Sammamish, WA

Urban Forest Inventory & Resource Analysis Summary Report

2023

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Executive Summary

Community trees play a vital role in the City of Sammamish. They provide numerous tangible and intangible benefits to residents, employees, visitors, and neighboring communities. The City of Sammamish recognizes that trees are a valued resource, a critical component of the urban infrastructure, and part of the City's identity. In 2021-22, the City of Sammamish contracted with Davey Resource Group, Inc. (DRG) to complete an inventory of community trees which included trees in parks and along city streets (right of way; ROW). The inventory data is maintained by the City of Sammamish using TreeKeeper8™, a tree asset management software system that allows managers to maintain current inventory specifics regarding tree characteristics, health, history, and maintenance needs.

To better understand Sammamish's street and park tree resource, complete inventory data was used in conjunction with i-Tree's *Eco* benefit-cost modeling software to develop a detailed and quantified analysis of the current structure, function, benefits, and value of this subset of the urban forest. The sample data for ROW street and park trees was summarized to understand their distinct species compositions, age distributions and maintenance needs. This report details the results of these analyses.

Structure

A structural analysis is the first step towards understanding the benefits provided by a tree resource, as well as its management needs. As of December 2022, Sammamish's ROW and park tree inventory includes 19,964 trees and 384 trees should be removed or reduced. Considering species composition and diversity, age distribution, condition, canopy coverage, and replacement value, the following information provide a summary characterization of Sammamish's public property tree inventory:

- 107 different tree species (Appendix C)
- Within the street ROW trees the most common tree is a Douglas Fir (*Pseudotsuga menziesii*, 26.6%), followed by Red Maple (*Acer rubrum,* 15.3%) and Western Red Cedar (*Thuja Plicata*, 13%).
- 28.5% of trees are less than 6-inches in diameter (DBH)
- 22% of street and park trees are in good condition
- Street and park trees provide an estimated 155.8 acres of canopy cover
- To date, Sammamish's street and park trees are storing 7,376 thousand tons of carbon (CO_2) in woody and foliar biomass
- Replacement of the 19,964 street and park trees with trees of equivalent size, species, and condition, would cost over $52.1 million
- i-Tree *Eco* estimates 83.2% of trees are susceptible to 36 emerging pests and disease threats including Asian longhorned beetle, Sudden oak death, and various Pine beetles.
- An estimated 148.34 tons of carbon are sequestered by the trees valued at $25,299 annually.
- An estimated 354,972 cu/ft per year of stormwater is mitigated annually.

Benefits

Annually, Sammamish's street and park trees provide cumulative benefits to the community totaling more than $82,673. The average annual benefit per tree is $4.14. These benefits include:

- 354,972 ft^3 of intercepted stormwater and reduced runoff, valued at $23,728/year, an average of $1.19 per tree
- 5.59 tons of air pollutants removed, including nitrogen dioxide, sulfur dioxide, carbon monoxide, ozone, and small particulate matter ($PM_{2.5}$) valued at $33,645/year, an average of $1.69 per tree
- 148.34 tons of additional carbon directly sequestered, valued at $25,299/year, an average of $1.27 per tree

This is likely a conservative accounting of the true environmental and socioeconomic benefits from Sammamish's street and park tree resource. Some natural areas were not inventoried. Areas where there was extremely dense tree canopy, or trees on steep slopes we considered lower priority for this project. Inventory areas in City Parks were selected by staff based on having high foot traffic and the potential for hazardous trees. The street tree inventory included trees along public ROWs that are both City-maintained or privately maintained. Many documented benefits from trees are unable to be quantified using current methods; for example, benefits to wildlife, slope stability, property values, and public health and welfare (University of Washington, 2018; University of Illinois, 2018).

Management & Investment

This tree inventory is a dynamic resource that requires continued investment to maintain and realize its full benefit potential. Trees are one of the few community assets that have the potential to increase in value with time and proper management. Annually, the City invests approximately half a million dollars a year in the management of trees in Sammamish (Sammamish UFMP, 2020). Most of these funds are used in the care of street trees and park trees.

Appropriate and timely tree care can substantially increase lifespan. When trees live longer, they provide greater benefits. As individual trees mature, and aging trees are replaced, the overall value of the community forest, and the amount of benefits provided, grow as well. However, this vital living resource is vulnerable to a host of stressors and requires sustained and routine application of best management practices to ensure a continued flow of benefits for future generations.

Although managers cannot foresee when a pest or pathogen may be introduced to the urban forest, being aware and equipped to identify potential threats allows the City to approach management and prevention in a way that fits the community's culture and available resources. Using best management practices to prepare for and/or manage pests and pathogens can lessen the detrimental impacts they have on the urban forest.

Overall, the street and park tree inventory in Sammamish is a resource in fair or better condition with an established age distribution. With proactive management, planning, and planting of new and replacement trees, the benefits from this resource will continue to increase as young trees mature.

Based on this resource analysis, the City would benefit from the following management activity:

- Increase genus and species diversity in new and replacement tree plantings to reduce reliance on abundant groups. At a minimum, managers should strive for no species representing more than 10% of the overall population and no genus representing more than 20% of the overall population.
- Use available planting sites to improve diversity, increase benefits, and further distribute the age distribution of street and park trees.
- Prioritize planting replacement trees for those trees that have previously been removed.
- Identify additional planting sites for trees and use the largest stature tree possible where space allows.
- Consider successional planting of important species, as determined by relative performance index (RPI) and the relative age distribution.
- Maintain species adequately represented by established age distributions in the inventory that lack recent plantings.
- Provide structural pruning for young trees and a regular pruning cycle for all trees.
- Regularly inspect trees to identify and mitigate structural and age-related defects to manage risk and reduce the likelihood of tree and branch failure.
- Consider opportunities to further support wildlife habitat and pollinators, including protecting diverse vegetation and preserving snags and deadwood in natural areas where targets are unlikely.

With adequate protection and planning, the value of the Sammamish's urban forest will continue to increase over time. Proactive management and planting trees are critical to ensuring that the community continues to receive a high level of benefits. Along with new tree installations and replacement plantings, funding for tree maintenance and inspection is highly recommended to preserve benefits, prolong tree life, and manage risk. Existing mature trees should be maintained and protected whenever possible since the greatest benefits accrue from the continued growth and longevity of the existing canopy. Managers can take pride in knowing that street and park trees support the quality of life for residents and neighboring communities.

1.0 Introduction

The City of Sammamish is in the Puget Sound area west of the Cascade Mountains and about 20 miles east of Seattle. The City is known as the Indigenous Land of Coast Salish, specifically the Snoqualmie Indian Tribe. Sammamish became incorporated in August of 1999. Sammamish has grown considerably since incorporation having started at 35,000 residents to nearly 68,000 today. Sammamish is home to ample recreational opportunities with numerous parks that offer plentiful trails, fishing, swimming, and leisure activities for all ages (Sammamish UFMP, 2020).

The community experiences a moderate climate with higher-than-average cloud cover. Sammamish's climate characterized by summer daytime temperatures over 70˚F and winter daytime temperatures in the 40˚F and 50˚F (Sperling's, Best Places, n.d.). Sammamish's moderate climate allows a long growing season, where temperatures do not drop below freezing for a period of almost 9 months (March through November, Weather Spark. n.d.). Typically, Sammamish receives 53 inches of rain and 6 inches of snow each year, with the majority occurring between October and March (Sperling's, Best Places, n.d.). The moderate temperatures coupled with high precipitation, allow many trees to thrive and some reach substantial heights.

Individual trees play an essential role in the community of Sammamish by providing many benefits, tangible and intangible, to residents, visitors, and neighboring communities. Research demonstrates that healthy urban trees can improve the local environment and lessen the impact resulting from urbanization and industry (Center for Urban Forest Research, 2017). Trees improve air quality, reduce energy consumption, help manage stormwater, reduce erosion, provide critical habitat for wildlife, and promote a connection with nature. When taken together, the urban forest contributes to a healthier, more livable, and prosperous Sammamish.

Through 2021-22, the City of Sammamish commissioned a tree inventory within City Street rights-of-way (ROW) and park trees. DRG started the tree inventory in January 2022 with the ROW's and completed an inventory of street trees in May 2022. Soon after finishing the street trees the City authorized park tree inventory efforts which were finished at the end of September 2022. The database resource created, will become an essential tool for the City to prioritize and budget for tree management. As part of this project, the City can now recognize some areas that require annual maintenance and are potentially hazardous that should be addressed.

This report provides the following information:

- A description of the current structure of Sammamish's street and park tree resource and an established benchmark for future management decisions
- The economic value of the benefits from the street and park tree resource
- Data that may be used by resource managers in the pursuit of alternative funding sources and collaborative relationships with utility purveyors, non-governmental organizations, air quality districts, federal and state agencies, legislative initiatives, or local assessment fees
- A breakdown of the structure, composition, and management needs of the tree in the ROWs and parks

As a part of the Sammamish's urban forestry programs, the street and park trees were analyzed with i-Tree *Eco* benefit-cost modeling software to generate a more robust resource analysis. The tree inventory data were analyzed with i-Tree's *Eco* (Eco v6.1.35) software application designed to use inventory data collected in the field along with local hourly air pollution and meteorological data to quantify urban forest structure, environmental effects, and value to communities. This USDA model makes estimates of the effects of urban forest based on peer-reviewed scientific equations to predict environmental and economic benefits. Although many of the socio-economic, human health, or wildlife sustainability benefits cannot be quantified, they are certainly an important benefit of Sammamish's street and park tree resources. The baseline data from this analysis can be used to make effective resource management decisions, develop policy, and set priorities.

2.0 Street (ROWs) and Park Tree Resource

There were 19,964 street and park trees identified as a tree resource for i-tree analysis purposes. This is slightly lower than the total sites provided in the database (19,999 sites). The total inventory is more thoroughly understood through examination of composition and species richness of diversity. Consideration of stocking level, canopy cover, age distribution, condition, and performance, provide a foundation for planning and management strategies. Inferences based on this data can help managers understand the importance of individual tree species to the overall forest as it exists today and provide a basis to project the future potential of the resource.

2.1 Composition & Species Richness

In this assessment, diversity was calculated as the proportion of species representing the total urban forest population (Figure 2, Table 1). The City of Sammamish's urban forest consists of trees spanning different size classes and growth forms so that the proportion of a species does not directly relate to the area it occupies.

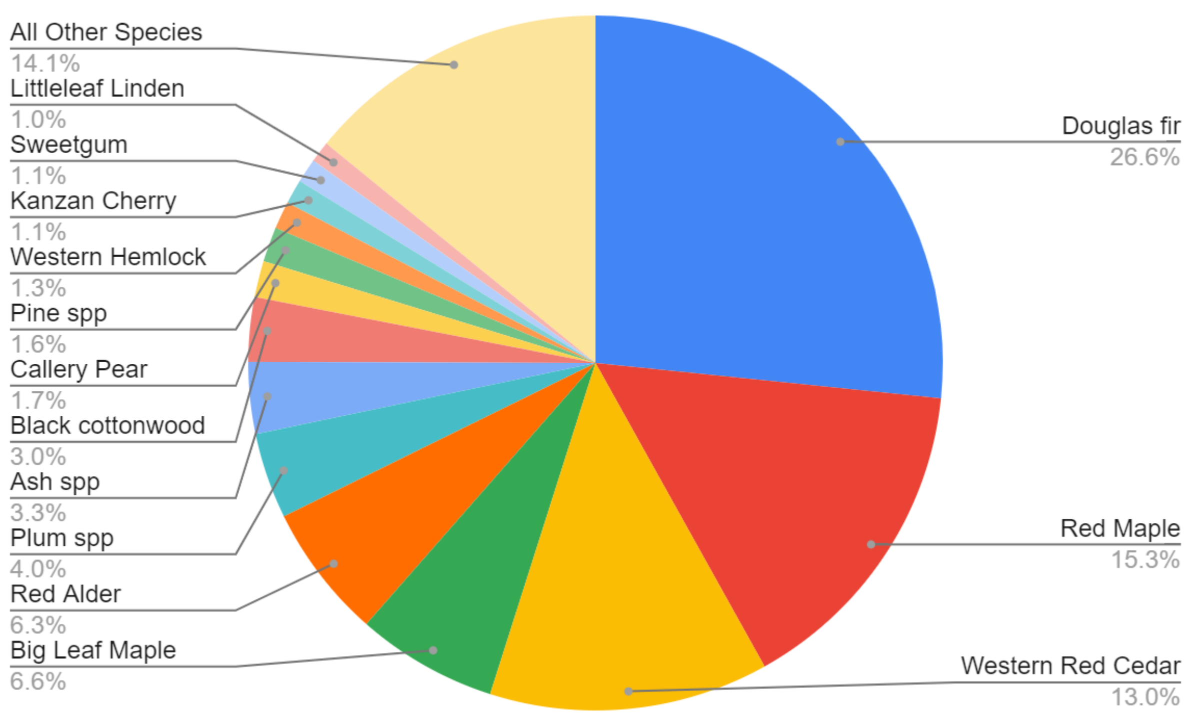


Figure 2: Species Composition of the tree inventory

2.2 Species Diversity

The City of Sammamish's tree resource includes a mix of 107 different species (Appendix C), with 58% of species native to Washington. The diversity in Sammamish is significantly more than the mean of 53 species reported by McPherson and Rowntree (1989) in their nationwide survey of street tree populations in 22 U.S. cities. The most prevalent species are Douglas Firs (*Pseudotsuga menziesii*, 26.6%), followed by Red Maple (*Acer rubrum,* 15.3%) and Western Red Cedar (Thuja Plicata, 13%) (Figure 2). All together, these 3 species make up 55% of the overall population. Sammamish's 10 most prevalent species (representing >1% of the overall population) make up 81.4% of the overall population.

Maintaining diversity in a community tree resource is important. Dominance of any single species or genus can have detrimental consequences in the event of storms, drought, disease, pests, or other stressors that can severely affect a community tree resource and the flow of benefits and costs over time. Catastrophic pathogens, such as Dutch elm disease (*Ophiostoma ulmi*), emerald ash borer (*Agrilus planipennis*), Asian longhorned beetle (*Anoplophora glabripennis*), and sudden oak death (*Phytophthora ramorum*) are some examples of unexpected, devastating, and costly pests and pathogens that highlight the importance of diversity and the balanced distribution of species and genera. In addition to these pests there is growing concern for polyphagous shot hole borer (PSHB) (*Euwallacea* spp.), a new pest complex that has devastated urban forests in Southern California due to its wide host range (Eskalen, 2015).

Table 1: Population Summary of Most Prevalent Species (Representing >1%)

	DBH Class (inches)										
Species	0-3	3-6	6-12	12-18	18-24	24-30	30-36	36-42	42-48	48+	Total	% of Population
Douglas fir	1.5	4.4	20.3	24.7	17.1	20.3	5.8	3.8	1.2	0.8	5,314	26.6
Red Maple	29.2	36.3	21.2	11.2	1.8	0.3					3,051	15.3
Western Red Cedar	0.9	6	28.4	21	12.3	14.5	5.7	5.9	3.2	2.1	2,595	13
Big Leaf Maple	0.2	5.1	34.5	26.4	13	12.1	2.4	2.4	1.6	2.1	1,309	6.6
Red Alder		11.1	62.8	19.4	3.7	3	0.1				1,249	6.3
Plum Spp	22.7	31.9	35.6	8.2	1.1	0.5					797	4
Ash Spp	12	19.5	37.4	25.1	3.2	2.3	0.5	0.2			666	3.3
Black Cottonwood		5.5	28.1	25.3	14.5	16.4	4.8	2.3	1.2	1.8	598	3
Callery Pear	38	41.8	19.9	0.3							337	1.7
Pine Spp	2.5	16.7	43.7	27.2	7.1	2.5	0.3				323	1.6
Western Hemlock		5.9	34.9	31.8	11.8	11.4	1.6	2.4	0.4		255	1.3
Kanzan Cherry	19.3	35.1	28.5	15.8	1.3						228	1.1
Sweetgum	20.9	31.6	36.4	8.4	2.7						225	1.1

Littleleaf Linden	30.6	16.3	53.1								196	1
All other species											2,821	14.12
Total											19,964	100

Recognizing that all tree species have a potential vulnerability to pests and disease, urban forest managers have long followed a rule of thumb that no single species should represent greater than 10% of the total population and no single genus more than 20% (Santamour, 1990). Among Sammamish's tree population, at the species level, Douglas fir (*Pseudotsuga menziesii*) and Red Maples (*Acer rubrum*) exceed this rule.

2.3 Species Importance

To quantify the significance of any one species in Sammamish's street and park tree resource, an importance value (IV) is derived for each of the most prevalent species. Importance values are particularly meaningful to community tree resource managers because they indicate a reliance on the functional capacity of a species. **i-Tree *Eco* calculates importance value based on the sum of two values: percentage of total population and percentage of total leaf area.** Importance value goes beyond tree numbers alone to suggest reliance on specific species based on the benefits they provide. The importance value can range from zero (which implies no reliance) to 100 (suggesting total reliance). A complete table, with importance values for all species, is included in Appendix C: Tables.

To reiterate from the previous section, research strongly suggests that no single species should dominate the composition of a community tree resource. Because importance value goes beyond population numbers, it can help managers to better understand the risks of loss of benefits from a catastrophic loss of any one species. When importance values are comparatively equal among the 10 to 15 most prevalent species, the risk of significant reductions to benefits is lower. Of course, suitability of the dominant species is another important consideration. Planting short-lived or poorly adapted species can result in short rotations and increased long-term management costs.

