</u>: The percent minority of census block groups will be negatively correlated with the size of the nearest public green space.	No: No significance	Yes: Found Support
<u>Hypothesis 5</u>: The average education of census block groups will be positively correlated with proximity to public green spaces.	No: No significance	No: No significance
<u>Hypothesis 6</u>: The average education of census block groups will be positively correlated with the size of the nearest public green space.	No: No significance	No: No significance
<u>Hypothesis 7</u>: The completion of the MAPS3 project will decrease inequality in access to green spaces in terms of income, race, and education	No: Limited change	No: No change

CHAPTER V

CONCLUSION

Discussion

My findings for distance to the nearest green space were not in the expected direction based on what has been found in the majority of literature; however, some other studies have found similar patterns of access, and have discussed why this might be the case in certain areas. Kessel et al. (2009) used Euclidean distance to green spaces to measure access; their study found that more deprived and less healthy areas had closer access to green spaces. Direct distance to green space is not the only important factor in determining actual use and benefits of the green space. Other factors such as the size, upkeep, attractiveness, and perceived safety of the green space can be very important in determining whether individuals actually use the green spaces that they are near (Kessel et al. 2009). For example, African American and other high needs communities were found to be located closer to parks in Baltimore Maryland than white neighborhoods and communities (Boone et al. 2009). However, like in my study, these African American and more deprived neighborhoods were also found to have nearby access to less park acreage overall. Boone et al. analyzed the history of Baltimore parks and found that though African American neighborhoods were now more likely to have close access to these parks, they were originally created in white neighborhoods, and following white flight out to the suburbs, the neighborhoods with parks became more dominated by poorer and minority group members (Boone et al. 2009). It is possible that the park access in Oklahoma City has occurred because of similar patterns of suburban sprawl of wealthier and white individuals. Even when the number and size of parks are accounted for, parks in higher income areas have been found to have greater biodiversity than those located in lower income areas (Kinzig et al 2005). This contributes to the quality of the parks, and could indicate a discrepancy in upkeep between parks in lower income and higher income areas. Furthermore, parks located in lower income and minority neighborhoods have been found to be more congested than those in higher income and white neighborhoods (Sister et al. 2010). As was discussed previously in my literature review on green spaces this decreases the ability of the park to provide benefits to the community in which it is located. While this was not measured in my study, further research could look at the biodiversity in parks in the Oklahoma City area to see if this pattern is maintained. Researchers could look at green space usage alongside green space access for a more comprehensive understanding of the benefits that green spaces provide.

When measuring access or distance to green spaces in a different way than used in this paper, studies have been more likely to find that higher income areas are closer to trees and green cover (Iverson and Cook 2000). Some studies measure green space access not by exclusively looking publicly accessible green spaces but instead by comparing tree coverage in different spaces or by looking at impervious versus natural grass and plant cover (Iverson and Cook 2000). Access to green space is likely to be very different when measured in this way. The large number of private lawns and gardens that would be included in the analysis would exist predominantly in higher income suburban neighborhoods. In this analysis I chose not to measure green spaces in this way because these private lawns and gardens cannot be accessed by all. Community parks and green spaces provide places of recreation and community cohesion that private green spaces cannot.

My study showed that lower income and higher percent minority census block groups were generally located closer to public green spaces than higher income and lower percent minority census block groups. However, lower income and higher percent minority census block groups were significantly more likely to be located nearest to smaller green spaces than higher income and lower percent minority census block groups. Because of the small size of the green spaces that these census blocks are located near, it is possible that they are less beneficial as places for exercise, relaxation, and community gathering than larger green spaces would be, and that individuals living near them are less likely to utilize the green spaces that they have access to. Though this study did not look at the upkeep and quality of the green spaces that were analyzed, future research could consider these characteristics for a more nuanced interpretation of access to green space. It is possible that though the lower income and higher percent minority census block groups were located nearer to green spaces than their higher income and lower percent minority counterparts, the green spaces that they have access to might be of much lower quality, more dangerous, less well kept, and less pleasant to use. This could indicate that the inequality in access to green space is not as simple as being near a green space, but that the type and quality of the green space could be equally if not more important.

