

# **EQUITY IN URBAN FOREST MANAGEMENT**

**An assessment of street tree condition, maintenance, and neighborhood income levels in Seattle, Washington**

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**Final Report for the U.S. Community Forestry Research Fellowship**

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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 (Anderson and Cordell 1985, Kuo and Sullivan 2001, Kuo et al. 1998, McPherson and Rowntree 1993, McPherson et al. 1997, 2002, Nowak 1993, Nowak et al. 1998, Rowntree and Nowak 1991, Sanders 1986, Wolf 2003). These benefits greatly enhance a neighborhood's social, ecological, and economic well being (Dwyer et al. 1992, Kaplan 1993, Ulrich 1984, 1986). 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 (Nowak 1991, Talarchek 1990, Welch 1991). 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 (Grey and Denke 1986).

## **Research Problem and Goals**

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 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 high-school students' involvement in this project benefited both the research and the sustainability of Seattle's urban forest.

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 1 shows the initial flyer that was used to attract students to the project. After a handful of visits and organizational meeting, 6 students committed to work on the project for the duration of the summer—after an initial interest of 46 students.

## 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.**

**S**eattle'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.



Figure 1. Recruitment flyer

## HYPOTHESES

The questions posed below 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?

## Research Methods

### SITE AND SAMPLE SELECTION

Census information, from both 1990 and 2000, were combined and synchronized to classify Seattle’s high- and low-income census tracts. The City of Seattle’s GIS-based Street Tree Inventory, 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’s database includes more than 75,000 street trees, and 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 high school students were not fully involved in the project until this point. Since the school year was still in session, there was limited time to participate; however, two lunch break open sessions took place, where students brainstormed about why the research could be considered a social justice issue, some hypotheses about why tree condition might differ between neighborhoods, and the benefit of their involvement.

At the start of the summer, some of the students gathered in a campus computer laboratory and took their first plunge into the research pool. Using credible statistical methods, the students systematically chose 6 random census tracts from the 108 acceptable tracts in the city— 3 of each income group. A creative process of using birthdays, parents addresses, and favorite numbers allowed the students to see the importance of proper research design as well as enjoy the often boring statistical process.

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 were matched with the following neighborhoods, from lowest income to highest income: the Central District, Fremont, Northgate, North Capitol Hill, Seward Park, and Madrona areas (shown in Figure 2).

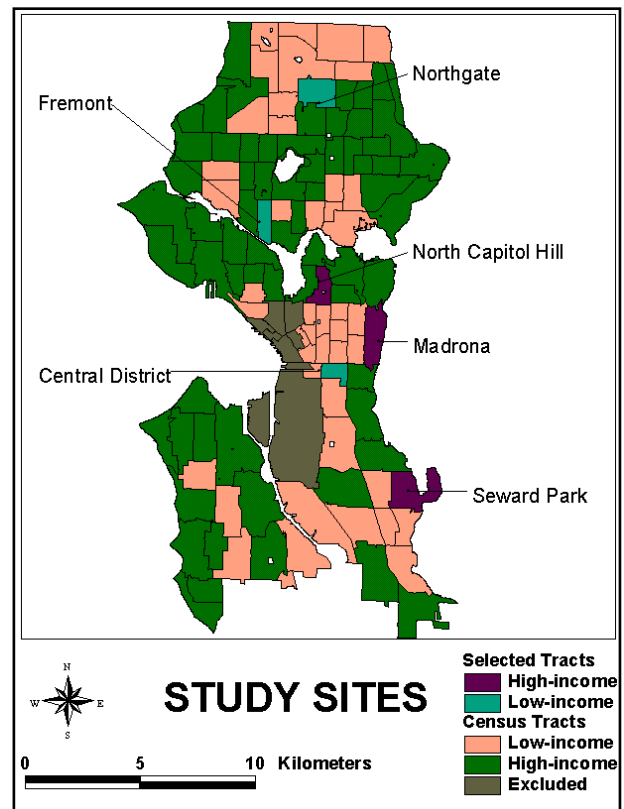


Figure 2. Map of study sites

Having close to 500 different tree species, Seattle’s streets are no exceptions to the diversity of the city’s natural landscape. Given the enormous task of training the high-school students in individual tree identification and condition assessment, 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.

