July 2016

What are the Physical Health Benefits of Urban Tree Canopy in the Springfield, Massachusetts Neighborhoods?

Robert A. Hummel
University of Massachusetts Amherst

WHAT ARE THE PHYSICAL HEALTH BENEFITS OF URBAN TREE CANOPY IN THE SPRINGFIELD, MASSACHUSETTS NEIGHBORHOODS?

A Thesis Presented

by

ROBERT HUMMEL

Submitted to the Graduate School of the
University of Massachusetts Amherst in partial fulfillment
of the requirements for the degree of

MASTER OF REGIONAL PLANNING

MAY 2016

Department of Landscape Architecture and Regional Planning

WHAT ARE THE PHYSICAL HEALTH BENEFITS OF URBAN TREE CANOPY IN SPRINGFIELD, MASSACHUSETTS NEIGHBORHOODS?

A Thesis Presented

By

ROBERT HUMMEL

Approved as to style and content by:

_____
Robert Ryan, Chair

_____
Flavia Montenegro-Menezes, Member

_____
David Bloniarz, Member

_____
Elisabeth Hamin, Department Head
Landscape Architecture and
Regional Planning

ACKNOWLEDGEMENTS

I would like to thank my advisor, Dr. Ryan, for his support and guidance in my research and analysis of the data. Thanks to Dr. Montenegro-Menezes for her support on my methodology and the data collection component of my thesis. I would also like to extend my gratitude to my third member of my committee, Dr. Bloniarz for his helpful comments and suggestions on the different stages of my thesis. I want to thank Dr. Carr and Dr. Ramsey-Musolf for their help in the research process and final formatting help.

I also wanted to thank the City of Springfield's Planning Office, Springfield's Forestry Division, and Pioneer Valley Planning Commission for their help with providing me with the necessary data resources and GIS layers that have helped me throughout my thesis. A final thank you to LiveWell Springfield, Mass in Motion, and ReGreen Springfield for their ongoing support on health resources. I appreciate the work and research that they have done for the City of Springfield.

A special thank you to all those whose support and friendship have helped me to stay focused on writing this thesis and those who have provided me with the encouragement to continue when it got harder.

ABSTRACT

WHAT ARE THE PHYSICAL HEALTH BENEFITS OF URBAN TREE CANOPY IN SPRINGFIELD, MASSACHUSETTS NEIGHBORHOODS?

MAY 2016

ROBERT HUMMEL, B.S., WESTFIELD STATE UNIVERSITY

M.R.P., UNIVERSITY OF MASSACHUSETTS AMHERST

Directed by: Dr. Robert Ryan

This thesis explores the relationship between urban tree canopy and physical health measures between different Springfield, Massachusetts neighborhoods. The study hypothesis was that there would be a correlation between urban tree canopy and human health. Statistical analysis was used to examine the correlation between available health data and urban trees. The existing neighborhood health data that was available comprised of asthma rate, infant mortality, and low birth weight. It also examined other data such as median household income, demographic percentages, home ownership, and green space. The research questions guiding this study were: Are there any correlations between urban trees canopy and the asthma rates, infant mortality rates, and low birth weight in Springfield neighborhoods? Do local residents have equal access to resources such as urban tree canopy and green space? Previous research reviewed in the literature shows that urban tree canopy provides social, environmental, physical benefits to their surroundings and to the residents of urban neighborhoods, such as those in Springfield.

The literature review also discussed some challenges with regard to unequal access to urban trees in other cities, such as Boston that show environmental justice issue may be an influence. The current study used data on health, demographic, and urban tree canopy data that was primarily collected by the Pioneer Valley Planning Commission, the US Forest Service and ReGreen Springfield. The major findings showed correlations between urban tree canopy and median household income, low birth weight, and demographics percentages. Those correlations indicated that there are signs of environmental justice issues in the City of Springfield. This correlation results verifies prior that was reviewed in the literature. One recommendation to offset the issues of environmental justice would be to invest in organization such as ReGreen Springfield and other organizations that promote planting trees by neighborhood groups.

TABLE OF CONTENTS

Page

LIST OF TABLES

Table Page

LIST OF MAPS

Maps Page

CHAPTER I

INTRODUCTION

This research thesis looks at the connections between urban tree canopy and human health factors in Springfield, Massachusetts neighborhoods. This thesis also examines the use of green infrastructure and how it has been used to improve human health. The thesis focuses on the effect of urban tree canopy on the physical health impacts in these neighborhoods. The Literature Review also discusses the collective information about the public health systems that are in place in this country, including their strengths and weaknesses. This information helped to connect the positive and any negative effects of green infrastructure and urban tree canopy on human health and the environment. There was not very much information that discussed the negative effects of green infrastructure on human health. The City of Springfield was chosen for this study because of its location and the different connections UMass Amherst has to the working professionals in this type of research. This study gathered data about urban tree canopy and health within different neighborhoods of Springfield, Massachusetts. The City of Springfield is the third largest City in the State, with a population of nearly 154,000 residents. My study hypothesis was that there would be a correlation between urban trees and human health. This thesis examined the correlation between available health data and urban trees using statistical analysis.

Two research questions that were asked when researching this topic were: Are there any correlations between urban tree canopy and the asthma rates, infant mortality rates, and low birth weight in the Springfield neighborhoods? Does everyone really have

the equal access to resources such as urban tree canopy and green space? This topic is important to researchers, teachers, and residents in urban areas because clean air is essential to improve health issues and unequal access to these resources is a major issue. It is important to research and conclude what exactly are the impacts of urban trees on the human health of the residents that live in these neighborhoods. The Literature Review discusses mental health as another factor in public health but due to the constraints within a master's thesis scope mental health was not studied.

CHAPTER II

LITERATURE REVIEW

A. Introduction

Benedict and McMahon defines "green infrastructure as an interconnected network of natural areas and other open spaces that conserves natural ecosystems functions and values, sustains clean water and air, and provides a wide range of benefits to people and the environment" (Benedict and McMahon 2006, 1). Qureshi et al. defines green infrastructure as ‘‘integrated built networks/systems and protected/managed urban ecosystems that provide multiple, corresponding functions in support of urban sustainability" (Qureshi et al. 2010, 187). Benedict and McMahon states, "while green space is often viewed as something that looks good and nice to have, green infrastructure indicates something that is crucial in communities" (Benedict and McMahon 2006, 2). Green infrastructure also provides a strong establishment for funding green space management and conservation. Benedict and McMahon 2006 explain, "just as sewer systems, roads, and other aspects of the built infrastructure provide for the critical needs of communities" (Benedict and McMahon 2006, 4). Green infrastructure is vital to a community's sustainability and health.

Benedict and McMahon states, "greenhouse gasses block the sun's radiant energy from escaping back into the atmosphere, which then raises the temperature on earth" (Benedict and McMahon 2006, 10). In the past 25 years, the earth's average temperature has risen about one degree and the temperature of the Pacific Ocean has risen up to three

degrees. Related effects of these dramatic changes include, ozone depletion, urban heat islands and urban dust plumes.

Coutts explains that, "many states are providing money for grants to preserve open space. Florida Communities Trust is a state land acquisition grant program that provides funding to eligible non-profit environmental organizations and to local governments for acquisition of open space, greenways and community-based parks that further outdoor recreation and natural resource protection needs that are recognized in the local government comprehensive plans" (Coutts 2010, 440-441). The question that Coutts' study was addressing was: is there fundamental support for public health in communities funded by the FCT? Coutts 2010 tells that "this was answered by examining the response patterns of communities whose FCT applications were successfully funded and comparing these responses with those that were unfunded to decide whether the differences between these two groups included principles with public health implications" (Coutts 2010, 439-440). The study revealed that communities proposing projects that support public health are being funded, and the Florida Communities Trust is consequently supporting public health.

B. Green Infrastructure

Benedict and McMahon explain "green infrastructure incorporates a wide variety of natural and restored native landscape and ecosystems features, including woodlands, conserved natural areas such as wetlands, waterways, and wildlife habitat" (Benedict and McMahon 2006, 12). It also includes public and private conservation lands such as nature preserves, wildlife corridors, national and states parks, greenways and wilderness areas. Benedict and McMahon describe that, "a green infrastructure network connects these

ecosystems and landscapes in a system of links, sites and hubs" (Benedict and McMahon 2006, 13). Various forms of conserved lands, from national forests to neighborhood parks, support health benefits in multiple ways. Coutts explains that, "for example, protecting a wetland improves water quality and it creates a park with different sport fields that may act as a setting for social interaction and physical activity" (Coutts 2010, 443). Conserved land in the form of linear greenways is possible to connect habitats and protect sensitive natural features while providing a location for recreational or efficient physical activity and the mitigation of psychological and social stressors.

C. Urban Tree Canopy

Tree canopy is one type of green infrastructure that landscape architects and planners can promote for neighborhoods. Benedict and McMahon explain, "studies at the University of Illinois at Urbana-Champaign have acknowledged less stress and lower crime rates in tree-lined neighborhoods" (Benedict and McMahon 2006, 76-77). Nowak and others states "many of the functions and benefits ascribed to urban forests are directly related to urban forest structure (e.g. number of trees, sizes, species composition, tree location" (Nowak et al. 2001, 38). They go on to explain that" the number of trees within urban areas of the US is estimated to be 3.8 billion bases on minimum and maximum city street-cover density estimates" (Nowak et al. 2001, 38). Lowery and Baker point out that, "urban trees have been shown to improve air quality and aid in carbon sequestration" (Lowery and Baker 2012, 2). Nowak and Crane states, "trees act as a sink for CO_2 by fixing carbon during photosynthesis as storing excess carbon as biomass. The net long-term CO_2 source/sink dynamics of forest change through time as trees grow die, and decay" (Nowak and Crane 2002, 381). Nowak and Crane also discuss that, "large

healthy trees greater than 77 cm in diameter sequester approximately 90 times more carbon than small healthy trees less than 8 cm in diameter" (Nowak and Crane 2002, 384). Lowery and Baker states, "urban trees have been shown to reduce energy consumption and control stormwater runoff" (Lowery and Baker 2012, 2). Lowery and Baker go on to explain that, "there has been recent research completed that shows the relationship of urban vegetation and the social, economic, and demographic characteristics of households within neighborhoods" (Lowery and Baker 2012, 3).

Air pollution is a major environmental concern in most urban areas across the US. An important focus of research has been on the role of urban vegetation in the formation and degradation of air pollutants in cities. Nowak and Crane explain, "more integrative studies are revealing that urban trees are a viable strategy to help reduce urban ozone levels" (Nowak and Crane 2006, 1). Across the US, urban trees and shrubs offer the ability to remove significant amounts of air pollutants and consequently improve environmental quality and human health. Nowak and Greenfield explain that, "trees not only provide many economic and ecosystem services and values to a community, but also experience various economic or environmental costs at the same time" (Nowak and Greenfield 2012, 1). Trees supply ecosystem services associated with air and water quality, building energy conservation, moderation of air temperatures, reductions in ultraviolet radiation.

Nowak and Greenfield states, "impervious surfaces block water infiltration and reduce percolation rates, impact water table levels, and effect stream base-flow regimes" (Nowak and Greenfield 2012, 1). Poorer water quality and increased temperatures, due to impervious surfaces, can considerably impact human health. Cheng et al. states, "trees

also provide social and cultural benefits to urban residents, such as reduction of noise levels" (Cheng et al 2014, 1).

The reduction of noise level is a benefit of urban trees that is expressed among different scholars. Cheng et al. states, "since urban trees provide important social and physical benefits to urban residents, inequitable access to these benefits creates an environmental justice condition" (Cheng et al 2014, 1). Cheng et al go on to states "this uneven distribution of urban trees is often the result of socioeconomic factors instead of ecological ones" (Cheng et al 2014, 1). Cheng et al. states, "our finding that higher percentages of minority residents had moderately more canopy cover may relate to the fact that in Boston some of the higher percentage minority neighborhoods are more distant from the high-density downtown which has fewer trees; and/or the resultant tree canopy could be the result of abandonment of property, which results in urban forests "regenerating" on vacant lots" (Cheng et al 2014, 13-14). Cheng et al. express, "Heynen and Lindsey investigated the correlation of canopy cover in urban areas in Central Indiana and found correlation between urban trees with education level and housing age" (Cheng et al 2014, 13).

D. Importance of Green Infrastructure for Planners

Jerrett and Wolch states, "the notion that green spaces and natural areas promote health gained prominence in the late 19th and early 20th centuries with the Garden Cities movement initiated by Sir Ebenezer Howard" (Jerrett and Wolch 2011, 1). Jerrett and Wolch explains, "moving populations from densely populated urban areas with poor sanitation to less dense areas removed from the city center was seen as a way of protecting large segments of the population from ills of the industrial city" (Jerrett and

Wolch 2011, 1). Jerrett and Wolch goes on to states, “those parks, green spaces, and other natural areas often play a role in defining ecological functions of urban and suburban environments. They support biodiversity and provide important ecosystem services” (Jerrett and Wolch 2011, 1). Parks and open space, as components of green infrastructure, are a community prerequisite.

The APA states, “by managing and planning urban parks as parts of an interconnected green Space system, cities can decrease flood control and stormwater management costs” (APA 2013, 1). The APA goes on to explain, “parks also protect biological diversity and preserve vital ecological functions, while serving as a place for recreation and community engagement. Linking parks and greenways together helps to create an interconnected green space system that provides far greater benefits for the community, environment, and the economy” (APA 2013, 2). It also helps to connect people and neighborhoods, provides opportunities for physical exercise that can help stop today's trends in obesity and adult onset diabetes.

When planning open space, it is more advantageous to connect isolated parks together. City parks can help protect the biological diversity of local plants and animals when they are managed to maintain and restore natural ecological functions. The APA explains, “there is value of interconnected urban green space systems that can help to improve urban quality of life” (APA 2013, 3). There is economic value when green infrastructure reduces the need for built infrastructure such as stormwater management and flood control. Green infrastructure assists in flood control by storing, carrying, and filtering storm runoff from the site.

According to the APA, "American Forests, it is estimated that the 187,767 acres of tree canopy in the Washington, D.C. metropolitan region provides 949 million cubic feet in avoided storage of water" (APA 2013, 3). The APA explains in more detail that; "this is annually valued at $4.7 billion" (APA 2013, 3). Lowery and Baker states "a better understanding of how environmental and human factors are related to urban forests will provide planners with information to improve residential neighborhood design, and will help to guide foresters in tree planting campaigns aimed at encouraging the education of urban trees" (Lowery and Baker 2012, 2).

E. Human Health

1. Functions

Tzoulas et al states, "the World Health Organization (WHO) defines human health as "a states of complete physical, mental and social well-being and not merely the absence of disease or infirmity" (Tzoulas et al. 2007, 168). Tzoulas et al explains, "this definition infers that to fully understand and describe the concept of health, a wide array of related factors ought to be considered including social, psychological and biological" (Tzoulas et al. 2007, 168).

Baker et al makes the point that, "the support of the public sector framework that establishes the health infrastructure includes the workforce competencies, the organizational capacities, and the communication and information systems" (Baker et al. 2005, 305). This type of infrastructure is the base that facilitates the various components within the health system to function both independently and together. Baker et al. states, "for a period of time that the rising challenges to Americans' health was a decline in workforce numbers, suggesting a serious decline of functional capacity in the public

health system" (Baker et al. 2005, 309).

2. Youth Health Impacts

Jerrett and Wolch explain, "despite these potential benefits, growing evidence suggests many urbanites lack sufficient access to green spaces and parks, and funding for parks programming differs considerably between neighborhoods and cities" (Jerrett and Wolch 2011, 1). They accessed the environmental quality around green space and whether access to park and recreation reduce the growth of body mass index. This study of health on green space was done for a sample of youth.

Jerrett and Wolch states, "in the North American context they point to several critical policy solutions as parks and park programming can have measureable benefits for children in terms of increased physical activity and reduced obesity" (Jerrett and Wolch 2011, 2). Wolch et al explain, "obesity is a serious and worsening public health problem" (Wolch et al 2011, 207). Wolch et al go on to states, "the occurrence of overweight risk and high body mass index (BMI) status in youth age 2–19 years increased to approximately 32% by 2003– 2006, up from approximately 15% in the 1970s" (Wolch et al 2011, 207). Wolch et al states, "the urban built environment, including parks and other green space, and recreation programs that provide structured settings for exercise, might also shape opportunities for physical activity, affecting development of obesity" (Wolch et al 2011, 207).

Research suggests that physical characteristics of the built environment surrounding a child's neighborhood or school can significantly influence physical activity and thus health outcomes. Wolch et al. states, "several studies have specifically examined relationships between parks and children's physical activity" "Many studies show that

children with more access to parks and recreational facilities are more active than children with less access" (Wolch et al 2011, 207). Wolch et al. states, "they reported that parks were more likely to encourage physical activity if they were perceived as aesthetically pleasing (minor traffic, sidewalks, trees, retail shops)" (Wolch et al 2011, 208). Wolch et al. explain, "finally, the social conditions, such as poverty and unemployment, as well as crime, may also negatively influence park use and recreational program utilization and be related to obesity" (Wolch et al 2011, 208).

Wolch et al. explain, "The Southern California Children's Health Study (CHS) consisted of 3,173 children aged 9–10 from 12 communities in Southern California in the years of 1993 and 1996 to assess associations between respiratory health and environmental factors" (Wolch et al 2011, 211). Wolch et al. states, "results for both models, indicated that access to both parkland and recreation programs reduce risk of overweight and obesity as measured by BMI attained at age 18" (Wolch et al 2011, 211). Wolch et al. explain, "this study breaks new ground, being the first to consider the impact of public recreation programs on obesity, compared to park access, in a longitudinal analysis of youth." "The longitudinal design is critical to understanding relationships between obesity trajectories and the built environment/recreational programming, and helps overcome self-selection problems that typify cross sectional research" (Wolch et al 2011, 213).

3. Health Issues

The most harmful pollutants found in developed cities are sulfur dioxide, nitrogen dioxide, ozone, and particulate matter. Baker et al explain, "threats to Americans' health, including chronic disease and emerging contagious disease that are present and growing,

and the public health system are responsible for addressing these challenges" (Baker et al. 2005, 304). Serious and constantly developing threats face the health of the American people. Baker and et explain, "these threats include a major burden of chronic disease, environmental illness and work-related hazards due to infectious diseases (Baker et al. 2005, 305). Public health systems today will be able to defend against existing and potential threats to Americans' health only if its additional infrastructure is increased.

F. Health Benefits

1. Linkages between the Environment and Public Health

The link between environmental quality and health was formalized decades ago in the WHO's Ottawa Charter for Health Promotion. Coutts explain, "this Charter recognizes the needs of supportive environments and the shared conservation between humans and natural environments" (Coutts 2010, 442). Many of the public health benefits that conserved lands support comes from their ability to be accessed by the public. According to Lafortezza et al. "green infrastructure is considered as supportive of ecosystem services, while at the same time contributing to many health benefits, which include psychological, physical, and socio-economic outcomes" (Lafortezza et al. 2013, 104). Health benefits derived from green infrastructure occur not just at the local level, but also at the neighborhood, city and regional levels. Lafortezza and others states, "for example, green infrastructure supports human health and well-being of local communities through the presence of more interconnected places to live, work and recreate in nature" (Lafortezza et al. 2013, 104).

According to Qureshi et al. "Kaplan and Kaplan underlined the importance of nature in urban settings and the necessary evidence that exists to draw the conclusion that

a vigorous and healthy green infrastructure is a vital public health factor for people who live in cities" (Qureshi et al. 2010, 188). Both green infrastructure and human health are key indicators of sustainable urban planning. The term "ecosystem services" refers to the supply and protection or maintenance of goods and benefits that humans gain from ecosystem functions (Tzoulas et al. 2007, 170). Alberti and Marzluff states, "urban sprawl also increases the per capita costs of human services and infrastructure provision" (Alberti and Marzluff 2004, 245). As a result, urbanization is seen as the process by which humans substitute ecosystem services with human services.