Furthermore, the addition of the MAPS 3 park was a drastic change to one section of the city which is largely surrounded by businesses and recreation. This did not prove to change access to green spaces for those who are less privileged. Additional work on smaller green spaces spread throughout other portions of the city, such as the remediation and transformation of brownfields and vacant lots would likely be beneficial to more people and neighborhoods. Furthermore, if increases in access to public transportation were to coincide with the MAPS 3 green space projects the access to overall green spaces would likely increase as well. In this way Oklahoma City provides an interesting case for study. The city is spending money and time working to increase the city's overall green spaces, parks, and outdoor recreation opportunities, but the manner in which these changes are being implemented might not be the most beneficial for all residents. Examining the current green space access in the city and the changes in access that will take place after the completion of the MAPS3 project will provide a unique comparison in a growing city.

Limitations

Due to the nature of this research there are various limitations which prove to be unavoidable. For this project, I am reliant on secondary data. Census data is useful and fairly comprehensive; however, the groupings of individuals within census datasets can only be as small as census blocks which are more likely to be homogenous in terms of the racial and socio-economic characteristics than larger groupings. While these are smallest grouping possible using this as the unit of analysis would be impractical due to their small size and large number within the city. No matter the unit of analysis it would be impossible for the data to always have the most useful groupings for any given study. Though the most accurate way to measure the access and proximity to green spaces of different groups would be to measure from each individual house or apartment, it would be impossible to conduct. Furthermore, the vector-based network analysis using Manhattan distance is more accurate than some more simplistic forms of network analysis in GIS; however, it still requires that the researcher measure the distance from the centroid of the census block group which will not be able to show the actual distance each individual household would have to travel to get to get to the green spaces. This study looks simply at the access by road to green spaces within the city and does not take into account which households have cars, making access to the green spaces easier, or what roads have sidewalks available for individuals who do not have vehicles. This research is also unable to look at all of the public transportation options available in certain areas which would affect the ease of access to green spaces. Furthermore, this study looks at all green spaces equally. Though private green spaces are not considered in this study, the type of public green space is not taken into account, and these differences are not discussed in their potential for having different benefits for the residents who have access to them. Overall, these limitations are common, and do not detract from the contributions that the research will provide to the field. Because little work has been done regarding these types of environmental justice issues, the proper methods and analysis for studies in this field are still being parsed out, and this paper will contribute to the overall trend in research building on problems of inequality in access and proximity to green space.

The most notable limitation and issue with this research is the use of the census block group as the unit of analysis. Because the census block groups are created to be as demographically homogenous as possible, with approximately the same number of people in each one, they are useful for the comparison of different groups of people. However, when using census block groups as the unit of analysis for a spatial comparison of groups this breakdown posed somewhat of a problem. The census block groups toward the outskirts of the city were much spatially larger than the census block groups in the more populated inner city area. This is in order to make the census block groups approximately the same in terms of population. Because of the size difference the comparison of travel distance from the center of the census block group to the nearest green space was inherently biased. Larger census block groups near the outside of the city area were mostly higher income and white dominated areas. The larger size and fewer number of these census block groups biased the travel distance from the centroid to be farther from green spaces. In future work this issue could be addressed by pulling out a sample of census blocks, neighborhoods, or another smaller unit of analysis, and running a network analysis for these smaller areas distance to green spaces to determine if the same results would be found. This comparison would help to eliminate any bias present due to the size issue of the census block groups.