Using ArcView, the tree inventory 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 and that fell within the six selected tracts, resulting in a total of 4107 trees. Systematic random sampling was used to select 40 trees from each of the six tracts, for a total tree sample of 240. A small group of the high school students were involved throughout this step, learning some basic GIS and database management skills.

### TREE CONDITION ASSESSMENT

The tree condition assessment used for this research separates a tree into five factors: roots, trunk, scaffolding branches, smaller branches and twigs, and foliage (Council of Tree and Landscape Appraisers 1983). When assessing the condition of a tree, each factor is looked at separately; using the characteristics in Figure 3 as guidance, and each factor is assigned a score based on if the characteristics present are positive or negative. The following scores match the level of problems (or lack of problems) associate with each score: 1 = extreme problem, 2 = major problem, 3 = minor problem, and 4 = no apparent problem.

**Table 1. Tree condition categories**

Sum of Five Factors	Condition Category	Condition Number	Characteristics
5-8	Dead or Dying	1	<ul style="list-style-type: none"> <li>▪ Dead, or death imminent, from disease or other causes</li> </ul>
9-12	Poor	2	<ul style="list-style-type: none"> <li>▪ General state of decline</li> <li>▪ May show severe mechanical, insect, or disease damage, but death not imminent</li> <li>▪ May require major repair or renovation</li> </ul>
13-16	Fair	3	<ul style="list-style-type: none"> <li>▪ Average condition and vigor for area</li> <li>▪ May need corrective pruning or repair</li> <li>▪ May lack desirable form characteristic of species</li> <li>▪ May show minor insect injury, disease, or physiological problem</li> </ul>
17-20	Good	4	<ul style="list-style-type: none"> <li>▪ Healthy vigorous tree</li> <li>▪ No signs of insect, disease, or mechanical injury</li> <li>▪ Little or no corrective work required</li> <li>▪ Form representative of species</li> </ul>

The five factor scores are summed together to get one final condition score, five (5) being the worst possible score and twenty (20) being the best. Consistent with the method used by the Center for Urban Forest Research, and many other urban forestry professionals, scores were divided into four categories. Table 1 shows the condition categories and the sums of the factor score and characteristics.

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. If more than one tree of the same species was present at the

specified address, a tree was chosen at random, always an entertaining decision process with the students. 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.

