Equity in Urban Forest Management:
An assessment of street tree condition, maintenance, and neighborhood income levels in Seattle, Washington

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Table of Contents

List of Figures ii
List of Tables iii
Introduction 1
Chapter 1: Background and Literature 3
  Urban Forests as Part of the Urban Infrastructure 3
  Benefits of Street Trees 5
  Distribution of Urban Forest Services 6
  Inputs and Outputs in Urban Forest Service Delivery 7
  Related Studies 9
  Research Objectives 12
  Hypotheses 13
Chapter 2: Research Methods 15
  Study Site 15
  Community Participation: Recruitment 16
  Data Sets 18
  Study Area Data Content 18
  Tree Sample Data Content 23
  Community Participation: Data Collection 27
  Tree Maintenance Data Content 28
  Analysis Procedures 29
Chapter 3: Results 32
  Comparison of Sampled Trees' Condition and City Inventory 32
  Is Tree Condition Related to Income Levels? 33
  Condition Categories in Low and High-Income Tracts 35
  Are Levels of Tree Maintenance Related to Income and/or Tree Condition? 38
  Other Factors 44
  Community Participation: New Skills 45
Chapter 4: Discussion 46
  Tree Condition and Income 47
  Tree Maintenace and Income 49
  Tree Condition and Maintenance 50
  Communtiy Participation: Survey results 52
  Delivery of Services: Equality versus Equity 53
Chapter 5: Conclusion 55
  Summary 55
  Implications 55
  Future research 56
References 58
Appendix A: Seattle Census Tract Information 63
Appendix B: Tree Maintenance in Seattle 67
Appendix C: Survey 71

Appendix D: Pamphlet....................73

List of Figures

Figure 1. Relationships between income and street tree condition and maintenance 14
Figure 2. Map of study site....................16
Figure 3. Recruitment flyer....................17
Figure 4. Map of study sites....................22
Figure 5. Tree condition assessment criteria....................25
Figure 6. Tree condition distribution....................33
Figure 7. Average tree condition in sampled tracts compared by income levels....................34
Figure 8. Distribution of tree condition categories in sampled tracts....................35
Figure 9. Average tree condition for high and low-income areas....................35
Figure 10. Distribution of tree condition categories for high and low-income areas 36
Figure 11. Map of tree condition....................37
Figure 12. Tree maintenance (per total trees): sampled tracts....................39
Figure 13. Tree maintenance (per total city trees): sampled tracts....................41
Figure 14. Tree maintenance (per total trees): high and low-income....................42
Figure 15. Tree maintenance (per total city trees): high and low-income....................43
Figure 16. Map of tree maintenance....................44
Figure 17. Factors affecting average tree condition between high and low-income areas....46
Figure 18. Citywide street tree maintenance....................68
Figure 19. Citywide street tree maintenance by year....................68
Figure 20. Map of citywide street tree maintenance....................70

List of Tables

Table 1. Data sets and sources....18
Table 2. Demographic information for selected areas....20
Table 3. Composition of Seattle's 15 most common street tree species....24
Table 4. Tree condition categories....26
Table 5. Example of work records entry....28
Table 6. Work record information for six areas....38
Table 7. Number of visits and number of trees worked on in six areas....39
Table 8. Work levels per total city trees for six areas....40
Table 9. Tree and work information for low and high-income areas....41
Table 10. Visits and trees worked on per total trees....41
Table 11. Visits and trees worked on per City trees....42
Table 12. Additional factors....45
Table 13. Census tract information....63
Table 14. Street tree maintenance 1998-2002: counts....67
Table 15. Street tree maintenance 1998-2002: frequencies....67

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Introduction

It is widely accepted that benefits of urban forests include energy savings, reduced stormwater runoff, clean air, reduced levels of violence, increased levels of community involvement and interaction, higher property values, aesthetic values and more. These benefits greatly enhance a neighborhood's social, ecological, and economic well-being. Because of the myriad of benefits provided by urban forests, it can be argued that the urban forest should be considered part of the basic infrastructure of urban cities and towns where people reside.

It is vital that the benefits of urban forests be equally distributed across communities, not just to select groups of individuals who have the financial, intellectual, and political resources to acquire increased levels of urban forest care and attention. Unfortunately, for an assortment of reasons, many cities appear to have varying degrees of street tree condition in different neighborhoods. Tree maintenance from homeowners, pollution levels, soil type, age and species of trees, and damage from automobiles are just a few explanations. One additional reason may be the socioeconomic level of a neighborhood; there is an unspoken assumption that the urban trees may be indirectly (or directly) affected by a neighborhood's economic status.

This study explored the relationships between neighborhood income levels, the condition of the neighborhood street trees, and the level of tree maintenance provided by the City of Seattle, Washington. A sample of tree condition, census data, and street tree maintenance records were used to investigate the above relationships. In addition, this study incorporated participatory research methods into the majority of the steps by including high-school students in the data preparation and data collection stages.

Chapter One begins with a brief background on urban forest benefits and the important roles trees play in the quality and health of life in a city—and the importance of equal access to these benefits. Additional information is presented regarding the documented need for good urban forest management and problems associated with the delivery of tree maintenance across an entire city. The background concludes with a review of studies on socioeconomic factors with regard to urban trees. The final sections of the first chapter are dedicated to research objectives, presentation of the hypotheses, and a description of the study site.

Chapter Two describes the methods used in the study: data sources, data manipulation, and the subsequent analysis. Chapter Three presents results from the tree condition assessment and tree maintenance records in relation to median household income. Discussion of the results and the larger context of the findings are presented in Chapter Four. The thesis concludes with a brief look at the limitations of this study, implications of the findings, and possibilities for future research. The community participation aspects of the project are presented throughout the paper.

Chapter 1: Background and Literature

URBAN FORESTS AS PART OF THE URBAN INFRASTRUCTURE

Urban forests are known to provide many benefits – ecologically and socially – to cities and their residents. It is gradually being accepted that urban forests are an integral part of the basic infrastructure of urban cities and urbanizing areas. Just as sewers direct wastewater, streetlights provide safety, and road systems provide safe, reliable transportation, people have begun to recognize the wealth of benefits provided by urban forests. Although these benefits often commingle, they can be described in three categories: ecological, social, and economic.

Ecological Benefits of Urban Forests

Reduced levels of storm water runoff

In cities with large amounts of rain, or infrequent yet heavy rainstorms, storm water management is costly and extremely important. With an ever-increasing amount of impervious surfaces in our expanding cities, storm water hits the ground and rapidly finds its way into storm drains and holding tanks, rather than seeping into the ground, resulting in large amounts of pollutants entering our waterways. Urban trees afford an opportunity for cities to significantly reduce the costs of storm water management and act as nature's water storage system. In Dayton, Ohio, Sanders calculated that the city tree canopy lowered potential water runoff by approximately 7% for a 6-h, 1-year storm event (Sanders 1986).

Removal of air pollutants

Air quality in cities continues to be extremely important as industry, vehicles, and other sources of pollution continue to emit harmful pollutants into the atmosphere. It is widely recognized that trees intercept some airborne pollutants from the air and remove some gaseous pollutants via stomata uptake. Depending on their size and species, urban trees can remove large amounts of pollutants from the air. From a computer simulation, it was estimated that trees in New York, Philadelphia, Baltimore, and Boston removed, respectively, 1821 metric tons, 1031 metric tons, 499 metric tons, and 278 metric tons from the air in 1994 (Nowak et al. 1998). In an earlier study, Chicago's trees removed an estimated 5575 metric tons of air pollutants (Nowak 1994).

Carbon storage

While the debate surrounding global climate change still wages, there is an accepted need to mitigate the large amounts of carbon being emitted into the atmosphere. It was estimated that the national urban tree cover plays a critical role in reducing the effects of carbon emissions as it stores between 350 and 750 million metric tons of carbon and approximately 27 tons/acre – a substantial carbon sink (Rowntree and Nowak 1991, Nowak 1993, McPherson et al. 1997).

Social Benefits of Urban Forests

Community ties

In a study conducted at a large public housing site in Chicago, researchers found that increased levels of vegetation and presences of trees resulted in stronger neighborhood social ties. People living near the green spaces had increased levels of interactions with neighbors, stronger senses of belonging, and were more apt to spend time outdoors than people living adjacent to barren spaces (Kuo et al. 1998). Urban forests also provide an opportunity for community interactions through tree-planting programs. Dwyer and others wrote, "Active involvement in tree-planting programs has been shown to enhance a community's sense of social identity, self-esteem, and territoriality...(Dwyer et al. 1992)."

Reduced levels of violence

Kuo and Sullivan also found that individuals living near the greener common spaces felt safer in their homes and buildings than the residents living near relatively barren spaces (Kuo et al. 1998). In another study, the researchers found that as greenness of the landscape increased the number of police reported crimes per building decreased (Kuo and Sullivan 2001).

Mental health and well-being

The body of literature connecting personal well being and health with urban nature is extraordinary and strong. Kaplan has shown that job satisfaction and a person's well-being can be drastically improved merely by nature viewed through a window (Kaplan 1993). Faster recover rates in hospital patients and reduced levels of stress in college students have also been associated with the presence of urban trees and vegetation (Ulrich 1984, 1986)

Economic Benefits of Urban Forests

Energy Conservation

The proven savings in heating and cooling costs for buildings near urban trees are well documented. McPherson and Rowntree showed that heating and cooling costs for a typical resident were reduced by 8% - 12% with an appropriately located single 25-ft tree (McPherson and Rowntree 1993). Another team of scientist showed that approximately three mature trees per building lot saved an estimated $50 to $90 per dwelling in heating and cooling costs in Chicago, Illinois (McPherson et al. 1997).

Property values and retail

In addition to energy savings, increased levels of property values are an economic benefit provided by urban trees. In a study conducted in Athens, Georgia, single-family homes were found to sell for 3 to 5% more than other homes when trees were located in their listings' photographs (Anderson and Cordell 1985). Recently, a study showed that consumers are willing to pay, on average, 11.95% more for equivalent good purchased in retail areas with high quality landscapes, including trees, compared to areas with little or no landscaping (Wolf 2003). This furthers the argument that urban trees provide a variety of economic benefits to both residents and commercial owners.

BENEFITS OF STREET TREES

The benefits discussed above are generated by diverse urban forest types – parks, private trees in yards, greenways, vacant lots, and street trees. Since this thesis's research is focused on street trees, it is important to note some of the science that focuses on street trees. The Center for Urban Forest Research, a unit of the USDA Forest Service's Pacific Southwest Research Station, is a leading group on quantifying the benefits and costs of urban forests, including both private and public trees. Here is a brief overview of information related solely to street trees' benefits.

In a study done in Modesto, California, energy savings (heating and cooling costs) from street trees were due to a mix of shade provision and climate effects (15% and 85% respectively). Compared to Residential trees in front and back yards, street trees provided much more savings from shade than from climate effects because of the proximity to the actual homes (McPherson et al. 1999). From a report focusing on urban forests in Western Washington and Oregon, estimates of the value of street trees on property values, rather than front yard trees presented in the Anderson and Cordell's Georgia study, showed that a typical large street tree increased property values by $0.118 per square foot (McPherson et al. 2002). Additionally, the average net benefits (calculated by adding the annual values of net energy savings, air quality improvements, carbon dioxide reductions, stormwater runoff reductions, and aesthetics and other benefits) of small, medium, and large street/park trees were, respectively, $1, $19, and $48 annually (McPherson et al. 2002).

DISTRIBUTION OF URBAN FOREST SERVICES

Researchers and professionals in the urban forestry field agree that, unfortunately, municipal decision makers and budgets often place urban tree care and maintenance low on the priority list. The following quote is a common theme being expressed in the current literature:

> Far from being an amenity, then, it appears that trees play multiple fundamental roles in the continued health of urban communities and should be regarded in the same light as other urban infrastructural elements...the fact remains that few urban politicians view these issues as central to their agendas (Kuo 2003).

Once acknowledged that urban forests are integral to the public infrastructure, managers, in turn, should distribute the benefits of the urban forests equally across the entire city. Unfortunately, urban forestry programs often receive scant funds from municipal budgets or limited attention from the decision makers due to the financial demands of more pressing political and social problems facing cities, such as crime and education (Parker

1995, Tate 2000). This lack of attention results in understaffed tree crews (for routine pruning and necessary tree care) and a scarcity of funding for community involvement and education projects. This is currently the case in Seattle, Washington – a large city proud of its trees, but plagued with a disproportionate number of older trees requiring maintenance and scarce resources (i.e. funding for additional tree crews) to care for both the young and old trees (Rundquist 2003). Nolan Rundquist, the Seattle City Arborist, claims that without additional tree crews the City cannot do much more than respond to emergency clean-ups and hazard trees – a "crisis management" situation. A routine management schedule is needed to manage a green infrastructure program.

If tree programs do not have sufficient resources to begin with, how can they best guarantee that the benefits of trees are equally distributed among all of the residents, regardless of socioeconomic status? In the case of Seattle, the city has made many street trees the responsibility of the adjacent property owner (Seattle Tree Ordinance #90047). This situation could lead to either an increase in attention towards urban trees if more private residents take responsibility of the trees in front of their homes, or a decrease in overall health of the urban forest if the city reduces maintenance and the trees are ignored. Some public policy experts believe that higher-income residents contract to the private sector to fill in when the city no longer provides infrastructure services, leaving the lower-income areas to fend for themselves, with limited resources (Merget 1979).

INPUTS AND OUTPUTS IN URBAN FOREST SERVICE DELIVERY

Continuing with the premise that the urban forest is part of the public infrastructure, a possible way to measure distribution of the public service is to measure the condition of trees and the level of tree maintenance across the entire city. The literature shows that maintained trees are, on average, in better condition than trees that are not maintained. Good maintenance practices include pruning, watering young trees, and protecting trees from construction and other potential damages (Miller and Sylvester 1981, Achinelli et al. 1997, Luley et al. 2002). Miller expands on the need for street tree maintenance in his book Urban Forestry: Planning and Managing Urban Greenspaces:

“Of all municipal tree management activities pruning is the most essential for long-term safety and survival(Miller 1997, page 263).” Without proper and adequate levels of maintenance, tree survival can be drastically reduced and tree growth can suffer (Miller 1997). The same body of literature shows that trees in better condition provide greater levels of benefits, especially trees that are older and more established (Abbott et al. 1991, McPherson 1995, Miller 1997). Since maintained trees are most likely in better condition, it can be argued that trees that are maintained result in greater levels of the known benefits of urban forests (Tate 2000).

Inputs and Outputs

In the study of urban-service distribution, there are many ways to compare goods and services. One interesting method is to measure the level of service as the “input” and the quality of the purpose for the service as the “output” (Lineberry 1977, Rundquist 2003). In urban forestry terminology, tree maintenance can be the input and tree condition can be the output (with the goal being a desired level of tree condition). Often, research is focused on the level of input, rather than output; unlike in many service-distribution situations, the urban forestry field can measure the output – tree condition. In order to maintain equal levels of benefits across an entire city, we cannot look solely at the services provided, but also at the benefits realized. In the literature surrounding urban-service distribution, it is well understood that output equality often requires unequal levels of the input (Lineberry 1977, Lucy 1981, Rich 1982).

The literature on distribution of public services is extensive. There appears, however, to be a general acceptance of the difficulty of measuring how services are distributed. In a case in Brooklyn, New York, the residents of a lower-income, predominately Puerto Rican and African-American neighborhood felt that the park in their neighborhood was under-funded compared to other parks in the area. The court ruled in favor of the city, after the city showed they spent proportionately more on the park in question than on other parks. Regrettably, the city was not able to show that their proportionally higher spending actually resulted in equal levels and numbers of park facilities (Merget and Wolff 1976). If the goal of the city was to spend the same amount of money on each park, and not be concerned with the quality of the park, then the ruling correctly dealt with the legal distribution of money spent. However, if the goal was to provide parks of equal quality to all residents, then the ruling may have not dealt with the ethical responsibility to provide equal levels of park services. It is a complex and difficult dilemma: should resources or services be distributed equally or equitably?

Service Delivery and Environmental Justice

One challenge facing many cities is in regard to environmental injustices in urban planning and management. Although the claims of environmental injustice are still debatable (Cutter et al. 2001), there is a general understanding that it is unjust when proposed sites for toxic waste areas, power plants, and other activities harmful to the health and well-being of nearby residents are more likely to be near disadvantaged populations, or when environmental management options are discriminatory in intent. One paper suggests, “the intersection of environmental management and the environmental injustice movement occurs when a governing body fails to manage resources effectively, resulting in all or part of a community unable to attain a minimum environmental equality (Macey and Her 2001).” Keeping this in mind, if, by providing equitable levels of tree maintenance, the benefits of urban trees are not equally distributed across an entire city, then the claim could be made that a minimum environmental equality is not being realized for all residents. Albeit unintentional, this would be a possible environmental injustice.

