CITY OF TUMWATER

# TREE BOARD MEETING AGENDA

**Online via Zoom and In Person at Tumwater City Hall, Sunset Room, 555 Israel Rd. SW, Tumwater, WA 98501**

**Monday, March 11, 2024**
**7:00 PM**

1. Call to Order
2. Roll Call
3. Changes to Agenda
4. Approval of Minutes
   a. November 13, 2023 Meeting Minutes
   b. December 11, 2023 Meeting Minutes
   c. February 12, 2024 Meeting Minutes
5. Tree Board Member Reports
6. Coordinator's Report
7. Public Comment
8. Annual Chair and Vice Chair Election
9. City Owned Tree Inventory & Community Urban Forest Maintenance Plan
10. Next Meeting Date - 04/08/2024
11. Adjourn

**Meeting Information**
The public are welcome to attend in person, by telephone or online via Zoom.

**Watch Online**
https://us02web.zoom.us/webinar/register/WN_9ElPhwp-T5C80KHLMutRXg

**Listen by Telephone**
Call (253) 215-8782, listen for the prompts and enter the Webinar ID 824 8422 3934 and Passcode 846098.

**Public Comment**
The public is invited to attend the hearing and offer comment. The public may register in advance for this webinar to provide comment: https://us02web.zoom.us/webinar/register/WN_9ElPhwp-T5C80KHLMutRXg

After registering, you will receive a confirmation email containing information about joining the webinar.

The public may also submit comments prior to the meeting by sending an email to: AJonesWood@ci.tumwater.wa.us. Please send the comments by 1:00 p.m. on the date of the meeting. Comments are submitted directly to the Commission/Board Members and will not be read individually into the record of the meeting.

If you have any questions, please contact Sustainability Coordinator Alyssa Jones Wood at (360) 754-4140 or AJonesWood@ci.tumwater.wa.us.

**Post Meeting**

Audio of the meeting will be recorded and later available by request, please email CityClerk@ci.tumwater.wa.us

**Accommodations**

The City of Tumwater takes pride in ensuring that people with disabilities are able to take part in, and benefit from, the range of public programs, services, and activities offered by the City. To request an accommodation or alternate format of communication, please contact the City Clerk by calling (360) 252-5488 or email CityClerk@ci.tumwater.wa.us. For vision or hearing impaired services, please contact the Washington State Relay Services at 7-1-1 or 1-(800)-833-6384. To contact the City's ADA Coordinator directly, call (360) 754-4128 or email ADACoordinator@ci.tumwater.wa.us.

**What is the Tree Board?**

The Tumwater Tree Board is a citizen advisory board that is appointed by and advisory to the City Council on urban forestry issues, including drafting and revising a comprehensive tree protection plan or ordinance, or any other tree matter. Actions by the Tree Board are not final decisions; they are Board recommendations to the City Council who must ultimately make the final decision. If you have any questions or suggestions on ways the Tree Board can serve you better, please contact the Community Development Department at (360) 754-4180.

**CONVENE:** 7:00 p.m.

**PRESENT:** Chair Trent Grantham and Boardmembers Brent Chapman, Brodrick Coval, Michael Jackson, Hannah Ohman, and Jim Sedore.

Excused: Boardmember Tanya Nozawa.

Staff: Sustainability Coordinator Alyssa Jones Wood and Intern Amita Devarajan.

**CHANGES TO AGENDA:** There were no changes to the agenda.

**TREE BOARD MEMBER REPORTS:** No reports were offered by members of the Board.

**COORDINATOR'S REPORT:** Coordinator Jones Wood reported the staff prepared and forwarded a letter to the Association of Washington Cities (AWC) in response to the new Washington Wildland-Urban Interface Code. AWC incorporated the letter and sent a separate letter to the Washington State Building Code Council. Staff is engaged in conversations with the Washington State Building Code Council to address some of the City's concerns surrounding the code. A meeting of the State Building Code Council is scheduled with possible action by the Council. The deadline for finalizing the code is March 2024. Many other cities plan to engage during the legislative session to improve the code.

Boardmember Sedore asked whether an environmental impact statement has been completed on the proposed legislation. Coordinator Jones Wood replied that the letter from AWC references environmental impacts and points out provisions in the code subject to an environmental impact statement. Manager Medrud had provided the Board with a memorandum of a synopsis of the proposed code. Additionally, the Water Resources & Sustainability Department released a memorandum on how the code would affect the City in terms of water usage for irrigation, stormwater inconsistencies, stream temperature inconsistencies, and other impacts.

Boardmember Sedore asked whether the code, if passed, would be retroactive or apply only to future construction. Coordinator Jones Wood advised that the law would be applicable to future construction and new building permits, which includes new decks and other smaller building renovations.

Coordinator Jones Wood advised that the three sections of forestry codes the Board and the City have been working are pending until the state adopts the code to avoid any City conflicts with state law. The code is scheduled for completion by March 15, 2024 and adopted by the Legislature prior to the end of the 2024 session. The City is required to adopt an ordinance adopting the code.

At the December meeting, the Board is scheduled to receive a briefing from City directors and staff on the status of implementation actions in the Urban Forestry Management Plan, as well as the street tree inventory. The City's consultant inspected and documented 1,508 trees located at City buildings and facilities. The consultant collected data on an additional 545 trees on 40 plots using sampling methods. Ground truthing has been initiated by staff based on the 2018 street tree inventory. Volunteers will assist in ground truthing. Coordinator Jones Wood described volunteer outreach efforts staff is pursuing to solicit volunteers. A data sheet will include space for notes, such as documenting the condition of a tree or sidewalk area in need of repair. The consultant is required to provide all inventory data by mid-December. Staff is preparing a list of areas with estimated times to complete an inventory of trees to provide to potential volunteers. She encouraged member to sign-up to inventory some sections of the City. She demonstrated the TreeKeeper software program to input tree inventory data. Because of the time of year, it will be difficult to identify species of trees. Because of the mid-December deadline, inventorying will be on a short timeline. Volunteers have the option of inventorying more than one area of street trees maintained by the City. Inventorying can be completed any time. The consultant is using the TreeKeeper program to track data collection. All City properties will be inventoried of existing trees except for large natural areas that will be inventoried as a sampling block.

Coordinator Jones Wood advised that information is on track to submit to Tree City USA to continue the City's Tree City USA designation.

Olympia Ecosystems has identified a restoration site in Tumwater and invited staff and the Board for a tour on Friday, November 17, 2023. Coordinator Jones Wood invited members to participate in the visit to the Deschutes River Preserve restoration site.

Boardmember Sedore asked whether efforts on tree inventorying are linked to City operations in terms of replacement or removal of trees to ensure the actions are included within the inventory. Coordinator Jones Wood responded that she is working with City GIS to complete the work as the action is included within the Urban Forestry Management Plan. Staff has been transitioning to new software used by the City for accounting, asset inventory, invoicing, and other operational processes. The work order system for staff is currently not compatible with the older system. Staff is working on transitioning existing data tree removal and tree additions.

Boardmember Sedore asked whether the inventory accounts for when trees were planted. Coordinator Jones Wood advised that the specific planting date is not included other than the data collection date. Boardmember Sedore recommended notating the date of tree planting for future reference. Coordinator Jones Wood noted that the inventory is specific to City maintained trees only.

**PUBLIC COMMENT:**

There were no public comments.

**INTERN STREET TREE REVIEW PROJECT:**

Intern Amita Devarajan reported their efforts included research on the affects of climate change in the Puget Sound Region to determine how bioclimatic changes predicted to occur will affect native trees and trees included in the City's draft of an approved tree list. Initial research acknowledges that cities are beginning to recognize the importance of urban forests for enhancing the general quality of life, as well as a way to combat and adapt to climate change. The resilience of trees and urban forests and ecosystem benefits are under threat from the impacts of climate change. Based on studies and several resources from Washington State agencies, impacts will worsen over time. It is crucial to take action and begin moving forward on climate adaptation by planting street trees and urban forests.

Intern Devarajan reported they reviewed broad bioclimatic conditions of the Puget Sound Region. The region has been warming at a rate of 0.2 °F per decade since 1960 with the average temperature projected to increase by 5 °F under a low climate change scenario. The range could increase by 8.6 °F under a high climate change scenario by the end of the century. The average number of days greater than 86 °F determine Heat Zones. The Puget Sound Region historically experiences Heat Zone 2 (1 to 7 days) exceeding 30 °C or 86 °F. Under the intermediate climate change scenario, climate is projected to stay in Heat Zone 5 by 2039 and shift to Heat Zone 3 (7 to 14 days) exceeding 30 °C by 2040 to 2069. Under the high climate change scenario, climate is projected to shift to Heat Zone 3 by 2039 and Heat Zone 4 (14 to 30) by 2040 to 2069. Eventually the region will experience Heat Zone 6 for 45 days exceeding 30 °C by 2070 through 2099.

The Puget Sound Region experiences Hardiness Zone 8 or -12.2 °C to -6.7 °C. Under a low climate change scenario, the hardiness zone is projected to stay in Zones 8A to 8B in the Puget Sound Region by 2039. The zone will then shift over time to Zone 9 by 2040 to 2069. Under a high climate change scenario, the hardiness zone is projected to shift completely to Zone 9 to 2039 and remain in Zone 9 until 2099.

The results imply that less hardy tree species may be able to grow in the region and could drastically alter the ecological benefits already existing in urban forests. Expanding on that possibility, Intern Devarajan reported they researched a report titled, *Climate Change Vulnerability of Urban Trees, Puget Sound Region, Washington.* The report assesses the impacts of climate change on habitat suitability and heat transfer zones of three tree species native to the Puget Sound Region of Western red cedar, Western hemlock, and Douglas fir. The report found that the range of those species in Puget Sound is likely to continue to provide climate conditions suitable for the species by the end of the century; however, individual seed transfer zones of the species are considered separately. Bioclimatic conditions that comprise the current seed transfer zone in Puget Sound for Western red cedar, Western hemlock, and Douglas fir are likely to diminish, shift further Northwest toward the Canadian islands, or disappear by the end of the century. With predicted bioclimatic conditions, the report suggests increasing the diversity of seed sources that include current seed zones as well as future seed zones as it may enhance and ensure the probability of successful reforestation and restoration of Western red cedar and other native trees species in the region.

Precipitation in the region has increased by 0.49 inches per decade since 1960 and is projected to increase by 2.1 to 3.2 inches under the low and high climate change scenarios by the end of the century. In a thesis authored by Jacquie S. Kwok on *An Evaluation Of Potential Policy Tools And Frameworks For Urban Tree Canopy Cover Management In North Vancouver*, the author documents through research that urban trees and urban forest canopy cover have a great capacity for rainfall retention and the ability to influence the lifetime velocity and peak flows of stormwater runoff. On average in coastal Vancouver, B.C., the rainfall interception rate of Douglas firs was 49.1% and in Western red cedars, the rate was 60.9%. The significant portions of rainfall captured and evaporated rather than contributing to urban storm flows have significant implications on flood protection in urban environments. The additional utilities by urban forests are also compromised as canopy cover decreases, which has been a trend in Washington State. The author emphasizes the notable advantages of planting large, longer lived trees as they reduce the number of trees required and removal of trees at the end of its lifespan, as well as lowering the long-term costs and fuel consumption required for maintenance.

The difference between deciduous and evergreen trees is also important as evergreen trees retain foliage year-round and have a greater ability to attenuate rainfall throughout the year. Aside from the direct impacts of climate change, other smaller impacts will occur in urban environments as an indirect consequence, such as insect outbreaks and pests. Scientists have documented the presence of pests as more abundant on urban trees than in rural trees. Research supports the conclusion that urban heat may explain those affects.

Intern Devarajan cited information in a study, *Urban Warming Drives Insect Pest Abundance on Street Trees* of evidence that scale insect populations may be locally adapted or individuals have been climatized to the temperature of urban habitat patches in which they reside. The effect was observed over a temperature gradient common in many urban heat islands indicating that urban warming poses a broad and immediate threat to urban trees and the services they provide including cooling and carbon sequestration. The adaptation or acclimatization of herbivorous pests to warm environments may represent an ecological tipping point after which pests can overwhelm plant defenses and escape natural enemy control. Temperature increases of similar magnitude are predicted under global climate change if rising global temperatures trigger herbivorous pests similar to the ones observed in the study as both urban and rural trees may be threatened by greatly increased herbivore pests in the future by several orders of magnitude of threat.

The main goal of the study and research was to provide usable information for the City. The research involved a tree species vulnerability assessment comprised of a list of numerous conditions that compile outcomes based on many research articles and studies. The goal was using the trees within the draft of the Street Tree List to cross compare to the assessment to develop a spreadsheet assessing the vulnerability of trees on the list.

The assessment summarizes climate change projections for the Puget Sound Region and provides an assessment of tree species vulnerability in the region. It considers projected shifts in plant hardiness and heat zones and compiles research of how species of interest are projected to tolerate future conditions while assessing the adaptability of planted trees to drought, flooding, wind damage, and air pollution, as well as environmental conditions such as shade, soils, and restricted rooting. The results summarize that of the evaluated tree species, 27% received a high adaptability score, 59% received a medium adaptability score, and 14% received a low adaptability score. When considering heat zones only, the majority of tree species fall into the low to moderate vulnerability category. The ratings remained the same between low and high climate change projections because all assessed tree species are considered suitable under the heat zone projections through the end of the century.

Intern Devarajan reviewed a list of tree species with a vulnerability rating of low, low-moderate, moderate-high, and high in heat and hardiness zones. Of the tree species, only big leaf maple is native to the Pacific Northwest. Many of the trees in the study were not native to the Pacific Northwest and some were from different countries. Policymakers should consider that tree species vulnerability does not represent a planting list and should be combined with knowledge of the region and other factors, such as aesthetics, local site conditions, wildlife value, or nursery availability. Other important considerations include using the information incongruent with information from local climate experts and studies of the local area.

Chair Grantham commented on the number of maple trees planted within the City. He asked about the species that would serve the City the best. Intern Devarajan advised that the best species are those ranked in low vulnerability for heat and hardiness including red maple. Several maple species are predicted for tolerance of high heat, such as red maple and Norway maple. Many native trees reflect some signs of struggle, as well as species used for reforestation, such as Douglas fir and Western hemlock.

Coordinator Jones Wood noted that the proposed draft of the Street Trees List includes some native trees for landscape areas only that are not located near sidewalks but for unimproved right-of-way. The current list does not include any native tree species.

Boardmember Sedore spoke to his former occupation in forestry and how the state's reforestation efforts are divided into seed zones. The state was careful in reforestation efforts to plant seeds from the area in which the seed had originated. However, it appears the cited research recommends not pursuing that methodology and using other seed sources that have been under more stress (higher temperatures, lower precipitation) and planting those seeds to reforest native forests because in the future, the species will need to have those genetic characteristics to survive climate change. He also understands that plants and animals are negatively affected by weather extremes rather than averages. He asked whether the research related to climate change is indicative of radical extremes in temperature and precipitation rather than average fluctuations in temperature, and whether the direction is to plant trees found in Northern California in the future, as the Pacific Northwest will be experiencing the same type of climate in the future.

Intern Devarajan said their understanding of the research speaks to a suggestion of a mix of diversity of seeds from different seedlots. However, in terms of weather extremes, most studies accounted for extreme weather other than for testing of high extreme in temperatures, which increases the pest population. Most of the information used data from the 1960s, averaged the data, and factored future parameters.

Coordinator Jones Wood added that in terms of extreme weather, a lower level of certainty exists amongst scientists for predictions because a greater level of certainty can be provided by using averages.

Boardmember Sedore noted that extreme temperature could kill, which speaks to the importance of planning for extreme temperatures.

Coordinator Jones Wood responded that the global average temperature of any temperature increase above 1.5 degrees results in more death and destruction and when it increases above 2 degrees, it creates significantly more destruction and deaths.

Boardmember Sedore pointed out that the Pacific Northwest climate receives much precipitation throughout most of the year except during the summer when 90 to 120 days of summer drought often occurs. If climate change increases the severity of summer drought regardless of the amount of precipitation the Pacific Northwest receives in December, the problem is not receiving any precipitation from May to October affecting plant survivability.

Boardmember Chapman reported that on the Capitol Campus, the Department of Enterprise Services is employing multiple strategies. He cited the importance of diversity of species that are tolerant of various conditions. More native species are being planted on the campus, as well as planting different species not considered 10 years ago, such as Chinese Pistache, which grows fast and can live up to 150 years, tolerates heat, drought, and a wide range of soils and pH levels. The Department has implemented a diversity of strategies, which he encouraged the City to consider rather than limiting a strategy to tree species reduce risk.

Discussion followed on the tree species for the annual Arbor Day tree giveaway. Coordinator Jones Wood invited the Board to assist staff in sourcing plants for the tree giveaway in April.

Intern Devarajan commented that many regions in the state are using seed sources from the Toutle area for reforestation and restoration efforts.

In response to questions about the vulnerability chart of different species, Intern Devarajan explained that the chart is based on the *Tree Species Vulnerability Assessment for the Puget Sound Region.* Most of the factors are related to urban conditions including heat and hardiness zones. They were asked about the score related to adaptability. Intern Devarajan said the plant adaptability score is based on a scoring system of different factors for vulnerabilities of disease, drought, ice, and other factors. They offered to follow-up with additional information.

Boardmember Chapman said that based on his experience, the adaptability scores are accurate in terms of the species that are more resilient. Street trees are more survivable during adverse conditions. However, other variables are included such as a species suitable for heat and hardiness that might score lower for adaptability because the species is not drought tolerant.

Coordinator Jones Wood advised that the next step is finalizing the list for review by the Board in conjunction with the Planning Commission during a joint worksession. The review will discuss the results, possible removal of some trees, and, and listing trees based on a series of factors rather than alphabetically.

Boardmember Chapman noted that availability is also an important factor to include.

Discussion ensued on resources to consult for annual updating of the list and sources of availability, such as Oregon rather than locally as it might speak to hardiness to future conditions.

Intern Devarajan reported that generally, urban trees in the Puget Sound Region would be facing the general effects of future bioclimatic conditions while experiencing altered ecological dynamics and changes pertinent to the urban environments of Tumwater. Indirect effects of the urban forest within the region may occur through the changing and increased abundance of insects, pests, and pathogens, and non-native invasive species, as well as the probability, severity, and extent of severe storms with urban storm runoff. The projected changes in climate, associated impacts, and vulnerabilities have important implications for urban forest management including the planting and maintenance of street and park trees, equity and environmental justice efforts, and long-term planning from partnerships. In terms of longevity of trees in the landscape, future scenarios of urban trees and forests that are resilient or in decline will depend on the management and planning actions. Recommendations from the references and articles highlight consideration by policymakers and urban forestry planners to:

- Incorporate the role of climate change as a driver of urban tree die back and mortality into adaptive management practice to reduce risks and economic losses, maintenance of urban canopy cover for rainfall interception as an adaptive measure
- Forming adaptive management using a combination of tree inventory analyses and monitoring with forecasts of urban forest responses under different climate change and management scenarios
- Collaboration between governments, scientists, and the public to develop locally engaged and long-term monitoring plans
- Selection of urban trees that have a critical influence on the adaptability of future urban forests and street trees particularly with the intricacies of climate change.
- Careful considerations for defining seed sources for restoration and reforestation of urban forests in the region and to adopt existing plant ecotypes.
- Identify species likely to be tolerant of future climate and support planting, maintenance, and preservation of trees through urban forestry planning and management.

Boardmember Sedore questioned the possibility of analyzing the data based on natural laws rather than municipal laws by considering the potential loss of specific species because of climate change as opposed to municipal practices. Coordinator Jones Wood advised against identifying any loss of individual trees because of climate change as most trees removed were because of infrastructure, visual, or screening issues. For natural areas, sample plot losses could be factored on climate change, as well as in the future as it would be possible to track the reason for removal. Boardmember Sedore offered that it would be helpful in the future to ensure some means of noting whether a loss of a tree(s) was by wind, drought, storm damage, etc., as it might be possible to recognize tree species that might be more vulnerable to storm damage than other species.

**PROPOSED NON-REGULATORY INCENTIVES AND PROGRAMS:**

Coordinator Jones Wood referred to a prior memorandum of proposed examples of regulatory incentives and programs. The information was drafted based on information from other towns and cities in the Pacific Northwest for different non-regulatory incentives for private and public properties. The Urban Forestry Management Plan includes two action items related to non-regulatory incentives and programs. Following the initial review by the Board, staff was asked to provide a recommendation based on the list of examples. During the interim, the City received a grant with a required 50% match. The request to the Board is to review the proposed list of recommendations and provide a recommendation to include some actions in the next biennium budget. The total recommended program would be budgeted at $58,465 per year with additional staff resources to administer the program with half of the cost funded by the grant for a total of approximately $29,000 allocated in the budget each year.

Coordinator Jones Wood reviewed the program proposal:

- Develop a subsidized street tree-trimming program to assist low- and moderate-income Tumwater residents struggling to maintain existing street trees. Income thresholds for the program and other qualifying programs included would be developed after stakeholder outreach. The City would contract with an ISA Certified Arborist to perform maintenance and trimming on properties selected for the program at a cost estimated at $32,000 per year (160 hours per year). The US Forest Service grant covers 50 percent or $16,000 of the program each year for four years of the grant.
- Recommendations for public plantings was not included for right-of-way and street trees pending information from the inventory identifying priority planting areas based on environment justice and equity measures.
- Two programs to address private properties: one for retaining existing trees and one for planting more trees:
    - Continue the annual Arbor Day Tree Giveaway and add one more data-driven targeted annual giveaway. The giveaway should prioritize and target participation from private property owners/renters of the City in census block groups with a Tree Equity Score of 84 or less, census tracts Environmental Health Disparity score of 8 or higher, or areas identified in the City of Tumwater Tree Inventory as priority

planting areas. Staff recommends retaining 60 percent of funding allocated for the program for addresses falling into the categories as identified. To reach those residents and property owners effectively in the target areas, the City would conduct an annual mailing and/or door hanger outreach campaign to encourage participation. The property owner participating in this program would be responsible for the trees once they leave the in-person planting workshop.

To participate residents would need to:

1. Apply to the program;
2. Attend a pre-recorded tree care webinar or the annual in-person planting and care workshop;
3. Be responsible for bringing the trees, watering bags, compost, and mulch home from the in-person planting and care workshop; and
4. Sign a Tree Care Pledge

The program is estimated to provide 100 trees per year. The trees would not be provided to apartment dwellers as the goal is to plant trees in soil in areas of single-family homes, duplexes, triplexes, four-plexes, or accessory dwelling units.

Boardmember Sedore questioned the authorities for determining where trees are planted. Coordinator Jones Wood said the program is an application-driven process that would be cross-referenced with a list of priorities. The in-person workshop and training would emphasize best practices for planting trees on private property and not in public right-of-ways.

Coordinator Jones Wood shared a map of environmental health disparities of Tumwater census tracks. The program would prioritize those areas with a score of 8 or more. The map was prepared by the Washington Department of Health after the development of the Urban Forestry Management Plan.

Boardmember Sedore commented that some of the sites are not conducive to trees. Coordinator Jones Wood responded that staff could include other plant species, such as prairie species. The map is reflective of the long-standing correlation between low tree canopy and areas with a higher concentration of people of color or poor and working class families. The 50% match requirement of the grant is tied to environmental justice and equity. She acknowledged the need to modify the program to some degree based on the Board’s feedback.

- Retain existing trees: recent community engagement in Tumwater suggests homeowners often remove trees because of the potential financial impacts of a falling tree or tree limbs. Those fears can often be addressed by conducting a tree health assessment by the future urban forester. Selection of applicants taking advantage of the program would be through an application to the City and targeted outreach throughout the City to advertise the program.

