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Degree of Master of Science

AN URBAN FOREST FOR ALL: USING GIS TECHNOLOGY TO ANALYZE THE EQUITY OF THE URBAN FOREST IN SEATTLE, WA, USA

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Author's declaration

No portion of the work referred to in this thesis has been submitted in support of an application for another degree or qualification of this or any other university or other institute of learning.

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ABSTRACT OF THESIS submitted by:
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for the degree of Master of Science and entitled: *An urban forest for all: Using GIS technology to analyse the equity of the urban forest in Seattle, WA, USA*
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A growing abundance of research continues to detail the positive effects urban forests have on social structures, public safety, health, and city infrastructure. As such, many cities are proactively investing in urban forestry. This paper is a case study of the urban forest in Seattle, WA, USA, a city that has both heavily invested in its urban forestry, while remaining economically and racially segregated.

The primary aim of this study is to analyse the distribution of Seattle's urban forest in light of income and race of Seattle residents. Geographic Information Systems (GIS) was used to combine census data with city datasets of the urban forest. Multiple urban forest features were analysed, including (a) average number of parks and area available within a quarter mile of different demographics (b) average number of residential trees, and (c) average percent canopy cover.

Descriptive statistics were done to analyse the extent to which there was a difference in access between different economic and racial groups in Seattle. Ultimately, canopy cover and residential trees showed the most significant discrepancies, primarily in regards to income and concentration of Asian residents, with higher income and lower concentrations of Asian residents having greater accesses to urban trees.

The study concludes with a deeper analysis into the potential drivers behind the results and draws from interviews to explore the ways in which the City of Seattle is currently integrating equity concerns into its urban forestry work.

Keywords: Environmental Justice, GIS, Spatial Analysis, Urban Forestry, Equity, City Planning

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List of Abbreviations

ACS	American Community Survey
EJ	Environmental Justice
FIPS	Federal Information Processing Standard
DOE	Department of Ecology
GIS	Geographic Information Systems
GSP	Green Seattle Partnership
OSE	Seattle Office of Sustainability and Environment
Pers.Comm.	Personal Communication
ROW	Right-of-Ways
SCL	Seattle City Light
SDOT	Seattle Department of Transportation
SPR	Seattle Parks and Recreation
SPU	Seattle Public Utilities
UFMP	Urban Forest Management Plan
WAGDA	Washington State Geospatial Data Archive

1. INTRODUCTION

1.1 Problem Statement

The past century has seen major shifts in society in regards to population. In the past 100 years, the global population has increased from 1 billion, to the current global population of 7.2 billion people. A recent study estimates that this number will increase to be between 9 and 12 billion by 2100 (Gerland *et al.* 2014). Yet, it is not just the quantity of humans that has changed, but also the migration of these humans. Of the 7.2 billion people currently in the world, 54% of them live in urban areas – and like population itself, this trend is only expected to increase (UN 2014). It is predicted that by 2050, 66% of the world's population will be living in urban areas across the globe (UN 2014).

Such numbers should not be taken lightly, for this holds many implications for future challenges of city planners as cities continue to push limits, both spatially and resource wise. There are already impacts and topics that accompany urbanization – land use changes and environmental degradation; public health and quality of life concerns; and issues of social disparity and equity.

This then, creates a major impetus for cities to proactively plan for this growth and develop sustainable strategies and policies to address these issues while they continue to grow. There are of course many aspects of city infrastructure and resource management that can be the focus of sustainability initiatives. However, one paramount feature of cities where the above issues of environmental degradation, public health, and equity intersect is the urban forest.

Urban forests are continually shown to provide immense benefits to cities and urban dwellers in a multitude of ways. However, as with any resource or goods, urban trees also are affected by the social, political, and economic context within which they exist. As will be seen in this study, these factors can determine where trees get planted, and who benefits from them. As such, this study understands urban forests as an environmental justice issue, and will analyze Seattle's urban forest within this framework.

1.2 Aims and Objectives

As will be made clear in the follow literature review, there is a growing body of research that is analyzing urban forestry through an environmental justice lens. The following paper hopes to contribute to this body of literature by studying Seattle, WA, a city that is both heavily investing in its urban forestry while at the same time grappling with equity issues within concentrated areas of poverty and diversity.

The aim of this paper is twofold. The primary aim is to analyze to what extent Seattle's urban forest is distributed equitably in regards to income and race – essentially creating a much-needed baseline of the current situation. However, in addition to this, this study also hopes to understand how the City of Seattle is integrating equity concerns within their urban forest planning. The two aims go hand-in-hand, as the overarching issue behind an equitable distribution of urban forest resources, is how well cities integrate equity concerns into their planning and operations.

To achieve these aims then, the following objectives were developed:

1.) Analyze the number of parks and amount of park area accessible within .25 mile of different income and racial categories.

2.) Analyze the number of residential trees contained within different income and racial categories.

3.) Calculate the percent canopy cover for different income and racial categories.

4.) Conduct appropriate statistical tests to calculate the significance of the above findings.

5.) Conduct interviews with city officials and research tools used by the city to ensure equity in its urban forestry work.

While the hypotheses behind these objectives will be further discussed in the Methodology section (Ch.4), the author entered this study under the overarching assumption that areas in Seattle associated with higher income or higher percentage of

White residents have greater access to the urban forest features stated above (parks, residential trees, and canopy cover).

2. LITERATURE REVIEW

2.1 Urban forestry

An "urban forest" can be defined as all the trees and understory vegetation within a city, including trees on private property, parking strips, right-of-ways (ROW) and street ends, parks, and commercial properties (City of Seattle 2007). Anymore, urban forests have been accepted as integral parts of a city that contribute to a city's livability and quality. This is due to the well-established benefits and services that urban trees provide for city infrastructure, as well as human wellbeing.

Urban Forestry & City Infrastructure

One reason cities are increasingly investing in maintaining the health of their urban forest is because of the role trees and green spaces play in supplementing grey infrastructure. This includes aiding in stormwater management, air purification, temperature regulation, and carbon sequestration.

Management of stormwater runoff is a significant issue, especially for cities who receive high amounts of rainfall or are situated near important water sources. Because developed cities greatly reduce the amount of permeable surfaces that normally absorb and filter stormwater, improper infrastructure can result in flooding issues and polluted freshwater systems, causing serious environmental harm (EPA 2013). Urban forests play a paramount role helping to absorb and reduce the flow of stormwater runoff: trees capture and store rainfall in their canopy; take up nutrients and pollutants in their root systems; and transform the soil to maximize absorption of rainwater (EPA 2013). For example, in New York City, NY, the city's trees intercepted 890 million gallons of rainfall in 2007, providing an estimated 35 billion USD in stormwater benefits (EPA 2013).

Trees also contribute to cleaner air, being continual sources of clean oxygen and removing pollution through leaf intake and interception (Nowak 2002). This is an important service in the context of urban areas which can suffer from high rates of pollution, which holds severe implications for the health of urban dwellers (WHO 2014). A study looking at rates of pollution removal by urban forests across the United States found that the total annual air pollution removal by U.S. trees was 711,000 metric tons, a 3.8 billion USD value (Nowak *et al.* 2006).

In addition to removing pollutants in general, trees play a particularly significant role in climate change mitigation and adaptation by acting as carbon sinks and temperature regulators. Urban trees store approximately 12.6% of the United States' carbon dioxide emissions, roughly over 708 million tons of CO2 (Nowak *et al.* 2013). Urban trees can also affect emissions by reducing energy – and the associated emissions- used in cooling and heating of adjacent buildings. Through shading and evapotranspiration, trees reduce the amount of solar radiation that hits the surface and heats buildings, keeping temperatures up to 20 to 45ºF cooler (EPA 2008). While these cooler temperatures could increase heating use during the winter, trees can also help keep heating costs down by insulating homes from cold winds during the winter (EPA 2008). Thus not only do urban trees help curb climate change by reducing emissions, but they also aid residents in adapting to the effects of climate change, protecting against increasing temperatures while saving residents on energy costs.

Urban Forestry & People

The benefits of trees extend beyond city infrastructure and into the everyday lives and wellbeing of people. These benefits include improvements in physical and mental health, public safety, and social unity.

Because green spaces influence the level of physical activity of nearby residents (Richardson *et al.* 2015), there are many links between green spaces and different illnesses including a lower risk of Type II diabetes (Astell-Burt *et al.* 2014); lower presence of cardiovascular risk factors in park users vs. non park users (Tamosiunas *et al.* 2014); and decreases in male mortality from cardiovascular and respiratory disease (Richardson & Mitchell 2010).

Improvements have also been witnessed in mental health and wellbeing. This has been particularly shown in studies researching effects of trees and green spaces on stress and recovery. One study from Denmark found evidence of a positive association between experienced stress and the distance from one's home to the nearest green space: Dane's who lived farther than 1km away from the nearest green space reported experiencing higher levels of stress than those who lived within 1km (Stigsdotter *et al.* 2010). In another study, participants exhibited less stress the longer they stayed in a green space (Hull & Michael 1995). Studies have also found that the visual presence of plants or foliage can aid in alleviating and preventing mental fatigue, which can potentially lead to a better work performance (Shibata & Suzuki 2002).

Issues of crime and public safety often plague urban areas, especially those with a large economic disparity and poverty (Bourguigonon 2001). Fortunately, trees have also been shown to have an effect on crime rates and perceived fear. A study of inner-city apartments in Chicago found that apartments with less greenery had higher rates of reported crimes, both property and violent crimes (Kuo & Sullivan 2001). The explanation for this is that green spaces increase surveillance of areas as people spend more time in greener spaces, as well as alleviating physiological stressors that can lead to violence. On the latter point, Kuo and Sullivan (2001) found that higher levels of vegetation systematically predicted lower levels of aggression in residents. Another study from Portland, Oregon found similar results, that larger trees in right-of-ways were associated with lower crime rates (Donovan & Prestemon 2012).

As was mentioned, one link between public safety and green spaces is that greener spaces are more heavily used, providing greater informal surveillance for neighborhoods. Yet, bringing community members into an open and shared space also contributes to overall social unity and community development. Kuo and Sullivan *et al.* (1998) researched common spaces in public housing communities, and found that more vegetated spaces received more use by residents. Furthermore, the residents living adjacent to these greener spaces reported more social ties and a sense of belonging within their community, compared to those living near more barren spaces. Similarly in another study, feelings of belonging and unity with neighbors were strongest in participants with greater exposure to green common spaces (Kweon *et al* 1998). This increase in social unity and mutual trust throughout a neighbor is important, because a lack of social cohesion within communities can affect the other aspects of human wellbeing already discussed – public health, mental wellbeing, and violence (Cubbins *et al.* 2008)

As can be seen, trees contain a plethora of tangible benefits and services that contribute to improved city infrastructure and human wellbeing alike. Yet, as with any goods and services, especially those managed by public entities, the issue of equity and distribution comes into question. This is particularly important, because marginalized or impoverished communities are those who could benefit most from many of these benefits of trees and green spaces. As will be discussed in the next section, the environmental justice movement has shown that there is often inequitable distribution of environmental benefits and burdens between different socio-economic groups, with low-income individuals and communities of color often on the losing end (Schlosberg 2013; Walker 2009); the urban forest is increasingly being understood within this framework.

2.2 Environmental Justice and Urban Forestry

Environmental Justice (EJ) generally refers to a discourse and social movement that understands the environment as inherently political and social as it exists within our current society. As such, EJ recognizes that, like many services and resources within society, environmental resources are also often available disproportionately along socioeconomic and racial lines, with racial minorities and marginalized communities suffering most. At the foundation of EJ advocacy is a call for distributional and procedural justice-- that environmental burdens and benefits are distributed equitably across all demographics, as well as an equal ability to affect decision making in regards to one's environment (Walker 2009). While this is a general definition, EJ continues to evolve as a movement, refining its framework and expanding the environmental features that are analyzed within it.

In the United States, EJ discourse gained prominence in the 1980s, as researchers found evidence of significant positive relationships between locations of toxic sites or levels of pollution and communities of color (Walker 2009); as such, the first wave of EJ research is categorized by a focus on the distribution of environmental costs throughout ethnic communities (Walker 2009). However, the next decade saw an expansion of the concept of EJ, as researchers and activists began to look at the distribution of environmental amenities and benefits as well. This evolution also started to consider other demographic variables, such as income, age, capabilities, etc. In addition to the adoption of additional variables within the framework, contemporary EJ discourse has begun to look beyond simply a spatial understanding (i.e. proximity/distribution/access to environmental cost and benefits), and researchers are now increasingly understanding that perceptions of access, intergenerational access, and political representation are all essential in ensuring an equitable and healthy environment for all (Walker 2009).

Throughout this transition, green spaces as environmental amenities have become a notable focus in EJ research. Initially this genre of EJ research focused specifically on the issue of access to types of usable open spaces, such as parks or playgrounds. While parks can be large contributors to the urban forest within a city, they are not necessarily viewed synonymously within EJ literature. Thus, it has not been until the past decade that the urban forest as a concept in itself has been understood as a matter of environmental justice in the ways that parks and usable green spaces have (Heyen 2003). Nikolas Heyen is a notable actor in guiding this shift to understanding the urban forest as an inherently political feature that is continually shaped and defined by the economic, social and political context within which it exists. According to Heyen (2013), this context is intrinsically capitalist and one that inevitably results in an inequitable distribution of goods and services along socioeconomic lines, and as urban trees provide many tangible services and are planted as such, the urban forest too remains more concentrated in wealthier and more affluent communities with the economic and political power to shape their urban environment (Heyen 2013). While others may not take as Marxist of a framework as Heyen, there is still a gradually increasing acceptance in the field of urban forestry – and inevitably city planning— that the urban forest must be understood through an environmental justice framework.

2.3 Related Case Studies

While not as ubiquitous as EJ studies done on issues of pollution/environmental costs and marginalized communities, case studies about the equity of urban forests are continuing to gain momentum and becoming an established area of research. Among the literature that focuses on urban forestry, several categories can be established, primarily based upon the environmental feature researchers choose to use as a proxy for measuring the urban forest. This next section will summarize the common trends of pervious case studies done.

Green Spaces

As mentioned previously, parks and large green spaces can be important contributors to the urban forest, providing large expanses for trees and forest stands to thrive protected. As such, many studies have used green space access and distance as a proxy for understanding equity and distribution of the urban forest.

While some studies focus on any type of park and "useable" open spaces, others are more concerned with the vegetation within these spaces and having access to it. Some methods within these studies include using geospatial software to analyze proximity of parks to different demographics (Wolch *et al.* 2005; Wendel *et al*. 2012; Zhou and Kim 2013) or the area of green space available per resident (Boone *et al.* 2009); conducting field research to analyze the demographic make-up of park users (Furuseth and Altman 1991); and more recently, conducting surveys and interviews to understand perceptions of park access and preferences (Sotoudehnia 2011; Wendel *et al*. 2012).

Most of these studies hypothesize that ethnic or economic disparities exist in relation to green space access, yet actual results vary. Researching six cities in Illinois in the United States, Zhou and Kim (2013) found no consistent relationship between proximity to green spaces and number of ethnic residents within a block group, while Wolch *et al.* (2005) found that low-income neighborhoods and communities of color in Los Angeles, CA had dramatically lower access to park resources than White-dominated neighborhoods. Boone *et al*. (2009) discovered that African Americans had access to a greater number of parks, yet less park area, resulting in more congested parks than in White neighborhoods.

While this category of case studies can vary in the level of attention given to specifically analyzing the urban forest as a whole, researching this feature of the urban forest remains important from a social perspective. Parks and green spaces can be some of the primary ways in which residents experience the urban forest and many of the social and physical benefits of urban forests come from these spaces. However there also remains limits to using green spaces as a proxy. Parks are simply one feature of the urban forest, and focusing exclusively on them ignores the important role played by street and residential trees in benefiting adjacent residents, especially those who are unable to frequent neighborhood green spaces.