RELATED STUDIES

There is a small, yet growing, body of literature regarding the levels of tree cover, distribution of forest structure, and participation in the care and management of urban trees amongst different socioeconomic groups. Currently, however, there is little research in the urban forestry field regarding the distribution of the benefits of urban trees across different socioeconomic groups. If trees are in worse condition in lower-income neighborhoods, the benefits of urban forests may not be available to the residents of those neighborhoods.

Making the Connection between Tree Condition and Socioeconomic Variables

Only one piece of research, to date, has been published discussing a direct link between socioeconomic variables and tree condition. A Ph.D. dissertation found that census tracts in Boston experienced a positive relationship between average income and good forest structure (both street and park trees) (Welch 1991). Welch's research used in-depth factor-analysis to sample two Boston neighborhoods, Roxbury and North Dorchester, in relation to forest structure. She classified forest structure by quality and quantity, meaning that good forest structure included both healthy trees and a certain quantity of trees. She then calculated the average median household income for all areas that had "good forest structure" and found that areas with above average income had higher percentages of good forest structure. The income aspect of Welch's research was just a small part of a much larger research design, and little interpretation was presented about why this correlation existed.

Grey and Deneke state in their 1986 book, *Urban Forestry*, "In areas of low resident income, the urban forest is often composed of declining older trees remaining from times of greater prosperity...In [the] areas of middle and upper income the urban forest is generally well planted and well tended, reflecting the options of affluence (Grey and Deneke 1986)." However, this appears to be a continuation of the anecdotal evidence regarding tree condition and socioeconomic factors. Additionally, in a study on newly planted street trees in Berkeley and Oakland, California, it was found that higher tree mortality was associated with lower socioeconomic status (Nowak 1990).

Differences in Urban Forest Structure

In the New Orleans study done in the late 1980's, Talarchek found that tree cover appeared to be more highly concentrated in neighborhoods with high-income and high-status white residents (Talarchek 1990). A 2000 study on the distribution of forest cover in the Chicago region found that wealthier areas tended to have higher tree cover than poorer areas (Iverson and Cook 2000). The study area, however, included both the highly urbanized city interior as well as the rural suburbs, offering comparisons of the urban poor residents and the wealthy rural residents.

Nowak concluded that the lower-income areas in Oakland, California, had more utilitarian trees (with intrinsic value of producing nuts or fruits) and fewer broadleaf, ornamental, and coniferous trees than the higher-income areas (Nowak 1991). Whitney and Adams (1980) performed a detailed analysis of plant communities in and around Akron, Ohio, and found that different complexes were distinguishable by socioeconomic patterns. Distribution ranged from the inner city maple complex to the conifer complex in the working-class neighborhoods, and finally to the old oak mixed suburban complex further outside of the city.

Residents' Ability and Involvement in Urban Forestry Issues

Many would argue that higher-income residents are more able to take part in community tree planting efforts and maintenance of right-of-way trees (Grey and Deneke 1978, Johnston 1985, Lorenzo et al. 2000), yet confirmatory evidence is scarce and hard to find. In a recent study, researchers found that the willingness of individuals in Mandeville, Louisiana, to pay higher prices for tree preservation and protection was directly related to income levels. While there was no notable difference in income among the respondents willing to pay between $6 and $12 per year, the percentage of respondents willing to pay more than $12 per year increased from 15.6% in the lowest income category to 37.8% in the highest income category (Lorenzo et al. 2000). Iles (1998) made this observation regarding the demographics of where urban forestry efforts are directed: "Generally speaking, traditional targets for urban and community forestry programs in the United States include financially comfortable, if not affluent, well-educated, predominantly Caucasian members of the community."

RESEARCH OBJECTIVES

As the literature review shows, there is sparse information regarding the condition of urban trees in relation to neighborhood socioeconomics. There is ample, and highly beneficial, science on urban tree cover and benefits; however, high percentages of tree cover may neither equate to healthy and well-maintained trees, nor allow for comparison of age or species diversity. With the intention of adding to this small body of literature, this study attempted to investigate if an association existed between neighborhood median household income, street tree condition, and levels of tree maintenance in Seattle, Washington.

Another objective of this project was to incorporate participatory research methods, allowing for a greater connection to the community and an increased awareness of urban forests. Made possible by funding from the Community Forestry Research Fellowship Program, a group formed by the Ford Foundation in 1996 to increase awareness of community forestry issues in the United States, high-school students were invited to participate in the project—from beginning to end. This participation allowed students to learn about a new, and often unknown field, while providing valuable insight as young residents of Seattle and future urban tree planters and caretakers. The Community Forestry Research Fellowship Program believes that enhancing research with local knowledge and participation, healthy and sustainable communities can thrive; thus, the high-school students' involvement in this project benefited both the research and the sustainability of Seattle's urban forest.

This research problem was sparked by observations while working as a summer intern for the Center for Urban Forest Research – a research unit in the USDA Forest Service's Pacific Southwest Research Station in Davis, CA. During the data collection phase in San Francisco, a disparity of tree condition was informally observed between high and low income neighborhoods; the trees in Pacific Heights appeared to be much healthier and vigorous than the trees in Bay View/Hunter's Point. The disparity could not simply be attributed to varied management efforts, as the trees are all maintained by the City of San Francisco. These initial observations inspired the thesis that inherent social inequities may exist in current urban forest management allocations.

This research is valuable in that it adds to the small body of literature surrounding urban forests and socioeconomic information. It is important to continue investigating the relationships that may exist between urban green resources and the residents of those urban areas. As the importance of environmental justice continues to become evident, it is pertinent that all fields address the issues of equal distribution of environmental benefits and the inherent inequalities that may exist in our current management systems, including urban forestry.

HYPOTHESES

The questions posed below, and the diagram in Figure 1, illustrate the hypothesized relationships tested in this study.

1) Is average street tree condition different between low and high-income areas–specifically, is average street tree condition higher in higher-income areas?
2) Is street tree maintenance, performed by the City's Tree Crew, different between low and high-income areas?
3) Is average street tree condition related to street tree maintenance?

The null hypotheses were that there was neither a difference in average tree condition between areas with different median household incomes nor a difference in public tree maintenance in the same areas.

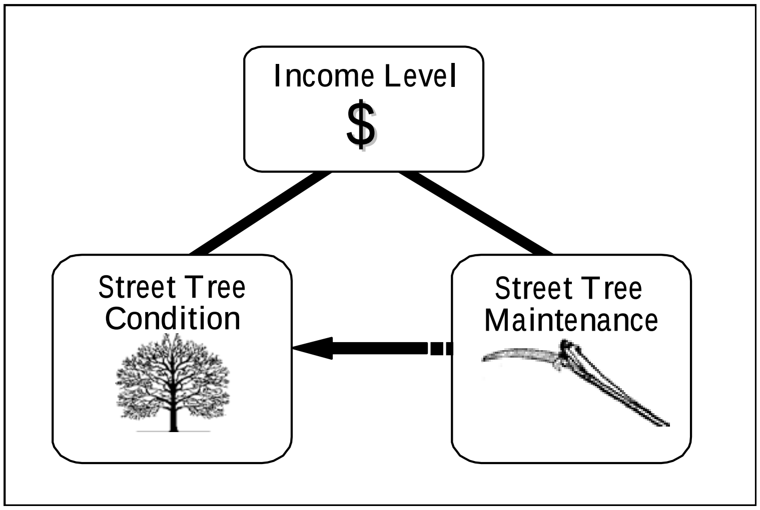

Figure 1. Relationships between income and street tree condition and maintenance

Chapter 2: Research Methods

This chapter provides an overview of the methodology used in this study. The first section describes the selection of the study area and how data was acquired from outside sources. The second section describes the tree sampling method–using Seattle's GIS-based street tree inventory–and the tree condition assessment used for data collection. The third section explains the processing of Seattle's tree crew work records, and the final section presents an overview of the analysis used to examine relationships in the data.

STUDY SITE

The City of Seattle, Washington was chosen as the study site for this project due to the immense interest in the management and continuation of the city's urban forest resource - as reflected by the development of the transportation department's urban forestry program, the city's 16-year Tree City USA status, and the Mayor's Urban Forest Coalition. Seattle boasts a fairly extensive urban forest presence, with more than 80,000 street trees and countless park, greenbelt, and backyard trees.

Figure 2. Map of study site

Seattle's street trees are scattered throughout the entire city. Many streets have planting strips, while the trees in higher density areas are planted in square or rectangular planting areas, usually quite small. Trees in Seattle have long growing cycles, due to the high levels of moisture during the rainy season and brilliant sunshine during the summer.

Seattle is a medium-sized city, with a total population close to 570,000. The city is topographically diverse, with many steep hills and valleys. The city is long and narrow, approximately 4 kilometers across at its most narrow, 14 kilometers at its widest, and 27 kilometers from north to south. Seattle is bordered by Lake Washington to the east and Puget Sound to the west. Seattle is well known for its small neighborhoods, each with their own unique characteristics and demographics. The areas in the northernmost and southernmost parts of the city limits are more residential, with lower-density residential living, while the areas in the mid-area are more developed and dense.

COMMUNITY PARTICIPATION: RECRUITMENT

In order to satisfy the requirements of participatory research methods, high school students were recruited to participate in the project. Incorporating high school students would introduce a group of young people to the often unfamiliar field of urban forestry, provide a fresh insight into community resources and social justice issues, and enhance the project with the perspective of young Seattle residents. Students were recruited through visits and e-mails to high school environmental clubs, science and humanities classes, and various environmental educational organizations across Seattle. Figure 3 shows the flyer that was used to attract students to the project. After a handful of visits and organizational meeting, six students committed to work on the project for the duration of the summer–after an initial interest of forty-six students. The students were pertinent to the project, and their involvement was a testament to the benefits of including community members in projects related to the health of cities and urban residents.

DO YOU CARE ABOUT TREES?

✷Be outside ✷Earn Service Learning Credits ✷Learn GIS
✷Make a difference in your community ✷Meet other students

Looking for motivated students interested in environmental issues, community involvement and social justice.

Seattle's urban forests provides vast benefits for all of us: clean air, clean water, shade on those hot summer days, cover from the never-ending Northwest rain, and a beauty that exceeds many other cities. We are the Emerald City, right? As urban foresters, we want to make sure that every neighborhood and every person receive the same benefits from healthy urban forests.

What is this about?

I am a graduate student at UW starting a summer project that will look at the condition of the urban forest in high and low income neighborhoods. We will measure the condition of street trees (those trees planted between the sidewalk and the street) to see if there is a difference between neighborhoods with different incomes. We will also talk with community people to find out how much care they give to the trees in front of their homes.

What will you get to do?

You will learn valuable skills in tree measurement and assessment and gain experience with cutting edge computer software…plus, you can add this to college applications and resumes. We will use software that allows us to find each and every tree in the city and make accurate maps that compare tree condition to income across the entire city. We will spend sunny days outside, measuring tree condition and meeting with community members. At a conference in September, near Hood Canal, you can come and share our project with important community leaders.

➲ Lunch, transportation, and extras paid for by a grant from the Community Forestry Research Fellowship program.

If you want to be part of the this important project, please call or e-mail Ara Erickson at

206.617.4142 or arake@u.washington.edu

Figure 3. Recruitment flyer

DATA SETS

This project included substantial data reconnaissance and transformation. Census information, from both 1990 and 2000, were combined and synchronized to classify Seattle's high- and low-income census tracts. The tree inventory map data–used to select trees–was adjusted to work with a manageable number of species and trees, and was aligned with census information for accurate location and selection of the trees. The City of Seattle's street tree maintenance records involved an enormous amount of data entering and recoding. In order to integrate the three types of data, months of data transformation work was necessary. The steps taken to manage the data are described, in further detail, in the following three sections. Table 1 lists this project's type and source of data.[1]

Table 1. Data sets and sources

DATA	SOURCE
Census Information	
2000 Demographic information	Custom tables via American FactFinder
2000 Census Tracts GIS files	Geolytics CD-ROM
1990 Demographic information	Geolytics CD-ROM
1990 Census Tracts GIS files	Washington State Geospatial Data Archive (WAGDA)
Seattle GIS Information	
Street Tree Inventory, City of Seattle	City Arborist's Office – Department of Transportation
Tree Crew Work Records, City of Seattle	City Arborist's Office – Department of Transportation
City Boundary	WAGDA
Street Network – Streets and Intersections	City of Seattle via WAGDA

STUDY AREA DATA CONTENT

Boundaries

Work began with locating 1990 and 2000 Census information for the Seattle area. Census boundary files and associated median household income, population, and ethnic make-up for each census tract in Seattle were downloaded via the U.S. Census Bureau's

[1] Full citations located at end of reference section, in the same order presented here.

American FactFinder and the Washington State Geospatial Data Archive (WAGDA). Census tracts are defined as small, relatively homogeneous areas, with respect to economic status, and living conditions, into which large cities and counties are divided (U.S. Census Bureau 1997). The GIS files were projected in Geographic Projection, Decimal Degrees for Map Units, and NAD 83 Datum. Using 1990 and 2000 data, a check for consistency of Census tract boundaries showed only five tracts dividing into two or more tracts between the selected years. Therefore, it was decided that using the 2000 boundaries would still provide accurate assessments of income for the areas from 1990 to 2000.

Areas that made up Seattle's primary business and industrial land use areas (i.e., downtown, Safeco Field, Seahawk Stadium, and Harbor Island) were excluded from site selection. It was not appropriate to include non-residential areas, as this study was aimed at exploring the differences in tree condition between areas of diverse household, not commercial, income.

Comparison of income level between 1990 and 2000

Since tree condition is often a function of time, it was necessary to have fairly consistent levels of income over a set-period of time. To ensure that selected areas did not have above-average income increases or decreases in the recent past, change in income level between 1990 and 2000 was calculated. Using the following Consumer Price Index (CPI) [2] formula, 1990 dollars were converted to 2000 constant dollars:

$$2000\ MHI = 1900\ MHI * (2000\ CPI/1900\ CPI)$$

where CPI for 1990=130.7 and 2000=172.2

On average, Seattle's census tracts' median household income increased by 24.76% (+/-20.98) between 1990 and 2000. Fourteen tracts were excluded because their change in median household income from 1990 to 2000 was greater than 46% (one standard deviation from the mean).[3]

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[2] CPI is a measurement that explains the change in the prices paid by urban consumers for a representative basket of goods and services from one year to another (reference). This means that the same basket of goods that an urban consumer could by for $130.70 in 1990 would have to be purchased for $172.20 in 2000.

[3] Percent change in median household income between 1990 and 2000 for Seattle's census tracts are listed in Appendix A.

Distribution of Median Household Income

Seattle's census tracts showed a normal distribution of median household income, with the majority of the tracts falling between $30,000 and $60,000 with an average median household income of $47,416 (+/- $16,000). Census tracts were divided into "high" and "low" income groups: greater than $47,416 and less than $47,416. Sixty-nine tracts were considered high-income, while forty-nine tracts were considered low-income, equaling a total of 108 acceptable tracts to select study sites from.

Selected Tracts

Six census tracts were randomly selected from the 108 acceptable tracts in the city–three of each income group. Median household incomes for each of the six areas were compared against each other to ensure an adequate distribution of income conditions. The selected tracts–from lowest income to highest income–were matched with the following approximate neighborhoods: the Central District, Fremont, Northgate, North Capitol Hill, Seward Park, and Madrona areas. Table 2 provides demographic information and total tree population for the six selected study areas. Additional information for all census tracts within Seattle's city boundaries, not just the selected tracts, is presented in Appendix A.

Table 2. Demographic information for selected areas

	Area	Census Tract #	Median Household Income	Population	Ethnicity	Housing Characteristics	Total Number of Trees
Low-income	Central District	90	$20,104	2134	19% White 30% African American 43% Asian	Apartments, Duplexes	407
	Northgate	12	$32,463	6106	66% White 17% Asian	Single-family homes, duplexes	449
	Fremont	49	$38,858	5525	88% White	Apartments, single-family homes, duplexes,	751
High-income	North Capitol Hill	65	$52,838	4045	88% White	Large single-family homes	1095
	Seward Park	102	$60,125	4870	51% White 19% African American 22% Asian	Single-family homes, duplexes	351

	Madrona	78	$82,635	5097	72% White 20% African American	Single-family homes	1054

A map of where the tracts are located in Seattle is shown in Figure 4. Northgate and Fremont are in the north, Seward Park is furthest south, and North Capitol Hill, Madrona, and the Central District are in the middle of the city and closest to downtown.