Boardmember Sedore commented on the City's regulations requiring homeowners removing six or more trees to obtain a permit. He suggested in those circumstances, the City might consider visiting the site and recommending against the removal of healthy trees, as there is no incentive if property owners have the legal right to remove up to six trees. Coordinator Jones Wood said in terms of the future, the City's tree and vegetation preservation ordinance could require property owners to retain a specific number of tree credits. The process would also help to inform property owners not aware of the City's tree removal permitting process.

Boardmember Sedore mentioned some neighbors who moved from Arizona to be closer to family and removed all their trees for the property to resemble their former property in Arizona, which speaks to the convincibility of such a program. Coordinator Jones Wood responded that the City does not anticipate 100% compliance in the implementation of any programs as there will be struggles and adjustments creating lessons learned to improve programs and processes.

Boardmember Sedore referred to City maintenance of trees. He asked about the status of tree maintenance by City utilities. Coordinator Jones Wood said it might be possible to utilize the utilities tree contractor for the program. She understands the City has encountered some difficulties of contracting with professionals to trim trees near utility lines. The City's maintenance is focused on street trees not obstructed by utility lines.

Coordinator Jones Wood reported the grant award is from the federal government and administered through the River Network, a non-profit organization. The award requires administrative processes as part of the pass-through.

Staff anticipates the budget process will be initiated in March 2024. Some time is available for the Board to delay a recommendation if desired until March 2024.

**MOTION:** **Chair Grantham moved, seconded by Boardmember Coval, to table the inclusion of the recommendations within the budget until March 2024. Motion carried unanimously.**

**OTHER BUSINESS:** The Board discussed the status of heritage tree nominations. Boardmember Sedore reported on a proposed tree nomination of a tree near the Panda Express Restaurant. The property owner refused to consider the nomination because the owner wants to retain the flexibility associated with the future of the tree(s).

Boardmember Sedore questioned whether the Board would have the opportunity to review data for the tree inventory, such as identifying the location of Garry oaks in the City. Coordinator Jones Wood advised that the data does not include unclassified street trees under review. However, she can download the data for sorting. Boardmember Sedore noted the Urban Forestry Management Plan included a pie chart identifying different tree species. He asked whether that type of information would be incorporated within inventory data. Coordinator Jones Wood said the City's data could be utilized for that and other types of analysis.

Boardmember Sedore advised of the discussions that spoke to updating the Urban Forestry Management Plan and that he is assuming staff is continuing to collect data and updating charts in the plan. Coordinator Jones Wood acknowledged the need for additional analysis with new information by utilizing grant funding for the urban forester to lead the process.

**NEXT MEETING DATE:** The next meeting is scheduled on Monday, December 11, 2023.

**ADJOURNMENT:** **With there being no further business, Chair Grantham adjourned the meeting at 8:40 p.m.**

Prepared by Valerie L. Gow, Recording Secretary/President
Puget Sound Meeting Services, psmsoly@earthlink.net

**CONVENE:** 7:00 p.m.

**PRESENT:** Chair Trent Grantham and Boardmembers Brent Chapman, Michael Jackson, Hannah Ohman, Jim Sedore, and Tanya Nozawa.

Excused: Boardmember Brodrick Coval.

Staff: City Administer Lisa Parks, Assistant Transportation and Engineering Director Mary Heather Ames, Planning Manager Brad Medrud, Parks and Facilities Manager Stan Osborn, and Sustainability Coordinator Alyssa Jones Wood.

**CHANGES TO AGENDA:** There were no changes to the agenda.

**APPROVAL OF OCTOBER 9, 2023 MEETING MINUTES:**

**MOTION:** **Boardmember Sedore moved, seconded by Boardmember Jackson, to approve the minutes of October 9, 2023 as published. Motion carried unanimously.**

**INTRODUCTION OF CITY ADMINISTRATOR LISA PARKS:** City Administrator Parks reported she joined the City on June 16, 2023. She shared her background in land use and environmental planning beginning in June 1990 when she earned a degree in urban and regional planning from Eastern Washington University. It was the same year the Growth Management Act (GMA) was adopted by the Legislature. Her first position was with Douglas County in North Central Washington as a long-range planner under the GMA requirements involving natural resource planning, critical areas, and community planning for small cities in Douglas County, as well as processing land use permits. She served in the position for approximately eight years and accepted the position of Community Development Director with the City of Leavenworth. She transitioned from county natural resource planning to a small city focused on tourism. She oversaw a variety of activities and the position afforded her with opportunities to be a member of the city's management team for a city that provided water, sewer, streets, and contracted fire and law enforcement services. She eventually opened a planning and environmental consulting firm based in North Central Washington serving mostly local governments (cities and counties) and expanding to serve port districts and public utility districts. She remained in business for approximately 11 years and then accepted a position as the Executive Director of the Port of Douglas County serving for approximately nine years. The Port of Douglas County partially owned an airport in the Wenatchee area but was primarily a small economic development-oriented port district. Following her move to the Olympia area in the fall of 2019, she began working for a consultant firm for environmental planning for port districts until July 2021 when she accepted a position with the Port of Olympia serving as the Environmental and Planning Program Director with responsibilities for capital facilities planning, government affairs, communications, and administrative functions. She applied for the City's position in early spring 2023 as it served as an opportunity to return working for city government. She has enjoyed her time at Tumwater and has found employees, elected officials, and community members very committed to the community. She invited members to visit with her at any time.

The Board asked about short-term goals for the City. City Administrator Parks responded that in addition to balancing resources with needs, she is interested in continuing to learn and build on the great workplace culture at the City. The City has many great employees with huge hearts for public service and for the City of Tumwater as well. Additionally, the City's upcoming biennial budget is scheduled to begin in 2024. Working with the new Council in 2024 and identifying the Council's priorities for the community, as well as establishing the budget to implement the strategies will be areas of focus in 2024. Working for a community that is 153 years old is also unique for her personally. The recruitment material spoke to Tumwater as a progressive community but also very connected to its past. She was appreciative of the message as having the history of the natural environment and those who settled the community adds to the unique character of the community.

City Administrator Parks said another priority is redevelopment of the brewery property. Every potential opportunity will be explored as it is the City's priority to clean-up the property of any environmental contamination that is very likely and probably present in the buildings and in surrounding land, as well as in the groundwater to help ensure appropriate and beneficial reuse of the property. Cleaning up the eyesore is a high priority for the City. Work on the brewery property is similar to some of the work on brownfield redevelopment at the Port of Douglas County, as well as at the Port of Olympia on the Budd Inlet Sediment Remediation Project.

**TREE BOARD MEMBER REPORTS:**

Boardmember Sedore mentioned numerous publications he receives monthly on gardening and horticulture. Within the last several months, many articles focused on native and ornamental shrubs. One article referred to a British YouTube video on the use of hedges and shrubs in the urban environment. The video highlighted some of the challenges the City is facing. In previous Arbor Day giveaways, the City offered Red-osier dogwood as an alternative to trees because many participants commented on the inability to plant trees in their small yards. He asked about ways the Board could address the urban environment of smaller spaces with respect to the species of plants that are typically associated with urban forests. In most cases, the species of trees and plants are oriented toward large areas, which in many cases, may be too large and result in unsuccessful plantings. The video featured numerous birds and insects inhabiting hedges, which provide habitat for those species. There could be some opportunities as the Board explores different planting options to consider different species of plants that provide different values and resources that should be included in the inventory. Many species of shrubs are valuable assets to the environment and to the community as a whole. He asked about the responsibility of the Board to consider other non-tree plants as part of the implementation of the Urban Forestry Management Plan and whether more of those plants should be considered within the City's promotions and activities. Historically, the focus has been on trees rather than shrubs and other species of plants. In many circumstances, the shrub may be the better choice to achieve a healthy environment that absorbs some of the radiation, runoff, and provides habitat for native animals. He suggested the Board pursue a discussion on the issue to include a possible name change of the Board.

Boardmember Jackson said the issue speaks to the City's history as the Board was created because of development occurring on Tumwater Hill when maple tree stumps were removed prompting efforts on a tree ordinance. The ordinance required the planting of three trees on each lot on Tumwater Hill in addition to the street trees planted by the developer. The Board expanded its discussions on the importance of both plant and tree canopy as understory vegetation is just as important as tree canopy.

Boardmember Chapman added that the Board intentionally included understory vegetation within the Urban Forestry Management Plan for those reasons.

Boardmember Jackson noted that today within the three-city area, many of the roundabouts with vegetation are impossible to see through because of the maturity of the plants and trees. Additionally, the state's new Wildland Urban Interface code may change the City's current tree retention of 12 trees per acre.

The Board discussed the importance of considering trees and shrubs as well as developing a preferred list of understory shrubs. Outreach to the community could guide and educate the community to help steer plantings that are more productive for the community. Native shrubs provide options that are more affordable and easier to replace. Members discussed options for promoting smaller plants in high density neighborhoods. Boardmember Sedore shared information about a local homeowner replacing grass with Astro turf, which might speak to potential violations of required impervious surface. Members commented on the possibility of enabling homeowners and other property owners to use plants to replace lawns to discourage the spread of noxious weeds.

Coordinator Jones Wood advised that the Board is scheduled to review the landscape ordinance following the adoption of the Wildland Urban Interface code.

The Board discussed appropriate descriptions for shrubs and hedges. The City's code speaks to plants as buffer plantings of different classifications of Type 1, Type 2, and Type 3 landscape screening. It is also important to ensure any replacement plantings meet the original plant or tree type required for the site

**COORDINATOR'S REPORT:**

Coordinator Jones Wood reported on her and Boardmember Sedore's recent visit to the Olympia Ecosystems Deschutes River Preserve. The restoration site is located near the City. The two-hour visit enabled them to learn about restoration efforts at the site. Olympia Ecosystems is a local non-profit operating throughout Thurston County. The restoration site of 367 acres is located near the Trails End area.

Coordinator Jones Wood reported on the release of the Comprehensive Plan Periodic Update survey on the City's website. She invited the Board to participate in the survey. Survey results will help guide the update process over the next 18 months.

Coordinator Jones Wood shared that with recent efforts to collect new data for the street tree inventory, staff plans to meet with GIS staff, Transportation and Engineering Department, and the Water Resources and Sustainability Department to review solutions to use the City's work order system to input data for mutual access across the City and to ensure data are maintained and updated.

**PUBLIC COMMENT:**

**Mary Turcotte** said she favors a broad plan that includes understory plants. She is also curious about the history of why many trees were cut down along Second Avenue as it served as good habitat for birds. Today, the sites are only grass. The removal of the plants occurred after trimming by a local tree service. Another issue is the appropriate species of plants in that area, such as salal or Oregon grape, but not St. John's Wort or other plants that do not provide food habitat for native animals.

**URBAN FORESTRY MANAGEMENT PLAN IMPLEMENTATION:**

Coordinator Jones Wood introduced the presenters. Brad Medrud serves as the City's Planning Manager, Mary Heather Ames serves as the Assistant Director of the Transportation and Engineering Department, and Stan Osborn is the Parks and Facilities Manager for the City.

Manager Osborn added that staff strives to maintain the right plant in the right place regardless if it is a tree or a plant.

Boardmember Chapman asked for an update on how staff manages understory to meet security needs. Manager Osborn said it is dependent upon the building. When he was employed by the school district, district crews planted much barberry plants to discourage entry through windows. Recent City efforts include installing lights to prevent incidents of vandalism.

Boardmember Chapman asked whether staff has received guidance or recommendation from the police department to aid officers. Manager Osborn affirmed the departments work closely together.

Coordinator Jones Wood added that code updates include focus on crime prevention through landscaping.

Boardmember Sedore asked whether his neighbor's recent contention that the City Council is considering action to open City parks to the homeless is accurate. Manager Osborn advised that the information is inaccurate. The City's current policy does not allow camping or overnight stays on any City park property. The proposed change would have enabled other City properties to fall under the same policy as it is technically possible for someone to camp in front of City Hall, but not a City park. The goal was to ensure the policies apply equally to all City properties.

Coordinator Jones Wood summarized the status of implementation of actions contained within the Urban Forestry Management Plan. Approximately 74% of the actions from 2021 through 2023 are on track, 12% of the actions are scheduled to begin in 2024, and 14% of the actions were delayed. Because of grant funding received last year, it was possible to pursue some actions.

The Board agreed to review actions that have been delayed.

Coordinator Jones Wood reviewed a list of delayed actions:

- Regularly review and update the Public Works standards, the Development Guide, and facilities procedures for the maintenance of City trees and the community and urban forest and modify to reflect best tree management practices and employee safety. *Delayed until the code amendment updates are finalized.*
- Formalize relationships with organizations and green industries that share common aims affecting community and urban forest sustainability. *Staff reached out to industry leaders for the Code Amendment update process but did not receive any participation from those industries. More work is necessary after completion of the code amendment process. Boardmember Chapman asked whether the addition of an urban forester would support efforts for relationship building between the City and other organizations, as the outcome could produce some data that would be helpful. Coordinator Jones Wood agreed and indicated that staff plans to advocate for inclusion of the position within the next biennium budget. She requested advocacy by the Board to support the addition of the position. If approved, the position would be effective in January 2025. The City has four years of grant funding for the position; however, following the end of the grant funds, the City would need to fund the position. The position is integral in implementing many actions in the Urban Forestry Management Plan. The City received a grant from the U.S. Forest Service that includes allocation of 50% of the funding for salaries and benefits for a full-time urban forester. The grant is effective in 2025 in alignment with the City's budget with the goal of receiving an allocation to cover the remaining 50% cost for the position. The match for five years equates to approximately $340,000.*
- Develop a stable funding source and budget for annual maintenance and selective harvest of trees within developed landscaped City property, such as City street trees and City facilities and parks. *The action will be evaluated for inclusion within the 2025/2026 general fund budget. Boardmember Chapman asked about the possibility of using some funds from the Tree Fund to fund the action. Coordinator Jones Wood explained that the Tree Fund has been used as a grant match for the tree inventory. Another use of the funds is for restoration activities in conjunction with some stormwater improvements.*
- Develop a stable funding source and budget for maintenance of natural forests on City lands such as critical or shoreline areas and their buffers and other such areas. *Staff will*

*evaluate the action for the 2025/2026 general fund budget; however, the tree inventory provides a nexus to stormwater as another funding source from the stormwater utility in addition to the general fund and Tree Fund. Boardmember Chapman commented on the success rate by the City of Olympia for increasing taxes for community benefits and programs. He asked whether the City has considered similar actions to improve the environment. Coordinator Jones Wood said staff has never pursued a request for a tax funding mechanism other than monitoring the City of Olympia's consideration of requesting voters to fund climate efforts, which did not reach the ballot. The recent regional fire authority measure that voters denied would have freed some general funds for allocation to other City activities.*

- Look for opportunities to build on and expand existing City educational outreach programs to increase the understanding of the value of the community and urban forest, as well as the responsibilities of the public and private landowners regarding its planting, maintenance, thinning, and harvest. *Staff recommends delaying action until the Urban Forester is hired; however, the Tumwater School District Forest and Stream summer course helped advance the action in 2023.*
- Develop education and incentive programs focused on maintaining the community and urban forest found on private property. *The Tree Board delayed the decision on incentive programs until the 2025/2026 budget process is initiated.*
- Support and incentivize the use of large-canopy trees in appropriate areas to provide maximum benefits. *Staff recommends delaying the action until the Urban Forester is hired.*
- Coordinate with the Fire Department on actions to minimize fire risks associated with urban forestry. *The Fire Department plans to begin the work when the Hazard Mitigation Plan is completed both regionally and for the City. The Hazard Mitigation Plan will be presented to the City Council for consideration in spring 2024. Additionally, the status of the Wildland Urban Interface code also complicates the action.*
- Remove trees and understory in specific situations identified in the Tumwater Annex to the Natural Hazard Mitigation Plan for the Thurston Region to guard against wildfire. *The Fire Department plans to begin the work when the Hazard Mitigation Plan is completed both regionally and for the City scheduled in spring 2024. Parks and Recreation staff typically removes all debris from projects to reduce fire*

*hazards.*

- Develop a program to work with public and private property owners in maintaining and providing for public safety with the community and urban forest. *Staff recommends delaying the action until the Urban Forester is hired.*

Boardmember Chapman asked about actions that were successful in assisting in the implementation of the plan. Coordinator Jones Wood said the update to the codes was progressing well and were specific to achieving many of the actions. The inventory project is another project that benefitted numerous actions in the Urban Forestry Management Plan. City departments meet quarterly to receive regular updates on the status of implementation actions. At least once a year, she briefs staff assigned to complete different actions in the plan.

Boardmember Chapman suggested providing an update to the Council on the status of actions within the Urban Forestry Management Plan.

**MOTION:** **Chair Grantham moved, seconded by Boardmember Sedore, to direct staff to provide an annual update to the City Council on the status of implementation actions within the Urban Forestry Management Plan. Motion carried unanimously.**

Chair Grantham asked about any permitting increases in response to any proposed code changes. Manager Medrud responded that the City generally has not experienced an increase in permit applications based on perceived tightening of regulations; however, the department is experiencing a reduction in permitting due to external factors, such as financing and material and labor costs.

Boardmember Jackson asked whether the state still owns the former Department of Transportation site off Capitol Boulevard. Manager Medrud affirmed the state is the property owner; however, the City is currently considering options for purchasing the property. The City completed an initial review of the property and is seeking state funding for remediation work on the property. The property serves as the centerpiece of the Capitol Boulevard Corridor Plan as a redevelopment site. The primary concern surrounds the use of the property for the last 100 years for transportation-related uses.

Boardmember Chapman asked about the vision for the property not abutting Capitol Boulevard. Manager Medrud said the plan calls for mixed-use development with some level of commercial abutting Capitol Boulevard and residential multifamily in the rear. The City plans to work within the industry to determine the market focus for the site. The goal is to increase more residential uses along Capitol Boulevard and additional commercial uses to support the community.

Discussion ensued on the goal to save existing trees on the property. There are likely many trees on the property that would be eligible for designation as a heritage tree.

Manager Osborn clarified that the Parks and Recreation Department is responsible for parks, stormwater ponds associated with parks, and other recreational and mitigation areas whereas the Transportation and Engineering Department is responsible for other right-of-ways in the City. Staff from both departments strive to work together to implement codes. The department currently employs a certified arborist and another employee who is pursuing arborist certification. However, unless the department receives funding, it has been difficult to tap into those resources as the department is short-staffed. Any request to the Council should include some funding to provide adequate coverage within the department. Coordinator Jones Wood noted in response, that the street tree maintenance plan would also include a budget request for needed maintenance of trees to include trees in parks with the exception of Pioneer Park and Sapp Road Park because many trees in those parks were not evaluated. The effort includes more specific information on each tree but the information is similar to the assessments completed several years ago by the Parks and Recreation Department.

Boardmember Chapman questioned whether the City has implemented an Adopt-a-Tree program enabling community members to sponsor the purchase and planting of trees. Manager Osborn said the City currently has no program but it would be worthy to explore. Boardmember Chapman pointed out that many members of the community would be willing to sponsor the cost of a tree for planting in a park. Manager Osborn explained that many of the crew's efforts are concentrated on older trees at the end of their lifespan that pose a threat because of rot and damage that are in parks and along trails.

The Board agreed to individually review the 2024 work program.

**2024 DRAFT MEETING SCHEDULE:**

Coordinator Jones Wood presented the 2024 draft meeting schedule. The April 9, 2024 joint meeting with the Planning Commission follows the scheduled adoption of the Wildland-Urban Interface Code, which might require an additional joint session dependent on the outcome of the legislation.

Discussion ensued on the timing for leadership elections and current member terms. Coordinator Jones Wood recommended scheduling elections in May following the Arbor Day event in April.

Boardmember Sedore inquired about the timing for the review of the recommended tree list. Coordinator Jones Wood said the review would likely be scheduled in April or rescheduled during another joint meeting. The review can be included as a pending item following the adoption of the Wildland-Urban Interface Code to assist in clarifying pending actions.

Boardmember Sedore inquired about the possibility of scheduling an annual analysis of the tree inventory as the intent is to maintain a current inventory that is relevant. An annual or bi-annual review might be necessary to review losses and gains especially with changes in climate that might require changes to avoid adding a specific species that is struggling because of climate change. Coordinator Jones Wood advised that the action is not included within the work plan; however, she could pursue the possibility of seeking the services of an intern. Otherwise, another item on the work plan would need to be removed to accommodate an additional item. Boardmember Sedore asked about the potential within the new inventory tracking procedures to provide a summary of removals and additions each year. Coordinator Jones Wood explained that she is working with the departments to integrate the tracking process and is unsure whether a summary could be produced by the end of 2024 other than other information produced by the joint tracking effort.

The Board discussed the timing associated with updating the City's vegetation/tree canopy. The plan calls for an update every five years with the last assessment completed in 2018. Coordinator Jones Wood affirmed she would follow up with GIS staff to check on the frequency of the update and if staff has the capacity to complete the assessment. The cost and the number of trees removed each year are recorded by Parks and Recreation staff.

**NEXT MEETING DATE:** The next meeting is scheduled on Monday, January 8, 2024.

**ADJOURNMENT:** **With there being no further business, Chair Grantham adjourned the meeting at 8:29 p.m.**

Prepared by Valerie L. Gow, Recording Secretary/President
Puget Sound Meeting Services, psmsoly@earthlink.net

| | |
|---|---|
| **CONVENE:** | 7:00 p.m. |
| **PRESENT:** | Chair Trent Grantham and Boardmembers Brent Chapman, Brodrick Coval, Michael Jackson, Hannah Ohman, and Tanya Nozawa.<br><br>Excused: Boardmember Jim Sedore.<br><br>Staff: Sustainability Coordinator Alyssa Jones Wood. |
| **CHANGES TO AGENDA:** | There were no changes to the agenda. |
| **TREE BOARD MEMBER REPORTS:** | Coordinator Jones Wood reported on the status of the potential removal of the historic Davis-Meeker oak tree from the City's Historic and Heritage Tree Registers. Members of the Historic Preservation Commission will consider the request on March 21, 2024 at 6:30 p.m. The Board is invited to attend. The purpose of the meeting is to review the Forester's report on the condition and health of the Davis Meeker Garry oak located off Old Highway 99.<br><br>Boardmember Chapman asked about any seedlings produced from the tree. Coordinator Jones Wood said she believes there are a number of younger Garry oaks located on the opposite side of the highway. The City's code for protected habitat and species refers to the Washington Department of Fish and Wildlife (WDFW) Management Plan. On January 4, 2024, a new management plan was developed by WDFW that includes Garry oak trees, which require replacement of a tree(s) based on the diameter of the tree.<br><br>Boardmember Nozawa noted that the information on the website for the Davis Meeker oak tree indicates the tree is approximately 400 years old. Coordinator Jones Wood noted that the tree was placed on the historic register because it was deemed a landmark along the Oregon Trail.<br><br>Boardmember Nozawa commented that she reviewed the Forester's report, which contained some conflicting information about the condition of the tree with a recommendation to remove the tree. |
| **COORDINATOR'S REPORT:** | Coordinator Jones Wood reported on February 28, 2024 the City is hosting the first of three quarterly trainings for staff from 9 a.m. to noon on the Principles of Urban Forestry. Staff from Community Development Department, Transportation and Engineering, Parks and Recreation Department, and Water Resources and Sustainability have been invited to participate. Boardmembers are welcome to attend. Four individuals from the Tumwater School District are attending the training as well. A representative from the Department |

of Natural Resources (DNR) is conducting the training. The training includes two hours in-class training and one-hour outdoors near City Hall.

The City received a federal grant to fund an urban forester position. The grant is considered a pass-through grant from the River Network, a non-profit organization. The organization executed the agreement with the U.S. Forest Service. Staff is scheduled to meet with the non-profit representatives on March 7, 2024 to discuss the scope of work. As part of the pass-through grant, all non-profits receiving federal funding also received match waivers. All awardees of the grant were also to receive match waivers; however, the City did not qualify for a match waiver. Staff is reviewing the scope to ensure the City qualifies for a match waiver. She initiated some conversations with representatives from the U.S. Forest Service on the possibility of utilizing the Washington Department of Health Environmental Health Disparities Map as a match for the grant based on an existing federal tool for environmental justice. It may be possible to utilize the tool to enable the City to qualify to receive the funding.