The importance value of 14 species represents 85.9% of the overall population and 93.6% of the total leaf area for a combined importance value of 179.3 (Table 2). Of these, Sammamish relies heavily on Douglas Fir (*Pseudotsuga menziesii*, IV=62.6). Sammamish also relies on the additional species Western Red Cedar (*Thuja Plicata*, IV=32.2), red maple (*Acer rubrum*, IV=21.4) and Bigleaf maple (*Acer macrophyllum*, IV=21.0). Combined, these four species represent 61.5% of the street and park tree inventory, providing significant benefits and a sense of place. They are the key species to sustaining the benefits provided by the community tree resource, as well as preserving the essence of Sammamish for years to come.

For some species, low importance values are primarily a result of species stature and/or age distribution. Immature or small-stature species frequently have lower importance values than their representation in the inventory might suggest. This is due to their relatively small leaf area and canopy coverage. For example, Callery pear (*Pyrus calleryana*), a medium-statured tree with a young age distribution, represents 1.7% of the overall population but only <1% of total leaf area resulting in an importance value of 2.0.

Some species are more significant contributors to the urban forest than population numbers would suggest. For example, Bigleaf Maple (*Acer macrophyllum,* IV = 21.4), makes up only 6.6% of the population and has an importance value of 21.0. This large-stature species is represented by individuals in almost every age class, with 60% well established (>12 inches in diameter) in Sammamish, representing 14.5% of the leaf surface area. In contrast, Red maples (*Acer rubrum,* IV = 21.0) represent 15.3% of the population, but just 13.3% are well established (>12 inches in diameter), and represent only 6.1% of the leaf surface area.

Table 2: Species Importance Value (IV) of Prevalent Species in Sammamish (Representing >1%)

Species	% of Trees	% of Leaf Area	Importance Value
Douglas Fir	26.6	38.5	65.2
Western Red Cedar	13	18.6	31.6
Red Maple	15.3	5.6	20.9
Bigleaf Maple	6.6	14	20.5
Red Alder	6.3	4.1	10.4
Black Cottonwood	3	4.9	7.9
Ash spp	3.3	2.7	6.1
Plum spp	4	1.4	5.4
Pine spp	1.6	1.3	2.9
Western Hemlock	1.3	1.1	2.4
Callery Pear	1.7	0.3	2
Kanzan Cherry	1.1	0.4	1.6
Sweetgum	1.1	0.4	1.6
Littleleaf Linden	1	0.3	1.2
All other species	14.1	6.2	19.8
Total	**100%**	**100%**	**200**

2.4 Canopy Cover

The amount and distribution of leaf surface area is the driving force behind the community tree resource's ability to produce benefits for the community (Clark et al, 1997). As canopy cover increases, so do the benefits afforded by leaf area. Sammamish covers an area of 24.03 square miles of which 20.42 are land acres. i-Tree *Eco* estimates that street and park trees are providing approximately 0.3 square miles (193.4 acres) of canopy cover, which accounts for 1.47% of total land area. This estimate, calculated from the tree inventory, is a subset to the 48% canopy identified on public properties provided to the City using 2015 aerial imagery (Sammamish UFMP, 2020).

2.5 Relative Age Distribution

The relative age distribution of individual trees within the resource (or by species) influences present and future costs as well as the flow of benefits. Age distribution can be approximated by considering the DBH range of the overall inventory and of individual species. Trees with smaller diameters tend to be younger. An ideally aged population allows managers to allocate annual maintenance costs uniformly over many years and assures continuity in overall tree canopy coverage and associated benefits. A desirable distribution has a high proportion of young trees to offset establishment and age-related mortality as older trees decline over time (Richards, 1982/83). This ideal distribution, albeit uneven, suggests a large fraction of trees (~40%) should be young, with a DBH less than eight inches, while only 10% should be in the large diameter classes (>24 inches DBH).

The age distribution of Sammamish's street and park trees shows an established population. In total, 28.5% of trees are 6-inches or less in diameter (DBH) and approximately 15.6% of trees are larger than 24-inches in diameter (Figure 3). Relative age distribution can also be evaluated for each individual species. The 10 most prevalent street and park tree species are compared against the ideal distribution in Figure 4.

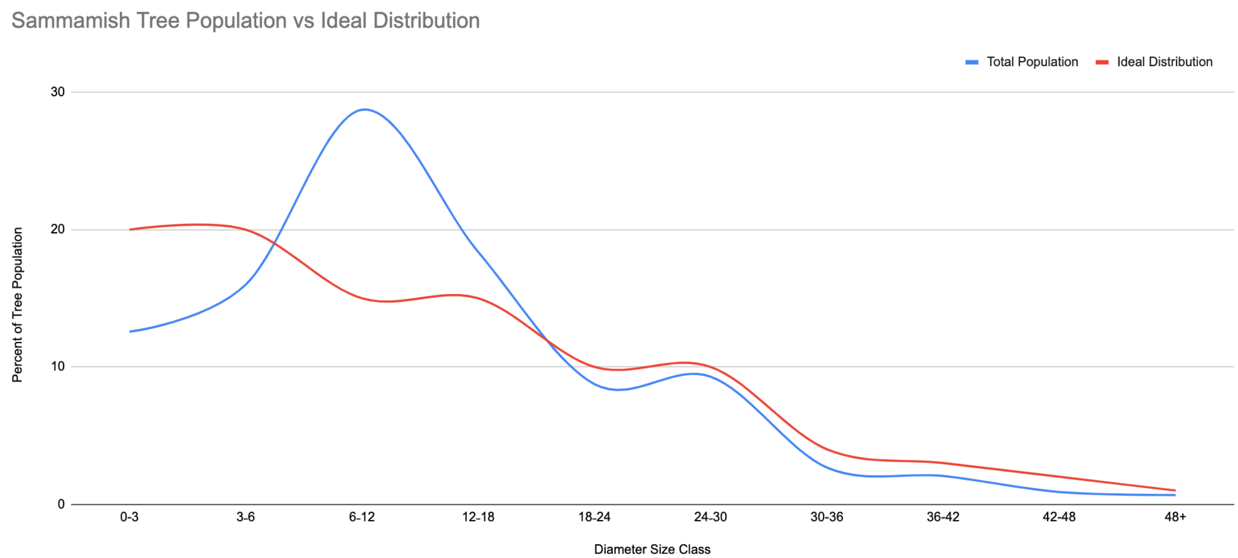


Figure 3: Street and Park Tree Inventory Relative Age Distribution for Sammamish

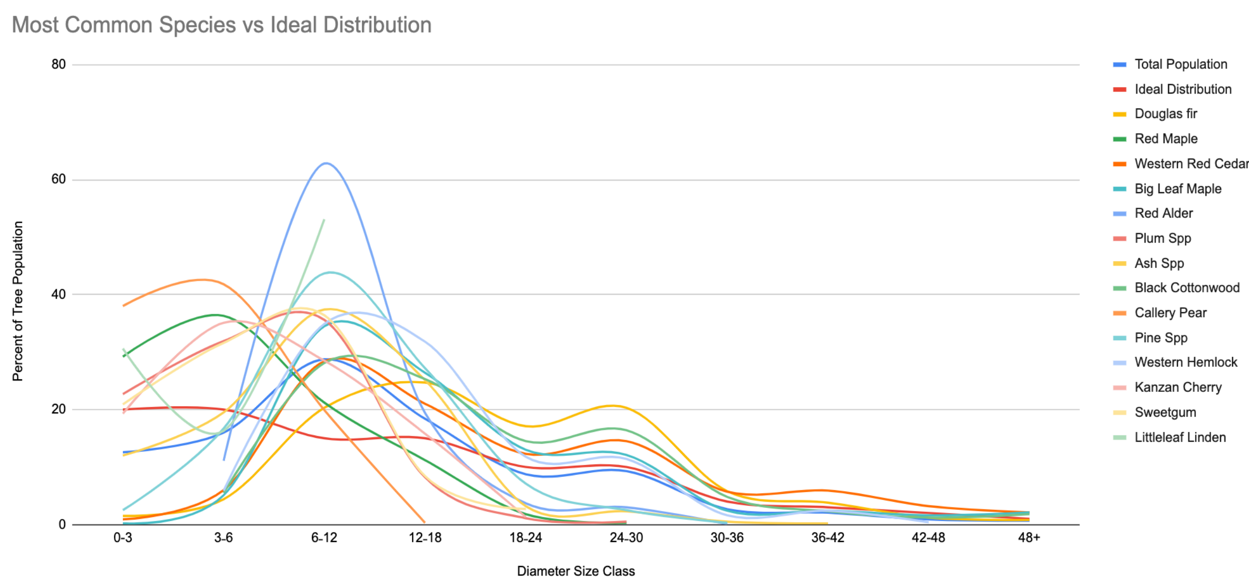


Figure 4: Relative Age Distribution of Sammamish's Top 14 Most Prevalent Species

The majority of the 10 most prevalent species in Sammamish's street and park tree inventory are well established. For example, the age distributions of Douglas fir (*Psuedotsuga menzeisii),* Western Red Cedar (*Thuja plicata),* and Bigleaf maple (*Acer macrophyllum)* all contain 60% or more of their population in the >12" diameter size class. In contrast, the age distribution of red maple (*Acer rubrum*) has the majority of its trees (66%) in the 0-6” size class, while red alder (*Alnus rubra)* has the majority (63%) in the 6-12” size class.

2.7 Tree Condition

Tree condition is an indication of how well trees are managed and how well they are performing in each site-specific environment (e.g., street, median, parking lot, park, etc.). Condition ratings can help managers anticipate maintenance and funding needs. In addition, tree condition is an important factor for the calculation of community tree resource benefits. A condition rating of good assumes that a tree has no major structural problems, no significant mechanical damage, and may have only minor aesthetic, insect, disease, or structural problems, and is in good health. When trees are performing at their peak, as those rated as good or better, the benefits they provide are maximized.

Street and park trees in Sammamish are in overall fair condition or better. Of the trees, 78.4% are in fair condition, 11.1% are in good condition, and approximately 7% are in poor or critical condition (Figure 5). There were 698 dead trees excluded from further benefits analysis.

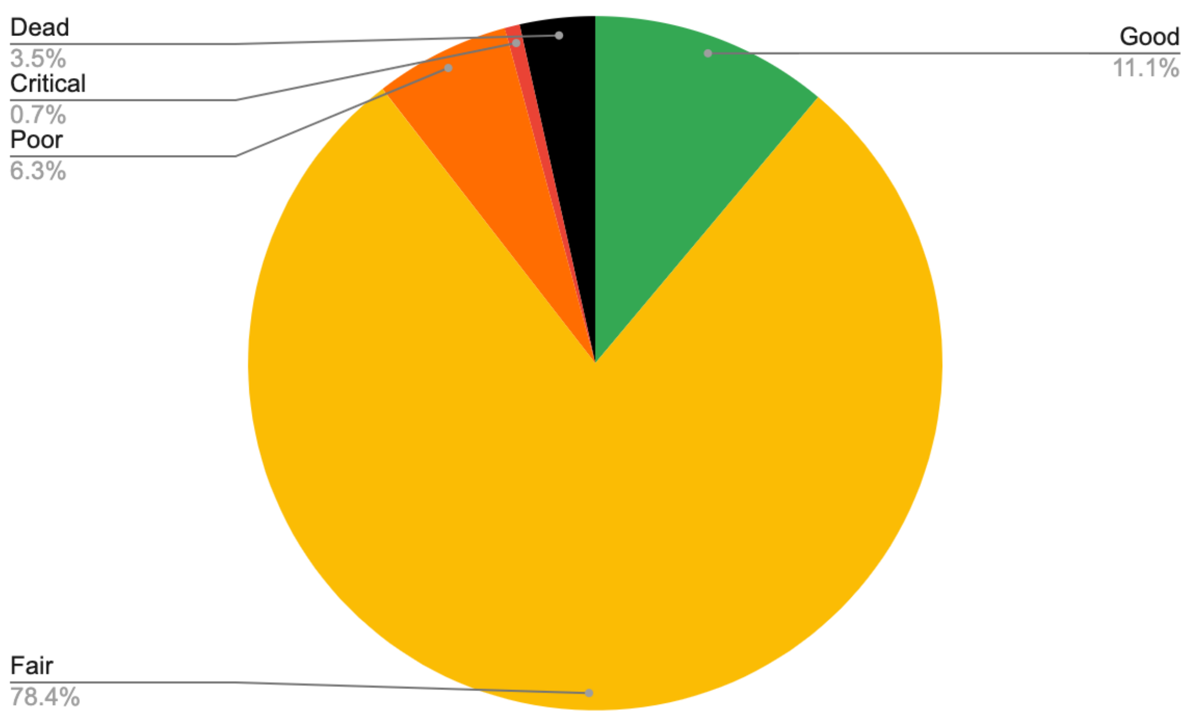


Figure 5: Condition of Sammamish’s Tree Population

In terms of Sammamish’s most prevalent species, several top species are in overall better condition than the citywide population. Red maple (*Acer rubrum)* and Littleleaf linden (*Tilia cordata)* both have over 20% of their population in good condition, nearly double the citywide total of 11.1% in good condition. On the other hand, bigleaf maple (*Acer macrophyllum)* and black cottonwood (*Populus trichocarpa)* were generally in worse condition than the city population, with less than 1% of each population in good condition. Western hemlock (*Tsuga heterophylla)* was in the worst condition of the top 14 most prevalent species, with 0 trees in good condition, 23% in poor condition, and 24% dead.

2.8 Relative Performance Index

The relative performance index (RPI) is another method to further describe the condition and suitability of a specific tree species. The RPI provides an urban forest manager with a detailed perspective on how different species are performing in comparison to each other. The index compares the condition rating of each tree species with the condition ratings of every other tree species within the inventory. An RPI of 1.0 or better indicates that the species is performing as well or better than average. An RPI value below 1.0 indicates that the species is not performing as well in comparison to the rest of the population.

Among the 14 most prevalent tree species, 11 have an RPI of 1.0 or greater (Table 3). Five of these top species (red maple, *Acer rubrum;* ash spp., *Fraxinus species;* Callery pear, *Pyrus calleryana;* Sweetgum, *Liquidambar styraciflua;* and Littleleaf linden, *Tilia cordata)* all had an RPI of 1.1. Citywide, the highest RPI achieved was 1.25, represented by 11 species with very small populations that had all trees in good condition. The largest of these was sugar maple (*Acer saccharum)* with 32 trees or 0.2% of the total population.

In contrast, western hemlock (*Tsuga heterophylla*), one of Sammamish's top 14 species, had the lowest RPI of all trees citywide at 0.7. Of the City's 107 different species, 13 had an RPI of less than 1. Sammamish's most abundant street and park species, Douglas fir (*Psuedotsuga menzeisii*, 26.2%), has an RPI of 0.99. However, there are many other species in the inventory that are performing well and better than average. Incorporating a greater variety of high-performing species in future plantings is recommended to increase diversity.

Table 3: Relative Performance Index of Most Prevalent Species

Species	Good (%)	Fair (%)	Poor (%)	Critical (%)	Dead (%)	RPI	# of Trees	% of all Trees
Douglas fir	5.7	86.0	3.5	0.4	4.3	1.0	5,314	26.6
Red maple	20.6	77.5	1.6	0.2	0.1	1.1	3,051	15.3
Western red cedar	1.0	75.8	15.0	2	6.1	0.9	2,595	13
Bigleaf maple	0.7	89.1	8.0	0.5	1.8	1.0	1,309	6.6
Red alder	0.0	69.6	15.5	1.9	13.1	0.8	1,249	6.3
plum spp	10.5	75.4	10.8	0.8	2.5	1.0	797	4
ash spp	18.5	75.8	4.5	0.2	1.1	1.1	666	3.3
Black cottonwood	0.2	87.3	7.2	0.7	4.7	1.0	598	3
Callery pear	17.8	81.6	0.6	0	0.0	1.1	337	1.7
pine spp	5.9	91.0	2.2	0.9	0.0	1.0	323	1.6
Western hemlock	0.0	49.4	23.1	3.9	23.5	0.7	255	1.3
Kanzan cherry	14.5	78.5	6.6	0.4	0.0	1.0	228	1.1
Sweetgum	16.9	80.4	2.7	0	0.0	1.1	225	1.1
Littleleaf linden	23.0	76.0	1.0	0	0.0	1.1	196	1
Total	**11.1**	**78**	**6.3**	**0.7**	**3.5**	**1**	**19,964**	**100**

The RPI of a species can be a useful tool for urban forest managers. For example, if a community has been planting two or more new species, the RPI can be used to compare their relative performance. If the RPI indicates that one is performing relatively poorly, managers may decide to reduce or even stop planting that species and subsequently save money on both planting stock and replacement costs. The RPI enables managers to look at the performance of long-standing species as well. Established species with an RPI of 1.00 or greater have performed well over time. These top performers should be retained, and planted, as a healthy proportion of the overall population. It is important to keep in mind that, because RPI is based on condition at the time of the inventory, it may not reflect cosmetic or nuisance issues, especially seasonal issues that are not threatening the health or structure of the trees.

An RPI value less than 1.00 may be indicative of a species that is not well adapted to local conditions. Poorly adapted species are more likely to present increased safety and maintenance issues. Species with an RPI less than 1.00 should receive careful consideration before being selected for future planting choices. However, prior to selecting or deselecting trees based on RPI alone, managers should consider the age distribution of the species, among other factors. A species that has an RPI of less than 1.00 but has a significant number of trees in larger DBH classes, may simply be exhibiting signs of population senescence. A complete table, with RPI values for all species, is included in Appendix C.