2. Water and Air Quality

Water quality if affected by stormwater. Runoff is often carried unchecked over impervious surfaces into lakes and streams, and it regularly carries pollutants that were on the runoff surface runoff often flows into our freshwater water sources and drinking water supplies. Trees also help to protect watersheds by improving the quality and quantity of drinking water. Benedict and McMahon explain, "green infrastructure networks provide many ecological benefits that people often take for granted" (Benedict and McMahon 2006, 64). In addition to providing habitat for animal and plant species, trees clean up the air we breathe. Nowak and Dwyer (2007, 28) states, "trees remove gaseous air pollution by uptake through leaf stomata, though some gases are removed by the plant surfaces". Urban trees remove carbon monoxide, nitrogen dioxide, ozone and sulfur dioxide. Nowak and Dwyer states, "because VOC emissions are temperature dependent and trees are generally lower air temperature, it is believed that increased tree cover lowers overall VOC emissions and, consequently, reduces O_3 levels in urban area" (Nowak and Dwyer 2007, 31).

MacDonagh explain, “a green roof, which is a type of green infrastructure, mitigates stormwater runoff from different sizes of impervious surfaces” (MacDonagh 2006, 1). MacDonagh goes on to states; “green roofs mitigate the urban heat island effect, provide wildlife habitat and improve urban air quality on a scale that is not possible in downtown urban areas such as Minneapolis” (MacDonagh 2006, 1). Coutts explain, “these pollutants impair asthma, which is a growing illness among young children in the USA” (Coutts 2010, 445). These pollutants are also associated with lung cancer and cardiopulmonary mortality.

3. Physical and Mental Health

Green infrastructure provides people with mental and physical health benefits resulting from living close to environment. Nielsen and Hansen explain “international studies have acknowledged positive health effects of green areas on human health” (Nielsen and Hansen 2007, 839). Frumkin states “Fredrick Law Olmstead observed, in the 19th century, that experiencing and viewing nature reduces the stress of daily life in urban areas” (Frumkin 2003, 1452). Frumkin goes on to explain, “parks and gardens have long been famous for their restorative effects on both physical and mental health” (Frumkin 2003, 1452). Nowak and Dwyer explain, “many of the benefits associated with urban trees contribute to improve human health in a wide variety of ways, ranging from improved air quality to reduction of stress and interpersonal conflict” (Nowak and Dwyer 2007, 36). They go on to explain, “with increased concern over obesity and the need for changing lifestyles (e.g. more exercise) to reduce obesity, trees and forests are receiving increased attention as a solution” (Nowak and Dwyer 2007, 36).

Obesity can cause cardiovascular disease risk, increased risk of certain cancers, and overall increased mortality. Lopez states, “one factor that plays a role in obesity risk is the built environment around them, which consists of human-made factors, including the characteristics, location, and allocation of residences, neighborhoods, and metropolitan areas” (Lopez 2007, 2111). He goes on to explain, “studies have shown that mixed-use community, accessible parks, the presence of public transportation, walkable destinations, sidewalks, and other Neighborhood factors can influence physical activity and the obesity risk” (Lopez 2007, 2112). According to Nielsen and Hansen, “cardiovascular and mental illnesses as well as low back and neck pain have been positively affected” (Nielsen and Hansen 2007, 839).

Benedict and McMahon explain, “another recent study showed that people living near parks and other natural areas live healthier lives with fewer hospital visits” (Benedict and McMahon 2006, 77). The results advocate that the more often a person visits green spaces, the less stressed he or she will be at that time. According to Benedict and McMahon “teens in green communities have been detected with fewer symptoms of ADD compared to those who live in places without trees” (Benedict and McMahon 2006, 77). Benedict and McMahon states, “natural environments stimulate positive feelings, reduce fear, and even help block stressful thoughts” (Benedict and McMahon 2006, 77). In additionally Coutts states, “the regular physical activity that could be achieved by walking to the store could reduce the risk of cardiovascular disease, type 2 diabetes, and selected forms of cancer, as well as improving mental health and mood” (Coutts 2010, 446). Nowak et al, states, “it is found that urban forms of trees and parks have a positive effect on human health. Nowak et al. states, “in general the greater the tree cover, the

greater the pollution removal: and the greater the removal and population density" (Nowak et al. 2014, 126).

4. Social Capital

Social capital is the value of the relationships that exist between the members of a community. Coutts states, "those bonds have been proven to be important indicators of many health outcomes promoted by the presence of shared public space in a community" (Coutts 2010, 446). More specifically Coutts states, "public spaces with natural elements such as vegetation are an important indicator of social capital" (Coutts 2010, 446-447). According to Jackson, "green space is a method of increasing informal contact. When researcher studied low-income residents, they found that the presence of grass and trees has a correlation of strong social ties in a neighborhood" (Jackson 2002, 194). By using the social ties of a community, green infrastructure and public health can help to use those spaces in that neighborhood.

G. Gaps in Research

The research does not suggest or find many negative effects of green infrastructure on human health. Not many researchers have explored, or expanded, in the current research. It is important to note that pollen allergies for certain people could be a result of certain tree species being planted. Research shows that unmanaged green space can have negative effects on human health. Green spaces that are seen to be overgrown or unmanaged may have a negative effect on people's well-being by increasing concern caused by the fear of crime (Tzoulas et al. 2007, 171). Furthermore, urban and peri-urban ecological changes can affect the location range of diseases such as Lyme Disease

(Tzoulas et al. 2007, 171). Green space can also help spread disease through different types of parasites such as ticks.

The main findings of the research in the Literature Review were that urban tree canopy provides social, environmental, physical/ mental benefits, and health benefits to their surroundings and to the residents. Green infrastructure was introduced to the readers to describe the benefits that it has on the environment. The Literature Review discussed the major health issues that are facing the American people such as asthma and obesity. However, the Literature Review also discussed the benefits that urban tree canopy has to manage those issues. The Literature Review also discussed some challenges that have been documented in Boston in relations to urban tree canopy. One of the authors describes how there are environmental justice issues due to inequitable access to the benefits of urban trees. The Literature Review additionally discussed the correlation canopy cover in urban areas between urban tree canopy with education level and housing age.

H. Research Questions

There are many ecological benefits that can be provided by urban tree canopy and green infrastructure for different sized neighborhoods. Urban tree canopy provides many benefits for people and the surrounding environment. Are there any correlations between urban tree canopy and the asthma rates, infant mortality rates, and low birth weight in the Springfield neighborhoods? Is there a correlation between the amount of urban trees and the amount of median household income of the residents in the City of Springfield? Are there environmental justice issues present in the City of Springfield? Does everyone really have the equal access to resources such as urban tree canopy and green space? One

claim that I wanted to make is that having urban tree canopy will have positive effects on the physical health of those residents in Springfield's neighborhoods. Another claim is that running correlations between the different demographics and health factors will indicate environmental justice issues that are present for the residents of the City of Springfield.

The Literature Reviewed to date concludes that green infrastructure, and specifically urban tree canopy has positive benefits related to the physical and mental health of residents in the areas where it is found. My research will contribute to the field by undertaking new research on the physical health benefits in urban neighborhoods for the City of Springfield. My goals in this study are to verify the assumptions for a case study that focuses on 17 Springfield neighborhoods.

CHAPTER III

METHODOLOGY

Originally, the research approach was to look at similar compact Neighborhoods based on criteria such as similar size, Home Ownership rates, Census Tract sizes, Median Income, Income Inequality, and geographic location of Springfield. Due to the small amount of Neighborhood level health data, this thesis examined all 17 Neighborhoods in the City of Springfield. The Urban Tree Canopy within each neighborhood will be studied as an independent variable. This analysis used statistics program such as SSPS to analyze correlations between urban tree canopy and human health. This process also utilized GIS layers from Mass GIS and available City of Springfield GIS layers to examine visual connections. The study then compared health data to urban tree canopy percentages, using physical health as the dependent variable. The study analyzed if there were significant positive correlations between the factors of physical health and other related physical health factors by the amount of Urban Tree Canopy in the different Neighborhoods. The study also considered existing health facilities, school, and social services, and non-profits organizations when studying the sample Neighborhoods.

The websites from organizations where some of the data was collected were the Centers for Disease Control, Massachusetts Department of Public Health, Pioneer Valley Planning Commission, LiveWell, City of Springfield, Partners for a Healthier Community, ReGreen Springfield, and US Forest Services.

Multiple categories were considered for each type of physical health impact that exists with urban tree canopy. The study examined the physical health benefits for

children and youth because they are the future generation when planning urban cities with urban trees within the boundaries of these Neighborhoods and because this specific type of data existed and was able to be shared. The three health categories are Asthma Rates, Infant Mortality, and Low Birth Weight. The Literature Review discussed mental health as another factor in public health but measuring mental health is not as easy to accomplish for a short-term research.

A. Existing Springfield Demographics

The indicating factors that were gathered in existing demographics involve housing, economic security, transportation, and children and youth. The specific indictors considered were Median Income, Income Inequality, Education Attainment, Home Ownership, Racial Composition, and Prenatal Care. The evaluation of Springfield demographics also included the Neighborhood Census Tracts and the Density rate of each of the 17 Neighborhoods. These existing data help to describe the similar and differences between the 17 Springfield Neighborhoods. Livewell Springfield and PVPC provided all of the data information that is shown in the tables in their data atlas (Pioneer Valley Planning Commission 2014). Other sources of information will be referenced when necessary.

Neighborhoods	Median Household Income
Bay	$26,600
Boston Road	$42,188
Brightwood	$15,495
East Forest Park	$64,362
East Springfield	$40,518
Forest Park	$40,513
Indian Orchard	$33,060
Liberty Heights	$33,651
McKnight	$25,991
Memorial Square	$16,974
Metro Center	$16,114
Old Hill	$23,021
Pine Point	$45,763
Six Corners	$18,763
Sixteen Acres	$54,606
South End	$17,441
Upper Hill	$35,581
Springfield	$31,356
Pioneer Valley	$51,381
Massachusetts	$65,339

Table 1. Median Household Income[1]

Median Household Income represents the amount of money an average household earns in a year. It is a usual indicator of household finances and economic security. The median amount of money a household brings in is possibly the most important indicator of economic security, as it is reflective of a household's ability to provide for itself. For this indicator, a household refers to the group of people who live within the same housing unit or house. This measure refers to the income received by all members of the household who are older than 14 during a year period. Household Income includes all forms of income such as wages, social security, retirement funds, and public assistance.

[1] Pioneer Valley Planning Commission. Data Atlas By Neighborhoods: City of Springfield. Springfield: Pioneer Valley Planning Commission, 2014. Accessed February 2, 2015. http://www.pvpc.org/sites/default/files/Springfield%20Data%20Atlas%209-23-14-web-reduced.pdf

The 2012 Median Household Income in Springfield ($31,356) falls far below both the Pioneer Valley ($51,381) and the State ($65,339). Springfield's latest decline in Median Household Income occurred during the recent recession, though as regional and State incomes have begun to recover, Springfield has continued to see decline. This suggests that city households did not possess the economic safety that allowed other Massachusetts' households to experience relative stability during hardships throughout the economy.

Within the city, there exist differences between the different Neighborhoods. Neighborhoods, such as East Forest Park and Sixteen Acres maintain a high level of Median Household Income that is close with the statewide average. This trend departs, though, as residents in Neighborhoods such as Brightwood, Metro Center, and Memorial Square possess the lowest economic capabilities. Median Household Income in East Forest Park is more than four times higher than that in Brightwood. Although Neighborhoods such as East Forest Park and Sixteen Acres offset the lowest-performing Neighborhoods in Springfield, their Median Household Income is still much less than that of Massachusetts.

Neighborhoods	Income Inequality
Bay	55.03%
Boston Road	41.39%
Brightwood	53.77%
East Forest Park	34.69%
East Springfield	38.88%
Forest Park	43.21%
Indian Orchard	48.73%
Liberty Heights	42.17%
McKnight	45.76%
Memorial Square	50.82%
Metro Center	49.96%
Old Hill	49.96%
Pine Point	43.37%
Six Corners	47.49%
Sixteen Acres	39.12%
South End	43.43%
Upper Hill	40.34%
Springfield	49.00%
Pioneer Valley	46.44%
Massachusetts	48.13%

Table 2. Income Inequality Percentage[2]

Measuring the overall level of income equality between the people throughout the region is greatly important to accurately analyze an area's economic condition. Looking at how income is distributed throughout a study area accomplishes this goal. In this case, the study area is the different defined Neighborhood boundaries. A community with lower levels of economic inequality is more likely to have economic and social stability and thus a higher quality of life. The income equality of an area is measured with the Gini Coefficient, which illustrates how uniformly income is distributed.[3] Calculating the Gini

[2] Pioneer Valley Planning Commission. Data Atlas By Neighborhoods: City of Springfield. Springfield: Pioneer Valley Planning Commission, 2014. Accessed February 2, 2015. http://www.pvpc.org/sites/default/files/Springfield%20Data%20Atlas%209-23-14-web-reduced.pdf

[3] "Gini Coefficient", Investropedia, Accessed February 2, 2015, http://www.investopedia.com/terms/g/gini-index.asp

Coefficient provides a number on a scale of 0 to 1, where 0 is complete equality and 1 is complete inequality.

Conducting these measurements are necessary, as patterns of inequality can be revealed which would otherwise not appear in a simple income analysis. The Gini Coefficient has the ability to account for higher incomes that would skew those analyses that analyze standard averages. Furthermore, this analysis depicts socioeconomic isolation. A Neighborhood may appear to have low levels of inequality, but when looked at collectively with other areas, the Neighborhood could be an area of concentrated poverty or concentrated wealth. Table 2 above lists the Income Inequality as a percentage.

Historically, as Income Inequality increased throughout the State, the Pioneer Valley and City of Springfield experienced a decline. This culminated in 2010, when Springfield experienced a rise in Income Inequality, from 45.6% (2010) to 48.96% (2011). During these years, the state's incremental growth in inequality continued. In 2012, Springfield's Gini, 48.8%, fell only slightly below that of the State, 48.1%. However, the Pioneer Valley's Income Inequality, 46.4%, is lower than both, yet the city's trend does not reflect the trend of the region and State.

This economic shift extremely affected certain Neighborhoods in the city. In 2012, the Neighborhoods of Brightwood, Memorial Square, and McKnight have inequality metrics that are higher than those of other Neighborhoods and the city, (49%) as a whole. Contrariwise, East Forest Park and East Springfield maintained a more similar distribution. These figures, coupled with the historical trend of heightened inequality overall, illustrate the disparity present amongst the different Neighborhoods of the city.

Neighborhoods	Education Attainment %
Bay	6.80%
Boston Road	10.00%
Brightwood	6.00%
East Forest Park	28.23%
East Springfield	12.62%
Forest Park	22.62%
Indian Orchard	11.42%
Liberty Heights	12.65%
McKnight	16.20%
Memorial Square	7.00%
Metro Center	12.66%
Old Hill	6.90%
Pine Point	14.44%
Six Corners	14.25%
Sixteen Acres	23.26%
South End	4.00%
Upper Hill	10.70%
Springfield	17.60%
Pioneer Valley	29.96%
Massachusetts	39.30%

Table 3. Education Attainment[4]

Higher education is increasingly necessary for long term access to well paying jobs. The extent of educational attainment is indicative of a population's ability to function and excel economically, thus leading to economic and social opportunities in life. While two year associate's degrees meet the needs of certain positions, a bachelor's degree is rapidly emerging as a requirement for entry level positions in many industries. Because a solid educational background, typically achieved during high school, is a prerequisite for getting a bachelor's degree, this indicator also measures a community's ability to prepare their children for college. Table 3 above is showing the percentage of residents that are 25 and older and have achieved a bachelor degree or more.

[4] Pioneer Valley Planning Commission. Data Atlas By Neighborhoods: City of Springfield. Springfield: Pioneer Valley Planning Commission, 2014. Accessed February 2, 2015. http://www.pvpc.org/sites/default/files/Springfield%20Data%20Atlas%209-23-14-web-reduced.pdf

Massachusetts is internationally renowned for being the home of a variety of outstanding college institutions. In 2012, 39.30% of State residents possessed a bachelor's degree or higher. Regionally, 29.96% of residents in the Pioneer Valley, an area that encompasses a cluster of colleges, reported holding a bachelor's degree or higher during the same year. In Springfield, only 17.60% of residents had education of that measured level.

Rates vary widely by neighborhood. Less than one in ten residents hold a bachelor's degree in five Neighborhoods of the city, including the South End, Brightwood, Bay, and Old Hill. East Forest Park, Forest Park, and Sixteen Acres are the city's most highly educated Neighborhoods.

Neighborhoods	Home Ownership
Bay	38.30%
Boston Road	73.30%
Brightwood	17.50%
East Forest Park	89.54%
East Springfield	73.06%
Forest Park	45.60%
Indian Orchard	41.50%
Liberty Heights	44.49%
McKnight	38.30%
Memorial Square	10.27%
Metro Center	4.04%
Old Hill	36.10%
Pine Point	65.06%
Six Corners	15.30%
Sixteen Acres	76.69%
South End	5.90%
Upper Hill	43.30%
Springfield	49.00%
Pioneer Valley	60.68%
Massachusetts	59.00%

Table 4. Household Ownership Percentage[5]

Home Ownership is also an important indicator of economic security. Owning a house represent financial stability and employment status. Home Ownership is expressed as the percent of all housing units that are occupied by the property's owner. Home Ownership rates have risen to 49% for Springfield residents, 60.68% for Pioneer Valley residents, and 59% for the State of Massachusetts

When examined in detail, it is evident that ownership is not share equally across Neighborhoods within the city. East Forest Park, Sixteen Acres, and East Springfield surround a significant portion of residents who own their homes and may experience a greater degree of economic stability. Many Neighborhoods reported rates between 35-

[5] Pioneer Valley Planning Commission. Data Atlas By Neighborhoods: City of Springfield. Springfield: Pioneer Valley Planning Commission, 2014. Accessed February 2, 2015. http://www.pvpc.org/sites/default/files/Springfield%20Data%20Atlas%209-23-14-web-reduced.pdf

45% and a fraction of the State and regional trends of Home Ownership. This figure continues to decrease in Neighborhoods closer to the urban core. The majority of residents in the Metro Center, the South End, and Memorial Square reported they did not own their housing

Racial Composition	White	Black	Hispanic
Bay	13.7%	54.7%	40.4%
Boston Road	56.3%	27.9%	21.1%
Brightwood	39.1%	11.9%	81.5%
East Forest Park	83.9%	7.6%	7.1%
East Springfield	60.8%	9.5%	34.2%
Forest Park	47.1%	18.0%	32.5%
Indian Orchard	65.0%	15.6%	30.8%
Liberty Heights	57.6%	10.0%	50.3%
McKnight	25.8%	42.0%	39.4%
Memorial Square	30.5%	4.5%	88.5%
Metro Center	61.2%	24.5%	47.2%
Old Hill	23.1%	48.8%	41.8%
Pine Point	42.1%	36.0%	25.1%
Six Corners	34.2%	27.8%	57.1%
Sixteen Acres	71.8%	17.8%	13.9%
South End	33.7%	11.2%	67.8%
Upper Hill	34.5%	44.0%	21.5%

Table 5. Racial Composition[6]

Table 5 above shows the percentage of the racial demographics within the 17 different Springfield Neighborhoods. There are major differences of racial composition between the Neighborhoods. The Neighborhoods that have the largest percentage of White residents are East Forest Park and Sixteen Acres. The Neighborhoods that have the largest percentage of Black residents are Old Hill and Bay. The Neighborhoods that have the largest percentage of Hispanic residents are Brightwood and Memorial Square.

[6] City of Springfield. Springfield MA Neighborhood Profiles: *Springfield Planning Office*. City of Springfield, 2014. Accessed February 2, 2015, http://www3.springfield-ma.gov/planning/fileadmin/Planning_files/Springfield_Neighborhood_Profiles_PDF.pdf

Examining the racial composition will help to better understand the residents that live in the selected Neighborhoods.