Coordinator Jones Wood updated members on the status of the Tree Inventory and Maintenance Plan and the Washington State Wildland-Urban Interface Code (WUI). A draft of the Tree Inventory and Maintenance Plan Report was completed. The Board will receive a copy of the report at its March meeting. The report includes the analysis of the tree inventory as requested by Boardmember Sedore, i-Tree analysis for species diversity, composition and species richness, management investments, information on ecosystem services, a section on urban forest pests and pathogens, tree care needs and costs sections, budget, and potential planting areas based on equity, stormwater, and urban heat. The report is under review by other City staff.

Boardmember Chapman asked whether the report includes recommendations on street tree species. Coordinator Jones Wood said the street tree list is included in the Street Tree Plan. The list is scheduled for review by the Board over the course of several meetings.

Coordinator Jones Wood reported on the results of a public hearing on the proposed Washington State Wildland-Urban Interface Code. Many individuals testified offering different perspectives to include one individual who is a member of the Technical Advisory Committee. On Friday, February 16, 2024 from 10 a.m. to 4 p.m., a public hearing is scheduled by the Legislature to vote on the amendments to the code. The two options for amendments include retaining the existing code and the second would remove all

Washington amendments leaving the International Wildland-Urban Interface Code as the state's requirements within the International Building Code.

Coordinator Jones Wood reviewed some of the proposed amendments including changes to defensible space to ensure urban areas have adequate fire protection, changes to building official discretions, distance between trees and structures, and removal of mature tree dead wood and litter. The City prefers the second option of removing the Washington amendments and following the International Building Code. Manager Medrud testified in support of the changes in defensible space and amendments to the International Building Code.

Concurrently, Senate Bill 6120 is moving forward addressing the map used in the Washington State Wildland-Urban Interface Code The bill directs DNR to establish and maintain a statewide wildfire hazard map and a base-level wildfire risk map for each county based on criteria established in coordination with the State Fire Marshal Office. Local governments may update the risk map based on local assessments and with approval by the jurisdiction's fire marshal. Pending the state map from DNR, local jurisdictions would be able to create a wildfire hazard and base level wildfire risk map until a new map is developed by the state.

Discussion ensued on the status of the legislative review process. Unless the Legislature elects to continue delaying a decision on the code, the effective date of the new code would be March 15, 2024. Based on the timing of the code's implementation (Legislature or State Building Code Council), staff plans to re-initiate reviews of the urban forestry sections of City codes.

**PUBLIC COMMENT:** There were no public comments.

**ARBOR DAY:** Coordinator Jones Wood updated members on the status of preparing for the Arbor Day event.

The City Council is scheduled to issue the Arbor Day proclamation on April 16, 2024. Historical Park has been reserved for the Arbor Day event on April 20, 2024. Plants and seeds have been ordered from a local vendor. Materials on planting instructions are available. A single page for each species will be provided to the public for each plant giveaway. Coordinator Jones Wood requested feedback on information contained in the materials.

Boardmember Chapman suggested including "recognized" names of each plant in addition to its botanical name. Members offered several suggested name additions.

Boardmember Coval inquired about the possibility of adding information that speaks to traditional uses or cultural importance of any of the plant species. Coordinator Jones Wood advised that she would include a citation of the source of the information. Boardmember Coval offered to provide information on sources of information. Local tribes were mentioned as a good source of information.

Boardmember Coval recommended adding dimensional width information for vine maple plants. Members and staff discussed the pros and cons of adding information on the mature widths of plants.

Coordinator Jones Wood said the seeds include showy milkweed and Pacific Northwest wildflower. One hundred seed packets of each will be available to giveaway during the event.

Coordinator Jones Wood advised that she would make the suggested changes and present an updated version of the materials during the March meeting.

Boardmember Chapman inquired about any feedback on scheduling formal tree planting ceremonies. Coordinator Jones Wood advised that staff would be informed of any future plantings to coordinate assistance by the Board to ensure plantings are completed properly. The Parks and Recreation Department filled the Volunteer Coordinator position. The full-time Coordinator is managing Earth Day activities. She is meeting with the Coordinator to review joint Arbor Day and Earth Day activities and to discuss volunteering. A tree was donated by the PARC Foundation.

**NEXT MEETING DATE:** The next meeting is scheduled on Monday, March January 11, 2024.

**ADJOURNMENT:** **With there being no further business, Chair Grantham adjourned the meeting at 7:43 p.m.**

Prepared by Valerie L. Gow, Recording Secretary/President
Puget Sound Meeting Services, psmsoly@earthlink.net

TO: Tree Board

FROM: Alyssa Jones Wood, Sustainability Coordinator

DATE: March 11, 2024

SUBJECT: City Owned Tree Inventory & Community Urban Forest Maintenance Plan

1) Recommended Action:

This item is for information only.

2) Background:

The City Council adopted the Urban Forestry Management Plan (UFMP) on March 2, 2021, by Ordinance No. 2020-004. The DNR grant-funded project to complete a City-Owned Tree Inventory and Maintenance Plan advances the following actions from the UFMP:

**Objective 2.2.** Develop a City street tree-trimming program.
Action A. Develop tree-trimming areas based on optimal equipment mobilization, priority locations, current tree inventory, and best management practices.

**Objective 3.1.** Promote efficient and cost-effective management of the community and urban forest by selecting, situating, and maintaining urban trees appropriately to maximize benefits and minimize hazards, nuisances, hardscape damage, and maintenance costs.
Action D: Prioritize and schedule City-assigned street tree maintenance activities according to inventory-documented needs.

**Objective 3.2.** Adopt best management practices and resource management assessment tools and data management to improve City tree maintenance to manage City-owned community and urban forest areas.
Action C. Develop a program to eliminate deferred maintenance while being mindful of budgetary constraints.

**Objective 5.1.** Develop a stable funding source and budget for activities that support the community and urban forest.
Action C. Secure funding for a four-year cycle of tree trimming.
Action D. Conduct, budget, and report to City staff on an inventory of trees for species, number, condition, and maintenance needs in developed landscaped areas on City property, such as City street trees and trees in City facilities and parks.

**Objective 7.1.** Promote collaborations between residents, neighborhood associations, governments, nonprofits, and businesses.
Action H. Involve volunteers in the tree inventory of all City street trees and trees in City Parks performed regularly.

This project is now complete. Staff will be submitting the final grant report, deliverables, and invoices to DNR before April 20, 2024.

3) Alternatives:

- ❑ No alternatives suggested.

4) Attachments:

A. City of Tumwater Tree Inventory and Maintenance Plan

Item 9.

# City of Tumwater
# Tree Inventory and Maintenance Plan

February 28, 2024

Prepared for:
The City of Tumwater
Alyssa Jones-Wood
Sustainability Coordinator
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Prepared by:
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# Acknowledgments

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Angela Jefferson, Councilmember
Eileen Swarthout, Councilmember
Joan Cathey, Councilmember
Kelly Von Holtz, Councilmember
Michael Althauser, Councilmember
Peter Agabi, Councilmember

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Stan Osborn, Parks and Facilities Manager

**Tree Board**
Trent Grantham, Chair
Mike Jackson, Vice Chair
Brent Chapman, PhD, Board Member
Broderick Coval, Board Member
Hannah Ohman, Board Member
Jim Sedore, Board Member
Tanya Nozawa, Board Member

Funds for this project were provided by the USDA Forest Service Urban and Community Forestry Program, administered through the State of Washington Department of Natural Resources Urban and Community Forestry Program. The USDA is an equal opportunity provider and employer.

WASHINGTON STATE DEPT OF NATURAL RESOURCES

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# i-Tree Glossary

The following terms and key concepts are referenced in this plan when evaluating trees for their environmental benefits. All field data was collected during the leaf-on season to properly assess tree canopies. 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).
- 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.

**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, $0.01 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 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 Tumwater (17,371) 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 $171 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 $171 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.

**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), $PM_{10}$ 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.

**Pollution removal** is calculated based on the prices of $1,397 per ton (carbon monoxide), $1,376 per ton (ozone), $161 per ton (nitrogen dioxide), $47 per ton (sulfur dioxide), $119,426 per ton (particulate matter less than 2.5 microns), and $6,565 per ton (particulate matter less than 10 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 2011 from the Forest Health Technology Enterprise Team (FHTET) (Forest Health Technology Enterprise Team, 2014) were used to determine the proximity of each pest to Thurston 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.

**Replacement 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.

# 1.0 Executive Summary

Trees play a vital role in the City of Tumwater. They provide numerous tangible and intangible benefits to residents, employees, visitors, and neighboring communities. The City of Tumwater recognizes that trees are a valued resource, a critical component of the urban infrastructure, and part of the City's identity. In 2023, the City of Tumwater contracted with Davey Resource Group, Inc. (DRG) to complete an inventory of city trees in parks, and at city facilities as well as plot sampling trees in natural areas (~201 Acres). The inventory data is being managed by the City of Tumwater using TreeKeeper, a tree asset management software system that allows managers to maintain current inventory specifics regarding tree characteristics, health, history, and maintenance needs. There are 7,345 sites in the TreeKeeper database. This includes a set of 5,286 tree sites that were previously collected by Tumwater community volunteers. The database also includes 2,062 trees added by Davey Resource Group inventory arborists in 2023.

To better understand Tumwater's inventoried tree resource, inventory data was analyzed in using i-Tree's *Eco* benefit modeling software to develop a detailed and quantified analysis of the current structure, function, benefits, and value of this subset of the urban forest. Only 4,890 tree sites had sufficient data to be analyzed in i-Tree Eco. Plot sample data was analyzed separately to understand distinct species compositions, age distributions and condition of trees in natural areas. The natural areas were then analyzed with i-Tree's *Canopy* modeling software to evaluate the tree cover in natural areas as well as environmental benefits provided by all natural area trees. This report details the results of these analyses.

## 1.1 Structure

Analyzing the composition and structure of inventoried trees as a group was the first step towards understanding the benefits provided by the inventoried tree resource, as well as its management needs. As of 2023, Tumwater's inventoried trees includes 4,890 trees. Considering species composition and diversity, age distribution, condition, canopy coverage, and replacement value, DRG determined that the following information characterizes Tumwater's inventoried tree population:

- 110 unique tree species (Appendix B)
    - Norway maple (*Acer platanoides*, 15.3%) was the most common species, followed by Callery pear (*Pyrus calleryana*, 9.5%), and red maple (*Acer rubrum*, 9.2%)
- 44.5% of trees are less than 6-inches in diameter (DBH)[1] and 9.8% of trees are larger than 24-inches in diameter, indicating an established age distribution.
- 65.1% of inventoried trees are in very good condition.
- To date, Tumwater's inventoried trees are storing 1,968 tons of carbon ($CO_2$) in woody and foliar biomass.
- Replacement of the 4,890 inventoried trees with trees of equivalent size, species, and condition, would cost nearly $11.9 million.
- i-Tree *Eco* estimates 95% of trees are susceptible to 44 emerging pests and disease threats including Asian longhorned beetle, defoliating moths, and pine shoot beetle.

[1] DBH: Diameter at Breast Height. DBH represents the diameter of the tree when measured at 1.4 meters (4.5 feet) above ground (U.S.A. standard).

The following characterizes Tumwater's natural areas, estimated from sample plots:

- 42 plots with a total of 593 trees sampled.
  - 87% of sampled trees are in fair or better condition.
  - 41.3% of sampled trees had dieback/deadwood as the primary defect.
  - Sampled plots had an average of 14 trees and an average of 3 unique species.
- 16 distinct species of trees were found with a nearly ideal age-class distribution (41% of trees are less than 11" DBH, trees under 6" DBH were not collected).
- Public Property natural areas were estimated at 201 acres.
  - *I-Tree Canopy* indicates there are 116 acres of canopy in natural areas (58% +/- 4.03%)
  - There are an estimated 16,271 trees in natural areas (+/- 4819 trees, 95% CI).
- To date, trees in Tumwater's natural areas are storing 4,003 tons of carbon ($CO_2$) in woody and foliar biomass.

## 1.2 Benefits

Annually, Tumwater's 4,890 trees analyzed in i-Tree Eco provide cumulative benefits to the community totaling more than $18,010. The average annual benefit per tree is $3.68. These benefits, and the benefits estimated from trees in natural areas (from plot samples) include:

- Inventoried trees intercepted 839,871 gallons of stormwater and reduced runoff, valued at $7,505, an average of $1.53 per tree.
  - Trees in natural areas intercepted 21,860 gallons of water and reduced 967 gallons of stormwater runoff (*i-Tree Canopy*).
- Inventoried trees removed 1.1 tons of air pollutants, including nitrogen dioxide, sulfur dioxide, carbon monoxide, ozone, and small particulate matter ($PM_{2.5}$) valued at $5,957, an average of $1.22 per tree.
  - Trees in natural areas removed 4.4 tons of air pollutants.
- Inventoried trees reduced costs and medical visits resulting from adverse health effects caused by air pollution, valued at $3,275.
- Inventoried trees directly sequestered 26.7 tons of additional carbon, valued at $4,548, an average of $0.93 per tree.
  - Trees in natural areas sequester 159 tons of carbon annually.

This is a limited and conservative accounting of the true environmental and socioeconomic benefits from Tumwater's inventoried and plot sampled trees. Many documented benefits from trees are unable to be quantified using current methods; for example, benefits to wildlife, property values, and public health and welfare (University of Washington, 2018; University of Illinois, 2018).

## 1.3 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 $1M in the management of trees in Tumwater. 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 inventoried forest and the amount of benefits provided grow as well. However, this vital living resource is vulnerable to a host of stressors and requires sustainable best management practices to ensure a continued flow of benefits for future generations.

Of the 4,890 trees in the inventory, there was maintenance work identified. The City anticipates prioritizing maintenance work and estimated costs on a four-year cycle:

- **Inspection** – 1,759 hours of inspection work are anticipated for 7,019 trees that should be inspected and updated in the database at an estimated cost of $41,770.
- **Priority Removals** – 56 trees were identified as higher priority tree removals. Trees would be planted to replace these trees. This was estimated as 1,568 person-hours at an estimated cost of $313,600.
- **Priority Pruning** – 29 Trees were identified requiring higher priority care at an estimated 232 person-hours, $44,800.
- **Large Tree Routine Pruning** – 208 trees were identified as large tree routine pruning at an estimated 1,664 person-hours or $499,200.
- **Small Tree Routine Pruning** - 59 trees were identified for small tree routine pruning at an estimated 236 person-hours or $47,200.
- **Unassigned Trees** – Within the database were trees identified for maintenance by community volunteers. These include 43 removals, 883 trees requiring crown raising, and 90 young trees with stakes to pull. While these trees should be inspected to confirm the work needs, a preliminary estimate is 8,141 person-hours at an estimated cost of $2,329,875.

**The total workload and cost estimates discovered through this project are approximately $3,403,356 (or $850,839 on a 4-year cycle).** These cost estimates assume prevailing wage rates apply and do not include additional costs such as program administration, emergency work or inflation.

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

## 1.4 Maintenance Plan Actions

Based on this maintenance report, the City would benefit from the following priority urban forest management actions:

- Maintain and Expand the Tree Inventory

  - Assign maintenance to all inventoried trees to proactively manage Tumwater's tree resource.
  - Prioritize planting replacement trees for those trees that have previously been removed.
  - Prioritize structural pruning for young trees and a regular maintenance cycle for all inventoried 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.
  - Species that are adequately represented by established age distributions but lack recent plantings should receive priority care.
  - Inventory updates should be incorporated as regular maintenance is performed, including updating the diameter and condition of existing trees.
- Plant New Trees
  - Increase genus and species diversity in new and replacement tree plantings to reduce reliance on abundant groups.
  - Plant trees in priority areas to improve diversity, increase benefits, and further distribute the age distribution of inventoried trees.
  - Use the largest stature tree possible where space allows to optimize urban forest benefits.
  - Consider successional planting of important species, as determined by relative performance index (RPI) and the relative age distribution.

With adequate protection and planning, the value of the Tumwater's inventoried trees will continue to increase over time. Proactive management and a tree replacement plan 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 inventoried trees support the quality of life for residents and neighboring communities.

# 2.0 Introduction

The City of Tumwater boasts a thriving urban forest that's integral to its identity. Home to nearly 26,000 people, Tumwater is known for being the earliest American settlement in Washington. Today, the community has an extensive urban forest that benefits both the City and its people. Tumwater is located amongst many beautiful, natural landmarks and has thriving arts, culture, and recreational opportunities.

The community experiences a moderate climate with higher-than-average cloud cover. Tumwater's climate is characterized by summer daytime temperatures in the 70°F and winter daytime temperatures in the 40°F and 50°F (Sperling's, Best Places, n.d.). Tumwater'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, Tumwater receives 44 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.

The urban forest stands as vital green space for the community, contributing to the City's environmental health and community well-being. Individual trees play an essential role in the community of Tumwater 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 Tumwater.

The City first began monitoring their public trees as a discrete population with an inventory gathered by community volunteers in 2018. In 2023, the City of Tumwater commissioned **additional tree inventory** within City parks and at City facilities to further the efforts of understanding and managing their urban forest. Another tree population included in this report was a **plot sample inventory** of trees in natural areas (201 Acres of public properties). Sample plots were selected from forest stands with full tree canopies. Plots were $1/10^{th}$ of an acre and the data from the plots was used to extrapolate composition, structure, condition for trees in natural areas. Trees under 6" DBH were not collected.

This report provides the following information:

- A description of the structure of Tumwater's tree resource and an established benchmark for future urban forest management decisions
- The economic value of the benefits from the inventoried 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

The tree data (inventoried trees) was analyzed with i-Tree *Eco* benefit-cost modeling software to generate this resource analysis. i-Tree's *Eco* (Eco v6.1.35) software application is 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. Tumwater's natural Area trees were analyzed with i-Tree *Canopy* to quantify benefits provided to the City. These benefit estimations are limited but include carbon storage and annual carbon sequestration, annual air pollution removal, and hydrological benefits such as avoided stormwater runoff.

These models make estimates of the effects of urban forests 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 Tumwater's inventoried tree resource and plot sampled natural areas resource. The baseline data from this analysis can be used to make effective resource management decisions, develop policy, and set priorities.

# 3.0 Inventory Results & Tree Resource Summary

### *Inventoried Trees*

There were 7,375 sites catalogued in a tree inventory database for this project. Within this is a subset of 4,890 sites that had sufficient information to model their benefits in i-Tree. These 4,890 inventoried trees identified are 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.

### *Trees in Natural areas*

Within the City of Tumwater there were approximately 201 acres categorized and managed as natural areas for this project. According to *i-Tree Canopy*, only 116 acres have tree canopy. The trees in these canopied areas typically receive care to mitigate safety concerns. For this reason, a sampling approach was used on the parcels to inspect and inventory a representative proportion of the population. Most trees are unmanaged and left to grow as part of the natural ecosystem processes, but some areas are being increasingly managed as the city grows in population and people increase their use of trails.

Information was gathered in 42 plots randomly selected from 8 different natural areas. Each plot was a circular plot of 1/10th of an acre. At each plot, the arborist inspected and inventoried trees to provide a statistical representation for the entire forest. The mean number of trees (>6" Diameter) found in each plot was 14.02 trees with a standard deviation of 7.93. Across 116 acres of tree canopy, the estimated number of trees 6" DBH or greater in the natural areas is 16,271 stems (+/- 4,819, 95% C.I.).

*Table 1: Natural Areas and Number of Plots*

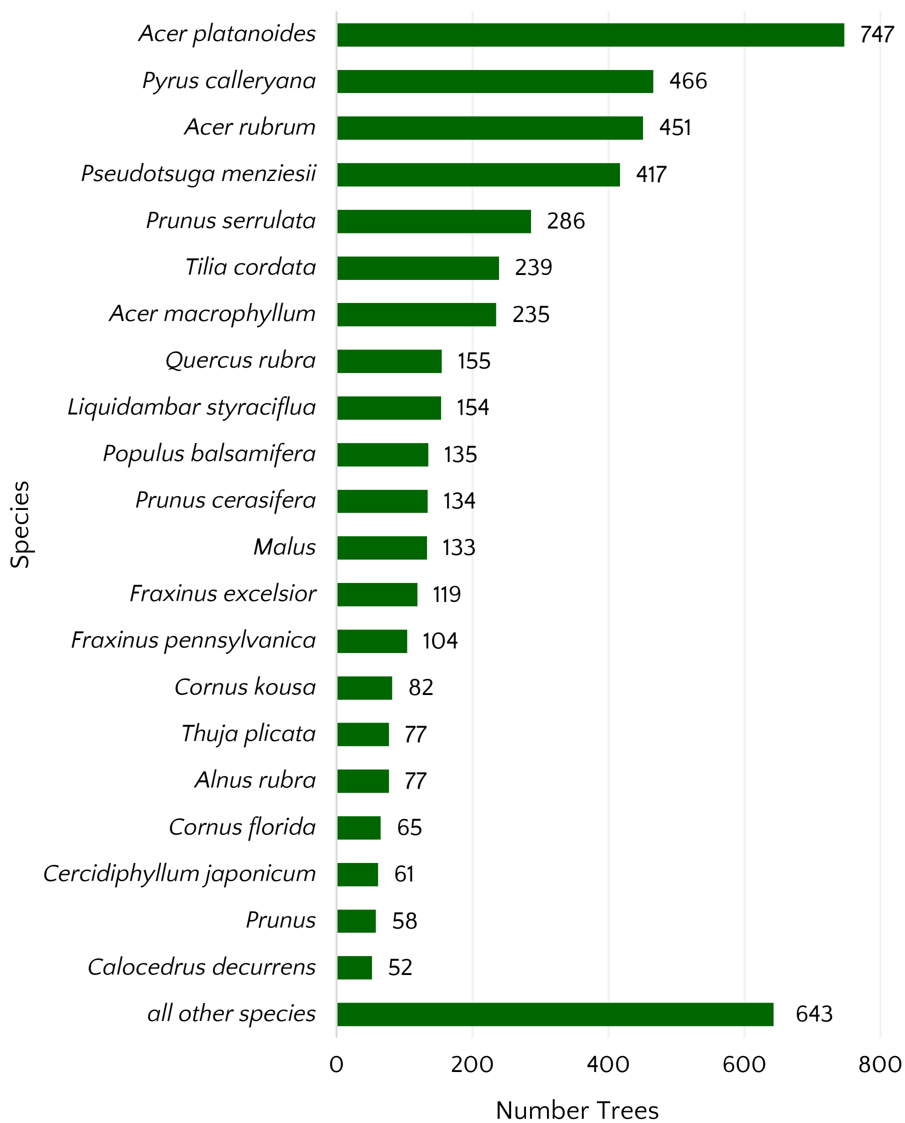
| Site | Acres | Sample Plots |
|---|---|---|
| 11th Ave SW (Storm Site) | 6.2 | 3 |
| 2332 SW SAPP DR | 11.8 | 3 |
| Barnes Blvd SW Natural Area | 7.3 | 2 |
| 436 LINWOOD AVE SW (Isabella Bush Park) | 19.5 | 3 |
| 305 O ST SE (Palermo Pocket Park and maintenance shop) | 20.5 | 9 |
| 5801 HENDERSON BLVD SE (Pioneer Park) | 87.1 | 9 |
| Trosper Lake Natural Area | 18.3 | 6 |
| 115 Ridgeview Loop SW (Tumwater Hill Park) | 29.0 | 6 |
| | Total | 41 |

## 3.1 Species Composition & Richness

### *Inventoried Trees*

The composition and richness of species was calculated as the proportion of species representing the inventoried forest population (Figure 1). The City of Tumwater's inventoried 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. As an example, red maple (*Acer rubrum*) and Douglas-fir (*Pseudotsuga menziesii*) each comprise nearly 9% of the overall population, but red maple is a broad-leafed shade tree and therefore covers more surface area when compared to Douglas-fir.