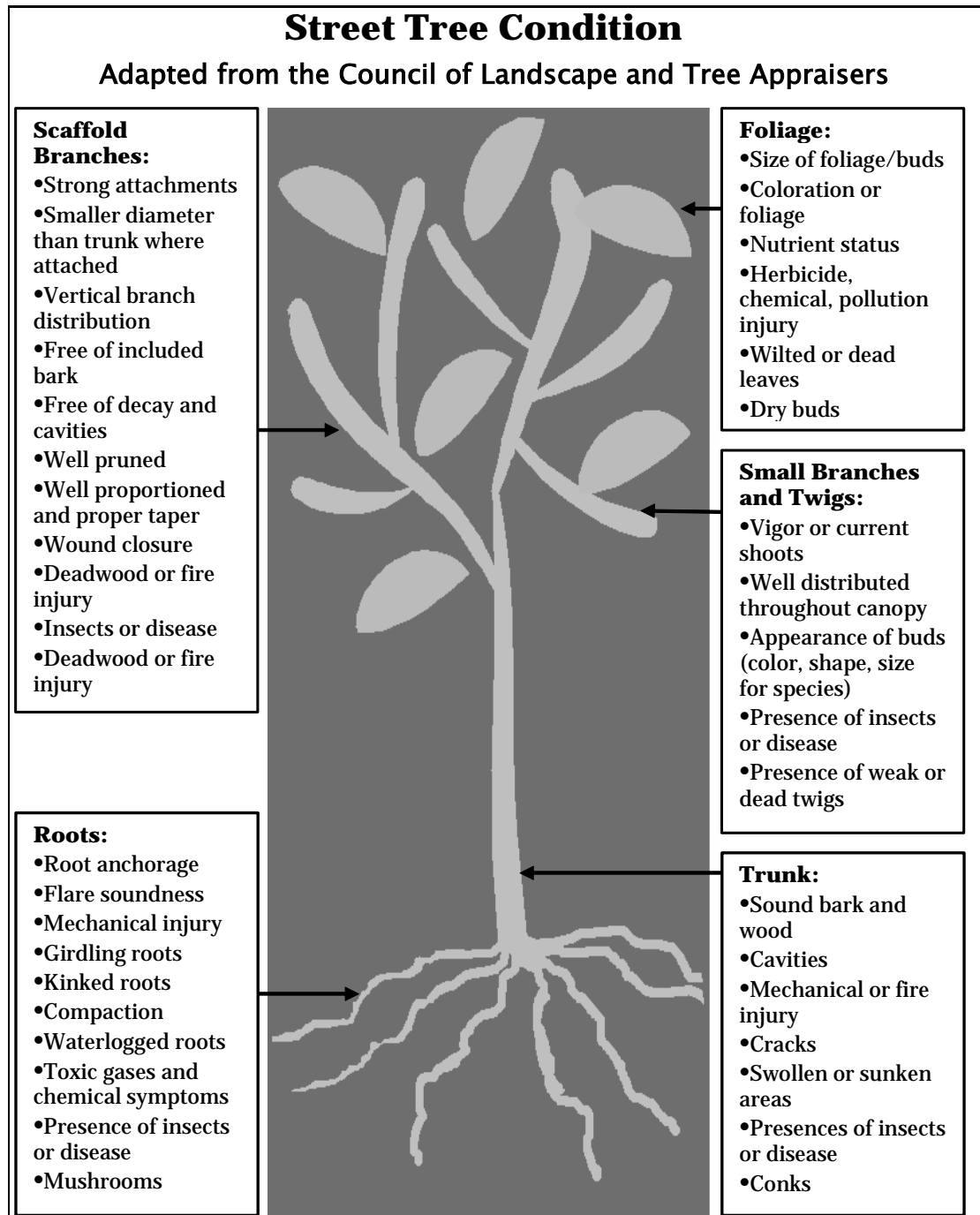


Figure 3. Tree condition assessment criteria

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 sampled trees were verified to the species level in the field. For tree condition, “cheat sheets” and diagrams

(similar to Table 1 and Figure 3) were used to guide the students in the correct direction when gauging tree condition.

The experience was valuable for both the students and the project; the students gained new skills and the project was rewarded with the knowledge that the students enjoyed the experience and learned new skills, 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**

Seattle's Arborist Office generously provided all of their weekly work records from March 1998 through December 2002. 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. Each work record was consolidated into a single spreadsheet and the end result was a database with 1236 individual entries of tree maintenance performed between 1998 and 2002. Each entry was matched to a location on the City's Street Network shapefile, using with ArcView's "geocode addresses" function, resulting in a GIS shapefile with 1171 separate work events. 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**

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).

### **Work Records and Income**

The distribution of tree maintenance (total visits and total number of trees worked on) was calculated for each of the six tracts and for the high- and low-income areas. Total number of visits and number of trees worked on were compared between the areas. 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.

## 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 was not adequate enough for robust analysis, a basic relationship between maintenance and average tree condition of the sampled trees could be detected with graphs and presented in tables. This information is presented in the Results section alongside the tree maintenance and income findings.

## Research Results

This section compares the tree condition assessed in this study to the condition assessed in the City's 1994 inventory, and reports average tree condition as it related to income and the level of tree care as it related to income and tree condition. For space considerations, only the results from the aggregated high- and low-income areas, rather than by the six selected tracts, are presented in this section; however, one map showing each of the six areas' average tree condition is provided.

### COMPARISON OF SAMPLED TREES' CONDITION AND CITY INVENTORY

As shown in the Figure 4, 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. 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.