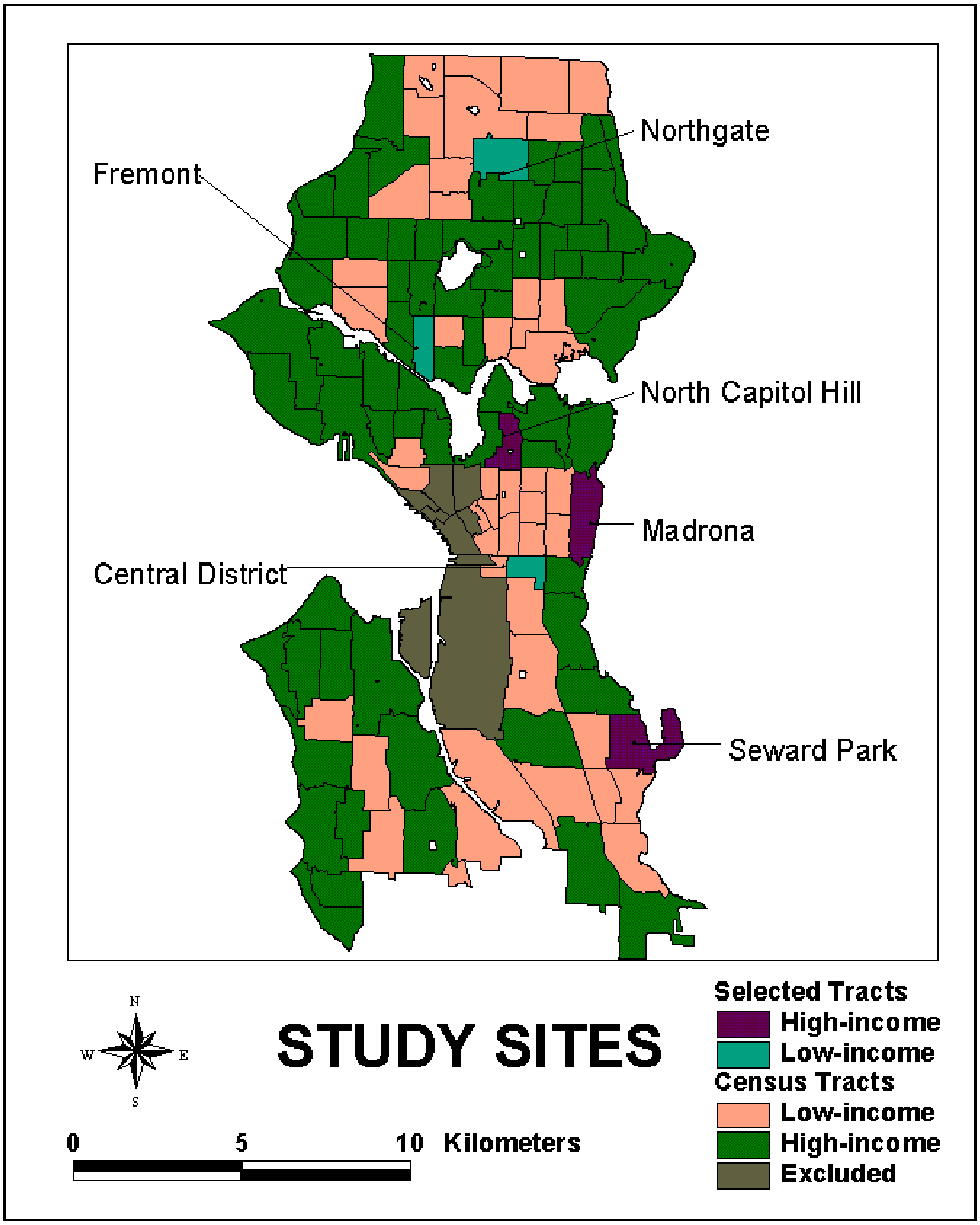

Figure 4. Map of study sites

TREE SAMPLE DATA CONTENT

Street Tree Inventory

The City of Seattle's GIS-based Street Tree Inventory, generously provided by the City Arborist's Office, was used as the data source for the tree sample. Although this inventory could be considered rather static (not used on a daily basis), the City Arborist's Office makes relatively frequent updates and has added more than 10,000 trees to the database since the original inventory done in 1990 (Rundquist 2003). Each street tree is geocoded to a particular address and location in Seattle and includes information about species, size, planting location, planting date, management responsibility, and more. The full database includes more than 75,000 street trees.

Species

Seattle is known as the "Emerald City"–a testament to the abundant green vegetation that adorns the parks and hills of the city. Having close to 500 different tree species, Seattle's streets are no exceptions to the diversity of the city's natural landscape. Due to the enormous task of training the high-school students in tree identification and condition assessment for such a large number of species, it was necessary to limit the number of tree species that would be part of this study. Therefore, tree species that amounted to less than 0.5% of the total street tree population were excluded from the tree sample. This reduced the number of tree species from 500 to 41–a much more manageable number of species.

Using ArcView, the tree inventory shapefile was "clipped"–similar to using a cookie cutter to cut out pieces of dough–to include only those trees that made up more than 0.5% of the total street tree population. The inventory was further clipped to include only the trees that fell within the six selected tracts, resulting in a total of 4107 trees. Systematic random sampling was used to select forty trees from each of the six tracts, for a total tree sample of 240.

Table 3 shows the fifteen most common tree species on Seattle's streets, and their composition of the total street tree population. Forty-one additional species, not listed in the table, made up the remaining trees that represented more than 0.5% of the total street tree population.

Table 3. Composition of Seattle's 15 most common street tree species

Rank	Common Name	Scientific Name	Percent
1	English midland hawthorn	*Crataegus laevigata*	4.6%
2	Norway maple	*Acer platanoides*	4.2%
3	Blireiana purpleleaf plum	*Prunus x blireiana*	3.9%
4	Red maple	*Acer rubrum*	3.8%
5	Thundercloud purpleleaf plum	*Prunus cerasifera 'Thundercloud'*	3.7%
6	Kwanzan flowering cherry	*Prunus 'Kwanzan' (Sato Zakura Group)*	3.7%
7	Sweetgum	*Liquidambar styraciflua*	3.6%
8	Myrob flowering plum	*Prunus cerasifera*	2.8%
9	Apple/crabapple	*Malus sp.*	2.8%
10	European white birch	*Betula pendula*	2.2%
11	Littleleaf linden	*Tilia cordata*	2.2%
12	Double chinese cherry	*Prunus serrulata*	2.2%
13	Red oak	*Quercus rubra*	1.8%
14	London plane	*Platanus x acerifolia*	1.7%
15	Japanese maple	*Acer palmatum*	1.5%

Tree Condition Rating

The Council of Landscape and Tree Appraisers Tree Assessment Guide includes a tree condition rating as part of the total assessment method (Council of Tree and Landscape Appraisers 1983). The condition assessment separates a tree into five factors: roots, trunk, scaffolding branches, smaller branches and twigs, and foliage. Figure 5 depicts a tree with lists of the characteristics used to gauge the level of problems associated with each of the five factors. When assessing the condition of a tree, each factor is looked at separately; using the characteristics in Figure 5 as guidance, each factor is assigned a score based on if the characteristics present on the factor are positive or negative. The following scores match the appropriate description of the level of problems (or lack of problems) associate with each score:

1 = extreme problem
2 = major problem
3 = minor problem
4 = no apparent problem

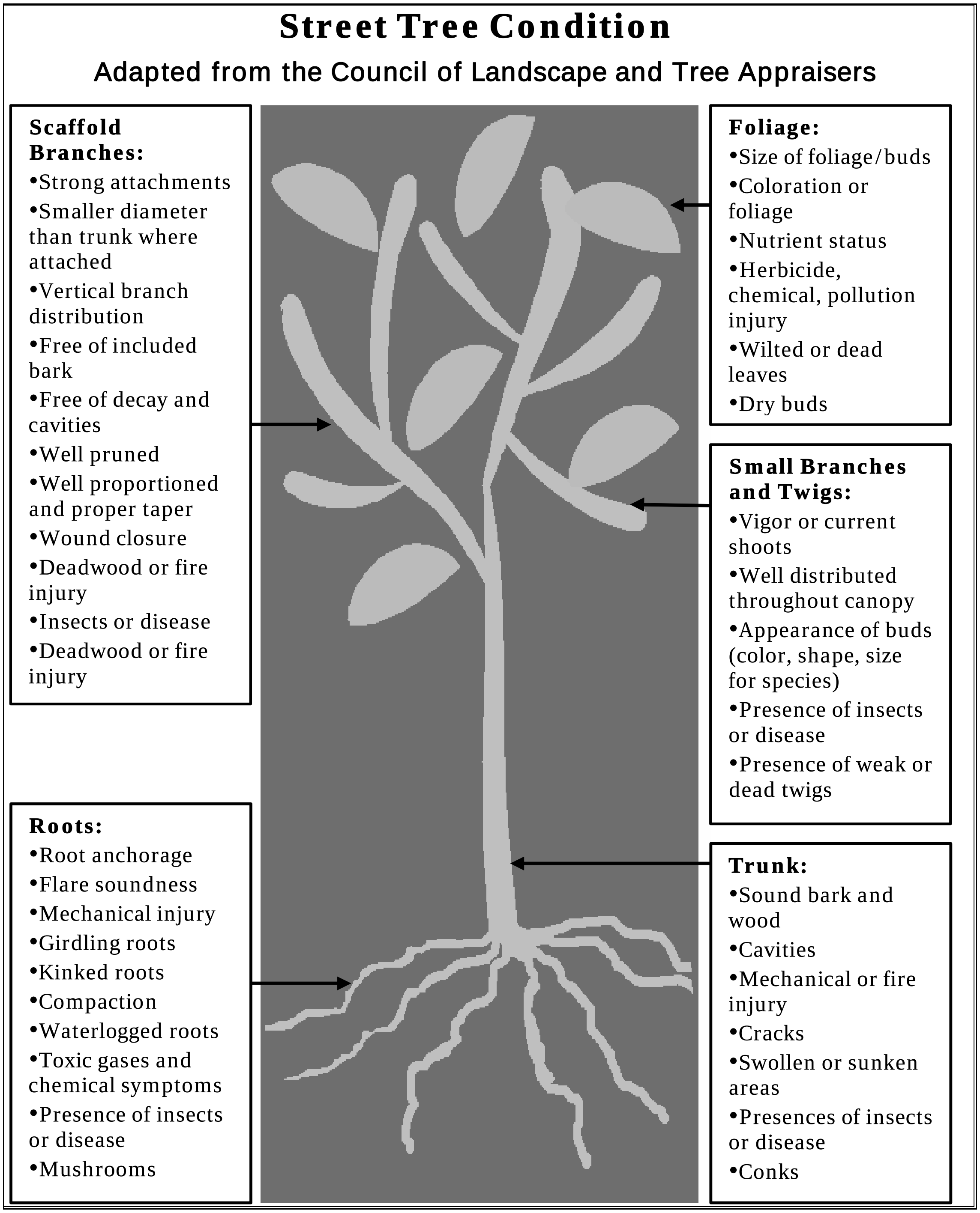

Figure 5. Tree condition assessment criteria

The five scores are then summed together to get one final condition score, with five (5) being the worst possible score and twenty (20) being the best. Consistent with the method used by the USDA Forest Service, Center for Urban Forest Research, and many other urban forestry professionals, scores were divided into four categories: dead or dying, poor, fair, and good. Table 4 lists the condition categories and their associated sums of the factor score and characteristics.

Table 4. Tree condition categories

Sum of Five Factors	Condition Category	Condition Number	Characteristics
5-8	Dead or Dying	1	▪ Dead, or death imminent, from disease or other causes
9-12	Poor	2	▪ General state of decline ▪ May show severe mechanical, insect, or disease damage, but death not imminent ▪ May require major repair or renovation
13-16	Fair	3	▪ Average condition and vigor for area ▪ May need corrective pruning or repair ▪ May lack desirable form characteristic of species ▪ May show minor insect injury, disease, or physiological problem
17-20	Good	4	▪ Healthy vigorous tree ▪ No signs of insect, disease, or mechanical injury ▪ Little or no corrective work required ▪ Form representative of species

Reliability Test of Condition Rating

The tree condition assessment technique relies on professional judgment, is highly reliable, and other experts would repeat very similar condition levels using the same method. Additionally, the technique is not “sensitive,” meaning that it does not give variable results depending on species or age. The assessed condition of twelve trees was compared with a Certified Arborist’s assessments of the same trees, using the same described method, and the results showed a high level of reliability (Number of Cases = 12, F= 2.20, Reliability coefficient Alpha = 0.9242). The sample did not stratify by tree age or species because condition assessment does not compare older trees to younger trees or one different species to another species; it looks solely at a particular species at a particular age. However, the assessor must be familiar enough with the species to know the characteristics of a "perfect" specimen as well as common problems associated with that particular species.

Tree Condition Assessment – Data Collection

Data collection was performed between June 15 and August 1, 2003. Spreadsheets were created with a list of the selected trees for each area and maps, created in ArcView GIS, assisted in locating the exact location of a specific tree. Thirty-six trees were missing, recently removed, or incorrectly listed. Diameter (DBH), planting width, planting area type, and planting area ground cover were also recorded. If more than one tree of the same species was present at the specified address, a tree was chosen at random. If the specified tree was not found at the address provided, either a nearby tree of the same species was selected or it was noted that the tree was missing.

COMMUNITY PARTICIPATION: DATA COLLECTION

The students participating in the project were trained in tree identification and basic tree condition assessment. Using tree identification books and printouts of each tree species, the selected trees' species were verified in the field. For tree condition, "cheat sheets" and diagrams (similar to Table 4 and Figure 5) were used to guide the students in the correct direction when gauging tree condition. In order to maintain consistency and accuracy throughout the entire project, the primary researcher was always part of the assessment team and assured that the appropriate condition scores were assigned. The experience was valuable for both the students and the project; the students gained new skills and the project was rewarded with knowing that students enjoyed the experience, as evident by the submission of the following poem from one of the students:

Standing tall and majestically,
Deep olive and light green hues contrasting against
The azure blue sky with white wisps,
Summer smells still in the air,
Sun burning down upon leaves,
Shadows cast down,
Stopping
Notepad in hand
To meticulously write measurements,

Side note to self: unusual number of tumors on bottom trunk
As you move on to the next tree.

TREE MAINTENANCE DATA CONTENT

Work Records

Beginning in March 1998, the City's tree crew reports weekly "accomplishments" to the City Arborist. The weekly reports describes where the tree crew went, what type of tree care activity was performed, and how many of what tree species were worked on. Seattle's Arborist Office generously provided all of the work records through December 2002. The total number of weekly accomplishments equaled 250 individual files, approximately one for each week between March 1998 and December 2002.

The "accomplishments" from each file were consolidated into a single spreadsheet and each entry included a unique ID, date, address (or intersection), type of tree work, number of trees worked on, and type of tree(s) worked on. The end result was a database with 1236 individual entries of tree maintenance performed between 1998 and 2002. Examples of these entries are shown in Table 5.

Table 5. Example of work records entry

Unique ID	Date	Address	Activity Main	Number of Trees	Tree Species
145	5/6/02	1833 S Dearborn St	Tree removal	1	Kwansan Cherry
203	5/13/02	21st S & Norman	Routine pruning	15	Tulip and Crabapple

Each entry was matched to a location on the City's Street Network shapefile, using with ArcView's "geocode addresses" function. The "batch match" method resulted in 563 individual "events" matched with a 75-100% accuracy and 511 events matched with a 50-70% accuracy rate. An interactive match (not automatically done by the software) located 97 additional events and 64 events were unable to be matched at all. The end result was a GIS shapefile with 1171 separate work events, spanning the entire time period of recorded weekly accomplishments. The total of the work events were matched with the six areas and a new file was created to include the work events that fell within the boundaries of the areas.

ANALYSIS PROCEDURES

Tree Condition and Income

Tree condition was analyzed using the Statistical Package for Social Sciences (SPSS), Microsoft Excel, and ArcView GIS. Average tree condition was calculated for each of the six tracts, using the condition number (1-4) associated with each condition category (poor, fair, etc.). A OneWay ANOVA test was used to compare the mean condition across all tracts and an Independent Sample T-Test was used to compare the mean condition between the aggregated high and low-income areas (the six tracts were collapsed into one high-income variable and one low-income variable, resulting in a comparison of two variables).

The mapping of tree condition and work records across the city was deemed an important visual display, enabling city managers and decision makers, unfamiliar with urban forestry terms, to use visually displayed data to assess current patterns in management and make appropriate decisions. Maps displaying tree condition in the different areas were also produced. Relevant to the goals of this study, one author writes:

> As a basis for planmaking, revelations about who benefits, presented in visual, spatially-oriented terms, enable communities to evaluate their distributional preferences and see whether or not they are in line with broader community goals and with notions of fairness (Talen 1998).