*Figure 1: Most Prevalent Species in Tumwater (Representing >1%)*



The City of Tumwater's inventoried tree resource includes a mix of 110 unique species (Appendix C), with 19% of species native to Washington. The diversity in Tumwater's inventoried trees is less 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 Norway maple (*Acer platanoides*, 15.3%), Callery pear (*Pyrus calleryana*, 9.5%), and red maple (*Acer rubrum*, 9.6%) (Figure 1). Together, these three species make up 34% of the overall population. Tumwater's 21 most prevalent species (representing >1% of the overall population) make up 86.9% of the overall population.

### *Trees in Natural areas*

Within the natural areas, 16 different species were identified dominated by big leaf maple (*Acer macrophyllum,* 28%), Douglas-fir (*Pseudotsuga menziesii,* 22%), red alder (*Alnus rubra,* 17%) and western red cedar (*Thuja plicata,* 15%). Twelve (12) other species represented the remaining 17% of the natural area tree population (Table 2). Further increasing biodiversity can increase the resilience of the natural areas and limit the reliance on any one species. This also helps protect the population from pests and disease.

*Table 2: Tree Population of Natural Areas*

| Species Breakdown | # of trees | % of trees |
|---|---|---|
| *Acer macrophyllum* | 167 | 28.2% |
| *Pseudotsuga menziesii* | 130 | 21.9% |
| *Alnus rubra* | 101 | 17.0% |
| *Thuja plicata* | 89 | 15.0% |
| *Prunus species* | 22 | 3.7% |
| *Populus balsamifera ssp. trichocarpa* | 17 | 2.9% |
| *Tsuga heterophylla* | 15 | 2.5% |
| *Picea sitchensis* | 13 | 2.2% |
| *Fraxinus latifolia* | 9 | 1.5% |
| *Crataegus species* | 7 | 1.2% |
| *Acer circinatum* | 7 | 1.2% |
| *Salix species* | 5 | 0.8% |
| *Corylus species* | 5 | 0.8% |
| *Arbutus menziesii* | 2 | 0.3% |
| *Pinus monticola* | 2 | 0.3% |
| *Ilex aquifolium* | 2 | 0.3% |

Maintaining diversity in a public 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, 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. They highlight the importance of diversity and the balanced distribution of species and genera.

Recognizing that all tree species have a potential vulnerability to pests and disease, urban forest managers have long observed a best management practice that no single species should represent greater than 10% of the total population and no single genus more than 20% (Santamour, 1990). Among Tumwater's tree population, at the species level, Norway maple (*Acer platanoides*) exceeds this rule. At the genus level, maples (*Acer spp.*) represent 31.2% of the overall population. To increase species diversity and promote greater resilience in the overall resource, future plantings should reduce reliance on species of maple trees.

## 3.2 Species Importance

To quantify the significance of any one species in Tumwater's inventoried 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 B: 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 comprehend the resulting 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 reduced. 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.

Table 4 lists the importance values of the most prevalent species. These 21 species represent 86.9% of the overall population and 86.5% of the total leaf area for a combined importance value of 270. Of these, Tumwater relies heavily on Norway maple (*Acer platanoides*, IV=42.5). Tumwater also relies on the additional species Callery pear (*Pyrus calleryana*, IV=26.7), red maple (*Acer rubrum*, IV=17.2), and Douglas-fir (*Pseudotsuga menziesii*, IV=11.1). Combined these four species represent 42.6% of the inventoried tree resource, 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 Tumwater 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, little-leaf linden (*Tilia cordata*), a large-statured tree with a young age distribution, represents 4.9% of the overall population and 3.2% of total leaf area resulting in an importance value of 8.1. As this large-stature tree matures the leaf area and subsequent importance value will increase significantly.

Some species are more significant contributors to the urban forest than population numbers would suggest. For example, Callery pear (*Pyrus calleryana*), 9.5% of the population and has an importance value of 26.7. This medium-statured species is mainly represented by individuals in the 6-11 inches DBH category (35.6% are established and >6 inches in diameter), representing 17.1% of the leaf surface area.

*Table 3: Inventoried Species Importance Value (IV) of Prevalent Species in Tumwater (Representing >1%)*

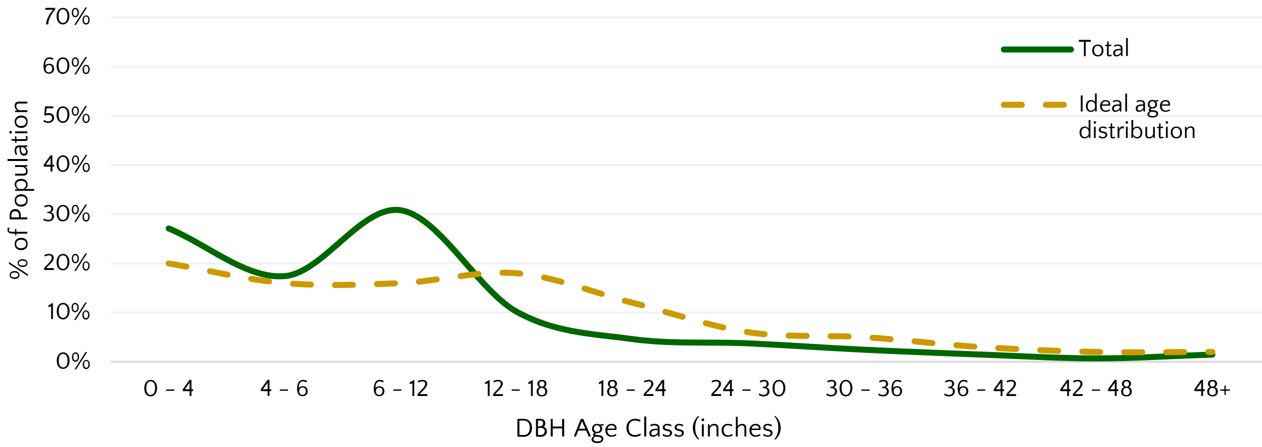
| Species | # of Trees | % of Trees | % Leaf Area | IV |
|---|---|---|---|---|
| *Acer platanoides* | 747 | 15.28 | 27.23 | 42.50 |
| *Pyrus calleryana* | 466 | 9.53 | 17.13 | 26.66 |
| *Acer rubrum* | 451 | 9.22 | 7.92 | 17.15 |
| *Pseudotsuga menziesii* | 417 | 8.53 | 3.54 | 11.07 |
| *Prunus serrulata* | 286 | 5.85 | 3.53 | 9.38 |
| *Tilia cordata* | 239 | 4.89 | 3.18 | 8.07 |
| *Acer macrophyllum* | 235 | 4.81 | 2.67 | 7.48 |
| *Quercus rubra* | 155 | 3.17 | 2.64 | 5.81 |
| *Liquidambar styraciflua* | 154 | 3.15 | 2.41 | 5.56 |
| *Populus balsamifera* | 135 | 2.76 | 2.22 | 4.98 |
| *Prunus cerasifera* | 134 | 2.74 | 2.11 | 4.86 |
| *Malus* | 133 | 2.72 | 1.80 | 4.52 |
| *Fraxinus excelsior* | 119 | 2.43 | 1.60 | 4.04 |
| *Fraxinus pennsylvanica* | 104 | 2.13 | 1.45 | 3.58 |
| *Cornus kousa* | 82 | 1.68 | 1.32 | 3.00 |
| *Alnus rubra* | 77 | 1.57 | 1.17 | 2.74 |
| *Thuja plicata* | 77 | 1.57 | 1.11 | 2.70 |
| *Cornus florida* | 65 | 1.33 | 0.92 | 2.25 |
| *Cercidiphyllum japonicum* | 61 | 1.25 | 0.87 | 2.11 |
| *Prunus* | 58 | 1.19 | 0.86 | 2.05 |
| *Calocedrus decurrens* | 52 | 1.06 | 0.76 | 1.83 |
| all other species | 643 | 13.15 | 13.52 | 26.67 |
| Total | 4,890 | 100% | 100% | 200 |

## 3.3 Relative Age Distribution

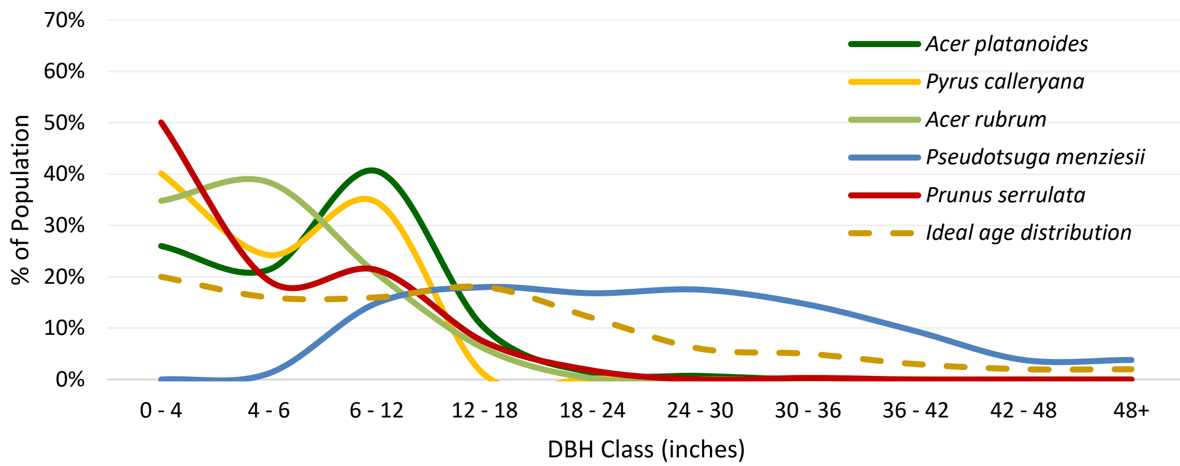
The relative age distribution of individual trees within the resource (or by species) influences present and future costs as well as the flow of benefits. Age distribution can be approximated by considering the DBH range of the overall inventory and of individual species. Trees with smaller diameters 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).

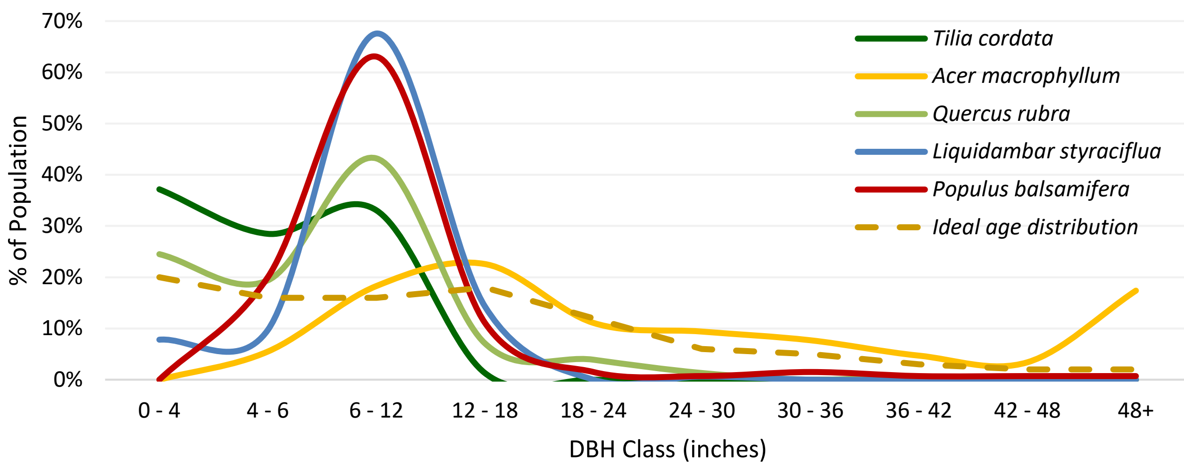
The age distribution of Tumwater's inventoried trees shows an established population. In total, 44.5% of trees are 6-inches or less in diameter (DBH) and approximately 9.8% of trees are larger than 24-inches in diameter (Figure 2). Relative age distribution can also be evaluated for each individual species. The 10 most prevalent inventoried tree species are compared against the ideal distribution in Figure 3.

*Figure 2: Inventoried Tree Relative Age Distribution for Tumwater*




The majority of the 10 most prevalent species in Tumwater's inventoried tree inventory have a young age distribution. For example, the age distributions of Norway maple (*Acer platanoides*), Callery pear (*Pyrus calleryana*), red maple (*Acer rubrum*), little-leaf linden (*Tilia cordata*), northern red oak (*Quercus rubra*), sweetgum (*Liquidambar styraciflua*), and balsam poplar (*Populus balsamifera*) all show that the majority of individuals are 0- to 11-inch DBH. While the majority of paper bark cherry (*Prunus serrulata*) are in the 0- to 11-inch DBH range, this is a small statured species and therefore many of these individuals may be mature rather than young. In contrast, the age distributions of



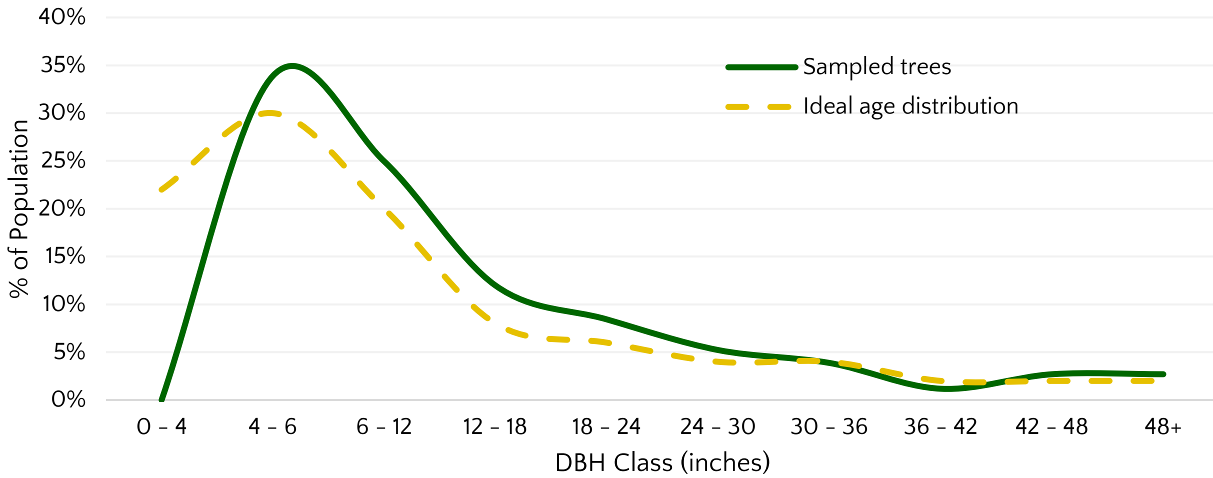

Douglas-fir (*Pseudotsuga menziesii*) and bigleaf maple (*Acer macrophyllum*) show significant representation in the mature DBH ranges with few young trees.

*Figure 3: Relative Age Distribution of Tumwater's Top 10 Most Prevalent Inventoried Species*

### *Relative Age Distribution of Trees in Natural Areas*

Within the natural areas, the average diameter was 18" (+/- 1.05", 95% CI). Some of the largest specimens found in the natural area include a bigleaf maple (*Acer macrophyllum*, 122" DBH), a Douglas-fir (*Pseudotsuga menziesii*, 42"), an alder (*Alnus rubra*, 68") and a western red cedar (*Thuja plicata*, 81"). The age distribution of Tumwater's natural areas shows a moderately established population, characterized by many young trees dispersed among larger and older trees. In total, nearly 42% of trees are 12-inches or less in diameter (DBH) and approximately 16% of trees are larger than 24-inches in diameter (Figure 4). It is important to note trees with a DBH of less than 6 inches were not collected.

*Figure 4: Relative Age Distribution of Tumwater's Natural Areas*

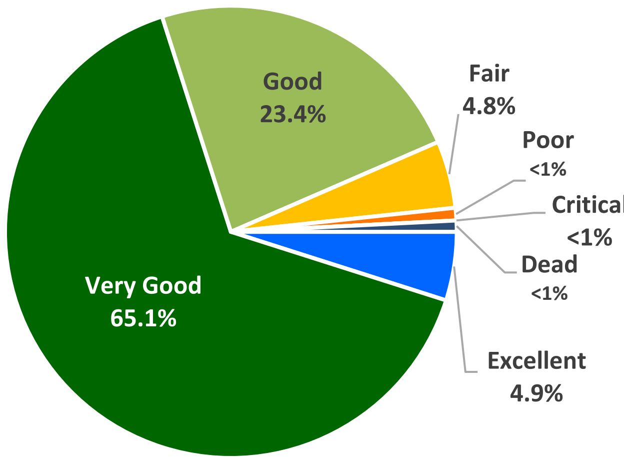



## 3.4 Tree Condition

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.

Inventoried trees in Tumwater are in overall fair or better condition. Of the trees, 98.2% are in fair or better condition. Approximately 1.8% are in poor or critical condition (Figure 5). There were six (6) dead trees excluded from further benefits analysis.

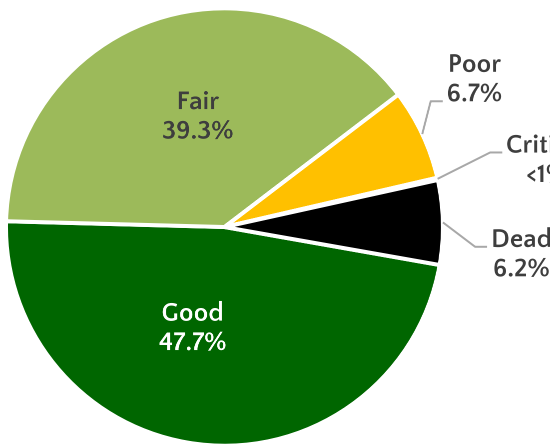
*Figure 5: Tree Condition of Inventoried Trees*




### *Trees in Natural Areas*

Trees in natural areas in Tumwater are in overall fair or better condition. Of the trees, 87% are in fair or better condition. Approximately 6.2% are dead and 6.7% are in poor condition (Figure 6). Dead trees and snags are beneficial and provide habitat for wildlife.

*Figure 6: Tree Condition of Trees in Natural Areas*



## 3.5 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.

RPI could only be evaluated for the inventoried tree population. Among the 21 most prevalent tree species, 9 have an RPI of 1.0 or greater (Table 4). Red maple (*Acer rubrum*) has the highest RPI at 1.06, followed by Norway maple (*Acer platanoides*) with an RPI of 1.05 and Callery pear (*Pyrus calleryana*) with an RPI of 1.04. In contrast, red alder (*Alnus rubra*), has the lowest RPI at 0.82. 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.

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.

*Table 4: Relative Performance Index of Most Prevalent Inventoried Species (Representing >1%)*

| Species | % Excellent | % Very Good | % Good | % Fair | % Poor | % Critical | % Dead | RPI | # of Trees | % of Trees |
|---|---|---|---|---|---|---|---|---|---|---|
| *Acer platanoides* | 6.0 | 85.5 | 5.8 | 1.7 | 0.5 | 0.0 | 0.4 | 1.05 | 747 | 15.28 |
| *Pyrus calleryana* | 3.4 | 83.5 | 10.7 | 2.1 | 0.2 | 0.0 | 0.0 | 1.04 | 466 | 9.53 |
| *Acer rubrum* | 11.9 | 74.3 | 10.2 | 1.8 | 0.9 | 0.0 | 0.0 | 1.06 | 451 | 9.22 |
| *Pseudotsuga menziesii* | 0.0 | 65.2 | 31.7 | 1.7 | 0.0 | 0.0 | 1.4 | 0.99 | 417 | 8.53 |
| *Prunus serrulata* | 3.5 | 73.8 | 16.1 | 4.9 | 1.4 | 0.0 | 0.3 | 1.01 | 286 | 5.85 |
| *Tilia cordata* | 21.8 | 54.0 | 16.7 | 5.4 | 1.3 | 0.0 | 0.8 | 1.04 | 239 | 4.89 |
| *Acer macrophyllum* | 0.0 | 35.7 | 57.0 | 4.7 | 0.4 | 0.0 | 2.1 | 0.92 | 235 | 4.81 |
| *Quercus rubra* | 1.9 | 80.6 | 11.6 | 3.2 | 1.9 | 0.0 | 0.6 | 1.02 | 155 | 3.17 |
| *Liquidambar styraciflua* | 3.2 | 53.2 | 37.7 | 4.5 | 1.3 | 0.0 | 0.0 | 0.98 | 154 | 3.15 |
| *Populus balsamifera* | 0.0 | 56.3 | 11.6 | 31.1 | 0.0 | 0.0 | 0.0 | 0.93 | 135 | 2.76 |
| *Prunus cerasifera* | 0.7 | 39.6 | 40.3 | 18.7 | 0.7 | 0.0 | 0.0 | 0.92 | 134 | 2.74 |
| *Malus* | 7.5 | 39.8 | 42.1 | 9.8 | 0.8 | 0.0 | 0.0 | 0.96 | 133 | 2.72 |
| *Fraxinus excelsior* | 1.7 | 83.2 | 5.9 | 5.0 | 4.2 | 0.0 | 0.0 | 1.02 | 119 | 2.43 |
| *Fraxinus pennsylvanica* | 0.0 | 62.5 | 37.5 | 0.0 | 0.0 | 0.0 | 0.0 | 1.00 | 104 | 2.13 |
| *Cornus kousa* | 0.0 | 57.3 | 32.9 | 3.7 | 3.7 | 0.0 | 2.4 | 0.95 | 82 | 1.68 |
| *Alnus rubra* | 0.0 | 22.1 | 55.8 | 10.4 | 0.0 | 0.0 | 11.7 | 0.82 | 77 | 1.57 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| *Thuja plicata* | 0.0 | 48.1 | 41.6 | 2.6 | 7.8 | 0.0 | 0.0 | 0.94 | 77 | 1.57 |
| *Cornus florida* | 0.0 | 46.2 | 38.5 | 6.2 | 6.2 | 0.0 | 3.1 | 0.91 | 65 | 1.33 |
| *Cercidiphyllum japonicum* | 11.5 | 72.1 | 14.8 | 1.6 | 0.0 | 0.0 | 0.0 | 1.05 | 61 | 1.25 |
| *Prunus* | 0.0 | 5.2 | 72.4 | 17.2 | 1.7 | 0.0 | 3.4 | 0.83 | 58 | 1.19 |
| *Calocedrus decurrens* | 0.0 | 36.5 | 55.8 | 7.7 | 0.0 | 0.0 | 0.0 | 0.94 | 52 | 1.06 |
| all other species | 5.0 | 58.3 | 31.0 | 4.5 | 0.3 | 0.0 | 0.9 | 0.99 | 643 | 13.15 |
| Total | 4.9% | 65.1% | 23.4% | 4.8% | 0.9% | 0% | 0.8% | 1.00 | 4,890 | 100% |

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 B.

RPI is also helpful for identifying underused species that are demonstrating reliable performance. Species with an RPI value greater than 1.00 and an established age distribution may indicate their suitability for the local environment. These species should receive consideration for additional planting. As an example, London plane (*Platanus x hybrida*) has an RPI of 1.03 and that is represented by young to mature trees (41.7% are less than 11-inches in diameter and 24.9% are more than 24-inches in diameter). Oregon white oak (*Quercus garryana*) is also performing well and adequately represented through the age distribution, (7.1% are less than 11-inches in diameter and 64.2% are more than 24-inches in diameter). The representation of the population and the age distribution of these species support the RPI values. Alternatively, European ash (*Fraxinus excelsior*, 2.4%) has an RPI of 1.02 and is primarily represented by trees less than 11-inches in diameter (99.2%). Although this species is likely to perform well in Tumwater, there are not enough mature trees to substantiate the high RPI due to the lack of evidence of long-term performance and longevity.