Residential Trees

While less common than studies on parks and green spaces, there are also case studies that choose to look at specific types of trees within urban areas, such as municipally managed street trees, vegetation in right-of-ways (ROW), and private residential trees. These studies explore additional variables, such as quantity of trees, tree conditions, tree species, or level of maintenance in relation to socioeconomic demographics.

Such was the focus of one of the few studies on Seattle, WA. Erikson (2004), analyzed the conditions of street trees and level of maintenance within six sampled census tracts that were categorized by different economic groups based on median household income. Based on the trees analyzed within each tract, the study found no significant difference in conditions based on income; however, low-income tracts did tend to have more publically maintained trees and received higher levels of maintenance, suggesting that while conditions remained similar regardless of income, trees in low-income areas required more support from the municipality - rather than private residents- to remain that way.

Another study (Landry 2009) analyzed ROW trees in Tampa, FL by using percent canopy cover from these trees. Conducting a regression analysis of ROW canopy cover in relation to race, median household income, and home ownership rates, Landry (2009) found significant positive relationships between % canopy cover in ROW and both income and home ownership; alternately, there was a significantly negative relationship between canopy cover and percent of African American or Hispanic residents.

Canopy Cover

While parks and street tree studies take a detailed perspective of the urban forest by looking at one particular feature, on the other end of the spectrum are studies that use citywide canopy cover as a more comprehensive approach to the urban forest. These studies often use remote sensing and orthophotography to construct GIS layers of a study area's canopy cover, with the aim to explore relationships between % canopy cover and different demographics (Heyen 2003 ; Zhou and Kim 2013; Schwartz *et al.* 2015).

While these studies often find canopy cover concentrated within one demographic over another, there are still questions about whether race or income is a greater predictor for canopy cover. Thus, while Zhou and Kim (2013) found a negative relationship between % canopy cover and concentrations of ethnic minorities, Schwartz *et al.* (2015) in a recent study on several major cities across the U.S., found income to be a greater predictor of canopy cover than race. While this method does provide the most comprehensive understanding of urban forest distribution, it also remains limited in answering full question of equity, as in itself, canopy cover does not communicate the issues of quality, use, or perceptions of a city's urban forest.

2.4 Geographic Information Systems

Geographic Information Systems (GIS) has increasingly gained momentum as a useful tool in various professional fields, but especially in the environmental field, from resource management and conservation to transportation and city planning (Foote and Lynch 2000). As ESRI, one of the most prominent GIS software developers, states, GIS software, “ is designed to capture, manage, analyze, and display all forms of geographically referenced information […] to view, understand, question, interpret, and visualize our world in ways that reveal relationships, patterns, and trends […]" (ESRI 2015). Because of these immense capabilities of ESRI software, this study utilized ArcMap 10.3.1 to address the first aim of this study.

As was discussed previously, issues of equity are intrinsically and historically issues of proximity and spatial distribution, and thus GIS software has naturally followed as the preferred tool for conducting research on EJ topics (Sheppard 1999; Aguilar and Haracz 2015). As implied by ESRI's definition of GIS above, GIS software contains tools crucial to conducing equity analyses, such as the ability to draw buffers, conduct zonal statistics, overlay analyses, create spatial models, and ultimately be able to integrate the different types of data that are necessary for understanding equity (Sheppard 1999). In addition to this, GIS can also play a crucial role in garnering change to address inequities due to the ability to visualize and communicate such issues to inform decision and policy making processes (Aguilar and Haracz 2015).

For this study and others previously mentioned, GIS is used to integrate census data with urban forest data, such as tree canopy cover or park polygons. However, the approach used often depends on the urban forest feature being analyzed. For case studies involving parks and green spaces, researchers often use GIS software to map buffer areas around parks to better understand what demographics live within a certain distance of the focus areas (Wolch *et al.* 2005; Wendel *et al*. 2012; Zhou and Kim 2013). Some studies who wish to compare spatial proximity with actual distance traveled not only utilize buffers, but also conduct network analyses to understand access as actually experienced (Boone *et al.* 2009), including issues of frequencies and congestions. For cases that use canopy cover as a measure of the urban forest, researchers use remote sensing and orthophotography to create raster files, that can then be utilized to calculate canopy cover for their study area (Heyen 2003 ; Zhou and Kim 2013; Schwartz *et al.* 2015).

This present study will be incorporating similar elements and methods from these previously mentioned studies, including the use of buffers and zonal statistics to help understand distribution and proximity, as well as spatial join tools to calculate the intersection of urban forest features with different demographics. More details on this process will be explained in Methodology (Ch. 4).

2.5 Conclusion

As has been illustrated throughout this literature review, this present study naturally follows from the historical trajectory of the topics on urban forestry and environmental justice. As EJ research has evolved and expanded – and the benefits and services of trees have become commonly accepted – research on urban forests through an EJ framework has gained prominence. However, the literature is still emerging with room to grow. While many of the case studies mentioned provide immense insight into the status of urban forest distribution and those who benefit from this resource, there still remain limits within these studies. One reason for this is that the majority of case studies tend to focus on one feature of the urban forest. This method is of course understandable, as each feature – whether it be parks or street trees- carry their own level of significance and focusing on one feature allows for a deeper analysis. However, the urban forest is not experienced in such a compartmentalized way in real life, and acts a one contiguous feature throughout the city and functions as such.

This current study deviates from previous literature in that it attempts to gain a comprehensive understanding of the urban forest as a whole by analyzing multiple features of the urban forest, including green spaces, residential trees, and canopy cover. The city of Seattle also provides a slightly unique context from which to conduct a case study, as Seattle is the fastest growing city in the United States, with multiple urban forestry and social justice initiatives currently being invested in and promoted by the city government. This not only creates a strong impetus to understand the current status of urban forest distribution, since few case studies on Seattle exist as of now, but it also has the potential to offer important insight into the implementation of social justice principles within urban forestry and city planning.

3. STUDY AREA

The study area for this research is the city of Seattle, WA, located in the Pacific Northwest of the United States (Figure 1). Laying between two prominent bodies of water, Seattle is 83.8 square miles, with a population density of 7,782 people per square mile (Census Reporter 2013). Seattle has an estimated population of 652,429 people, and is one of the fastest growing cities in the United States (AP 2014). Demographically, the median household income is about 70,000 USD, and the population is 67% White, 13% Asian, 7% Black, and 6% Hispanic. While the overall population remains predominately White, Seattle contains strong concentrations of communities of color, particularly in the South, which contains one of the most racially diverse zip codes in the U.S. (Seattle Times Staff 2010). These concentrations of ethnic communities are due in large part to Seattle's history of racial segregation in the 20^{th} century (Silva 2009). It was during this time that overtly discriminatory redlining and racial restrictive covenants prevented ethnic minorities from moving into certain neighborhoods throughout Seattle, pushing many communities of color into limited areas in central and south Seattle. These discriminatory practices were finally federally deemed illegal in 1968, but their impact continues to linger in the current distribution of minority communities in Seattle, as will be seen later in this study.

Study Area: Seattle, Washington

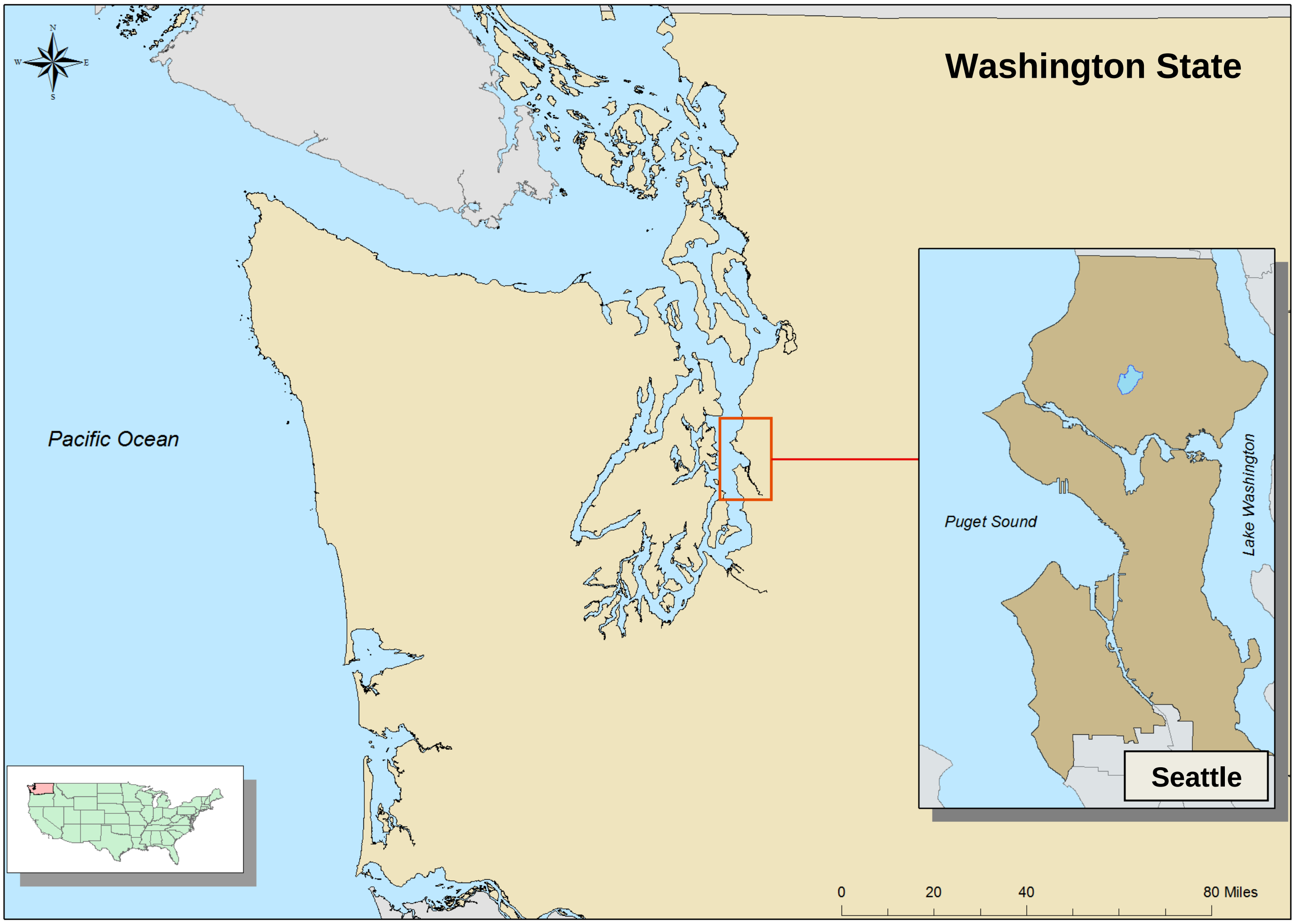


Fig.1. Study Area ; Data Sources: U.S. Base map- ESRI , Washington State – WA DOE , Seattle – King County

3.1 Seattle's Urban Forest, Past and Present

Seattle has a temperate climate with long wet winters and dry summers. Average annual rainfall is 37 in. and temperatures average between 30-50 °F in the winter and 50-70 °F in the summer (Walsh 2015). Prior to its establishment in 1851, Seattle used to be old growth coniferous forests. It was these forests and access to the sea that attracted white settlers, establishing prominent logging operations and pulp mills in the region (City of Seattle 2007). Since then, Seattle's original forest has all but been logged, with the exception of a few forested parks intentionally set aside by the Olmsted Plan in 1904 (GSP 2005).

Seattle's current urban forest has between 1.6 – 3 million trees (City of Seattle 2013). While originally dominated by evergreen conifers with a small mix of deciduous trees, Seattle's current forest is dominated by shorter-lived, second-growth deciduous trees. Citywide, 69% of trees are deciduous, 22% coniferous, and 9% evergreen broad-leafs (City of Seattle 2013). The total canopy cover in Seattle was estimated at 23% from an analysis of 2007 QuickBird Satellite data. While tree canopy is understandably most concentrated in natural areas (80% cover), Single-family residential units account for the largest area of the city (23% cover) (Table 1).

Management unit	Land area (acres)	% of city land area	Estimated 2007 canopy cover
Single-Family Residential	30,452	56%	26%
Multi-Family Residential	5,982	11%	17%
Commercial/Mixed Use	4,350	8%	10%
Downtown	544	1%	9%*
Industrial	5,982	11%	4%
Institutional	1,088	2%	19%
Developed Parks	2,175	4%	25%
Parks' Natural Areas	3,807	7%	80%
City-wide	54,379		23%
Right-of-Way	14,682	27%	18%

*Shading caused by downtown tall buildings was the reason why canopy cover for this management unit was under-represented. SDOT analysis of their existing tree inventory confirmed that downtown's canopy cover is closer to 9 percent.

Table 1. Seattle Canopy Cover by Management Unit Source: City of Seattle 2007

3.2 Urban Forest Policies and Initiatives

Seattle has long been dubbed the "emerald city" for its prominent greenery, and has been awarded accolades such as a Tree City USA recognition and named one of the top ten urban forests in the U.S. (American Forests 2013). However, despite the positive reputation, many have recognized that it is an urban forest in decline. The combination of increasing urban growth, invasive species, and dominance of short-lived, deciduous trees has created the impetus for the City of Seattle to invest in reforesting and increasing the city's canopy cover (City of Seattle 2007). This investment is manifested in two paramount goals set by the City: to restore 2,500 acres of forested parkland by 2025 and to reach 30% citywide canopy cover by 2037.

The first goal – to restore 2,500 acres of forested parkland – was initiated in 2004 with the creation of the Green Seattle Partnership (GSP). While community members and various city departments had been working in Seattle's forested parks to maintain the health of the trees by removing invasive species and replanting with native trees, it was the formation of GSP which unified these different actors into an organized effort supported by the City (GSP 2005).

While GSP focused on the urban forest within parklands, it was in 2007 that the City of Seattle expanded its urban forestry efforts by developing its first Urban Forest Management Plan (UFMP) which introduced Seattle's second major goal of 30% canopy cover by 2037 (City of Seattle 2007). The inauguration of the UFMP has been followed by the creation of the Urban Forestry Commission to advice city policy, as well as several supplemental reports, including an ecosystem services valuation report (GCRA 2012) and an update to the management plan in 2013 (City of Seattle 2013). A total of eight city departments have responsibilities related to the urban forest, which range from community engagement and outreach to routine maintenance of public trees (City of Seattle 2013).

3.3 Previous Assessments

As attention has continued to increase on the urban forest, several assessments have been conducted that provide insight into issues of distribution; however none yet have explicitly analyzed this distribution in relation to race or income. A primary example would be canopy cover assessments conducted over the past few years, both by the City in 2009 (NCDC 2009) and Seattle Audubon Society in 2011 (Seattle Audubon Society 2011). Both estimated the canopy to be between 22-23% citywide, and even assessed canopy cover between different land uses, or in the Audubon assessment, different neighborhoods. While inferences could be made from this information about race or income, it is not enough to make conclusive assessments about equity. Another example would be assessments conducted by the Seattle Department of Parks and Recreation (SPR) that have looked at gaps in usable open spaces throughout the city, including green spaces (City of Seattle 2011). Once again, while these assessments provide information about accessibility within neighborhoods, they do not compare disparities between neighborhoods, or specifically look at the relation between usable open spaces and race or income. The main shortcoming of these assessments is that they aggregate their findings into citywide or neighborhood wide results, which fails to expose demographic inequalities. This method is one that Pearsall and Pierce (2010) see as a common pattern among cities who struggle to fully implement principles of social justice and sustainability within their overall city planning.

As mentioned previously, the only current research done explicitly about Seattle's urban forest and equity is a former Master's thesis from the University of Washington, which assessed tree conditions and levels of maintenance from six sample census tracts which represented high or low income households based on Median Household Income (Erikson 2004). While this research is helpful in understanding the equity of Seattle's urban forest, it is also limited in its scope by looking only at street trees, from six samples, and only in relation to income. This research was also done prior to the establishment of GSP and the Urban Forest Managements Plan, creating a need to assess the urban forest as these programs progress and continue to input resources into Seattle's forests. While this current research will be drawing from many of the previous studies done on urban forest equity, including Erikson's, it is also diverging from current research in hopes of contributing a nuanced understanding of the issue.