Work Records and Income

The distribution of tree maintenance (total visits and total number of trees worked on) was calculated for the entire city (See Appendix B), for each of the six tracts, and for the high and low-income areas. Total number of visits and number of trees worked on (from 1999-2002) were compared between the six areas and the aggregate low and high-income areas. Additionally, the type of activity performed at each location (pruning, removing, etc.) was calculated for the entire city (see Appendix B).

Work records from 1998 began in March and were slightly incomplete, thus were eliminated from analysis. Additionally, the number of visits and trees worked on were weighted by total street tree population and total city-maintained trees, to ensure an accurate comparison of tree maintenance in relation to the actual number of trees present and the number of trees under City responsibility[4].

Work Records and Condition

Average tree condition among each area and between the high and low-income areas was graphed in relation to the number of visits and number of trees worked on per visit. Although this information is not adequate enough for robust analysis, a basic relationship between maintenance and average tree condition of the sampled trees can be detected with graphs and presented in tables. This information is presented in the Results section alongside the tree maintenance and income findings.

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[4] Trees were weighted by total-city maintained trees due to an interesting, yet common, practice of tree responsibility in cities strapped for funding. The City Arborist Office, part of the Department of Transportation, manages Seattle's street trees with help from Seattle City Light, the utility company, and Parks and Recreation. All city trees are considered publicly owned, but responsibility of the trees is often in the hands of the adjacent property owner. Unless the city physically planted the tree, the property owner is responsible for any pruning, removal, or costs associated with damage of the tree. However, the property owner still does not "own" the tree; they must apply for a tree work permit through the City Arborist, pay a $265 refundable fee, and have the final work inspected by the City. If the work is not up to standard, the fee is not refunded.

City planted trees, on the other hand, are the responsibility of the City Arborist's Office – who only has one permanent tree crew, made up of two or three people. Most of the City maintained trees are located on the main arterial streets and commercial districts throughout Seattle. The one exception is a large part of the Central District; in the 1970's the Federal Government funded a program called "Forward Thrust," aimed at encouraging development and improvement in low-income areas. Seattle used a large part of that money to plant a large number of street trees in one of its poorer neighborhoods. Thus, the City is responsible for the maintenance of those trees. Although the City is not responsible for maintaining trees other than the ones they plant, the City tree crew will respond to occasional pruning requests, tree removal, and clean-up/clearing needs in neighborhoods throughout Seattle.

Other Factors

In order to ensure the validity of the findings, it was necessary to investigate if other factors were contributing to the average condition in the different areas. Although soil quality and type, air pollution levels, and precipitation levels could contribute to different tree conditions, they were outside the scope of the project. Nevertheless, the effect of tree diameter, genera, and planting strip width and cover on tree condition was analyzed.

Chapter 3: Results

This chapter presents the results from the tree condition assessment and the tree work records analysis. First, it compares the tree condition assessed in this study to the condition assessed in the City's 1994 inventory. The second section reports average tree condition as it related to income and the third section reports the level of tree care as it related to income and tree condition.

COMPARISON OF SAMPLED TREES' CONDITION AND CITY INVENTORY

With more than 98,000 street trees, Seattle boasts many tree-lined streets. However, the condition of the street trees varies. As shown in the Figure 6, this study found that approximately 23% of the sampled street trees were in good condition and 65% were in fair condition, with 12% of the trees in poor and dead or dying condition. Similar to the above percentages, calculations of tree condition from the entire inventory (N=70,023) showed that condition results from this study did not vary widely from the condition assessments performed by the City in their 1994 inventory.[5] This similar pattern of street tree condition between the two assessments was important to the reliability of this project's findings as it increased the possibility of extending to the rest of Seattle.

[5] In the original inventory, the City Arborist assigned condition values from 1-5 for each tree. For comparison to this study, the numbers were translated as follows: 1 = Dead or dying; 2 = Poor; 3 or 4 = Fair; 5 = Good.

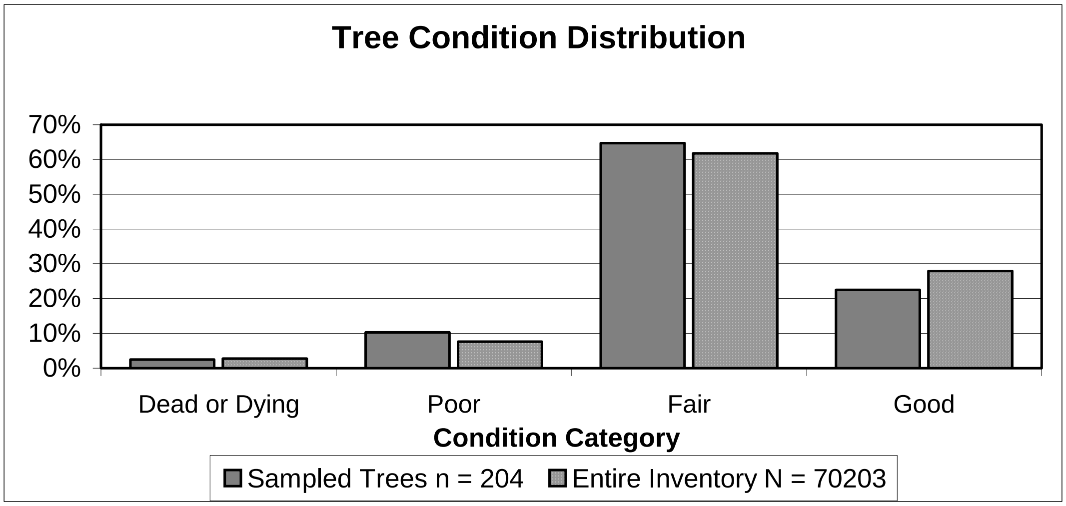

Figure 6. Tree condition distribution

IS TREE CONDITION RELATED TO INCOME LEVELS?

Tree Condition in Six Tracts

Surprisingly, as Figure 7 shows, the six areas shared very similar mean street tree condition levels. Moreover, mean street tree condition showed no significant relationship to income; tree condition neither increased nor decreased with median household income[6]. Figure 7 shows the absence of any statistical relationship between median household income and average tree condition; the line is relatively flat across all income levels and the average condition scores do not vary by median household income.

[6] One-Way ANOVA results = Sum of Squares = 1.617, df = 5, F=0.7598, p > 0.5

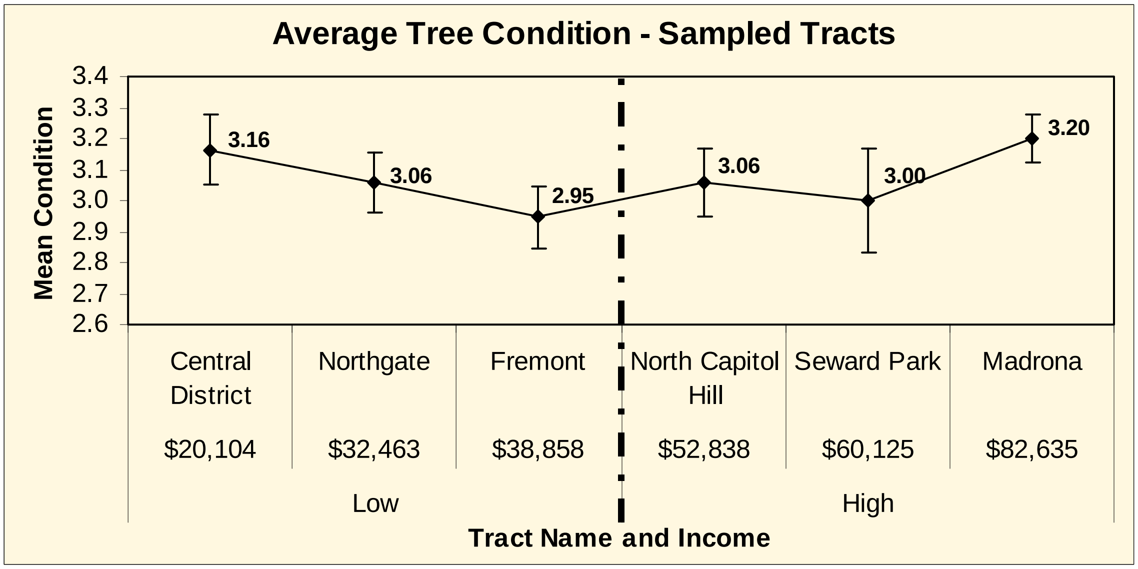

Figure 7. Average tree condition in sampled tracts compared by income levels

Condition Categories in Six Tracts

Figure 8 shows the percent of trees in the different condition categories for the six areas. The majority of the trees were in fair condition, with good being the second most common condition of trees. A Chi-Square Test performed on the distribution of tree condition categories showed no significant difference in distribution among the six tracts (Pearson Chi-Square Value = 15.129, df = 15, $p > 0.4$).

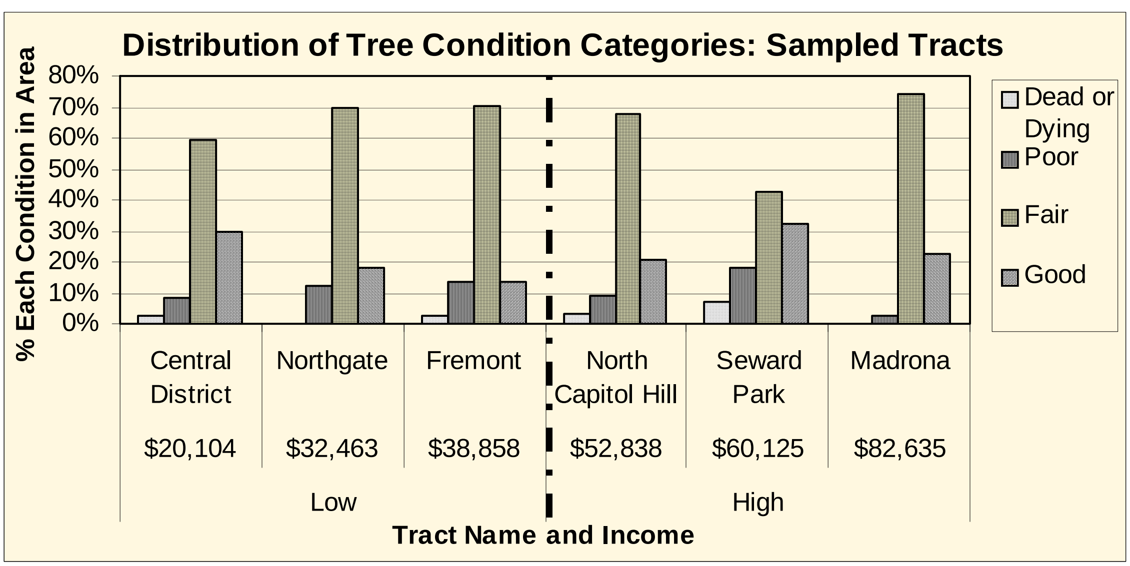

Figure 8. Distribution of tree condition categories in sampled tracts

Tree Condition in Low and High-Income Tracts

Similar to the results from the tract-by-tract analysis, average tree condition was not significantly different between the aggregated high and low-income areas (Figure 9). The high-income areas' average tree condition was 3.09 (standard deviation = 0.6783), while the low-income areas' average tree condition was 3.06 (standard deviation = 0.6269). A t-test performed on these means showed no significant difference between the two income areas, thus the null hypothesis could not be rejected.[7]

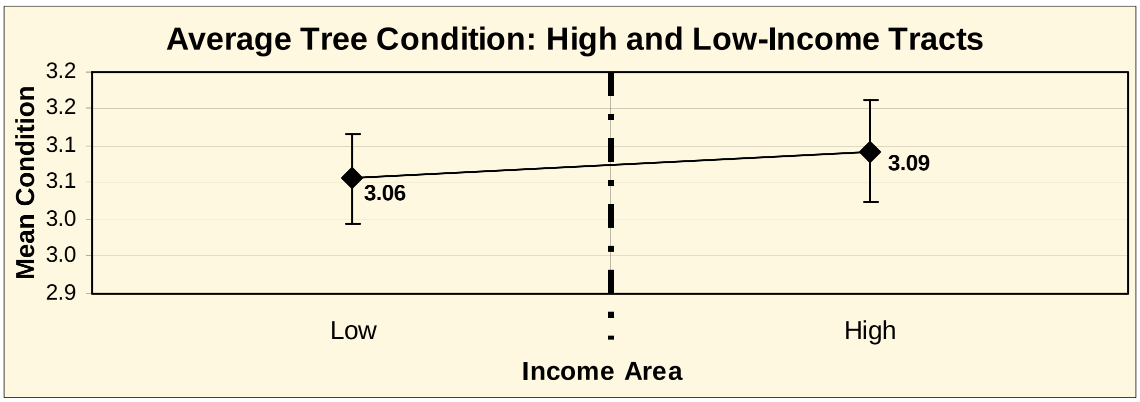

Figure 9. Average tree condition for high and low-income areas

Condition Categories in Low and High-Income Tracts

Figure 10 shows that there was little to no difference in the patterns of tree condition distribution of between the high and low-income areas[8]. Although the high-income areas had slightly more trees in good and poor condition and slightly less trees in fair condition, the difference between the income groups was insignificant.

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[7] $t = -0.4001$, $df = 195.88$, $p > 0.6$

[8] (Pearson Chi-Square Value = 0.9853, $df = 3$, $p > 0.8$)

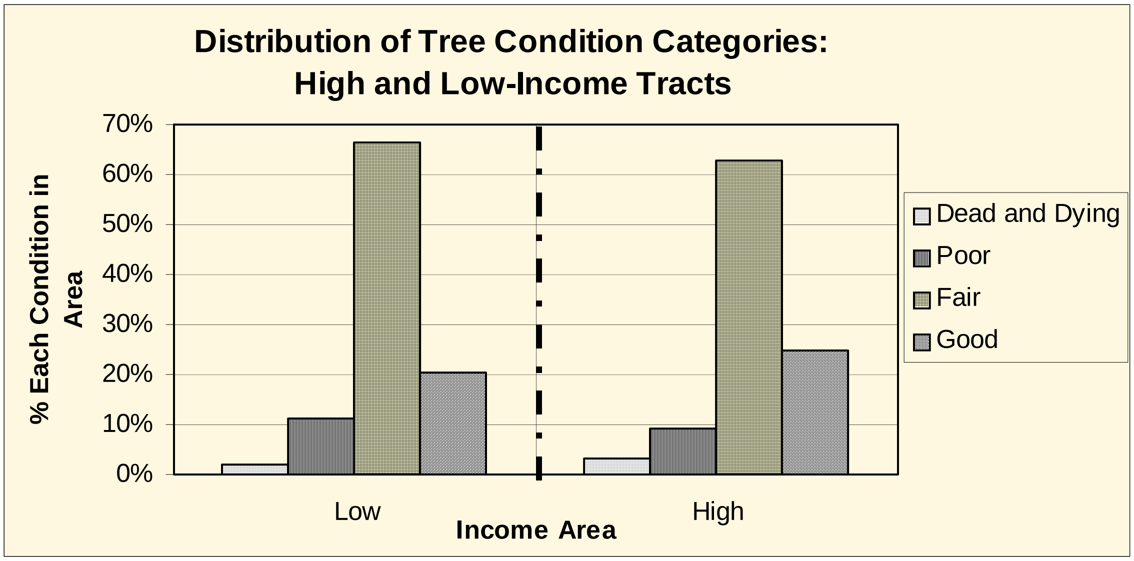

Figure 10. Distribution of tree condition categories for high and low-income areas

Visual Display of Tree Condition

Figure 11 is a map displaying tree condition across all sampled tracts. Tree icons in four different colors represent the tree condition categories: dead or dying, poor, fair, and good. The tracts on the right-hand side, with purple backgrounds, are the three high-income areas and the tracts on the left-hand side, with green backgrounds, are the three low-income areas. At first glance, this visual representation of tree condition does not show any obvious distinctions in color patterns – nor tree condition - among the different areas. There is a large presence of yellow and green trees scattered throughout all of the areas, with no particular differences in location. On the other hand, there are a larger number of red and orange colored trees in Seward Park – one of the lower average tree condition tracts. This tool can be useful for managers to notice subtle patterns of tree condition throughout a city, rather than needing to decipher complicated numbers and charts.