## 3.6 Replacement Value

The current replacement value of Tumwater's inventoried tree resource is nearly $11.9 million for the inventoried tree population. 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, 24.5% is attributable to Douglas-fir (*Pseudotsuga menziesii*), for a total of nearly $3 million (Table 5). Bigleaf maple (*Acer macrophyllum*) has the highest per tree replacement value of $10,006 per tree for a total replacement value of nearly $2.4 million. The average per tree replacement value is $2,435. To replace all 4,890 inventoried trees in Tumwater with trees of equivalent size and condition would cost nearly $11.9 million.

The replacement value for Tumwater's inventoried 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 inventoried 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 5: Replacement Value for Most Prevalent Inventoried Species (Representing >1%)*

| Species | # of Trees | % of Pop. | Replacement Value ($) | % of Replacement |
|---|---|---|---|---|
| *Acer platanoides* | 747 | 15.28 | 1,092,056 | 9.17 |
| *Pyrus calleryana* | 466 | 9.53 | 327,636 | 2.75 |
| *Acer rubrum* | 451 | 9.22 | 315,733 | 2.65 |
| *Pseudotsuga menziesii* | 417 | 8.53 | 2,916,093 | 24.49 |
| *Prunus serrulata* | 286 | 5.85 | 276,028 | 2.32 |
| *Tilia cordata* | 239 | 4.89 | 214,457 | 1.80 |
| *Acer macrophyllum* | 235 | 4.81 | 2,351,445 | 19.75 |
| *Quercus rubra* | 155 | 3.17 | 326,338 | 2.74 |
| *Liquidambar styraciflua* | 154 | 3.15 | 275,052 | 2.31 |
| *Populus balsamifera* | 135 | 2.76 | 144,963 | 1.22 |
| *Prunus cerasifera* | 134 | 2.74 | 253,427 | 2.13 |
| *Malus* | 133 | 2.72 | 172,095 | 1.45 |
| *Fraxinus excelsior* | 119 | 2.43 | 80,296 | 0.67 |
| *Fraxinus pennsylvanica* | 104 | 2.13 | 54,116 | 0.45 |
| *Cornus kousa* | 82 | 1.68 | 29,703 | 0.25 |
| *Alnus rubra* | 77 | 1.57 | 265,980 | 2.23 |
| *Thuja plicata* | 77 | 1.57 | 396,425 | 3.33 |
| *Cornus florida* | 65 | 1.33 | 37,342 | 0.31 |
| *Cercidiphyllum japonicum* | 61 | 1.25 | 95,088 | 0.80 |
| *Prunus* | 58 | 1.19 | 179,669 | 1.51 |
| *Calocedrus decurrens* | 52 | 1.06 | 70,969 | 0.60 |
| all other species | 643 | 13.15 | 2,032,813 | 17.07 |
| Total | 4,890 | 100% | $11,907,733 | 100% |

Trees and urban forests provide tangible and 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). If trees are healthy and vigorous, they often produce more leaf surface area each year.

Urban forests have important functional benefit values based on the environmental functions the trees perform. In addition to air quality benefits like producing oxygen and filtering out particulates, trees slow down and absorb stormwater as well as remove pollutants. Resulting in reduced stormwater management costs for municipalities. Tree growth sequesters carbon in the production of new woody stems and roots. The value of these ecosystem functions is calculated in terms of both volume and cost savings.

## 3.7 iTree Analysis & 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, Tumwater's inventoried trees provide annual environmental benefits valued at $18,010 (Figure 11). The annual environmental benefits provided by the inventoried tree resource are conservative estimates due to limitations in the i-Tree *Eco* program, which does not calculate benefit values for trees larger than 100-inches in diameter. As such, some trees in the inventory exceeded the maximum allowable diameter and were therefore assigned a default measurement of 100-inches in diameter to accommodate the analysis.

## 3.8 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])

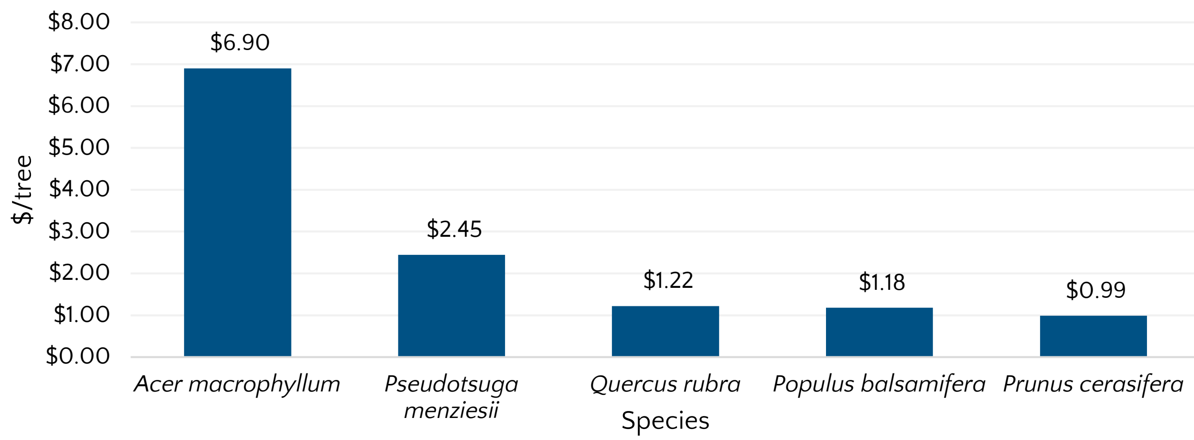
Air pollutants are known to contribute adversely to human health. Trees lessen the amount of air pollutants in the atmosphere, which can reduce the incidence of numerous negative health effects (Table 8).

Ozone is an air pollutant that is particularly 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 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 2,181 pounds of nitrogen dioxide ($NO_2$), sulfur dioxide ($SO_2$), small particulate matter ($PM_{2.5}$), and ozone ($O_3$) are intercepted or absorbed by Tumwater's inventoried trees, for a total value of $5,957, an average of $1.22 per tree. (Table 6). Among prevalent inventoried trees, bigleaf maple (*Acer macrophyllum*), Douglas-fir (*Pseudotsuga menziesii*), and Norway maple (*Acer platanoides*) remove the most pollutants, 27%, 17%, and 8% of the total pollutants removed, respectively (Figure 7). These species are the greatest contributors to air quality benefits and combined provide benefits of $5,957 annually.

*Figure 7: Air Pollution Removal by Inventoried Trees*




Trees produce oxygen during photosynthesis, and inventoried trees in Tumwater produce an estimated 71.1 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.

*Table 6: Annual Air Pollution Removal Benefits of Inventoried Trees*

| Pollutant | Pollutant Removal (lb.) | Value ($) | % of Benefit |
|---|---|---|---|
| $PM_{10}$ | 811.93 | 2,665.19 | 44.74 |
| $PM_{2.5}$ | 43.36 | 2,588.84 | 43.46 |
| $O_3$ | 960.56 | 660.93 | 11.09 |
| $NO_2$ | 299.56 | 24.08 | 0.40 |
| CO | 24.69 | 17.24 | 0.29 |
| $SO_2$ | 41.00 | 0.95 | 0.02 |
| Total | 2,181 | $5,957 | 100% |

Inventoried trees in Tumwater are emitting 601.9 pounds of volatile organic compounds (VOCs) each year (232.1 tons of isoprene and 369.8 pounds of monoterpenes). Emissions vary based on species characteristics and amount of leaf biomass. Balsam poplar (*Populus balsamifera*) produce the second highest VOC emissions (64.4 lb/yr), followed by Douglas-fir (*Pseudotsuga menziesii*, 60.7 lb/yr). Overall, Northern red oak (*Quercus rubra*, 116 lb/yr) produce the greatest volume of VOC emissions and 19% of total emissions, largely due to their size (2.6% of overall leaf area) and prevalence in the inventory (3.2%).[2]

[2] Some economic studies have estimated VOC emission costs. These costs are not included here as there is a tendency to add positive dollar estimates of ozone removal effects with negative dollar values of VOC emission effects to determine whether tree effects are positive or negative in

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 inventoried trees on Tumwater'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.

### *Air Pollution Removal in Natural Areas*

Each year, around 8,733 pounds of nitrogen dioxide ($NO_2$), sulfur dioxide ($SO_2$), small particulate matter ($PM_{2.5}$), and ozone ($O_3$) are intercepted or absorbed by Tumwater's trees in natural areas, for a total value of $27,898. (Table 7). Trees in natural areas removed 287.6 lb. of $PM_{2.5}$ for a value of $15,308 (54.9%). 5,629 lb. of $O_3$ was removed for a value of $7,312 (26.2%).

*Table 7: Air Pollution Removal for Trees in Natural Areas*

| Pollutant | Pollutant Removal (lb.) | Value ($) | % of Benefit |
|---|---|---|---|
| $PM_{2.5}$ | 287.57 | 15,308 | 54.87 |
| $O_3$ | 5,629.15 | 7,312 | 26.21 |
| $PM_{10}$* | 1,597.67 | 5,007 | 17.95 |
| $NO_2$ | 728.72 | 159 | 0.57 |
| CO | 131.91 | 88 | 0.32 |
| $SO_2$ | 358.23 | 24 | 0.09 |
| Total | 8,733 | $27,898 | 100% |

## 3.9 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).

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relation to ozone. This combining of dollar values to determine tree effects should not be done, rather estimates of VOC effects on ozone formation (e.g., via photochemical models) should be conducted and directly contrasted with ozone removal by trees (i.e., ozone effects should be directly compared, not dollar estimates). In addition, air temperature reductions by trees have been shown to significantly reduce ozone concentrations (Cardelino and Chameides 1990; Nowak et al 2000) but are not considered in this analysis. Photochemical modeling that integrates tree effects on air temperature, pollution removal, VOC emissions, and emissions from power plants can be used to determine the overall effect of trees on ozone concentrations (itreetools.org).

The Center for Public Urban Forest Research (CUFR) recently led the development of the 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 inventoried tree resource in Tumwater 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.

As global temperatures rise this effect can be magnified in urban centers with plenty of hard surfaces, particularly concrete and asphalt, which retain heat and are slow to cool. Cities can be many degrees hotter than surrounding countryside. This effect is known as a 'heat island' and is explained in more detail in section 3.10. It can however be mitigated by having shade trees and an expansive urban forest. Therefore the percentage of canopy cover - the shade from trees - in a city is such an important metric. As with other infrastructure, this 'green' infrastructure can be unevenly distributed. Tree inventory databases can help redress the balance with targeted planting and maintenance programs."

To date, inventoried trees within Tumwater are estimated to have stored 1,968 tons of carbon ($CO_2$) in woody and foliar biomass valued at $335,667. Annually, the inventoried tree resource directly sequesters an additional 26.7 tons of carbon valued at $4,548 (Table 8).

Among prevalent inventoried tree species, bigleaf maple (*Acer macrophyllum*) contributes the most per tree to atmospheric carbon removal at $2.39, sequestering a gross 3.3 tons of carbon annually (11.4% of overall total benefits) (Figure 8).

*Figure 8: Carbon Sequestration by Inventoried Trees*

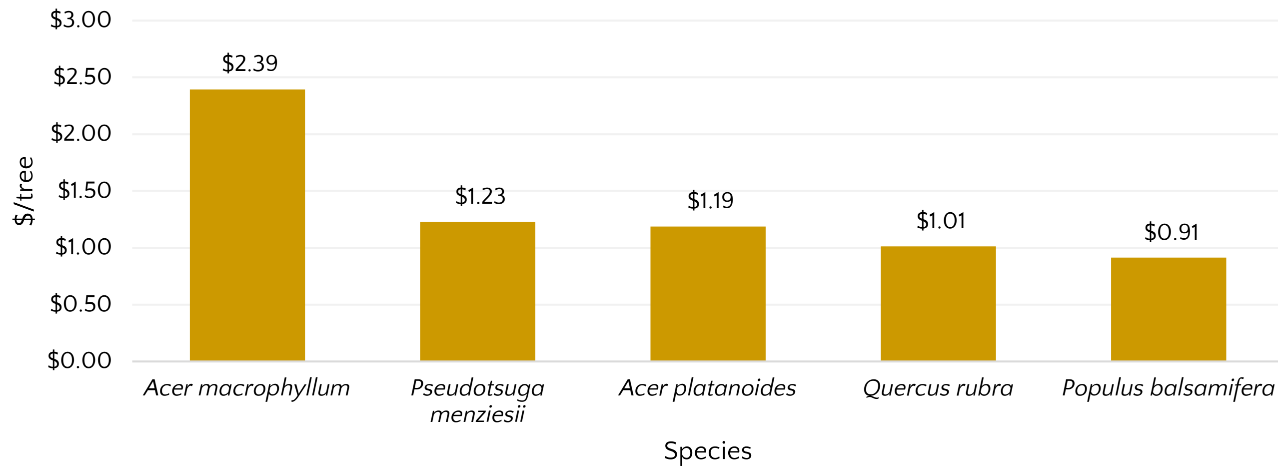



*Table 8: Annual Gross Carbon Sequestration by Most Prevalent Inventoried Species*

| Species | # of Trees | % of Pop. | Carbon Sequestration (ton/yr.) | Carbon Sequestration ($/yr.) | Carbon Storage ($) | Average $/tree | % of Annual Benefit |
|---|---|---|---|---|---|---|---|
| *Acer platanoides* | 747 | 15.28 | 5.20 | 887.46 | 22,368 | 1.19 | 19.51 |
| *Pyrus calleryana* | 466 | 9.53 | 1.59 | 271.52 | 5,529 | 0.58 | 5.97 |
| *Acer rubrum* | 451 | 9.22 | 2.20 | 375.05 | 6,903 | 0.83 | 8.25 |
| *Pseudotsuga menziesii* | 417 | 8.53 | 3.01 | 513.03 | 60,845 | 1.23 | 11.28 |
| *Prunus serrulata* | 286 | 5.85 | 1.16 | 198.14 | 8,592 | 0.69 | 4.36 |
| *Tilia cordata* | 239 | 4.89 | 0.65 | 110.77 | 2,307 | 0.46 | 2.44 |
| *Acer macrophyllum* | 235 | 4.81 | 3.30 | 562.62 | 92,572 | 2.39 | 11.37 |
| *Quercus rubra* | 155 | 3.17 | 0.92 | 156.77 | 6,304 | 1.01 | 3.45 |
| *Liquidambar styraciflua* | 154 | 3.15 | 0.63 | 107.56 | 2,577 | 0.70 | 2.37 |
| *Populus balsamifera* | 135 | 2.76 | 0.72 | 113.24 | 6,283 | 0.91 | 2.71 |
| *Prunus cerasifera* | 134 | 2.74 | 0.67 | 113.81 | 9,645 | 0.85 | 2.50 |
| *Malus* | 133 | 2.72 | 0.35 | 59.25 | 6,186 | 0.45 | 1.30 |
| *Fraxinus excelsior* | 119 | 2.43 | 0.36 | 61.45 | 2,328 | 0.52 | 1.35 |
| *Fraxinus pennsylvanica* | 104 | 2.13 | 0.23 | 39.14 | 833 | 0.38 | 0.86 |
| *Cornus kousa* | 82 | 1.68 | 0.09 | 15.43 | 385 | 0.19 | 0.34 |
| *Alnus rubra* | 77 | 1.57 | 0.41 | 70.17 | 6,008 | 0.91 | 1.54 |
| *Thuja plicata* | 77 | 1.57 | 0.18 | 30.34 | 6,432 | 0.39 | 0.67 |
| *Cornus florida* | 65 | 1.33 | 0.13 | 22.47 | 754 | 0.35 | 0.49 |
| *Cercidiphyllum japonicum* | 61 | 1.25 | 0.16 | 27.87 | 677 | 0.46 | 0.61 |
| *Prunus* | 58 | 1.19 | 0.36 | 61.51 | 10,039 | 1.06 | 1.35 |
| *Calocedrus decurrens* | 52 | 1.06 | 0.16 | 27.75 | 2,211 | 0.53 | 0.61 |
| all other species | 643 | 13.15 | 4.11 | 711.59 | 75,888 | 1.11 | 15.67 |
| Total | 4,890 | 100% | 26.67 | $4,548 | $335,667 | 100% | 100% |

### *Carbon Sequestration in Natural Areas*

Environmental benefit estimates for trees in natural areas were generated using *i-Tree Canopy*. To date, trees in natural areas within Tumwater are estimated to have stored 4,002.7 tons of carbon ($CO_2$) in woody and foliar biomass valued at $682,654. Annually, the trees in natural areas directly sequester an additional 159.4 tons of carbon valued at $27,182.

## 3.10 Energy Savings

Trees modify climate and conserve energy in three principal ways:

- Shading reduces the amount of radiant energy absorbed and stored by hardscape surfaces, thereby reducing the heat island effect.
- Transpiration converts moisture to water vapor, thereby cooling the air by using solar energy that would otherwise result in heating of the air.
- Reduction of wind speed plus the movement of outside air into interior spaces, and conductive heat loss where thermal conductivity is relatively high (e.g., glass windows) (Simpson, 1998).

The heat island effect describes the increase in urban temperatures in relation to surrounding suburban and rural areas. Heat islands are associated with an increase in hardscape and impervious surfaces. Trees and other vegetation within an urbanized environment help reduce the heat island effect by lowering air temperatures 5°F (3°C) compared with outside the green space (Chandler, 1965). On a larger scale, temperature differences of more than 9°F (5°C) have been observed between city centers without adequate canopy coverage and more vegetated suburban areas (Akbari et al, 1997). The relative importance of these effects depends upon the size and configuration of trees and other landscape elements (McPherson, 1993). Tree spacing, crown spread, and vertical distribution of leaf area each influence the transport of warm air and pollutants along streets and out of urban canyons. Trees reduce conductive heat loss from buildings by reducing air movement into buildings and against conductive surfaces (e.g., glass, metal siding). Trees can reduce wind speed and the resulting air infiltration by up to 50%, translating into potential annual heating savings of 25% (Heisler, 1986).

### *Electricity & Natural Gas Reductions*

Trees contribute to electric and natural gas savings through shading and climate buffering effects to buildings and structures. Energy reduction metrics can be calculated using data on tree distance and direction from buildings taken during the inventory process. The annual energy reductions from Tumwater’s inventoried trees were not calculated because this data was not obtained during the inventory process. However, trees in Tumwater contribute to electric and natural gas savings through shading and climate buffering effects.

## 3.11 Stormwater Runoff Reductions

Rainfall interception by trees reduces the amount of stormwater that enters collection and treatment facilities during large storm events (Figure 6). 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 which in turn will improve water quality.
- Tree canopies reduce soil erosion and surface flows by diminishing the impact of raindrops on bare soil.

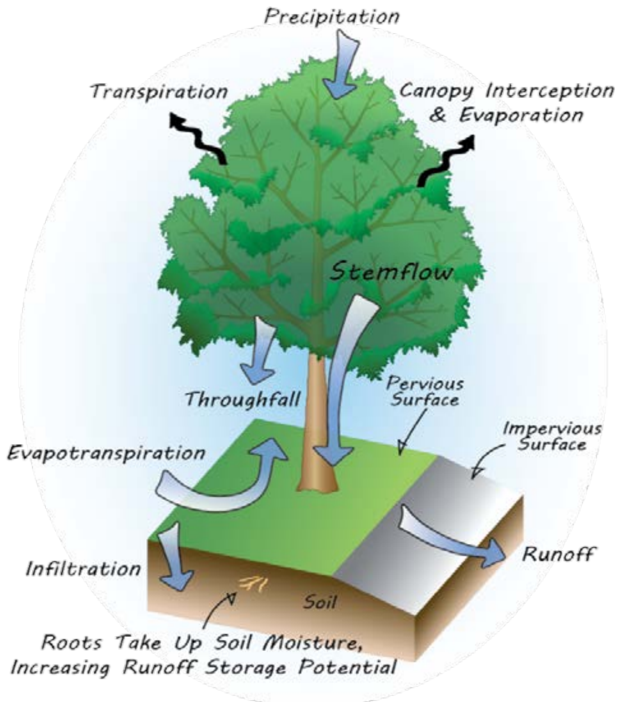



*Figure 6: Trees Reduce Stormwater Runoff*

Tumwater's inventoried tree resource is estimated to contribute to the avoidance of more than 829,870 gallons of stormwater runoff annually through the interception of precipitation on the leaves and bark of trees for an average of 172 gallons per tree.

Bigleaf maple (*Acer macrophyllum*) provides 27.2% of the estimated total avoided runoff (Figure 9; Table 9). Their abundance, coupled with the age distribution and stature of these trees, allow them to provide a larger benefit in comparison to other species. In contrast, the sixth most prevalent species, little-leaf linden (*Tilia cordata*) provides 1.8% of the estimated total avoided runoff value. 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 9: Top 5 Inventoried Species for Stormwater Benefits*

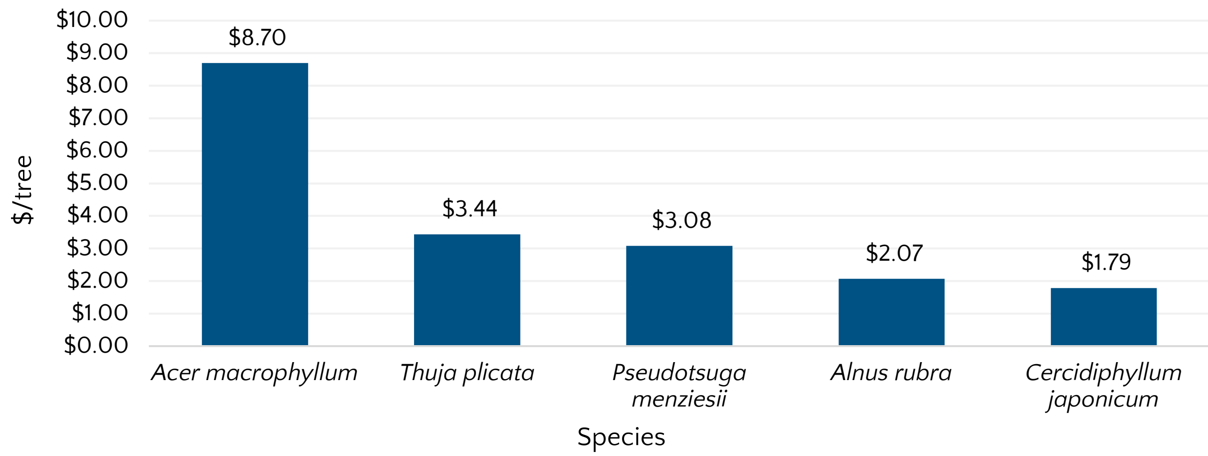



*Table 9: Stormwater Benefits from Tumwater's Most Prevalent Species*

| Species | # of Trees | % of Pop. | Avoided Runoff (gal./yr.) | Avoided Runoff ($/yr.) | % of Benefit | $/tree |
|---|---|---|---|---|---|---|
| *Acer platanoides* | 747 | 15.28 | 66,570 | 594.87 | 7.93 | 0.80 |
| *Pyrus calleryana* | 466 | 9.53 | 22,172 | 198.13 | 2.64 | 0.43 |
| *Acer rubrum* | 451 | 9.22 | 29,700 | 265.40 | 3.54 | 0.59 |
| *Pseudotsuga menziesii* | 417 | 8.53 | 143,886 | 1,285.76 | 17.13 | 3.08 |
| *Prunus serrulata* | 286 | 5.85 | 13,450 | 110.19 | 1.60 | 0.42 |
| *Tilia cordata* | 239 | 4.89 | 15,136 | 135.25 | 1.80 | 0.57 |
| *Acer macrophyllum* | 235 | 4.81 | 228,664 | 2,043.34 | 27.23 | 8.70 |
| *Quercus rubra* | 155 | 3.17 | 26,697 | 238.56 | 3.18 | 1.54 |
| *Liquidambar styraciflua* | 154 | 3.15 | 20,272 | 181.15 | 2.41 | 1.18 |
| *Populus balsamifera* | 135 | 2.76 | 22,473 | 200.82 | 2.68 | 1.49 |
| *Prunus cerasifera* | 134 | 2.74 | 18,625 | 166.43 | 2.22 | 1.24 |
| *Malus* | 133 | 2.72 | 6,290 | 56.20 | 0.75 | 0.42 |
| *Fraxinus excelsior* | 119 | 2.43 | 9,836 | 87.89 | 1.17 | 0.74 |
| *Fraxinus pennsylvanica* | 104 | 2.13 | 6,402 | 57.20 | 0.76 | 0.55 |
| *Cornus kousa* | 82 | 1.68 | 1,093 | 9.77 | 0.13 | 0.11 |
| *Alnus rubra* | 77 | 1.57 | 17,821 | 159.25 | 2.11 | 2.07 |
| *Thuja plicata* | 77 | 1.57 | 29,627 | 264.75 | 3.53 | 3.44 |
| *Cornus florida* | 65 | 1.33 | 1,556 | 13.90 | 0.19 | 0.21 |
| *Cercidiphyllum japonicum* | 61 | 1.25 | 11,202 | 109.04 | 1.45 | 1.79 |
| *Prunus* | 58 | 1.19 | 11,074 | 98.96 | 1.32 | 1.71 |
| *Calocedrus decurrens* | 52 | 1.06 | 7,299 | 65.23 | 0.87 | 1.25 |
| all other species | 643 | 13.15 | 119,027 | 1,152.98 | 15.36 | 1.79 |
| Total | 4,890 | 100% | 839,871 | $7,505 | 100 | 1.53 |

## 3. 13 Aesthetic, Property Value, & Socioeconomic Benefits

While perhaps the most difficult to quantify, the aesthetic and socioeconomic benefits from trees may be among their greatest contributions, including:

- Beautification, comfort, and aesthetics
- Shade and privacy
- Wildlife habitat
- Opportunities for recreation
- Reduction in violent crime
- Creation of a sense of place and history
- Human health
- Reduced illness and reliance on medication and quicker recovery from injury or illness

Some of these benefits are captured as a percentage of property values, through higher sales prices where individual trees and forests are located.