Contributions

This research provides important contributions to the current research in the areas of environmental justice and urban geography. Only a few studies have been conducted that use a

GIS-based network analysis method to study disparities between groups in terms of access to green spaces, parks, and nature in urban areas. Most studies in this field of research have used less specific methods of GIS analysis than a vector based network analysis. Furthermore, only a few environmental justice scholars in sociology have adopted the use of GIS; and most studies using a network analysis to examine access to green spaces were done in geography. More sociological studies using GIS methods will help to expand our understanding of access, as well as normalize the use of GIS. Environmental justice research with a focus on access to environmental goods rather than proximity to environmental bads is still in a relatively early stage, and more research needs to be done to expand on these inequalities and how they affect the groups that face them. The importance of having access to green spaces and nature has been highlighted in many studies discussed above; and in an increasingly urbanized world, the need for urban green spaces is quickly becoming more noticeable and important. The inequalities that are beginning to emerge in the research need to be further explored so that city planners and lawmakers, academics, and others can work to more effectively alleviate any inequalities that emerge. The significant changes being made to the downtown Oklahoma City area to the Myriad Gardens and Oklahoma River allow me to examine the change in access that will actually occur through the planned changes being funded through Oklahoma City tax revenue. No research of this kind has been done in Oklahoma City, nor in a Midwestern city of a similar size; therefore, this research will be contributing new information to the field regarding whether or not the pattern of inequalities that has previously been found is replicated in a city of this kind. This paper also brings in the importance of green spaces and nature in terms of their contribution to resilience and human security in an urban area. This theoretical discussion based on previous research and literature links green spaces in urban areas to literature regarding what makes a resilient system. This connection is significant and has not been frequently discussed in the research. The inclusion of access to green spaces and public parks as an important piece of urban resilience could help to change the way that cities are built and developed.

Future Directions

Initially this thesis project was going to include a second network analysis which observed the distance of each census block group to the nearest green space OR vacant lot or brownfield. This second network analysis would have allowed for a comparison between the current trends in access to green spaces in Oklahoma City and the access to green spaces that would be possible if vacant lots and brownfields were transformed into parks, gardens, or other green spaces. Unfortunately, through the process of the project I found that running this second network analysis would be implausible for two reasons. The data provided by the Oklahoma City GIS department was supposed to have included the current vacant lots in Oklahoma City; however the definition of these areas was not descript enough. The vacant lots were unable to be separated from empty or unused buildings and other "undefined" spaces. Furthermore, running the network analysis for the first part of the project was very time consuming. Being unfamiliar with GIS methods at the start of the project, I did not correctly anticipate the timeframe for completing a second network analysis. However, based on the literature I reviewed during the proposal stage of the project, I still believe that future projects should further this research with an emphasis on the greening of vacant lots. Though these green spaces would be small, most cities have many vacant spaces usually located in lower income and minority neighborhoods, and the greening of these lots would provide greater access to citizens in poorer neighborhoods.

Due to changes in the built environment over time, urban areas are often plagued with numerous abandoned buildings and vacant lots. These vacant lots are commonly overgrown and sometimes polluted areas which, due to their lack of upkeep, do not provide the same benefits to residents as green spaces such as parks (Nemeth and Langhorst 2014; McPhearson et al. 2013) and even lead residents to report these lots having negative effects on community well-being and physical and mental health (Garvin et al. 2012). However, vacant lots and even brownfields have the potential to be transformed or remediated into beneficial green spaces. Abandoned and vacant lots in urban areas frequently contain soil pollution from the land's previous use, runoff from roads, and pollution from nearby industries; when these sites are plagued by pollution they can be categorized by the government as brownfield sites which can receive government funding for cleanup and revitalization. Brownfields are defined in the "Brownfields Revitalization and Environmental Restoration Act of 2001" as "a parcel of real property at which expansion, redevelopment, or reuse may be hindered by the presence, or potential presence, of hazardous substances, pollutants, or contaminants" (Committee on Environment and Public Works 2001). This definition is similar to the one put forth by the EPA which considers brownfields to be "a property, the expansion, redevelopment, or reuse of which may be complicated by the presence or potential presence of a hazardous substance, pollutant, or contaminant" (EPA).