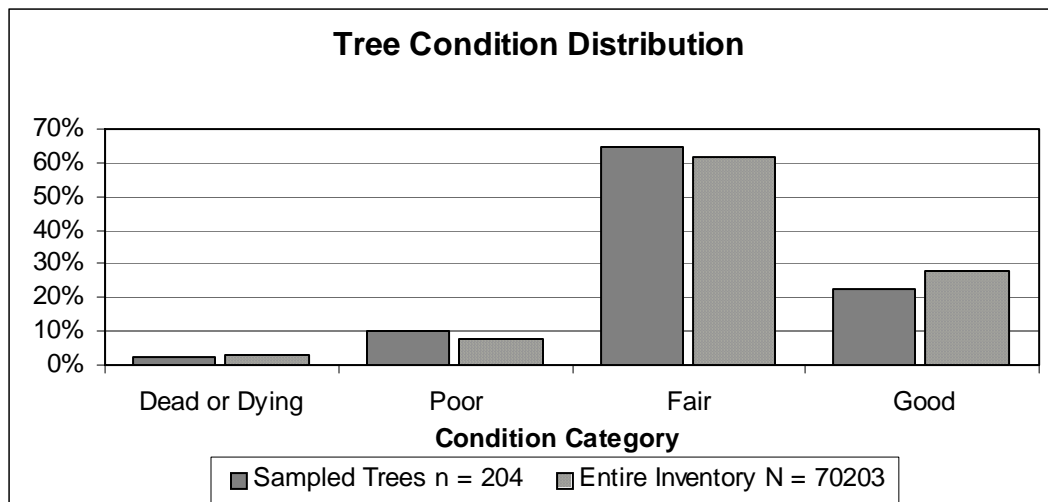


Figure 4. Tree condition distribution

### IS TREE CONDITION RELATED TO INCOME LEVELS?

Average tree condition was not significantly different between the aggregated high- and low-income areas (Figure 5). A t-test performed on these means showed no significant difference between the two income areas, thus the null hypothesis could not be rejected.<sup>1</sup>

<sup>1</sup> t = -0.4001, df = 195.88, p > 0.6

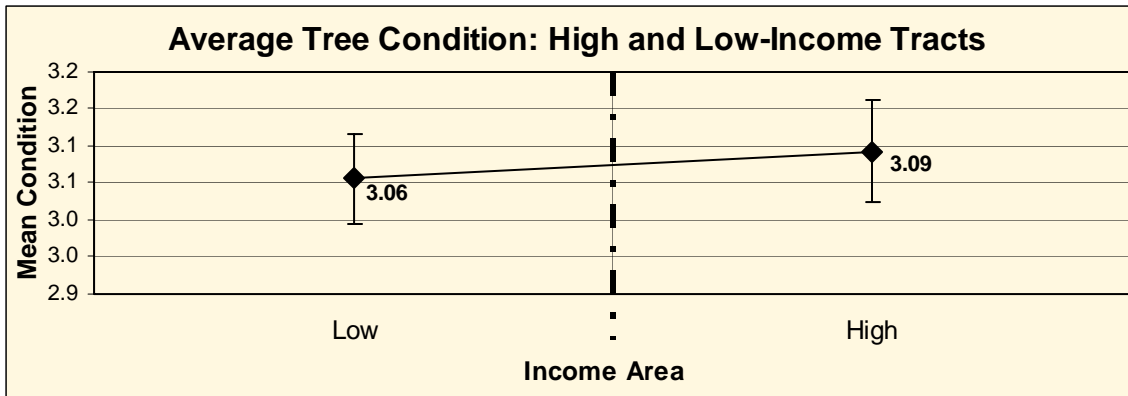


Figure 5. Average tree condition for high- and low-income are

Figure 6 shows that there was little to no difference in the patterns of tree condition distribution between the high- and low-income areas<sup>2</sup>. 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.