While some of the benefits of forests are intangible and/or difficult to quantify (e.g., the impacts on physical and psychological health, crime, and violence), empirical evidence of these benefits does exist (Kaplan, 1989; Ulrich, 1986). However, there is limited knowledge about the physical processes at work, and their interactions make quantification imprecise. Exposure to nature, including trees, has a healthy impact on humans, such as increased worker productivity, higher test scores, reduced symptoms of ADD, and faster recovery times following surgery. In addition, trees and forests have positive economic benefits for retailers. There is documented evidence that trees promote better business by stimulating more frequent and extended shopping and a willingness to pay more for goods and parking (Wolf, 2007). Trees further generate socioeconomic and health benefits by generating better school performance, less workplace illness, and increased concentration, all of which yield an increase to overall productivity. In addition, the trees throughout the built environment (and especially among vacant lot conversions and streets) promote active living connectors and reduce crime rates. Thus, trees provide for their community by generating new economic income and removing judicial system costs (Wolf, 2014).

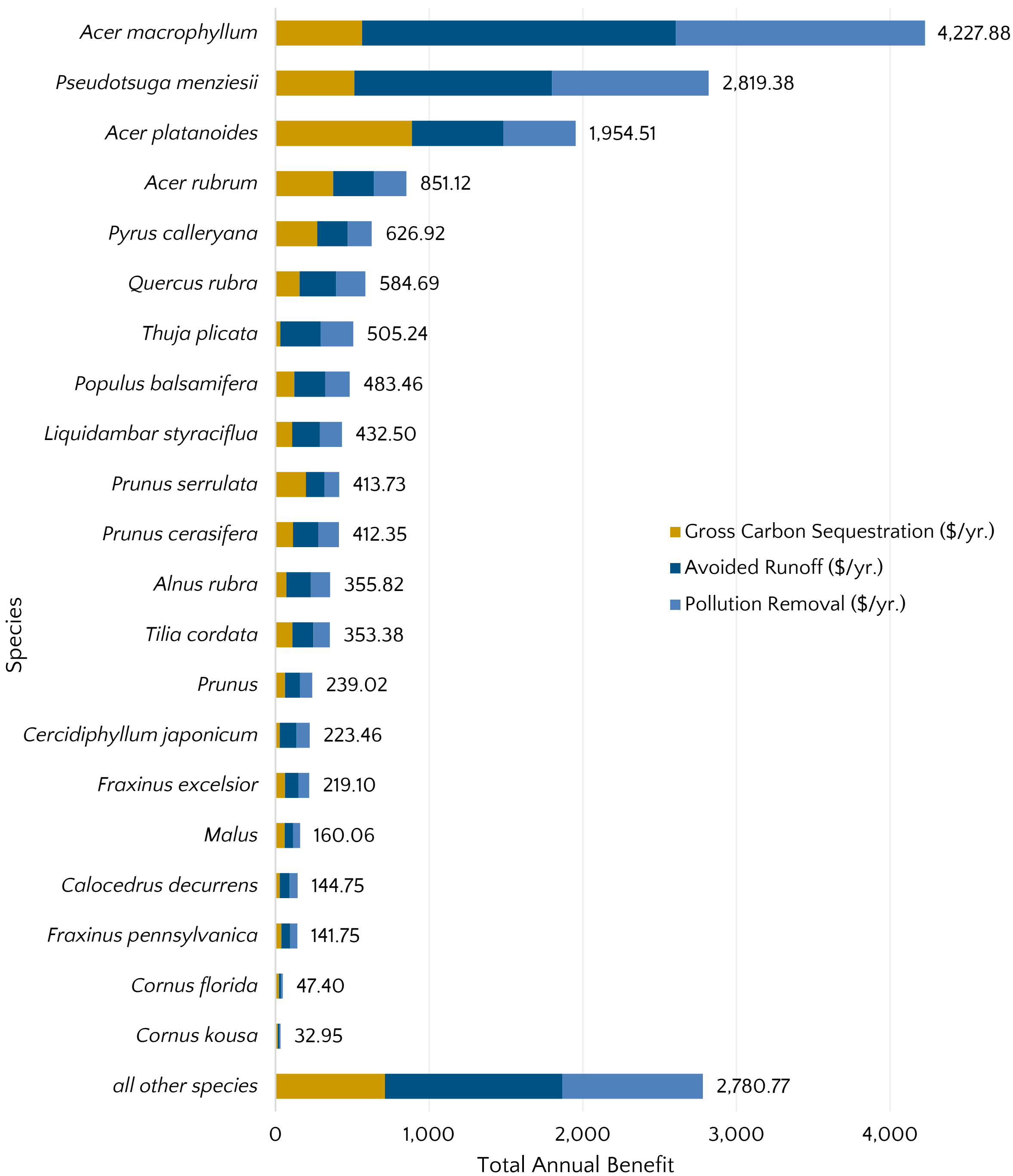
In addition, trees and forestlands provide critical habitat (foraging, nesting, spawning, etc.) for mammals, birds, and fish as well as other aquatic species, along with limitless opportunities for recreation, offering a healthful respite from the pressures of work and everyday stress.

Trees provide beauty in the urban landscape, privacy and screening, improved human health, a sense of comfort and place, and habitat for urban wildlife. 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.

## 3.14 Annual Benefits of Most Prevalent Species

It is important to keep in mind that a benefits analysis provides a snapshot of the inventoried 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 annual per species benefits of the most prevalent species was calculated (Figure 10, Table 10), but to determine if these benefits are a true indicator of performance, age distribution and stature of the species must also be considered (Table 3, Figure 2).

*Figure 10: Summary of Annual Total Tree Benefits for Most Prevalent Inventoried Species*



Of the most prevalent inventoried trees in Tumwater, bigleaf maple (*Acer macrophyllum*) is providing the greatest overall per tree benefit ($17.99). This large-stature species is represented by an established and mature population (23.8% are less than 11-inches in diameter and 42.6% are more 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.

In contrast, three of the most prevalent species are small -stature species, representing 5.7% of the overall inventory: apple species (*Malus*, $1.20), kousa dogwood (*Cornus kousa*, $0.40), and flowering dogwood (*Cornus florida*, $0.73). **Because of their small -stature, and smaller canopies, benefits from these species are unlikely to change much over time.**

*Table 10: Summary of Annual Benefits for Most Prevalent Inventoried Species*

| Species | # of Trees | % of Pop. | Carbon Sequestration ($/yr.) | Avoided Runoff ($/yr.) | Pollution Removal ($/yr.) | Total Benefit ($) |
|---|---|---|---|---|---|---|
| *Acer platanoides* | 747 | 15.28 | 887.46 | 594.87 | 472.18 | 1,954.51 |
| *Pyrus calleryana* | 466 | 9.53 | 271.52 | 198.13 | 157.27 | 626.92 |
| *Acer rubrum* | 451 | 9.22 | 375.05 | 265.40 | 210.67 | 851.11 |
| *Pseudotsuga menziesii* | 417 | 8.53 | 513.03 | 1185.76 | 1020.59 | 2,819.38 |
| *Prunus serrulata* | 286 | 5.85 | 198.14 | 110.19 | 95.40 | 413.73 |
| *Tilia cordata* | 239 | 4.89 | 110.77 | 135.25 | 107.36 | 353.38 |
| *Acer macrophyllum* | 235 | 4.81 | 562.62 | 2043.34 | 1621.92 | 4,227.88 |
| *Quercus rubra* | 155 | 3.17 | 156.77 | 238.56 | 189.36 | 584.69 |
| *Liquidambar styraciflua* | 154 | 3.15 | 107.56 | 181.15 | 143.79 | 432.50 |
| *Populus balsamifera* | 135 | 2.76 | 113.24 | 200.82 | 159.40 | 483.46 |
| *Prunus cerasifera* | 134 | 2.74 | 113.81 | 166.43 | 132.11 | 411.35 |
| *Malus* | 133 | 2.72 | 59.25 | 56.20 | 44.61 | 160.06 |
| *Fraxinus excelsior* | 119 | 2.43 | 61.45 | 87.89 | 69.76 | 219.10 |
| *Fraxinus pennsylvanica* | 104 | 2.13 | 39.14 | 57.20 | 45.41 | 141.75 |
| *Cornus kousa* | 82 | 1.68 | 15.43 | 9.77 | 7.75 | 32.95 |
| *Alnus rubra* | 77 | 1.57 | 70.17 | 159.25 | 116.40 | 355.82 |
| *Thuja plicata* | 77 | 1.57 | 30.34 | 264.75 | 210.15 | 505.24 |
| *Cornus florida* | 65 | 1.33 | 22.47 | 13.90 | 11.03 | 47.40 |
| *Cercidiphyllum japonicum* | 61 | 1.25 | 27.87 | 109.04 | 86.55 | 223.46 |
| *Prunus* | 58 | 1.19 | 61.51 | 98.96 | 78.55 | 239.02 |
| *Calocedrus decurrens* | 52 | 1.06 | 27.75 | 65.23 | 51.77 | 144.75 |
| all other species | 643 | 13.15 | 711.59 | 1152.98 | 915.20 | 2,780.77 |
| Total | 4,890 | 100% | $4,548 | $7,505 | $5,957 | $18,010 |

## 3.15 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).

## 3.16 Net Benefits

Tumwater receives substantial benefits from the inventoried tree resource. However, it is important to also understand the investment involved in preserving this tree resource and the benefits that it provides.

### *Benefits*

Tumwater's inventoried tree resource has beneficial effects on the environment, and annually contributes to $18,010 in benefits to the community, a value of $3.68 per tree and $1.04 per capita (Table 9). Individual components of the environmental benefits include improved air quality $5,957 (33.1%), carbon reductions of $4,548 (25.3%), and stormwater management for $7,505 (41.7%) (Figure 11).

*Figure 11: Annual Benefits of Inventoried Trees*

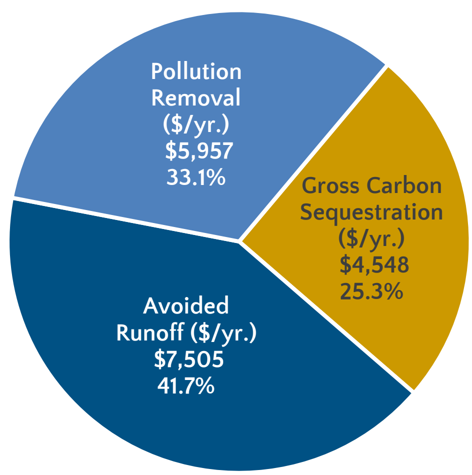


*Table 11: Benefits from the Inventoried Tree Resource in Tumwater*

| Species | # of Trees | % of Pop. | Carbon Sequestration ($/yr.) | Avoided Runoff ($/yr.) | Pollution Removal ($/yr.) | Total Benefit ($) | % of Benefit | $/tree |
|---|---|---|---|---|---|---|---|---|
| *Acer platanoides* | 747 | 15.28 | 887.46 | 595 | 472 | 1,955 | 2.62 | 2.62 |
| *Pyrus calleryana* | 466 | 9.53 | 271.52 | 198 | 157 | 627 | 1.35 | 1.35 |
| *Acer rubrum* | 451 | 9.22 | 375.05 | 265 | 211 | 851 | 1.89 | 1.89 |
| *Pseudotsuga menziesii* | 417 | 8.53 | 513.03 | 1,286 | 1,021 | 2,819 | 6.76 | 6.76 |
| *Prunus serrulata* | 286 | 5.85 | 198.14 | 120 | 95 | 414 | 1.45 | 1.45 |
| *Tilia cordata* | 239 | 4.89 | 110.77 | 135 | 107 | 353 | 1.48 | 1.48 |
| *Acer macrophyllum* | 235 | 4.81 | 562.62 | 2,043 | 1,622 | 4,228 | 17.99 | 17.99 |
| *Quercus rubra* | 155 | 3.17 | 156.77 | 239 | 189 | 585 | 3.77 | 3.77 |
| *Liquidambar styraciflua* | 154 | 3.15 | 107.56 | 181 | 144 | 433 | 2.81 | 2.81 |
| *Populus balsamifera* | 135 | 2.76 | 123.24 | 201 | 159 | 483 | 3.58 | 3.58 |
| *Prunus cerasifera* | 134 | 2.74 | 113.81 | 166 | 132 | 412 | 3.08 | 3.08 |
| *Malus* | 133 | 2.72 | 59.25 | 56 | 45 | 160 | 1.20 | 1.20 |
| *Fraxinus excelsior* | 119 | 2.43 | 61.45 | 88 | 70 | 219 | 1.84 | 1.84 |
| *Fraxinus pennsylvanica* | 104 | 2.13 | 39.14 | 57 | 45 | 142 | 1.36 | 1.36 |
| *Cornus kousa* | 82 | 1.68 | 15.43 | 10 | 8 | 33 | 0.40 | 0.40 |
| *Alnus rubra* | 77 | 1.57 | 70.17 | 159 | 126 | 356 | 4.62 | 4.62 |
| *Thuja plicata* | 77 | 1.57 | 30.34 | 265 | 210 | 505 | 6.56 | 6.56 |
| *Cornus florida* | 65 | 1.33 | 22.47 | 14 | 11 | 47 | 0.73 | 0.73 |
| *Cercidiphyllum japonicum* | 61 | 1.25 | 27.87 | 109 | 87 | 223 | 3.66 | 3.66 |
| *Prunus* | 58 | 1.19 | 61.51 | 99 | 79 | 239 | 4.12 | 4.12 |
| *Calocedrus decurrens* | 52 | 1.06 | 27.75 | 65 | 52 | 145 | 2.78 | 2.78 |
| all other species | 643 | 13.15 | 712.59 | 1,153 | 915 | 2,781 | 4.32 | 4.32 |
| **Total** | **4,890** | **100%** | **$4,548** | **$7,505** | **$5,957** | **$18,010** | **100%** | **$3.68** |

A limitation of the annual benefits summary is that it does not fully account for all benefits provided by the inventoried tree resource, as some benefits are intangible and/or difficult to quantify, such as impacts on psychological health, crime, and violence (University of Washington, 2018; University of Illinois, 2018).

Empirical evidence of these benefits does exist (Wolf, 2007; Kaplan and Kaplan, 1989; Ulrich, 1986), but there is limited knowledge about the physical processes at work and the complex nature of interactions make quantification imprecise. Tree growth and mortality rates are highly variable. A true and full accounting of benefits and investments must consider variability among sites (e.g., tree species, growing conditions, maintenance practices) throughout the City, as well as variability in tree growth. In other words, trees are worth far more than what one can ever quantify!

### *Investments*

Annually, Tumwater invests approximately $1 million in the management of the inventoried tree resource[3] . Of the total investments, 25% is attributed to administration ($250,000), 20% pruning ($200,000), 15% inspections ($150,000), 10% irrigation ($100,000), and 10% removal ($100,000). The remaining 20% ($200,000) goes toward litter clean up, tree planting and maintenance, infrastructure repair, liability claims, and pest and disease control.

[3] Investment costs were provided by the City of Tumwater's staff

# 4.0 Urban Forest Pests and Pathogens

Involvement in the global economy and a highly mobile human population increase the risk of an invasive pest or pathogen introduction into Tumwater. To further investigate the risk of pests and pathogens, i-Tree *Eco* identifies the susceptibility of tree populations to 44 emerging and existing pests and pathogens in the United States (Table 12). According to the analysis, 4,624 (95%) of the 4,980 trees are susceptible to these pests and pathogens and the potential risk is estimated at nearly $11.3 million. The pests and pathogens identified as most relevant to Tumwater are included in Table 10. Anticipating and monitoring for these threats is an important part of urban forest management.

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 42.7% of Tumwater's inventoried trees susceptible to the borer, managers should regularly inspect trees and plant non-host species.

The 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, nearly 10% of Tumwater's inventoried 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.

Defoliating moths, such as gypsy moth (*Lymantria dispar*) and winter moth (*Operophtera brumata*) threaten a broad range of tree hosts present in Tumwater (30% and 40% of the inventoried 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 85 miles north of Tumwater. 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.

### *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
- Participate in state sponsored pest preparedness program

*Table 12: Pest & Pathogen Threats to Tumwater*

| Pest Name | | Number of Trees | | Replacement Value ($) | | Leaf Area (%) | | Leaf Area (ac) | |
|---|---|---|---|---|---|---|---|---|---|
| | | Susceptible | Not Susceptible | Susceptible | Not Susceptible | Susceptible | Not Susceptible | Susceptible | Not Susceptible |
| asian longhorned beetle | *Anoplophora glabripennis* | 2,088 | 2,802 | 4,879,443 | 7,028,290 | 49.6 | 50.4 | 105.2 | 106.8 |
| winter moth | *Operophtera brumata* | 1,943 | 2,947 | 4,839,153 | 7,068,580 | 48.9 | 51.1 | 103.8 | 108.2 |
| spotted lanternfly | *Lycorma delicatula* | 1,795 | 3,095 | 2,407,690 | 9,500,043 | 18.5 | 81.5 | 39.2 | 172.9 |
| polyphagous shot hole borer | *Euwallacea nov. sp.* | 1,543 | 3,347 | 4,095,707 | 7,811,026 | 42.2 | 57.8 | 89.4 | 112.6 |
| gypsy moth | *Lymantria dispar* | 1,482 | 3,408 | 2,325,587 | 9,582,146 | 19.4 | 80.6 | 41.1 | 170.9 |
| sudden oak death | *Phytophthora ramorum* | 941 | 3,949 | 5,817,875 | 6,089,858 | 49.6 | 50.4 | 105.1 | 106.9 |
| heterobasidion root disease | *Heterobasidion irregulare/occidentale* | 559 | 4,331 | 3,522,835 | 8,384,898 | 22.9 | 77.1 | 48.5 | 163.5 |
| armillaria root disease | *Armillaria spp.* | 553 | 4,337 | 3,422,027 | 8,485,706 | 21.9 | 78.1 | 46.4 | 165.6 |
| black stain root disease | *Leptographium wageneri* | 474 | 4,416 | 3,114,741 | 8,782,993 | 19.3 | 80.7 | 41.0 | 171.0 |
| western spruce budworm | *Choristoneura occidentalis* | 466 | 4,424 | 3,105,586 | 8,802,147 | 19.0 | 81.0 | 40.4 | 171.7 |
| pine shoot beetle | *Tomicus piniperda* | 464 | 4,426 | 3,038,409 | 8,869,324 | 18.6 | 81.4 | 39.3 | 172.7 |
| Douglas-fir black stain root disease | *Leptographium wageneri var. pseudotsugae* | 462 | 4,428 | 3,084,030 | 8,823,703 | 18.9 | 81.1 | 40.1 | 171.9 |
| western blackheaded budworm | *Acleris gloverana* | 431 | 4,459 | 2,979,498 | 8,928,236 | 17.7 | 82.3 | 37.5 | 174.5 |
| spruce budworm | *Choristoneura fumiferana* | 428 | 4,462 | 2,918,553 | 8,989,180 | 17.2 | 82.8 | 36.4 | 175.6 |
| fir engraver | *Scolytus ventralis* | 424 | 4,466 | 2,954,633 | 8,953,100 | 17.5 | 82.5 | 37.1 | 174.9 |
| Douglas-fir beetle | *Dendroctonus pseudotsugae* | 417 | 4,473 | 2,916,093 | 8,991,640 | 17.1 | 82.9 | 36.3 | 175.7 |
| browntail moth | *Euproctis chrysorrhoea* | 358 | 4,532 | 711,992 | 11,195,742 | 5.6 | 94.4 | 11.9 | 200.1 |
| large aspen tortrix | *Choristoneura conflictana* | 311 | 4,579 | 715,465 | 11,192,268 | 7.3 | 92.7 | 15.5 | 196.5 |
| emerald ash borer | *Agrilus planipennis* | 252 | 4,638 | 165,843 | 11,741,891 | 2.3 | 97.7 | 4.9 | 207.1 |
| aspen leafminer | *Phyllocnistis populiella* | 216 | 4,674 | 405,724 | 11,502,009 | 4.7 | 95.3 | 9.9 | 202.1 |
| oak wilt | *Ceratocystis fagacearum* | 182 | 4,708 | 659,317 | 11,248,416 | 4.9 | 95.1 | 10.5 | 201.5 |
| forest tent caterpillar | *Malacosoma disstria* | 165 | 4,725 | 520,082 | 11,387,651 | 4.2 | 95.8 | 8.9 | 203.1 |
| dogwood anthracnose | *Discula destructiva* | 151 | 4,739 | 74,987 | 11,832,746 | 0.4 | 99.6 | 0.8 | 211.3 |

| Pest Name | | Number of Trees | | Replacement Value ($) | | Leaf Area (%) | | Leaf Area (ac) | |
|---|---|---|---|---|---|---|---|---|---|
| | | Susceptible | Not Susceptible | Susceptible | Not Susceptible | Susceptible | Not Susceptible | Susceptible | Not Susceptible |
| southern pine beetle | *Dendroctonus frontalis* | 65 | 4,825 | 186,563 | 11,721,170 | 2.0 | 98.0 | 4.3 | 207.7 |
| Mediterranean oak borer | *Xyleborus monographus* | 57 | 4,833 | 118,741 | 11,788,992 | 1.0 | 99.0 | 2.0 | 210.0 |
| sirex wood wasp | *Sirex noctilio* | 47 | 4,843 | 112,316 | 11,785,417 | 1.4 | 98.6 | 3.0 | 209.0 |
| mountain pine beetle | *Dendroctonus ponderosae* | 38 | 4,852 | 106,150 | 11,801,583 | 1.2 | 98.8 | 2.6 | 209.4 |
| western five-needle pine mortality | *western five-needle pine mortality summary* | 18 | 4,872 | 86,416 | 11,821,317 | 0.9 | 99.1 | 2.0 | 210.1 |
| white pine blister rust | *Cronartium ribicola* | 18 | 4,872 | 86,416 | 11,821,317 | 0.9 | 99.1 | 2.0 | 210.1 |
| Dutch elm disease | *Ophiostoma novo-ulmi* | 17 | 4,873 | 40,042 | 11,867,691 | 0.3 | 99.7 | 0.6 | 211.4 |
| balsam woolly adelgid | *Adelges piceae* | 15 | 4,875 | 40,210 | 11,867,523 | 0.4 | 99.6 | 0.8 | 211.2 |
| Jack pine budworm | *Choristoneura pinus* | 14 | 4,876 | 19,444 | 11,888,289 | 0.3 | 99.7 | 0.6 | 211.4 |
| pine black stain root disease | *Leptographium wageneri var. ponderosum* | 14 | 4,876 | 19,444 | 11,888,289 | 0.3 | 99.7 | 0.6 | 211.4 |
| aspen running canker | *Neodothiora populina* | 13 | 4,877 | 15,787 | 11,891,946 | 0.1 | 99.9 | 0.2 | 211.8 |
| hemlock sawfly | *Neodiprion tsugae* | 13 | 4,877 | 62,077 | 11,845,657 | 0.6 | 99.4 | 1.2 | 210.8 |
| spruce beetle | *Dendroctonus rufipennis* | 11 | 4,879 | 2,460 | 11,905,273 | 0.1 | 99.9 | 0.1 | 211.9 |
| bur oak blight | *Tubakia iowensis* | 6 | 4,884 | 54,640 | 11,853,093 | 0.4 | 99.6 | 0.8 | 211.2 |
| Port-Orford-cedar root disease | *Phytophthora lateralis* | 6 | 4,884 | 29,510 | 11,878,224 | 0.2 | 99.8 | 0.3 | 211.7 |
| northern spruce engraver | *Ips perturbatus* | 5 | 4,885 | 2,170 | 11,905,563 | 0.1 | 99.9 | 0.1 | 211.9 |
| butternut canker | *Sirococcus clavigignenti juglandacearum* | 3 | 4,887 | 9,825 | 11,897,909 | 0.1 | 99.9 | 0.2 | 211.8 |
| chestnut blight | *Cryphonectria parasitica* | 2 | 4,888 | 29,890 | 11,877,843 | 0.2 | 99.8 | 0.3 | 211.7 |
| beech leaf disease | *Litylenchus crenatae mccannii* | 1 | 4,889 | 2,460 | 11,905,274 | 0.1 | 99.9 | 0.1 | 211.9 |
| fusiform rust | *Cronartium quercuum f. sp. Fusiforme* | 1 | 4,889 | 694 | 11,907,040 | 0.1 | 100.0 | 0.1 | 211.0 |
| thousand canker disease | *Geosmithia morbida* | 1 | 4,889 | 5,095 | 11,902,639 | 0.1 | 100.0 | 0.1 | 211.9 |
| All Pests | | 4,624 | 266 | $11,295,873 | $611,860 | 95.3 | 4.7 | 202.1 | 9.9 |