2.9 Replacement Value

The current replacement value of Sammamish's street and park tree resource is nearly $52.1 million. The replacement value accounts for the historical investment in trees over their lifetime. This value is also a way of describing the value of a tree population (and/or average value per tree) at a given time. The replacement value reflects current population numbers, stature, placement, and condition. There are several methods available for obtaining a fair and reasonable perception of a tree's value (Council of Tree and Landscape Appraisers, 2018; Watson, 2002). The trunk formula method used in this analysis assumes the value of a tree is equal to the cost of replacing the tree in its current state (Cullen, 2002).

Of the overall replacement value, 44.6% is attributable to Douglas fir (*Psuedotsuga menzeisii*) for a total of over $23.2 million (Table 4). Among the most prevalent species, Bigleaf maples (*Acer macrophyllum*) had the highest per-tree replacement value of $4,516 per tree for a total replacement value of nearly $6 million. Among all species, Sammamish's four giant sequoias (*Sequoiadendron giganteum*) had the highest per-tree replacement value with $8,877 each. The average per-tree replacement value is $2,610. To replace all 19,964 street and park trees in Sammamish with trees of equivalent size and condition would cost over $52 million.

The replacement value for Sammamish's street and park tree resource reflects the vital importance of these assets to the community. With proper care and maintenance, the value will continue to increase over time. It is important to recognize that replacement values are separate and distinct from the value of annual benefits produced by the street and park tree resource and in some instances the replacement value of a tree may be greater than or less than the benefits that that tree may provide.

Table 4: Replacement Value for Most Prevalent Species

Species	Number of Trees	% of Population	Replacement Value ($)	Replacement Value ($) Per-Tree	% of Replacement Value
Douglas fir	5,314	26.62%	$23,244,942	$4,374	44.61%
Red maple	3,051	15.28%	$2,529,220	$829	4.85%
Western red cedar	2,595	13.00%	$10,876,473	$4,191	20.88%
Bigleaf maple	1,309	6.56%	$5,911,588	$4,516	11.35%
Red alder	1,249	6.26%	$1,852,672	$1,483	3.56%
plum spp	797	3.99%	$715,657	$898	1.37%
ash spp	666	3.34%	$920,484	$1,382	1.77%
Black cottonwood	598	3.00%	$1,519,118	$2,540	2.92%
Callery pear	337	1.69%	$173,923	$516	0.33%
pine spp	323	1.62%	$355,774	$1,101	0.68%
Western hemlock	255	1.28%	$507,551	$1,990	0.97%
Kanzan cherry	228	1.14%	$245,011	$1,075	0.47%
Sweetgum	225	1.13%	$281,851	$1,253	0.54%
Littleleaf linden	196	0.98%	$156,990	$801	0.30%
Total	**19,964**	**100%**	**$52,101,865**	**$2,610**	**100%**

3.0 Street and Park Tree Benefits

Trees and urban forests provide quantifiable benefits to the community. They continuously mitigate the effects of urbanization and development and protect and enhance the quality of life within the community. The amount and distribution of leaf surface area is the driving force behind the ability of the urban forest to produce benefits for the community (Clark et al, 1997). Healthy trees are vigorous, often producing more leaf surface area each year.

Urban forests have functional benefit values based on the environmental function's the trees perform. In addition to air quality benefits, trees slow down stormwater and remove pollutants, resulting in reduced stormwater management costs for municipalities. Tree growth sequesters carbon in woody stems and roots. The value of these ecosystem functions is calculated in terms of both volume and cost savings.

3.1 Annual Environmental Benefits

Annual environmental functional values tend to increase with increased number and size of healthy trees (Nowak et al, 2002). Through proper management, urban forest values can be increased over time as trees mature and with improved longevity. Climate, pest, and weather events can cause values to decrease as the amount of healthy tree cover declines. Excluding energy benefits of trees, Sammamish's street and park trees provide annual environmental benefits valued at $82,673.50 (Appendix B). The annual environmental benefits provided by the street and park tree resource are conservative estimates due to limitations in the i-Tree *Eco* program.

Table 5. Annual benefits provided by Sammamish's urban tree population.

	Gross Carbon Sequestration	Avoided Runoff	Pollution Removal
$/yr	$25,300	$23,728	$33,646
% benefit	30.60%	28.70%	40.70%
$ per tree	$1.27	$1.19	$1.69

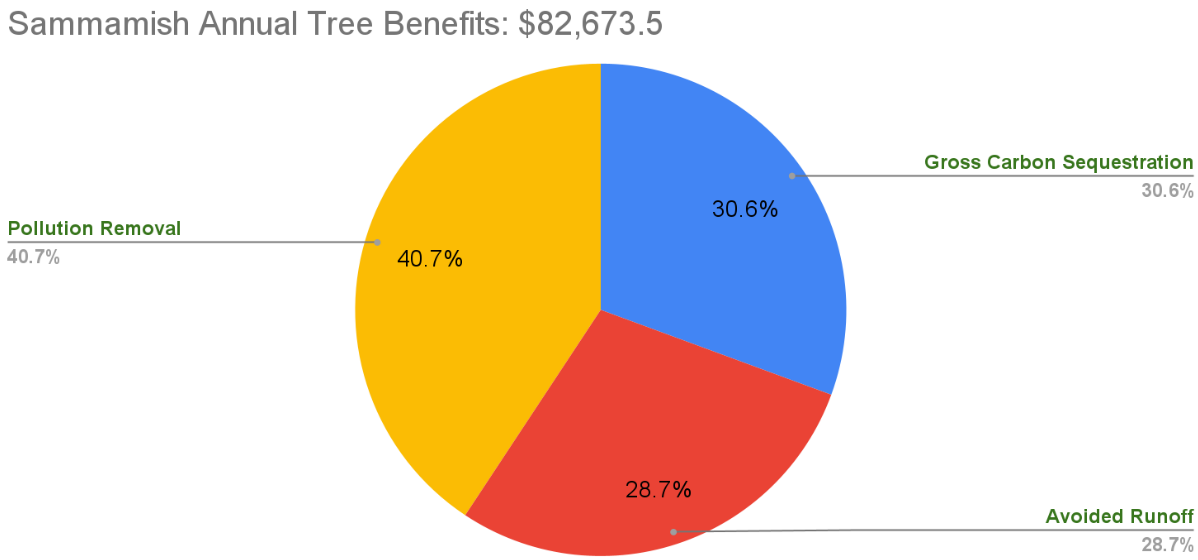


Figure 6. Proportion of Sammamish's total annual tree benefits from sequestration, pollution removal, and stormwater.

3.2 Air Quality

Urban trees improve air quality in five fundamental ways:

- Absorption of gaseous pollutants such as ozone (O_3), sulfur dioxide (SO_2), and nitrogen dioxide (NO_2) through leaf surfaces
- Reduction of emissions from power generation by reducing energy consumption
- Increase of oxygen levels through photosynthesis
- Transpiration of water and shade provision, resulting in lower local air temperatures, thereby reducing ozone (O_3) levels
- Interception of particulate matter ($PM_{2.5}$), (i-Tree *Eco* analyzes particulate matter less than 2.5 micrometers which is generally more impactful on human health [i-Tree *Eco* User Manual, 2019])

Air pollutants are known to contribute adversely to human health. Trees lessen the amount of air pollutants in the atmosphere, which can reduce the incidence of numerous negative health effects.

Ozone is an air pollutant that is particularly harmful to human health. Ozone forms when nitrogen oxide from fuel combustion and volatile organic gasses from evaporated petroleum products react in the presence of sunshine. In the absence of cooling effects provided by trees, higher temperatures contribute to ozone formation. Additionally, short-term increases in ozone concentrations are statistically associated with increased tree mortality for 95 large US cities (Bell et al, 2004). However, it should be noted that while trees do a great deal to absorb air pollutants (especially ozone and particulate matter); they also negatively contribute to air pollution. Trees emit volatile organic compounds (VOCs), which also contribute to ozone and carbon monoxide formation. i-Tree *Eco* analysis accounts for these VOC emissions in the air quality cumulative benefit.

Deposition, Interception, & Avoided Pollutants

Each year, nearly 5.6 tons of nitrogen dioxide (NO_2), sulfur dioxide (SO_2), small particulate matter ($PM_{2.5}$), and ozone (O_3) are intercepted or absorbed by Sammamish's street and park trees, for a total value of $33,646, an average of $1.69 per tree. (Table 6).

Table 6: Annual Air Pollution Removal Benefits

Pollutant	Removal (pounds)	Value ($)
CO	272	$196
NO2	1,694	$392
O3	5,300	$5,549
PM10	3,390	$11,495
PM2.5	212	$15,996
SO2	315	$18
Total	**11,184**	**$33,646**

Among prevalent street and park trees, Douglas Firs (*Pseudotsuga menziesii*) and Western Red Cedar (*Thuja Plicata*) remove the most pollutants, 2.01 and 1.07 tons/year respectively (Figure 7). These species are the greatest contributors to air quality benefits and provide benefits of $12,092 and $6,458 annually. Big leaf maple (*Acer macrophyllum)*, however, provides the greatest air pollution benefits per-tree, with $3.72 (compared with $2.28 for Douglas firs and $2.49 for Western red cedar), for a total benefit of $4,865.

Trees produce oxygen during photosynthesis, and street and park trees in Sammamish produce an estimated 395.6 tons of oxygen annually. Additionally, trees contribute to energy savings by reducing air pollutant emissions (NO_2, $PM_{2.5}$, SO_2, and VOCs) that result from energy production.

Street and park trees in Sammamish are emitting 2,802.1 tons of volatile organic compounds (VOCs) each year (826.8 tons of isoprene and 1,975.3 tons of monoterpenes). Emissions vary based on species characteristics and amount of leaf biomass. Oak species (*Quercus spp.)* produce the highest individual VOC emissions (210.4 lbs/acre), followed by Northern oak (*Quercus rubra,* 136.3 lbs/acre) and Black Cottonwood (*Populus trichocarpa*, 102.6 lb/acre). Overall, Douglas fir (*Psuedotsuga menzeisii*, 13.11 lbs/acre) produce the greatest volume of VOC emissions (674.9 lbs/year or 24.1% of all emissions), largely due to their size (35.9% of overall leaf area) and prevalence in the inventory (26.6%). However, this figure is closely followed by black cottonwood (*Populus trichocarpa*, 102.6 lb/acre) which produce 594.2 lbs/year and 21.2% of total emissions despite making up just 5.1% of total leaf area and 3% of the inventory.

Air quality impacts of trees are complex, and the i-Tree *Eco* software models these interactions to help urban forest managers evaluate the true impact of street and park trees on Sammamish's air quality. The cumulative and interactive effects of trees on climate, pollution removal, VOCs, and power plant emissions determine the net impact of trees on air pollution. Local urban forest management decisions also can help improve air quality by prioritizing tree species recognized for their ability to improve air quality and planting next to large traffic corridors.

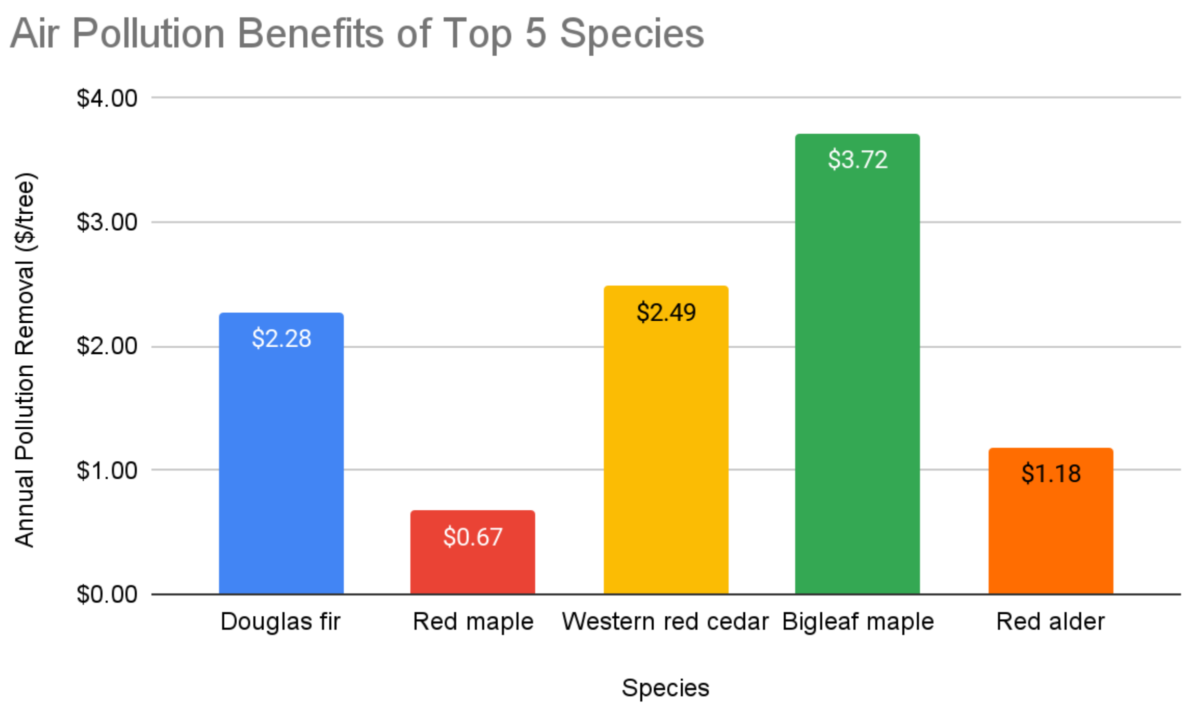


Figure 7: Air Pollution Removal Benefit of Top 5 Species

3.3 Atmospheric Carbon Dioxide Reductions

As environmental awareness continues to increase, governments are paying attention to global warming and the effects of greenhouse gas (GHG) emissions. As energy from the sun (sunlight) strikes the Earth's surface it is reflected into space as infrared radiation (heat). GHGs absorb some of this infrared radiation and trap heat in the atmosphere, modifying the temperature of the Earth's surface. Many chemical compounds in the Earth's atmosphere act as GHGs, including carbon dioxide (CO_2), water vapor, and human-made (gases/aerosols). As GHGs increase, the amount of energy radiated back into space is reduced, and more heat is trapped in the atmosphere. An increase in the average temperature of the Earth may result in changes in weather, sea levels, and land-use patterns, commonly referred to as "climate change" (NASA, 2020).

The Center for Public Urban Forest Research (CUFR) recently led the development of Public Urban Forest Project Reporting Protocol. The protocol, which incorporates methods of the Kyoto Protocol and Voluntary Carbon Standard (VCS), establishes methods for calculating reductions, provides guidance for accounting and reporting, and guides community tree resource managers in developing tree planting and stewardship projects that could be registered for GHG reduction credits (offsets). The protocol can be applied to urban tree planting projects within municipalities, campuses, and utility service areas anywhere in the United States.

While the street and park tree resource in Sammamish may or may not qualify for carbon-offset credits or be traded in the open market, these City trees are nonetheless providing a significant reduction in atmospheric carbon dioxide (CO_2) for a positive environmental and financial benefit to the community.

Urban trees reduce atmospheric CO_2 in two ways:

- Directly, through growth and the sequestration of CO_2 in wood, foliar biomass, and soil.
- Indirectly, by lowering the demand for heating and air conditioning, thereby reducing the emissions associated with electric power generation and natural gas consumption.

To date, street and park trees within Sammamish are estimated to have stored 7,376.2 tons of carbon (CO_2) in woody and foliar biomass valued at nearly $1.3 million. Annually, the street and park tree resource directly sequesters an additional 148.34 tons of carbon valued at $25,299 (Table 8).

Douglas fir (*Psuedotsuga menzeisii)* has the greatest amount of stored carbon with 2,755.3 tons stored (37.6% of all carbon storage benefits). Western red cedar (*Thuja plicata)* and bigleaf maple (*Acer macrophyllum)* also each store over 1,000 tons of carbon and comprise another 14.4 and 15.8% of all carbon storage benefits, respectively.

Among Sammamish's most prevalent street and park tree species, Bigleaf maple (*Acer macrophyllum)* also contributes the most per-tree to atmospheric carbon removal with a value of $2.89 per-tree, sequestering a gross 22.16 tons of carbon annually (14.9% of overall sequestration benefits). Douglas fir (*Psuedotsuga menzeisii)* and Red maple (*Acer rubrum)* are also top contributors in terms of sequestration benefits, annually sequestering 41.6 tons (28.4% of total) or $1.33 per-tree, and 23.7 tons (15.9% of total) or $1.32 per-tree, respectively.