As mentioned previously, this study greatly diverges from previous work by assessing multiple features of the urban forest to gain a more comprehensive understanding of the forest as a whole rather than isolated aspects of the urban forest. Secondly, while many studies focus on the immediate issue of a study area's misdistribution of resources, this study aims to place results into the context of the overarching issue of integrating equity concerns within city planning and urban forestry. Lastly, while research is growing on the distribution of urban forests, there remains a prominent void on research in Seattle specifically, which this study will be alleviating.

4. METHODOLOGY

This next section discusses the different processes and methodologies that were used to conduct this study. First, the types of data and their sources that were used will be outlined, followed by a more detailed account of how they were used and manipulated in ArcMap. Finally, the statistical tests that were used to analyze the data will be explained.

4.1 Division of Data

To gain a comprehensive understanding of the urban forest as a whole, this study analyzed three different features of Seattle's forest: Parks, residential trees, and vegetation as a whole (canopy cover). While all were analyzed using ArcMap 10.3.1, each differs in the specific methodology used.

Parks

Parks are important sources for a city's urban forest, as they provide large expanses of protected land for trees and natural vegetation to flourish and expand. SPR maintains hundreds of properties, and over 3,700 acres of open space, 2,500 of which have been specifically deemed as forested natural areas (GSP 2005). The City of Seattle has classified its parkland into different types and includes small neighborhood parks, p-patches, playfields, and even recreation centers (City of Seattle 2015).

To understand the distribution of park spaces, this study followed similar methods to the previous studies mentioned in the literature review (Wolch *et al.* 2005; Wendel *et al*. 2012; Zhou and Kim 2013; Boone *et al.* 2009). This study utilized a shape file provided by Seattle Public Utilities which was created in 2011 but updated in 2014 (for full list of data used and sources see Appendix A). This study analyzes both the number of parks and average park area available within a quarter mile of different demographics. A quarter mile was chosen as it is recognized by the City of Seattle (City of Seattle 2011) as the ideal proximity of urban residents to usable open spaces. According to the Open Space Gap Report, Seattle specifically has a goal to have 1 acres of green space per 100 residents. A quarter mile is deemed the reasonable distance one is willing to walk to visit an open space, which is crucial in terms of access, since marginalized individuals may lack the resources to travel farther distances to visit green spaces (Wolch *et al.* 2002).

Since the shape file contains data for all types of SPR properties, the author utilized SPR classification descriptions (City of Seattle 2015) to edit the shape file to only include parks that were most likely to contribute to the urban forest. Thus properties such as playfields, community centers, boat launches, and p-patches were removed, essentially spaces that - while undoubtedly fulfilling other community needs - often lack in trees compared to regular parks; as these trees are the focus of this study, the inclusion of these spaces did not seem appropriate. There is of course the argument that not all park spaces contain large amounts of trees or vegetation beyond simply maintained grass, and thus only designated natural areas or green spaces should be included. However, a wider range of parks were kept to avoid the assumption that all individuals interact with their environment in the same way. While normative culture views green spaces and natural areas as places to visit and recreate, for others from divergent cultures or backgrounds, parks that are more developed or contain more man-made amenities might align more with their needs and desires. While these quasi-natural parks vary in their canopy or tree density compared to completely natural areas and greenbelts, they may still be the main point of access to the urban forest for certain populations.

Residential Trees

While shorter distances to parks can improve access to the urban forest for marginalized residents, it does not necessarily guarantee it— there are those who simply lack the means to leisurely frequent these spaces. Thus, residential trees outside of parks can play an essential and often undervalued role in exposing residents to the numerous benefits of a healthy urban forest. Residential trees include publically funded trees along planting strips, right-of-ways (ROW), and street ends, as well as private trees planted by property owners. To measure access to these trees, this study utilized a shape file from SPU created in 2011 that documents an inventory of public and private trees throughout Seattle. While surely not containing all trees within Seattle, the file is the most comprehensive record available in GIS format, and the file contains 122,673 trees, offering a sufficient sample for this study. Using this file, the average number of trees per demographic group was determined.

Canopy Cover

While the above two datasets cover many trees within Seattle, canopy cover was also assessed to account for possible deficiencies within the other datasets, capturing vegetation that may have been missed. Both the City of Seattle and the State of Washington have conducted canopy cover assessments within the past decade, using remote sensing to gather satellite imagery and developing a land cover classification dataset to perform the assessment (NCDC 2009; Dept. of Ecology 2014). Fortunately, the Washington State Department of Ecology has made the 2006 canopy assessment available as a raster file. This data was created from 2006 Landsat imagery, which was geo-referenced by the U.S. Geological Survey. Utilizing this data, the average percentage of canopy cover was determined per demographic group.

Demographic Data

To measure the above urban forest features in relation to marginalized individuals, census information at the block group level from the U.S. Census Bureau was used. Block groups are the smallest geographic unit for which census information is collected, containing between 600-3,000 people. The U.S. Census Bureau conducts "long form" surveys of demographic information every ten years, yet since 2010 several demographic indicators have been removed from the decennial survey (U.S. Census Bureau 2012). These indicators are now tracked on a yearly basis through the American Community Survey (ACS), which while more frequent, draws from a smaller sample of every 1 in 38 people. For this study, demographic information was used from the ACS 2013 5-year estimates Survey and downloaded from the Census Bureau's clearinghouse, Americanfactfinder.org in .xls format and later joined with a block group boundaries shape file provided by King County through the Washington State Geospatial Data Archive (WAGDA).

As a measure of economic disparities, Median Household Income was used. While Median Household Income has its limits since it is generalizing household income for a whole area and can be skewed by outliers, it still remains one of the more convenient measurements and is more accurate than an aggregate or mean measure of income, hence its use in similar studies (Erikson 2004; Zhou and Kim 2013 ; Heyen 2006; Wolch *et al.* 2005). In addition to understanding those economically marginalized, this study also analyzes Seattle's urban forest in relation to those marginalized due to ethnicity. Thus, this study also looked at the urban forest in relation the percent of Asian and Black residents within each block group, since Asian and Black American's represent the two largest racial minorities in Seattle. This study also compared block groups with a majority White residents and those with a majority non-White residents.

4.2 Analysis Procedures

The geographic and demographic data was processed and visualized using ArcMap 10.3.1, SPSS statistical software, and Microsoft excel. First census information was joined with geographic boundaries. The three urban forest features were then overlaid with the demographic data using different tools from Arc toolbox. Data gathered from these processes were then analyzed using a variety of statistical tests.

Social Demographics

The first step was to join the census information downloaded in .xls format to block group boundaries downloaded from WAGDA in vector format (all data was projected in NAD_1983_HARN_StatePlane, WA_North_FIPS_4601_feet). The block group boundaries were originally of King County, and thus a base map of the city of Seattle was also downloaded from WAGDA, and the clip tool was used to create block group boundaries of just Seattle instead of the entire county. There were some block groups that appeared in the attribute table that were appearing as lines along the borders instead of actual polygons, and so they were removed so they did not impact results. There were 500 block groups in total used for this study.

Median Household Income

Median household income was downloaded in an .xls spreadsheet, and edited to be compatible with ArcMap. This included changing headings, as well as adding a join field to the block group boundaries shape file using the Federal Information Processing Standards (FIPS) codes assigned to each block group. While the boundaries already contained FIPS codes, a new field had to be created in double integer format to be compatible with the .xls spreadsheet. 'Join table' tool was then used to join the .xls spreadsheet to the block group boundaries attribute table based on the FIPS codes, so that every block group polygon contained their corresponding median household income. Block groups were then classified into four different income groups: Low Income (0 - $30,000); Lower Middle Income (31- $60,000); Upper Middle Income (61- $90,000); and High Income (> $90,000). In total, income ranged from $3,393 at the lowest, and $225,813 at the highest. While the previous study done by Erikson (2004) only grouped income into high or low, the author felt it beneficial to look at a wider spectrum of income groups, particularly splitting Middle Income residents into two different groups.

Race

Information about race was joined in the same manner as household income. The only difference is that the spreadsheets available through the census bureau (one for each racial group) only contained total population of White, Black, and Asian residents rather than percentages. Thus, these numbers were divided by the total populations of each block group, and the resulting percentages were added to the spreadsheets. These spreadsheets were then joined to the block group boundaries, and each block group was classified into different groups based on the percentage for each racial group (low, medium, high), to be used later in the statistical analysis. At the end of this phase each block group contained median household income, % White residents, % Black residents, and % Asian residents.

Urban Forest Features

Parks

Once the block group polygons contained the necessary census information, proximity of parks could be calculated for each demographic group. As mentioned before, the attribute table of the parks shape file was edited so that only those features that were likely to contain trees or natural areas were included. The shape file had to be further edited, as it subdivided parks into multiple polygons despite actually being the same park as designated by the property management area (PMA) number. Thus the 'dissolve' tool was used to merge these subdivisions by their PMA number to provide a more accurate analysis on the number of parks within a quarter mile of each block group.

Once the park shape file was prepared (n=431), a .25-mile buffer was created around each block group. 'Spatial join' was then used to calculate the number of parks that intersected within each buffer. Through spatial join, the area of each park polygon within each buffer was summed together so that averages could be calculated later.

Residential Trees

The number of residential trees (private and public) within each block group were calculated using another shape file from SPU, which contained points of individual trees. Once again, the attribute table had to be edited since several trees were noted as having been removed, thus these entries were deleted from the table (n= 122,673). 'Spatial join' was once again used to calculate the number of trees found within each block group polygon.

Canopy Cover

While the previous two features were manifested in vector format, canopy cover was calculated using a raster file provided by the WA Department of Ecology (DOE). This canopy cover data was originally of Western Washington, and thus 'extract to mask' was used to isolate the canopy cover of only Seattle, using the Seattle base map -- While the City of Seattle also has canopy cover data available that is specific to only Seattle, DOE's data was chosen since it was more recent (2006 instead of 2001) and was also in raster format which was necessary to calculate % canopy cover. Finally 'zonal statistics by table' was used to calculate % canopy cover within each block group.

Statistical Analysis

There are a variety of different statistical tests that could be run to answer the aim of this study. Many similar case studies use types of regression analyses to analyze their data (Zhou and Kim 2013; Landry and Chakraborty; Martin *et al. 2004;* Sotoudehnia and Comber 2011). Regression tests can be useful for understanding relationships between variables and especially predicting the amount of change one variable has on the other. However, for this study a set of descriptive statics were chosen, primarily due to a lack of expertise in running regression analyses by the author, but also because the small number of independent variables considered in this study could result in an insufficient model. Three different statistical tests were used for this study: Cross tabulation using Kendall’s Tau-b coefficient; One-way ANOVA; and independent T-test.

Cross Tabulation

Cross tabulations (crosstabs) was used to evaluate the relationship between the different categories created for each demographic group. This test was used alongside Kendall’s tau-b and tau-c correlation coefficients to test the measure of association between the variables. Tau-b was used when there were the same number of dependent and independent ordinal categories (e.g. Income), and tau-c when there was not (Race Because Kendall’s tau-b/ tau-c is used to evaluate ordinal categories, the urban forest features (the dependent variables in this study), were also grouped into ordinal categories, similar to the independent variables. The ‘recode into different variables’ tool in SPSS was used for this, and the different categories are explained in Table 2 below.

Independent Variables				
Income	Low Income 0-$30,000	Lower Middle Income 31-$60,000	Upper Middle Income 61-$90,000	High Income >$91,000
Asian	Low 0-15%	Medium 16-30%	High 31-80%	
Black	Low 0-15%	Medium 16-30%	High 31-70%	
Dependent Variables				
Parks- #	Low 0-5	Average 6-10	Above Average 11-15	High >15
Parks - Acres	Low 0-50	Average 51-100	Above Average 101-350	High >351
Residential Trees	Low 0-200	Average 201-400	Above Average 401-600	High >600
Canopy Cover	Low 0 -10%	Average 11-20%	Above Average 21-30%	High >30%

Table 2 Ordinal Categories for Independent and Dependent Variables

Crosstab tables show what percentage of each dependent group makes up each independent group. The Kendall's coefficients also provide a table which shows the relationships and significance of these results, with a positive Kendall value signifying a positive relationship between independent and dependent variables, and *vice-versa*.).
A further explanation of all the crosstabs tables will follow in the Results section.

One-way ANOVA

One-way analysis of variance (ANOVA) tests were used to determine if significant differences existed in the means of the dependent variables between each independent variable group. If significant differences ($p<.05$) were determined, then a post-hoc Tukey test was run in order to see between what specific groups there was a difference.

Independent t-test

While crosstabs and one-way ANOVA were useful to determine differences within each demographic group, they were not fully able to compare differences across the different racial groups (Black, Asian, and White). Thus racial data for each block group was recoded into two categories: > 50% White and > 50% non-White. The means of each dependent variable were found for these two categories, and independent t-tests were used to determine whether differences between these means were statistically significant.

Hypotheses

Once again, the initial aim of this study was to determine to what extent Seattle's urban forest is distributed equitably in regards to income and race. Thus the following questions are posed to address this aim:

1.) Is there a difference in the mean number of parks within a quarter mile and amount of park area among the different income groups or racial groups?

2.) Is there difference between the average number of trees among the different income groups or racial groups?

3.) Is there a difference between the % canopy cover among the different income groups or racial groups?

4.) Does higher income or higher percentage of white residents result in increases in these three urban forest features?

For the ANOVA and Independent t-tests, the null hypothesis is that there is no difference in any of these urban forest features between different income groups, or between the different racial groups.

Interviews

While not originally planned as an integral method of data collection, the author decided to conduct four semi-structured interviews with City of Seattle employees upon analyzing the results of the above statistical tests (Table 3). Because part of this study was to discuss the overarching issue of integrating social justice and equity concerns within urban forest management, the author felt that speaking with City employees whom work in this field could provide important insight to guide the discussion of this topic. Thus, interviews were conducted over two weeks in June 2015 : Two in person; one over the phone; and one over email (See Appendix C for interview questions). The first three were recorded and each lasted between 25-30 minutes. Unfortunately the recording of the phone interview later malfunctioned and was thus lost, leaving only notes to recall from. The other two were transcribed, with common themes noted from all the interviews. Because these interviews were conducted in response to the findings, information collected from these interviews will appear in the Discussion section of this study.

Title	City Department
Environmental Sustainability Policy Advisor (urban forest management and electric vehicles)	Office of Sustainability and Environment
Vegetation Management Supervisor; Co-chair on Race and Social Justice Change Team	Seattle City Light
Strategic Advisor - Equity Planning & Analysis	Seattle Public Utilities
Seattle reLeaf Program Manager	Seattle Public Utilities

Table 3. Interview Participants

5. RESULTS

The following section will detail the results of the various statistical tests that were used to help determine whether or not significant differences in distribution of parks, residential trees, and canopy cover exist between income groups or racial groups. Results will be organized by urban forest feature, starting with park proximity and area, followed by number of residential trees, and ending with percent canopy cover. The main findings as a whole will be summarized in a brief conclusion at the end of this section, including a table of significant findings as well as distribution maps. While details from the tests will be noted throughout the sections, Appendix B also contains the cross tabulation output tables for further reference.