Neighborhoods	Prenatal Care
Bay	62.50%
Boston Road	72.00%
Brightwood	67.70%
East Forest Park	83.50%
East Springfield	67.50%
Forest Park	75.90%
Indian Orchard	66.90%
Liberty Heights	67.60%
McKnight	54.60%
Memorial Square	67.70%
Metro Center	74.10%
Old Hill	73.80%
Pine Point	72.00%
Six Corners	66.90%
Sixteen Acres	80.10%
South End	75.60%
Upper Hill	65.80%
Springfield	70.96%
Pioneer Valley	77.14%
Massachusetts	83.45%

Table 6. Prenatal Care Percentage[7]

The use of Prenatal Care is a crucial indicator because it relates directly to the outcomes of pregnancy such as birth weight, labor complications, and overall infant health.[8] This health factor can lead to premature deliveries and Low Birth Weight. Roughly, the presence of care relates to the absence or presence of birth issues. It is important to analyze if most of the Neighborhoods have similar Prenatal Care percentages and how this relates to youth and children's health. Overall, Springfield has a

[7] Pioneer Valley Planning Commission. Data Atlas By Neighborhoods: City of Springfield. Springfield: Pioneer Valley Planning Commission, 2014. Accessed February 2, 2015. http://www.pvpc.org/sites/default/files/Springfield%20Data%20Atlas%209-23-14-web-reduced.pdf

[8] Pioneer Valley Region values were calculated by using total Births to weight data for Hampden and Hampshire counties.

lower Prenatal Care percentage than both the Pioneer Valley and the State of Massachusetts. There are disparities in care between Neighborhoods in Springfield. More than a third, and in some cases nearly half; of pregnant women in McKnight (54.5%), Bay (62.5%), and Upper Hill (65.82%) Neighborhoods of Springfield do not receive adequate levels of Prenatal Care. In Springfield, the only Neighborhoods of East Forest Park (83.5%) and Sixteen Acres (80.1%) were at the adequate level of the State of Massachusetts.

Neighborhoods	Census Tract(s)				
Bay	8,014				
Boston Road	8,015				
Brightwood	8,007				
East Forest Park	8,024	8,025			
East Springfield	8,002	8,002			
Forest Park	8,021	8,022	8,023	8,026	8,026
Indian Orchard	8,001	8,001			
Liberty Heights	8,003	8,004	8,005	8,009	
McKnight	8,013				
Memorial Square	8,006	8,008			
Metro Center	8,010	8,011	8,011	8,012	
Old Hill	8,018				
Pine Point	8,014	8,015	8,015		
Six Corners	8,019	8,019	8,019		
Sixteen Acres	8,016	8,016	8,016	8,016	8,016
South End	8,020				
Upper Hill	8,017				

Table 7. Neighborhood Census Tracts[9]

The Census Tracts of each of the Neighborhoods demonstrates how equal the population falls within the designated Neighborhood boundaries. The census tracts were calculated by the 1,000's because this is how some of the recorded data were calculated. When looking above in Table 7, some of the smaller Neighborhoods in size and

[9] Pioneer Valley Planning Commission. Data Atlas By Neighborhoods: City of Springfield. Springfield: Pioneer Valley Planning Commission, 2014. Accessed February 2, 2015. http://www.pvpc.org/sites/default/files/Springfield%20Data%20Atlas%209-23-14-web-reduced.pdf

population only have one census tract, while some of the bigger ones have a range of two to five. In some cases, some census tracts overlap other Neighborhoods. Overall, most of the smaller Neighborhoods have one census tract and that is easier to analysis and visualize for health benefits.

Neighborhoods	Density per Sq. Mi	Population	Area
Bay	3,866	3,781	0.978
Boston Road	2,939	4,311	1.467
Brightwood	6,879	3,639	0.529
East Forest Park	4,298	10,443	2.43
East Springfield	2,449	7,147	2.918
Forest Park	6,288	24,717	3.931
Indian Orchard	N/A	N/A	N/A
Liberty Heights	6,396	14,972	2.341
McKnight	7,915	5,794	0.732
Memorial Square	8,115	4,666	0.575
Metro Center	9,554	8,914	0.933
Old Hill	8,988	4,674	0.520
Pine Point	4,339	10,995	2.534
Six Corners	9,685	4,988	0.515
Sixteen Acres	2,791	22,125	7.927
South End	9,281	4,158	0.448
Upper Hill	10,924	7,767	0.711
Springfield	4,610	153,060	33.2
Massachusetts	639	6,745,408	10,555

Table 8. Density Rate (People/ Sq. Mi)[10]

Density is calculated to see how compact or non-compact certain Neighborhoods are. For this thesis, compact Neighborhood is defined, as a Neighborhood that is both no larger than one square mile and no less than 7,000 people per square mile. This process is meant to eliminate bigger Neighborhoods that have large population and that are also larger in land size. The following Neighborhoods that meet the two requirements are

[10] "Springfield, MA Neighborhoods Maps", City-Data.com, accessed February 2, 2015, http://www.city-data.com/nbmaps/neigh-Springfield-Massachusetts.html

McKnight, Memorial Square, Metro Center, Old Hill, Six Corners, South End and Upper Hill. The Density information was missing for the Indian Orchard Neighborhood from the data source.

In summary, the main findings of the collected data demographics data are that that there is an unbalance of the racial makeup in each of the 17 different Neighborhoods. In terms of Median Household Income, many of the Neighborhoods fall a lot under the Pioneer Valley's average and the State's average. This demonstrates that many people are struggling to live on small budgets. The findings in Median Income are also found in Income Inequality, as many of the Neighborhoods are not balanced. The findings in Educational Attainment are a problem when less than one in ten residents holds a bachelor's degree. Prenatal Care is an important step in ensuring that babies that are being born are healthy. Nine out of seventeen of the Neighborhoods had lower Prenatal Care percentages than the City's average.

	Median Income	Income Inequality	Education Attainment	House Ownership	Prenatal Care	Density
Bay	$26,600	55.03%	6.80%	38.30%	62.50%	3,866
Boston Road	$42,188	41.39%	10.00%	73.30%	72.00%	2,939
Brightwood	$15,495	53.77%	6.00%	17.50%	67.70%	6,879
East Forest Park	$64,362	34.69%	28.23%	89.54%	83.50%	4,298
East Springfield	$40,518	38.88%	12.62%	73.06%	67.50%	2,449
Forest Park	$40,513	43.21%	22.62%	45.60%	75.90%	6,288
Indian Orchard	$33,060	48.73%	11.42%	41.50%	66.90%	N/A
Liberty Heights	$33,651	42.17%	12.65%	44.49%	67.60%	6,396
McKnight	$25,991	45.76%	16.20%	38.30%	54.60%	7,915
Memorial Square	$16,974	50.82%	7.00%	10.27%	67.70%	8,115
Metro Center	$16,114	49.96%	12.66%	4.04%	74.10%	9,554
Old Hill	$23,021	49.96%	6.90%	36.10%	73.80%	8,988
Pine Point	$45,763	43.37%	14.44%	65.06%	72.00%	4,339
Six Corners	$18,763	47.49%	14.25%	15.30%	66.90%	9,685
Sixteen Acres	$54,606	39.12%	23.26%	76.69%	80.10%	2,791
South End	$17,441	43.43%	4.00%	5.90%	75.60%	9,281
Upper Hill	$35,581	40.34%	10.70%	43.30%	65.80%	10,924

Table 9. Summarized Data for the Main Existing Springfield Demographics[11][12]

Table 9 above displays the main results of the collected Springfield demographics from the different data sources within the City.

[11] Pioneer Valley Planning Commission. Data Atlas By Neighborhoods: City of Springfield. Springfield: Pioneer Valley Planning Commission, 2014. Accessed February 2, 2015. http://www.pvpc.org/sites/default/files/Springfield%20Data%20Atlas%209-23-14-web-reduced.pdf

[12] "Springfield, MA Neighborhoods Maps", City-Data.com, accessed February 2, 2015, http://www.city-data.com/nbmaps/neigh-Springfield-Massachusetts.html

CHAPTER IV

EXISTING SPRINGFIELD NEIGHBORHOOD HEALTH DATA

A. Mass in Motion Program

The State of Massachusetts launched a health program in 2009 to promote wellness and to prevent overweight and obesity for the commonwealth with particular focus on the importance of healthy eating and physical activity.[13] Springfield Massachusetts is along with the other 44 Towns and Cities that participate in this State run program. Mass in Motion is a statewide movement that promotes opportunities for healthy eating and active living in the places people live, learn, work and play. It is an initiative of the Health and Human Services of the Massachusetts government agencies.

In 2009, Springfield was awarded one of the ten statewide grants to prioritize wellness initiates at the community level. In year 1, the City of Springfield created the Wellness Leadership Council comprised of key decision makers and community stakeholders. One of the focuses of the grant in the City of Springfield is to decrease the obesity rate among the current residents by encouraging physical exercise. The program is also involved in helping to build healthier communities, schools and worksites.

[13] "Mass in Motion, Program Overview", City of Springfield Health & Human Services, last modified March 22, 2012, accessed February 2, 2015, http://www3.springfield-ma.gov/hhs/mass-in-motion-2.0.html

B. Springfield LiveWell Program

LiveWell Springfield is the recognized Mass in Motion organization in the City. LiveWell Springfield is a community-based coalition that includes over 20 organizations working in Springfield. LiveWell's goals are to support healthy living and active living.[14] The coalition supports a grassroots movement towards health and equity through improving access to healthy eating and active living opportunities. The movement works to increase access to and awareness of healthy food and physical activity options for residents in the City of Springfield. The work also includes a mobile farmer's market, work to bring a full line grocery store into Mason Square, rowing and biking programs on the Connecticut River, and the development of a comprehensive Bike and Pedestrian Plan for the City of Springfield. In 2012 Pioneer Valley Planning Commission received a Community Transformation Grant (CTG) from the Center for Disease Control to further this movement. In the fall of 2014, PVPC completed and released a data atlas of their findings.

C. Pioneer Valley Planning Commission

The Pioneer Valley Planning Commission secured funding from the Centers for Disease Control and Prevention (CDC) to significantly expand the work of LiveWell Springfield, a community based coalition that includes over 20 organizations working in the City of Springfield. The coalition supports a grassroots movement towards health equity through improving access to healthy eating and active living opportunities. Great

[14] "Live Well, Springfield". Mass in Motion Program, accessed February 2, 2015, http://www.livewellspringfield.org/

strides have been made in this effort and ongoing action is essential to continue the momentum.

As part of PVPC's work on the LiveWell Springfield initiative, they have produced a Data Atlas in order to provide community based advocacy and service delivery organizations, residents, and City Government with health, economic, and educational information on each of the City's 17 Neighborhoods.[15] Collectively, they seek to answer the question: how is the City of Springfield doing? The data atlas examined long-term trend comparison to the region (Pioneer Valley) and the State. The Pioneer Valley Planning Commission Department that worked on the collection and analysis was the Department of Regional Information Center. Including the data atlas report, Pioneer Valley Planning Commission also produced interactive online GIS maps for the public to access and use.

D. Process of Collecting the Current Health Data

The process of gathering information and data from different organizations across the City of Springfield started from gathering the data that the PVPC has done with LiveWell Springfield to analyze CDC and census data. In that collection of data, they collected Asthma Rates among Elementary School children. The school boundaries on the school district website were weighted to see if delineating the boundary by school district would be a better way to demonstrate the connection between health data by youth and urban tree canopy. This process also included contacting different employees from LiveWell Springfield and Springfield's Planning Office.

[15] "Springfield Neighborhood Data Atlas Released". Pioneer Valley Planning Commission, accessed February 2, 2015, http://www.pvpc.org/content/springfield-neighborhood-data-atlas-released

E. Existing Data

The existing Neighborhood health data comprises of children and youth physical health. These factors are Asthma Rate, Infant Mortality, and Low Birth Weight. The maps in Appendix A show the data in map format.

Asthma Rates	
Neighborhoods	Elementary School Average %
Bay	20.00%
Boston Road	20.70%
Brightwood	19.10%
East Forest Park	13.55%
East Springfield	18.85%
Forest Park	19.38%
Indian Orchard	21.70%
Liberty Heights	16.05%
McKnight	22.30%
Memorial Square	24.95%
Metro Center	22.80%
Old Hill	16.90%
Pine Point	21.95%
Six Corners	3.80%
Sixteen Acres	21.61%
South End	N/A
Upper Hill	3.00%
Springfield	17.20%
Pioneer Valley	13.50%
Massachusetts	10.90%

Table 10. Elementary School Asthma Rates[16]

Indoor and outdoor air pollutants and allergens can trigger "acute asthma attacks", according to the Massachusetts Bureau of Environmental Health. Twenty percent of the U.S. population, or nearly 55 million people, spend their days in elementary and secondary schools. In the mid-1990s, studies showed that 1 in 5 of the nation's 110,000

[16] Pioneer Valley Planning Commission. Data Atlas By Neighborhoods: City of Springfield. Springfield: Pioneer Valley Planning Commission, 2014. Accessed February 2, 2015. http://www.pvpc.org/sites/default/files/Springfield%20Data%20Atlas%209-23-14-web-reduced.pdf

schools reported unsatisfactory indoor air quality, and 1 in 4 schools reported unsatisfactory ventilation, which has an impact on indoor air quality."[17]

This health factor reflects the prevalence of Asthma, an ailment commonly caused by negative environmental factors, in the children who attend schools in the City of Springfield, the Pioneer Valley Region and the State. It reflects the living environments of the region and may also capture trends about the status of school facilities and unhealthy air qualities. The percentages of all students enrolled in Elementary Schools across the City who have Asthma are measured in this factor.

Springfield's students have Asthma rates that are higher than that of the State. As of 2009, 10.9% of all enrolled students in Massachusetts were diagnosed with Asthma. Reasonably, 13.5% of Pioneer Valley students and 17.2% of Springfield students suffered from Asthma during the same year. Since 2007, these rates, and their corresponding injustices, have been remained stable. Table 10 above is only looking at Asthma Rates within the Elementary Schools. There is also information about Asthma rate among middle school students. Most of the Neighborhoods have only one Elementary School, but many of the bigger Neighborhoods in population have 2-6 Elementary Schools. Table 10 above shows the average of the Asthma Rates within the different Neighborhood Elementary Schools. It is important to note that the word "N/A" was inserted for the South End Neighborhood because there is no Elementary School located in that Neighborhood boundary.

On average the highest cases of Asthma occasions in the City of Springfield are located in the Neighborhoods of Memorial Square, Metro Center, and McKnight. On

[17] "Environmental Health", Massachusetts Bureau of Environmental Health. Accessed February 2, 2015, http://www.mass.gov/eohhs/gov/departments/dph/programs/environmental-health/

average the lowest cases of Asthma occasions in Springfield are located in the Neighborhoods of Upper Hill, Six Corners, and East Forest Park.

Specifically, the highest cases of Asthma were located at the Elementary Schools of Mary M. Walsh School (Sixteen Acres), Kensington Avenue (Forest Park), and the Lincoln School (Memorial Square), all of which possess higher rates of asthma that are statistically significant when compared against the State. Indeed, in these schools more than a quarter of all students experience the negative effects of Asthma. Conversely, the Homer Street School (Upper Hill), Elias Brooking School (Six Corners), Frederick Harris School (East Forest Park), and Alfred G. Zanetti School (Liberty Heights) reported Asthma Rates far below those of both the State and the Pioneer Valley Region.

Infant Mortality	
Neighborhoods	Percentage
Bay	0.96%
Boston Road	1.27%
Brightwood	N/A
East Forest Park	1.04%
East Springfield	1.71%
Forest Park	1.60%
Indian Orchard	2.42%
Liberty Heights	0.36%
McKnight	2.27%
Memorial Square	N/A
Metro Center	N/A
Old Hill	1.25%
Pine Point	1.27%
Six Corners	N/A
Sixteen Acres	0.89%
South End	N/A
Upper Hill	3.79%
Springfield	0.92%
Pioneer Valley	0.59%
Massachusetts	0.44%

Table 11. Infant Mortality Rate[18]

Infant Mortality measures the percentage of babies who do not survive past the first year after their Birth. The number of infant deaths per 1000 is what is calculated to determine the Infant Mortality Rate. According to the CDC, "Mortality statistics are frequently used to quantify the extent of public health problems and to determine the relative importance of the various causes of death."[19] This factor measures Infant Mortality, or number of infant deaths, per 1000 Births. Comprehensive health care, including Prenatal Care and nutrition, can combat Infant Mortality. Still, it is necessary

[18] Pioneer Valley Planning Commission. Data Atlas By Neighborhoods: City of Springfield. Springfield: Pioneer Valley Planning Commission, 2014. Accessed February 2, 2015. http://www.pvpc.org/sites/default/files/Springfield%20Data%20Atlas%209-23-14-web-reduced.pdf

[19] "Infant Mortality", Centers for Disease Control, Accessed February 2, 2015, http://www.cdc.gov/reproductivehealth/maternalinfanthealth/infantmortality.htm

for one to examine the specific causes in order to identify what public health policy and resources would be most effective.

In Massachusetts, Infant Mortality is quite low, due to the presence of many health care institutions. In 2010, the State reported the Infant Mortality rate was .44%. This number was slightly higher in the Pioneer Valley region, which recorded the Infant Mortality to be .59%. Springfield reported the Infant Mortality to a concerning .92%.

Certain Springfield Neighborhoods reported remarkably high percentage of Infant Mortality in 2010. Upper Hill, Indian Orchard, and McKnight had exceptional percentage of infant deaths, ranging from five-eight times higher than rates Statewide. Compounded by public health factors, Birth Defects, Low Birth Weights, and maternal pregnancy complications often lead to these deaths. In Springfield, only Liberty Heights, which reported .36% in 2010, fell below the State average There are five missing percentages for the Neighborhood of Brightwood, Memorial Square, Metro Center, Six Corner, and the South End that were never reported by PVPC.

Neighborhoods	Low Birth Weight
Bay	12.5%
Boston Road	8.9%
Brightwood	10.37%
East Forest Park	5.20%
East Springfield	6.85%
Forest Park	11.20%
Indian Orchard	11.30%
Liberty Heights	7.50%
McKnight	12.50%
Memorial Square	10.37%
Metro Center	10.30%
Old Hill	11.30%
Pine Point	8.90%
Six Corners	11.70%
Sixteen Acres	8.90%
South End	10.90%
Upper Hill	10.10%
Springfield	9.80%
Pioneer Valley	8.30%
Massachusetts	7.80%

Table 12. Low Birth Weight Percentage[20]

Low Birth Weight is a complex but important public health factor that often reflects a difficult pregnancy. Causes include poor nutrition, substance abuse, or inadequate Prenatal Care. The reason why Low Birth Weight is one of the health factors is because Low Birth Weight could potentially leads to serious physical or mental health complications for a baby. Consequently, it reflects both the present and future health of Springfield's population. According to Massachusetts Department of Health, a newborn weighing less than 2,500 grams is considered to have "Low Birth Weight." [21] The percentage of all Births that fall into this category is represented in this factor. The

[20] Pioneer Valley Planning Commission. Data Atlas By Neighborhoods: City of Springfield. Springfield: Pioneer Valley Planning Commission, 2014. Accessed February 2, 2015. http://www.pvpc.org/sites/default/files/Springfield%20Data%20Atlas%209-23-14-web-reduced.pdf

[21] "Department of Public Health", Massachusetts Department of Health and Human Services, Accessed February 2, 2015, http://www.mass.gov/eohhs/gov/departments/dph/

percent of babies of Low Birth Weight is determined by dividing the number of low (includes "very low") Birth Weight newborns by the total number of newborns.

Certain Neighborhoods in Springfield show an excessive percentage of newborns that are below a healthy weight. While a few Neighborhoods in Springfield, such as East Forest Park, East Springfield, and Liberty Heights had relatively low rates of Low Birth Weight newborns, a majority of Neighborhoods (11 out of 16) had rates exceeding 10%.

Neighborhoods	Asthma Rate	Infant Mortality	Low Birth Weight %
Bay	20.00%	0.96%	12.50%
Boston Road	20.70%	1.27%	8.90%
Brightwood	19.10%	N/A	10.37%
East Forest Park	13.55%	1.04%	5.20%
East Springfield	18.85%	1.71%	6.85%
Forest Park	19.38%	1.60%	11.20%
Indian Orchard	21.70%	2.42%	11.30%
Liberty Heights	16.05%	0.36%	7.50%
McKnight	22.30%	2.27%	12.50%
Memorial Square	24.95%	N/A	10.37%
Metro Center	22.80%	N/A	10.30%
Old Hill	16.90%	1.25%	11.30%
Pine Point	21.95%	1.27%	8.90%
Six Corners	3.80%	N/A	11.70%
Sixteen Acres	21.61%	0.89%	8.90%
South End	N/A	N/A	10.90%
Upper Hill	3.00%	3.79%	10.10%
Springfield	17.20%	0.92%	9.80%
Pioneer Valley	13.50%	0.59%	8.30%
Massachusetts	10.90%	0.44%	7.80%

Table 13. Summarized Data for the Existing Springfield Health Data[22]

Table 13 above displays the results of the collected Springfield health data from the different sources within the City.