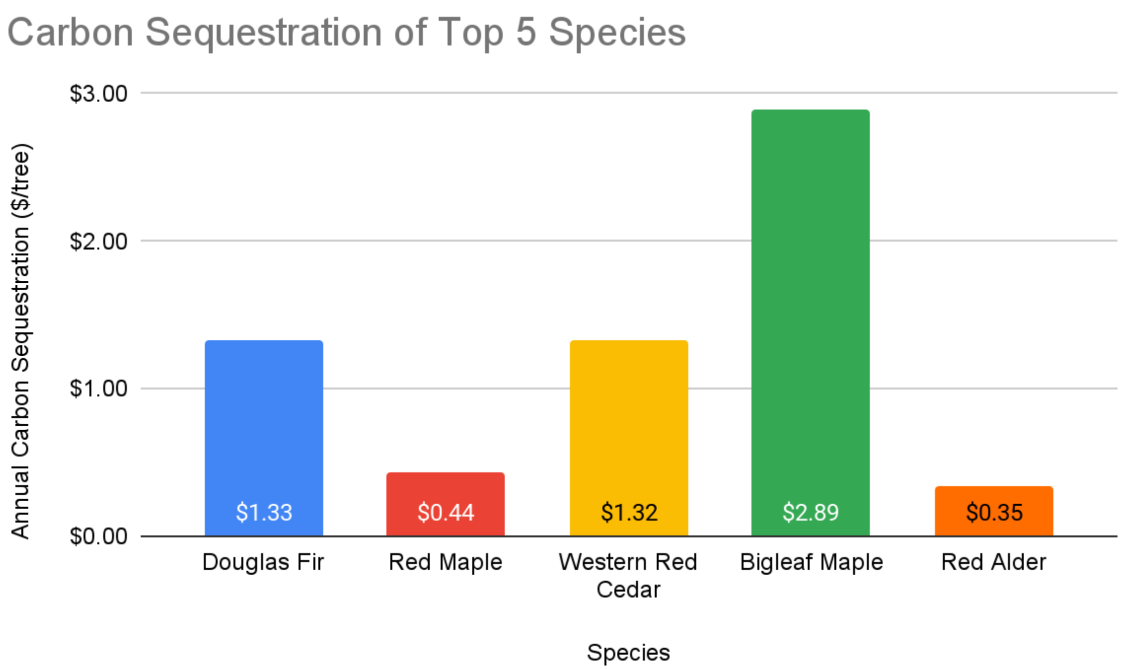


Figure 8: Carbon Sequestration Benefits of Top 5 Species

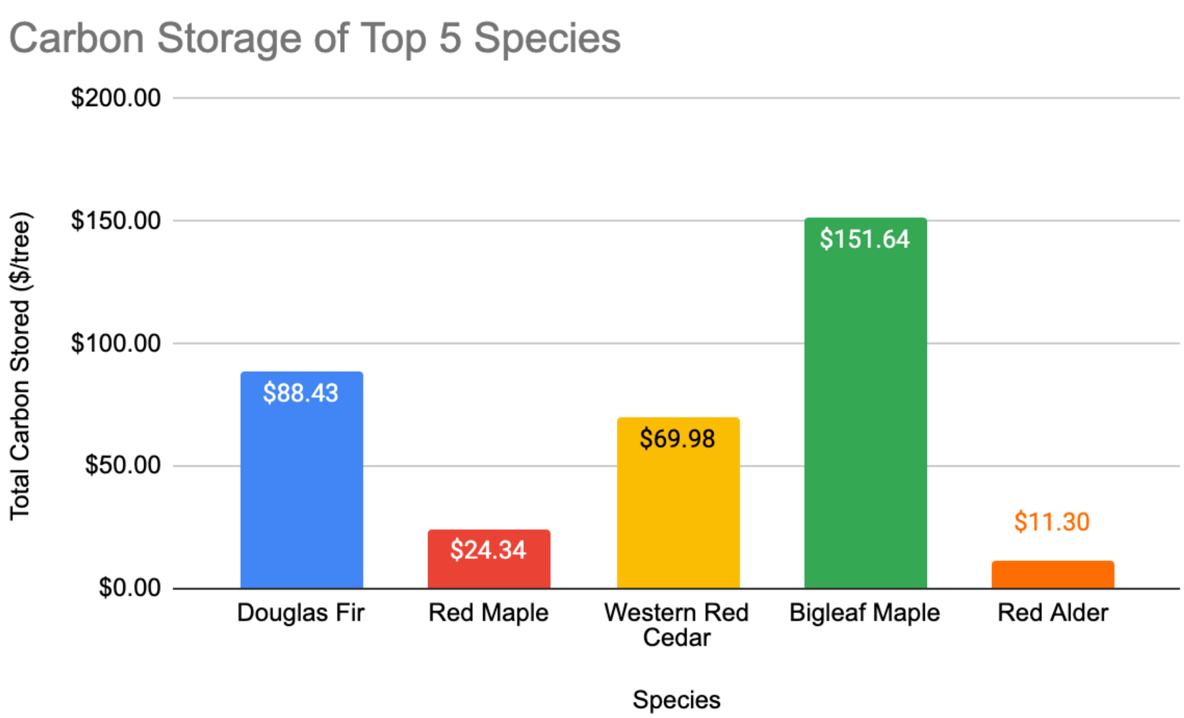


Figure 9: Carbon Storage Benefits of Top 5 Species

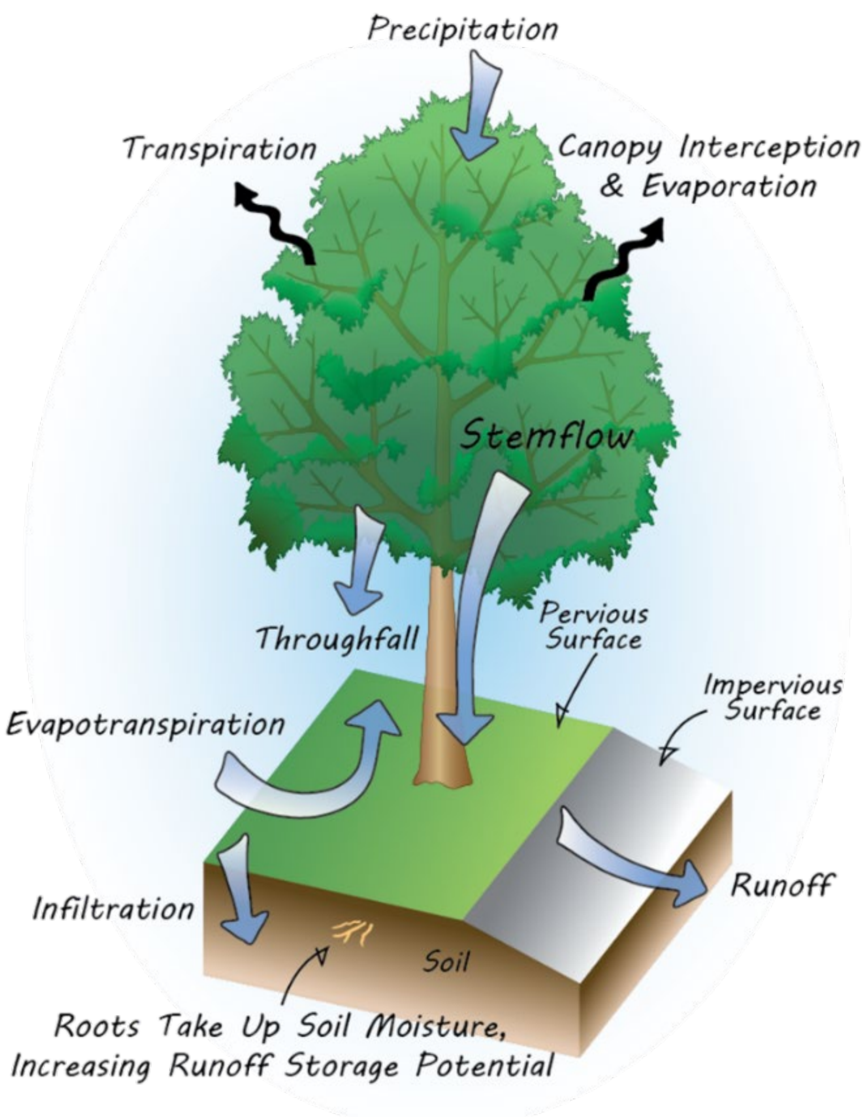
Table 7: Annual Gross Carbon Storage and Sequestration Benefits of Most Prevalent Species

Species	Tree number	Carbon Storage		Carbon Sequestration		
	(#)	(ton)	($)	Gross (ton/yr)	CO2 Equivalent (ton/yr)	($/yr)
Douglas fir	5,314	2,755.3	$469,921	41.6	152.5	$7,094
Red maple	3,051	435.4	$74,252	23.7	86.9	$4,040
Western red cedar	2,595	1,064.8	$181,608	6.7	24.6	$1,142
Bigleaf maple	1,309	1,163.9	$198,496	22.2	81.3	$3,779
Red alder	1,249	82.7	$14,110	2.5	9.3	$432
plum spp	797	145.7	$24,848	4.9	18.0	$837
ash spp	666	319.3	$54,449	8.9	32.6	$1,514
Black cottonwood	598	533.0	$90,910	10.7	39.2	$1,823
Callery pear	337	15.4	$2,633	1.2	4.4	$205
pine spp	323	154.6	$26,367	4.4	16.0	$746
Western hemlock	255	84.8	$14,468	0.8	2.9	$137
Kanzan cherry	228	47.9	$8,164	2.0	7.4	$344
Sweetgum	225	15.8	$2,698	0.9	3.3	$155
Littleleaf linden	196	10.7	$1,830	0.7	2.5	$116
All Other Species	2,821	546.8	$93,249	17.2	63.1	$2,935
Total	**19,964**	**7,376.1**	**$1,258,004**	**148.3**	**544.0**	**$25,299**

3.4 Stormwater Runoff Reductions

Rainfall interception by trees reduces the amount of stormwater that enters collection and treatment facilities during large storm events (Figure 9). Trees intercept rainfall in their canopy, acting as mini reservoirs, controlling runoff at the source. Healthy urban trees reduce the amount of runoff and pollutant loading in receiving waters in three primary ways:

- Leaves and branch surfaces intercept and store rainfall, thereby reducing runoff volumes and delaying the onset of peak flows.
- Root growth and decomposition increase the capacity and rate of soil infiltration by rainfall and reduce overland flow.
- Tree canopies reduce soil erosion and surface flows by diminishing the impact of raindrops on bare soil.



Sammamish's street and park tree resource is estimated to contribute to the avoidance of more than 355,000 cubic feet of stormwater runoff annually through the interception of precipitation on the leaves and bark of trees for a value of $23,728 per year or $1.19 per-tree.

Douglas fir (*Pseudotsuga menziesii*) provides 35.9% of the estimated total avoided runoff (Figure 10; Table 8). Their abundance, coupled with the age distribution and stature of these trees, allow them to provide a larger benefit in comparison to other species. Western red cedar (*Thuja plicata)* and bigleaf maple (*Acer macrophyllum)* are also significant contributors to stormwater interception amongst the City's most prevalent species, contributing to 68,137 cubic feet (19.2% of stormwater benefits) and 51,332 cubic feet (14.5% of all benefits) respectively. In contrast, red maple (*Acer rubrum)* provides just 6.1% of the estimated total avoided runoff value (21,682 cubic feet) despite being the second-most prevalent species, due to their smaller stature and age structure. The high proportion of young trees likely limits its ability to intercept stormwater. Characteristics that contribute to greater stormwater capture include large leaves, broad or dense canopies, and furrowed bark.

As trees grow, the benefits that they provide tend to grow as well. Some species provide more benefits than others, based on their architecture and leaf morphology. Some trees have characteristics that hinder their ability to be strong contributors to stormwater runoff reduction, possibly due to a tree having smaller leaves and thinner canopies.

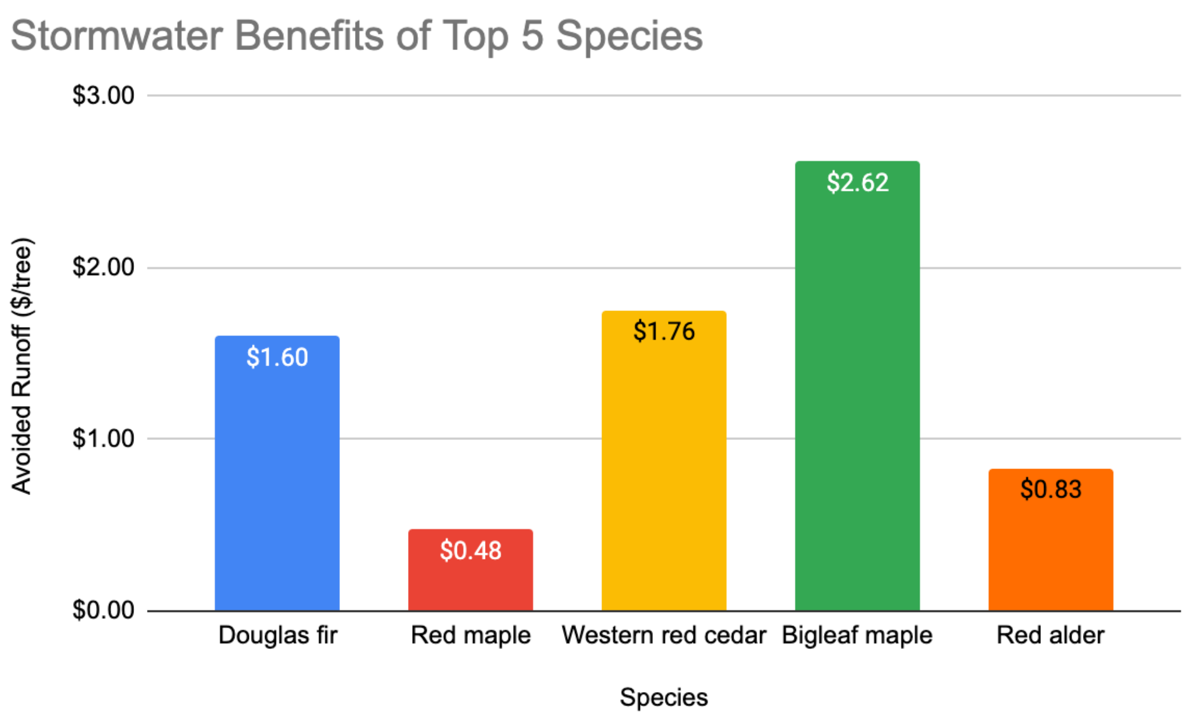


Figure 10: Stormwater Benefits of Top 5 Species

Table 8: Stormwater Benefits from Most Prevalent Tree Species

Species Name	Number of Trees	Leaf Area	Potential Evapo-transpiration	Evaporation	Transpiration	Water Intercepted	Avoided Runoff	Avoided Runoff Value
		(ac)	(ft^3/yr)	(ft^3/yr)	(ft^3/yr)	(ft^3/yr)	(ft^3/yr)	($/yr)
Douglas fir	5,314	355.51	3,687,150	663,915	1,357,845	664,279	127,579	8,528
Red maple	3,051	60.42	626,633	112,833	230,766	112,894	21,682	1,449
Western red cedar	2,595	189.87	1,969,237	354,584	725,200	354,779	68,137	4,555
Bigleaf maple	1,309	143.04	1,483,547	267,130	546,337	267,277	51,332	3,431
Red alder	1,249	43.43	450,432	81,106	165,878	81,150	15,585	1,042
plum spp	797	14.51	150,510	27,101	55,428	27,116	5,208	348
ash spp	666	28.04	290,845	52,370	107,108	52,399	10,064	673
Black cottonwood	598	50.84	527,319	94,950	194,193	95,002	18,246	1,220
Callery pear	337	2.89	30,017	5,405	11,054	5,408	1,039	69
pine spp	323	13.1	135,834	24,459	50,023	24,472	4,700	314
Western hemlock	255	11.45	118,796	21,391	43,748	21,402	4,110	275
Kanzan cherry	228	4.72	48,918	8,808	18,015	8,813	1,693	113
Sweetgum	225	4.62	47,901	8,625	17,640	8,630	1,657	111
Littleleaf linden	196	2.6	26,952	4,853	9,925	4,856	933	62
All Other Species	2,821	64.13	664,953	119,733	244,878	119,798	23,008	1,538
Total	**19,964**	**989.17**	**10,259,042**	**1,847,262**	**3,778,039**	**1,848,275**	**354,972**	**23,728**

3.5 Aesthetic, Property Value, & Socioeconomic Benefits

Trees provide beauty in the urban landscape, privacy and screening, improved human health, a sense of comfort and place, and habitat for urban wildlife. Research shows that trees promote better business by stimulating more frequent and extended shopping and a willingness to pay more for goods and parking (Wolf, 2007). In residential areas, the values of these benefits are captured as a percentage of the value of the property on which a tree stands. There is no current model for calculating the aesthetic benefits of an urban forest. Although, there are many indicators that suggest trees and tree canopy cover contribute significantly to quality of life and community well-being.

3.6 Annual Benefits of Most Prevalent Species

It is important to keep in mind that a benefits analysis provides a snapshot of the street and park tree inventory as it exists today. The calculated benefits are based on the size and condition of existing trees. To provide greater context, the overall per tree and per species benefits of the most prevalent species was calculated (Figure 11, Table 9), but to determine if these benefits are a true indicator of performance, age distribution and stature of the species must also be considered (Table 1, Figure 4).