5.1 Proximity to Parks

Income

When analyzing the number of parks available within a quarter mile of each block group, there were only slight differences among the four different income categories.[1] A larger percentage of High Income block groups had access to the highest number of parks (5% as opposed to <1% for the other income groups), yet the majority of all income groups were adjacent to between 0-5 parks. It also was the case that the Low Income category contained the largest percentage of block groups with access to >351 acres (7.3%), while the Upper Middle Income category contained the lowest (3.1% of block groups adjacent to >351 acres). In fact, Figure 2 shows that on average, the lower income groups were adjacent to more park area than the higher income groups, contrary to what was expected. However, the differences between all the income groups were not statistically significant (p>.17)

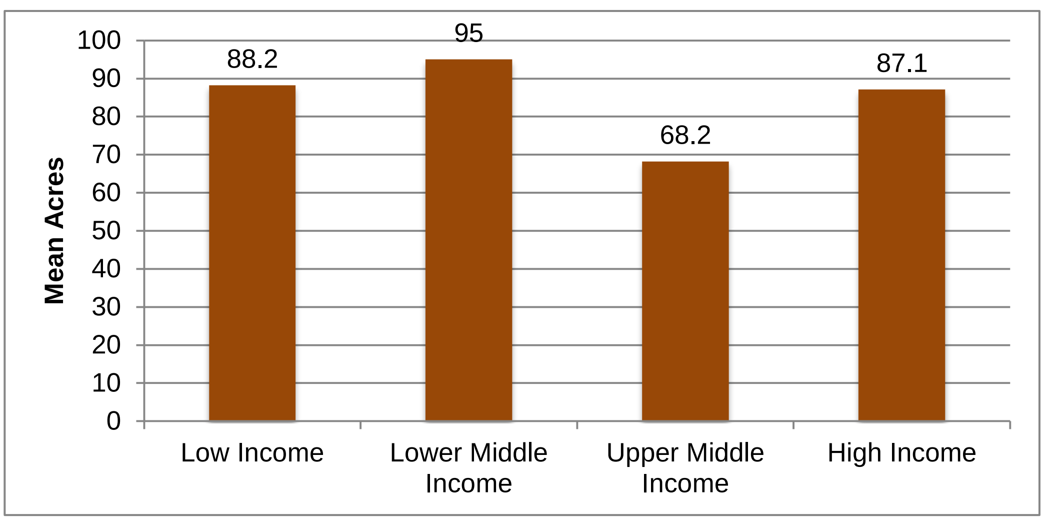


Fig. 2 Average Park Acres within .25 Mile

[1] ANOVA results: sum of squares=237, df=499, F=1.078, p>0.3

Race

Race remained similar to income in regards to the number of parks and park area. No consistent relationships within any of the racial categories existed, and both crosstabs and ANOVA suggested no significance ($p > .05$). This was further reflected in the independent t-test between >50% White and >50% non-White block groups.[2] Block groups with more White residents averaged at slightly higher acreage and number of parks than block groups with more non-White residents. However, neither of these differences were of statistical significance, and thus, the null hypothesis could not be rejected.

5.2 Quantity of Residential Trees

Income

Crosstabs seemed to show a consistently positive association between income and number of trees, with high income block groups containing a higher percentage of trees than the lower income groups.[3] This association was further confirmed with the ANOVA test.[4] The post-hoc test showed that significant differences lay between the Low Income groups and both the Upper Middle Income and High Income groups (Figure 3). There was also a significant difference between Lower Middle Income and High Income group.

[2] # of Parks: $t= -1.135$, $df= 150.099$, $p > 0.3$; Acres: $t= -1.357$, $df= 122.637$,$p >0.2$)
[3] Kendall's = .257 $p <.00$
[4] ANOVA results: sum of squares= 166655486.18, $df=499$, $F=9.95$, $p < .00$

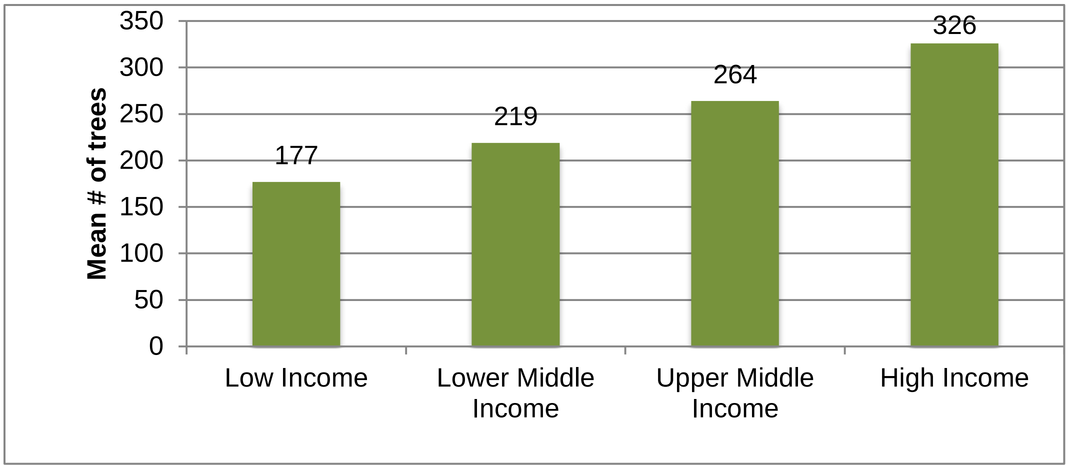


Fig.3. Average Number of Residential Trees per Income Group

Race

There was not a consistent relationship found between % of Black residents and the number of residential trees. There was however, a significant negative association between the number of trees and the % of Asian residents, with the number of trees predominately increasing as the % of Asian residents decreased (Figure 4).[5] The most significant differences existed between Low % Asian group and both Medium and High % groups, though High percentage of Asian residents averaged slightly higher than Medium.[6]

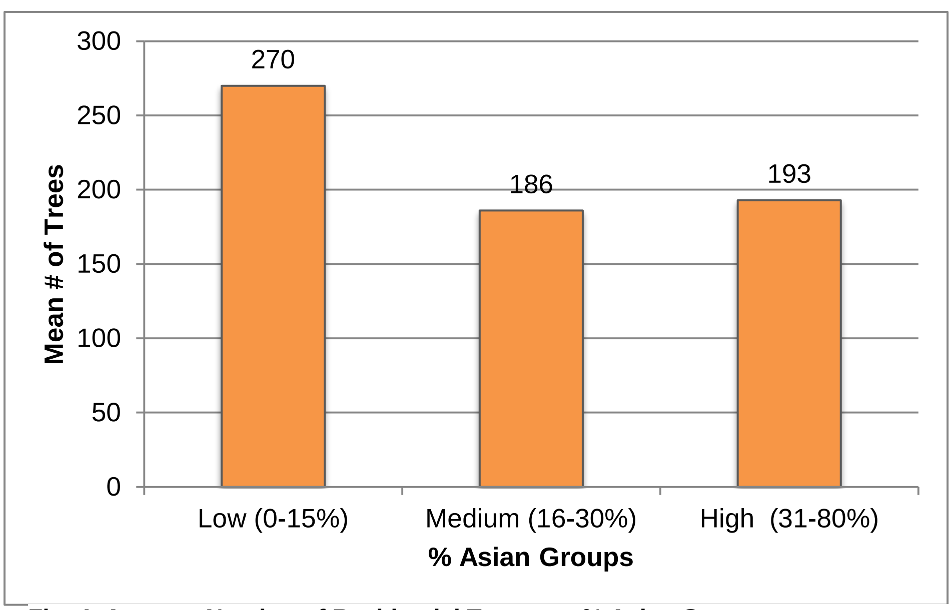
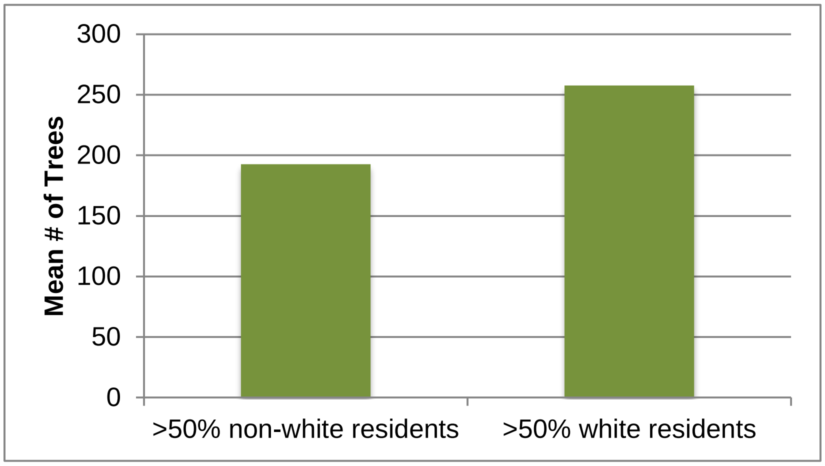


Fig. 4. Average Number of Residential Trees per % Asian Group

[5] Kendall's = -.182, p <.00
[6] ANOVA Results: Sum of Squares= 16655486.18 df=499 F=10.902 P<.00

While crosstabs and ANOVA only found relationships between concentrations of Asian residents and number of residential trees, there was a significant difference between block groups with >50% White residents and block groups with >50% non-White residents.[7] Block groups with more White residents contained an average of 258 trees (std = 207), while block groups with more non-White averaged at 193 trees (std = 175) (Figure 5).



. **Fig. 5. Average Number of Residential Trees between White and Non-White block groups**

5.3 Percent Canopy Cover

Income

The biggest differences were found in regards to canopy cover and the different income categories. For income there was a clear increase in the percent canopy cover as income increased, with a higher percentage of high income block groups containing canopy cover > 31%.[8] The ANOVA and post-hoc test showed significant differences between all the income categories except between Low Income and Lower Middle Income (Figure 6).[9]

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[7] T-Test results: t= -2.763, df= 117.09, p <.01
[8] Kendall's= .308 p<.00
[9] ANOVA results: sum of squares= 72599.324, df= 477, F= 23.58, p <.00

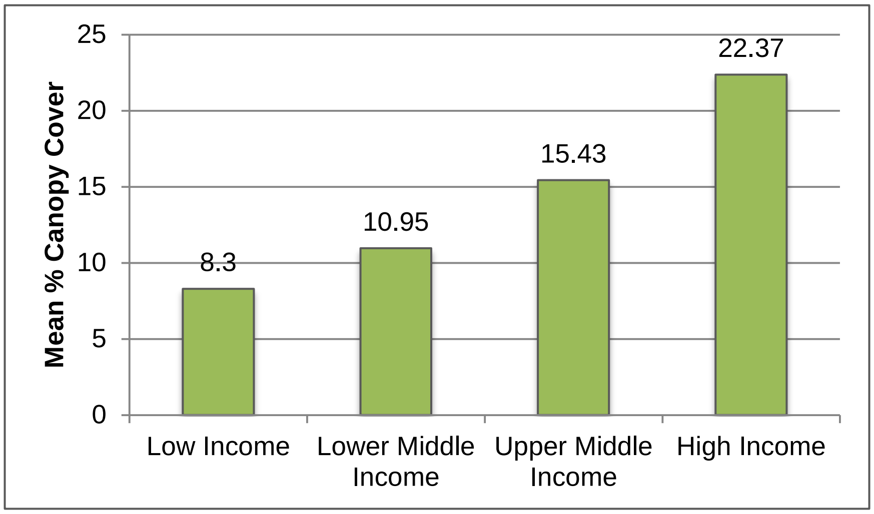


Fig. 6. Average Percent Canopy Cover per Income Group

Race

Canopy cover and race followed a similar pattern to the findings in regards to residential trees. Crosstabs did show that a higher percentage of block groups with a low % of Black residents, contained more canopy cover (14.8% with canopy >31%); yet, these differences were not significant. However, there was a significant difference between block groups with a low % Asian population and those with a high % Asian population, with the former containing significantly more tree canopy cover (Figure 7).[10]

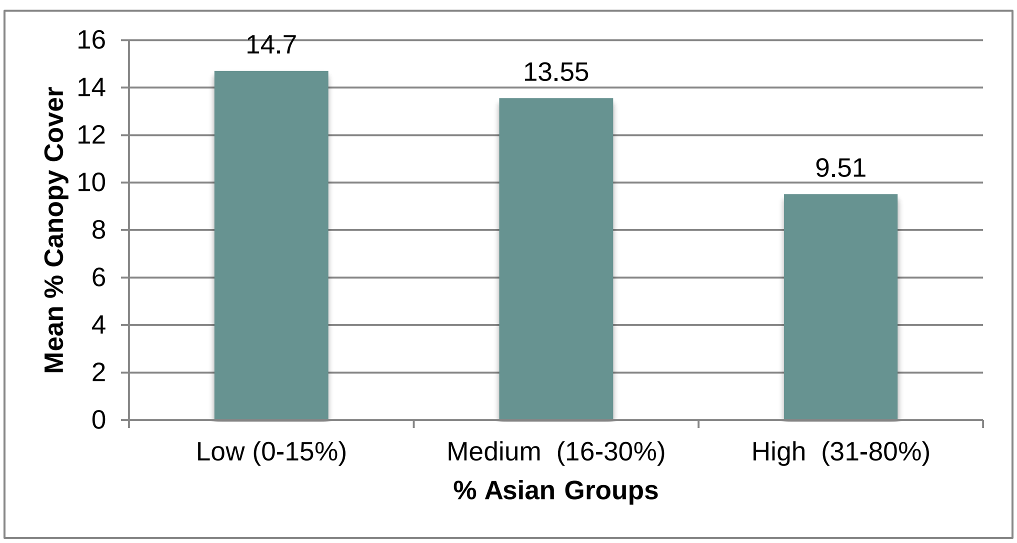


Fig. 7. Average Canopy Cover per % Asian Group

[10] ANOVA results: sum of squares= 72599.324, df= 477 , F= 4.491 , p < .01

The independent t-test also showed that block groups with a majority White resident averaged with significantly more canopy cover at 14.41% (std= 12.72) than those block groups with majority non-White residents with 11.10% cover (std= 9.77) (Figure 8).[11]