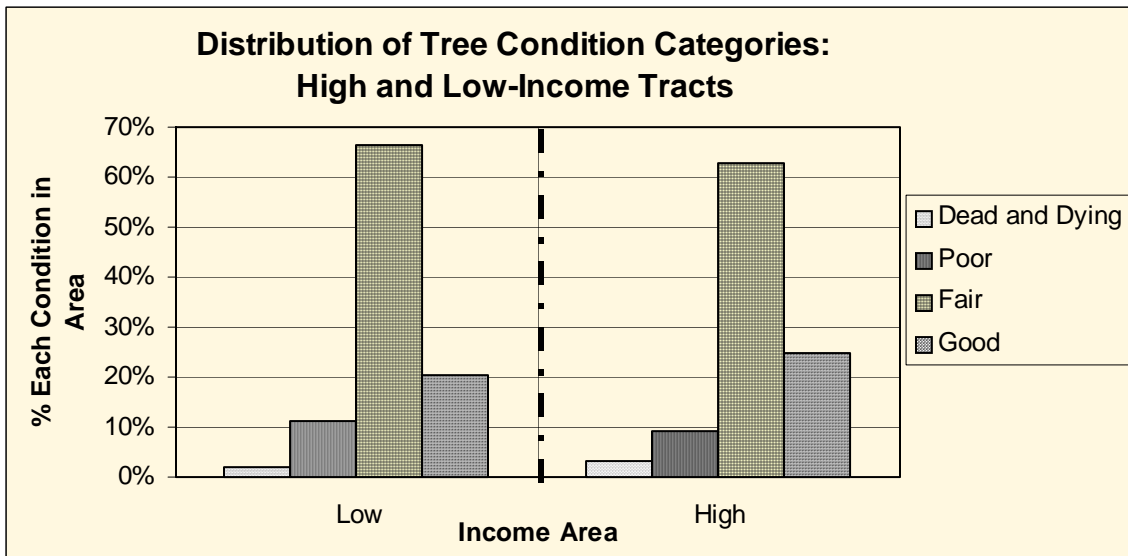


Figure 6. Distribution of tree condition categories for high- and low-income areas

Figure 7 displays tree condition across the sampled tracts. At first glance, this visual representation of tree condition does not show any obvious distinctions in color patterns or 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.