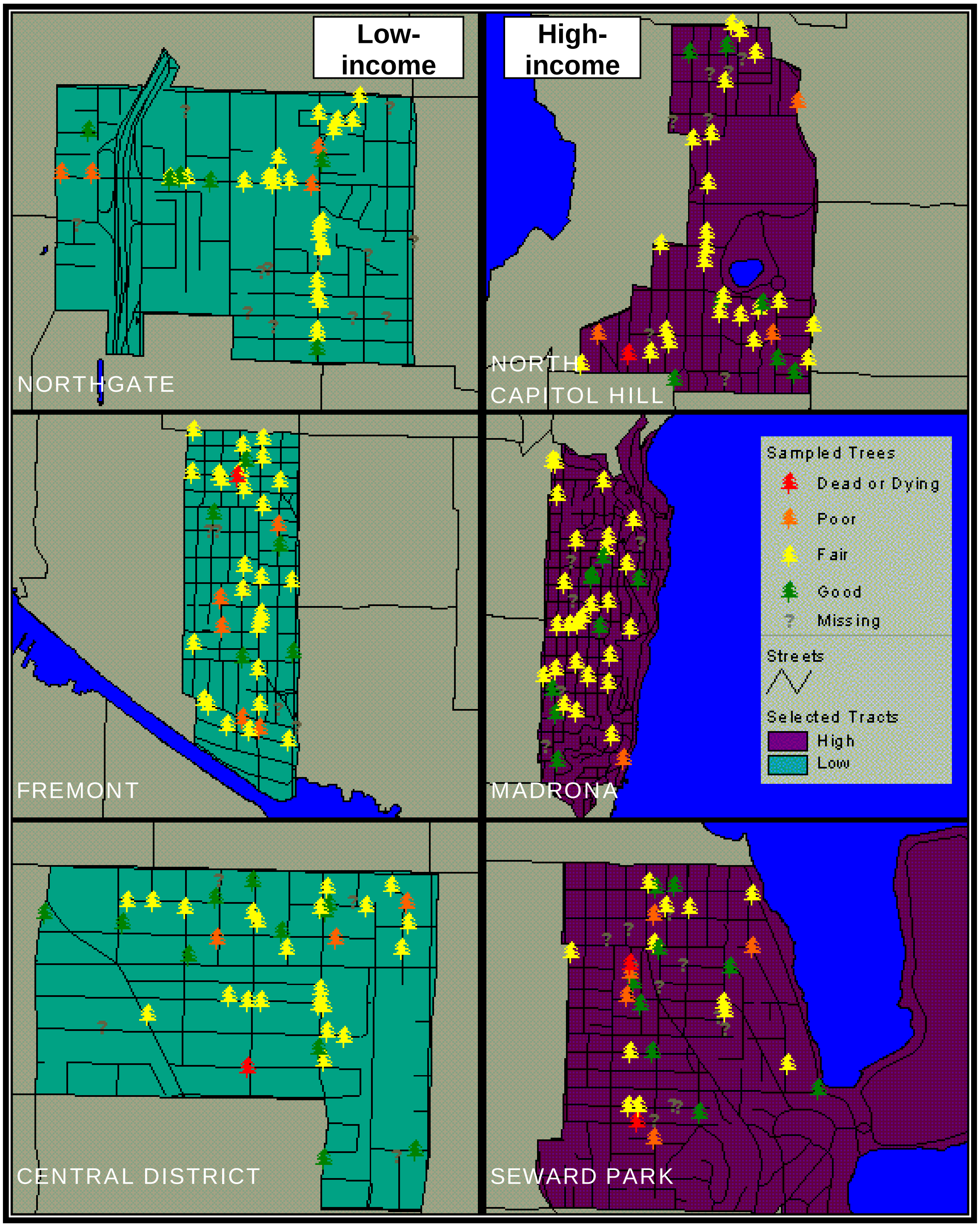

Figure 11. Map of tree condition

ARE LEVELS OF TREE MAINTENANCE RELATED TO INCOME AND/OR TREE CONDITION?

This section presents the results from the tree crew work records. Tree maintenance among the six tracts is discussed first and the aggregated high and low-income areas are discussed second. For simplicity and to avoid repetitiveness with the graphs, the testing of the relationship between tree maintenance and tree condition is presented alongside the maintenance and income data.

Tree Maintenance in Six Tracts

Earlier, it was shown that average tree condition neither differed significantly between the different income groups nor among the six different areas. Table 6 shows the average tree condition of each area as well as the total number of visits and total number of trees worked on between 1999 and 2002. The first three areas, the low-income areas, tended to have a greater number of trees worked on and a greater number of total visits than the last three areas, but mean tree condition tended to stay the same. The table also shows the total number of trees and total number of city-maintained trees for each area. The three low-income areas have a much higher proportion of city-maintained trees than the high-income areas, but trees per hectare does not display a pattern in relation to income.

Table 6. Work record information for six areas

	Tract Name	Average Condition	Hectares	Total Trees	City Trees	Trees/ Hectare	Visits	Trees Worked On
Low-income	Central District	3.16	83.25	407	231	4.8892	21	57
	Northgate	3.06	187.89	449	295	2.3897	19	37
	Fremont	2.95	108.99	751	217	6.8903	26	107
High-income	North Capitol Hill	3.06	112.62	1095	32	9.7228	8	13
	Seward Park	3.00	278.82	351	1	1.2589	1	2
	Madrona	3.20	213.18	1054	194	4.9442	21	21

For analysis, the data was weighted by total number of trees in each area and total number of city-maintained trees to ensure equal comparison of tree work in relation to the total number of street trees. Data was also weighted by size of tract (hectares), but results did not vary from the weighting by tree total, so results from this analysis are not discussed.

As shown in Table 7, the Central District, Fremont, and Northgate areas had the greatest number of trees worked on per the total number trees, approximately 0.14, 0.21, and 0.19 respectively, while North Capitol Hill, Madrona, and Seward Park showed significantly less number of trees worked on per total trees, 0.02, 0.05, and 0.02 respectively. The number of visits per total trees did not show quite as large of difference between the areas but followed a similar proportional pattern. Figure 12 clearly shows that the level of tree care was greater in the three low-income areas, while mean tree condition stayed the same among all of the areas.

Table 7. Number of visits and number of trees worked on in six areas

Tract Name	Visits per total trees	Percent of all visits	Trees Worked On per total trees	Percent of all trees
Central District	0.0516	24.9%	0.1400	22.3%
Northgate	0.0646	31.1%	0.2094	33.3%
Fremont	0.0426	20.5%	0.1864	29.7%
North Capitol Hill	0.0146	7.0%	0.0210	3.3%
Seward Park	0.0142	6.9%	0.0513	8.2%
Madrona	0.0199	9.6%	0.0199	3.2%
Total		100.0%		100.0%

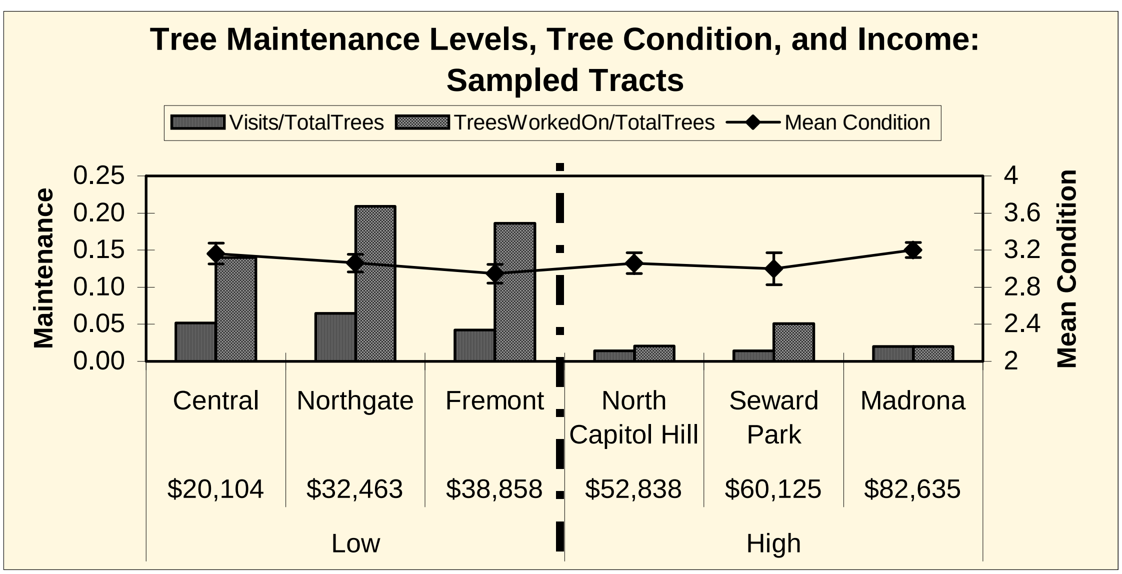

Figure 12. Tree maintenance (per total trees): sampled tracts

A slightly different pattern emerged when the data was weighted by total number of city-maintained trees - the amount of maintenance appeared to shift to the three high-income areas (Table 8 and Figure 13). The Central District and Northgate no longer had higher levels of tree care, rather they showed the lowest number of visits and trees worked on per total city maintained trees. However, Seward Park, with one city maintained tree and one unweighted visit, appeared to receive 84.1% of the visits; thus, this analysis is inadequate if the areas have extremely low numbers of city maintained trees. Figure 13 shows that low and high-income tree care did not follow the same pattern as previously displayed; North Capitol Hill and Fremont had high levels of tree care, while the Central District, Northgate, and Madrona had much lower levels.

Table 8. Work levels per total city trees for six areas

Area Name	Visits per total city trees	Percent of all visits	Trees Worked On per total city trees	Percent of all trees
Central District	0.0909	1.5%	0.2468	1.2%
Northgate	0.0983	1.7%	0.3186	1.6%
Fremont	0.1475	2.5%	0.6452	3.2%
North Capitol Hill	0.5000	8.4%	0.7188	3.6%
Seward Park	5.0000	84.1%	18.0000	89.8%
Madrona	0.1082	1.8%	0.1082	0.5%
Total		100.0%		100.0%

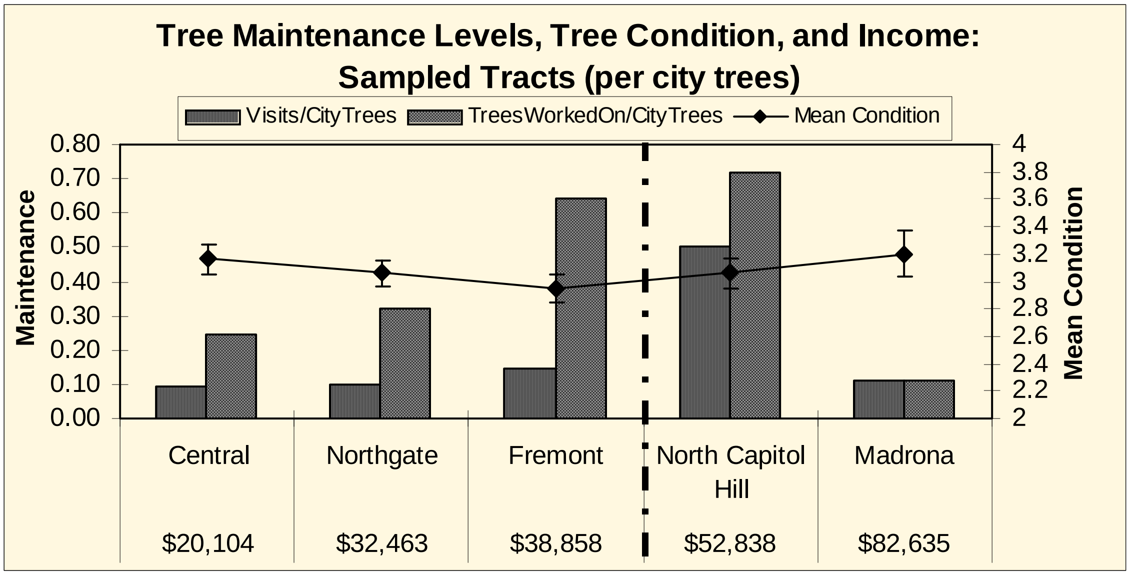

Figure 13. Tree maintenance (per total city trees): sampled tracts
Seward Park was excluded from the graph due the inadequate data

Tree Maintenance in Low and High-Income Areas

Similar to the results from each the six areas, the number of visits and number of trees worked on were higher in the low-income areas than the high-income areas (82 and 42 compared to 291 and 62), but the average condition did not significantly change. Table 9 also shows that the low-income areas have fewer trees than the high-income areas, but a greater proportion of city-maintained trees.

Table 9. Tree and work information for low and high-income areas

Income Group	Mean Condition	Hectares	Total trees	City trees	Trees/ha	Visits	Trees Worked On
Low	3.06	380.132	1607	743	4.2275	82	291
High	3.09	604.618	2500	227	4.1348	42	62

Table 10 shows this same information weighted by total trees. The low-income areas received 75.2% of the total visits and 88% of the total trees worked on, compared to the high-income areas which only received 24.8% and 12% respectively.

Table 10. Visits and trees worked on per total trees

Income Group	Visits per total trees	Percent	Trees Worked On per total trees	Percent
Low	0.0510	75.2%	0.1811	88.0%
High	0.0168	24.8%	0.0248	12.0%
Total		100.0%		100.0%

Figure 14, once again shows that the high-income areas received less overall tree care than the low-income areas, while average tree condition stayed relatively the same.

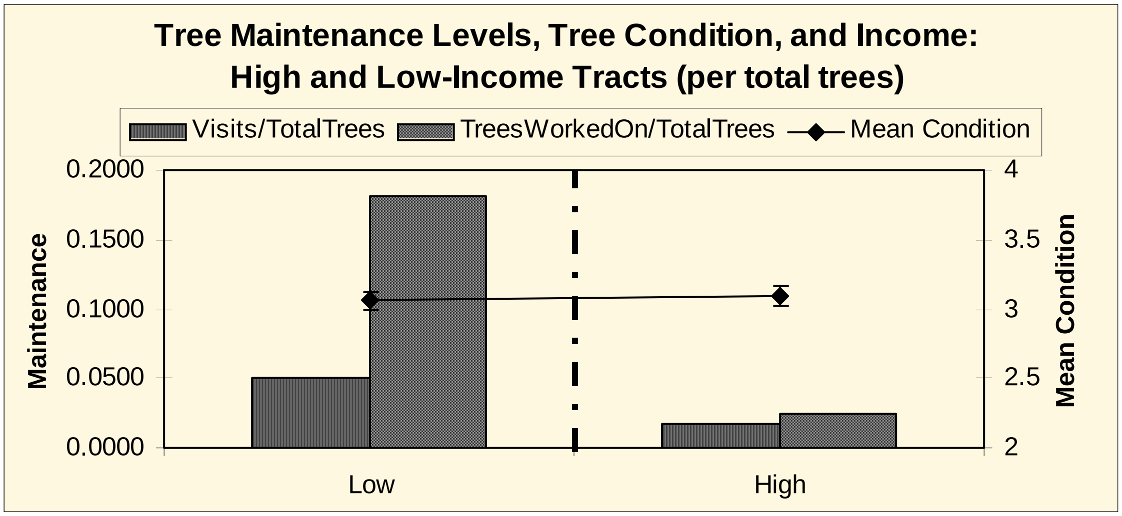

Figure 14. Tree maintenance (per total trees): high and low-income

Once again, a very different pattern emerged when the data was weighted by the number of city-maintained trees (Figure 15). The high-income areas received a greater percentage of visits than the low-income areas, and only a slightly lower number of trees worked on. The low-income areas received only 37.4% of all visits per city trees, compared to the high-income areas that received 62.6% of all visits. However, the low-income areas still received more trees worked on per city trees, 58.9%. Figure 15 shows the apparent increase of visits and trees worked on for the high-income areas when weighted by number of city trees in each area.

Table 11. Visits and trees worked on per City trees

Income Group	Visits per City Trees	Percent	Trees Worked On per City trees	Percent
Low	0.1104	37.4%	0.3917	58.9%
High	0.1850	62.6%	0.2731	41.1%
Total		100.0%		100.0%

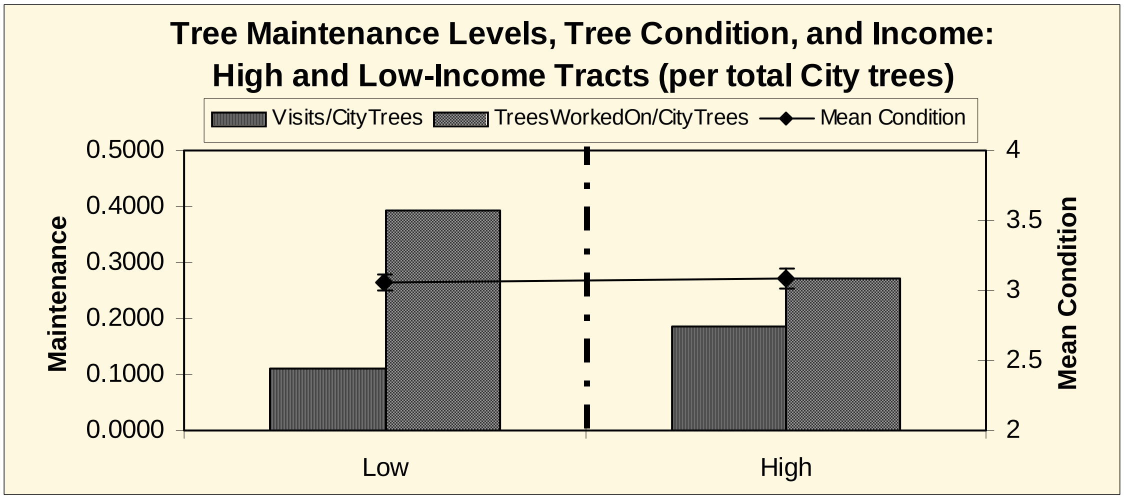

Figure 15. Tree maintenance (per total city trees): high and low-income

Visual Display of Tree Maintenance

Figure 16 displays tree maintenance patterns in the six tracts. Each "dot" represents an individual visit and the size of the dot is dependent on the number of trees worked on for the specific visit – the larger the dot, the more trees. As the map shows, the larger dots are much more frequent in the three low-income areas than the three high-income areas. Once again, this can be a valuable tool for urban forest managers to use when wanting to get an informational snapshot of where their tree maintenance efforts are being directed or patterns undetected on paper.