[22] Pioneer Valley Planning Commission. Data Atlas By Neighborhoods: City of Springfield. Springfield: Pioneer Valley Planning Commission, 2014. Accessed February 2, 2015. http://www.pvpc.org/sites/default/files/Springfield%20Data%20Atlas%209-23-14-web-reduced.pdf

CHAPTER V

EXISTING URBAN TREE CANOPY DATA

A. ReGreen Springfield

ReGreen Springfield is a local organization that assists in planting new trees in the 17 different Springfield Neighborhoods. Through their tree advocacy efforts, ReGreen Springfield has collaborated with businesses, community organizations, educational partners and government agencies to promote the reforestation of Springfield, improve growing conditions for trees and engage new allies in tree care and monitoring.[23] ReGreen Springfield realizes that strength of our City is found in the Neighborhoods. They state on their website, "with that as the foundation for our work, we have embarked on an effort to partner with civic associations, religious institutions, businesses and other advocacy groups to assist in helping to 'regreen' the city."

B. US Forest Service

The US Forest Service is a multi-faceted agency that manages and protects 154 national forests and 20 grasslands in 44 States. The agency's mission is to sustain the health, diversity, and productivity of the nation's forests and grasslands to meet the needs of present and future generations.[24] Their experts provide technical and financial help to States and local government agencies, businesses, private landowners and work government-to-government with tribes to help protect and manage non-federal forest and associated range and watershed lands. They work through partnerships with public and private agencies that help to plant trees, improve trails, educate the public, and improve

[23] "Welcome to ReGreen Springfield!", ReGreen Springfield, accessed February 18, 2015, http://regreenspringfield.com/
[24] "About the Agency", US Forrest Service, accessed February 18, 2015, http://www.fs.fed.us/

conditions in wild land/urban interfaces and rural areas. Gifford Pinchot, the first Chief of the Forest Service, summed up the mission of the Forest Service: "to provide the greatest amount of good for the greatest amount of people in the long run."

C. i-tree Software Toolkit

i-Tree is a state-of-the-art, peer- reviewed software suite from the US Forest Service that provides urban and community forestry analysis and benefits assessment tools.[25] The i-Tree tools help communities of all sizes to strengthen their urban forest management and advocacy efforts by quantifying the environmental services that trees provide and the structure of the urban forest. i-Tree has been used by communities, non-profit organizations, consultants, volunteers, and students to report on the urban forest at all scales from individual trees, parcels, neighborhoods, cities, to entire States.

D. i-Tree Canopy

The i-Tree tool offers an easy way to produce a statistically valid estimate of land cover types (e.g., tree cover) using aerial images available in Google Maps. Urban forest managers to estimate tree Canopy cover, set Canopy goals and monitor Canopy changes over time can use Urban Tree Canopy information.

E. Tree Canopy Goals

Tree Canopy is defined as the layer of leaves, branches, and stems of trees that cover the ground when viewed above. Tree Canopy provides many benefits to communities by improving water quality, saving energy, lowering City temperatures, reducing air pollution, enhancing property value, providing wildlife habitat, facilitating social and

[25] ReGreen Springfield. i-Tree Canopy Assessment of Springfield Neighborhoods. Amherst: US Forest Service, 2014

educational opportunities and providing aesthetic benefits. Establishing a Tree Canopy goal has many crucial aesthetic benefits. Establishing a Tree Canopy goal is crucial for communities seeking to improve their Green Infrastructure and environment quality. A Tree Canopy assessment is the first step in this goal setting process, providing estimates for the amount of Tree Canopy currently present in a City as well as the amount of Tree Canopy that could theoretically be established.

F. The i-tree Canopy Assessment Report

The Tree Canopy cover in the 17 Neighborhoods of Springfield, Massachusetts was examined in their report, and a summary of the percent Tree Canopy within each community was established, using i-Tree software. Additionally, the area of Tree Canopy, in acres in each Neighborhood was determined using the i-Tree toolkit. This study was completed in the middle of the year 2014 and provided the City's Forestry Division with a baseline measure of Springfield's Tree Canopy, as it moves toward establishing Tree Canopy goals for the next decade. Additionally, the comparison of Neighborhood tree cover provides useful information that will assist in targeting new tree planting efforts across the City.

G. Process of Collecting the Current Urban Tree Canopy Data

In order to collect the Urban Tree Canopy data, the City of Springfield's Forestry Division was contacted and they provided multiple reports that document the percentage measured in the 17 different Neighborhoods. A partnership of ReGreen Springfield, US Forest Service, and the local employees of the Springfield Forestry Division completed the final report that was used in this thesis.

H. Existing Data

A partnership between the US Forest Service and the Department of Environmental Conservation collected and created a report that displayed their findings. The Urban Tree Canopy Assessment for Massachusetts 10 Largest Communities report was meant to assess Urban Tree Canopy cover for the State of Massachusetts and to assess how overall the State of Massachusetts is doing at different health and tree biodiversity goals. Table 14 & 15 below display the finding that was collected and displayed.

City Rank	City	Total Area (Sq. Mi)	Population
1	Boston	48.8	645,966
2	Worcester	38.44	182,544
3	**Springfield**	**33.07**	**153,703**
4	Lowell	14.52	108,861
5	Cambridge	6.65	107,289
6	New Bedford	20.2	95,078
7	Brockton	21.4	94,089
8	Quincy	17.2	93,494
9	Lynn	11.5	91,589
10	Fall River	38.5	88,687

Table 14. Area and Population[26]

Table 14 above is sorted by the category of total population as the City of Springfield has the third largest population. While Springfield has the third largest population, it also has the fourth largest total area at 33.07 Square Miles.

[26] ReGreen Springfield. Urban Tree Canopy (UTC) Assessment for Massachusetts 10 Largest Communities. Amherst: US Forest Service, 2014.

City Rank	City	Canopy Cover %	Report by Area (Sq. Mi)
1	Boston	27.9	13.90
2	Worcester	39.3	14.10
3	**Springfield**	**36.7**	**11.80**
4	Lowell	31.0	4.59
5	Cambridge	34.0	2.08
6	New Bedford	32.8	6.58
7	Brockton	45.9	9.88
8	Quincy	43.1	7.21
9	Lynn	40.5	4.58
10	Fall River	59.3	18.70

Table 15. Canopy Cover Percentage[27]

The City of Springfield was recorded at having 36.7% of the land covered by Urban Tree Canopy above in Table 15. The City of Springfield ranked 6th among the 10 major cities that were part of the Urban Tree Canopy Assessment for Massachusetts Cities study. The City of Springfield contains 11.80 reported square miles of Urban Tree Canopy in results of the i-tree data part of the US Forest report. Similar to the i-tree Canopy work that was completed for the 10 major cities in the State of Massachusetts, the US Forest Service also completed the same type of project for the 17 different Springfield Neighborhoods.

[27] ReGreen Springfield. Urban Tree Canopy (UTC) Assessment for Massachusetts 10 Largest Communities. Amherst: US Forest Service, 2014.

City	Green Space %	Green Space (Sq. Mi)
Boston	17.50%	8.54
Worcester	11.37%	4.37
Springfield	**13.46%**	**4.45**
Lowell	12.95%	1.88
Cambridge	15.64%	1.04
New Bedford	20.40%	4.12
Brockton	10.84%	2.32
Quincy	36.16%	6.22
Lynn	25.22%	2.9
Fall River	41.97%	16.16

Table 16. Statewide Green Space Percentages[28]

Table 16 above is also sorted by the total population. The data was calculated in QGIS by me using the analysis tools. The Cities that have the largest amount of Green Space are Fall River, Quincy, and Lynn. The Cities that have the smallest Green Space are Brockton, Worchester, and Lowell. One of the reasons for these results is that some of the Cities are much larger than others. For example, Boston is the largest City in square miles and you would not expect the City to have the largest amount of Green Space.

The City of Springfield has the 7th largest amount of Green Space compared to the other 10 major cities that were discussed in the study. Fall River had the largest percentage of Green Space at 41.97%, while Brockton had the smallest at 10.84%. In regards of square miles of Green Space, Springfield has the fourth largest amount within the 10 different cities. You would expect that a smaller City might have a larger percentage of Green Space because they might have a portion set aside for natural protection. Second, where the City is located geographically is important to note how much Green Space is found within the City boundaries. This is the case for the City of Fall River because most of the population of the City of Fall River is located together and there is a large segment of Green Space that is found on the east segment of the City.

[28] Office of Geographic Information (MassGIS), Commonwealth of Massachusetts, MassIT, 2015.

Neighborhoods	Canopy Cover %	Area Cover (Sq. Mi)
Bay	26.75%	0.29
Boston Road	44.00%	1.02
Brightwood	20.00%	0.12
East Forest Park	30.70%	0.86
East Springfield	17.30%	0.54
Forest Park	41.30%	1.45
Indian Orchard	30.20%	0.77
Liberty Heights	28.00%	0.77
McKnight	11.40%	0.07
Memorial Square	9.30%	0.05
Metro Center	6.70%	0.06
Old Hill	15.90%	0.08
Pine Point	29.30%	0.71
Six Corners	13.30%	0.07
Sixteen Acres	50.00%	4.04
South End	13.30%	0.06
Upper Hill	12.00%	0.08

Table 17. iTree Canopy Analysis[29]

Canopy cover is important for economic and ecological reasons and that those are some of the reason why many different organizations in Springfield are studying and recording data on the different amounts. The Neighborhoods that have the largest percentage of Canopy cover are Sixteen Acres, Boston Road, Forest Park, East Forest Park, and Indian Orchard. It is important to note that the bigger Neighborhoods are the Neighborhoods that were found to have the larger amount of tree Canopy. For example, the Sixteen Acres Neighborhood contains about 50% of tree Canopy. One reason for this is that the lot sizes in these Neighborhoods are large enough to contain a large amount tree Canopy on each lot. In Neighborhoods such as Six Corners, the houses are closer together and this causes less room for the Urban Tree Canopy to be located.

[29] ReGreen Springfield. i-Tree Canopy Assessment of Springfield Neighborhoods. Amherst: US Forest Service, 2014.

Neighborhoods	Green Space %	Green Space (Sq. Mi)
Bay	39.61%	0.4317
Boston Road	5.71%	0.0879
Brightwood	9.41%	0.0762
East Forest Park	8.70%	0.2400
East Springfield	2.72%	0.0884
Forest Park	27.77%	1.2220
Indian Orchard	6.52%	0.1799
Liberty Heights	11.34%	0.3414
McKnight	2.06%	0.0144
Memorial Square	2.07%	0.0146
Metro Center	4.31%	0.0453
Old Hill	2.30%	0.0122
Pine Point	12.47%	0.3143
Six Corners	15.46%	0.0881
Sixteen Acres	13.66%	1.2320
South End	3.67%	0.0202
Upper Hill	6.01%	0.0439

Table 18. Green Space Percentage[30]

The Green Space included in this data set includes parks, cemeteries, conservation land, and Elementary School yards. This Green Space that was calculated was only for public Green Space and private Green Space was left out in this analysis. The Green Space percentage was also calculated myself by analyzed the statewide open space data layer in QGIS. The Neighborhoods that have the largest percentage of Green Space are Bay, Forest Park, Six Corners, and Pine Point. The Neighborhoods that have the least amount of Green Space are McKnight, Memorial Square, Old Hill, and East Springfield.

[30] Office of Geographic Information (MassGIS), Commonwealth of Massachusetts, MassIT, 2015.

Neighborhoods	Environmental Friendly Transportation
Bay	23.10%
Boston Road	11.60%
Brightwood	28.30%
East Forest Park	10.45%
East Springfield	19.01%
Forest Park	20.17%
Indian Orchard	14.77%
Liberty Heights	25.28%
McKnight	19.60%
Memorial Square	35.98%
Metro Center	42.18%
Old Hill	21.90%
Pine Point	17.59%
Six Corners	33.13%
Sixteen Acres	10.54%
South End	45.90%
Upper Hill	25.80%
Springfield	20.80%
Pioneer Valley	16.02%
Massachusetts	23.80%

Table 19. Environmental Friendly Transportation[31]

Driving to work by single occupancy vehicle is one of the major causes of air pollution. Unsustainable Greenhouse Gas (GHG) emissions are released by traffic congestion, a rush hour familiarity. The portion of residents that use "Environmentally Friendly" modes of Transportation during their commute is a key component in evaluating how well the region's population is moving away from environmentally harmful modes, which helps to reduce GHG emissions. "Environmentally Friendly" Transportation options are defined as carpooling, buses, bicycling, or walking.

[31] Pioneer Valley Planning Commission. Data Atlas By Neighborhoods: City of Springfield. Springfield: Pioneer Valley Planning Commission, 2014. Accessed February 2, 2015. http://www.pvpc.org/sites/default/files/Springfield%20Data%20Atlas%209-23-14-web-reduced.pdf

Alternatively, this indicator can illuminate possible issues regarding vehicular congestion, parking availability, air quality, and the ability to walk or bike. The percentage of all residents who utilize one of these "Environmentally Friendly" methods to commute to work is reflected in this factor. In Massachusetts during 2012, 23.8% of those surveyed reported that they utilized sustainable modes during their commute. Regionally, only 16% of the population in the Pioneer Valley commutes in an environmentally friendly manner.

In the City of Springfield, reported that 20.8% of City residents used sustainable travel during their commute in 2012. When examined closely in 2012, there are divergences at the Neighborhood level, which may suggest major differences in Neighborhood walkability or access to transit. For example, the South End, Metro Center, Memorial Square, and Six Corners all exhibited robust commuting habits with approximately twice as many residents utilizing sustainable modes of transport. In contrast, East Forest Park, Sixteen Acres, Boston Road, and Indian Orchard reported a much higher majority of residents commuting in single occupancy vehicles. This reported data though, remain only slightly below those of the City and the region. The Neighborhoods that are closer to the downtown area are the Neighborhoods that exhibit the most sustainable modes of transportation.

CHAPTER VI

DATA ANALYSIS

The data analysis process consists of importing the collected data that I have gathered from the multiple organizations across the City of Springfield's resources. I used the data program SSPS to accomplish the task of analyzing the data. I had assistance from ISSR at UMass with the analysis process and what types of statistical test I should run for the limited data set. The testing process was to discover from the data set if there were correlations between Urban Tree Canopy and the health factors. The t-test in this analysis was testing if the data showed correlation between the different factor and they were not testing or explaining the causality of those factors. A regression was not conducted in this analysis process because of the size of the data set. My main focus was to test if there were significant differences between the amount of Green Space and Urban Tree Canopy in the 17 different Neighborhoods.

I conducted t-square tests to determine if there were significant differences amount between the different independent and dependent variables. I expanded looking at other factors such as Median Income, Racial Ethnicity, and Home Ownership Rates. The method of how I analyzed in using t-square were by first dividing the upper and lower groups by the mean of the independent variable. This first step helped to find where the information was about even. There were some different data split due to some of the collective data having missing information for multiple Neighborhoods. The even split helped to produce better results based on the specific data. This different collective data was present for the categories of Density, Asthma Rate, and Infant Mortality. The Group Statistics and Independent Sample Test tables for the variables that were tested are

located in Appendix B at the end. Some of the t-test that was run was formed from my research questions and others test were formed from research that I reviewed in the Literature Review.

A. Urban Tree Canopy Links to Asthma Rate, Infant Mortality, and Low Weight

An independent-samples t-test was conducted of the amount of Urban Tree Canopy to the health factors of Asthma Rate, Infant Mortality and Low Birth Weight. When reading the results below, M= Mean, SD= Standard Deviation, t= the test value, and p= the p value. There were no significant differences in the amount of Asthma Rate in Neighborhoods that have more than 26.7% Urban Tree Canopy (Mean=.193, SD=.030) and Neighborhoods that have less than 26.7% of Urban Tree Canopy (M=.164, SD=.084) conditions; $t(14)=.915$, $p = 0.376$. These results suggest that Urban Tree Canopy in this instance does not have a significant effect on the Asthma Rate within the different Neighborhoods.

There were no significant differences of Infant Mortality Rate in Neighborhoods that have more than 26.7% Urban Tree Canopy (M=.112 SD=.006) and Neighborhoods that have less than 26.7% of Urban Tree Canopy (M=.225, SD=.011) conditions; $t(10)=2.13$, $p = 0.059$. These results suggest that Urban Tree Canopy also does not have a significant effect on the Infant Mortality Rate within the different Neighborhoods.

There were no significant differences in of the Low Birth Weight in Neighborhoods that have more than 26.7% Urban Tree Canopy (M=.093 SD=.023) and Neighborhoods that have less than 26.7% of Urban Tree Canopy (M=.104, SD=.015) conditions; $t(15)=1.24$ $p =.234$. These results suggest that Urban Tree Canopy does not have a significant effect on the Low Birth Weight within the different Neighborhoods.

Overall, the Urban Tree Canopy percentage from the collected data does not show significant health benefit from what I originally had thought. The small sample size of the raw data could have affected the non-significant results between the factors that were not part of the research. More data would be needed to be included to make any claims at significant between the Urban Tree Canopy percentage and the health factors.

B. Green Space Links to Asthma Rate, Infant Mortality, and Low Birth Weight

An independent-samples t-test was conducted of the amount of Green Space to the health factors of Asthma Rate, Infant Mortality and Low Birth Weight. There were no significant differences in the amount of Asthma Rate in Neighborhoods that have more than 9.4% Green Space (M=.174 SD=.063) and Neighborhoods that have less than 9.4% of Green Space (M=.183, SD=.066) conditions; $t(14)=.272$, $p = 0.790$. These results suggest that Green Space in this instance does not have a significant effect on the Asthma Rate within the different Neighborhoods.

There were significant differences in the Rate of Infant Mortality in Neighborhoods that have more than 9.4% Green Space (M=.010 SD=.004) and Neighborhoods that have less than 9.4% of Green Space (M=.019, SD=.009) conditions; $t(10)=2.02$, $p = 0.049$ (unequal variance assumed). When the Infant Mortality Rate goes up, Green Space percentage goes down. This is a negative correlation. These results suggest that Green Space is significantly related to the Infant Mortality Rate within the different Neighborhoods.

There were no significant differences in of the Low Birth Weight in Neighborhoods that have more than 9.4% Green Space (M=.101 SD=.017 and Neighborhoods that have less than 9.4% of Green Space (M=.097, SD=.022) conditions;

t(15)=.375 p = .713 These results suggest that Green Space does not have a significant effect on the Low Birth Weight within the different Neighborhoods. Overall, the Green Space percentage from the data I collected does not show significant health benefits.

C. Median Household Income Links to Asthma Rate, Infant Mortality, and Low Birth Weight

An independent-samples t-test was conducted of Median Household Income compared to Asthma Rate, Infant Mortality and Low Birth Weight. There were no significant differences in the amount of Asthma Rate in Neighborhoods that have households that earn more than $33,060 (M=.174 SD=.061) and Neighborhoods have households that earn less than $33,060 (M=.185, SD=.070) conditions; t(14)=.344, p = 0.736. These results suggest that Median Household Income in this instance does not have a significant effect on the Asthma Rate within the different Neighborhoods.

There were no significant differences in the Infant Mortality Rate in Neighborhoods that have households that earn more than $33,060 M=.015 SD=.010) and Neighborhoods have households that earn less than $33,060 (M=.014, SD=.006) conditions; t(10)=.160, p = .876. These results suggest that Median Household Income does not have a significant effect on the Infant Mortality Rate within the different Neighborhoods.

There were significant differences in of the Low Birth Weight in Neighborhoods that have households that earn more than $33,060 (M=.087 SD=.020) and Neighborhoods have households that earn less than $33,060 (M=.112, SD=.009) conditions; t(15)=3.25, p = .006. These results suggest that Median Household Income does have a significant effect on the Low Birth Weight within the different Neighborhoods. When the Median Household Income goes up, the Low Birth Weight goes down. This is a negative

correlation. Residents who have higher Median Household Income are the families that will have more money to spend in the process of raising a family.