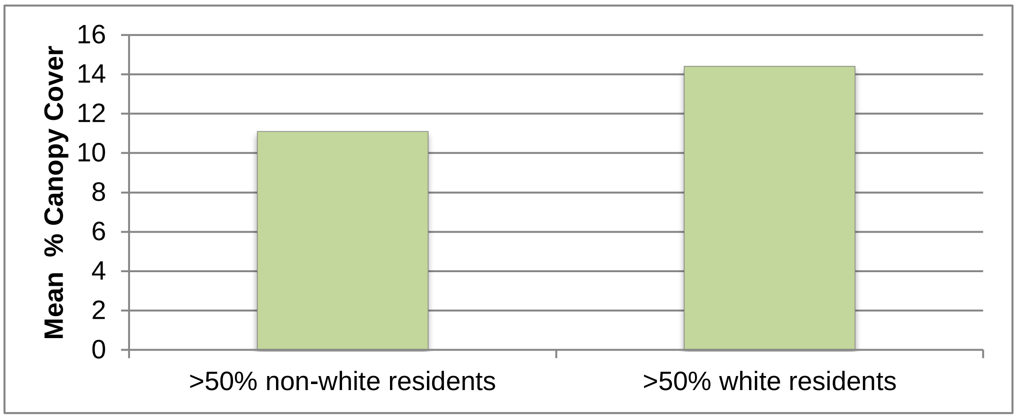


Fig. 8. Average Canopy Cover: White vs. non-White

5.4 Summary of Findings

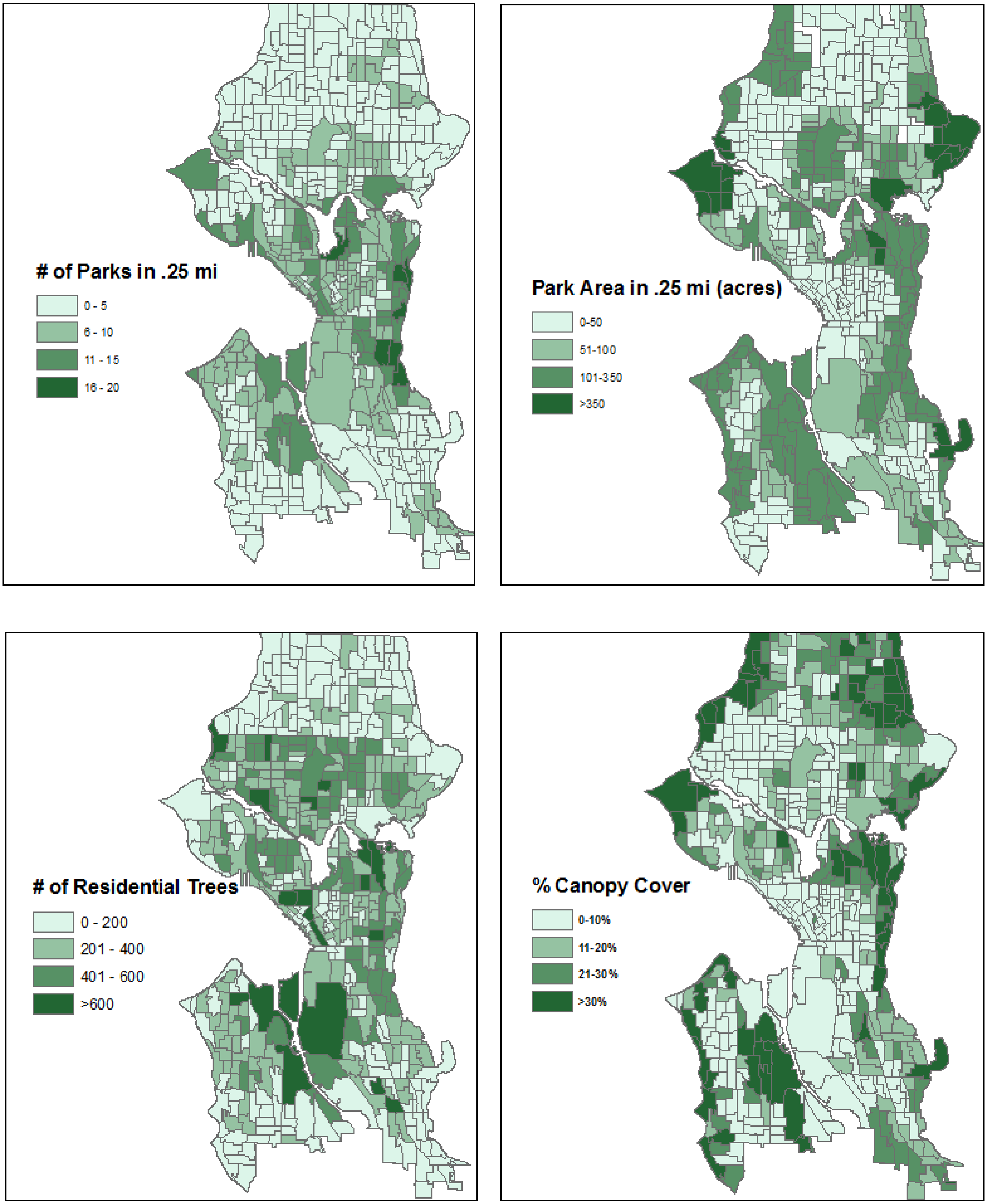
Numerous variables were tested with a variety of methodologies. The most significant differences were apparent in canopy cover and residential trees in regards to race and income; other discrepancies were found, but remained statistically insignificant. A summary of these results are in Table 4 below, followed by Figures 9 and 10 which offer a visual summary of the different urban forest distributions as well as the distributions of income and race.

[11] T-Test results: $t=-2.579$, $df=131.150$, $p <.01$

	Parks - #	Parks- Acres	Residential Trees	% Canopy Cover
Income	Slightly higher proportion of High Income blocks adjacent to high # of parks	Lower income groups slightly higher average of adjacent acres	Notable differences between lower income and higher income groups	Notable association between high canopy cover and high income blocks
White vs. Non-White	Predominately White blocks slightly higher average # of parks	Predominately White blocks slightly higher average acres	Predominately White blocks have significantly higher average amount of trees	Predominately White blocks have significantly higher % canopy cover
% Black	-	-	-	Slight association between Low % Black and higher % canopy cover
% Asian	-	-	Higher proportion of Low % Asian blocks contain larger amount of trees	Higher proportion of Low % Asian blocks contain higher % canopy cover

No consistent association | Slight association | Significant association

Table 4. Summary of Results



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Data Source: Seattle Public Utilities ; Canopy Cover - WA Dept. of Ecology

Fig. 9. Distribution of Urban Forest Features

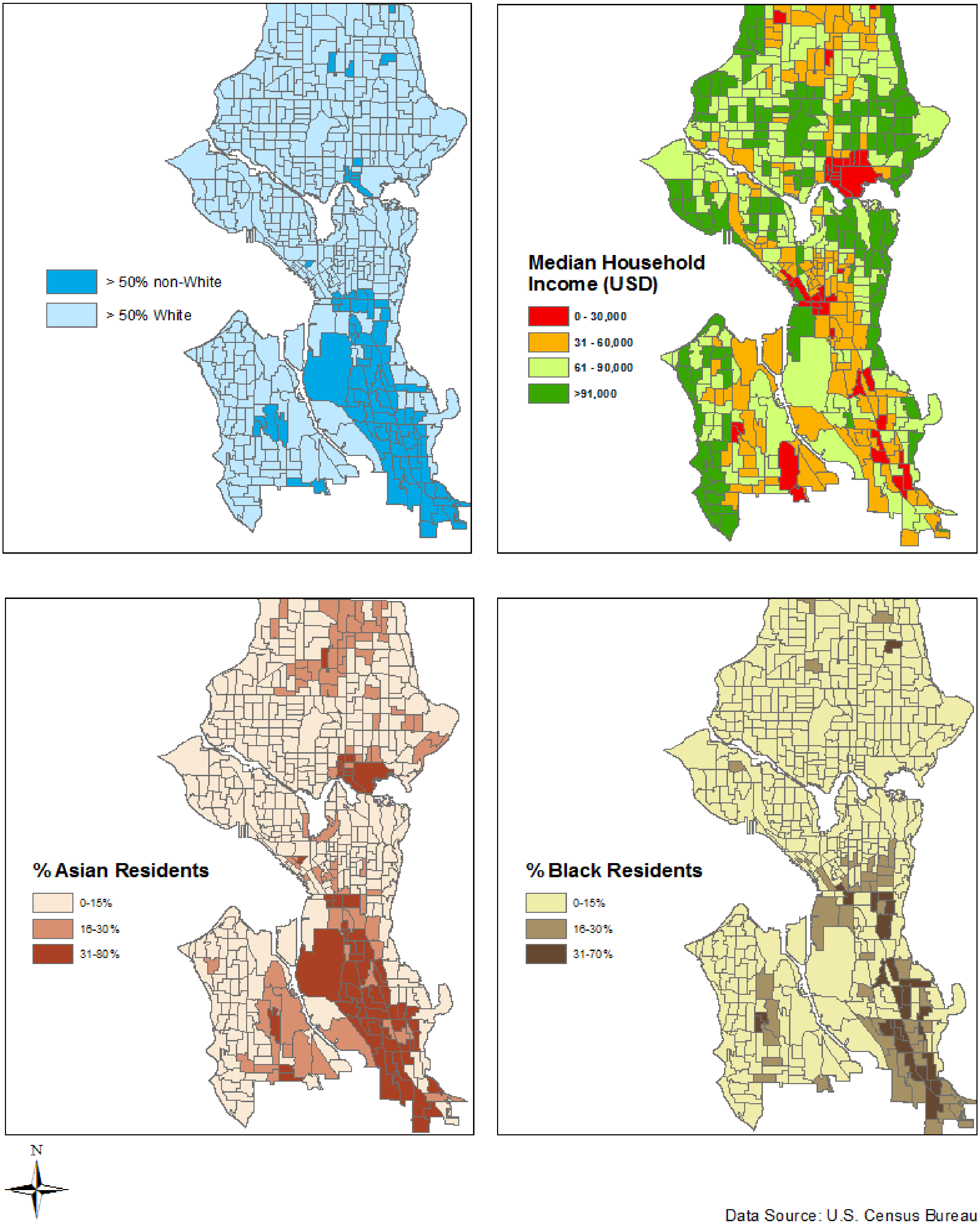

Fig. 10. Distribution of Income and Race

6. DISCUSSION

This section will discuss the implications of the results from the previous section, and address the primary research question of this study – to what extent is Seattle's urban forest equitably distributed across income and race. From this, the overarching issue of integrating equity concerns within urban forestry will be discussed with reference to particular insights gained from the interviews conducted with City of Seattle officials. The section will conclude with the ways Seattle is integrating social justice within its urban forest programs, and a summary of recommendations for achieving greater equity in urban forestry.

6.1 Is Seattle's urban forest distributed equitably?

As the results show, some null hypotheses were in fact rejected, meaning that there were instances in which one demographic group was more heavily associated with different urban forest features than the others. As was seen, this was particularly the case in regards to trees and canopy cover for both income and race, with high income and more predominately White block groups having higher averages in both of these categories. It was surprising that no notable differences existed in regards to parkland, and if anything, it appears as though lower income areas have access to more park area. There are of course further questions that could be asked in regards to parks, such as the quality of parks in different area, or level of vegetation. It is also important to remember that while wealthier neighborhoods do not necessarily lay adjacent to more parkland, these resident may still have greater access and mobility to visit green spaces beyond their immediate neighborhood. Thus while the different demographics may have close to *equal* number of parks or park area, whether this is *equitable* considering residents' situations is still in question.

While the null hypotheses were rejected in regards to residential trees and canopy cover, the actual differences among these different demographics were not as drastic as had been anticipated. It was also unexpected that, within the racial groups, the biggest differences were associated with the concentration of Asian residents only. Yet when one looks at the current and historical geographic location of concentrated Asian populations within the city, these results make sense.

First of all, the International District, which lays adjacent to the downtown commercial area of Seattle, has historically been home to Asian immigrant communities, particularly the Chinese and Vietnamese communities of Seattle (Silva 2009). While Asian communities have expanded beyond the International District over time, Figure 11 shows that higher concentrations of Asian residents are still predominately in the more industrialized areas, as well as multi-family zones.

Commercial and industrial areas remain highly developed with few potential spaces for vegetation and street trees. While those living in multi-family zones may have more space available for residential trees, multi-family residencies tend to be homes such as apartment buildings and duplexes, and thus these residents are predominately renters rather than homeowners. This then can impact both the space available for new trees, especially private trees, as well as residents' ability to plant new trees if they are renters. Table 1 in Ch. 3 (Study Area) further confirms that citywide, multi-family zones contain much lower canopy cover than single-family. These factors of geography are likely contributing to the differences in access within the Asian communities in Seattle, since it could also explain why marginal difference existed in relation to concentration of Black residents. When comparing the historical geographic distribution of Seattle's African American communities to Seattle's Asian American communities, African Americans were historically restricted to more central residential neighborhoods in Seattle -- and thus more potential for residential trees—while Asian American's were concentrated in the previously mentioned industrial and commercial areas (Figures 12 and 13).