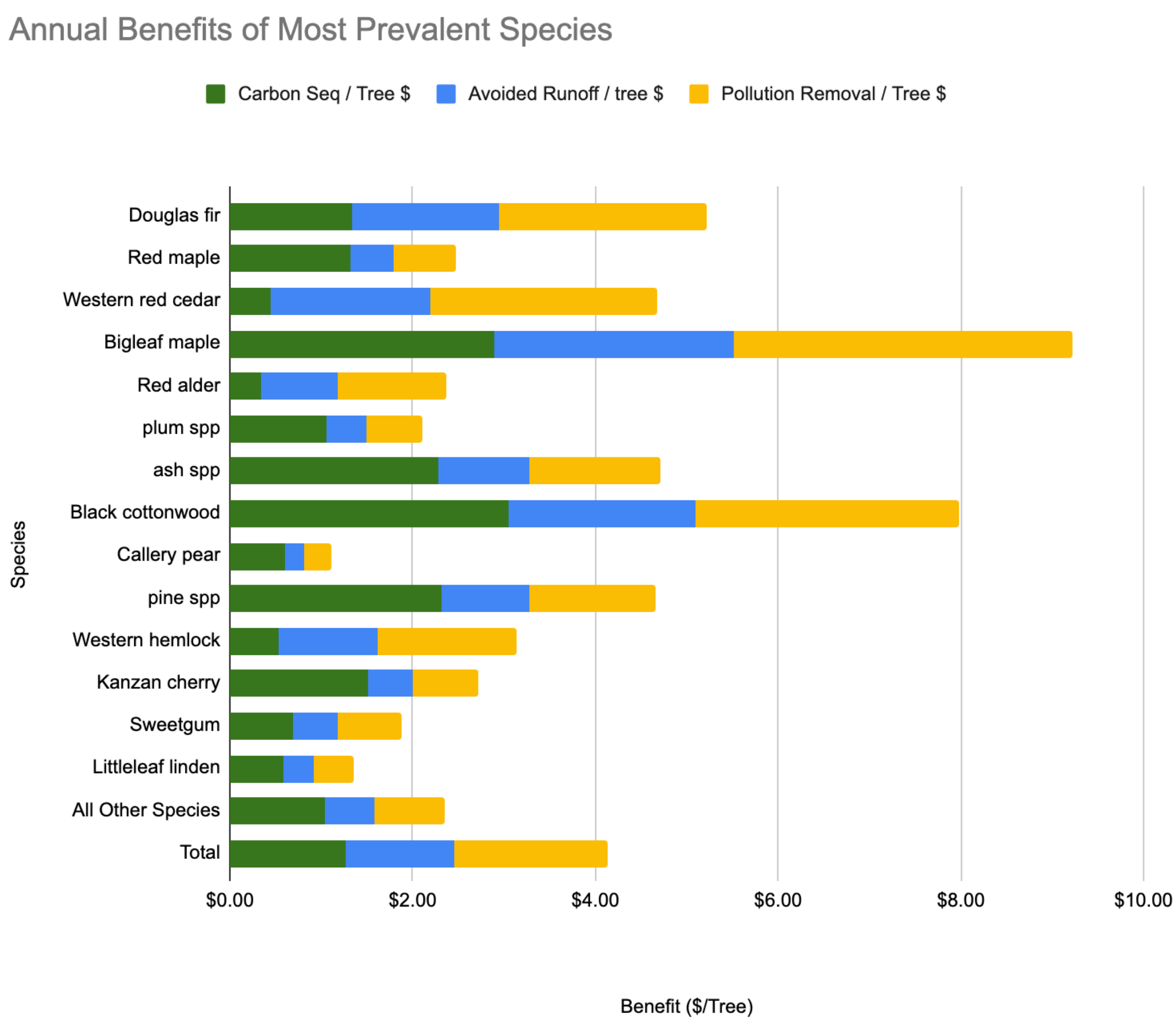


Figure 11: Summary of Annual Per Tree Benefits for Most Prevalent Species

Of the most prevalent street and park trees in Sammamish, Bigleaf maple (*Acer macrophyllum*) is providing the greatest overall per tree benefit ($9.23). This large-stature species is represented by an established and mature population (160% are greater than 12-inches in diameter and 20% are greater than 24-inches in diameter). The age distribution indicates that some new trees are being planted to allow for replacement of aging individuals. These benefits should remain stable over time, especially if managers continue to plant new trees as the population ages.

Some of the City's most prevalent species are represented by a relatively younger age structure, which indicates that although their per-tree values are currently lower due to the proportion of small-sized trees. This is the case for red maples (*Acer rubrum,* $2.47), which had 86.7% of its trees under 12"; red alder (*Alnus rubra,* $2.36) with 73.9% of its trees under 12"; sweetgum (*Liquidambar styraciflua,* $1.88) with 88.9% of its population under 12"; and littleleaf Linden (*Tilia cordata,* $1.36) with its entire population less than 12". These tree species' benefit values will likely increase as the population matures.

In contrast, several of the most prevalent species are small-stature species: plums (*Prunus spp.*, $2.11), and Callery pear (*Pyrus calleryana,* $1.11). Because of their small-stature, and smaller canopies, benefits from these species are unlikely to change much over time.

Table 9: Summary of Annual Benefits for Most Prevalent Species

Species	Tree number	Carbon Storage		Gross Carbon Sequestration		Avoided runoff		Pollution Removal		Replacement value ($)
	(#)	(ton)	($)	(ton/yr)	($/yr)	(ft^3/yr)	($/yr)	(ton/yr)	($/yr)	($)
Douglas fir	5,314	2,755.31	469,921	41.59	7,094	127,579	8,528	2.01	12,092	23,244,942
Red maple	3,051	435.37	74,252	23.69	4,040	21,682	1,449	0.34	2,055	2,529,220
Western red cedar	2,595	1,064.83	181,608	6.70	1,142	68,137	4,555	1.07	6,458	10,876,473
Bigleaf maple	1,309	1,163.85	198,496	22.16	3,779	51,332	3,431	0.81	4,865	5,911,588
Red alder	1,249	82.73	14,110	2.53	432	15,585	1,042	0.25	1,477	1,852,672
plum spp	797	145.69	24,848	4.91	837	5,208	348	0.08	494	715,657
ash spp	666	319.25	54,449	8.88	1,514	10,064	673	0.16	954	920,484
Black cottonwood	598	533.04	90,910	10.69	1,823	18,246	1,220	0.29	1,729	1,519,118
Callery pear	337	15.44	2,633	1.20	205	1,039	69	0.02	98	173,923
pine spp	323	154.6	26,367	4.37	746	4,700	314	0.07	445	355,774
Western hemlock	255	84.83	14,468	0.80	137	4,110	275	0.06	390	507,551
Kanzan cherry	228	47.87	8,164	2.02	344	1,693	113	0.03	160	245,011

Sweetgum	225	15.82	2,698	0.91	155	1,657	111	0.03	157	281,851
Littleleaf linden	196	10.73	1,830	0.68	116	933	62	0.01	88	156,990
All Other Species	2821	546.76	93,249	17.18	2,935	23,008	1,538	0.32	2,181	2,810,610
Total	**19,964**	**7,376.12**	**1,258,004**	**148.31**	**25,299**	**354,972**	**23,728**	**5.55**	**33,646**	**52,101,865**

3.8 Calculating Individual Tree Benefits

While all these tree benefits are provided by the urban forest, it can be useful to understand the contribution of just one tree. Individuals can calculate the benefits of individual trees to their property by using i-Tree *Design* (design.itreetools.org) or MyTree (mytree.itreetools.org).

4.0 Urban Forest Pests & Pathogens

Involvement in the global economy and a highly mobile human population increase the risk of an invasive pest or pathogen introduction into Sammamish. To further investigate the risk of pests and pathogens, i-Tree *Eco* identifies the susceptibility of tree populations to 36 emerging and existing pests and pathogens in the United States (Appendix B). According to the analysis, 16,612 (83.21%) of the 19,964 trees are susceptible to these pests and pathogens and the potential risk is estimated at nearly $32.6 million. The pests and pathogens identified as most relevant to Sammamish are included in Table 12. Anticipating and monitoring for these threats is an important part of urban forest management.

The greatest risk to Sammamish's tree population comes from Sudden oak death, a tree disease caused by a pathogen that could affect over 34% of the City's trees. Sudden oak death has been present in Washington state since 2004, although there are no current outbreaks (WSU).

The Asian longhorned beetle (ALB, *Anoplophora glabripennis*) is an invasive insect that threatens many hardwood trees such as maple (*Acer*), willow (*Salix*), and elm (*Ulmus*) (USDA APHIS, n.d.). Currently, the state of Washington does not have any ALB infestations, but had an outbreak in nearby Tukwila in the last ten years. With 30.39% of Sammamish's street and park trees susceptible to the borer, managers should regularly inspect trees and plant non-host species.

Pine shoot beetle (*Tomicus piniperda*) is an invasive beetle that is not present in Washington but was introduced to Ohio in 1992 and subsequently spread to several states in eastern USA (USDA, 2000). If this pest spreads, 29.13% of Sammamish's street and park trees are at risk. This beetle feeds on shoots of pine (*Pinus*), true fir (*Abies*), and Douglas fir (*Pseudotsuga menziesii*) which results in stunting, deformed growth, and in severe cases tree death. Since Douglas fir is the most prevalent species in Sammamish as well as the largest contributor to certain tree benefits, protecting the urban tree population from this pest is of particular importance. Similarly, up to 28.3% of the tree population could be susceptible to Douglas fir black stain root disease, a wilting disease that affects conifers in the area (USFS).

Defoliating moths, such as winter moth (*Operophtera brumata*) and gypsy moth (*Lymantria dispar*) threaten a broad range of tree hosts present in Sammamish (26.95% and 16.1% of the street and park tree inventory is susceptible, respectively). Both moth species are present in western Washington. While winter moth has been established since the 1970s (WSU, 2020), gypsy moth was recently detected in Snohomish County and is approximately 25 miles north of Sammamish. Gypsy moth management is occurring through the state's monitoring and eradication program (WSDA, 2020). During moth outbreaks, the feeding damage weakens the tree host, and renders it more vulnerable to other pests and diseases (Collins, 1996). These moth species are known to feed on hundreds of species of trees and shrubs.

Another emergent pest of concern is the polyphagous shot hole borer, of which 12% of trees in Sammamish are susceptible. This boring pest works in tandem with fusarium dieback, a tree disease that affects several kinds of hardwoods, to weaken and kill trees (USFS). This pest was first located in Portland and has spread to parts of Washington state and is currently ravaging southern California, so urban forest managers on the West coast should remain alert to its risks (UCNR).

Pest Management

Although managers cannot foresee when a pest or pathogen may be introduced to the urban forest, being aware of potential threats is the first step in a preparedness program. Following Integrated Pest Management (IPM) protocol and best management practices when preparing for and addressing pest and diseases can help to minimize their economic, health, and environmental consequences (Wiseman and Raupp, 2016). Some management practices include:

- Obtain current information on emergent pests and pathogens
- Increase understanding of the biology of the pest and pathogen as well as the tree symptoms that indicate infestation/infection
- Identify procedures and protocols that will be followed in the case of an introduced pest or pathogen
- Complete training and licensing in the case of pesticide or fungicide use
- Plant tree species that are resistant or tolerant to identified pest and pathogen threats
- Choose healthy, vigorous nursery stock
- Diversify plantings at the genus level, as many pests threaten several species within a genus
- Prevent the movement of felled tree materials that may be harboring pests or pathogens such as untreated logs, firewood, and woodchips

Table 10: Pest & Pathogen Threats to Sammamish

Pest Name	Number of Trees Susceptible	% of Trees Susceptible	Replacement Value ($)	Leaf Area (%)	Leaf Area (ac)
Aspen Leafminer	1,472	8.86%	$1,903,650	6.50	42.80
Asian Longhorned Beetle	6,068	36.53%	$8,100,382	23.10	151.30
Beech Bark Disease	7	0.04%	$3,175	0.00	0.10
Butternut Canker	0	0.00%	$0	0.00	0.00
Balsam Woolly Adelgid	159	0.96%	$107,835	0.50	3.40
Chestnut Blight	3	0.02%	$8,706	0.00	0.20
Dogwood Anthracnose	154	0.93%	$59,518	0.10	0.50
Douglas-fir Black Stain Root Disease	5,639	33.95%	$19,207,033	39.80	260.90
Dutch Elm Disease	0	0.00%	$0	0.00	0.00
Douglas-Fir Beetle	5,314	31.99%	$18,750,193	38.50	252.70
Emerald Ash Borer	679	4.09%	$752,146	2.80	18.30
Fir Engraver	5,425	32.66%	$18,815,943	38.80	254.20
Fusiform Rust	82	0.49%	$186,508	0.50	3.30
Gypsy Moth	3,222	19.40%	$3,846,666	11.60	76.40
Goldspotted Oak Borer	0	0.00%	$0	0.00	0.00
Hemlock Woolly Adelgid	0	0.00%	$0	0.00	0.00

Jeffrey Pine Beetle	0	0.00%	$0	0.00	0.00
Large Aspen Tortrix	2,874	17.30%	$3,517,732	11.00	71.90
Laurel Wilt	0	0.00%	$0	0.00	0.00
Mountain Pine Beetle	102	0.61%	$71,015	0.40	2.60
Northern Spruce Engraver	0	0.00%	$0	0.00	0.00
Oak Wilt	245	1.47%	$392,321	1.20	7.50
Pine Black Stain Root Disease	0	0.00%	$0	0.00	0.00
Port-Orford-Cedar Root Disease	147	0.88%	$112,077	0.30	2.10
Pine Shoot Beetle	5,815	35.00%	$19,154,035	40.40	264.60
Polyphagous Shot Hole Borer	2,397	14.43%	$5,523,425	15.80	103.90
Spruce Beetle	215	1.29%	$135,989	0.60	4.10
Spruce Budworm	5,461	32.87%	$18,846,269	39.00	256.00
Sudden Oak Death	6,850	41.24%	$23,706,579	53.10	348.40
Southern Pine Beetle	870	5.24%	$881,929	3.20	20.70
Sirex Wood Wasp	428	2.58%	$359,547	1.70	11.00
Thousand Canker Disease	0	0.00%	$0	0.00	0.00
Winter Moth	5,381	32.39%	$8,362,630	25.60	167.60
Western Pine Beetle	0	0.00%	$0	0.00	0.00
White Pine Blister Rust	1	0.01%	$193	0.00	0.00
Western Spruce Budworm	5,795	34.88%	$19,300,452	40.30	264.10
All Pests	**16,612**	**100.00%**	**$32,548,558**	**79.80**	**523.50**

5.0 Summary of Maintenance Needs

Appropriate and timely care can substantially increase the lifespan of trees. When trees live longer, they provide greater benefits. As individual trees mature, and aging trees are replaced, the overall value of the urban forest resource and the amount of benefits provided grow as well. However, this vital living resource is vulnerable to a host of stressors and requires ecologically sound and sustainable best management practices to ensure a continued flow of benefits for future generations.

The City of Sammamish now has a database of total of 19,999 trees located in parks and along streets around the City. While only 19,964 trees could be analyzed in i-Tree, the maintenance needs found in the database reveals how 14% were recommended some sort of maintenance tree care. While there are a greater number of Park Trees (11,380) than Street Trees (8,619) in Sammamish, the majority of trees in need of maintenance were Street Trees: 2,234 or 11% of the total tree population, compared with 522 Park Trees or 3% of the total tree population (Table 11).

Table 11: Summary of Maintenance Needs in Sammamish, WA.

Sammamish, WA	Total Trees		No Maintenance		Maintenance Recommended	
	Count	% of Pop	Count	% of Pop	Count	% of Pop
Park Trees	11,380	57%	10,858	54%	522	3%
Street Trees	8,619	43%	6,385	32%	2,234	11%
Total	**19,999**	**100%**	**17,243**	**86%**	**2,756**	**14%**

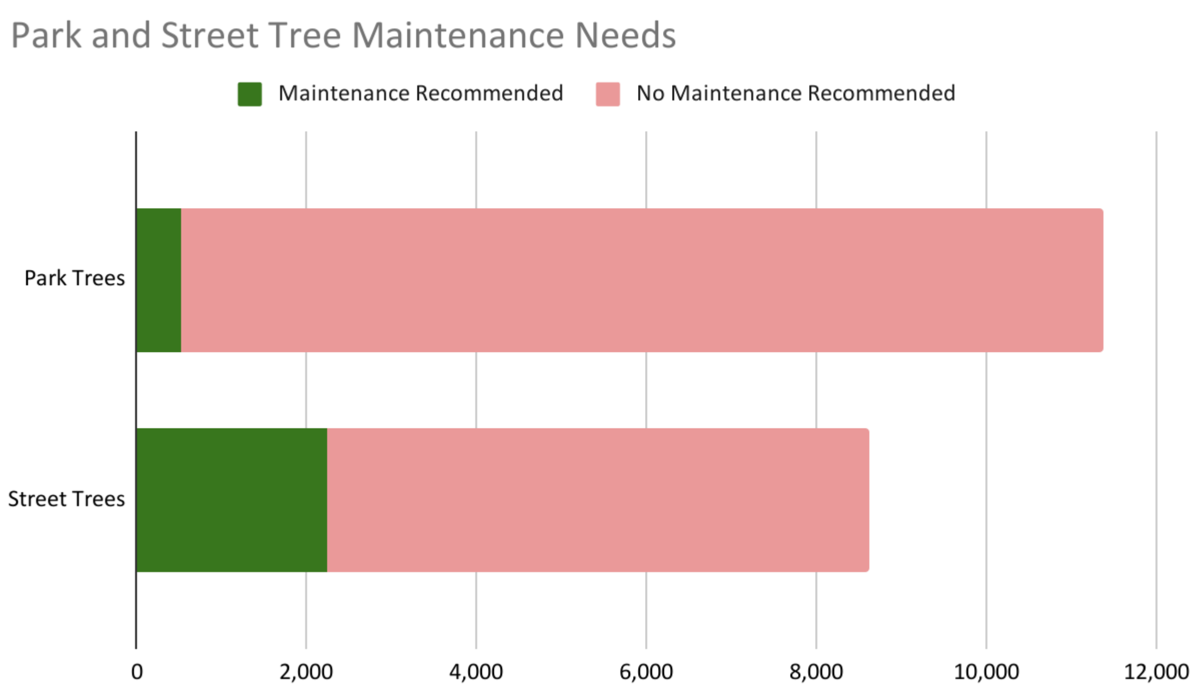


Figure 12: Park and Street Tree Maintenance Needs

5.1 Park and Street Tree Maintenance Needs

Trees along Streets and in Parks were commonly prescribed some form of pruning treatment, but tree removals and other maintenance needs were also prescribed. Across the City, pruning work accounted for 85% of the workload for this population, with Street Trees having the most pruning work prescribed (2,179 trees or 79% of the total population). Trees needing removal accounted for 15% of the tree population, with the majority of these being in Parks (346 trees or 13% of the total population). Other forms of tree maintenance made up less than 1% of the total tree population's Primary Maintenance Needs.