Regardless of the definition used, brownfields pose environmental and physical health risks to residents, but with revitalization and renovation have the potential to be transformed into green spaces that provide benefits rather than harm to communities (Committee on Environment and Public Works 2001). There have been many studies which have examined the spread and influence of both brownfields and other less polluted vacant lots. Nassauer and Raskin (2014) have looked at what spatial and temporal characteristics affect urban socio-ecological systems, how past land use and vacancy affect the systems, and what aspects of human well-being and environment should be considered for the management of vacant urban lands. These locations, while often being overtaken by plants and foliage, are not a part of what would have been considered the natural ecosystem in the area. They find that often times these vacant re-appropriated green spaces are unusable for food gardens or recreation areas without remediation because of the pollution and trash that are left behind (Nassauer and Raskin 2014).

Vacant lots and brown fields are generally representative of a deteriorating tax revenue and the loss of business and industry opportunity in the area of the city in which they are located. This means that the health and safety issues related to proximity to brown fields and vacant lots disproportionately affect low-income and minority neighborhoods as the areas of the city most likely to be deteriorating (Garvin et al. 2012; Dillon 2014; Eckerd and Keeler 2012). Because brownfields and vacant or abandoned lots are located most frequently in poor and minority neighborhoods, the transformation and remediation of these sites into positive green spaces would have the potential to change the distribution of green space access across the city. In terms of vacant lots that are not too polluted for a community or local government to easily revitalize, research has been done which supports the idea that the greening of vacant lots can have an impact on the health and safety of a community. The "greening" of vacant lots includes removing trash and clutter, planting trees and other foliage, mowing grass, installing low fences, and generally maintaining the upkeep of the area (Branas et al. 2011). The health and safety effects can be seen through a reduction in crime, and an increase in reported health benefits such as lower levels of stress and increased exercise in communities where vacant lots were replaced with green spaces (Branas et al. 2011). Other researchers have done studies attempting to discern the amount of food which could be produced for a city if vacant spaces were to be re-appropriated as urban gardens. Using GIS and aerial photography, McClintock et al. (2013) observed the spread and amount of both public and private vacant land in Oakland, California and calculated the benefits that turning these areas into urban agricultural spots could provide the city (McClintock et al. 2013). Some research has even been done into the impact that the "greening" of vacant land has on overall access to green spaces, as well as the potential that this process could have to decrease the inequalities currently present in proximity and access to green spaces. Heckert (2013) looked at these two issues specifically in Philadelphia and found that the greening of vacant spaces in the city would significantly increase the number of residents who lived within walking distance of a green space and would decrease the inequality present in access to green spaces (Heckert 2013).

Future work should specifically observe the changes that could occur if vacant lots and brownfields in Oklahoma City were transformed into green spaces. Furthermore, future work in general relating to green spaces and environmental justice should include more focus on the impact that the greening of vacant lots and brownfields could have. Not only would this increase access of green spaces for poor and minority neighborhoods, but would actually transform areas that are currently perceived of as negative and even dangerous, into spaces of health, exercise, relaxation, and community cohesion.

Conclusion

The benefits of having access to green spaces, parks, community gardens, and nature are becoming more and more obvious and supported through studies in various fields. As the world becomes increasingly urbanized, providing adequate access to natural green spaces for those living in cities becomes both more difficult and more important. The literature shows that having access to green spaces and "natural" areas can be beneficial at many levels. Green spaces provide ecosystem services and physical environmental benefits in urban areas. They provide areas for exercise and have shown to be associated with health benefits. They provide places of relaxation, and even the visibility of nearby green spaces seems to provide stress relief for adults and children, and benefit the overall mental health of those living nearby. Finally, green spaces have benefits for community cohesion as they are places for gathering, socializing, and meeting new people in the community. All of these benefits provided by green spaces contribute to the overall resilience of the urban system and the human security of the individuals living within it. Because of these benefits, some researchers have become interested in the ways green spaces are distributed in cities and who has more access to their benefits. This has become a small but growing branch of environmental justice literature which focuses on the inequalities in access to environmental benefits. Many studies have found that green spaces and other environmental benefits are distributed unequally in cities with lower income and minority neighborhoods often being farther from green spaces and having access to less natural space, tree cover, and biodiversity. Oklahoma City is a growing and changing city, with an internationally recognized enhancement in green space in recent years (NewsOK.com 2015). Oklahoma City provided an interesting location to study because of the notable changes being made to specific parks in the city. I was therefore able to examine inequalities currently present in access to green spaces throughout the city and the changes that will occur in access after the MAPS 3 Central Park is complete.