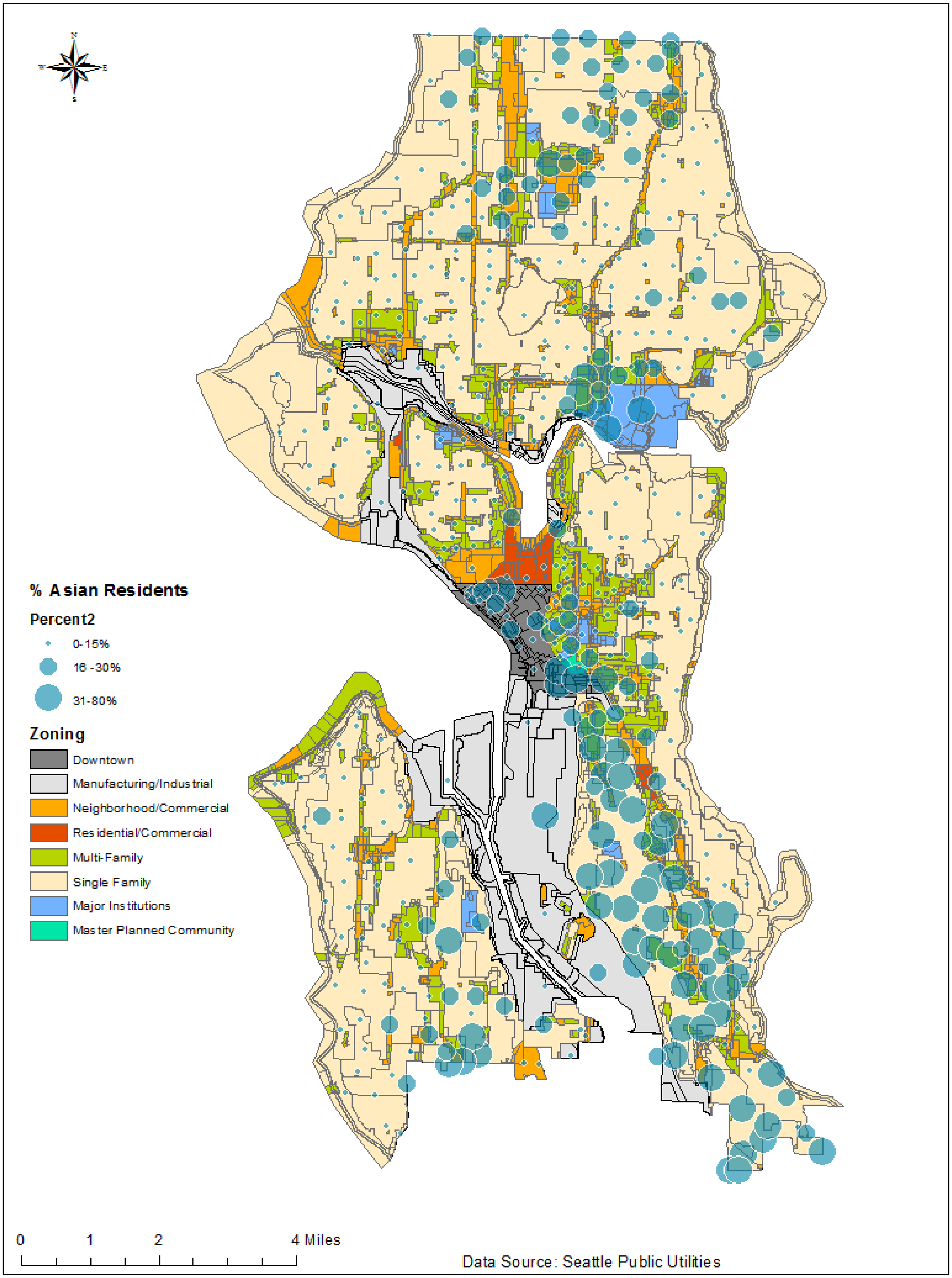

Fig. 11. Concentration of Asian Residents in Relation to Seattle Zoning

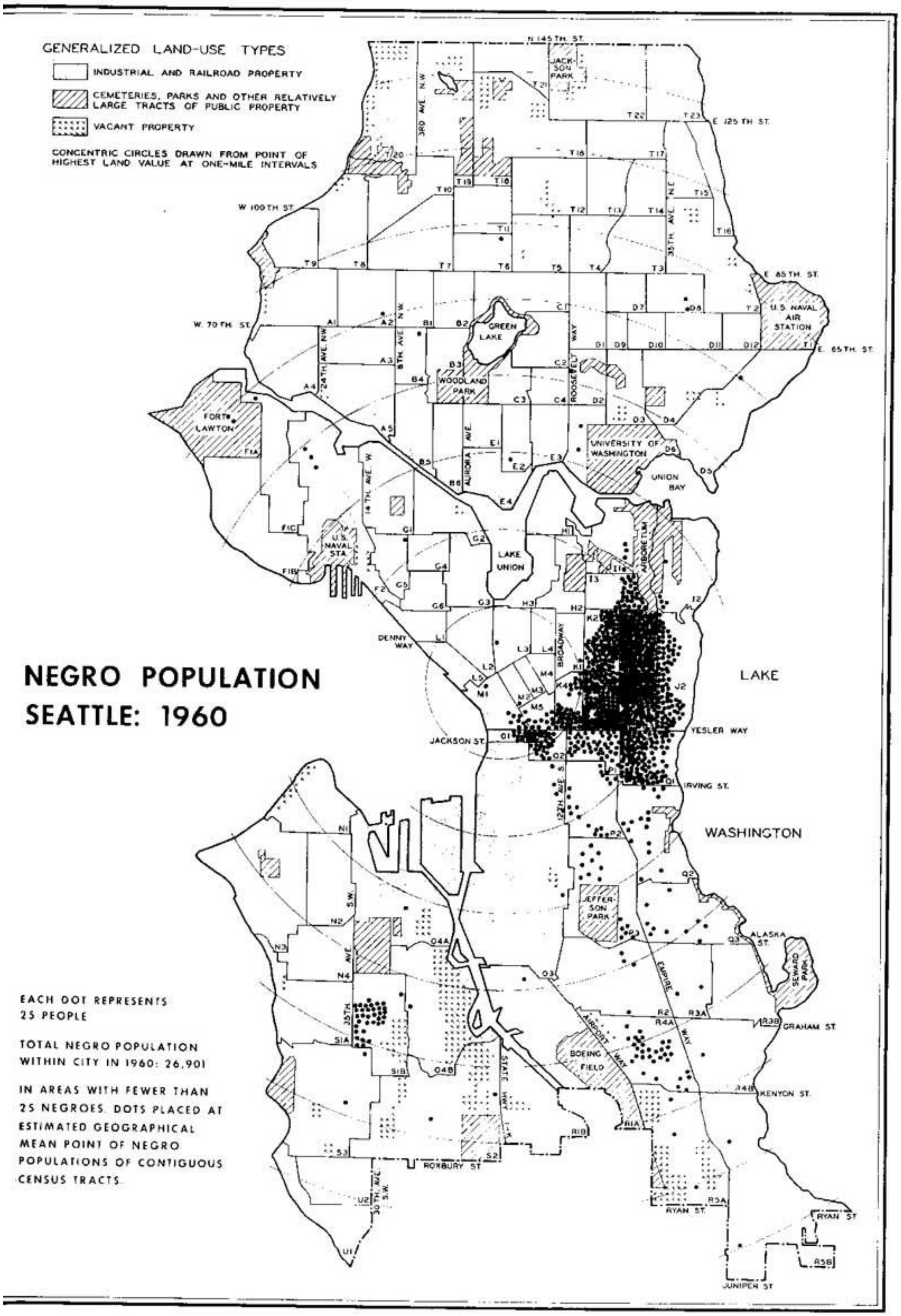

Fig. 12. Historical Map of Black Resident Distribution
Source: Schmid *et al.* 1968

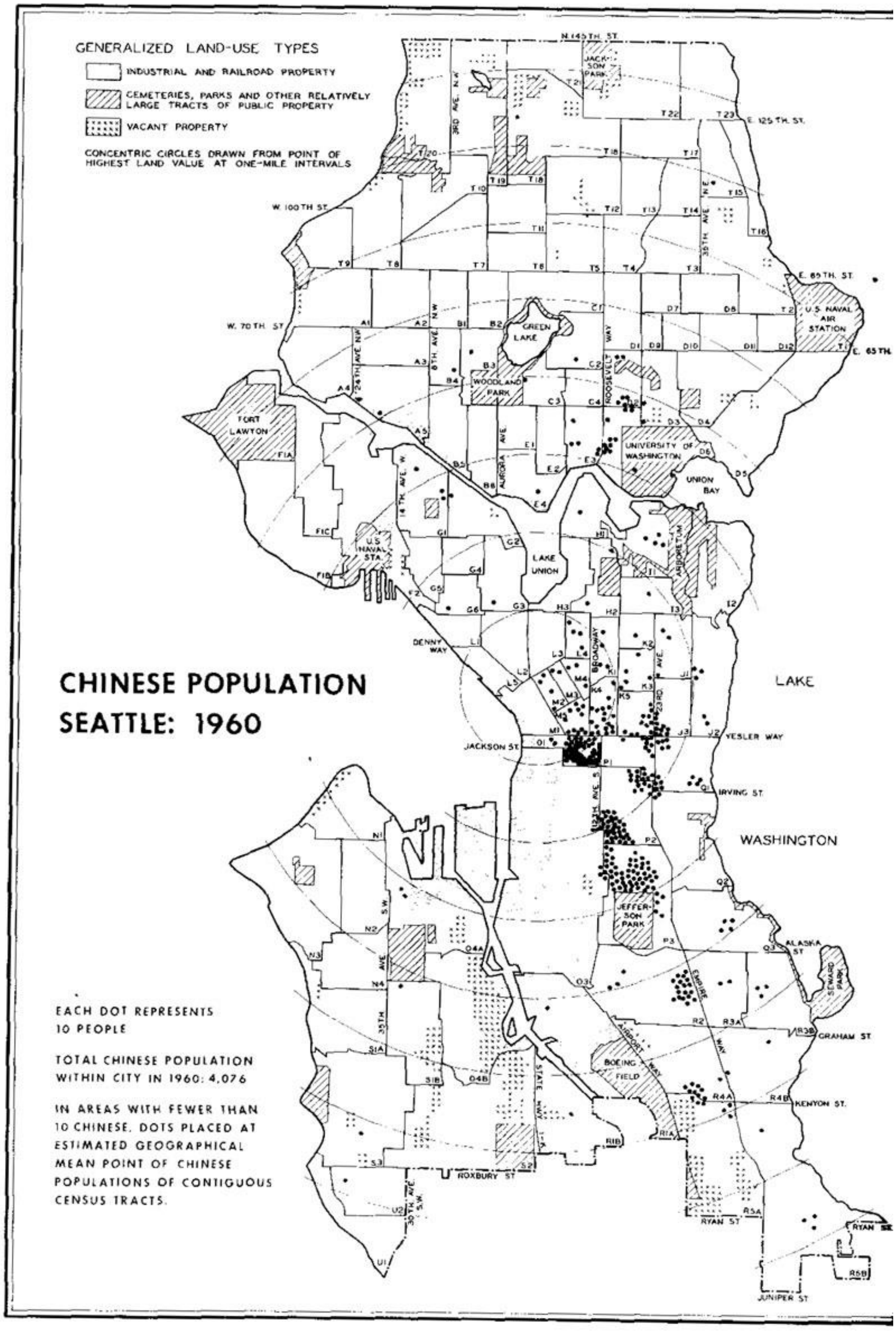

Fig. 13. Historical Map of Chinese Resident Distribution
Source: Schmid *et al.* 1968

Ultimately, while inequities exist within Seattle's urban forest, the extent of the inequity is predominately concentrated on residential trees (as indicated by both the individual tree data and canopy cover); yet, even considering those discrepancies, Seattle appears to have a far less radical misdistribution of urban forest resources than in the case studies previously mentioned in the literature review. This may be a manifestation of the efforts the City of Seattle has done to represent equity concerns in its urban forest management, but it also suggests that perhaps urban forestry does not necessarily follow the same patterns or generalizations that other EJ topics do.

6.2 Urban Forests as City Infrastructure – Nuances and Challenges

When considering this study's findings in relation to the previous case studies discussed in the literature review (Ch.2), the results seemed to mostly support a similar conclusion to Schwartz *et al.* (2015) recently published study. The crux of Schwartz *et al.* findings suggested that canopy cover was more heavily correlated with income rather than race. While this present study did find some differences in regards to race, there was a more consistently positive relationship between income and residential trees/ canopy cover. However, there are also several case studies in which there has been very valid negative relationships between the urban forest and race (Zhou and Kim 2013; Landry and Chakraborty 2009; Boone *et al.* 2009.; Wolch *et al.* 2005). Essentially, while many studies try to draw greater generalizations from their own findings, it seems that urban forest distribution is an EJ topic that cannot be as easily generalized as other EJ topics, such as access to healthy food or exposure to pollution.

There could be several reasons for this, but at the most obvious foundation is that urban forests depend heavily on the geography and history of a city, in a way that is different from other types of infrastructure. This topic was brought up during interviews with both the vegetation management supervisor and the Environmental Sustainability Policy Advisor. An example of this mentioned by both interviewees was the fact that, unlike other cities, Seattle's steep hills and surrounding lakes and mountains create highly coveted views that are predominately occupied by wealthier households. This fact then often disrupts the assumption that wealthier neighborhoods will always have or desire greater tree canopy, since often, residential trees are sacrificed for the sake of these views.

Also unlike other types of infrastructure, urban forests require significant amount of time to reach full fruition to provide significant benefits to urban dwellers (as opposed to other amenities such as transportation or public services). Thus, the history of a city's planning in regards to its green spaces has a significant impact on the distribution of urban trees, even before race or income becomes a consideration. Fortunately, Seattle was proactively designed with a significant parks system in mind, much due to the Olmsted Plan of 1904 (GSP 2005). This proactive planning and legacy of support for abundant parks throughout the city could explain why the different demographics considered in this study all had close access to a similar number of parks. This of course does not guarantee equitable distribution of these resources over time, especially as marginalized communities are gentrified and displaced - however, already having significant amounts of parks and trees from the beginning of Seattle's development could help explain how distribution is less drastic than in other cities whose green spaces and trees are more scarce to begin with or who may have less robust public urban forest programs— such as the case of park distribution and funding in Los Angeles, CA as studied by as Wolch *et al. (2005)*. The issue of less publically managed urban forestry work is particularly significant since this would mean that increases in urban trees would be more dependent on private homeowners who have the means and resources to plant and manage private trees.

There are limits to proactive urban forest planning of course, and the vegetation management supervisor brought up an example during the interview of how this creates barriers for the city government to help address urban forest gaps throughout Seattle. In the interview he discussed how neighborhoods in South Seattle have a low canopy cover, yet the departments responsible for planting street trees remain unable to alleviate this scarcity because many of these neighborhoods were developed without planting strips between the sidewalk and road where municipal trees are usually planted; ultimately, while this issue impacts the work of urban forest teams, addressing the underlying issue is beyond their purview to affect. Incidentally, as Seattle has grown, communities of color and low income household have been displaced to these outer edges of the city where such infrastructure exists, and chances are these communities lack the resources to plant their own private trees.

Geography, history, and city planning contribute to the nuances between urban forestry and other types of infrastructure that often are analyzed within an EJ framework. However, one of the most significant differences is the necessity of community involvement for urban forest efforts to be successful (Bayard pers.comm; Pinto de Bader pers.comm.; Dilley pers.comm). Other types of infrastructure - roads, communications, utilities, public services - are built or installed by a municipality, and then remain maintained by them. Obtaining these resources in underserved communities may require community engagement and grassroots efforts to spur municipalities to fill equity gaps, but ultimately once this infrastructure is secured and installed, it begins providing for the community.

Urban trees, on the other hand, take decades to provide full benefits to a community, and require significant maintenance in the meantime. Urban forest programs are rarely fully funded to meet their needs, and thus even well intentioned municipalities cannot maintain public trees to full capacity. For instance, the industry standard is that urban trees should be pruned on a 5-7 year cycle; the City of Seattle is currently pruning public trees on a 17 year cycle, much of which is reactive (Pinto de Bader pers.comm). What this means is that, even municipalities who take an active stance on alleviating urban tree disparities and are prioritizing tree planting in underserved communities will struggle to succeed if the community itself is not invested in the management of these trees. Ultimately, there are advantages to viewing urban trees as "infrastructure" necessary for livable communities - however, addressing inequities within urban forestry contains unique challenges compared to other types of infrastructure that is discussed in EJ literature.

6.3 Integrating Equity in Urban Forestry

While the results of this study provide important insight into the current distribution of Seattle's urban forest from different perspectives (parks; residential trees; canopy cover), the overarching question remains: how can a city address equity concerns in urban forestry? It was this question that motivated the author to follow up the findings with interviews with City of Seattle employees involved in urban forestry work, to not only understand the efforts Seattle is making towards integrating social justice in its city planning, but to also find ways that cities in general could work towards equity in their urban forest.

City of Seattle: Racial Equity Toolkit

Previously in this discussion, it was suggested that perhaps Seattle's less drastic misdistributions of urban forest resources was due in part to the efforts by the City of Seattle to address possible inequities within its city planning. When asked about what the city government does to integrate equity concerns into its work- including urban forestry- most of the interview participants stated Seattle's Racial Equity Toolkit as one of the most tangible examples of how the City is implementing its commitment to social justice in its everyday operations (Appendix D). Initiated from the Race and Social Justice Initiative (RSJI), which is coordinated by the Seattle Office for Civil Rights, the Racial Equity Toolkit, "lays out a process and a set of questions to guide the development, implementation and evaluation of policies, initiatives, programs, and budget issues to address the impacts on racial equity." (City of Seattle 2012) The goal is for every city department to use this toolkit as an integral step in the project planning process, so racial equity concerns and impacts are at the forefront of city operations. By intentionally developing projects within this framework, the hope is that institutional racism will eventually be dismantled within City of Seattle government. While the Toolkit is explicitly focused on racial justice, this inadvertently addresses disparities between economic groups as well, since in Seattle a disproportionate amount of people of color live in poverty (City of Seattle 2008).

While a certainly ambitious goal, it raises the question of whether or not the Toolkit is achieving its goal or is actually being utilized within city departments. This point was one expressed by Pearsall and Pierce (2010) when discussing the growing of trend of cities developing lofty goals of sustainability and social justice, but ultimately lacking the ability to implement these ideals. While the full extent of the Toolkit's success is a topic unable to be fully covered in this present study, the interviews indicated that, at least within Seattle's urban forestry teams, the Toolkit is beginning to gain traction and is becoming a regular aspect of project development. Thus, perhaps something like the Racial Equity Toolkit is the type of tool that cities should be trying to develop in order to bridge the pernicious gap between abstract goals and actual results.

Caveats

While interviews indicated that the Racial Equity Toolkit is a significant step towards ensuring equity in city planning and urban forestry, there were several caveats to the success of such a tool that were routinely discussed during the interviews.

First is that the Toolkit and the considerations it asks project managers and departments to undertake should be done at the very beginning of the project development process (Bayard pers.comm; Pinto de Bader pers.comm.; Hamai pers.comm.). While this is stated in the intention of the Toolkit itself, interviewees expressed that one of the initial struggles when introducing such equity analyses into city departments and projects was that officials were trying to integrate equity concerns into projects that had already been developed. Ultimately, the data needed to understand equity implications of projects had not been collected prior to project implementation, and thus retroactively conducting equity analyses proved difficult, if not completely futile (Pinto de Bader pers.comm.).

This leads to the second caveat, expressed explicitly by the Office of Sustainability and Environment (OSE) Policy Advisor: the need for accurate data. Without data baseline conditions, demographics, and potential impacts, doing a proper equity analysis is nearly impossible - hence the importance of case studies such as this present study. For urban forestry, this means not only having data on socioeconomic demographics and understanding the history of underserved communities, but also having accurate data on the urban forest itself. One of the crucial proxies that the City of Seattle is working on obtaining is accurate canopy cover using LiDAR and understanding how the increasing development in the city is changing the canopy cover - changes which could certainly change the distribution of the urban forest in regards to socio-economic demographics (Pinto de Bader, pers.comm.).

The last main caveat is one that underlies many of the other points brought up in the interviews, which is the need for a significant level of real commitment to dismantling intuitional racism and inequities. There are a multitude of ways that this level of commitment can be manifested, some of which were mentioned in the interviews. One of these ways is the establishment of city departments and positions dedicated solely to the topic of equity. While Seattle has much work yet to do, the city has made strides in achieving its social justice goals, primarily because it has an Office for Civil Rights to coordinate such efforts. It is from this office that the Race and Social Justice Initiative and the Racial Equity Toolkit were created and implemented citywide. Yet, even in addition to this Department, there are positions within different departments that are dedicated to addressing equity issues within their specific field, such as the Equity Planning & Analysis Strategic Advisor from SPU who was interviewed. In addition to this, is the creation of specific deliverables for each city department to achieve within the RSJI, and conducting equity assessments on different departments (Pinto de Bader pers.comm.). Essentially, what all of this does is create substantial sources of accountability so that city departments a sure to follow through with developed commitments to social justice.