D. Income Inequality Links to Low Birth Weight

An independent-samples t-test was conducted of Income Inequality compared to Low Birth Weight. There were significant differences in the amount of Low Birth Weight in Neighborhoods that have Income Inequality greater than 45.76%, (M=.112 SD=.009) and Neighborhoods that have Income Inequality less than 45.76% (M=.087, SD=.019) conditions; t(15)=3.419, p = 004. When the Income Inequality percentage goes up, the Low Birth Weight percentage also goes up. This is a positive correlation. These results suggest that the Income Inequality percentage in this instance does have a significant effect on the Low Birth Weight within the different Neighborhoods.

E. White Demographics Links to Asthma Rate, Infant Mortality, and Low Birth Weight

An independent-samples t-test was conducted of White residents compared to Asthma Rate, Infant Mortality and Low Birth Weight. There were no significant differences in the amount of Asthma Rate in Neighborhoods have a percentage of White residents greater than 47.1%, (M=.193 SD=.031) and Neighborhoods that have a percentage of White residents less than 47.1% (M=.165, SD=.084) conditions; t(14)=.890, p = .389. These results suggest that percentage of White residents in this instance does not have a significant effect on the Asthma Rate within the different Neighborhoods.

There were no significant differences of the Infant Mortality Rate in Neighborhoods have a percentage of White residents greater than 47.1%, (M=.132

SD=.006) and Neighborhoods that have a percentage of White residents less than 47.1% (M=.019, SD=.011) conditions; t(10)=1.10, p = .294.

There were significant differences of the Low Birth Weight in Neighborhoods that have a percentage of White residents greater than 47.1%, (M=.087 SD=.021) and Neighborhoods that have a percentage of White residents less than 47.1% (M=.109, SD=.011) conditions; t(15)=2.63, p = .019. The higher percentages of Neighborhoods that have White residents are in Neighborhoods that have the lower amount of Low Birth Weight. When the percentage of White residents goes up, the Low Birth Weight goes down. This is a negative correlation.

F. Black Demographics Links to Asthma Rate, Infant Mortality, and Low Birth Weight

An independent-samples t-test was conducted of Black residents compared to Asthma Rate, Infant Mortality and Low Birth Weight. There were no significant differences in the amount of Asthma Rate in Neighborhoods have a percentage of Black residents greater than 24.5%, (M=.164 SD=.0825) and Neighborhoods that have a percentage of Black residents less than 24.5% (M=.193, SD=.035) conditions; t(14)=.936, p = .365. These results suggest that percentage of Black residents in this instance does not have a significant effect on the Asthma Rate within the different Neighborhoods.

There were no significant differences of the Infant Mortality Rate in Neighborhoods have a percentage of Black residents greater than 24.5%, (M=.018 SD=.010) and Neighborhoods that have a percentage of Black residents less than 24.5% (M=.013, SD=.007) conditions; t(10)=.880, p = .399.

There were no significant differences of the Low Birth Weight in Neighborhoods that have a percentage of Black residents greater than 24.5%, (M=.107 SD=.014) and

Neighborhoods that have a percentage of Black residents less than 47.1% (M=.091, SD=.0.021) conditions; t(15)=1.74, p = .102. Overall, there were no significant differences measured between the percentage of Black residents and the three health factors.

G. Hispanic Demographics Links to Asthma Rate, Infant Mortality, and Low Birth Weight

An independent-samples t-test was conducted of Hispanic residents compared to Asthma Rate, Infant Mortality and Low Birth Weight. There were no significant differences in the amount of Asthma Rate in Neighborhoods have a percentage of Hispanic residents greater than 41.8%, (M=.172 SD=.074) and Neighborhoods that have a percentage of Hispanic residents less than 41.8% (M=.183, SD=.059) conditions; t(14)=.308, p = .762. These results suggest that the percentage Hispanic resident in this instance does not have a significant effect on the Asthma Rate within the different Neighborhoods.

There were no significant differences of the Infant Mortality Rate in Neighborhoods have a percentage of Hispanic residents greater than 41.8%, (M=.008. SD=.006) and Neighborhoods that have a percentage of Hispanic residents less than 41.8% (M=.017, SD=.008) conditions; t(10)=.1.35, p = .205.

There were no significant differences of the Low Birth Weight in Neighborhoods that have a percentage of Hispanic residents greater than 41.8%, (M=.103 SD=.013) and Neighborhoods that have a percentage of Hispanic residents less than 47.1% (M=.096, SD=.0.023) conditions; t(15)=.712, p = .487.

H. Density Links to Low Birth Weight

An independent-samples t-test was conducted of Density compared to Low Birth Weight. Density in this instance is defined as number of people per square area. There were significant differences in the amount of Low Birth Weight in Neighborhoods that have Density greater than 6,879 people, (M=.109 SD=.008) and Neighborhoods that have Density less than 6,879 people (M=.087, SD=.023) conditions; t(14)=2.515, p = .025. These results suggest that Low Birth Weight in this instance does have a significant effect on the Density within the different Neighborhoods. When the amount of amount of Density goes up, the Low Birth Weight Rate also goes up. This is a positive correlation.

I. Median Household Income Links to Green Space and Urban Tree Canopy

An independent-samples t-test was conducted of Median Household Income compared to Green Space and Urban Tree Canopy. There were no significantly different in the amount of Green Space in Neighborhoods that have households that earn more than $33,060 (M=.105 SD=.073) and Neighborhoods have households that earn less than $33,060 (M=.098, SD=.128) conditions; t(15)=.136, p = 0.894. These results suggest that Median Household Income in this instance does not have a significant effect on the Green Space within the different Neighborhoods.

There were significant differences in the amount of Urban Tree Canopy in Neighborhoods that have households that earn more than $33,060 (M=.314 SD=.122) and Neighborhoods have households that earn less than $33,060 (M=.145, SD=.063) conditions; t(15)=3.49, p = 0.003. It does show that Median Household Income does have a significant effect on the amount of Urban Tree Canopy that is found in the different

neighborhood. When the Median Household Income goes up, the amount of Urban Tree Canopy also goes up. This is a positive correlation. This t-test confirms my initial hypothesis that was based on the literature on environmental justice.

J. Income Inequality Links to Urban Tree Canopy

An independent-samples t-test was conducted of Income Inequality compared to Urban Tree Canopy. There were significant differences in the amount of Urban Tree Canopy in Neighborhoods that have Income Inequality greater than 45.76%, (M=.116 SD=.085) and Neighborhoods that have Income Inequality less than 45.76% (M=.295, SD=.136) conditions; $t(15)=2.32$, $p = .036$. These results suggest that the Urban Tree Canopy percentage in this instance does have a significant effect on the Income Inequality within the different Neighborhoods. When the percentage of Income Inequality goes up, the amount of Urban Tree Canopy goes down. This is a negative correlation. This is expected because of the significant differences between Urban Tree Canopy and Median Household Income.

K. White Demographics Links to Green Space and Urban Tree Canopy

An independent-samples t-test was conducted of the percentage of White residents compared to Green Space and Urban Tree Canopy. There were no significant differences in the amount of Green Space in Neighborhoods that have a percentage of White residents greater than 47.1%, (M=.100 SD=.080) and Neighborhoods that have a percentage of White residents less than 47.1% (M=.103, SD=.120) conditions; $t(15)=.050$, $p =.961$ These results suggest that the percentage of White residents in this instance does not have a significant effect on the Green Space within the different Neighborhoods.

There were significant differences in the amount of Urban Tree Canopy in Neighborhoods that have a percentage of White residents greater than 47.1%, (M=.310 SD=.142) and Neighborhoods that have a percentage of White residents less than 47.1% (M=.168, SD=.070) conditions; t(15)=2.65, p = .018. When the percentage of White residents goes up, the percentage of Urban Tree Canopy also goes up. This is a positive correlation. These results suggest that the percentage of White residents in this instance does have a significant effect on the percentage of Urban Tree Canopy within the different Neighborhoods. This demonstrates that the percentage of White residents in the different Neighborhoods does make an impact on where there are higher amounts of Urban Tree Canopy. This is connected to the early significant differences of the percentage of White residents and Low Birth Weight.

M. Black Demographics Links to Green Space and Urban Tree Canopy

An independent-samples t-test was conducted of the percentage of Black residents compared to Green Space and Urban Tree Canopy. There were no significant differences in the amount of Green Space in Neighborhoods that have a percentage of Black residents greater than 24.5%, (M=.109 SD=.125) and Neighborhoods that have a percentage of Black residents less than 24.5% (M=.095, SD=.078) conditions; t(15)=.290, p = .776. These results suggest that the percentage of Black residents in this instance does not have a significant effect on Green Space within the different Neighborhoods.

There were no significant differences in the amount of Urban Tree Canopy in Neighborhoods that have a percentage of Black residents greater than 24.5%, M=.199 SD=.124) and Neighborhoods that have a percentage of Black residents less than 24.5% (M=.266, SD=.132) conditions; t(15)=1.08, p = .297. These results suggest that

percentage of Black residents in this instance does not have a significant effect on Urban Tree Canopy within the different Neighborhoods.

N. Hispanic Demographics Links to Green Space and Urban Tree Canopy

An independent-samples t-test was conducted of the percentage of Hispanic residents compared to Green Space and Urban Tree Canopy. There were no significant differences in the amount of Green Space in Neighborhoods that have a percentage of Hispanic residents greater than 41.1%, (M=.069 SD=.051) and Neighborhoods that have a percentage of Hispanic residents less than 41.1% (M=.125, SD=.120) conditions; $t(15)=1.14$, $p = .271$. These results suggest that the percentage of Hispanic resident in this instance does not have a significant effect on Green Space within the different neighborhoods.

There were significant differences in the amount of Urban Tree Canopy in Neighborhoods that have a percentage of Hispanic residents greater than 41.1%, (M=.152 SD=.070) and Neighborhoods that have a percentage of Hispanic residents less than 41.1% (M=.292, SD=.1321) conditions; $t(15)=2.56$, $p = .022$. These results suggest that the percentage of Hispanic residents in this instance does have a significant effect on Urban Tree Canopy within the different Neighborhoods. When the percentage of Hispanic residents goes down, the percentage of Urban Tree Canopy goes up. This is a negative correlation. The larger percentages of Hispanic residents in the Springfield live in Neighborhoods that have less than 41.1% of Urban Tree Canopy.

O. Home Ownership Rates Links to Green Space and Urban Tree Canopy

An independent-samples t-test was conducted of Home Ownership compared to Green Space and Urban Tree Canopy. There were no significant differences in the

amount of Green Space in Neighborhoods that have Home Ownership Rates greater than 43.3%, (M=.110 SD=.077) and Neighborhoods that have Home Ownership rates less than 43.3% (M=.090, SD=.121) conditions; t(15)=.311, p = .760. These results suggest that Green Space percentage in this instance does not have a significant effect on the Home Ownership Rate within the different Neighborhoods.

There were significant differences in the amount of Urban Tree Canopy in Neighborhoods that have Home Ownership Rates greater than 43.3%, (M=.315 SD=.130) and Neighborhoods that have Home Ownership rates less than 43.3% (M=.163, SD=.079) conditions; t(15)=2.99, p = .010. These results suggest that Urban Tree Canopy in this instance does have a significant effect on the Home Ownership Rate within the different Neighborhoods. When the Home Ownership rate goes up, the percentage of Urban Tree Canopy goes up. This is a positive correlation.

P. Environmental Transportation Links to Urban Tree Canopy

An independent-samples t-test was conducted of Environmental Transportations compared to Urban Tree Canopy. There were significant differences in the amount of Urban Trees in Neighborhoods that have Environmental Transportation greater than 23.10%, (M=.161 SD=.079) and Neighborhoods that have Environmental Transportation rates less than 23.10% (M=.300, SD=.133) conditions; t(15)=2.53, p = .022. These results suggest that Urban Tree Canopy percentage in this instance does have a significant effect on the Environmental Transportation within the different Neighborhoods. When the percentage of residents using Environmental Transportation goes up, then the percentage of Urban Tree Canopy goes down. This is a negative correlation.

Correlations Matrix					
	Asthma Rate	**Infant Mortality**	**Low Birth Rate**	**Urban Tree Canopy**	**Green Space**
Urban Tree Canopy	No	No	No	*	*
Green Space	No	Yes	No	*	*
Median Income	No	No	Yes	Yes	No
White	No	No	Yes	Yes	No
Black	No	No	No	No	No
Hispanics	No	No	No	Yes	No
Income Inequality	**	**	Yes	Yes	**
Density	**	**	Yes	No	No
Home Ownership	**	**	**	Yes	No
Environmental Transportation	**	**	**	Yes	No

Table 20. Correlation Matrix Results

* = Duplicate factor
** = No Correlation was discovered when the t-tests were conducted and this relationship between factors was not discussed in the Thesis Report

Q. Discussion

My research tried to evaluate if there were any correlations between urban tree canopy and the asthma rates, infant mortality rates, and low birth weight in the Springfield neighborhoods? From running the different correlations between these factors, the results didn't show any significant differences Is there a correlation between the amount of urban trees and the amount of median household income of the residents in the City of Springfield? The results of the analysis displayed a correlation between urban tree canopy and median household income. Does everyone really have the equal access to resources such as urban tree canopy and green space? From running the different t-test, the result indicated that there were correlations between the different percentages of White and Hispanic residents in relations to the amount of urban tree canopy. The analysis showed that there isn't equal access to green space and urban trees for many of the residents in these cities neighborhoods.

Are there environmental justice issues present in the City of Springfield? A few of the correlations results showed signs of environmental justice issues.

The Literature Review discussed social capital but its relations to the health of the residents in the neighborhoods were not discussed in depth. green space is part of social capital and that type of social bond was discussed briefly in the data that was collected.

What I expected to find in the end was that there would be clear correlations between urban tree canopy and the health factors of the residents in those neighborhoods. I did not run the t-test for causality, so the discussion of the results displayed the correlations between the different t-test. There was lack of data available at the neighborhood level and this made it hard find sufficient data that met my research needs. The need of providing more detail data at the neighborhood level would be helpful for future research studies in Springfield. In this research study of making connections of the percentage of urban tree canopy and the health factors, it was hard to control outside factors of the study. Some of these control factors were discussed in the Literature Review.

From running and analyzing the t-test, there were no clear correlations of urban tree canopy on the asthma rate and infant mortality, which could be a result from the small data set that was collected. There were clear correlations between the green space percentages and the infant mortality rate within the 17 different neighborhoods. What I actually discovered is that there are many environmental justice issues present within the different neighborhoods.

The t-test showed that there were correlations between the amount of median household income and the amount of urban tree canopy present in the neighborhoods.

This becomes a planning problem because the residents in all of the neighborhoods do not have equal access to urban trees because of their median household income might not be high enough to afford to live in neighborhoods that have more urban tree canopy. There are other environmental justice issues that showed that larger percentages of Hispanic residents live in neighborhoods that have less than 41.8% of urban tree canopy, while the data showed the opposite trend for White residents in the same neighborhoods. The factor of the percentage of Black residents that live in the same neighborhoods did not show any clear correlation after the t-tests that were run.

Median household income also showed a correlation with the low birth weight. The median household income of the residents that earn more than $33,060 showed a correlation with the collected low birth weight percentages. It verified that the higher the income that the residents earn, the more money that can be spent to ensure that the newborn's weight is healthy. The t-test also confirmed that there were correlations between the amounts of income inequality between low birth weight and urban tree canopy. This is not really a surprise due to the t-test showing the significant differences between median household income and urban tree canopy. Furthermore, there was a correlation between home ownership and environmental transportation with urban trees. These correlations for were the major factors that helped form the argument for signs of environmental justice issues for the neighborhoods in Springfield.

In the literature, Cheng explains that the uneven distribution of urban trees is often the result of socioeconomic factors instead of ecological ones. This was seen in the results of the correlation between median household income and urban tree canopy in Springfield. Cheng's findings are that higher percentages of minority residents had

moderately more canopy cover may relate to the fact that in Boston some of the higher percentage minority neighborhoods are more distant from the high-density downtown which has fewer trees; and/or the resultant tree canopy could be the result of abandonment of property, which results in urban forests "regenerating" on vacant lots. This is true somewhat in the City of Springfield. The neighborhoods of McKnight, Upper Hill, Six Corners and Old Hill have more urban tree canopy than Metro Center and South End. There are also higher percentage of minorities in those neighborhoods compared to Metro Center and South End.

One lesson for urban planners from the results is that more research is needed to be done to fully understand how these current environmental justice issues that are affected by the correlation of multiple factors. Urban planners need to understand the issues in the City to help better plan the City for the future.

Another lesson for urban planners from the results of the thesis is that promoting the use green space and urban trees in future projects will benefit the residents' health and promotes walkability. In the case of Springfield, from the data that was collected, the Neighborhoods that have the most urban trees have the least amount of walkability. The neighborhoods that have the lowest amounts of urban trees in Springfield have the greater amounts of walkability. Springfield is a unique case because of the median household Income of the residents in the neighborhoods that have the greatest walkability.

R. Limitations

Some limitations of this thesis were that I was not able to find health data at the neighborhood scale that I originally wanted. I originally wanted to look into physical health data such as obesity and diabetes but that type of data is not available. I had to change what types of physical health to compare with urban tree canopy due to what types of data at the neighborhood level that were accessible for me to use. Because of the small data size, I wasn't able to run a regression of the data to further test the collected data.

It is important to note some of areas of health data were not directly addressed in the data set. In the Literature Review, I discussed physical and mental health as important factor at looking at public health compared to urban tree canopy. Obesity rates and Heart Diseases are difficult data to measure and find in existing data sets across Springfield at the neighborhood level. There is currently no data at the neighborhood level that measures those health factors. That is one reason, why I searched for other types of health data because they are were not existed and I didn't have the right resources at the time to collect the data.

Another problem in that case is that baseline health data that I used are not shared among the different organizations as much as they could or should be. Sharing and collaboration would cut down the amount of work and it would also aid new research that could tackle those missing holes that would help to make it assessable for all to use. One question that I have now is how can more sharing of knowledge and data be done across the City? For this thesis, I had to talk to multiple different organizations and people to collect different types of data and some of the data that I received from different

organizations could possibly come from one source if that information was shared within the organizations.

S. Recommendations

My first recommendation to offset this issue of environmental justice would be to invest in organization such as ReGreen Springfield and other organizations that promote neighborhood gathering of planting trees. It is the mission is to plant more trees in these neighborhoods that have lower median household income and fewer urban trees

My second recommendation is to establish a citywide database of baseline demographics and health data within the different organizations. This citywide database would support future research and the different working professionals in the City.

My third recommendation is for health organizations to conduct more health related research at the neighborhood level to fill the gap of missing data. Some examples of missing health data that would be helpful to be completed are obesity and diabetes rates.

My fourth recommendation is for the City of Springfield to encourage the need for more green space and urban trees with any new private or public development project. This would include the proposed MGM Casino. The City of Springfield should push for green space and urban trees when discussing this future development in the South End Neighborhood. These landscape elements help to shape the character of an area while improving public health.