Table 12: Detail of Street and Park Tree Maintenance Needs

General Maintenance	Pruning		Removal		Other Tree Care		Total
	Count	% of Pop	Count	% of Pop	Count	% of Pop	Count
Park Trees	172	6%	346	13%	4	0%	522
Street Trees	2,179	79%	55	2%		0%	2,234
Grand Total	**2,351**	**85%**	**401**	**15%**	**4**	**0%**	**2,756**

Pruning

Trees were also assigned a Maintenance Detail attribute, which provides more specific information about their Primary Maintenance Need. In this category, 2,334 trees needing some form of pruning treatment had specific treatments recommended. Of these trees, 7% were Park Trees while 93% were street trees. The most common pruning treatment along streets was for Clearance (87% of all trees assigned a pruning task). Other pruning treatments such as Structural pruning and pruning of Deadwood were prescribed in lesser proportions (10% and 3%, respectively).

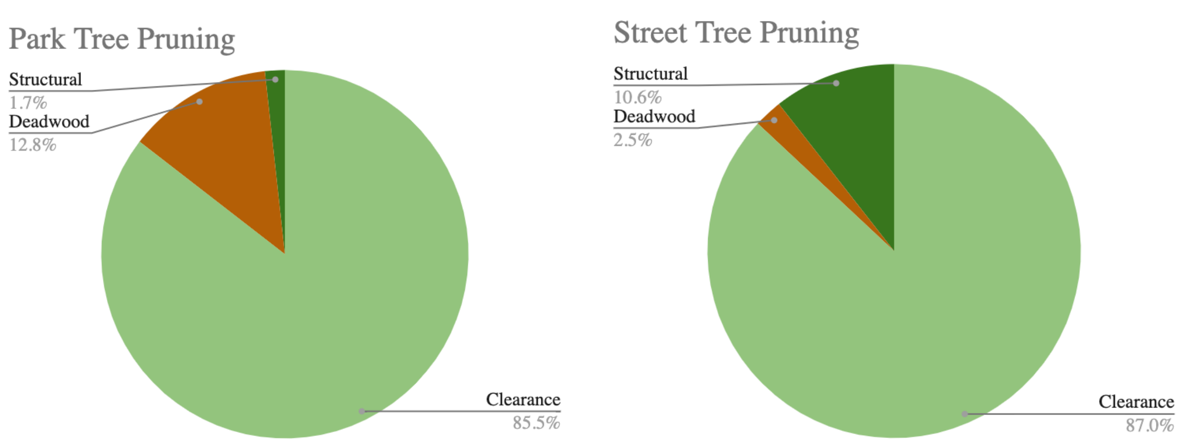


Figure 13: Detail of Park and Street Tree Pruning Needs by Percent of Tree Populations.

Table 13: Detail of Park and Street Tree Pruning Needs by Number of Trees.

Pruning	Clearance	Deadwood	Structural	Total
Park	147	22	3	172

Street	1,880	53	229	2,162
Grand Total	**2,027**	**75**	**232**	**2,334**

Removals

There were 401 trees recommended for removal along streets and in parks. The significance of this workload is better understood by considering the size distribution of these trees. Smaller trees are typically less costly to remove and are also likely a lower risk to public safety. In Sammamish, the majority of trees recommended for removal were sized 13-24” (159 trees or 40% of all removals), followed by trees sized 7-12” (130 trees or 32% of all removals). 86% of trees recommended for removal were found in Parks, while the other 14% were Street Trees.

Table 14: Detail of Park and Street Tree Removal Needs

Tree Removals	DBH Class				
	0-6"	7-12"	13-24"	>24"	Total
Park Trees	15	116	152	63	346
Street Trees	32	14	7	2	55
Total	**47**	**130**	**159**	**65**	**401**

Other Maintenance Treatments

Various other maintenance treatments were prescribed for the park and street tree populations. A total of 163 trees were assigned an “Other” maintenance detail task (neither pruning nor removal). The most common treatment prescribed was to Remove Stakes (145 trees or 89% of “Other” recommendations, all of which were located along streets). This maintenance task refers to young trees which were initially staked for support at the time of planting and are now established. Their stakes should be removed to prevent the hardware from girdling the tree. A few trees were also assigned a maintenance task of Inspect (13 trees or 8%) or Monitor (5 trees or 3%). These maintenance tasks refer to trees that will require further review beyond their initial assessment during the inventory.

Table 15: Detail of Other Park and Street Tree Maintenance Needs

Other Treatments	Inspect	Monitor	Remove Stakes	Total
Park	5	1	-	6
Street	8	4	145	157
Grand Total	**13**	**5**	**145**	**163**

Conclusion

This analysis describes the current structural characteristics of Sammamish's public tree resource, using established numerical modeling and statistical methods to provide a general accounting of the benefits. The analysis provides a "snapshot" of this resource at its current population, structure, and condition. Trees are providing quantifiable impacts on air quality, reduction in atmospheric CO_2, stormwater runoff, and aesthetic benefits. Sammamish's 19,964 street and park trees provide cumulative annual benefits worth $82,673, a value of $4.14 per tree and $1.24 per capita.

Industry standards suggest that no one tree species should represent more than 10% of the urban forest. As of 2022, at the species level, Douglas fir (*Pseudotsuga menziesii,* 26.6%), red maple (*Acer rubrum,* 15.3%) and Western red cedar (*Thuja plicata,* 13%) exceed this rule. Additionally, no one genera should represent more than 20% of a population. In Sammamish, maples (*Acer* spp.) represent 46.8% of the overall street and park tree population and violate this rule. Future new and replacement tree plantings should focus on increasing species diversity to improve urban forest resilience.

Sammamish's street and park tree resource has an established age distribution in fair or better condition with 107 distinct species. The City should continue to focus resources on preserving existing and mature trees to promote health, strong structure, and tree longevity. Structural and training pruning for young trees will maximize the value of this resource, reduce long-term maintenance costs, reduce risk, and ensure that as trees mature, they provide the greatest possible benefits over time.

Based on this resource analysis, the city would benefit from the following management activity:

- Increase genus and species diversity in new and replacement tree plantings to reduce reliance on abundant groups. At a minimum, managers should strive for no species representing more than 10% of the overall population and no genus representing more than 20% of the overall population.
- Use available planting sites to improve diversity, increase benefits, and further distribute the age distribution of street and park trees.
- Prioritize planting replacement trees for those trees that have previously been removed.
- Identify additional planting sites for trees and use the largest stature tree possible where space allows.
- Consider successional planting of important species, as determined by relative performance index (RPI) and the relative age distribution.
- Species that are adequately represented by established age distributions but lack recent plantings should receive priority care.
- Prioritize structural pruning for young trees and a regular maintenance cycle for all trees.
- Regularly inspect trees to identify and mitigate structural and age-related defects to manage risk and reduce the likelihood of tree and branch failure.
- Consider opportunities to further support wildlife habitat and pollinators, including protecting diverse vegetation and preserving snags and deadwood in natural areas where targets are unlikely.

Urban forest managers can better anticipate future trends with an understanding of the status of the tree population. Managers can also anticipate challenges and devise plans to increase the current level of benefits. Performance data from this analysis can be used to make determinations regarding species selection, distribution, and maintenance policies. Understanding the current structure is necessary for establishing goals and performance objectives and can serve as a benchmark for measuring future success.

Sammamish's public trees are of vital importance to the environmental, social, and economic well-being of the community. Inventory data can be used to plan a proactive and forward-looking approach to the future care of street and park trees. Updates should continue to be incorporated into the inventory as regular maintenance is performed, including updating the diameter and condition of existing trees. Current inventory data will help staff to efficiently plan maintenance activities and will provide a strong basis for making informed management decisions. A continued commitment to planting, maintaining, and preserving these trees will support the health and welfare of the City and the community at large.

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Appendix B: i-Tree Methods

The i-Tree *Eco* model uses inventory data, local hourly air pollution, and meteorological data to quantify the urban forest and its structure and benefits (Nowak & Crane, 2000), including:

- Urban forest structure (e.g., genus composition, tree health, leaf area, etc.).
- Amount of pollution removed hourly by the urban forest, and its associated percent air quality improvement throughout a year. Pollution removal is calculated for ozone, sulfur dioxide, nitrogen dioxide, carbon monoxide and particulate matter (<2.5 microns and <10 microns).
- Total carbon stored and net carbon annually sequestered by the urban forest.
- Structural value of the forest as a replacement cost.
- Potential impact of infestations by pests or pathogen.

Definitions and Calculations

Avoided surface water runoff value is calculated based on rainfall interception by vegetation, specifically the difference between annual runoff with and without vegetation. Although tree leaves, branches, and bark may intercept precipitation and thus mitigate surface runoff, only the precipitation intercepted by leaves is accounted for in this analysis. The U.S. value of avoided runoff, $0.0089 per gallon, is based on the U.S. Forest Service's Community Tree Guide Series (McPherson et al, 1999-2010; Peper et al, 2009; 2010; Vargas et al, 2007a-2008).

Carbon dioxide emissions from automobile assumed six pounds of carbon per gallon of gasoline if energy costs of refinement and transportation are included (Graham et al, 1992).

Carbon emissions were calculated based on the total city carbon emissions from the 2010 US per capita carbon emissions (Carbon Dioxide Information Analysis Center, 2010) This value was multiplied by the population of Sammamish (63,470) to estimate total city carbon emissions.

Carbon sequestration is removal of carbon from the air by plants. Carbon storage and carbon sequestration values are calculated based on $133.04 per short ton (EPA, 2015; Interagency Working Group on Social Cost of Carbon, 2015).

Carbon storage is the amount of carbon bound up in the above-ground and below-ground parts of woody vegetation. Carbon storage and carbon sequestration values are calculated based on $133.04 per ton (EPA, 2015; Interagency Working Group on Social Cost of Carbon, 2015).

Diameter at Breast Height (DBH) is the diameter of the tree measured 4’5” above grade.

Energy savings are calculated based on the prices of $85.00 per MWH and $48.19 per MBTU.

Household emissions average is based on average electricity kWh usage, natural gas Btu usage, fuel oil Btu usage, kerosene Btu usage, LPG Btu usage, and wood Btu usage per household in 2009 (EIA, 2013; EIA, 2014), CO_2, SO_2, and NO_3 power plant emission per KwH (Leonardo Academy, 2011), CO emission per kWh assumes 1/3 of one percent of C emissions is CO (EIA, 2014), PM10 emission per kWh (Layton 2004), CO_2, NO_3, SO_2, and CO emission per Btu for natural gas, propane and butane (average used to represent LPG), Fuel #4 and #6 (average used to represent fuel oil and kerosene) (Leonardo Academy, 2011), CO_2

emissions per Btu of wood (EIA, 2014), CO, NO_3 and SO_2 emission per Btu based on total emissions and wood burning (tons) from (British Columbia Ministry, 2005; Georgia Forestry Commission, 2009).

Leaf area was estimated using measurements of crown dimensions and percentage of crown canopy missing.

Monetary values ($) are reported in US dollars throughout the report.

Ozone (O_3) is an air pollutant that is harmful to human health. Ozone forms when nitrogen oxide from fuel combustion and volatile organic gases from evaporated petroleum products react in the presence of sunshine. In the absence of cooling effects provided by trees, higher temperatures contribute to ozone (O_3) formation.

Passenger automobile emissions assumed 0.72 pounds of carbon per driven mile (U.S. Environmental Protection Agency, 2010) multiplied by the average miles driven per vehicle in 2011 (Federal Highway Administration, 2013).

Pollution removal is calculated based on the prices of $1,469 per ton (carbon monoxide), $10,339 per ton (ozone), $10,339 per ton (nitrogen dioxide), $2,531 per ton (sulfur dioxide), $6,903 per ton (particulate matter less than 2.5 microns) (Nowak et al., 2014).

Potential pest impacts were estimated based on tree inventory information from the study area combined with i-Tree *Eco* pest range maps. The input data included species, DBH, total height, height to crown base, crown width, percent canopy missing, and crown dieback. In the model, potential pest risk is based on pest range maps and the known pest host species that are likely to experience mortality.

Pest range maps for 2012 from the Forest Health Technology Enterprise Team (FHTET) (Forest Health Technology Enterprise Team, 2014) were used to determine the proximity of each pest to King County For the county, it was established whether the insect/disease occurs within the county, is within 250 miles of the county edge, is between 250 and 750 miles away, or is greater than 750 miles away. FHTET did not have pest range maps for Dutch elm disease and chestnut blight. The range of these pests was based on known occurrence and the host range, respectively (Eastern Forest Environmental Threat Assessment Center; Worrall 2007). Due to the dates of some of these resources, pests may have encroached closer to the tree resource in recent years.

Structural value is based on the physical resource itself (e.g., the cost of having to replace a tree with a similar tree). Structural values were based on valuation procedures of the Council of Tree and Landscape Appraisers, which uses tree species, diameter, condition, and location information (Nowak et al 2002a; 2002b).

Ton is equivalent to a U.S. short ton, or 2,000 pounds.

Appendix C: Street and Park Tree Tables

Table 1: Botanical and Common Names of Tree Species

Common Name	Botanical Name	Number of Trees	% of Population
Douglas fir	*Pseudotsuga menziesii*	5,314	26.6%
Red Maple	*Acer rubrum*	3,051	15.3%
western redcedar	*Thuja plicata*	2,595	13%
Big leaf Maple	*Acer marcophyllum*	1,309	6.6%
red alder	*Alnus rubra*	1,249	6.3%
plum spp	*Prunus spp*	797	4%
ash spp	*Fraxinus spp*	666	3.3%
Black cottonwood	*Populus trichocarpa*	598	3.0%
Callery Pear	*Pyrus calleryana*	337	1.7%
Pine spp	*Pinus spp*	323	1.6%
western hemlock	*Tsuga heterophylla*	255	1.3%
Kanzan Cherry	*Prunus 'Kanzan'*	228	1.1%
Sweetgum	*Liquidambar styraciflua*	225	1.1%
Littleleaf linden	*Tilia cordata*	196	1.0%
Japanese zelkova	*Zelkova serrata*	188	<0.1%
Katsura tree	*Cercidiphyllum japonicum*	152	<0.1%
Port Orford cedar	*Chamaecyoparis lawsoniana*	134	<0.1%
Hawthorn spp	*Cragaegus spp*	108	<0.1%
European hornbeam	*Carpinus betulus*	100	<0.1%
Pacific Dogwood	*Cornus nuttallii*	100	<0.1%
vine maple	*Acer circinatum*	99	<0.1%
Norway spruce	*Picea abies*	97	<0.1%
London planetree	*Platanus x acerifolia*	97	<0.1%
Northern Red Oak	*Quercus rubra*	92	<0.1%

Oak spp	*Quercus*	82	<0.1%
False Cypress spp	*Chamaesyparis*	75	<0.1%
Spruce spp	*Picea spp*	73	<0.1%
Cherry Plum	*Prunus cerasifera*	70	<0.1%
Mountain Hemolck	*Tsuga mertensiana*	69	<0.1%
Paper Birch	*Betula papyrifera*	68	<0.1%
common chokecherry	*Prunus virginiana*	62	<0.1%
paperbark maple	*Acer griseum*	61	<0.1%
deodar cedar	*Cedrus deodara*	57	<0.1%
apple spp	*Malus spp*	57	<0.1%
Freeman maple	*Acer x freemanii*	56	<0.1%
Japanese maple	*Acer palmatum*	56	<0.1%
Incense cedar	*Calocedrus decurrens*	55	<0.1%
Dogwood spp	*Cornus spp*	54	<0.1%
Japanese Red Cedar	*Cryptomeria japonica*	54	<0.1%
Northern Pin Oak	*Quercus ellipsoidalis*	50	<0.1%
maple spp	*Acer spp*	46	<0.1%
Blue Spruce	*Picea pungens*	45	<0.1%
Quaking Aspen	*Populus tremuloides*	40	<0.1%
Willow spp	*Salix spp*	35	<0.1%
Noble Fir	*Abies procera*	32	<0.1%
Sugar Maple	*Acer saccharum*	32	<0.1%
Pear spp	*Pyrus spp*	29	<0.1%
Zelkova spp	*Zelkova spp*	28	<0.1%
Norway Maple	*Acer platanoides*	26	<0.1%
Birch spp	*Betula spp*	23	<0.1%
southern magnolia	*Magnolia grandiflora*	20	<0.1%
tulip tree	*Liriodendron tulipifera*	17	<0.1%
Common Plum	*Prunus domestica*	17	<0.1%
Fir spp	*Abies spp*	15	<0.1%
pacific madrone	*Arbutus menziesii*	15	<0.1%

Atlas cedar	*Cedrus atlantica*	14	<0.1%
Oriental arborviate	*Platyclasdus orientalis*	14	<0.1%
hinoki cypress	*Chamaecyparis obtusa*	13	<0.1%
Green Ash	*Fraxinus pennsylvanica*	13	<0.1%
White Oak	*Quercus alba*	13	<0.1%
black tupelo	*Nyssa sylvatica*	12	<0.1%
Black Locust	*Robinia pseudoacacia*	11	<0.1%
grand fir	*Abies grandis*	10	<0.1%
European mountain ash	*Sorbus aucuparia*	10	<0.1%
lace-leaf maple	*Acer palmatum 'Seiryu'*	7	<0.1%
European Beech	*Fagus sylvatica*	7	<0.1%
Japanese flowering cherry	*Prunus serrulata*	7	<0.1%
Pin Oak	*Quercus palustris*	7	<0.1%
Thornless honeylocust	*Glenditsia triacanthos inermis*	6	<0.1%
Persian ironwood	*Parrotia persica*	6	<0.1%
Balasam Fir	*Abies balsamea*	5	<0.1%
Hazelnut spp	*Corylus spp*	5	<0.1%
Flowering Plum	*Prunus domestica*	5	<0.1%
Smooth Service berry	*Amelanchier laevis*	4	<0.1%
Crepe Myrtle	*Lagerstroemia indica*	4	<0.1%
Scots pine	*Pinus sylverstris*	4	<0.1%
Giant Sequoia	*Sequoiodendron giganteum*	4	<0.1%
American chestnut	*Castanea dentata*	3	<0.1%
Eastern redbud	*Cercis canadensis*	3	<0.1%
Snowdrop tree	*Halesia diptera*	3	<0.1%
Magnolia spp	*Magnolia spp*	3	<0.1%
Austrian Pine	*Pinus nigra*	3	<0.1%
Japanese snowbell	*Styrax japonicus*	3	<0.1%
Yew spp	*Taxus spp*	3	<0.1%
Northern hackberry	*Celtis occidentalis*	2	<0.1%
Smoke tree	*Cotinus coggygria*	2	<0.1%