In addition to creating accountability within city government, significant commitment is created in another paramount way: community relationships. Such was a key point mentioned by SPU's reLeaf program manager, who discussed that successfully addressing community concerns and needs, especially in marginalized communities, requires real and consistent relationships with community members. Often times there can be turnover in project managers who often lose the context of the community being affected in order to achieve their own conceived goals. Thus accounting for this need, either through community liaison programs or partnerships with local community groups, is another and crucial way cities can work towards addressing inequities, in both their urban forest, and their city planning in general.

6.4 Limitations & Future Research

While this present study provides important insight into the current distribution of Seattle's urban forest in relation to race and income, there were certainly limitations that potentially affected the accuracy and level of detail that could be derived and discussed.

One of the most foundational limitations was the accuracy of the datasets used. Having more current or accurate data sets of any of the urban forest features could affect the results. This is particularly true of the canopy cover data or residential tree points, which could have significantly changed over the past decade due to rapid development in the city – or alternately implementation of the UFMP and GSP.

Furthermore, the residential tree shape file used from SPU is by no means comprehensive, and thus if one wanted to explore the distribution of residential trees further, a better methodology for future research would be to follow Erikson's (2004) method of choosing sample block groups. While it may be beneficial to choose more than six samples, choosing samples would allow researchers to ground-truth the data, as well as account for spatial differences by choosing samples of similar area. One major issue discovered in the method of looking at Seattle as a whole was that the block groups vary greatly in size. Thus, some block groups appeared to have a high number of trees, but were also significantly larger than other block groups, resulting in a far less tree density than one might assume. This issue is reflected in Figure 9 (Ch.5.4), where some block groups that appear to have low canopy cover, at the same time, are coded as having high number of residential trees. Some of these issues were mitigated by finding averages among all the different block groups, but there is always a chance that outliers skewed results.

In addition to the datasets themselves, another limitation was in the tests used to analyze them. As mentioned earlier, a set of descriptive statics was chosen since these were the tests the author was most familiar with. However, in the future it would be useful to run a regression analysis to understand what variables impact distribution of the urban forest the most, and to be able to make predictions about how this might impact Seattle's urban forest in the future.

Lastly, there were significant limitations to the interview aspect of the study. While interviews provided the author with interesting insight into the overarching question that motivated the thesis, larger generalizations about the equity work of Seattle's government cannot be made due to the small number of participants. There was simply a lack of time to fully integrate interviews as a major aspect of the study, but would surely be a great topic for future research. In the future it would be more ideal to do a larger number of interviews, and to gain the perspectives of those outside of City government, such as community members or non-profit leaders.

7. CONCLUSION & RECOMMENDATIONS

7.1 Summary

The findings of this study suggest that in Seattle there is a positive association between some aspects of the urban forest and both income and % of White residents. Ultimately, higher income and whiter neighborhoods have a higher number of residential trees/canopy cover. Furthermore, between the African American and Asian communities, it was within the Asian communities that the biggest discrepancies existed. In regards to parkland, all demographics were adjacent to a similar number of parks and park area, though whiter neighborhoods still averaged slightly higher than non-white.

However, the study also suggests that while discrepancies exist, they are not quite as drastic as other cases throughout the United States. There can be several reason for this, including Seattle's geography, city history – both in regards to urban forestry as well as migration of ethnic communities - and the current efforts the City of Seattle is undergoing to ensure equity in its operations. On the latter of these reasons, one of the most prominent tools being utilized to address equity in Seattle's urban forestry work is the Racial Equity Toolkit. While still a work in progress, the Toolkit enables City departments to intentionally integrate equity concerns and analyses into urban forest projects. As this Toolkit spurs equity data and community relationships, perhaps the discrepancies found in this study can be addressed and remedied.

7.2 Recommendations

-**More accurate and consistent urban forest assessments.** As Seattle continues to develop at a rapid rate, understanding current urban forest distribution and changes are paramount. Assessments should also automatically analyze this data in relation to demographic information, rather than aggregating results city or neighborhood wide.

- **Develop projects that can integrate trees and vegetation into industrialized and commercial areas.** As was seen in the data on Asian populations in Seattle, marginalized communities can become concentrated in these areas, especially as cities gentrify. Finding ways to plant trees and create green spaces in these otherwise gray areas is challenging but essential to alleviating inequities in the urban forest. Perhaps creating policies that incentivizes developers to maintain or establish green areas could help fill these gaps as Seattle continues to grow.

- **Develop lasting relationships within marginalized communities to help further support efforts to reforest areas in Seattle with the most need.** Whether it be through continuing to support and fund current community engagement efforts, or develop a more robust community liaison program that recruits members from within the community to conduct research, such engagement is essential to ensuring urban forest equity within any city. Engagement efforts should also be used to educate all residents about the benefits of urban trees and how to plant and maintain them.

- **Promote tools such as the Racial Equity Toolkit with specific deliverables for all city departments.** While Seattle appears to be at the forefront of this work, this recommendation applies to all major cities that struggle with equity and environmental justice issues. Seattle should continue to use and support this Toolkit at the implementation of city projects, with strong oversight to ensure departments are being held accountable for the implementation of such equity analyses.

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APPENDIX A: DATA SOURCES

GIS Layers

Seattle Base map	King County
King County Block Group Boundaries	WAGDA
Seattle Parks	Seattle Public Utilities
Residential Trees	Seattle Public Utilities
Canopy Cover	WA Dept. of Ecology
Zoning	Seattle Public Utilities

Other

Median Household Income	U.S. Census Bureau
Race	U.S. Census Bureau

APPENDIX B: CROSSTABS TABLES

Parks- Number

income groups * park groups Crosstabulation

			park groups				Total
			0-5 (low)	6-10 (average)	11-15 (above average)	15-20 (High)	
income groups	Low Income	Count	21	19	2	0	42
		% within income groups	50.0%	45.2%	4.8%	0.0%	100.0%
	Lower Middle Income	Count	146	81	15	1	243
		% within income groups	60.1%	33.3%	6.2%	0.4%	100.0%
	Upper Middle Income	Count	83	37	11	1	132
		% within income groups	62.9%	28.0%	8.3%	0.8%	100.0%
	High Income	Count	50	19	10	4	83
		% within income groups	60.2%	22.9%	12.0%	4.8%	100.0%
Total		Count	300	156	38	6	500
		% within income groups	60.0%	31.2%	7.6%	1.2%	100.0%

Symmetric Measures

		Value	Asymp. Std. Error[a]	Approx. T[b]	Approx. Sig.
Ordinal by Ordinal	Kendall's tau-b	-.008	.042	-.199	.843
N of Valid Cases		500			

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

Crosstab							
			park groups				Total
			0-5 (low)	6-10 (average)	11-15 (above average)	15-20 (High)	
Black groups	0- 15 percent (low)	Count	247	132	33	5	417
		% within Black groups	59.2%	31.7%	7.9%	1.2%	100.0%
	16-30 percent (medium)	Count	35	15	4	0	54
		% within Black groups	64.8%	27.8%	7.4%	0.0%	100.0%
	31 - 70 percent (high)	Count	18	9	1	1	29
		% within Black groups	62.1%	31.0%	3.4%	3.4%	100.0%
Total		Count	300	156	38	6	500
		% within Black groups	60.0%	31.2%	7.6%	1.2%	100.0%

Symmetric Measures

		Value	Asymp. Std. Error[a]	Approx. T[b]	Approx. Sig.
Ordinal by Ordinal	Kendall's tau-c	-.020	.025	-.815	.415
N of Valid Cases		500			

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

Crosstab							
			park groups				Total
			0-5 (low)	6-10 (average)	11-15 (above average)	15-20 (High)	
Asian group	0-15 percent (low)	Count	199	116	28	4	347
		% within asian group	57.3%	33.4%	8.1%	1.2%	100.0%
	16-30 percent (medium)	Count	59	21	7	2	89
		% within asian group	66.3%	23.6%	7.9%	2.2%	100.0%
	31 - 80 percent (high)	Count	42	19	3	0	64
		% within asian group	65.6%	29.7%	4.7%	0.0%	100.0%
Total		Count	300	156	38	6	500
		% within asian group	60.0%	31.2%	7.6%	1.2%	100.0%

Symmetric Measures

		Value	Asymp. Std. Error[a]	Approx. T[b]	Approx. Sig.
Ordinal by Ordinal	Kendall's tau-c	-.055	.031	-1.787	.074
N of Valid Cases		500			

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

Parks- Acres

income groups * acres groups Crosstabulation

			acres groups				Total
			0 - 50 (low)	51-100 (average)	101-350 (above average)	>351 (high)	
income groups	Low Income	Count	23	6	9	3	41
		% within income groups	56.1%	14.6%	22.0%	7.3%	100.0%
	Lower Middle Income	Count	100	61	67	10	238
		% within income groups	42.0%	25.6%	28.2%	4.2%	100.0%
	Upper Middle Income	Count	84	20	21	4	129
		% within income groups	65.1%	15.5%	16.3%	3.1%	100.0%
	High Income	Count	34	18	20	3	75
		% within income groups	45.3%	24.0%	26.7%	4.0%	100.0%
Total		Count	241	105	117	20	483
		% within income groups	49.9%	21.7%	24.2%	4.1%	100.0%

Symmetric Measures

		Value	Asymp. Std. Error[a]	Approx. T[b]	Approx. Sig.
Ordinal by Ordinal	Kendall's tau-b	-.067	.041	-1.660	.097
N of Valid Cases		483			

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

Crosstab							
			acres groups				Total
			0 - 50 (low)	51-100 (average)	101-350 (above average)	>351 (high)	
Black groups	0- 15 precent (low)	Count	198	90	96	18	402
		% within Black groups	49.3%	22.4%	23.9%	4.5%	100.0%
	16-30 percent (medium)	Count	27	11	13	1	52
		% within Black groups	51.9%	21.2%	25.0%	1.9%	100.0%
	31 - 70 percent (high)	Count	16	4	8	1	29
		% within Black groups	55.2%	13.8%	27.6%	3.4%	100.0%
Total		Count	241	105	117	20	483
		% within Black groups	49.9%	21.7%	24.2%	4.1%	100.0%

Symmetric Measures

		Value	Asymp. Std. Error[a]	Approx. T[b]	Approx. Sig.
Ordinal by Ordinal	Kendall's tau-c	-.014	.027	-.504	.614
N of Valid Cases		483			

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

Crosstab							
			acres groups				Total
			0 - 50 (low)	51-100 (average)	101-350 (above average)	>351 (high)	
Asian group	0-15 percent (low)	Count	159	78	84	13	334
		% within asian group	47.6%	23.4%	25.1%	3.9%	100.0%
	16-30 percent (medium)	Count	47	13	22	6	88
		% within asian group	53.4%	14.8%	25.0%	6.8%	100.0%
	31 - 80 percent (high)	Count	35	14	11	1	61
		% within asian group	57.4%	23.0%	18.0%	1.6%	100.0%
Total		Count	241	105	117	20	483
		% within asian group	49.9%	21.7%	24.2%	4.1%	100.0%

Symmetric Measures

		Value	Asymp. Std. Error[a]	Approx. T[b]	Approx. Sig.
Ordinal by Ordinal	Kendall's tau-c	-.045	.033	-1.356	.175
N of Valid Cases		483			

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

Residential Trees

income groups * Tree groups Crosstabulation							
			Tree groups				Total
			0-200 (low)	201-400 (average)	401-600 (above average)	600 + (high)	
income groups	Low Income	Count	32	6	2	2	42
		% within income groups	76.2%	14.3%	4.8%	4.8%	100.0%
	Lower Middle Income	Count	135	78	23	7	243
		% within income groups	55.6%	32.1%	9.5%	2.9%	100.0%
	Upper Middle Income	Count	53	54	21	4	132
		% within income groups	40.2%	40.9%	15.9%	3.0%	100.0%
	High Income	Count	22	29	27	5	83
		% within income groups	26.5%	34.9%	32.5%	6.0%	100.0%
Total		Count	242	167	73	18	500
		% within income groups	48.4%	33.4%	14.6%	3.6%	100.0%

Symmetric Measures

		Value	Asymp. Std. Error[a]	Approx. T[b]	Approx. Sig.
Ordinal by Ordinal	Kendall's tau-b	.257	.038	6.582	.000
N of Valid Cases		500			

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

Crosstab

			Tree groups				Total
			0-200 (low)	201-400 (average)	401-600 (above average)	600 + (high)	
Black groups	0- 15 precent (low)	Count	194	144	65	14	417
		% within Black groups	46.5%	34.5%	15.6%	3.4%	100.0%
	16-30 percent (medium)	Count	34	15	3	2	54
		% within Black groups	63.0%	27.8%	5.6%	3.7%	100.0%
	31 - 70 percent (high)	Count	14	8	5	2	29
		% within Black groups	48.3%	27.6%	17.2%	6.9%	100.0%
Total		Count	242	167	73	18	500
		% within Black groups	48.4%	33.4%	14.6%	3.6%	100.0%

Symmetric Measures

		Value	Asymp. Std. Error[a]	Approx. T[b]	Approx. Sig.
Ordinal by Ordinal	Kendall's tau-c	-.043	.027	-1.593	.111
N of Valid Cases		500			

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

Crosstab							
			Tree groups				Total
			0-200 (low)	201-400 (average)	401-600 (above average)	600 + (high)	
Asian group	0-15 percent (low)	Count	140	129	64	14	347
		% within asian group	40.3%	37.2%	18.4%	4.0%	100.0%
	16-30 percent (medium)	Count	59	22	7	1	89
		% within asian group	66.3%	24.7%	7.9%	1.1%	100.0%
	31 - 80 percent (high)	Count	43	16	2	3	64
		% within asian group	67.2%	25.0%	3.1%	4.7%	100.0%
Total		Count	242	167	73	18	500
		% within asian group	48.4%	33.4%	14.6%	3.6%	100.0%

Symmetric Measures

		Value	Asymp. Std. Error[a]	Approx. T[b]	Approx. Sig.
Ordinal by Ordinal	Kendall's tau-c	-.182	.031	-5.814	.000
N of Valid Cases		500			

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

Canopy Cover

income groups * canopy groups Crosstabulation

			canopy groups				Total
			Low (0-10%)	Average (11-20%)	Above Average (21-30%)	High (>31%)	
income groups	Low Income	Count	30	7	1	2	40
		% within income groups	75.0%	17.5%	2.5%	5.0%	100.0%
	Lower Middle Income	Count	139	39	23	13	214
		% within income groups	65.0%	18.2%	10.7%	6.1%	100.0%
	Upper Middle Income	Count	56	31	14	17	118
		% within income groups	47.5%	26.3%	11.9%	14.4%	100.0%
	High Income	Count	18	20	13	27	78
		% within income groups	23.1%	25.6%	16.7%	34.6%	100.0%
Total		Count	243	97	51	59	450
		% within income groups	54.0%	21.6%	11.3%	13.1%	100.0%

Symmetric Measures

		Value	Asymp. Std. Error[a]	Approx. T[b]	Approx. Sig.
Ordinal by Ordinal	Kendall's tau-b	.308	.038	7.827	.000
N of Valid Cases		450			

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

Crosstab

			canopy groups				Total
			Low (0-10%)	Average (11-20%)	Above Average (21-30%)	High (>31%)	
Black groups	0- 15 precent (low)	Count	202	77	44	56	379
		% within Black groups	53.3%	20.3%	11.6%	14.8%	100.0%
	16-30 percent (medium)	Count	27	12	5	2	46
		% within Black groups	58.7%	26.1%	10.9%	4.3%	100.0%
	31 - 70 percent (high)	Count	14	8	2	1	25
		% within Black groups	56.0%	32.0%	8.0%	4.0%	100.0%
Total		Count	243	97	51	59	450
		% within Black groups	54.0%	21.6%	11.3%	13.1%	100.0%

Symmetric Measures

		Value	Asymp. Std. Error[a]	Approx. T[b]	Approx. Sig.
Ordinal by Ordinal	Kendall's tau-c	-.040	.025	-1.612	.107
N of Valid Cases		450			

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

Crosstab

			canopy groups				Total
			Low (0-10%)	Average (11-20%)	Above Average (21-30%)	High (>31%)	
asian group	0-15 percent (low)	Count	163	70	35	49	317
		% within asian group	51.4%	22.1%	11.0%	15.5%	100.0%
	16-30 percent (medium)	Count	43	14	11	9	77
		% within asian group	55.8%	18.2%	14.3%	11.7%	100.0%
	31 - 80 percent (high)	Count	37	13	5	1	56
		% within asian group	66.1%	23.2%	8.9%	1.8%	100.0%
Total		Count	243	97	51	59	450
		% within asian group	54.0%	21.6%	11.3%	13.1%	100.0%

Symmetric Measures

		Value	Asymp. Std. Error[a]	Approx. T[b]	Approx. Sig.
Ordinal by Ordinal	Kendall's tau-c	-.077	.032	-2.395	.017
N of Valid Cases		450			

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

APPENDIX C: SAMPLE INTERVIEW QUESTIONS

- What considerations must be made when ensuring equity within urban forestry goals?