# 5.0 Tree Maintenance and Costs

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 tree 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 Tumwater has a total of 4,890 inventoried trees located in areas around the City. Of that population, 7.3% were recommended some sort of maintenance tree care and 14% of inventoried trees had a primary defect (Table 11, Table 13).

Trees in natural areas were sampled using 42 1/10-acre plots. In total, 16 species representing 593 trees were sampled. Trees less than 6 inches were excluded. Estimations for benefits and area of trees in the natural areas was preformed using i-tree canopy. There is approximately 201 acres of natural areas in Tumwater and an estimated 28,200 trees.

### *Pruning*

Trees needing some form of pruning treatment had specific treatments recommended. The most common pruning treatment was for large tree routine prune (4.3% of the population). Other pruning treatments such as structural pruning and prioritized pruning were prescribed in lesser proportions (between 2.2% and 0.4%).

### *Removals*

There were 51 trees recommended for removal in the inventoried tree population. 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.

### *Other Maintenance Treatments*

Various other maintenance treatments were prescribed for the inventoried tree populations. The most common treatments were to raise (910 trees) and clean/deadwood (144 trees). There are 3,353 (69%) trees inventoried that have a recommended maintenance of "unassigned". Trees with structural defects and unassigned maintenance may require priority maintenance or removal. Those trees in good condition with minimal defects could be assigned large or small tree routine prune. All inventoried trees should be given some type of maintenance task to manage Tumwater's urban forest more proactively and better predict future funding.

*Table 13: Recommended Maintenance of Inventoried Trees*

| Recommended Maintenance | # of Trees |
|---|---|
| Unassigned | 3,353 |
| No Maintenance | 1,074 |
| Large Tree Routine Prune | 208 |
| Other- see notes | 104 |
| Small Tree Routine Prune | 59 |
| Priority 3 Removal | 39 |
| Priority 2 Pruning | 19 |
| Additional Inspection | 16 |
| Priority 2 Removal | 11 |
| Training Prune | 4 |
| Priority 1 Pruning | 2 |
| Priority 1 Removal | 1 |
| Total | 4,890 |

*Table 14: Summary of Maintenance Tasks for Inventoried Trees*

| Maintenance Task | # of Trees |
|---|---|
| Unassigned | 2,386 |
| None | 1,145 |
| Raise | 910 |
| Clean/Deadwood | 144 |
| Structural Prune | 108 |
| Remove | 86 |
| Remove Stakes | 80 |
| Monitor | 14 |
| Reduce | 8 |
| Water | 5 |
| Install/Inspect Cables | 4 |
| Total | 4,890 |

*Table 15: Summary of Primary Defects of Inventoried Trees*

| Primary Defect | # of Trees |
|---|---|
| Other – See Site Comments | 2,993 |
| None | 693 |
| Unassigned | 418 |
| Dieback/Deadwood | 218 |
| Poor Structure/Taper | 214 |
| Suppressed | 88 |
| Pruning History | 53 |
| Stem/Root Girdling | 33 |
| Serious Decline | 31 |
| Broken Limbs/Hangers | 29 |
| Cavity/Decay/Nest hole | 25 |
| Signs of Stress | 25 |
| Included Bark/Weak Union(s) | 18 |
| Mechanical Damage | 15 |
| Unbalanced Crown | 11 |
| Fungal Fruiting Bodies | 7 |
| Oozing through bark | 5 |
| Uncorrected Lean | 4 |
| Crack/Seams | 3 |
| Previous Failure(s) | 3 |
| Cankers/Galls/Burls | 1 |
| Root Plate Lifting | 1 |
| Soil heaving | 1 |
| Total | 4,890 |

## 5.1 Cost of Tree Care

Where the City has responsibility for maintaining trees, achieving the greatest efficiency or lowest costs is derived from proactive scheduled maintenance of the trees. Proactive maintenance includes regular inspection and routine tree care activities that are critical to tree health and public safety. **The City intends to proactively manage its inventoried tree population on a 4-year maintenance cycle.** In this approach, the following services were modeled for maintenance in the management of Tumwater's trees:

- **Inspection.** A one-person crew qualified to inspect trees, update tree records, and prescribe tree care and maintenance.
- **Priority Removals.** A 3-person crew with all necessary equipment to safely remove a tree.
- **Priority Pruning.** A 2-person crew with all necessary equipment to safely prune a tree.
- **Large Tree Routine Pruning.** A 2-person crew with all necessary equipment to safely prune a tree that may require bucket truck or climbing.
- **Small Tree Routine Pruning.** A 1 or 2-person crew with all necessary equipment to safely prune a tree from the ground.
- **Unassigned Trees.** These trees have legacy tree data and should be inspected to confirm work prescriptions and tasks.

The following considerations and assumptions were used to estimate service costs:

- Inspections
    - Initial tree inspection verifies existing inventory data and identifies maintenance tasks and priorities. All crews caring for trees would be trained to provide tree inventory updates to basic tree information upon completion of tree work. Post-work administrative costs to keep inventory updated are included in pruning, removal, and planting. Costs do not include tree inventory management software.
- Pruning a Removal Work
    - Routine work would be provided by contracted tree-care professionals at prevailing wage rates. Equipment, vehicles, personnel, and training costs are included in the costs.
    - Various routine pruning tasks can be performed on the same visit, with the same crew complement, which allows for a standard cost per tree to prune. Most trees benefit from routine pruning to direct growth, optimize structure, and remove branches that are crowded, have poor angles of attachment, or conflict with clearance or infrastructure. Routine pruning allows trees and urban infrastructure to coexist in the built environment, reduces the formation of hazards, and prolongs tree longevity.
    - Debris removal and disposal is included in all pruning and tree removal estimates.
    - Tree removal costs include underground utility location, grinding of the resulting stump and site preparation for a replacement tree.
    - All removed trees would have a tree planted to replace them.
- Emergency Hazard Abatement

- Emergencies are not included since these are performed with more urgent timeframes. Costs for urgent work are often greater than scheduled work due to additional safety precautions and mobilization.

- Tree Planting
  - Planting costs include labor and equipment necessary for tree installation, including planting day services such as watering, structural pruning, and mulching.
  - Average standard nursery stock is estimated to cost $250 for a 1.5" - 2.5" caliper tree, stakes, ties, and mulch. Tree costs are excluded so the model can be adjusted by program managers based on actual nursery stock costs when the program begins.
  - Establishment Care is Not Included
    - Young tree establishment care is an essential component of replacement tree planting. For every tree planted, 3 years of establishment care should be provided, and one post-establishment care visit is required in the $5^{th}$-$8^{th}$ year of the tree's life.
    - Watering, mulching, and weeding are considered the basic services of Establishment Care and are confined to the tree well or adjacent planting strip only.
    - Structural pruning is performed within the first two years following planting and is considered part of Establishment Care and Post Establishment Care.

***Inspection Costs***

The inventory database has two sets of trees, those that were collected as part of the 2023 tree inventory (arborist data), and those that had been collected using City volunteers (volunteer data). The arborist data was collected following the ISA BMPs for tree inventory and can be used to implement tree work. The volunteer data had inconsistent details on tree maintenance needs and may require additional inspections. This resulted in a total of 7,019 trees being identified for further inspection over the next 4 years. This effort should be completed with a 1-person crew and is estimated as 1,759 hours of work (~450 person-hours per year). At a crew rate of $95 per hour, this would be $41,770 per year for tree inspection effort.

***Priority Removals***

There were 56 trees identified for removal at various sizes. Each tree identified for removal was evaluated as 8 hours of effort to remove by a tree removal crew at the rate of $600 per hour. This was estimated as 448 crew hours for a total cost of $268,800 over a 4-year cycle (or $67,200 per year, average of $4,800 per tree).

***Priority Pruning***

There were 29 trees identified as requiring priority pruning. These trees all have branch issues that could impact public safety. Tree pruning could likely be accomplished with a smaller crew complement (2-person crew, $400 per hour) at an average rate of 4 hours per tree. This was estimated as a total of 116 hours for a total cost estimate of $46,400 over 4 years ($11,600 per year, average $1,600 per tree).

***Large Tree Routine Pruning***

Various tree maintenance tasks fall into this category. These tasks were identified by the arborist without any urgency as they are low-risk maintenance needs. Most importantly, these trees are considered large-stature trees that would typically require a climbing crew or lift-truck to accomplish the pruning required averaging 4 hours per tree. There were 208 trees identified in this category and a crew rate of $600 per hour for a total of 832 crew hours ($499,200 over 4 years) or $114,800 per year.

***Small Tree Routine Pruning***
Various tree maintenance tasks fall into this category. These tasks were identified by the arborist without any urgency as they are low-risk maintenance needs. Most importantly, these trees are considered small-stature trees that would typically be pruned from the ground with a pole-pruner or hand tools. There were 59 trees identified in this category and a crew rate of $400 per hour for a total of 118 crew hours ($47,200 over 4 years) or $11,800 per year.

***Unassigned Trees***
Although most tree records in the database have unassigned maintenance, a small proportion are recommended for removal, crown raising or stake removal. Removal tasks in this category were evaluated the same as priority removals (eg. 8 hours per tree). Crown raising was also evaluated as a pruning task (eg 4 hours per tree) and stake removal is considered a low-skill tree maintenance task estimated at 30 minutes per tree. The total cost estimated for managing the recommended maintenance on these trees was $2,329,875 ($582,469 per year).

## 5.2 Summary of Costs

For the City to manage their tree population on a 4-year cycle, the City should set a target budget of $850,839 annually for tree care and maintenance of existing trees (Table 16). This cost could be managed or controlled through proactive planning and competitive bidding processes.

*Table 16: Annual Labor & Equipment Cost Estimates for Tree Care of Inventoried Tree Population*

| Recommended Maintenance TASK | # of Trees | Hours per Tree | Crew Size (persons) | Person Hours | Crew Hours | Crew Cost ($)/Hour | 4-year budget | Annual Budget |
|---|---|---|---|---|---|---|---|---|
| Inspection | | | | | | | | |
| Unassigned Maintenance | 5264 | 0.25 | 1 | 1316 | 1316 | $95 | $115,020 | $31,255 |
| No Maintenance | 1635 | 0.25 | 1 | 408.75 | 408.75 | $95 | $38,831 | $9,708 |
| Other -See Notes | 104 | 0.25 | 1 | 26 | 26 | $95 | $2,470 | $618 |
| Additional Inspection | 16 | 0.5 | 1 | 8 | 8 | $95 | $760 | $190 |
| Priority Removals (1, 2 & 3) | 56 | 8 | 3 | 1344 | 448 | $600 | $268,800 | $67,200 |
| Tree Planting to replace removals | 56 | 2 | 2 | 224 | 111 | $400 | $44,800 | $11,200 |
| Priority Pruning (1 & 2) | 29 | 4 | 2 | 232 | 116 | $400 | $46,400 | $11,600 |
| Large Tree Routine Pruning | | | | | | | | |
| Crown Cleaning | 116 | 4 | 2 | 928 | 464 | $600 | $278,400 | $69,600 |
| Crown Raising | 30 | 4 | 2 | 240 | 110 | $600 | $72,000 | $18,000 |
| Structural Pruning | 59 | 4 | 2 | 472 | 236 | $600 | $141,600 | $35,400 |
| None/Unnassigned | 3 | 4 | 2 | 24 | 11 | $600 | $7,200 | $1,800 |
| Small Tree Routine Pruning | | | | | | | | |
| Crown Cleaning | 11 | 2 | 2 | 48 | 24 | $400 | $9,600 | $2,400 |
| Crown Raising | 6 | 2 | 2 | 24 | 11 | $400 | $4,800 | $1,200 |
| Structural Pruning | 39 | 2 | 2 | 156 | 78 | $400 | $31,200 | $7,800 |
| None/Unnassigned | 2 | 2 | 2 | 8 | 4 | $400 | $1,600 | $400 |
| Unassigned Trees (see inspection first) | | | | | | | | |
| Removal | 43 | 8 | 3 | 1032 | 344 | $600 | $206,400 | $51,600 |
| Crown Raising | 883 | 4 | 2 | 7064 | 3532 | $600 | $2,119,200 | $529,800 |
| Remove Stakes | 90 | 0.5 | 1 | 45 | 45 | $95 | $4,275 | $1,069 |
| | | | | | | TOTAL | $3,403,356 | $850,839 |

# 6.0 Priority Planting Analysis

An analysis was conducted to assess priority planting locations for the city of Tumwater. Data sources were considered for a variety of factors that contribute toward optimizing tree canopy benefits for the City. Analysis included data sets from the city of Tumwater, US Department of Agriculture, American Forests, and the Washington State Department of Health. The resulting analysis found plantable areas in both public and private properties across the city and will help the City increase its canopy coverage and optimize environmental benefits of trees,

The current canopy layer provided by Tumwater (2019 data) was used to help locate possible planting areas. In addition, the 2021 NAIP imagery was used to create an impervious layer as well to aid with finding plantable space. An analysis to identify the most suitable locations was conducted by analyzing each planting location to assign a priority ranking for benefit factors such as **stormwater, urban heat island and environmental equity (social equity)**. Each data source utilized the most current version available and described in the subsequent sections. Stormwater uses the most recent NAIP imagery, soil data, hydrography data, and elevation data. Heat islands were derived from averaging Landsat 8 surface temperature data from July 28, 2022 and August 15, 2023 data to find hotspots at varying points in time to locate areas of potential heat mitigation.

Planting location polygons were created by taking all grass/open space and bare ground areas and combining them into a single dataset. Non-feasible planting areas such as agricultural fields, recreational fields, major utility corridors, airports, etc. were restricted and noted as a searchable attribute in the final GIS dataset. This layer was reviewed and approved by the city of Tumwater before the analysis proceeded. The remaining planting space was consolidated into a single feature and then, exploded to multipart features creating separate, distinct polygons for each location. The final step broke polygons up again to note planting restrictions as their own feature.

## 6.1 Social Equity

To identify and prioritize planting potential based on Social Equity, data was analyzed including Environmental health disparities and the Tree Equity Score. Each factor was separated to its own grid map. The values were broken into five classes and ranked from 0 - 4 (with zero being the lowest priority and 4 being the highest priority). These factors were classified into five final rankings from

Very Low to Very High for each of the social equity and public health criteria using quantile classification breaks within ArcGIS. This step of the process was completed to statistically subset data evenly into five classes of increasing importance. Higher priorities of social equity give a focused effort of providing trees and tree canopy to all community members regardless of social status. These priority areas are deemed to have the greatest return due to their importance of providing residents of the community equal access to nature.

## 6.2 Stormwater

To identify and prioritize planting potential based on the stormwater analysis, locations were assessed with several environmental features, including proximity to hardscape, proximity to canopy, floodplain proximity, soil permeability, slope, and soil erosion factor (K-factor). These factors are based on numerous historic projects completed by DRG for stormwater analysis. Each factor was assessed using data from various sources and analyzed using separate grid maps. Values between zero and four (with zero having the lowest priority) were assigned to each grid assessed. A value of zero indicates that this classified piece of information yielded little or no overall value within the dataset. The grids were overlain with the values averaged to determine the priority levels at an area on the map. A priority ranging from Very Low to Very High was assigned to areas on the map based on the calculated average of all grid maps using quantile classification breaks within ArcGIS. This step of the process was completed to statistically subset data evenly into five classes of increasing importance. Areas of higher potential for runoff and erosion were considered higher priority due to their ability to diminish water quality within urban areas.

## 6.3 Urban Heat Island

To identify and prioritize planting potential based on heat islands, a land surface temperature analysis was conducted. Using Landsat 8 imagery data from the United States Geological Survey (USGS), a calculation of land surface temperature by using the both Landsat 8 thermal bands. Imagery from July 28, 2022 and August 15, 2023 was used to find the radiance, at-satellite brightness temperature and proportion of vegetation, which were used to calculate the land surface temperature for each year. Surface temperatures were averaged and a priority ranking of Very Low to Very High was assigned based on the averaged temperatures using quantile classification breaks within ArcGIS. This step of the process was completed to statistically subset data evenly into five classes of increasing importance. Higher surface temperatures were considered higher priority due to the adverse effects of elevated microclimates within urban areas.

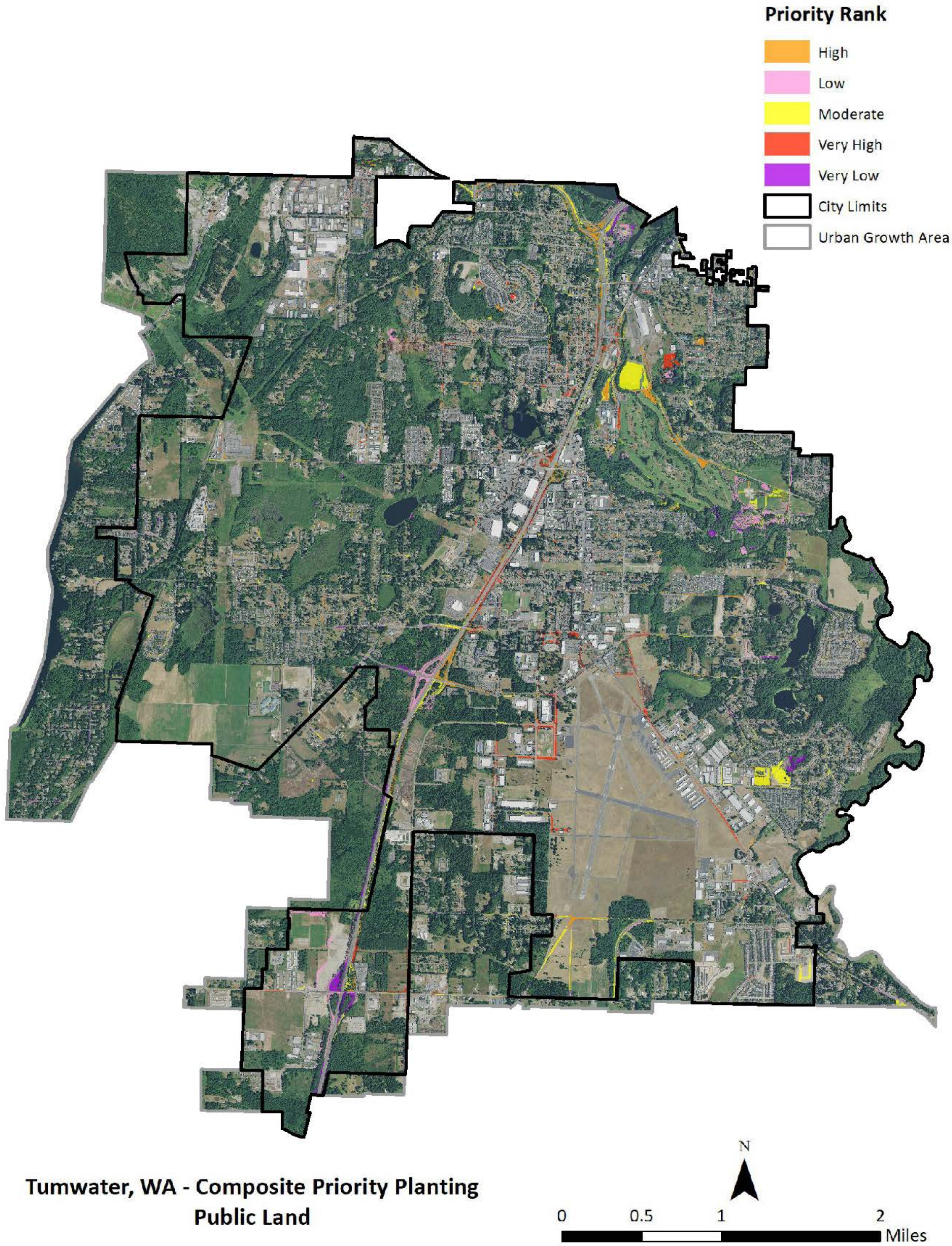
## 6.4 Composite Priority

Using zonal statistics, each raster data for stormwater, heat island, and social equity were used to calculate a total aggregate value for each individual planting location polygon. The values for each factor were statistically binned into five classes using quantile classification within ArcGIS. This classification method distributes values into groups that have an equal number of values. The higher numbers indicate higher priority for planting when assessing all factors through the same scope. These classes ranged from Very Low to Very High to mirror the criteria group rankings. These rankings were then used to combine all criteria to create a composite ranking based on all analytical factors pertaining to the city.