Ginkgo	*Ginkgo biloba*	2	<0.1%
English Holly	*Llex aquifolium*	2	<0.1%
Marshelder spp		2	<0.1%
Dawn Redwood	*Metasequoia glyptostroboides*	2	<0.1%
Empress Tree	*Paulownia tomentosa*	2	<0.1%
Yoshino Flowering cherry	*Prunus x yedoensis*	2	<0.1%
Pussy willow	*Salix discolor*	2	<0.1%
Red cedar spp	*Juniperus viriniana*	2	<0.1%
Monkeypuzzle tree	*Araucaria araucana*	1	<0.1%
Catalpa spp	*Catalpa spp*	1	<0.1%
Mockernut hickory	*Carya tomentosa*	1	<0.1%
Common fig	*Ficus carica*	1	<0.1%
Honeylocust	*Gleditsia triacanthos*	1	<0.1%
holly spp	*Ilex spp*	1	<0.1%
Western white pine	*Pinus monticola*	1	<0.1%
American Sycamore	*Platanus occidentalis*	1	<0.1%
White Poplar	*Populua alba*	1	<0.1%
Black cherry	*Prunus serotina*	1	<0.1%
scarlet oak	*Quercus coccinea*	1	<0.1%
sumac spp	*Rhus typhina*	1	<0.1%
American snowbell	*Styrax americanus*	1	<0.1%
Total		**19,964**	**100%**

Table 2: Population Summary for All Tree Species

	% of Species within DBH Class (in)									
Species	**0 – 3**	**3 – 6**	**6 – 12**	**12 – 18**	**18 – 24**	**24 – 30**	**30 – 36**	**36 – 42**	**42 – 48**	**48+**
American chestnut				66.7	33.3					
American snowbell	100.0									
American sycamore				100.0						
apple spp	63.2	3.5	8.8	14.0	7.0	3.5				
ash spp	12.0	19.5	37.4	25.1	3.2	2.3	0.5	0.2		
Atlas cedar	21.4		7.1	57.1		14.3				
Austrian pine			100.0							
Balsam fir			60.0	40.0						
Bigleaf maple	0.2	5.1	34.5	26.4	13.0	12.1	2.4	2.4	1.6	2.1
birch spp	4.3	26.1	43.5	17.4	4.3	4.3				
Black cherry				100.0						
Black cottonwood		5.5	28.1	25.3	14.5	16.4	4.8	2.3	1.2	1.8
Black locust		18.2	36.4	27.3	18.2					
Black tupelo	16.7		83.3							
Blue spruce	11.1	24.4	53.3	8.9		2.2				
Callery pear	38.0	41.8	19.9	0.3						
catalpa spp						100.0				
Cherry plum	61.4	18.6	20.0							
Common chokecherry	1.6	30.6	62.9	3.2	1.6					
Common fig		100.0								
Common plum	100.0									
Dawn redwood				50.0	50.0					
Deodar cedar		17.5	17.5	26.3	15.8	19.3	3.5			
dogwood spp	57.4	35.2	7.4							
Douglas fir	1.5	4.4	20.3	24.7	17.1	20.3	5.8	3.8	1.2	0.8
Eastern redbud	66.7	33.3								
English holly	50.0	50.0								
European beech	28.6	57.1	14.3							
European hornbeam	29.0	34.0	36.0	1.0						
European mountain ash		100.0								
false cypress spp	25.3	17.3	34.7	13.3	8.0	1.3				
fir spp	6.7	26.7	20.0	13.3	33.3					
Flowering plum	100.0									
Freeman maple	8.9	46.4	44.6							
Giant sequoia			25.0	25.0		25.0			25.0	
Ginkgo	100.0									

Grand fir	60.0	30.0	10.0							
Green ash	7.7	38.5	53.8							
hawthorn spp	81.5	9.3	6.5	1.9	0.9					
hazelnut spp			60.0	40.0						
Hinoki cypress	61.5	7.7	23.1	7.7						
holly spp			100.0							
Honeylocust			100.0							
Incense cedar	56.4	14.5	12.7	12.7	1.8	1.8				
Japanese flowering cherry		85.7	14.3							
Japanese maple	39.3	26.8	28.6	5.4						
Japanese red cedar	20.4	24.1	40.7	14.8						
Japanese snowbell		66.7	33.3							
Japanese zelkova	73.9	12.8	11.7	0.5		1.1				
Kanzan cherry	19.3	35.1	28.5	15.8	1.3					
Katsura tree	40.1	28.3	26.3	4.6	0.7					
Lace-leaf maple	85.7	14.3								
lagerstroemia spp	100.0									
Littleleaf linden	30.6	16.3	53.1							
London planetree		8.2	38.1	47.4	4.1	2.1				
magnolia spp			66.7	33.3						
maple spp	65.2	19.6	13.0	2.2						
marshelder spp		50.0	50.0							
Mockernut hickory				100.0						
Monkeypuzzle tree			100.0							
Mountain hemlock	30.4	23.2	24.6	14.5	5.8		1.4			
Noble fir	12.5	31.3	50.0	6.3						
Northern hackberry		100.0								
Northern pin oak	16.0	54.0	28.0	2.0						
Northern red oak	14.1	26.1	34.8	23.9	1.1					
Norway maple	73.1	23.1	3.8							
Norway spruce		20.6	50.5	23.7	2.1	3.1				
oak spp	14.6	6.1	37.8	26.8	11.0	3.7				
Oriental arborvitae		78.6	14.3	7.1						
Pacific dogwood	31.0	50.0	19.0							
Pacific madrone	6.7	26.7	53.3	6.7		6.7				
Paper birch	64.7	7.4	17.6	8.8		1.5				
Paperbark maple	54.1	42.6	3.3							
pear spp	79.3	13.8	6.9							
Persian ironwood	100.0									
Pin oak	42.9		57.1							

pine spp	2.5	16.7	43.7	27.2	7.1	2.5	0.3			
plum spp	22.7	31.9	35.6	8.2	1.1	0.5				
Port orford cedar	11.2	30.6	33.6	17.2	5.2	2.2				
Pussy willow		50.0	50.0							
Quaking aspen		15.0	50.0	30.0	5.0					
Red alder		11.1	62.8	19.4	3.7	3.0	0.1			
red cedar spp			100.0							
Red maple	29.2	36.3	21.2	11.2	1.8	0.3				
Royal paulownia			100.0							
Scarlet oak			100.0							
Scots pine		100.0								
Smoke tree		50.0	50.0							
Smooth service berry	100.0									
Snowdrop tree	66.7	33.3								
Southern magnolia	60.0	35.0	5.0							
spruce spp	17.8	21.9	50.7	1.4	4.1	1.4		2.7		
Sugar maple	90.6	9.4								
sumac spp		100.0								
Sweetgum	20.9	31.6	36.4	8.4	2.7					
Thornless honeylocust		50.0	50.0							
Tulip tree	5.9	5.9	82.4	5.9						
Vine maple	39.4	31.3	23.2	6.1						
Western hemlock		5.9	34.9	31.8	11.8	11.4	1.6	2.4	0.4	
Western red cedar	0.9	6.0	28.4	21.0	12.3	14.5	5.7	5.9	3.2	2.1
Western white pine		100.0								
White oak		53.8	46.2							
White poplar	100.0									
willow spp		5.7	51.4	8.6	11.4	11.4	8.6	2.9		
yew spp		66.7	33.3							
Yoshino flowering cherry	100.0									
zelkova spp	53.6	25.0	17.9		3.6					

Table 3 Importance Values for All Tree Species

Species	Percent Population	Percent Leaf Area	Importance Value
Douglas fir	26.6	35.9	62.6
Western red cedar	13.0	19.2	32.2
Red maple	15.3	6.1	21.4
Bigleaf maple	6.6	14.5	21.0
Red alder	6.3	4.4	10.6
Black cottonwood	3.0	5.1	8.1
ash spp	3.3	2.8	6.2
plum spp	4.0	1.5	5.5
pine spp	1.6	1.3	2.9
Western hemlock	1.3	1.2	2.4
Callery pear	1.7	0.3	2.0
Kanzan cherry	1.1	0.5	1.6
Sweetgum	1.1	0.5	1.6
Littleleaf linden	1.0	0.3	1.2
Katsura tree	0.8	0.4	1.1
London planetree	0.5	0.6	1.1
Japanese zelkova	0.9	0.2	1.1
Port orford cedar	0.7	0.3	1.0
oak spp	0.4	0.5	0.9
Northern red oak	0.5	0.5	0.9
Norway spruce	0.5	0.4	0.9
Vine maple	0.5	0.2	0.7
European hornbeam	0.5	0.2	0.7
hawthorn spp	0.5	0.0	0.6
Deodar cedar	0.3	0.3	0.6
Pacific dogwood	0.5	0.1	0.6
false cypress spp	0.4	0.2	0.5
spruce spp	0.4	0.1	0.5
Mountain hemlock	0.3	0.2	0.5

Japanese red cedar	0.3	0.2	0.4
Paper birch	0.3	0.1	0.4
Common chokecherry	0.3	0.1	0.4
Freeman maple	0.3	0.1	0.4
Cherry plum	0.4	0.1	0.4
Paperbark maple	0.3	0.1	0.4
willow spp	0.2	0.2	0.4
Incense cedar	0.3	0.1	0.4
Northern pin oak	0.3	0.1	0.3
apple spp	0.3	0.1	0.3
Japanese maple	0.3	0.1	0.3
Blue spruce	0.2	0.1	0.3
maple spp	0.2	0.1	0.3
dogwood spp	0.3	0.0	0.3
Quaking aspen	0.2	0.1	0.3
Noble fir	0.2	0.1	0.2
birch spp	0.1	0.1	0.2
zelkova spp	0.1	0.0	0.2
Sugar maple	0.2	0.0	0.2
pear spp	0.1	0.0	0.2
Tulip tree	0.1	0.1	0.2
Norway maple	0.1	0.0	0.1
fir spp	0.1	0.0	0.1
Atlas cedar	0.1	0.0	0.1
Pacific madrone	0.1	0.0	0.1
Southern magnolia	0.1	0.0	0.1
Black locust	0.1	0.1	0.1
Green ash	0.1	0.0	0.1
White oak	0.1	0.0	0.1
Black tupelo	0.1	0.0	0.1
Common plum	0.1	0.0	0.1

Oriental arborvitae	0.1	0.0	0.1
Hinoki cypress	0.1	0.0	0.1
Pin oak	0.0	0.0	0.1
Grand fir	0.1	0.0	0.1
Giant sequoia	0.0	0.0	0.1
European mountain ash	0.1	0.0	0.1
European beech	0.0	0.0	0.0
Thornless honeylocust	0.0	0.0	0.0
American chestnut	0.0	0.0	0.0
hazelnut spp	0.0	0.0	0.0
Balsam fir	0.0	0.0	0.0
Japanese flowering cherry	0.0	0.0	0.0
Lace-leaf maple	0.0	0.0	0.0
Persian ironwood	0.0	0.0	0.0
Dawn redwood	0.0	0.0	0.0
Flowering plum	0.0	0.0	0.0
magnolia spp	0.0	0.0	0.0
Scots pine	0.0	0.0	0.0
Austrian pine	0.0	0.0	0.0
Smooth service berry	0.0	0.0	0.0
lagerstroemia spp	0.0	0.0	0.0
Japanese snowbell	0.0	0.0	0.0
catalpa spp	0.0	0.0	0.0
yew spp	0.0	0.0	0.0
Snowdrop tree	0.0	0.0	0.0
Eastern redbud	0.0	0.0	0.0
American sycamore	0.0	0.0	0.0
Black cherry	0.0	0.0	0.0
Royal paulownia	0.0	0.0	0.0
Mockernut hickory	0.0	0.0	0.0
Northern hackberry	0.0	0.0	0.0

marshelder spp	0.0	0.0	0.0
red cedar spp	0.0	0.0	0.0
Smoke tree	0.0	0.0	0.0
Pussy willow	0.0	0.0	0.0
English holly	0.0	0.0	0.0
Yoshino flowering cherry	0.0	0.0	0.0
Ginkgo	0.0	0.0	0.0
Scarlet oak	0.0	0.0	0.0
Monkeypuzzle tree	0.0	0.0	0.0
holly spp	0.0	0.0	0.0
Honeylocust	0.0	0.0	0.0
Common fig	0.0	0.0	0.0
Western white pine	0.0	0.0	0.0
sumac spp	0.0	0.0	0.0
White poplar	0.0	0.0	0.0
American snowbell	0.0	0.0	0.0

Table 4: Condition and RPI for All Tree Species

Species	Good (%)	Fair (%)	Poor (%)	Critical (%)	Dead (%)	RPI	# of Trees	% of all Trees
American chestnut	0.0	66.7	33.3	0	0.0	0.9	3	0
American snowbell	0.0	100.0	0.0	0	0.0	1.0	1	0
American sycamore	0.0	100.0	0.0	0	0.0	1.0	1	0
apple spp	29.8	50.9	19.3	0	0.0	1.0	57	0.3
ash spp	18.5	75.8	4.5	0.2	1.1	1.1	666	3.3
Atlas cedar	21.4	78.6	0.0	0	0.0	1.1	14	0.1
Austrian pine	33.3	66.7	0.0	0	0.0	1.1	3	0
Balsam fir	0.0	100.0	0.0	0	0.0	1.0	5	0
Bigleaf maple	0.7	89.1	8.0	0.5	1.8	1.0	1,309	6.6
birch spp	0.0	100.0	0.0	0	0.0	1.0	23	0.1
Black cherry	0.0	100.0	0.0	0	0.0	1.0	1	0
Black cottonwood	0.2	87.3	7.2	0.7	4.7	1.0	598	3
Black locust	0.0	100.0	0.0	0	0.0	1.0	11	0.1
Black tupelo	83.3	16.7	0.0	0	0.0	1.2	12	0.1
Blue spruce	6.7	93.3	0.0	0	0.0	1.1	45	0.2
Callery pear	17.8	81.6	0.6	0	0.0	1.1	337	1.7
catalpa spp	0.0	100.0	0.0	0	0.0	1.0	1	0
Cherry plum	30.0	68.6	1.4	0	0.0	1.1	70	0.4
Common chokecherry	72.6	22.6	3.2	1.6	0.0	1.2	62	0.3
Common fig	0.0	100.0	0.0	0	0.0	1.0	1	0
Common plum	35.3	64.7	0.0	0	0.0	1.1	17	0.1
Dawn redwood	0.0	100.0	0.0	0	0.0	1.0	2	0
Deodar cedar	3.5	96.5	0.0	0	0.0	1.1	57	0.3
dogwood spp	50.0	48.1	1.9	0	0.0	1.1	54	0.3
Douglas fir	5.7	86.0	3.5	0.4	4.3	1.0	5,314	26.6
Eastern redbud	0.0	100.0	0.0	0	0.0	1.0	3	0
English holly	50.0	50.0	0.0	0	0.0	1.1	2	0
European beech	14.3	85.7	0.0	0	0.0	1.1	7	0