- In what ways does the City of Seattle incorporate social justice principles within its urban forestry work?

- What are the largest barriers to implementing social justice principles within urban forestry?

- How does long term equity work within city departments differ from short term?

APPENDIX D: RACIAL EQUITY TOOLKIT

Racial Equity Toolkit

to Assess Policies, Initiatives, Programs, and Budget Issues

RACE & SOCIAL JUSTICE INITIATIVE

The vision of the Seattle Race and Social Justice Initiative is to eliminate racial inequity in the community. To do this requires ending individual racism, institutional racism and structural racism. The Racial Equity Toolkit lays out a process and a set of questions to guide the development, implementation and evaluation of policies, initiatives, programs, and budget issues to address the impacts on racial equity.

When Do I Use This Toolkit?

Early. Apply the toolkit early for alignment with departmental racial equity goals and desired outcomes.

How Do I Use This Toolkit?

With Inclusion. The analysis should be completed by people with different racial perspectives.

Step by step. The Racial Equity Analysis is made up of six steps from beginning to completion:

Step 1. Set Outcomes.
Leadership communicates key community outcomes for racial equity to guide analysis.

Step 2. Involve Stakeholders + Analyze Data.
Gather information from community and staff on how the issue benefits or burdens the community in terms of racial equity.

Step 3. Determine Benefit and/or Burden.
Analyze issue for impacts and alignment with racial equity outcomes.

Step 4. Advance Opportunity or Minimize Harm.
Develop strategies to create greater racial equity or minimize unintended consequences.

Step 5. Evaluate. Raise Racial Awareness. Be Accountable.
Track impacts on communities of color overtime. Continue to communicate with and involve stakeholders. Document unresolved issues.

Step 6. Report Back.
Share information learned from analysis and unresolved issue with Department Leadership and Change Team.

Racial Equity Toolkit Assessment Worksheet

Title of policy, initiative, program, budget issue: ___________________________

Description: ____

Department: _____________________ **Contact:** _______________________

☐**Policy** ☐**Initiative** ☐**Program** ☐**Budget Issue**

Step 1. Set Outcomes.

1a. What does your department define as the most important racially equitable community outcomes related to the issue? *(Response should be completed by department leadership in consultation with RSJI Executive Sponsor, Change Team Leads and Change Team. Resources on p.4)*

1b. Which racial equity opportunity area(s) will the issue primarily impact?

☐**Education**
☐**Community Development**
☐**Health**
☐**Environment**
☐**Criminal Justice**
☐**Jobs**
☐**Housing**

1c. Are there impacts on:

☐**Contracting Equity**
☐**Workforce Equity**
☐**Immigrant and Refugee Access to Services**
☐**Inclusive Outreach and Public Engagement**

Please describe:

Step 2. Involve stakeholders. Analyze data.

2a. Are there impacts on geographic areas? ☐Yes ☐No

Check all neighborhoods that apply *(see map on p.5)*:

☐All Seattle neighborhoods
☐Ballard
☐North
☐NE
☐Central
☐Lake Union
☐Southwest
☐Southeast
☐Delridge
☐Greater Duwamish
☐East District
☐King County (outside Seattle)
☐Outside King County
Please describe:

2b. What are the racial demographics of those living in the area or impacted by the issue?
(See Stakeholder and Data Resources p. 5 and 6)

2c. How have you involved community members and stakeholders? *(See p.5 for questions to ask community/staff at this point in the process to ensure their concerns and expertise are part of analysis.)*

2d. What does data and your conversations with stakeholders tell you about existing racial inequities that influence people's lives and should be taken into consideration? *(See Data Resources on p.6. King County Opportunity Maps are good resource for information based on geography, race, and income.)*

2e. What are the root causes or factors creating these racial inequities?
Examples: Bias in process; Lack of access or barriers; Lack of racially inclusive engagement

Step 3. Determine Benefit and/or Burden.

Given what you have learned from data and from stakeholder involvement…

3. How will the policy, initiative, program, or budget issue increase or decrease racial equity? What are potential unintended consequences? What benefits may result? Are the impacts aligned with your department's community outcomes that were defined in Step I.?

Step 4. Advance Opportunity or Minimize Harm.

4. How will you address the impacts (including unintended consequences) on racial equity? What strategies address immediate impacts? What strategies address root causes of inequity listed in Q.6? How will you partner with stakeholders for long-term positive change? If impacts are not aligned with desired community outcomes, how will you re-align your work?

Program Strategies? ____

Policy Strategies? ____

Partnership Strategies? ____

Step 5. Evaluate. Raise Racial Awareness. Be Accountable.

5a. How will you evaluate and be accountable? How will you evaluate and report impacts on racial equity over time? What is your goal and timeline for eliminating racial inequity? How will you retain stakeholder participation and ensure internal and public accountability? How will you raise awareness about racial inequity related to this issue?

5b. What is unresolved? What resources/partnerships do you still need to make changes?

Step 6. Report Back.

Share analysis and report responses from Q.5a. and Q.5b. with Department Leadership and Change Team Leads and members involved in Step 1.

Creating Effective Community Outcomes

Outcome = the result that you seek to achieve through your actions.

Racially equitable **community outcomes = the specific result you are seeking to achieve that advances racial equity in the community.**

When creating outcomes think about:

- What are the greatest opportunities for creating change in the next year?
- What strengths does the department have that it can build on?
- What challenges, if met, will help move the department closer to racial equity goals?

Keep in mind that the City is committed to creating racial equity in seven key opportunity areas: **Education, Community Development, Health, Criminal Justice, Jobs, Housing, and the Environment.**

Examples of community outcomes that increase racial equity:

OUTCOME	OPPORTUNITY AREA
Increase transit and pedestrian mobility options in communities of color.	Community Development
Decrease racial disparity in the unemployment rate.	Jobs
Ensure greater access to technology by communities of color.	Community Development, Education, Jobs
Improve access to community center programs for immigrants, refugees and communities of color.	Health, Community Development
Communities of color are represented in the City's outreach activities.	Education, Community Development, Health, Jobs, Housing, Criminal Justice, Environment
The racial diversity of the Seattle community is reflected in the City's workforce across positions.	Jobs
Access to City contracts for Minority Business Enterprises is increased.	Jobs
Decrease racial disparity in high school graduation rates	Education

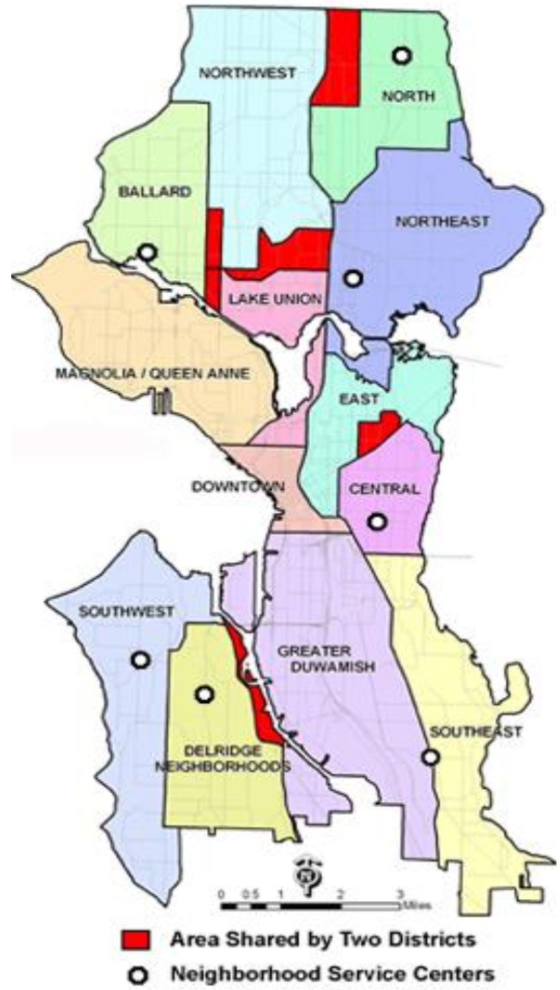
Additional Resources:

- **RSJI Departmental Work Plan:** http://inweb/rsji/departments.htm
- **Department Performance Expectations:** http://web1.seattle.gov/DPETS/DPETSWEbHome.aspx
- **Mayoral Initiatives:** http://www.seattle.gov/mayor/issues/

Identifying Stakeholders + Listening to Communities of Color

Identify Stakeholders

Find out who are the **stakeholders** most affected by, concerned with, or have experience relating to the policy, program or initiative? Identify racial demographics of neighborhood or those impacted by issue. *(See District Profiles in the Inclusive Outreach and Public Engagement Guide or refer to U.S. Census information on p.7)*



Once you have indentified your stakeholders ….

Involve them in the issue.
Describe how historically underrepresented community stakeholders can take a leadership role in this policy, program, initiative or budget issue.

Listen to the community. Ask:
1. What do we need to know about this issue? How will the policy, program, initiative or budget issue burden or benefit the community? *(concerns, facts, potential impacts)*

2. What factors produce or perpetuate racial inequity related to this issue?

3. What are ways to minimize any negative impacts (harm to communities of color, increased racial disparities, etc) that may result? What opportunities exist for increasing racial equity?

Tip: Gather Community Input Through…

- Community meetings
- Focus groups
- Consulting with City commissions and advisory boards
- Consulting with Change Team

Examples of what this step looks like in practice:
- A reduction of hours at a community center includes conversations with those who use the community center as well as staff who work there.
- Before implementing a new penalty fee, people from the demographic most represented in those fined are surveyed to learn the best ways to minimize negative impacts.

For resources on how to engage stakeholders in your work see the **Inclusive Outreach and Public Engagement Guide:** http://inweb1/neighborhoods/outreachguide/

Data Resources

City of Seattle Seattle's Population and Demographics at a Glance:
http://www.seattle.gov/dpd/Research/Population_Demographics/Overview/default.asp
Website updated by the City Demographer. **Includes: Housing** Quarterly Permit Report • **Employment data** • 2010 Census data • **2006-2010 American Community Survey** • 2010 Census: Demographic highlights from the 2010 Census; Basic Population and Housing Characteristics Change from 1990, 2000, and 2010 – PDF report of counts of population by race, ethnicity and over/under 18 years of age as well as a total, occupied and vacant housing unit count; Three-page subject report – PDF report of detailed population, household and housing data • American Community Survey: **2010 5-year estimates and 2009 5-year estimates** • Census 2000 • Permit Information: Comprehensive Plan Housing Target Growth Report for Urban Centers and Villages; Citywide Residential Permit Report • Employment Information: Comprehensive Plan Employment Target Growth Report for Urban Centers and Villages; Citywide Employment 1995-2010 • The Greater Seattle Datasheet: a report by the Office of Intergovernmental Relations on many aspects of Seattle and its region.

SDOT Census 2010 Demographic Maps (by census blocks): Race, Age (under 18 and over 65) and Median Income http://inweb/sdot/rsji_maps.htm

Seattle's Population & Demographics Related Links & Resources (From DPD website: http://www.seattle.gov/dpd/Research/Population_Demographics/Related_Links/default.asp)

Federal

- American FactFinder: The U.S. Census Bureau's main site for online access to population, housing, economic, and geographic data.
- Census 2000 Gateway: The U.S. Census Bureau's gateway to Census 2000 information.

State

- Washington Office of Financial Management: OFM is the official state agency that provides estimates, forecasts, and reports on the state's population, demographic characteristics, economy, and state revenues.

Regional

- Puget Sound Regional Council: PSRC is the regional growth management and transportation planning agency for the central Puget Sound region in Washington State.

County

- King County Census Viewer: A web-based application for viewing maps and tables of more than 100 community census data indicators for 77 defined places in King County.
- King County Department of Development and Environmental Services: the growth management planning agency for King County.
- Seattle & King County Public Health - Assessment, Policy Development, and Evaluation Unit: Provides health information and technical assistance, based on health assessment data
- King County Opportunity Maps: A Study of the Region's Geography of Opportunity. Opportunity maps illustrate where opportunity rich communities exist, assess who has access to those neighborhoods, and help to understand what needs to be remedied in opportunity poor neighborhoods. Puget Sound Regional Council.

City

- The Greater Seattle Datasheet: A Seattle fact sheet courtesy of the City of Seattle's Office of Intergovernmental Relations.

Other

- Seattle Times Census 2000: articles, charts related to Census 2000 and the Seattle/Puget Sound region.

Glossary

Accountable- Responsive to the needs and concerns of those most impacted by the issues you are working on, particularly to communities of color and those historically underrepresented in the civic process.

Community outcomes- The specific result you are seeking to achieve that advances racial equity.

Contracting Equity- Efforts to achieve equitable racial outcomes in the way the City spends resources, including goods and services, consultants and contracting.

Immigrant and Refugee Access to Services- Government services and resources are easily available and understandable to all Seattle residents, including non-native English speakers. Full and active participation of immigrant and refugee communities exists in Seattle's civic, economic and cultural life.

Inclusive Outreach and Public Engagement- Processes inclusive of people of diverse races, cultures, gender identities, sexual orientations and socio-economic status. Access to information, resources and civic processes so community members can effectively engage in the design and delivery of public services.

Individual racism- Pre-judgment, bias, stereotypes about an individual or group based on race. The impacts of racism on individuals including white people internalizing privilege and people of color internalizing oppression.

Institutional racism- Organizational programs, policies or procedures that work to the benefit of white people and to the detriment of people of color, usually unintentionally or inadvertently.

Opportunity areas- One of seven issue areas the City of Seattle is working on in partnership with the community to eliminate racial disparities and create racial equity. They include: Education, Health, Community Development, Criminal Justice, Jobs, Housing and the Environment.

Racial equity- When social, economic and political opportunities are not predicted based upon a person's race.

Racial inequity-When a person's race can predict their social, economic and political opportunities and outcomes.

Stakeholders- Those impacted by proposed policy, program or budget issue who have potential concerns or issue expertise. Examples might include: specific racial/ethnic groups, other institutions like Seattle Housing Authority, schools, community-based organizations, Change Teams, City employees, unions, etc.

Structural racism - The interplay of policies, practices and programs of multiple institutions which leads to adverse outcomes and conditions for communities of color compared to white communities that occurs within the context of racialized historical and cultural conditions.

Workforce Equity- Ensure the City's workforce diversity reflects the diversity of Seattle