<sup>2</sup> Pearson Chi-Square Value = 0.9853, df = 3, p > 0.8



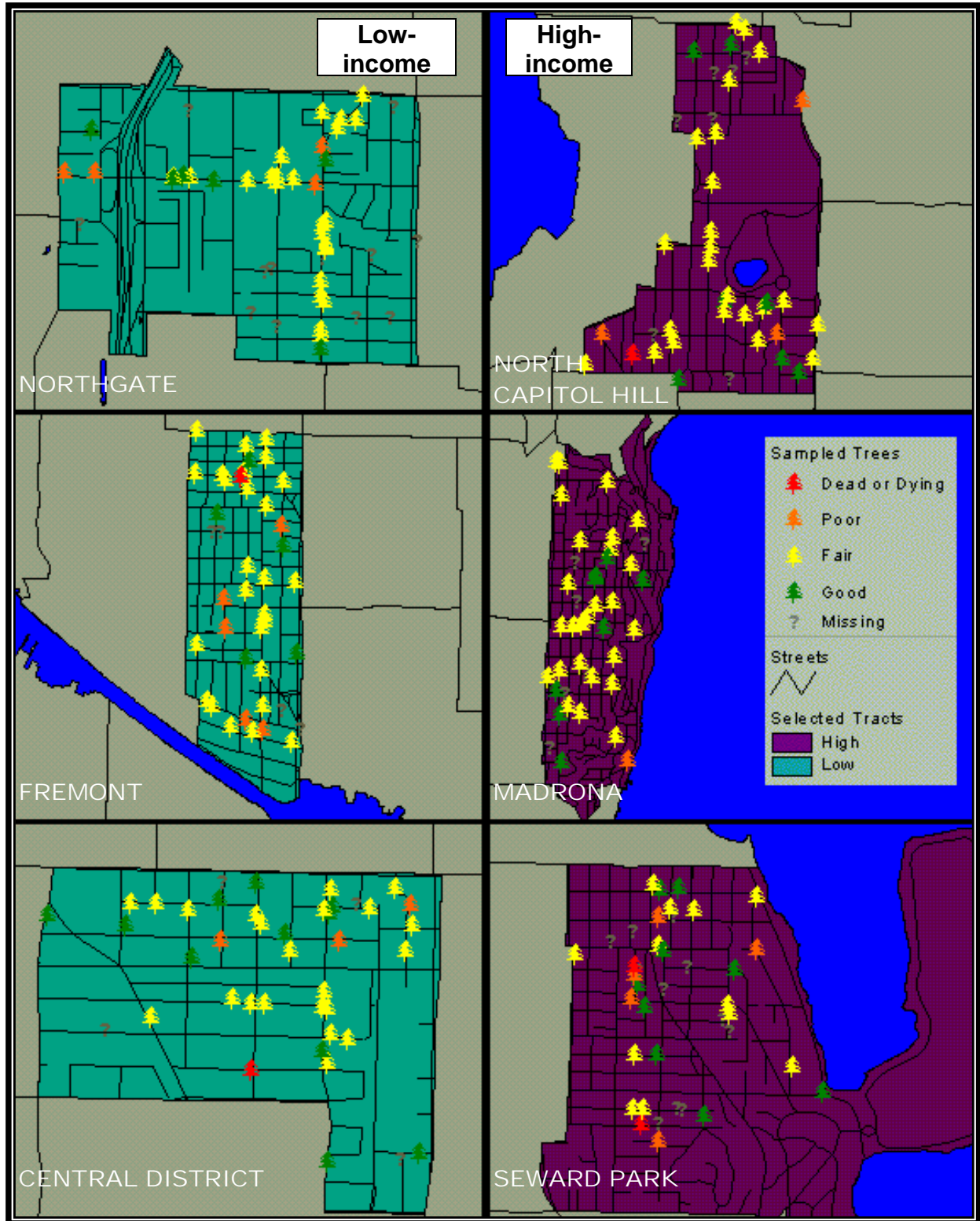


Figure 7. Map of tree condition

## IS TREE MAINTENANCE RELATED TO INCOME AND/OR TREE CONDITION?

As shown in Table 2, 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 2 also shows that the low-income areas have fewer trees than the high-income areas, but a greater proportion of city-maintained trees.

**Table 2. Tree and work information for low- and high-income areas**

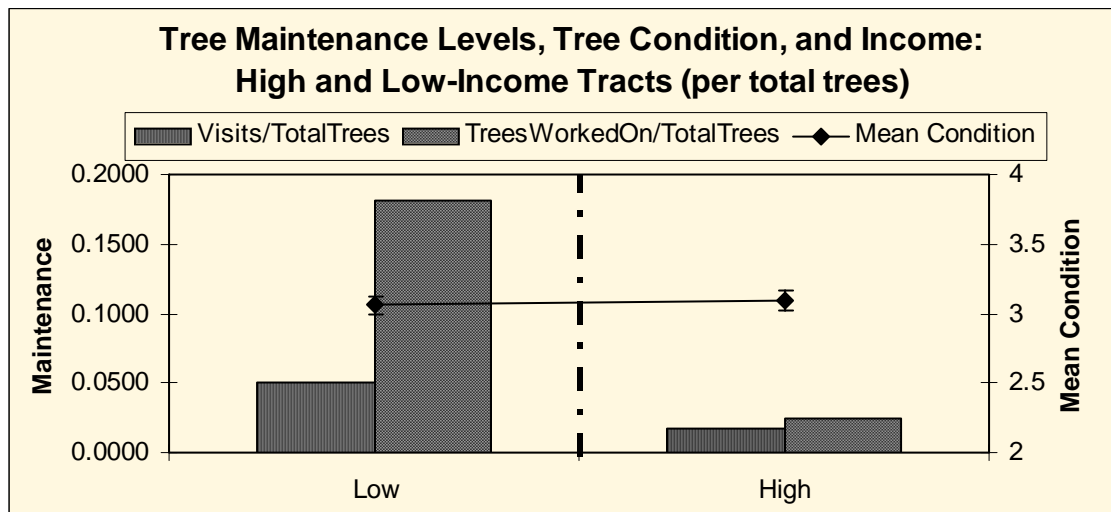
Income Group	Mean Condition	Hectares	Total trees	City trees	Trees/hectare	Visits	Trees Worked On
Low	3.06	380.132	1607	743	4.2275	82	291
High	3.09	604.618	2500	227	4.1348	42	62

Table 3 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 3. 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%
<b>Total</b>		100.0%		100.0%

Figure 8, 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 8. Tree maintenance (per total trees): high- and low-income**

A very different pattern emerged when the data was weighted by the number of city-maintained trees. 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. Table 4 shows that 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 9 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 4. 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%