CHAPTER VII

CONCLUSION

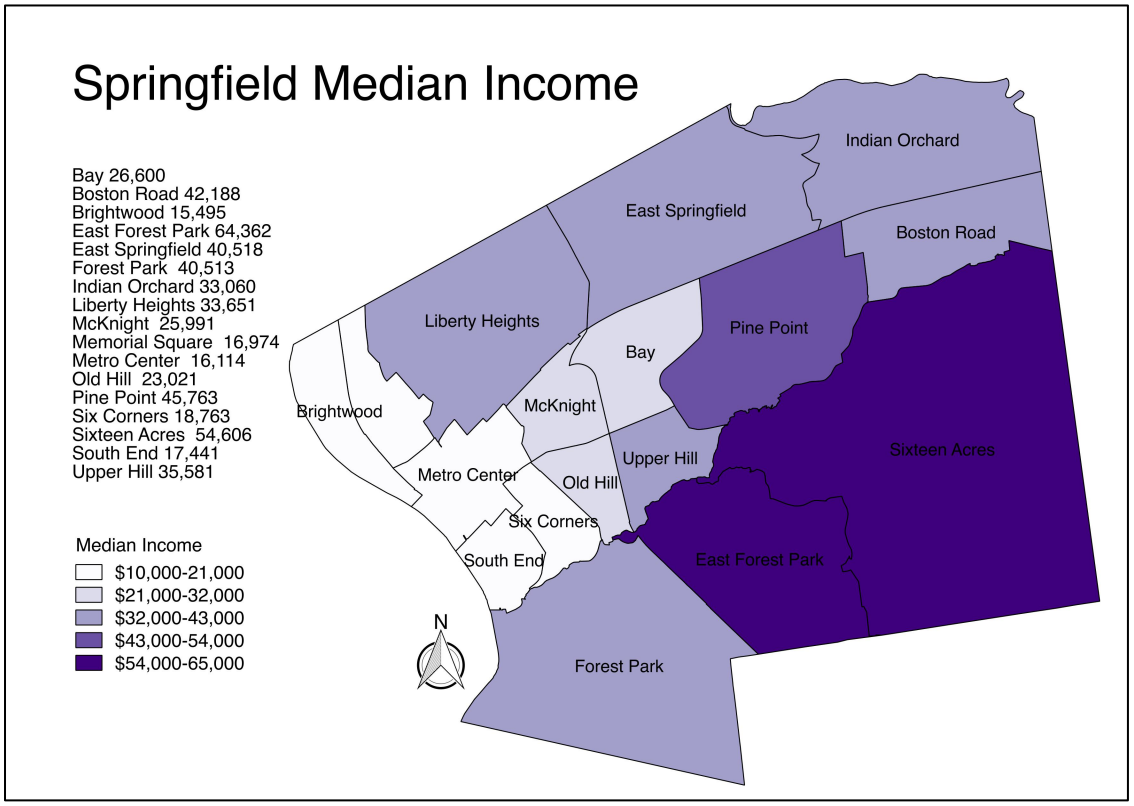
Revealing environmental justice issues were major outcomes from the t-test results. Urban tree canopy and median household income were two main factors that demonstrated environment justice issues in the City of Springfield Massachusetts. I originally thought that urban tree canopy would have significant impact on health factors of asthma rate, infant mortality, and low birth weight. From running the t-square test, there was not enough data to support a significant correlation between some of the factors. The lack of true heath data prevented me from analyzing more correlations between health factors and urban tree canopy. More data would be needed to fully rule out any non-significant factor. However, there were significant correlations between urban tree canopy and the factors of low birth weight, median household income, and environmental transportation. These factors and the other factors in the discussion section pointed out major environment justice issue claims that were indicated in some of the Literature Review but now are stronger supported from the t-test results.

For other Cities like Springfield additional research is needed to learn more about the relationship between public health and green space and urban tree canopy at the neighborhood level. Based on other research by Cheng et al 2014 and Heynen and Lindsey, there is much support for this connection for the residents in the City of Boston. However, specific studies are needed to look at these indicators in many situations. In cities like Springfield that have seen incredible shifts in racial, ethnic, and economic makeup, the connections between green space and health may be influenced by different

historic settlement patterns. Neighborhoods that were traditionally lower density and have more green space, or higher income are no longer that way which may skew the study results.

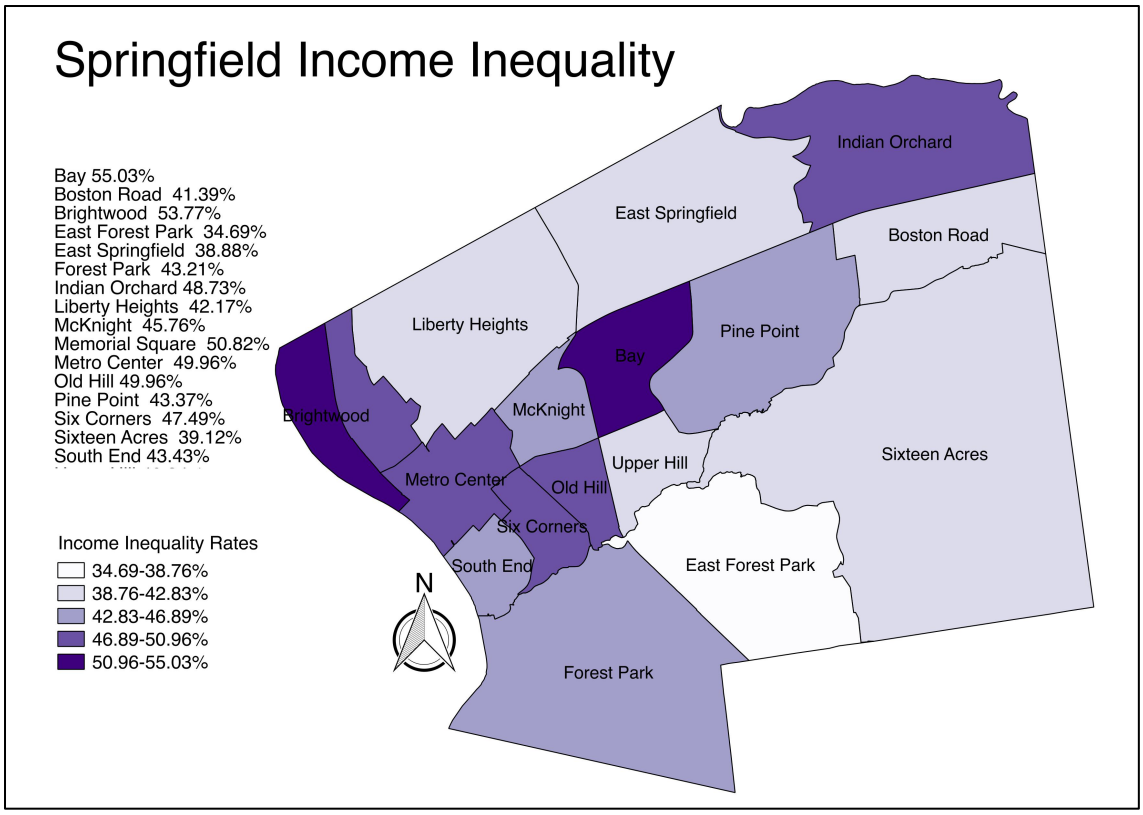
APPENDIX A

DISPLAYED RESEARCH



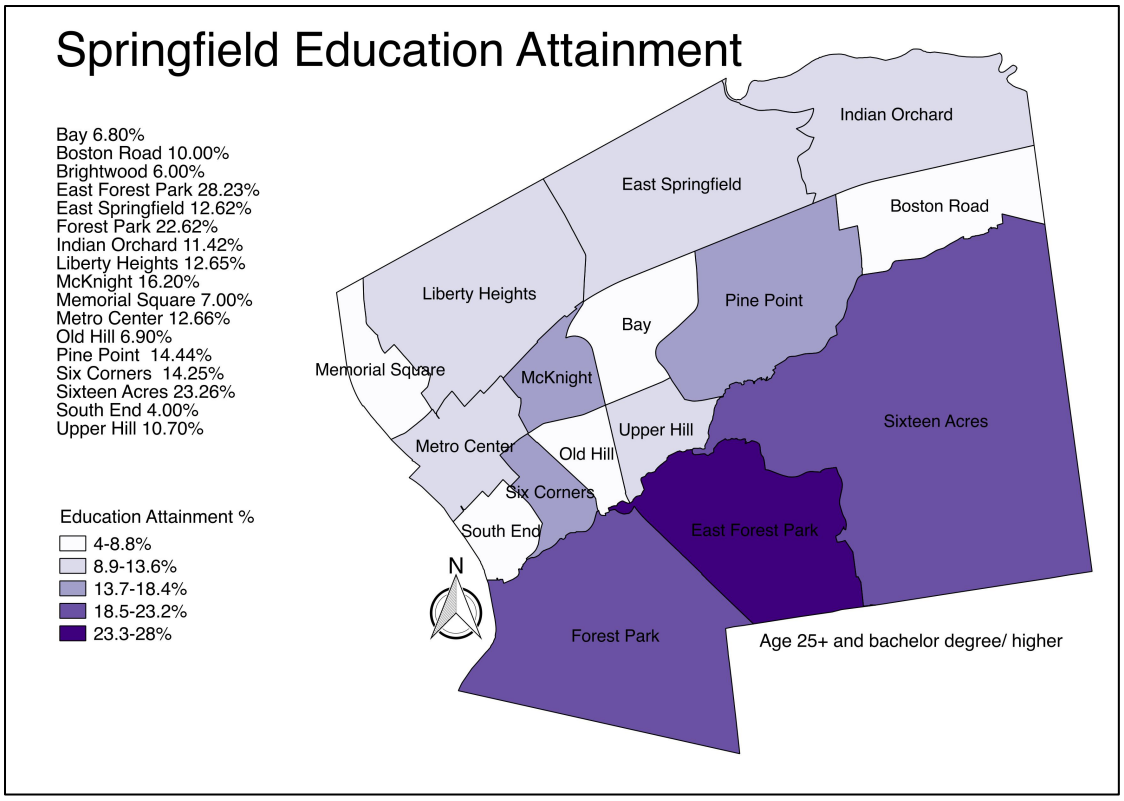
Map 1. Springfield Median Income[32]

[32] Pioneer Valley Planning Commission. Data Atlas By Neighborhoods: City of Springfield. Springfield: Pioneer Valley Planning Commission, 2014. Accessed February 2, 2015. http://www.pvpc.org/sites/default/files/Springfield%20Data%20Atlas%209-23-14-web-reduced.pdf



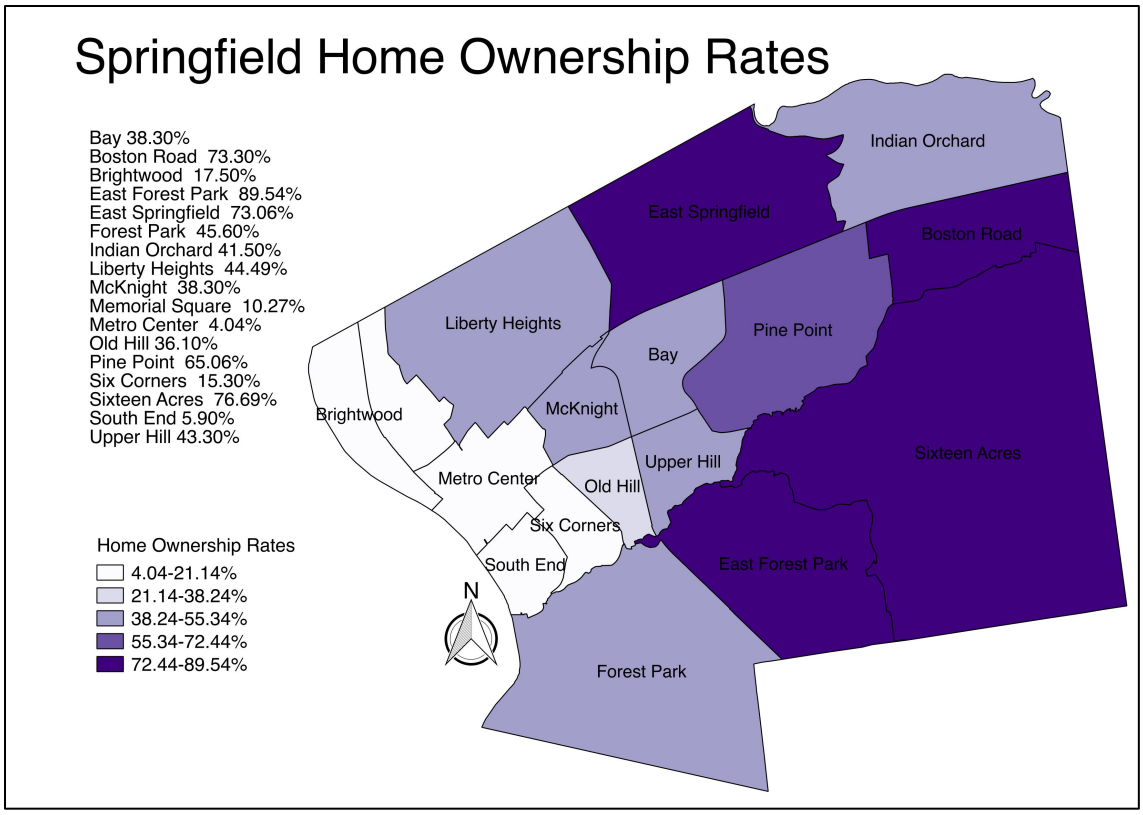
Map 2. Springfield Income Inequality[33]

[33] Pioneer Valley Planning Commission. Data Atlas By Neighborhoods: City of Springfield. Springfield: Pioneer Valley Planning Commission, 2014. Accessed February 2, 2015. http://www.pvpc.org/sites/default/files/Springfield%20Data%20Atlas%209-23-14-web-reduced.pdf



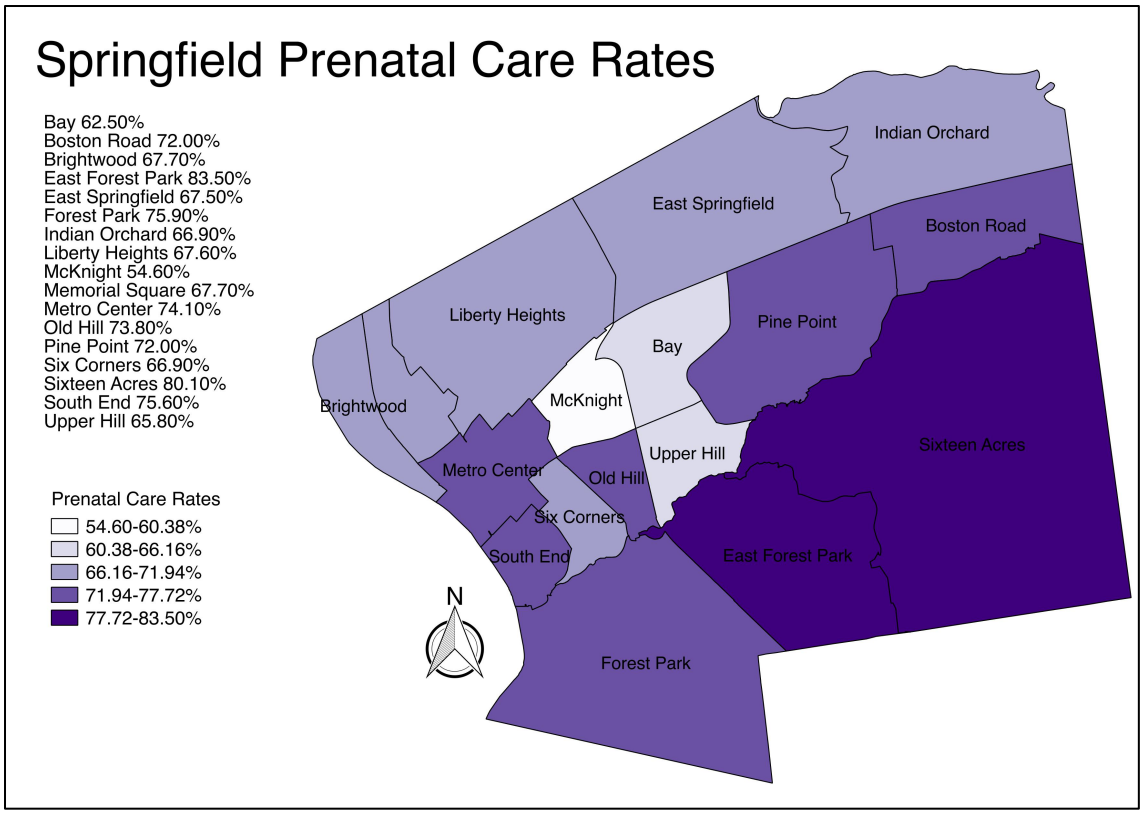
Map 3. Springfield Education Attainment[34]

[34] Pioneer Valley Planning Commission. Data Atlas By Neighborhoods: City of Springfield. Springfield: Pioneer Valley Planning Commission, 2014. Accessed February 2, 2015. http://www.pvpc.org/sites/default/files/Springfield%20Data%20Atlas%209-23-14-web-reduced.pdf



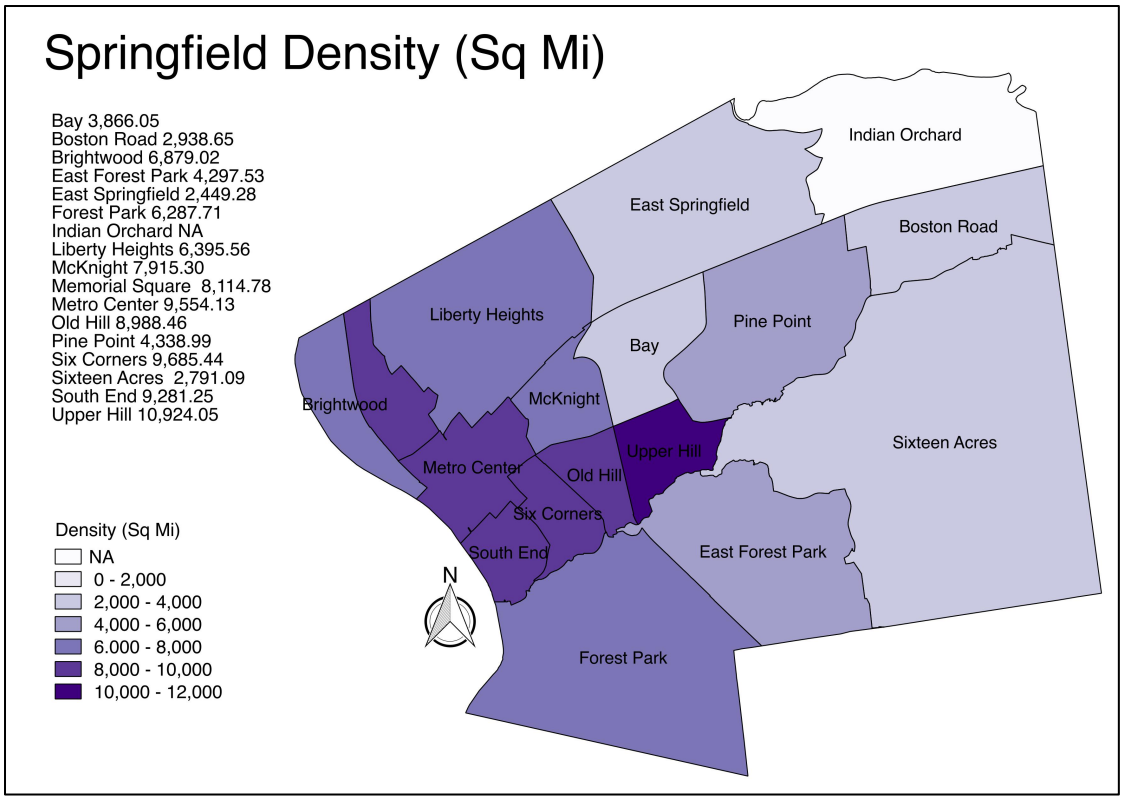
Map 4. Springfield Home Ownership Rates[35]

[35] Pioneer Valley Planning Commission. Data Atlas By Neighborhoods: City of Springfield. Springfield: Pioneer Valley Planning Commission, 2014. Accessed February 2, 2015. http://www.pvpc.org/sites/default/files/Springfield%20Data%20Atlas%209-23-14-web-reduced.pdf