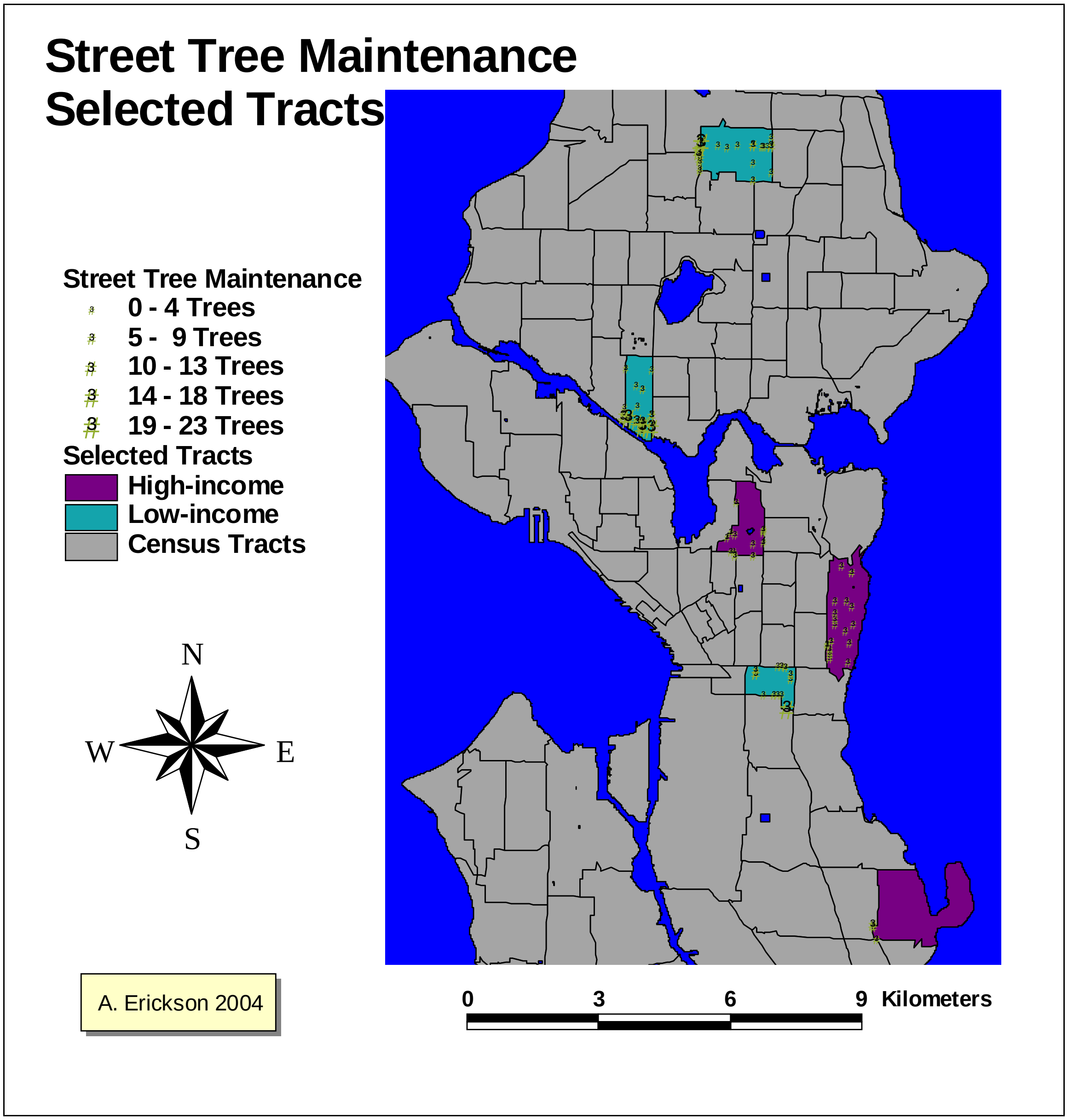

Figure 16. Map of tree maintenance

OTHER FACTORS

Table 12 shows the other factors, recorded during the tree condition assessment phase, which were compared to tree condition, income, and tree maintenance. The results from a general investigation into these additional factors that could be related to tree condition showed no other notable explanations for the relationships discussed earlier. A matrix was plotted in SPSS (Statistical Package for Social Science), and not patterns were detected that could provide alternative explanations for the assessed tree condition.

Table 12. Additional factors

Factor	Description
Genus	Eight most common genera
Tree location	Planting strip/sidewalk cutout
Planting strip type	Grass/mulch/soil
Planting strip width	Meters
Tree ownership	City/private

COMMUNITY PARTICIPATION: NEW SKILLS

It is beneficial for both the project and the participants to include community members in a project. The project gains the expertise and insight from members of the community, especially valuable when dealing with a resource as visible as street trees, as the participants learn new skills and can gain a sense of ownership and responsibility for the resource. The following quote is from one of the students who participated in the project and describes her newly found skill in tree identification and hints at a future sense of responsibility and care for urban trees.

> "Before I volunteered for this project to study the urban forest, I knew nothing about trees. I seriously could not tell a maple from an ash. In helping with this project, I learned to tell if a tree was actually healthy or not. To this day, I am still seeing trees and mentally noting their leaf color, visible damages, tumors, etc. I am beginning to notice the physical aspect and health as well as the beauty in trees."

Chapter 4: Discussion

This chapter will discuss the results from Chapter Three and provide explanations for the detected relationships between tree condition, income level, and tree maintenance. There is no single explanation for the equal levels of tree condition and the higher levels of tree maintenance in the low-income areas; rather, it is likely that different factors interact with each other to form the detected patterns – as with most events involving a number of players and circumstances. The diagram below, Figure 17, provides a visual tool to reference back to throughout the Chapter. The arrows represent the possible effect on tree condition (higher or lower) of each factor. For example, City tree maintenance results in an increased average tree condition, but the increase is higher in the low-income areas than the high-income areas.

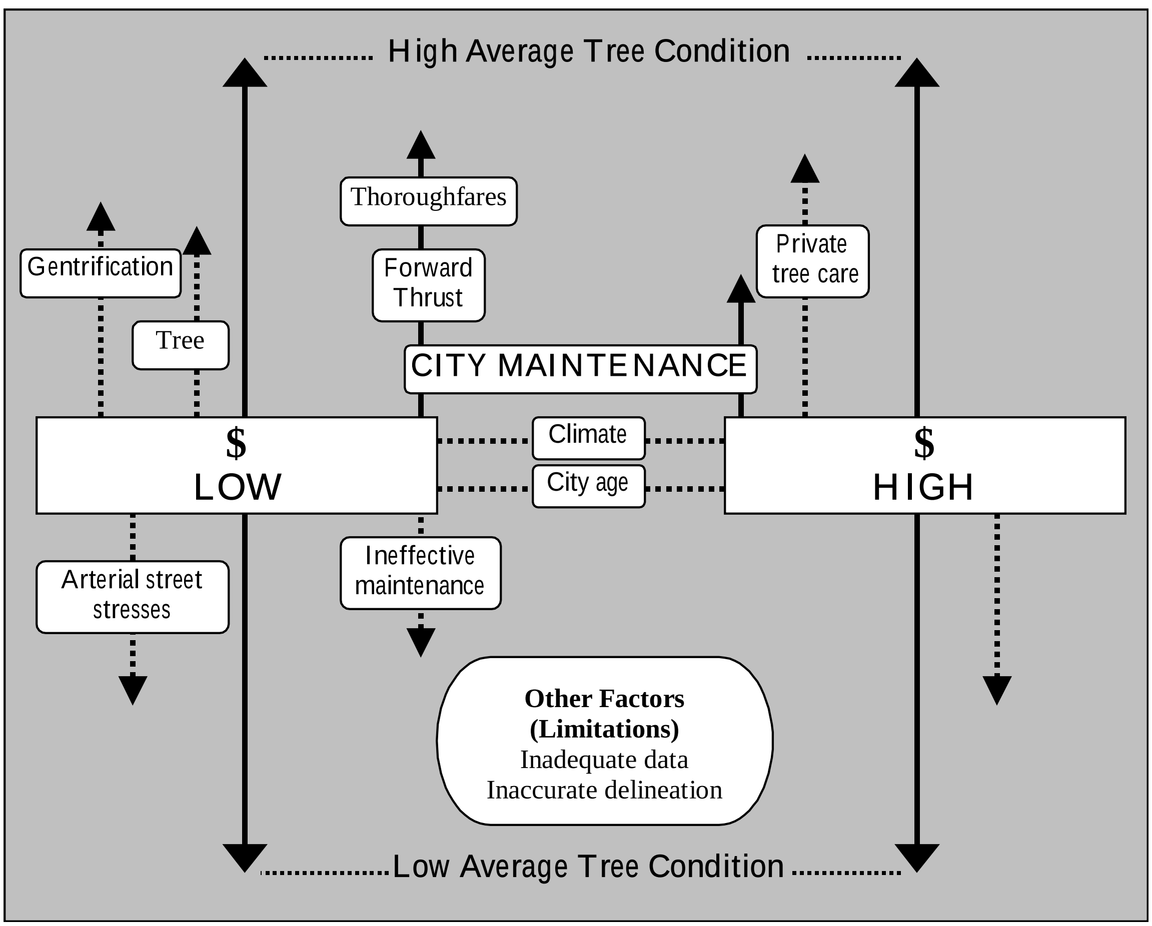

Figure 17. Factors affecting average tree condition between high and low-income areas

TREE CONDITION AND INCOME

There are a number of reasons why the relationship between condition and income, is not as hypothesized at the beginning of this project. The following section discusses some of the possible reasons for equal levels of tree condition shown from this study, such as tree age, city age, favorable climate, and inaccurate income boundaries.

Tree age

In the studied tracts, the youngest and oldest trees were typically in the worst condition. Out of all of the trees sampled, the higher-income areas had the majority of the oldest and youngest trees, while the lower-income areas had most of the mid-age trees, which were in noticeably better condition than both the young and old trees. It appears that the higher-income areas' conditions were influenced by the distribution of tree age and the presence of the majority of the young and old trees, while the lower-income areas had mostly mid-age trees. This distribution of tree age most likely resulted in a balancing of average tree condition between the high and low-income areas.

One of the higher-income tracts, North Capitol Hill, was significantly older than the other tracts and had a much more established street tree population. The older trees often had signs of major limb breakage, rotten trunks and branches, and many dead large branches. On the other hand, Seward Park, another higher-income tract, was mostly devoid of any substantial tree populations. It looked as if the neighborhood participated in a recent tree planting effort, but the young trees did not fare very well. Many of the newly planted trees were either planted incorrectly or not watered enough during those important first years of growth; the result being trees either already dead or quickly on their way to dying.

Compared to the higher-income tracts, the lower-income tracts had many more mid-size trees, in the 20-30 year range. These mid-size trees were often in better condition than the older or younger trees. Although many of the trees in Northgate had numerous swellings and other signs of distress, most of the trees in Fremont were growing in very small spaces, and the trees in the Central District were experiencing a large insect infestation, the overall average in the these tree low-income areas was similar to the higher-income areas.

City age

The argument was just made that the distribution of tree age may have caused the results to show that there was not a difference in average tree condition between the high and low-income areas. It could also be argued that since Seattle is a relatively young city, there is less of a range of tree age when compared to older cities in the Northeast and Midwest of the United States. With less range of tree age, there is more likely less range of tree condition.

Favorable climate

A third contributor to the apparent equal tree condition across the income groups may be that Seattle's trees are fortunate to have a favorable growing climate, and less stresses, than other cities. With a moderate weather pattern and infrequent to no freezing temperatures, hurricanes, and extreme heat, trees may not experience some of the same stresses that other city trees are faced with. Thus, tree condition may not differ across the entire city, as trees are growing fairly well, even with minimal maintenance and care.

Inaccurate delineation of neighborhood income level

Delineating income boundaries was a difficult and possibly imprecise procedure. Income data from the Census is not a 100% sample, but a representative sample of only part of the population. Although the selected census tracts were meant to be homogenous in income and race, they occasionally included areas that were distinctly different than neighboring blocks and households. This was most apparent in Seward Park, where part of a low-income area was grouped into a census tract designated high-income. This disparity may have resulted in inaccurate income delineation, and an incorrect comparison of tree condition between high and low-income areas.

Limiting factors

Lastly, it is possible that limitations of this study may have resulted in the insignificant difference in tree condition. Tree condition may have been assessed incorrectly, or with too much of a subjective measurement. The tree sample (204) may not have been large enough – this study could have benefited from a much larger tree sample. Or, the selected tracts may not have had distinct enough income levels; the results may have been very different if extreme (polar opposite) areas of income were used, rather than a range of high and low-incomes that was used in this project.

TREE MAINTENACE AND INCOME

The comparison of tree maintenance records between the different income areas showed that the low-income areas were receiving much more attention than the high-income areas. There are a variety of explanations for this occurrence, mainly that the low-income areas have most of the main thoroughfares in the Seattle, thus increasing the City's level of responsibility for those areas' street trees.

Thoroughfares

Many of the sampled trees in Fremont, Central District, and Northgate were located on main thoroughfares, which most likely garnered more attention from the City because of traffic clearance and safety issues as well as an increased chance of City ownership and responsibility. On the other hand, the higher-income areas were mainly small residential streets, with few main thoroughfares. It appeared that most of the street trees in the higher-income areas were selected and cared for by the home owners adjacent to the planting strip, rather than the City.

The fact that the lower-income areas have more main streets, and thus receive more tree maintenance, may be a different sort of environmental justice issue. During past transportation planning, it was common that lower-income and areas with ethnic minorities were displaced with major transportation corridors. It may have been difficult for these areas to resist the disruptive streets, due to lack of political clout and resources, but they now have public trees as compensations.

Forward Thrust

Between 1968 and 1978, Seattle experienced a rush of funding from a series of voter approved bonds called Forward Thrust; money was allotted for such things as neighborhood improvements, a new aquarium, park development and maintenance, and a large street tree planting effort in low-income and deteriorating neighborhoods. Thirty years later, many of these neighborhoods now have a substantial street tree population, all under the City's responsibility. This could be one explanation for the much larger proportion of City tree maintenance directed towards lower-income areas. The driving force for tree maintenance decisions could be a result of the Forward Thrust efforts, rather than neighborhood income levels. Coincidentally, the Central District is one of the neighborhoods that was slated for neighborhood improvements and had many trees planted in the 1970s.

Inadequate Data

Once again, the limitations of this study may have affected the results of the comparison between maintenance and income levels. Caution must be used when looking at the tree maintenance levels when weighted by City maintained trees. Although it would be useful to see how many visits an area received in proportion to the number of trees the City is responsible for, Seward Park was an example of when there was inadequate data to conduct robust analysis. Seward Park only showed a handful of City owned trees and had a total of two visits from the City, showing that close to 100% of the visits were in this area. When compared with an area with 100 City trees and 50 visits, (only 50% of the trees visited), it looks as if Seward Park is receiving more care – when in fact this is not the case.

Gentrification

One final explanation of the difference in tree maintenance between the high and low-income areas is the possibility that Seattle's recent and rapid gentrification of many low-income areas has resulted in more attention in these low-income areas. The high levels of renewal action may be attracting (or even demanding) more City attention to deal with increased citizen efficacy in communicating public needs and requests.

TREE CONDITION AND MAINTENANCE

If the theory is correct that better maintained trees are in better condition, then there should be a positive relationship between maintenance and condition. However, this research found that as maintenance increased among the six areas, average tree condition stayed relatively the same.