Previous literature has found inequalities in distance to nearby parks, size of nearby parks, area of nearby green space and tree cover, and amount of biodiversity, however these studies have measured green space access in a wide variety of ways. I chose to use ArcGIS network analysis to measure distance to green spaces in Oklahoma City because this method allowed me to measure the actual travel distance by road to green spaces rather than the Euclidian distance or "crow flies" distance which does not usually measure the actual distance a person might have to travel. Using GIS I was able to calculate the centroids of each census block group and measure from the centroid to the nearest street access point of the nearest green space to approximate the travel distance that an resident of the census block group might have to travel to get to a park. GIS is not yet commonly used in sociology, and therefore, this study helps to bring network analysis into a more prominent place in the field. GIS methodologies have many potential benefits for sociological studies, including the benefits for studies relating to environmental justice and access to environmental goods and green spaces.

Based on the literature previously discussed, I ran several OLS regression models looking at the influence of median income, percent minority, and average years of schooling of the census block groups on two dependent variables: distance to nearest green space, and size of nearest green space. In terms of distance to nearest green space, my findings were not in the expected direction based on previous literature. My study found that in Oklahoma City, census block groups with higher median income, and lower percent minority were actually located farther from the nearest green space than were census block groups with lower median income and higher percent minority. In terms of size of nearest green space however, these variables were both found to be significant in the expected direction. Census block groups with higher median income and lower percent minority were located nearest to larger green spaces than lower median income and higher percent minority census block groups. Some other studies have found similar patterns, and discussed possible reasons. In some cases green spaces were created when neighborhoods were dominated by white and higher income individuals, and after moving to suburbs became lower income housing. These parks are often poorly maintained and therefore less frequently used and therefore less beneficial than parks that are larger, yet slightly farther away located farther outside of the city nearer to white and higher income neighborhoods. Further research looking at quality of parks and use of parks could help to determine if there are more nuanced inequalities in terms of green space access than just distance to nearest green space. Access to green spaces did not change significantly with the addition of the MAPS 3 Central Park. Further research could look into the possible changes in access that could occur with the transformation of vacant lots and brownfields that often plague cities. These are spaces that are usually found to be detrimental to neighborhoods and perceived as dangerous; if they were transformed to be well maintained green spaces, the low income and minority neighborhoods that these lots are most commonly located in would likely benefit. The importance of green spaces is becoming more commonly accepted and this research helps to bring to light some of the inequalities and issues that are associated with green space availability in Oklahoma City.

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VITA

Daisha Lee Delano

Candidate for the Degree of

Master of Science

Thesis: GREEN SPACE DISTRIBUTION AND ENVIRONMENTAL JUSTICE IN OKLAHOMA CITY

Major Field: Sociology

Biographical:

Education:

Completed the requirements for the Master of Science in sociology at Oklahoma State University, Stillwater, Oklahoma in July, 2015.

Completed the requirements for the Bachelor of Arts in sociology at Oklahoma State University, Stillwater, Oklahoma in May 2013.

Experience:

EPSCoR OSU
Research assistant on EPSCoR OSU National Science Foundation Grant

ADVANCE OSU
Evaluation Research Assistant on the OSU ADVANCE grant.

The Khmer Rouge: Ritual, Control, and Genocide
Independent undergraduate research study

2014 Delano, Daisha and David Knottnerus. "Deritualization and Reritualization under the Khmer Rouge." Presented at the annual meeting of the Southwestern Social Science Association, San Antonio, Texas.

2012 Delano, Daisha and David Knottnerus. "The Khmer Rouge: Ritual, Control and Genocide." Presented at the annual meeting of the Mid-South Sociological Association, Mobile, Alabama.

Professional Memberships:

Member of Phi Kappa Phi National Honor Society (2012)
Member of AKD National Sociology Honor Society (2011 to present)