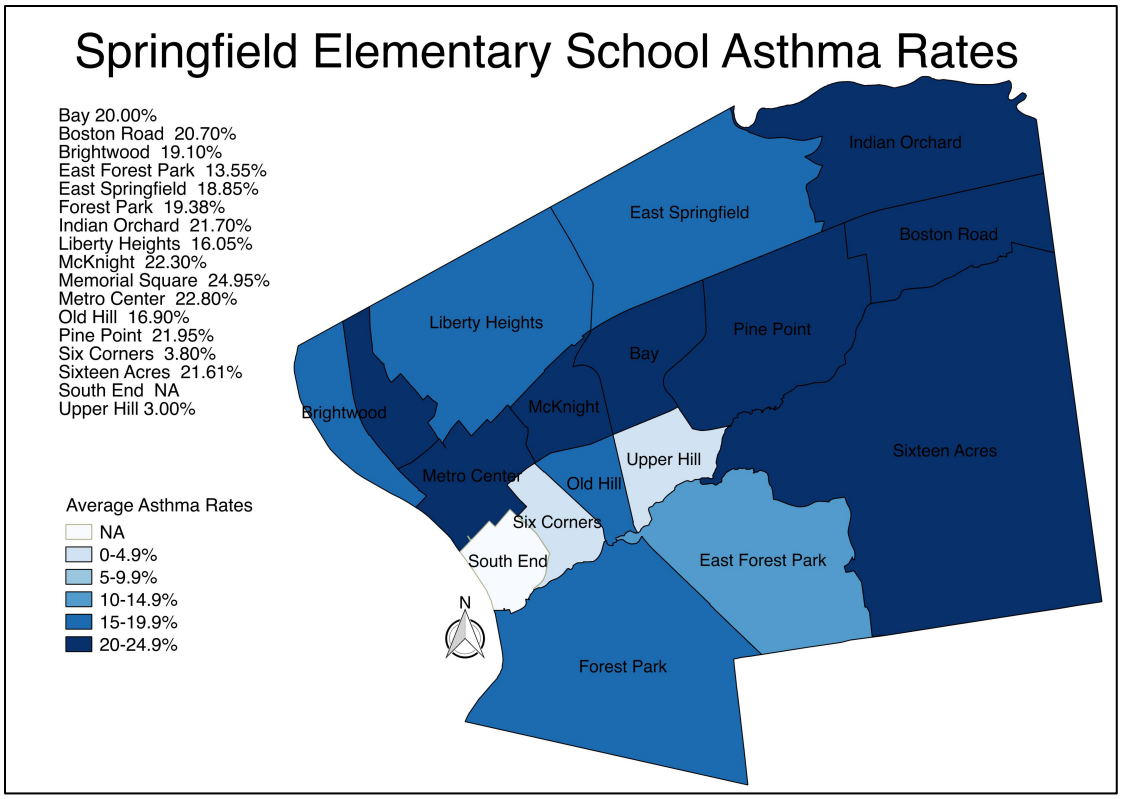
Map 5. Springfield Prenatal Care Rates[36]

[36] Pioneer Valley Planning Commission. Data Atlas By Neighborhoods: City of Springfield. Springfield: Pioneer Valley Planning Commission, 2014. Accessed February 2, 2015. http://www.pvpc.org/sites/default/files/Springfield%20Data%20Atlas%209-23-14-web-reduced.pdf



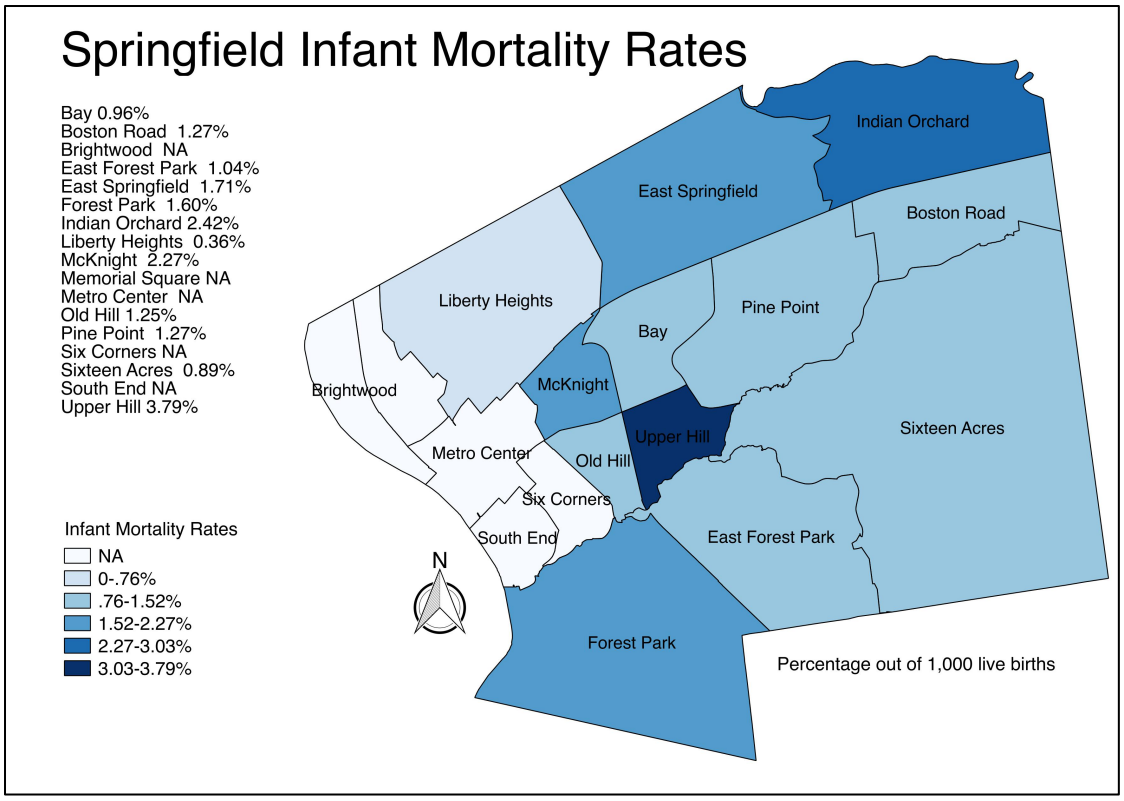
Map 6. Springfield Density Rates[37]

[37] "Springfield, MA Neighborhoods Maps", City-Data.com, accessed February 2, 2015. http://www.city-data.com/nbmaps/neigh-Springfield-Massachusetts.html



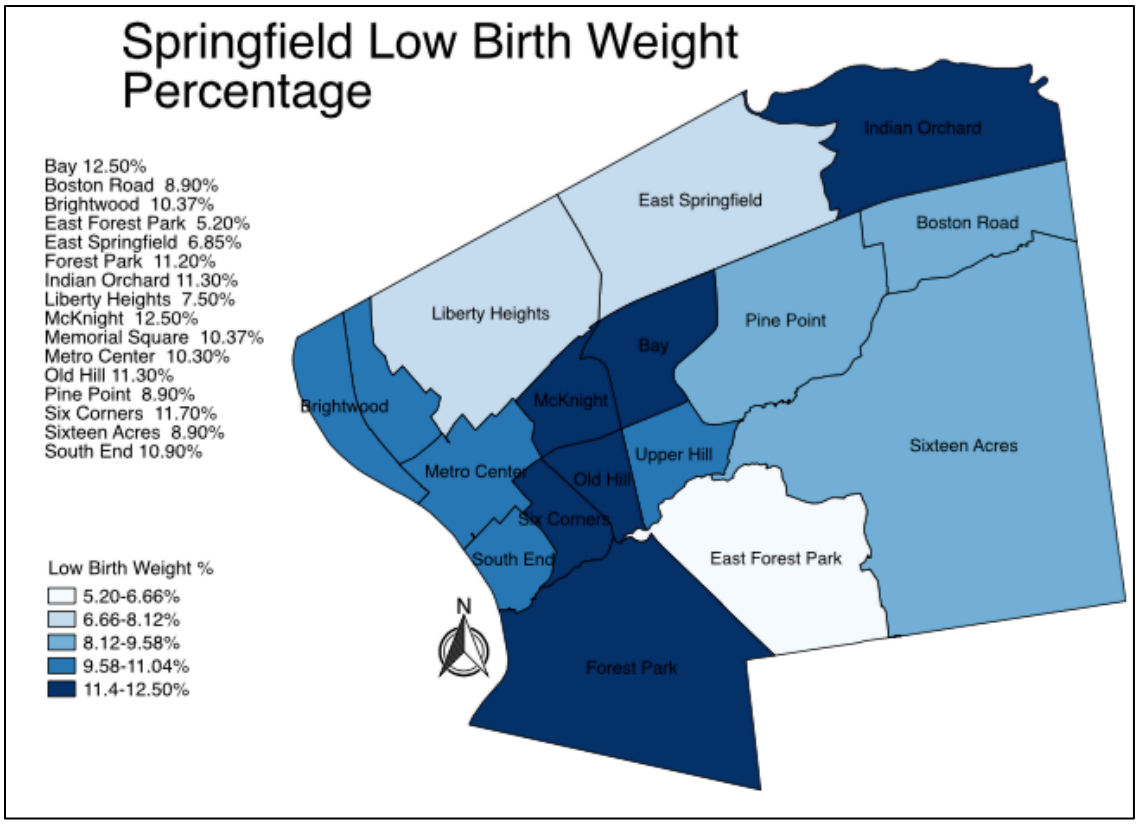
Map 7. Springfield Asthma Rates[38]

[38] Pioneer Valley Planning Commission. Data Atlas By Neighborhoods: City of Springfield. Springfield: Pioneer Valley Planning Commission, 2014. Accessed February 2, 2015. http://www.pvpc.org/sites/default/files/Springfield%20Data%20Atlas%209-23-14-web-reduced.pdf



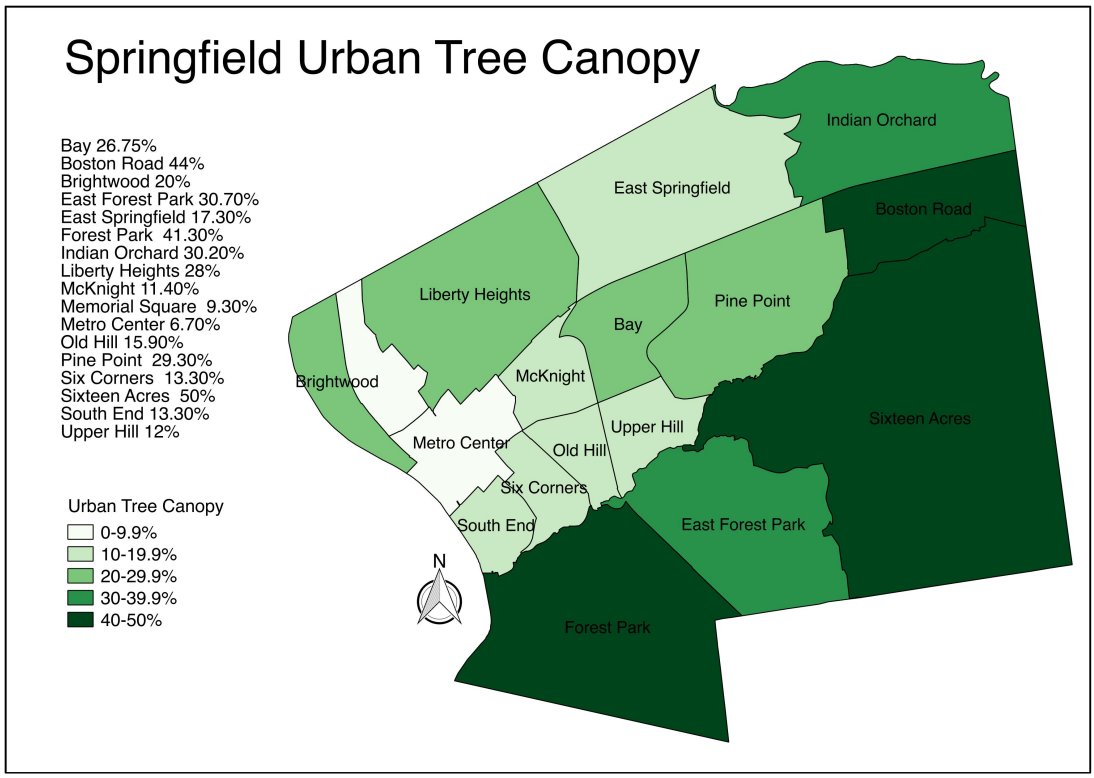
Map 8. Springfield Infant Mortality Rates[39]

[39] Pioneer Valley Planning Commission. Data Atlas By Neighborhoods: City of Springfield. Springfield: Pioneer Valley Planning Commission, 2014. Accessed February 2, 2015. http://www.pvpc.org/sites/default/files/Springfield%20Data%20Atlas%209-23-14-web-reduced.pdf



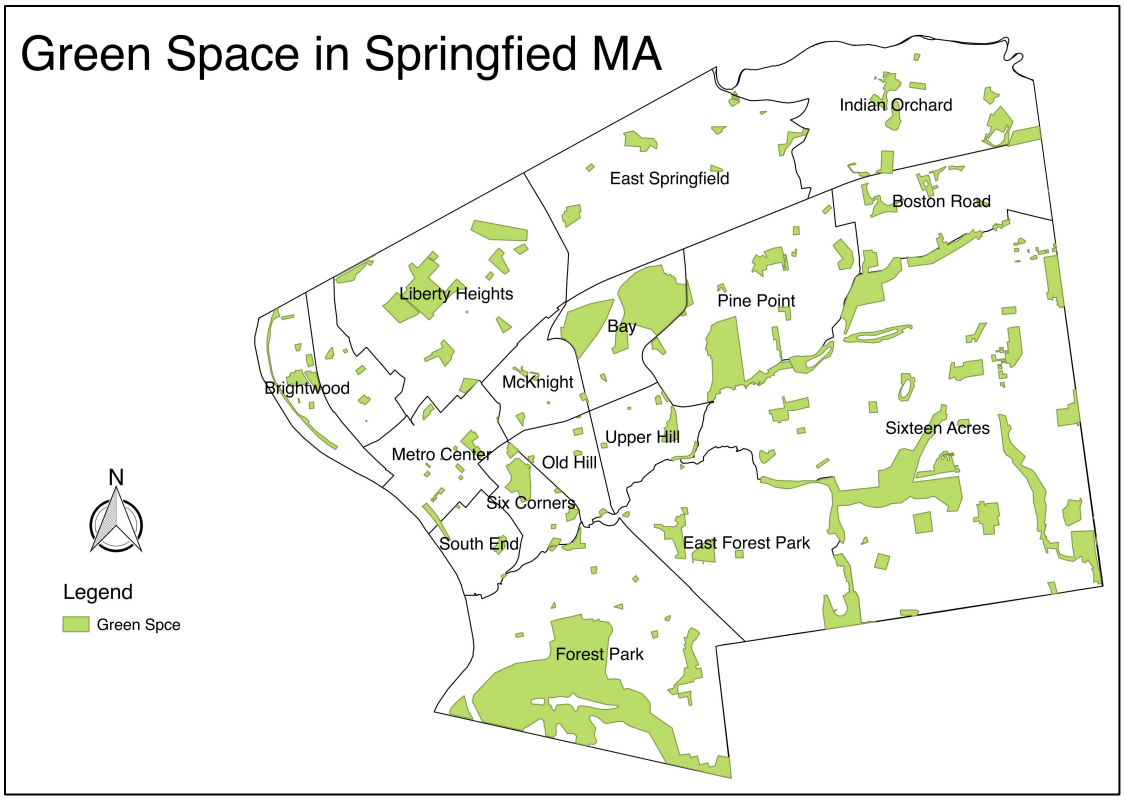
Map 9. Springfield Low Birth Weight Percentage[40]

[40] Pioneer Valley Planning Commission. Data Atlas By Neighborhoods: City of Springfield. Springfield: Pioneer Valley Planning Commission, 2014. Accessed February 2, 2015. http://www.pvpc.org/sites/default/files/Springfield%20Data%20Atlas%209-23-14-web-reduced.pdf



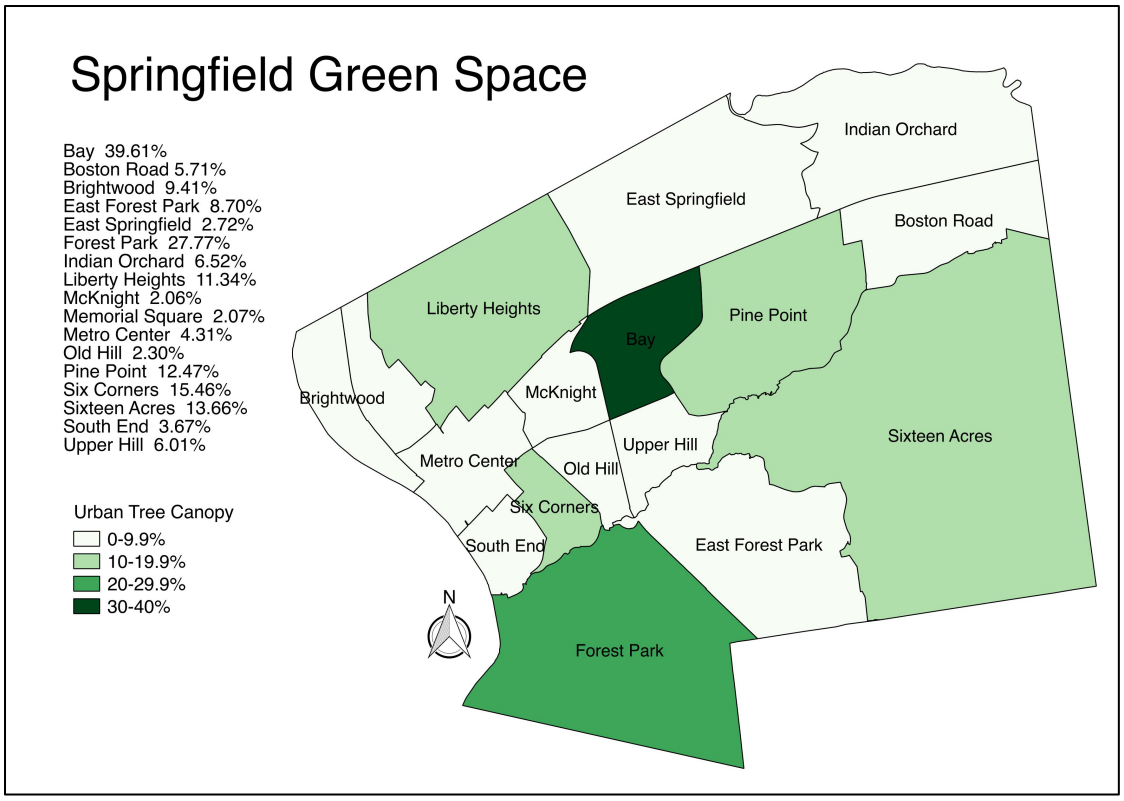
Map 10. Springfield Urban Tree Canopy Percentage[41]

[41] ReGreen Springfield. i-Tree Canopy Assessment of Springfield Neighborhoods. Amherst: US Forest Service, 2014.



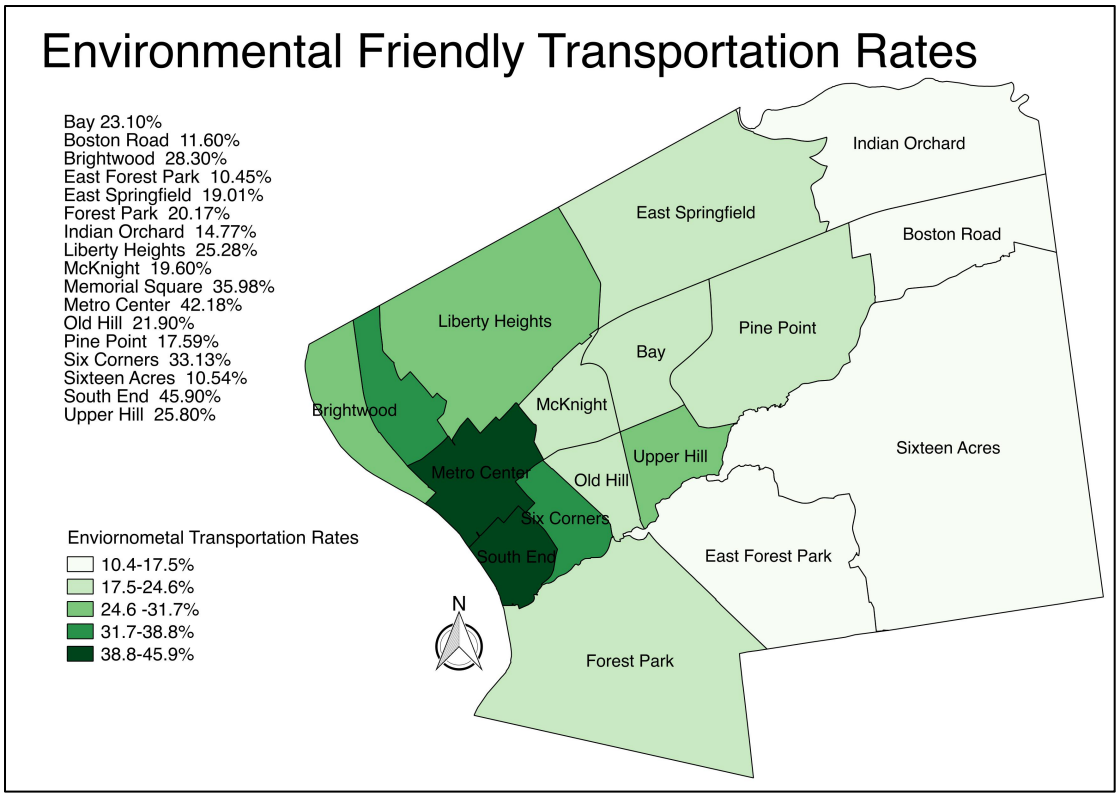
Map 11. Green Space in Springfield[42]

[42] Office of Geographic Information (MassGIS), Commonwealth of Massachusetts, MassIT, 2015.