Climate

As discussed earlier, the Pacific Northwest's moderate climate makes for excellent growing conditions – and a possible reason why tree maintenance does not necessarily affect tree condition. Seattle's street trees may not need as much maintenance as in other parts of the country due to the favorable climate and lack of stresses like frequent ice storms, freezing weather, long droughts, and hurricanes. This does not imply that tree maintenance is not necessary in Seattle; on the contrary, tree maintenance is crucial to extending the life of many of the young trees as well as maintaining a safe and hazard-free tree population.

Ineffective maintenance

Another explanation is that the City tree crew's current level of maintenance may not be making a measurable difference in average tree condition in the sampled tracts. As alluded to in Chapter 1, the City's urban forestry program is operating mainly with a "crisis management" approach. The lack of routine pruning and scheduled maintenance may be taking care of the hazards and major street tree problems, but may not contribute to a general increase of tree condition in the areas served by the City.

Stresses from arterial streets

Reflecting on the fact that the low-income areas have more thoroughfares than the high-income areas, it could be possible that the trees in the low-income areas are experiencing an increase in the amount of stresses, such as air pollution, damage from traffic, and vandalism, from the main arterials. The effect of these stresses could be lowering the average tree condition, but when complemented with the higher levels of tree maintenance, average tree condition is equal between high and low-income areas.

Private tree care

The most compelling possibility for the equal tree condition yet different levels of tree maintenance between the low and high-income areas is that the residents of the higher-income areas are supplementing street tree maintenance with either their own tree care or by hiring private arborists or tree care companies. This additional tree maintenance could be resulting in an equaling of total tree maintenance between the two income areas – and a balancing of average tree condition.

COMMUNTIY PARTICIPATION: SURVEY RESULTS

After six weeks of gathering street tree condition information, and observing patterns of tree care and condition, the assessment team contemplated that one possibility in the undetected difference in tree condition was that the trees in the higher-income areas were displaying evidence of more routine tree care from what appeared to be the residents of the adjacent property. Interested in if this thought was accurate, the students carried out a small survey of residents' tree care habits and awareness of ownership and responsibility of the street trees in front of their homes, apartment buildings, or - if a storeowner - businesses.

The students designed a short survey (designed to take only a few minutes to complete), two poster boards, and a three-fold pamphlet to use for attracting participants and promoting tree care and knowledge. The poster boards described the project's goals and methods and provided information about common tree problems in Seattle, while the pamphlet contained a wealth of information for citizens to learn about tree problems to look for, important tree care steps (such as watering young trees, not walking on the roots, and not topping trees), and who to contact with questions or references about the trees on their street.

Two neighborhoods were chosen to carry-out the survey – Madrona and the Central District. One weekday- and one weekend-day, the poster boards, and a small table, were set up in front of a store and coffee shop–areas in the neighborhoods thought to have substantial pedestrian traffic. Armed with clipboards and pamphlets, the students asked passerbys to participate in a short survey regarding street trees. After determining if the participants were residents of the neighborhood (by showing a map of the area), the students asked a series of questions relating to tree care habits and awareness levels. Approximately fifty surveys were completed between the two areas, about thirty in Madrona and twenty in the Central District. A copy of the survey is located in Appendix C and the pamphlet is shown in Appendix D.

Results from the survey were interesting, and confirmed the assessment team's belief that the higher-income neighborhoods had more people who (1) either maintained the tree in front of their home or hired someone to maintain the tree and (2) were aware that there even were street trees in front of their homes. Survey participants in the lower-income areas, rarely answered that they cared for the trees or hired outside services. However, residents from neither neighborhood were aware of who was actually responsible for the street trees. Some assumed it was the city, some assumed it was the utility company, some assumed it was their apartment managers, and just a handful thought it was their responsibility.

The general findings from this exploratory survey were helpful for the students to begin to understand what other factors may be contributing to tree condition across Seattle. It was incredibly worthwhile to speak with residents about street trees and to share the information the students' learned with fellow Seattleites. Although no scientifically viable conclusion can be drawn from this endeavor, it was an excellent method of basic survey administration and how best to garner attention from residents. Additionally, valuable information about tree care and tree benefits was passed along to residents of the two neighborhoods, increasing the chance of people taking responsibility for their urban tree resource. One resident was gracious enough to e-mail the group that he went and found out who was responsible for the trees in front of his home and was setting up a time with the City Arborist to come and look at some problems he had noticed.

DELIVERY OF SERVICES: EQUALITY VERSUS EQUITY

Referring back to the short literature review in Chapter 1 of urban service delivery as it relates to urban forestry issues, the results of this project can be summed up as a comparison between the input, street tree maintenance, and the output, average tree condition. By measuring the input and output, a general conclusion can be drawn about the service delivery pattern, specifically if it is either equal or equitable.

Input: Maintenance

The results clearly show that the input, tree maintenance, is not equal between the low and high-income areas. The low-income areas received as much as 60% more of the City tree maintenance between 1999 and 2002 than the high-income areas. As discussed in the previous section, there are numerous reasons why this might be happening, but there is still no doubt that more of the City tree crew's efforts are being directed towards the low-income areas.

Output: Condition

The results of the tree condition assessment are not as clear or distinct as the maintenance data. Nevertheless, it can be concluded that in the scope of this project, average tree condition was not different between the high and low-income areas. Therefore, it can be stated that the output, tree condition, is distributed equally between the different areas and is not related to income.

Relationship between Input and Output

Whatever the reasons may be for the disproportionate amount of tree maintenance between the high and low-income areas, the end result is a pattern of equal distribution of the benefits from the street trees (since the trees are in equal conditions). Thus, it can be concluded that the current levels of tree maintenance is equitable; the input is unequal, but the output is equal. This inequality in the input causing equality in the output is an example of a "compensatory" service delivery pattern. Thus, the City can be reassured that they are not directing their efforts towards higher-income areas, as the hypotheses stated. Their current distribution of tree maintenance is appropriate to ensure equal levels of tree condition across the city.

Chapter 5: Conclusion

SUMMARY

This project's goal was to investigate the relationships between street tree condition, income, and tree maintenance. It was determined that the relationship between tree condition and income followed neither a positive nor negative direction; tree condition was relatively the same between high and low-income areas. Nevertheless, the relationship between tree maintenance and income followed a very different pattern; much more maintenance was being directed towards the low-income areas than the high-income areas. In the end, it was concluded that although tree maintenance was unequal across the income levels, overall tree condition was equal – a desirable condition if the City of Seattle wants to maintain equal distribution of the benefits provided by urban trees. The goal of including members of the local community was a huge success. The students gained valuable skills in data collection and management, scientific exploration, and the vast field of urban forestry. The research gained the perspective of non-experts and the people who interact with the urban tree resource most often – local citizens. Finally, by incorporating theories and ideas form service delivery and environmental justice fields, it is hoped that this research can expand the urban forestry literature into new realms.

IMPLICATIONS

The results from this project expanded beyond the three hypotheses. A variety of topics were discussed in the previous chapter; how the City of Seattle, or other interested parties, chooses to use the information presented in this thesis depends on their ultimate objectives. Briefly discussed in this next section are thoughts on how these findings related to the larger context of urban forest management, particularly in respect to Seattle.

Continued urban forestry efforts

There should be a continued effort on the part of the urban forestry divisions to have local neighborhoods plant and care for their trees, since the people in the high-income areas may be making up for the lack of tree care provided to them because of the current tree ordinance rules. Additionally, when Seattle's large population of older trees begin failing, the City's tree crew may shift some of their work to the high-income areas, which may cause tree condition to drop in the low-income neighborhoods (since there will be less maintenance in those areas).

The greater urban forest

This study only looked at the street trees, and did not include the larger urban forest – trees in backyards, front yards, parks, and greenways. These trees tend to provide greater levels of benefits than street trees since there are less maintenance costs associated with more growing space and less infrastructure problems. In order to accurately assess the distribution of benefits provided by the entire urban forest resource, it would be necessary to include the abovementioned trees. However, this does not mean that attention toward street trees should be diminished. In a city like Seattle, with extensive vegetation in back yards and parks, the street trees still provide a valuable resource.

Public policy

Urban forests can be a good avenue for public policy. In the reviewed literature, there appeared to be a wealth of references and research relating to urban parks when discussing delivery of urban services and public resources. However, there was not nearly as much information about urban trees outside of parks, especially street trees. It would be beneficial to continue expanding the urban forestry literature into the public policy arena. The substantial work being developed on benefits and costs of urban forests, by the Center for Urban Forest Research in Davis, California, is an excellent example of information that can be used as an effective tool to discuss urban policy and budget issues.

FUTURE RESEARCH

As with many research projects, many lessons can be learned and much can be improved upon this project. As discussed earlier, this project had its limitations: a small data sample, possible inaccurate income delineations, lack of the extreme income groups, and no information regarding soil quality. Many of these limitations were unavoidable with the short time available, while the rest were unknown until after the research was completed.

In the future, a more in-depth comparison of high and low-income areas would be useful. Rather than relying solely on Median Household Income, a more accurate calculation of neighborhood income levels could be obtained from household interviews or estimating "actual" income by including number of members in the household, annual income per person rather than household, and additional information from the Census.

Additionally, a look at the extreme areas of income – the poorest and the wealthiest - would be beneficial. This study used a range of income, with the intention of investigating for a positive relationship between tree condition and increasing levels of income. A more extreme look would allow for a more accurate testing of the difference between high and low, rather than a range of income.

Finally, it would be interesting to expand on the short survey. While reviewing the literature, it was surprising that there was not more hard data surrounding the subject of tree care. There appeared to be anecdotal evidence and any assumptions that higher-income neighborhoods were more often involved in community tree care programs (and more often targeted by those programs), yet there was little information that actually tracked residents' levels of tree care activities. This information would be valuable for community tree care programs and could aid in deciding what neighborhoods should be targeted for increased educational and training opportunities in future tree management endeavors.

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<u>Geospatial Data</u>

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Appendix A: Seattle Census Tract Information

Table 13. Census tract information

Tract 2000	MHI 2000	Tract 1990	MHI 1990 (in2000Real$)	Percent change in MHI from 1990-2000	Income Group	Notes
000100	$31,980	000100	$31,333	2.06%	Low-income	
000200	$43,470	000200	$41,364	5.09%	Low-income	
000300	$45,108	000300	$39,924	12.98%	Low-income	
000401	$28,821	000400	$34,794	-17.17%	Low-income	
000402	$42,444	000400		0.00%	Low-income	
000500	$71,983	000500	$68,147	5.63%	High-income	
000600	$42,938	000600	$39,954	7.47%	Low-income	
000600	$42,938	000600	$39,954	7.47%	Low-income	
000700	$36,080	000700	$37,270	-3.19%	Low-income	
000800	$59,000	000800	$48,202	22.40%	High-income	
000900	$81,118	000900	$70,501	15.06%	High-income	
001000	$50,536	001000	$51,163	-1.23%	High-income	
001100	$54,776	001100	$47,290	15.83%	High-income	
001200	$32,463	001200	$31,390	3.42%	Low-income	Northgate
001300	$32,983	001300	$32,844	0.42%	Low-income	
001400	$46,022	001400	$42,341	8.69%	High-income	
001500	$63,207	001500	$61,215	3.25%	High-income	
001600	$61,329	001600	$56,796	7.98%	High-income	
001700	$42,436	001700	$34,482	23.07%	Low-income	
001800	$41,941	001800	$37,088	13.09%	Low-income	
001900	$51,760	001900	$47,436	9.12%	High-income	
002000	$50,351	002000	$45,145	11.53%	High-income	
002100	$50,284	002100	$46,772	7.51%	High-income	
002200	$68,450	002200	$66,229	3.35%	High-income	
002400	$62,784	002400	$48,655	29.04%	High-income	
002500	$57,778	002500	$53,833	7.33%	High-income	
002600	$66,066	002600	$54,422	21.40%	High-income	
002700	$63,952	002700	$45,410	40.83%	High-income	
002800	$58,446	002800	$39,648	47.41%	Excluded	%ChangeHigh
002900	$62,150	002900	$42,095	47.64%	Excluded	%ChangeHigh
003000	$57,116	003000	$44,914	27.17%	High-income	
003100	$56,580	003100	$48,423	16.85%	High-income	
003200	$46,366	003200	$39,017	18.84%	High-income	
003300	$43,934	003300	$36,259	21.17%	Low-income	
003400	$55,885	003400	$42,921	30.20%	High-income	
003500	$56,000	003500	$48,851	14.63%	High-income	
003600	$47,547	003600	$33,942	40.08%	High-income	
003800	$59,432	003800	$50,410	17.90%	High-income	
003900	$58,114	003900	$54,429	6.77%	High-income	

Table 13 ContInued						
004000	$54,833	004000		0.00%	High-income	
004100	$81,866	004100	$68,692	19.18%	High-income	
004200	$65,136	004200	$51,933	25.42%	High-income	
004300	$30,516	004300	$28,988	5.27%	Low-income	
004400	$40,984	004400	$29,678	38.10%	Low-income	
004500	$68,300	004500	$44,879	52.19%	Excluded	%ChangeHigh
004600	$62,159	004600	$50,358	23.43%	High-income	
004700	$34,667	004700	$25,570	35.58%	Low-income	
004800	$53,948	004800	$44,449	21.37%	High-income	
004900	$38,858	004900	$31,336	24.00%	Low-income	Fremont
005000	$45,826	005000	$37,236	23.07%	Low-income	
005100	$61,995	005100	$48,084	28.93%	High-income	
005200	$37,816	005200	$28,797	31.32%	Low-income	
005301	$17,437	005300	$14,953	16.61%	Low-income	
005302	$31,607	005300	$13,320	137.29%	Excluded	%ChangeHigh
005400	$49,451	005400	$39,088	26.51%	High-income	
005600	$87,578	005600	$77,035	13.69%	High-income	
005700	$60,410	005700	$50,661	19.24%	High-income	
005801	$48,906	005800	$41,859	16.84%	High-income	
005802	$47,021	005800	$43,111	9.07%	High-income	
005900	$59,070	005900	$51,205	15.36%	High-income	
006000	$59,127	006000	$48,241	22.57%	High-income	
006100	$53,995	006100	$44,038	22.61%	High-income	
006200	$101,319	006200	$73,141	38.53%	High-income	
006300	$75,034	006300	$59,472	26.17%	High-income	
006400	$88,834	006400	$70,092	26.74%	High-income	
006500	$52,838	006500	$38,817	36.12%	High-income	North Capitol Hill
006600	$47,440	006600	$41,796	13.50%	High-income	
006700	$54,115	006700	$42,161	28.35%	High-income	
006800	$69,440	006800	$41,806	66.10%	Excluded	%ChangeHigh
006900	$61,540	006900	$45,752	34.51%	High-income	
007000	$40,531	007000	$30,543	32.70%	Low-income	
007100	$35,659	007100	$23,906	49.16%	Excluded	%ChangeHigh
007200	$27,462	007200	$20,419	34.49%	Excluded	Non-resident
007300	$21,605	007300	$13,350	61.84%	Excluded	%Change & Non-resident
007400	$32,389	007400	$25,079	29.15%	Low-income	
007500	$31,233	007500	$23,996	30.16%	Low-income	
007600	$37,534	007600	$29,456	27.42%	Low-income	
007700	$44,894	007700	$31,883	40.81%	Low-income	
007800	$82,635	007800	$64,966	27.20%	High-income	Madrona
007900	$30,417	007900	$25,244	20.49%	Low-income	
008001	$38,361	008000	$20,041	91.41%	Excluded	%Change & Non-resident