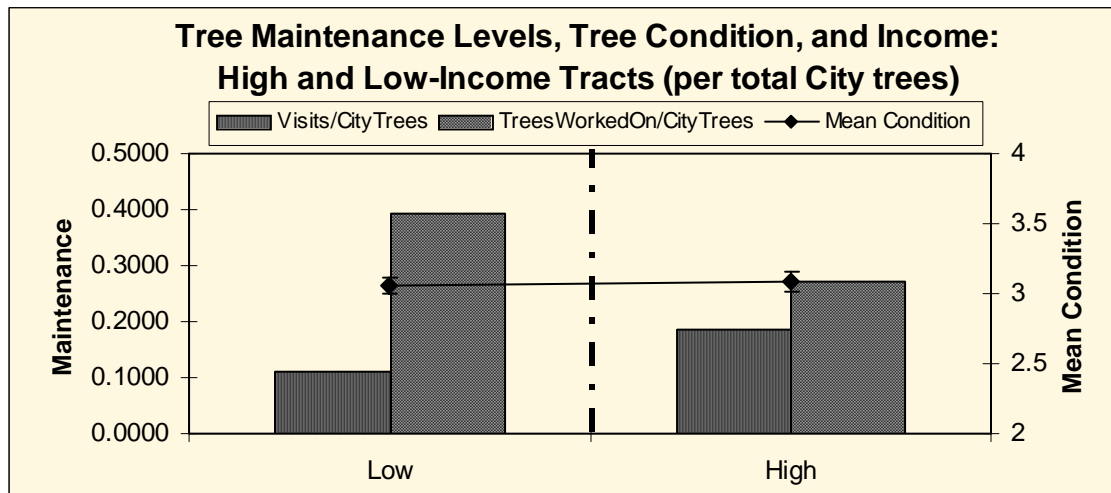


Figure 9. Tree maintenance (per total city trees): high- and low-income

## NEIGHBORHOOD SURVEY

After six weeks of gathering street tree condition information, and observing patterns of tree care, the high school students 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 businesses.

The students designed a short survey, two poster boards, and a three-fold pamphlet, shown in Figure 10, 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.

## 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.htm> or contact the City Arborist Office at <http://www.cityofseattle.net/transportation/treplanting.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](http://www.cityofseattle.net/environment/urban_forest.htm) or <http://www.pnwisa.org/tree-care.htm> or <http://www.cityofseattle.net/transportation/treplanting.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



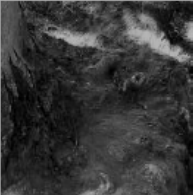
### What is the Urban Forest Project?

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*



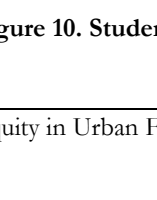
**Roots:**  
May wrap around tree or grow out of the ground as shown.



**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!**






Figure 10. Student-designed pamphlet

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.

## **Discussion**

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.

### **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. 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, are discussed below.

#### **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. This distribution of tree age most likely resulted in a balancing of average tree condition between the high- and low-income areas.

#### **City age**

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 MAINTENANCE 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 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 in extending the life of many of the young trees as well as maintaining a safe and hazard-free tree population.

### **Ineffective maintenance**

Another possible 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 areas. According the City Arborist, Seattle’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 and damage from traffic and vandalism. 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 becomes equal between high- and low-income areas.

### **Private tree care**

Another 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.

## **COMMUNITY PARTICIPATION**

The high school students' involvement was incredibly beneficial for both the project and the participants. The project gained the expertise and insight from members of the community, especially valuable when dealing with a resource as visible as street trees, and the participants learn new skills and gained 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.*

Although the high school students did not take part in some of beginning data manipulation and the later statistical analysis of the project, their insight and exemplary ideas were invaluable in the formulation of the discussion of the results. Once the summer data collection was completed, and the students returned to school, there were a few opportunities where the students were able to see the progress of the research and provide additional opinions and thoughts. Finally, when this research was presented for a Master's defense, the highlight of the presentation was the 15 minutes where three of the students were introduced to the audience and each shared their thoughts of what it was like to participate in this research. Not only was the audience thrilled to hear the students experiences, they were enthusiastic about the possibilities of incorporating participatory research methods into the realm of more traditional research.