European hornbeam	5.0	95.0	0.0	0	0.0	1.1	100	0.5
European mountain ash	0.0	40.0	60.0	0	0.0	0.8	10	0.1
false cypress spp	25.3	68.0	6.7	0	0.0	1.1	75	0.4
fir spp	13.3	86.7	0.0	0	0.0	1.1	15	0.1
Flowering plum	100.0	0.0	0.0	0	0.0	1.3	5	0
Freeman maple	0.0	100.0	0.0	0	0.0	1.0	56	0.3
Giant sequoia	0.0	100.0	0.0	0	0.0	1.0	4	0
Ginkgo	100.0	0.0	0.0	0	0.0	1.3	2	0
Grand fir	50.0	20.0	20.0	10	0.0	1.0	10	0.1
Green ash	84.6	15.4	0.0	0	0.0	1.2	13	0.1
hawthorn spp	50.0	49.1	0.9	0	0.0	1.1	108	0.5
hazelnut spp	0.0	40.0	60.0	0	0.0	0.8	5	0
Hinoki cypress	7.7	92.3	0.0	0	0.0	1.1	13	0.1
holly spp	0.0	100.0	0.0	0	0.0	1.0	1	0
Honeylocust	100.0	0.0	0.0	0	0.0	1.3	1	0
Incense cedar	47.3	52.7	0.0	0	0.0	1.1	55	0.3
Japanese flowering cherry	0.0	100.0	0.0	0	0.0	1.0	7	0
Japanese maple	33.9	66.1	0.0	0	0.0	1.1	56	0.3
Japanese red cedar	44.4	48.1	7.4	0	0.0	1.1	54	0.3
Japanese snowbell	66.7	33.3	0.0	0	0.0	1.2	3	0
Japanese zelkova	78.2	19.7	2.1	0	0.0	1.2	188	0.9
Kanzan cherry	14.5	78.5	6.6	0.4	0.0	1.0	228	1.1
Katsura tree	26.3	71.7	2.0	0	0.0	1.1	152	0.8
Lace-leaf maple	57.1	42.9	0.0	0	0.0	1.2	7	0
lagerstroemia spp	50.0	50.0	0.0	0	0.0	1.1	4	0
Littleleaf linden	23.0	76.0	1.0	0	0.0	1.1	196	1
London planetree	9.3	90.7	0.0	0	0.0	1.1	97	0.5
magnolia spp	0.0	100.0	0.0	0	0.0	1.0	3	0
maple spp	41.3	52.2	4.3	0	2.2	1.1	46	0.2

marshelder spp	0.0	100.0	0.0	0	0.0	1.0	2	0
Mockernut hickory	0.0	100.0	0.0	0	0.0	1.0	1	0
Monkeypuzzle tree	100.0	0.0	0.0	0	0.0	1.3	1	0
Mountain hemlock	21.7	71.0	2.9	2.9	1.4	1.0	69	0.3
Noble fir	53.1	46.9	0.0	0	0.0	1.2	32	0.2
Northern hackberry	0.0	100.0	0.0	0	0.0	1.0	2	0
Northern pin oak	86.0	14.0	0.0	0	0.0	1.2	50	0.3
Northern red oak	45.7	53.3	1.1	0	0.0	1.1	92	0.5
Norway maple	26.9	73.1	0.0	0	0.0	1.1	26	0.1
Norway spruce	0.0	97.9	2.1	0	0.0	1.0	97	0.5
oak spp	3.7	96.3	0.0	0	0.0	1.1	82	0.4
Oriental arborvitae	7.1	92.9	0.0	0	0.0	1.1	14	0.1
Pacific dogwood	34.0	64.0	1.0	1	0.0	1.1	100	0.5
Pacific madrone	6.7	86.7	6.7	0	0.0	1.0	15	0.1
Paper birch	5.9	86.8	2.9	1.5	2.9	1.0	68	0.3
Paperbark maple	45.9	52.5	1.6	0	0.0	1.1	61	0.3
pear spp	86.2	13.8	0.0	0	0.0	1.2	29	0.1
Persian ironwood	100.0	0.0	0.0	0	0.0	1.3	6	0
Pin oak	42.9	57.1	0.0	0	0.0	1.1	7	0
pine spp	5.9	91.0	2.2	0.9	0.0	1.0	323	1.6
plum spp	10.5	75.4	10.8	0.8	2.5	1.0	797	4
Port orford cedar	3.7	96.3	0.0	0	0.0	1.1	134	0.7
Pussy willow	0.0	0.0	100.0	0	0.0	0.7	2	0
Quaking aspen	0.0	97.5	2.5	0	0.0	1.0	40	0.2
Red alder	0.0	69.6	15.5	1.9	13.1	0.8	1,249	6.3
red cedar spp	0.0	50.0	50.0	0	0.0	0.9	2	0
Red maple	20.6	77.5	1.6	0.2	0.1	1.1	3,051	15.3
Royal paulownia	0.0	100.0	0.0	0	0.0	1.0	2	0
Scarlet oak	100.0	0.0	0.0	0	0.0	1.3	1	0

Scots pine	0.0	100.0	0.0	0	0.0	1.0	4	0
Smoke tree	0.0	100.0	0.0	0	0.0	1.0	2	0
Smooth service berry	100.0	0.0	0.0	0	0.0	1.3	4	0
Snowdrop tree	0.0	100.0	0.0	0	0.0	1.0	3	0
Southern magnolia	15.0	85.0	0.0	0	0.0	1.1	20	0.1
spruce spp	5.5	89.0	5.5	0	0.0	1.0	73	0.4
Sugar maple	100.0	0.0	0.0	0	0.0	1.3	32	0.2
sumac spp	0.0	100.0	0.0	0	0.0	1.0	1	0
Sweetgum	16.9	80.4	2.7	0	0.0	1.1	225	1.1
Thornless honeylocust	100.0	0.0	0.0	0	0.0	1.3	6	0
Tulip tree	0.0	100.0	0.0	0	0.0	1.0	17	0.1
Vine maple	12.1	87.9	0.0	0	0.0	1.1	99	0.5
Western hemlock	0.0	49.4	23.1	3.9	23.5	0.7	255	1.3
Western red cedar	1.0	75.8	15.0	2	6.1	0.9	2,595	13
Western white pine	0.0	100.0	0.0	0	0.0	1.0	1	0
White oak	30.8	69.2	0.0	0	0.0	1.1	13	0.1
White poplar	100.0	0.0	0.0	0	0.0	1.3	1	0
willow spp	2.9	65.7	28.6	0	2.9	0.9	35	0.2
yew spp	0.0	100.0	0.0	0	0.0	1.0	3	0
Yoshino flowering cherry	100.0	0.0	0.0	0	0.0	1.3	2	0
zelkova spp	35.7	60.7	3.6	0.0	0.0	1.1	28	0.1
Total	**11.1**	**78**	**6.3**	**0.7**	**3.5**	**1**	**19,964**	**100**

Table 5: Annual Benefits for All Tree Species

Species	Tree number	Carbon Storage		Gross Carbon Sequestration		Avoided runoff		Pollution Removal		Replacement value ($)
	(#)	(ton)	($)	(ton/yr)	($/yr)	(ft^3/yr)	($/yr)	(ton/yr)	($/yr)	($)
Douglas fir	5,314	2,755.31	469,921.46	41.59	7,093.71	127,578.80	8,528.11	2.01	12,092.43	23,244,942.07
Red maple	3,051	435.37	74,252.18	23.69	4,040.06	21,682.07	1,449.36	0.34	2,055.11	2,529,220.43
Western red cedar	2,595	1,064.83	181,607.81	6.7	1,142.13	68,137.42	4,554.70	1.07	6,458.34	10,876,473.14
Bigleaf maple	1,309	1,163.85	198,495.87	22.16	3,779.10	51,332.11	3,431.34	0.81	4,865.46	5,911,588.46
Red alder	1,249	82.73	14,110.49	2.53	432.3	15,585.35	1,041.82	0.25	1,477.24	1,852,671.62
plum spp	797	145.69	24,847.64	4.91	836.9	5,207.79	348.12	0.08	493.62	715,656.72
ash spp	666	319.25	54,449.09	8.88	1,514.13	10,063.51	672.7	0.16	953.86	920,483.77
Black cottonwood	598	533.04	90,910.42	10.69	1,822.74	18,245.73	1,219.65	0.29	1,729.40	1,519,118.40
Callery pear	337	15.44	2,633.35	1.2	205.01	1,038.60	69.43	0.02	98.44	173,922.78
pine spp	323	154.6	26,367.46	4.37	745.98	4,699.99	314.17	0.07	445.48	355,773.80
Western hemlock	255	84.83	14,468.24	0.8	136.85	4,110.44	274.77	0.06	389.6	507,551.41
Kanzan cherry	228	47.87	8,163.54	2.02	344.43	1,692.61	113.14	0.03	160.43	245,011.27
Sweetgum	225	15.82	2,697.55	0.91	155.06	1,657.41	110.79	0.03	157.1	281,851.40
Littleleaf linden	196	10.73	1,829.88	0.68	116.06	932.56	62.34	0.01	88.39	156,989.69
Japanese zelkova	188	5.2	886.34	0.26	43.7	644.63	43.09	0.01	61.1	89,020.69
Katsura tree	152	6.15	1,049.69	0.32	55.15	1,355.79	90.63	0.02	128.51	137,434.33
Port orford cedar	134	29.3	4,996.70	0.81	138.98	1,189.28	79.5	0.02	112.73	135,638.02
hawthorn spp	108	3.14	535.92	0.14	23.14	127.13	8.5	0	12.05	30,125.40
European hornbeam	100	7.33	1,250.93	0.44	75.21	544.57	36.4	0.01	51.62	61,689.30
Pacific dogwood	100	4.18	713.4	0.33	56.68	196.83	13.16	0	18.66	53,499.22

Vine maple	99	17.7	3,018.26	0.74	126.2	760.65	50.85	0.01	72.1	62,136.57
Norway spruce	97	25.58	4,362.67	0.52	88.31	1,515.04	101.27	0.02	143.6	87,816.55
London planetree	97	24.08	4,106.54	0.8	136.76	2,301.48	153.84	0.04	218.14	276,555.50
Northern red oak	92	18.04	3,076.35	0.78	133.5	1,651.00	110.36	0.03	156.49	176,688.06
oak spp	82	39.87	6,799.43	1	170.57	1,841.54	123.1	0.03	174.55	233,097.40
false cypress spp	75	32.41	5,527.19	1.01	171.55	550.68	36.81	0.01	52.2	63,029.12
spruce spp	73	41.18	7,023.82	0.92	156.06	528.4	35.32	0.01	50.08	55,183.34
Cherry plum	70	3.33	567.11	0.22	38.05	196.01	13.1	0	18.58	28,565.83
Mountain hemlock	69	8.44	1,438.87	0.16	27.33	596.15	39.85	0.01	56.51	63,130.02
Paper birch	68	8.03	1,369.40	0.34	58.17	360.47	24.1	0.01	34.17	42,884.92
Common chokecherry	62	11.06	1,886.07	0.76	129.87	463.28	30.97	0.01	43.91	71,867.21
Paperbark maple	61	3.31	564.53	0.23	39.52	233.1	15.58	0	22.09	20,504.97
Deodar cedar	57	37.6	6,412.67	0.9	153.96	1,018.37	68.07	0.02	96.52	228,118.58
apple spp	57	14.81	2,525.22	0.17	29.75	198.51	13.27	0	18.82	62,576.47
Freeman maple	56	9.38	1,600.16	0.74	126.2	459.67	30.73	0.01	43.57	38,233.12
Japanese maple	56	3.9	665.24	0.13	22.56	187.76	12.55	0	17.8	35,932.98
Incense cedar	55	5.33	909.84	0.12	20.71	266.08	17.79	0	25.22	28,653.75
dogwood spp	54	1.79	304.83	0.2	34.08	63.63	4.25	0	6.03	17,277.47
Japanese red cedar	54	5.42	923.97	0.29	50.29	632.45	42.28	0.01	59.95	36,904.16
Northern pin oak	50	5.45	929.07	0.35	59.72	335.88	22.45	0.01	31.84	44,764.44
maple spp	46	5.26	897.02	0.3	50.51	247.58	16.55	0	23.47	19,135.92
Blue spruce	45	6.83	1,164.52	0.16	27.86	372.17	24.88	0.01	35.28	26,735.94
Quaking aspen	40	7.92	1,350.80	0.38	64.01	232.17	15.52	0	22.01	52,193.33
willow spp	35	68.99	11,766.52	0.9	153.63	658.77	44.04	0.01	62.44	89,102.43
Noble fir	32	3.12	531.72	0.17	29.3	234.57	15.68	0	22.23	16,958.15

Sugar maple	32	0.16	26.89	0.02	4.21	31.38	2.1	0	2.97	4,084.89
pear spp	29	0.68	115.3	0.05	9.07	44.18	2.95	0	4.19	7,569.65
zelkova spp	28	2.42	412.16	0.1	16.93	135.11	9.03	0	12.81	19,799.33
Norway maple	26	0.51	87.16	0.08	12.85	35.04	2.34	0	3.32	7,444.48
birch spp	23	14.54	2,480.56	0.4	68.68	345.66	23.11	0.01	32.76	44,526.46
Southern magnolia	20	0.38	65.54	0.03	5.83	49.01	3.28	0	4.65	5,338.82
Tulip tree	17	2.22	378.08	0.14	23.16	247.71	16.56	0	23.48	28,976.73
Common plum	17	0.02	3.62	0.01	1.79	5.02	0.34	0	0.48	1,005.38
fir spp	15	11.06	1,885.78	0.26	44.32	174.57	11.67	0	16.55	22,519.08
Pacific madrone	15	4.47	762.25	0.15	25.34	145.55	9.73	0	13.8	23,603.58
Atlas cedar	14	5.9	1,005.63	0.13	22.18	174.7	11.68	0	16.56	36,127.00
Oriental arborvitae	14	1.38	235.95	0.07	12.25	47.01	3.14	0	4.46	4,857.27
Hinoki cypress	13	1.12	191.19	0.03	5.73	41.11	2.75	0	3.9	4,353.10
Green ash	13	1	169.73	0.07	11.58	147.5	9.86	0	13.98	11,930.45
White oak	13	1.07	182.87	0.05	8.65	114.53	7.66	0	10.86	12,448.29
Black tupelo	12	1.09	186.46	0.07	12.4	126.54	8.46	0	11.99	16,479.01
Black locust	11	4.28	729.75	0.16	26.92	193.12	12.91	0	18.3	28,716.69
Grand fir	10	0.26	44.99	0.02	3.04	16.19	1.08	0	1.53	1,386.14
European mountain ash	10	0.26	44.1	0.03	5.24	10.54	0.7	0	1	3,520.82
Lace-leaf maple	7	0.19	32.09	0.03	4.71	11.99	0.8	0	1.14	1,287.29
European beech	7	0.32	54.64	0.02	3.1	44.99	3.01	0	4.26	3,957.94
Japanese flowering cherry	7	0.5	85.06	0.04	6.74	16.54	1.11	0	1.57	4,380.36
Pin oak	7	1.22	207.83	0.06	9.64	80.95	5.41	0	7.67	8,939.57
Thornless honeylocust	6	0.87	148.86	0.06	9.41	57.51	3.84	0	5.45	6,072.97
Persian ironwood	6	0.01	2.1	0	0.54	5.19	0.35	0	0.49	475.78

Balsam fir	5	1.13	192.92	0.02	3.51	55.68	3.72	0	5.28	5,475.81
hazelnut spp	5	2.4	409.94	0.06	10.27	56.99	3.81	0	5.4	7,213.39
Flowering plum	5	0.05	9.2	0.01	2	6.83	0.46	0	0.65	966.44
Smooth service berry	4	0	0.83	0	0.54	1.31	0.09	0	0.12	254.88
lagerstroemia spp	4	0	0.56	0	0.33	0.86	0.06	0	0.08	233.64
Scots pine	4	0.12	20.5	0.01	2.12	11.42	0.76	0	1.08	710.58
Giant sequoia	4	12.87	2,195.29	0.07	11.41	117.5	7.85	0	11.14	35,509.49
American chestnut	3	1.54	261.81	0.05	7.74	98.08	6.56	0	9.3	10,882.62
Eastern redbud	3	0.03	4.36	0	0.56	2.85	0.19	0	0.27	676.84
Snowdrop tree	3	0.03	5.12	0	0.55	5.86	0.39	0	0.56	1,081.06
magnolia spp	3	0.77	130.79	0.03	5.35	40.64	2.72	0	3.85	4,559.10
Austrian pine	3	0.33	56.35	0.01	2.37	24.99	1.67	0	2.37	3,119.93
Japanese snowbell	3	0.19	32.28	0.01	2.03	17.64	1.18	0	1.67	2,430.03
yew spp	3	0.38	63.98	0.02	3.85	11.67	0.78	0	1.11	1,050.25
Northern hackberry	2	0.03	4.41	0	0.38	6.85	0.46	0	0.65	1,071.64
Smoke tree	2	0.15	26.38	0.01	1.65	5.41	0.36	0	0.51	1,684.08
Ginkgo	2	0	0.07	0	0.03	0.76	0.05	0	0.07	151.88
English holly	2	0.04	6.96	0	0.49	2.23	0.15	0	0.21	639.7
marshelder spp	2	0.19	33.02	0.01	2.17	6.79	0.45	0	0.64	1,496.40
Dawn redwood	2	0.82	139.15	0.02	3.72	67.84	4.53	0	6.43	8,086.57
Royal paulownia	2	0.08	12.88	0.01	0.95	9.44	0.63	0	0.89	1,791.31
Yoshino flowering cherry	2	0	0.28	0	0.19	0.8	0.05	0	0.08	127.44
Pussy willow	2	0.26	44.73	0.02	2.7	3.5	0.23	0	0.33	767.44
red cedar spp	2	0.6	102.82	0.02	3.45	5.79	0.39	0	0.55	2,158.09
Monkeypuzzle tree	1	0.1	16.99	0.01	1.01	8.5	0.57	0	0.81	609.26
catalpa spp	1	2.65	451.7	0.03	4.86	48.05	3.21	0	4.55	7,262.35

Mockernut hickory	1	0.26	44.44	0.01	1.12	24.65	1.65	0	2.34	2,330.92
Common fig	1	0.06	10.64	0.01	1.1	3.58	0.24	0	0.34	666.88
Honeylocust	1	0.06	9.98	0.01	1.02	7.15	0.48	0	0.68	824.29
Holly spp	1	0.26	44.05	0.01	1.85	8.16	0.55	0	0.77	1,467.62
Western white pine	1	0.03	4.49	0	0.41	2.93	0.2	0	0.28	241.17
American sycamore	1	0.26	44.48	0.01	1.85	32.44	2.17	0	3.07	3,549.69
White poplar	1	0.01	1.17	0	0.31	1.06	0.07	0	0.1	98.72
Black cherry	1	0.87	149.15	0.03	5.09	30.57	2.04	0	2.9	4,270.22
Scarlet oak	1	0.1	17.78	0.01	1.7	11.71	0.78	0	1.11	1,313.35
Sumac spp	1	0.03	5.88	0	0.53	1.93	0.13	0	0.18	529.25
American snowbell	1	0	0.08	0	0.03	0.23	0.02	0	0.02	53.1
Total	**19,964**	**7,376.12**	**1,258,003.84**	**148.34**	**25,299.35**	**354,972.39**	**23,728.43**	**5.59**	**33,645.72**	**52,101,864.62**