Table 13 Continued

008002	$28,949	008000		0.00%	Excluded	Non-resident
008100	$23,404	008100	$11,581	102.09%	Excluded	%Change & Non-resident
008200	$30,625	008200	$19,789	54.76%	Excluded	%Change & Non-resident
008300	$30,671	008300	$28,208	8.73%	Low-income	
008400	$25,821	008400	$21,343	20.98%	Low-income	
008500	$16,760	008500	$11,729	42.89%	Low-income	
008600	$21,659	008600	$16,553	30.85%	Low-income	
008700	$31,917	008700	$21,030	51.77%	Excluded	%ChangeHigh
008800	$39,514	008800	$33,656	17.41%	Low-income	
008900	$47,431	008900	$38,130	24.39%	High-income	
009000	$20,104	009000	$18,817	6.84%	Low-income	Central District
009100	$13,057	009100	$7,856	66.20%	Excluded	%ChangeHigh
009200	$11,265	009200	$8,694	29.57%	Excluded	Non-resident
009300	$42,208	009300	$34,256	23.21%	Excluded	Non-resident
009400	$34,382	009400	$32,760	4.95%	Low-income	
009500	$53,447	009500	$40,839	30.87%	High-income	
009600	$60,245	009600	$49,369	22.03%	High-income	
009701	$61,582	009700	$48,993	25.70%	High-income	
009702	$62,557	009700		0.00%	High-income	
009800	$57,703	009800	$43,416	32.91%	High-income	
009900	$46,684	009900	$43,472	7.39%	High-income	
010000	$37,122	010000	$33,310	11.44%	Low-income	
010100	$47,926	010100	$34,333	39.59%	High-income	
010200	$60,125	010200	$50,711	18.56%	High-income	Seward Park
010300	$39,554	010300	$26,065	51.75%	Excluded	%ChangeHigh
010400	$48,697	010400	$41,713	16.74%	High-income	
010500	$43,872	010500	$40,154	9.26%	Low-income	
010600	$54,583	010600	$42,769	27.62%	High-income	
010700	$27,574	010700	$22,916	20.33%	Low-income	
010800	$53,198	010800	$40,888	30.11%	High-income	
010900	$33,654	010900	$27,698	21.50%	Low-income	
011000	$36,754	011000	$20,949	75.45%	Excluded	%ChangeHigh
011101	$40,293	011100		0.00%	Low-income	
011102	$43,917	011100		0.00%	Low-income	
011200	$30,917	011200	$27,005	14.49%	Low-income	
011300	$46,838	011300	$42,999	8.93%	High-income	
011400	$36,849	011400	$36,610	0.65%	Low-income	
011500	$51,132	011500	$43,042	18.80%	High-income	
011600	$61,340	011600	$52,179	17.56%	High-income	
011700	$47,621	011700	$44,354	7.37%	High-income	
011800	$40,592	011800	$33,688	20.49%	Low-income	
011900	$50,091	011900	$46,248	8.31%	High-income	

Table 13 Continued						
012000	$55,735	012000	$43,773	27.33%	High-income	
012100	$67,875	012100	$57,964	17.10%	High-income	
026500	$16,285	026500	$14,763	10.31%	Low-income	

Appendix B: Tree Maintenance in Seattle

Table 14. Street tree maintenance 1998-2002: counts

Street Tree Maintenance (Counts)		YEAR											
		1998		1999		2000		2001		2002		Grand Total	
		Visits	Trees	*Visits*	Trees	*Visits*	Trees	*Visits*	Trees	*Visits*	Trees	*Visits*	Trees
MAINTENANCE TYPE	Branch removal	*12*	12	*27*	27	*18*	19	*28*	28	*22*	23	*107*	109
	Clear	*7*	23	*24*	45	*36*	26	*46*	54	*38*	109	*151*	257
	Miscellaneous	*2*	7	*4*	13	*2*	2	*5*	6	*3*	7	*16*	35
	Pruning	*16*	139	*59*	264	*28*	82	*13*	53	*36*	101	*152*	639
	Pruning request	*32*	105	*70*	200	*84*	291	*114*	486	*101*	444	*401*	1526
	Routine pruning	*8*	75	*1*	4	*41*	504	*33*	677	*26*	434	*109*	1694
	Tree removal	*13*	18	*84*	128	*57*	78	*84*	139	*59*	92	*297*	455
	Grand Total	*90*	379	*269*	681	*266*	1002	*323*	1443	*285*	1210	*1233*	4715

Table 15. Street tree maintenance 1998-2002: frequencies

Street Tree Maintenance (Frequencies)		YEAR											
		1998		1999		2000		2001		2002		Grand Total	
		Visits	Trees	*Visits*	Trees	*Visits*	Trees	*Visits*	Trees	*Visits*	Trees	*Visits*	Trees
MAINTENANCE TYPE	Branch removal	*13%*	3%	*10%*	4%	*7%*	2%	*9%*	2%	*8%*	2%	*9%*	2%
	Clear	*8%*	6%	*9%*	7%	*14%*	3%	*14%*	4%	*13%*	9%	*12%*	5%
	Miscellaneous	*2%*	2%	*1%*	2%	*1%*	0%	*2%*	0%	*1%*	1%	*1%*	1%
	Pruning	*18%*	37%	*22%*	39%	*11%*	8%	*4%*	4%	*13%*	8%	*12%*	14%
	Pruning request	*36%*	28%	*26%*	29%	*32%*	29%	*35%*	34%	*35%*	37%	*33%*	32%
	Routine pruning	*9%*	20%	*0%*	1%	*15%*	50%	*10%*	47%	*9%*	36%	*9%*	36%
	Tree removal	*14%*	5%	*31%*	19%	*21%*	8%	*26%*	10%	*21%*	8%	*24%*	10%
	Grand Total	*100%*	100%	*100%*	100%	*100%*	100%	*100%*	100%	*100%*	100%	*100%*	100%

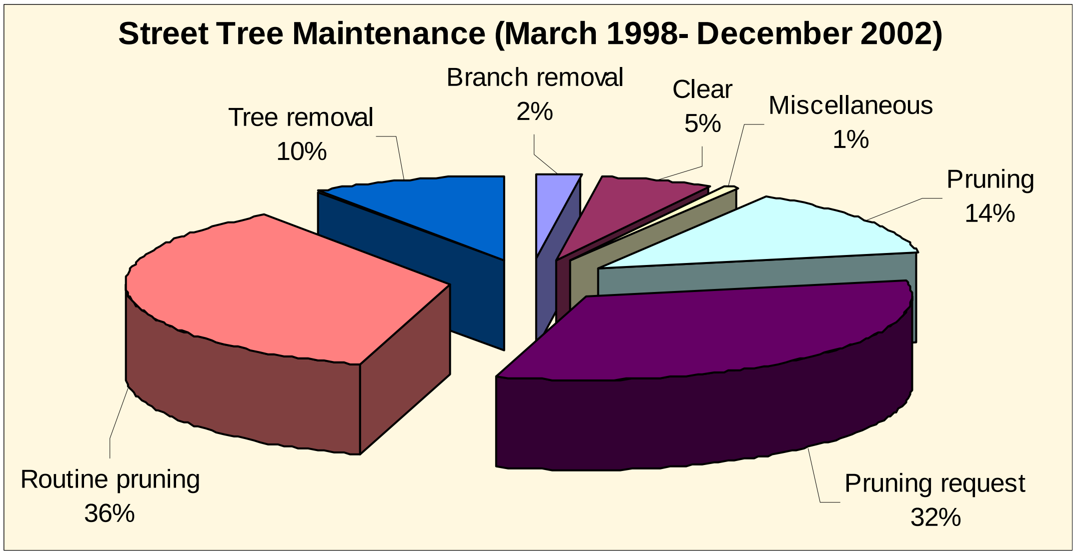

Figure 18. Citywide street tree maintenance

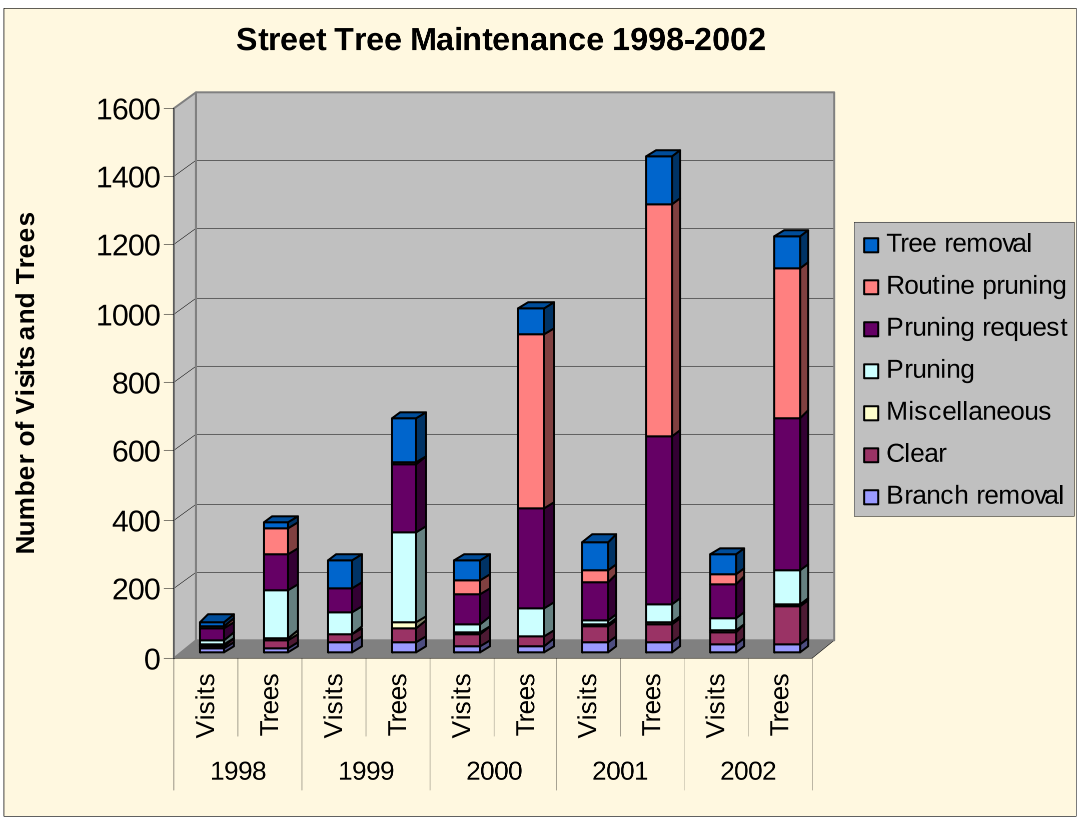

Figure 19. Citywide street tree maintenance by year

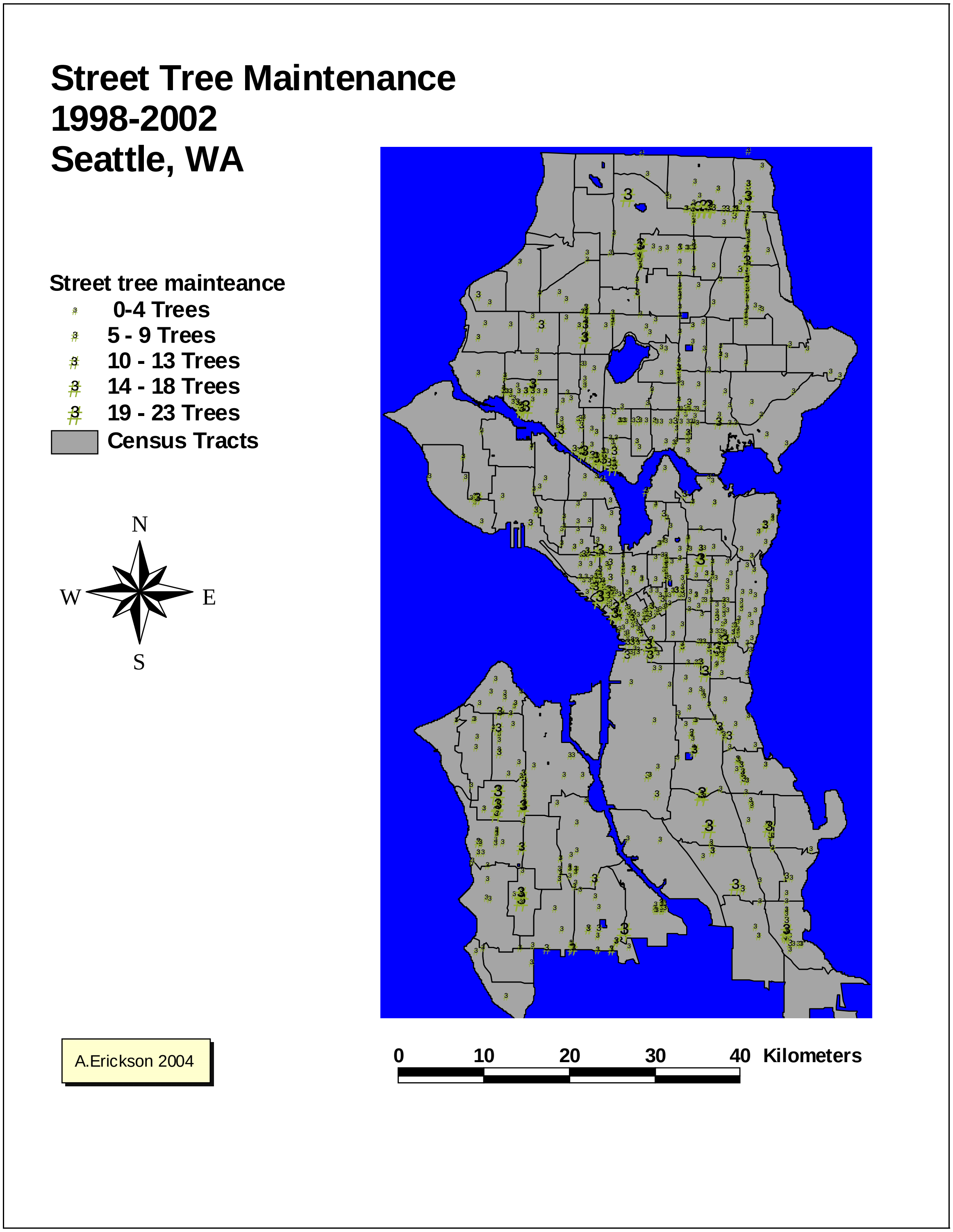

Figure 20. Map of citywide street tree maintenance

Appendix C: Survey

Do you live in this area? Yes ☐ OR Do you own a business in this area? Yes ☐

Show a map of the neighborhood and have them mark or circle, generally, where they live or own a business.

Do you have a tree (or trees) in the parking strip in front of your home/business?

Yes ☐ How many? ________

No ☐

Do you know what kind of tree you have?

Show a list and pictures of commonly planted trees in the neighborhood

Yes ☐ What kind? ____________________

No ☐

How old (or young) is the tree? ____________

How big (or small) is the tree? ____________

Did you plant the tree or was it there when you moved there?

Planted ☐ How long ago did you plant it? ________

Moved ☐ How long ago did you move there? ________

Do you take care of the tree? Yes ☐ No ☐

Does someone else take care of the tree?

Yes ☐ Who? ____________________

No ☐

Do you know if the tree is your responsibility or who's responsibility it is?

Yes ☐ Who? ____________________

No ☐

Do you water your tree?

Yes ☐ How often and when? ____________________

No ☐

Do you prune it? Yes ☐ No ☐

Do you look for and remove insects from the tree(s)? Yes ☐ No ☐

Do you walk on or around the roots of the tree(s)? Yes ☐ No ☐

Do you re-soil or ever apply mulch to the base of the tree? Yes ☐ No ☐

Do you own or rent your home? Rent ☐ Own ☐
Do you live in a house or an apartment? House ☐ Apartment ☐ Other ☐

Appendix D: Pamphlet

FAQ

Frequently Asked Questions

- What kind of tree do I have? Go to: http://www.oplin.lib.oh.us/products/tree/
- Why is a tree of importance to me? They provide shade, shelter for animals, and oxygen. Plus, they are attractive and increase your home's value.
- How can I prune my tree correctly? Go to: http://www.pnwisa.org/tree-care.html or contact the City Arborist Office at http://www.cityofseattle.net/transportation/treeplanting.htm
- How can I plant more trees in my neighborhood and care for the ones I have? Go to: http://www.cityofseattle.net/environment/urban_forest.htm or http://www.pnwisa.org/tree-care.html or http://www.cityofseattle.net/transportation/treeplanting.htm or http://www.cityofseattle.net/neighborhoods/nmf/treefund.htm

Who's involved in the Urban Forest Project?

Northwest School:
Catherine Wilson
Mackenzie Brown
The Center School:
Emily Alli
Kimiko Utsunomiya
Lauren Overman
Witney Lonseth
University of Washington:
Ara Erickson

Urban Forest Project

Tree Care Pamphlet

What is the Urban Forest Project?

The Urban Forest Project (UFP) exists to randomly select city trees and check their health/condition.

The UFP wants you to have this pamphlet so you can keep your trees healthy.

Problems

that may occur with your tree

Roots: May wrap around tree or grow out of the ground as shown.

Trunk: May have sprouts, holes, pruning injuries, twisting, or multiple trunks as shown.

Scaffold & Small Branches: May have injuries, be growing wrong, or be dead.

Foliage: May have insects, holes, spots, or discoloration as shown.

Solutions

Roots: Avoid walking or driving over roots. Protect roots out of the ground by adding more soil around the tree. Don't forget to water the tree!

Trunk: Avoid hitting trunk with cars or other objects. Make sure pruning is done correctly (see FAQ for more information). Do not spray paint on any injuries. Prune sprouts on trunk (below) to keep the tree from putting its energy there instead of other branches.

Scaffold & Small Branches: Prune dead branches correctly (see FAQ for more information). Avoid hitting any branches with cars or other objects.

Foliage: Avoid wilting and insects by watering trees regularly and consulting an arborist (see FAQ for more information). To avoid insects and diseases don't top your tree!

Example Trees

Healthy trunk & branches:

Healthy foliage:

Please keep your trees healthy!