## **Conclusion**

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.

### **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.

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.

Finally, it would be beneficial to do a follow-up survey with the high school students a few years after the project. Are they still interested in urban forestry, or social justice issues in their neighborhoods or cities? Do they still look at new trees with a sense of wonder? The Community Forestry Research Fellowship program provides opportunities for so many people to be involved in research projects; now, it would be interesting to see how long the impression lasts after the research project is completed.

## References

- Anderson, L.M., and H.K. Cordell. 1985. Residential property values improve by landscaping with trees. *Southern Journal of Applied Forestry* **9**:162-166.
- Council of Tree and Landscape Appraisers. 1983. *Guide for Establishing Values of Trees and Other Plants*. International Society of Arboriculture, Urbana, Illinois.
- Dwyer, J.F., E.G. McPherson, H.W. Schroeder, and R.A. Rowntree. 1992. Assessing the benefits and costs of the urban forest. *Journal of Arboriculture* **28**:270-276.
- Grey, G.W., and F.J. Deneke. 1986. *Urban Forestry*, Second edition. Brisbane and Sons, New York. 299 Pages.
- Kaplan, R. 1993. The role of nature in the context of the workplace. *Landscape and Urban Planning* **26**:193-201.
- Kuo, F.E., and W.C. Sullivan. 2001. Environment and crime in the inner city: does vegetation reduce crime? *Environment and Behavior* **33**:343-367.
- Kuo, F.E., W.C. Sullivan, R.L. Coley, and L. Brunson. 1998. Fertile ground for community: inner-city neighborhood common spaces. *American Journal of Community Psychology* **26**:823-851.
- McPherson, E.G., S.E. Maco, J.R. Simpson, P.J. Peper, Q. Xiao, A.M. VanDerZanden, and N. Bell. 2002. *Western Washington and Oregon Community Tree Guide: Benefits, Costs and Strategic Planting*. International Society of American Arboriculture, Pacific Northwest Chapter, Silverton, OR. 76 Pages.
- McPherson, E.G., D. Nowak, G. Heisler, S. Grimmond, C. Souch, R. Grant, and R. Rowntree. 1997. Quantifying urban forest structure, function, and value: the Chicago Urban Forest Climate Project. *Urban Ecosystems* **1**:49-61.
- McPherson, E.G., and R.A. Rowntree. 1993. Energy conservation potential of urban tree planting. *Journal of Arboriculture* **19**:321-331.
- Nowak, D.J. 1991. *Urban forest development and structure: analysis of Oakland, California*. Ph.D. Dissertation. University of California, Berkeley. 242 Pages.
- Nowak, D.J. 1993. Atmospheric carbon-reduction by urban trees. *Journal of Environmental Management* **37**:207-217.
- Nowak, D.J., P.J. McHale, M. Ibarra, D. Crane, J. Stevens, and C. Luley. 1998. Modeling the effects of urban vegetation on air pollution. *In* S. Gryning and N. Chaumerliac, editors. *Air Pollution Modeling and Its Application XII*. Plenum Press, New York. Pages 399-407.
- Rowntree, R.A., and D.J. Nowak. 1991. Quantifying the role of urban forests in removing atmospheric carbon dioxide. *Journal of Arboriculture* **17**:269-275.
- Sanders, R.A. 1986. Urban vegetation impacts on the hydrology of Dayton, Ohio. *Urban Ecology* **9**:361-376.
- Talarchek, G.M. 1990. The urban forest of New Orleans: an exploratory analysis of relationships. *Urban Geography* **11**:65-86.
- Ulrich, R.S. 1984. View through a window may influence recovery from surgery. *Science* **224**:420-421.
- Ulrich, R.S. 1986. Human responses to vegetation and landscapes. *Landscape and Urban Planning* **13**:29-44.
- Welch, J.M. 1991. *An assessment of socioeconomic and land use histories that influence urban forest structure: Boston's neighborhoods of Roxbury and North Dorchester*. Ph.D. Dissertation. Boston University, Boston. 219 Pages.
- Wolf, K.L. 2003. Public response to the urban forest in inner-city business districts. *Journal of Arboriculture* **29**:117-126.