Map 12. Springfield Green Space Percentage[43]

[43] Office of Geographic Information (MassGIS), Commonwealth of Massachusetts, MassIT, 2015.



Map 13. Environmental Friendly Transportation Rates[44]

[44] Pioneer Valley Planning Commission. Data Atlas By Neighborhoods: City of Springfield. Springfield: Pioneer Valley Planning Commission, 2014. Accessed February 2, 2015. http://www.pvpc.org/sites/default/files/Springfield%20Data%20Atlas%209-23-14-web-reduced.pdf

APPENDIX B

DATA ANALYSIS TABLES

	Urban Tree	N	Mean	Std. Deviation	Std. Error Mean
Asthma Rate	>= .2675	8	.193675	.0302758	.0107041
	< .2675	8	.164625	.0845749	.0299017
Infant Mortality	>= .2675	8	.012263	.0060209	.0021287
	< .2675	4	.022550	.0110506	.0055253
Low Birth Weight	>= .2675	8	.093000	.0234155	.0082786
	< .2675	9	.104878	.0157301	.0052434

		Levene's Test for Equality of Variances		t-test for Equality of Means			
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference
Asthma Rate	Equal variances assumed	5.555	.034	.915	14	.376	.0290500
	Equal variances not assumed			.915	8.765	.385	.0290500
Infant Mortality	Equal variances assumed	1.433	.259	-2.133	10	.059	-.0102875
	Equal variances not assumed			-1.737	3.920	.159	-.0102875
Low Birth Weight	Equal variances assumed	1.625	.222	-1.241	15	.234	-.0118778
	Equal variances not assumed			-1.212	12.046	.249	-.0118778

Table 21. The Effect of Urban Tree Canopy on the Health Impacts

	Green Space	N	Mean	Std. Deviation	Std. Error Mean
Asthma Rate	>= .0940	7	.174129	.0630844	.0238437
	< .0940	9	.183056	.0667745	.0222582
Infant Mortality	>= .0940	5	.010160	.0046231	.0020675
	< .0940	7	.019643	.0096139	.0036337
Low Birth Weight	>= .0940	7	.101529	.0178994	.0067653
	< .0940	10	.097720	.0221935	.0070182

		Levene's Test for Equality of Variances		t-test for Equality of Means			
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference
Asthma Rate	Equal variances assumed	.051	.825	-.272	14	.790	-.0089270
	Equal variances not assumed			-.274	13.388	.789	-.0089270
Infant Mortality	Equal variances assumed	2.364	.155	-2.024	10	.070	-.0094829
	Equal variances not assumed			-2.268	9.085	.049	-.0094829
Low Birth Weight	Equal variances assumed	.121	.733	.375	15	.713	.0038086
	Equal variances not assumed			.391	14.594	.702	.0038086

Table 22. The Effect of Green Space on the Health Impacts

	Median Income	N	Mean	Std. Deviation	Std. Error Mean
Green Space	>= 33060	9	.105444	.0737835	.0245945
	< 33060	8	.098613	.1289752	.0455996
Urban Tree	>= 33060	9	.314222	.1222597	.0407532
	< 33060	8	.145813	.0635374	.0224638

		Levene's Test for Equality of Variances		t-test for Equality of Means			
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference
Green Space	Equal variances assumed	1.185	.294	.136	15	.894	.0068319
	Equal variances not assumed			.132	10.861	.898	.0068319
Urban Tree	Equal variances assumed	2.223	.157	3.491	15	.003	.1684097
	Equal variances not assumed			3.619	12.302	.003	.1684097

Table 23. The Effects of Median Income on Green Space and Urban Tree Canopy

	Median Income	N	Mean	Std. Deviation	Std. Error Mean
Asthma Rate	>= 33060	9	.174211	.0610154	.0203385
	< 33060	7	.185500	.0702110	.0265373
Infant Mortality	>= 33060	9	.015944	.0100333	.0033444
	< 33060	3	.014933	.0068806	.0039725
Low Birth Weight	>= 33060	9	.087611	.0200527	.0066842
	< 33060	8	.112425	.0091833	.0032468

		Levene's Test for Equality of Variances		t-test for Equality of Means			
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference
Asthma Rate	Equal variances assumed	.021	.888	-.344	14	.736	-.0112889
	Equal variances not assumed			-.338	12.011	.741	-.0112889
Infant Mortality	Equal variances assumed	.193	.670	.160	10	.876	.0010111
	Equal variances not assumed			.195	5.188	.853	.0010111
Low Birth Weight	Equal variances assumed	2.601	.128	-3.205	15	.006	-.0248139
	Equal variances not assumed			-3.339	11.489	.006	-.0248139

Table 24. The Effect of Median Income on the Health Impacts

	White	N	Mean	Std. Deviation	Std. Error Mean
Green Space	>= .4710	8	.100912	.0800425	.0282993
	< .4710	9	.103400	.1200614	.0400205
Urban Tree	>= .4710	8	.310250	.1426281	.0504267
	< .4710	9	.168056	.0706446	.0235482

		Levene's Test for Equality of Variances		t-test for Equality of Means			
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference
Green Space	Equal variances assumed	.522	.481	-.050	15	.961	-.0024875
	Equal variances not assumed			-.051	14.000	.960	-.0024875
Urban Tree	Equal variances assumed	2.345	.146	2.654	15	.018	.1421944
	Equal variances not assumed			2.555	9.971	.029	.1421944

Table 25. The Effects of White Demographics on Green Space and Urban Trees

Black	N	Mean	Std. Deviation	Std. Error Mean

Green Space	>= .2450	8	.109913	.1250050	.0441959
	< .2450	9	.095400	.0789905	.0263302
Urban Tree	>= .2450	8	.199188	.1244732	.0440079
	< .2450	9	.266778	.1323610	.0441203

		Levene's Test for Equality of Variances		t-test for Equality of Means			
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference
Green Space	Equal variances assumed	.925	.351	.290	15	.776	.0145125
	Equal variances not assumed			.282	11.575	.783	.0145125
Urban Tree	Equal variances assumed	.010	.922	-1.080	15	.297	-.0675903
	Equal variances not assumed			-1.085	14.938	.295	-.0675903

Table 26. The Effects of Black Demographics on Green Space and Urban Trees

	Hispanic	N	Mean	Std. Deviation	Std. Error Mean
Green Space	>= .4180	7	.069371	.0517860	.0195733
	< .4180	10	.125230	.1207630	.0381886
Urban Tree	>= .4180	7	.152143	.0709047	.0267995
	< .4180	10	.292950	.1317216	.0416540

		Levene's Test for Equality of Variances		t-test for Equality of Means			
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference
Green Space	Equal variances assumed	1.957	.182	-1.144	15	.271	-.0558586
	Equal variances not assumed			-1.302	13.004	.216	-.0558586
Urban Tree	Equal variances assumed	2.021	.176	-2.564	15	.022	-.1408071
	Equal variances not assumed			-2.843	14.314	.013	-.1408071

Table 27. The effects of Hispanic Demographics on Green Space and Urban

	White	N	Mean	Std. Deviation	Std. Error Mean
Asthma Rate	>= .4710	8	.193300	.0314263	.0111109
	< .4710	8	.165000	.0843001	.0298046
Infant Mortality	>= .4710	7	.013271	.0066176	.0025012
	< .4710	5	.019080	.0116315	.0052018
Low Birth Weight	>= .4710	8	.087687	.0216216	.0076444
	< .4710	9	.109600	.0117736	.0039245

		Levene's Test for Equality of Variances		t-test for Equality of Means			
		F	Sig.	t	df	Sig. (2 Tailed)	Mean Difference
Asthma Rate	Equal variances assumed	5.462	.035	.890	14	.389	.0318082
	Equal variances not assumed			.890	8.909	.397	.0318082
Infant Mortality	Equal variances assumed	2.041	.184	-1.106	10	.294	.0052501
	Equal variances not assumed			-1.006	5.855	.354	.0057719
Low Birth Weight	Equal variances assumed	2.793	.115	-2.639	15	.019	.0083046
	Equal variances not assumed			-2.550	10.536	.028	.0085930

Table 28. The Effects of White Demographics on the Health Factors

	Black	N	Mean	Std. Deviation	Std. Error Mean
Asthma Rate	>= .2450	8	.164313	.0825127	.0291727
	< .2450	8	.193988	.0352166	.0124509
Infant Mortality	>= .2450	6	.018017	.0107246	.0043783
	< .2450	6	.013367	.0072439	.0029573
Low Birth Weight	>= .2450	8	.107750	.0145381	.0051400
	< .2450	9	.091767	.0219475	.0073158

		Levene's Test for Equality of Variances		t-test for Equality of Means			
		F	Sig.	t	df	Sig. (2-Tailed)	Mean Difference
Asthma Rate	Equal variances assumed	5.174	.039	-.936	14	.365	-.0296750
	Equal variances not assumed			-.936	9.468	.373	-.0296750
Infant Mortality	Equal variances assumed	.760	.404	.880	10	.399	.0046500
	Equal variances not assumed			.880	8.776	.402	.0046500
Low Birth Weight	Equal variances assumed	2.143	.164	1.744	15	.102	.0159833
	Equal variances not assumed			1.788	13.960	.096	.0159833

Table 29. The Effects of Black Demographics on the Health Factors

	Hispanic	N	Mean	Std. Deviation	Std. Error Mean
Asthma Rate	>= .4180	6	.172667	.0742938	.0303303
	< .4180	10	.183040	.0594988	.0188152
Infant Mortality	>= .4180	2	.008050	.0062933	.0044500
	< .4180	10	.017220	.0089603	.0028335
Low Birth Weight	>= .4180	7	.103486	.0136341	.0051532
	< .4180	10	.096350	.0237815	.0075204

		Levene's Test for Equality of Variances		t-test for Equality of Means			
		F	Sig.	t	df	Sig. (2-Tailed	Mean Difference
Asthma Rate	Equal variances assumed	.188	.672	-.308	14	.762	-.0103733
	Equal variances not assumed			-.291	8.860	.778	-.0103733
Infant Mortality	Equal variances assumed	.279	.609	-1.356	10	.205	-.0091700
	Equal variances not assumed			-1.738	1.940	.228	-.0091700
Low Birth Weight	Equal variances assumed	3.178	.095	.712	15	.487	.0071357
	Equal variances not assumed			.783	14.606	.446	.0071357

Table 30. The Effects of Hispanic Demographics on the Health Factors

	Home Ownership	N	Mean	Std. Deviation	Std. Error Mean
Green Space	>= .4330	8	.110475	.0772102	.0272979
	< .4330	9	.094900	.1211582	.0403861
Urban Tree	>= .4330	8	.315750	.1306093	.0461774
	< .4330	9	.163167	.0790119	.0263373

		Levene's Test for Equality of Variances		t-test for Equality of Means			
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference
Green Space	Equal variances assumed	.611	.447	.311	15	.760	.0155750
	Equal variances not assumed			.320	13.709	.754	.0155750
Urban Tree	Equal variances assumed	1.872	.191	2.955	15	.010	.1525833
	Equal variances not assumed			2.870	11.253	.015	.1525833

Table 31. The Effects of Home Ownership on Green Space and Urban Trees

	Environmental Transportation	N	Mean	Std. Deviation	Std. Error Mean
Urban Tree	>= .2310	8	.161687	.0790384	.0279443
	< .2310	9	.300111	.1337334	.0445778

		Levene's Test for Equality of Variances		t-test for Equality of Means			
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference
Urban Tree	Equal variances assumed	1.501	.239	-2.553	15	.022	-.1384236
	Equal variances not assumed			-2.631	13.194	.021	-.1384236

Table 32. The Effect of Environmental Transportation on Urban Tree Canopy

	Income Inequality	N	Mean	Std. Deviation	Std. Error Mean
Low Birth Weight	>= .4576	8	.112925	.0090785	.0032097
	< .4576	9	.087167	.0194551	.0064850

		Levene's Test for Equality of Variances		t-test for Equality of Means			
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference
Low Birth Weight	Equal variances assumed	2.877	.111	3.419	15	.004	.0257583
	Equal variances not assumed			3.560	11.604	.004	.0257583

Table 33. The Effect of Income Inequality on Low Birth Weight.

	Income Inequality	N	Mean	Std. Deviation	Std. Error Mean
Urban Tree	>= .4576	8	.166938	.0835970	.0295560
	< .4576	9	.295444	.1365184	.0455061

		Levene's Test for Equality of Variances		t-test for Equality of Means			
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference
Urban Tree	Equal variances assumed	1.611	.224	-2.302	15	.036	-.1285069
	Equal variances not assumed			-2.368	13.440	.033	-.1285069

Table 34. The Effect of Income Inequality on Urban Tree Canopy

	Density	N	Mean	Std. Deviation	Std. Error Mean
Low Birth Weight	>= 6879	8	.109425	.0083729	.0029603
	< 6879	8	.087437	.0232708	.0082275

		Levene's Test for Equality of Variances		t-test for Equality of Means			
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference
Low Birth Weight	Equal variances assumed	3.323	.090	2.515	14	.025	.0219875
	Equal variances not assumed			2.515	8.783	.034	.0219875

Table 35. The Effect of Density on Low Birth Weight

BIBLIOGRAPHY

"About the Agency", US Forest Service, accessed February 18, 2015, http://www.fs.fed.us/

Alberti, Marina and John M. Marzluff. 2004. "Ecological resilience in urban ecosystems: Linking urban patterns to human and ecological functions." *Urban Ecosystems* 7, no. 3: 241-265.

APA. 2013. "How Cities use Parks for Green Infrastructure." *American Planning Association* 1-4

Baker Jr., Edward L., et al. 2005. "The Public Health Infrastructure and our Nation's Health." *Annual Review of Public Health* 26, no. 1: 303-318.

Benedict, Mark and Edward T. McMahon. 2006. Green Infrastructure: Linking Landscapes and Communities. Washington, DC, USA: Island Press.

Cheng, Chingwen, Rachel Danford, Craig Nicolson, Robert Ryan, Michael W. Strohbach, and Paige S. Warren. 2014. "What Does It Take to Achieve Equitable Urban Tree Canopy Distribution? A Boston Case Study". Cities and the Environment (CATE): Vol. 7: Iss. 1, Article 2.

City of Springfield. Springfield MA Neighborhood Profiles: *Springfield Planning Office*. City of Springfield, 2014. Accessed February 2, 2015, http://www3.springfield-ma.gov/planning/fileadmin/Planning_files/Springfield_Neighborhood_Profiles_PDF.pdf

Coutts, Christopher. 2010. "Green Infrastructure and Public Health in the Florida Communities Trust Public Land Acquisition Program." *Planning Practice and Research* 25, no. 4: 439-459.

"Department of Public Health", Massachusetts Department of Health and Human Services, Accessed February 2, 2015, http://www.mass.gov/eohhs/gov/departments/dph/

"Environmental Health", Massachusetts Bureau of Environmental Health. Accessed February 2, 2015, http://www.mass.gov/eohhs/gov/departments/dph/programs/environmental-health/

Frumkin, Howard. 2003. *Healthy Places: Exploring the Evidence*. Vol. 93American Public Health Association.

"Infant Mortality", Centers for Disease Control, Accessed February 2, 2015, http://www.cdc.gov/reproductivehealth/maternalinfanthealth/infantmortality.htm

Jackson, Laura E. 2003. "The relationship of urban design to human health and condition." *Landscape and Urban Planning* 64, no. 4: 191-200.

Jerrett, Michael and Jennifer Wolch. 2011, "Green visions of health for children: on the links between parks, recreational programming, physical activity and obesity." accessed February 10, 2015. http://www.ncbi.nlm.nih.gov/pubmed/?term=Jerrett+M%5BAuthor%5D+wolch

Lafortezza, Raffaele, et al. 2013. "Green Infrastructure as a tool to support spatial planning in European urban regions." *iForest - Biogeosciences & Forestry* 6, no. 3: 102-108.

"Live Well, Springfield". Mass in Motion Program, accessed February 2, 2015, http://www.livewellspringfield.org/

Lopez, Russ. 2007. "Neighborhood Risk Factors for Obesity." *Obesity* 15, no. 8: 2111-2119.

Lowry, John H., Matthew E. Baker, and R. Douglas Ramsey. 2012. "Determinants of Urban Tree Canopy in residential neighborhoods: Household characteristics, urban form, and the geophysical landscape." *Urban Ecosystems* 15, no. 1: 247-266.

MacDonagh, Peter. 2011. "Target Center Arena Vegetated Roof." *American Society of Landscape Architects* no. 476:1-4

"Mass in Motion, Program Overview", Health & Human Services, last modified March 22, 2012, accessed February 2, 2015, http://www3.springfield-ma.gov/hhs/mass-in-motion-2.0.html

Nielsen, Thomas Sick and Karsten Bruun Hansen. 2007. "Do green areas affect health? Results from a Danish survey on the use of green areas and health indicators." *Health & place* 13, no. 4: 839-850.

Nowak, David J., Mary H. Noble, Susan M. Sisinni, and John F. Dwyer. 2001. "People and Trees: Assessing the US Urban Forest Resource." *Journal of Forestry* 99, no. 3:37-42.

Nowak, David J. and Daniel E. Crane. 2002. "Carbon storage and sequestration by Urban Trees in the USA." *Environmental Pollution* 116, no. 3: 381-389.

Nowak, David J., Daniel E. Crane, and Jack C. Stevens. 2006. "Air pollution removal by Urban Trees and shrubs in the United States." *Urban Forestry & Urban Greening* 4, no. 3–4: 115-123.

Nowak, David J. and John F. Dwyer. Urban and Community Forestry in the Northeast. Netherland Springer Netherlands, 2007. 25-46

Nowak, David J. and Eric J. Greenfield. 2012. "Tree and impervious cover in the United States." *Landscape and Urban Planning* 107, no. 1: 21-30.

Nowak, David J., et al. 2014. "Tree and forest effects on air quality and human health in the United States.". *Environmental Pollution* 193, no. 0: 119-129.

Pugh, Thomas A. M., et al. 2012. "Effectiveness of Green Infrastructure for Improvement of Air Quality in Urban Street Canyons." *Environmental science & technology* 46, no. 14: 7692-7699.

Pioneer Valley Planning Commission. Data Atlas By Neighborhoods: *City of Springfield.* Springfield: Pioneer Valley Planning Commission, 2014. Accessed February 2, 2015. http://www.pvpc.org/sites/default/files/Springfield%20Data%20Atlas%209-23-14-web-reduced.pdf

Qureshi, S., Hasan Kazmi, S.J., Breuste, J.H. 2010. "Ecological disturbances due to high cutback in the green infrastructure of Karachi: Analyses of public perception about associated health problems." *Urban Forestry & Urban Greening* 9, no. 3: 187-198.

ReGreen Springfield. i-Tree Canopy Assessment of Springfield Neighborhoods. Amherst: US Forest Service, 2014

ReGreen Springfield. Urban Tree Canopy (UTC) Assessment for Massachusetts 10 Largest Communities. Amherst: US Forest Service, 2014

"Springfield, MA Neighborhoods Maps", City-Data.com, accessed February 2, 2015, http://www.city-data.com/nbmaps/neigh-Springfield-Massachusetts.html

Tzoulas, Konstantinos, et al. 2007. "Promoting ecosystem and human health in urban areas using Green Infrastructure: A literature review." *Landscape and Urban Planning* 81, no. 3: 167-178.

"Welcome to ReGreen Springfield!", ReGreen Springfield, accessed February 18, 2015, http://regreenspringfield.com/

Wolch, Jennifer, Michel Jerrett, Kim Reynolds, Rob McConell, Roger Chang, Nicholas Dahmann, Kirby Brady, Frank Gilliand, Jason G. Su, and Kiros Berhane. 2010. "Childhood obesity and proximity to urban parks and recreational resources: A longitudinal cohort study". *Health & Place* 17. 207-214