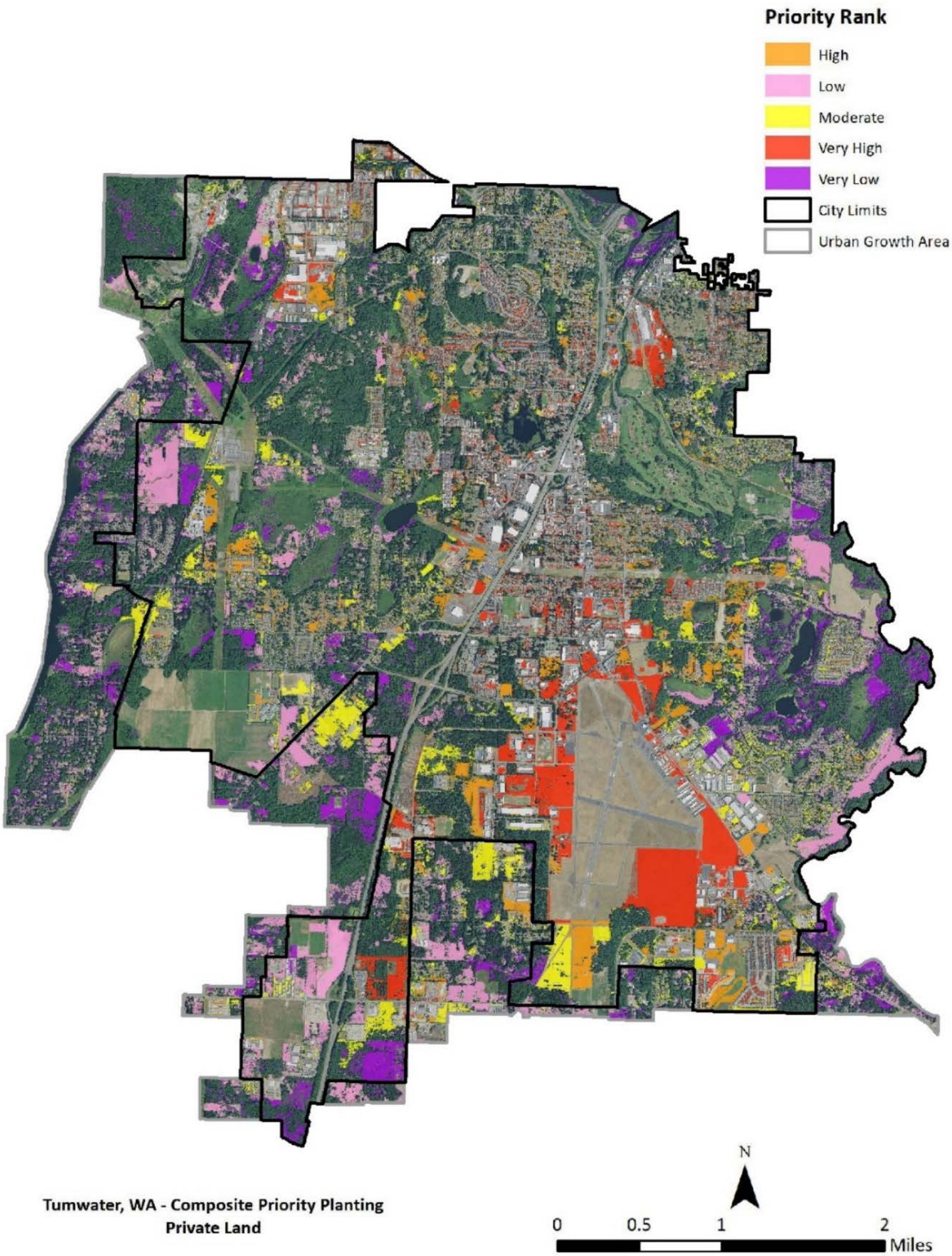
*Table 17: Data Sources for Composite Priority Planting Analysis*

| Group | Criteria | Data Origin | Last Update | Weighting |
|---|---|---|---|---|
| Stormwater | Distance to Hardscape | Tumwater Urban Tree Canopy Assessment | 2022 | 0.10 |
| | Distance to Canopy | Tumwater Urban Tree Canopy Assessment | 2022 | 0.20 |
| | Floodplain | National Hydrologic Dataset | 2022 | 0.10 |
| | Soil Permeability | Natural Resource Conservation Service | 2022 | 0.20 |
| | Soil Erosion | Natural Resource Conservation Service | 2022 | 0.20 |
| | Slope | National Elevation Dataset | 2022 | 0.20 |
| Urban Heat Island | Heat Islands – July 28, 2022 | Earth Explorer - USGS | 2022 | |
| | Heat Islands – August 15, 2023 | Earth Explorer - USGS | 2023 | |
| Census | Environmental Health Disparities | Washing State Department of Health | 2022 | |
| | Tree Equity Score | American Forests | 2023 | |

*Map 1: Public Land Priority Planting Composite*



*Map 2: Private Land Priority Planting Composite*



## 6.4 Tree Planting Strategy

Working with the priority planting area composite results clarified the tree planting opportunities in Tumwater. Areas of the city where additional tree canopy is possible were evaluated, including grass, low-lying vegetation, and bare soil. Some locations were excluded because they are not suitable or realistic planting locations due to soil quality and/or conflicts with the intended use of the site. Examples of this include areas designated and intended to be open and free from trees and canopy cover such as sports fields or airports. The land cover assessment determined a total of 4,390 acres (Public: 1,663 acres, Private: 2,727 acres) with the potential to support tree canopy (Map 1 & Map 2).

While available planting sites may ultimately be planted over the next several decades, the trees that are planted in the next several years should be planned for areas of greatest need and where they will provide the most benefits and return on investment. The composite planting analysis of **stormwater, urban heat island and environmental equity (social equity)** identified the following acres for priority planting:

Public Property

- Very High– 479.67 acres
- High– 281.19 acres
- Moderate– 327.79 acres
- Low– 388.69 acres
- Very Low– 185.99 acres

Private Property

- Very High– 599.46 acres
- High– 410.46 acres
- Moderate– 497.71 acres
- Low– 725.70 acres
- Very Low– 494.49 acres

A tree placement model was developed to estimate the number of large, medium, and small stature trees that could be planted based on the identified potential planting areas. In the tree placement model, a total of 18,650 public sites and 68,321 private sites were identified as suitable spaces. Under this model, each tree would have an average crown radius of 35 feet at maturity. The actual number of trees to plant would depend on species selection and could be more should the city choose smaller stature trees at some sites.

*Table 18: Tree Placement by Public and Private Land Planting Sites*

| Priority Rank | Total Sites | Public Sites | Private Sites |
|---|---|---|---|
| Very Low | 16,075 | 1,741 | 14,334 |
| Low | 16,971 | 3,394 | 13,577 |
| Moderate | 17,648 | 4,199 | 13,449 |
| High | 18,157 | 4,940 | 13,217 |
| Very High | 18,110 | 4,376 | 13,744 |
| Total | 86,971 | 18,650 | 68,321 |

# 7.0 Maintenance Plan Actions

The analysis of the tree inventory through the i-Tree models provides the City with a detailed understanding of Tumwater's tree resource. Using established numerical modeling and statistical methods provides the City a general accounting of the benefits. Trees provide quantifiable benefits to air quality, reduction in atmospheric $CO_2$, stormwater runoff, and aesthetic benefits. **Tumwater's 4,890 inventoried trees provide cumulative annual benefits worth $18,010, a value of $3.68 per tree and $1.04 per capita. Benefits from trees in the natural areas in Tumwater were estimated using i-Tree Canopy and are providing benefits worth almost $55,100 annually.** While not a complete accounting of every tree within the city limits, this summary of benefits provides a reference benchmark of the quality and conditions associated with the urban forest resource.

Urban forestry best management practices suggest that no one tree species should represent more than 10% of the urban forest. As of 2024, at the species level, Norway maple (*Acer platanoides*) exceeds this rule. Additionally, no one genera should represent more than 20% of a population. In Tumwater, maples (*Acer* spp.) represent 30.4% of the overall inventoried tree population. Future new and replacement tree plantings should focus on increasing species diversity and reducing reliance on a particular species.

Tumwater's inventoried tree resource (7,345 tree sites) has an established age distribution in fair or better condition with 110 distinct species. In the natural areas, the tree species diversity drops to an estimated 14 distinct species, has an estimated 28,182 trees, and a nearly ideal age distribution. However, trees under 6 inches were not included in the plot sampled data. This means that the health and condition of young trees in Tumwater's natural forests remains uncertain.

Regarding tree maintenance needs, 9.5% have some type of maintenance recommended and 69% of trees have unassigned maintenance. Developing a proactive maintenance schedule and budget can greatly control future costs. 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 analysis, the city would benefit from the following priority urban forest management actions:

- Maintain and Expand the Tree Inventory
    - Schedule maintenance to all inventoried trees to proactively manage Tumwater's tree resource.
    - Prioritize planting replacement trees for those trees that have previously been removed.
    - Prioritize structural pruning for young trees and a regular maintenance cycle for all inventoried 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.
   - Species that are adequately represented by established age distributions but lack recent plantings should receive priority care.
   - Inventory updates should be incorporated as regular maintenance is performed, including updating the diameter and condition of existing trees.
- Plant New Trees
   - Increase genus and species diversity in new and replacement tree plantings to reduce reliance on abundant groups.
   - Plant trees in priority areas to improve diversity, increase benefits, and further distribute the age distribution of inventoried trees.
   - Use the largest stature tree possible where space allows to optimize urban forest benefits.
   - Consider successional planting of important species, as determined by relative performance index (RPI) and the relative age distribution.

Current tree inventory data will help staff to efficiently plan maintenance activities and provide a strong basis for making informed management decisions that align with greater city-wide strategic goals. Urban forest managers can anticipate future trends with this understanding of the status of the tree population. They 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.

Documenting current structure as provided in this plan is an important step for establishing goals and performance objectives and can serve as a benchmark for measuring future success. 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: Priority Planting Analysis Data Sources

## Stormwater

Distance to Hardscape
*Source:* Tumwater Impervious Assessment
Data: Distance to Impervious
Distance to hardscape is derived by selecting the impervious surfaces data from the Tumwater landcover layer. This impervious raster is used as an input layer into the Euclidean Distance tool within ArcGIS to create a layer that measures straight-line distance from each impervious surface location within the city. These distances are grouped into five classes from 0 - 4 with 4 being the closest to impervious surfaces and, therefore, the highest priority. The further a location is from an impervious surface, the lower the ranking it receives. A ranking of 0 is given to locations that are currently represented as impervious surfaces in the land cover data while the value of 4 indicates that the open area next to the impervious surface is available for planting trees to reduce the amount of runoff and sedimentation.

| Distance to Hardscape | |
|---|---|
| Rank | Distance to Impervious (ft) |
| 0 | 0 |
| 1 | Over 100 |
| 2 | 51 - 100 |
| 3 | 26 – 50 |
| 4 | 1 – 25 |

## Distance to Canopy

*Source:* Tumwater Canopy layer
Data: Distance to Canopy
Distance to canopy is derived by selecting the tree canopy data from the Tumwater landcover layer. This canopy raster is used as an input layer into the Euclidean Distance tool within ArcGIS to create a layer that measures straight-line distance from each canopy location within the city. These distances are grouped into five classes from 0 - 4 with 4 being the closest to Canopy and therefore the highest priority. The further a location is from the canopy, the lower the ranking it receives. A ranking of 0 is given to locations that are currently occupied by tree canopy and not plantable. Higher values in this ranking will prioritize areas that have small gaps that can be filed in order to increase tree canopy closure, which has great impact of wildlife habitat by providing larger corridors to support a variety of different species.

| Distance to Canopy | |
|---|---|
| Rank | Distance to Canopy (ft) |

| | |
|---|---|
| 0 | 0 |
| 1 | Over 200 |
| 2 | 101 – 200 |
| 3 | 51 – 100 |
| 4 | 1 – 50 |

### Floodplain

Source: National Hydrologic Dataset – USDS Geospatial Data Gateway
*Link: https://datagateway.nrcs.usda.gov/*
Data Attribute: Cost Distance
The floodplain is derived by using the hydrography lines from the United States Department of Agriculture (USDA) website and the Slope Percent Rise (found by calculating Slope using the Digital Elevation Model (DEM) from the USDA website). The Cost Distance tool within ArcGIS was used with these layers to create a raster dataset that shows a cost-weighted distance from the hydrography lines based on the percent rise of the land. This process identifies the first major slope break which indicates the normal stream bank channel that will fill during flooding events. The resulting data layer will show locations of where water will travel during periods of flood. These distances are grouped into five classes from 0 – 4 with 4 being in the floodplain area and therefore the highest priority. The further a location is from the floodplain, the lower the ranking it receives. A ranking of 0 is given to locations that are the furthest from the floodplain.

| Floodplain – Cost Distance | |
|---|---|
| Rank | Cost Distance (ft) |
| 0 | Over 2,500 |
| 1 | 1,001 – 2,500 |
| 2 | 501 – 1,000 |
| 3 | 101 – 500 |
| 4 | 0 – 100 |

### Soil Permeability

Source: Natural Resource Conservation Service – USDA Web Soil Survey
*Link: https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx*
Data Attribute: Hydrologic Soils Group (HSG)
Soil Permeability is found by analyzing the Hydrologic Soils Group (HSG) information from the USDA Soil Surveys. This data is classified into four classes: A, B, C and D. Group A soils have a high infiltration rate, Group B has a moderate infiltration rate, Group C has a slow infiltration rate, and Group D has a very slow infiltration rate. The remaining values are classified as W denoting water. These areas are typically larger bodies of water such as ponds, lakes or rivers. The rankings range from 0 – 4 with 4 being the highest priority. A ranking of 4 is given to the D classification due to its low infiltration rate. Planting in these locations will increase stormwater uptake and therefore, reduce the amount of runoff. Lower rankings are given to the A, B and C classes as these classes have higher infiltration rates where water is able to percolate through the soil without creating

surface runoff leading to an decrease in harmful pollutants and sediment into streams and stormwater infrastructure over time. The W class is given a 0 ranking because these areas are classified as water and have no bearing of runoff.

| Soil Permeability - HSG | |
|---|---|
| Rank | Threat |
| 0 | W |
| 1 | A |
| 2 | B |
| 3 | C |
| 4 | D |

### Soil Erosion

Source: Natural Resource Conservation Service – USDA Web Soil Survey
*Link: https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx*
Data Attribute: K-factor
Soil Erosion is found by analyzing the K-factor information from the USDA Soil Surveys. This data is classified into decimal numbers that range from 0.02 – 0.69. The higher numbers within this range mean that the area is more susceptible to sheet and rill erosion by water. Remaining values are given a value of 0 of which can represent water, quarries, pits, and other harder surface types. Water features are typically ponds, lakes and rivers. Rankings for this data are based on the susceptibility to erosion. A 0 ranking is given to areas that have little to no risk of erosion. The ranking increases as the risk of erosion increases with the highest ranking being 4. Planting in these priority areas will help decrease erosion vulnerability.

| Soil Erosion – K-factor | |
|---|---|
| Rank | K-factor (expressed as whole numbers) |
| 0 | 0 - 10 |
| 1 | 11 - 20 |
| 2 | 21 - 30 |
| 3 | 31 - 37 |
| 4 | Over 38 |

### Slope

Source: National Elevation Dataset – USDA Geospatial Data Gateway
*Link: https://datagateway.nrcs.usda.gov/*
Data: DEM
Slope is calculated by using the Digital Elevation Model (DEM) from the USDA and finding the slope percent rise of the DEM. The Percent Rise results were grouped into five classes from 0 - 4 with 4 being the highest priority as shown below. The rankings for this data are based on the percent rise of the area. The larger the percent rise of the land, the higher the planting priority. A ranking of 0 is

given to areas of no percent rise and the rankings then increase as the percent rise increase with the highest ranking being 4. Planting trees on areas of high percent rise can help decrease stormwater runoff.

| Slope – Percent Rise | |
|---|---|
| Rank | Percent Rise |
| 0 | 0 |
| 1 | 0 - 3 |
| 2 | 3 - 6 |
| 3 | 6 - 11 |
| 4 | Over 11 |

## Urban Heat Islands

Land Surface Temperature (LST)
Source: Earth Explorer (USGS) Landsat 8 Thermal Imagery
*Link:* *https://earthexplorer.usgs.gov/*
Data Attribute: Land Surface Temperature (LST)
Land surface temperature is calculated using Landsat 8 imagery thermal bands. Using both thermal bands, a conversion from Digital Number (DN) to radiance, at-satellite brightness temperature and proportion of vegetation can be calculated. These values are used to find the land surface temperature. Imagery from July 28, 2022 and August 15, 2023 was used to create two separate surface temperature raster datasets. The two years were averaged and binned into five class from 0 - 4 based on a quantile classification with ArcGIS. Rankings are determined by the surface temperature ranges. The lowest surface temperature range received a 0 ranking. The ranking will increase as the surface temperature increases with the high rank being 4. Planting in areas of high surface temperature helps mitigation urban heat islands by providing more shade to cool not only air temperature but heat absorbed by pavements.

| Land Surface Temperature – July 28, 2022 and August 15, 2023 | |
|---|---|
| Rank | Temperature (Fahrenheit) |
| 0 | 50 – 76 |
| 1 | 76 – 80 |
| 2 | 80 – 84 |
| 3 | 84 – 88 |
| 4 | 88 – 95 |

## Social Equity Data

Environmental Health Disparities
Source: Washington State Department of Health
*Link:* https://fortress.wa.gov/doh/wtnibl/WTNIBL/
Data Attribute: Environmental Health Disparities V 2.0

The Washington Environmental Health Disparities Map evaluates environmental health risk factors in communities by census tract and ranks them on a scale of 1 - 10. These ranks are classified into five groups within ArcGIS and ranked from 0 - 4 based on the given rank. A ranking of 4 is given to areas with ranks 8 or over. The lower the environmental health rank is, the lower the priority planting ranking. A ranking of 0 is given to areas that have an environmental health rating of 3 or under. Planting in these high priority areas may help address social equity issues and provide residents equal access to nature.

| Environmental Health Disparities V 2.0 | |
|---|---|
| Rank | Environmental Health Disparities Rank |
| 0 | 3 and Under |
| 1 | 4 |
| 2 | 5 -6 |
| 3 | 7 |
| 4 | 8 and Over |

## Tree Equity Score

Source: American Forests
*Link:* https://www.treeequityscore.org/map#11.56/46.9955/-112.8872
Data Attribute: Tree Equity Score & Priority
The Tree Equity Score was developed to help address environmental and social inequities by prioritizing tree planting in areas of need by block group. Using the Tree Equity Score's existing ranking system, the block groups were binned into 5 groups and ranked from 0 – 4. A Tree Equity Score priority of 'Highest' which is a Tree Equity Score number under 70 was given a rank of 4 (none of the block groups in Tumwater had this score). The rank decreased as the Tree Equity Score priority decreased and the Tree Equity Score Number increased. A rank of 0 was given to block groups with a Tree Equity Score priority of 'None' and a Tree Equity Score number of 100. Planting in these high priority areas may help address social equity issues and provide residents equal access to nature as well as the environmental and health benefits from trees.

| Tree Equity Score | |
|---|---|
| Rank | Score and Priority |
| 0 | 100 and 'None' |
| 1 | 90 – 99 and 'Low' |
| 2 | 80-89 and 'Moderate' |
| 3 | 70-79 and 'High' |
| 4 | Below 70 and 'Highest' |

## Stormwater

In urban areas, the substantial extent of impervious surface increases the amount of surface runoff and the cost of infrastructure a community must invest to manage stormwater for the safety of residents and property. Tree planting provides an opportunity to help mitigate the risk of flooding by reducing the volume of stormwater runoff that enters bodies of water. Research has demonstrated that strategic plantings of trees affect the peak height of a flood in an urban location (University of Birmingham, 2016).

The majority of areas identified as high and very high priority planting to mitigate the effects of stormwater runoff occur in the north and east parts of Tumwater (Map 2). In the tree placement model to mitigate stormwater runoff, 43.7% of potential planting sites are located within high or very high public planting areas (Table 14) and 38.1% of potential planting sites are located within high or very high private planting areas (Table 14).

*Table 19: Potential Planting Priority Sites for Stormwater Management*

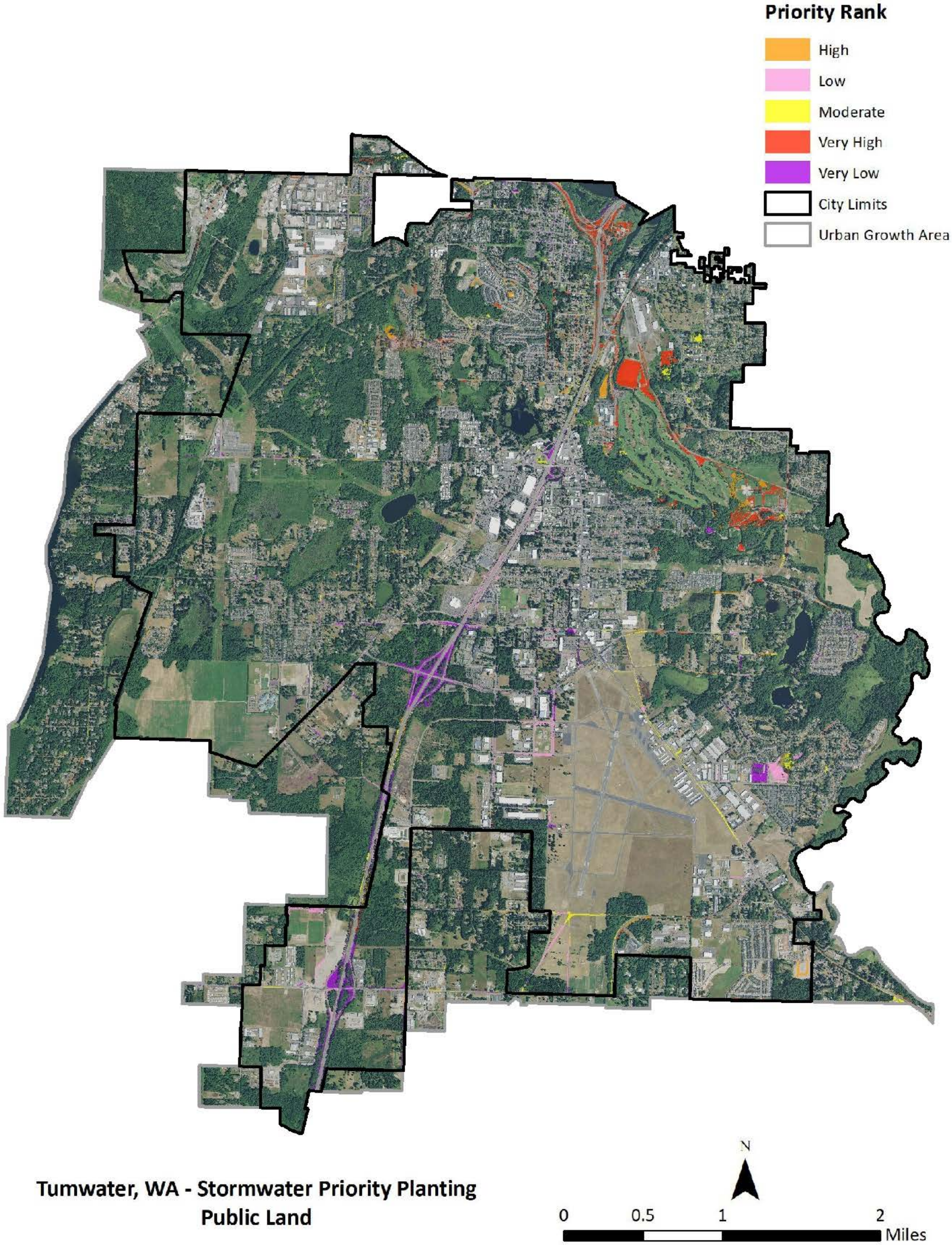
Public

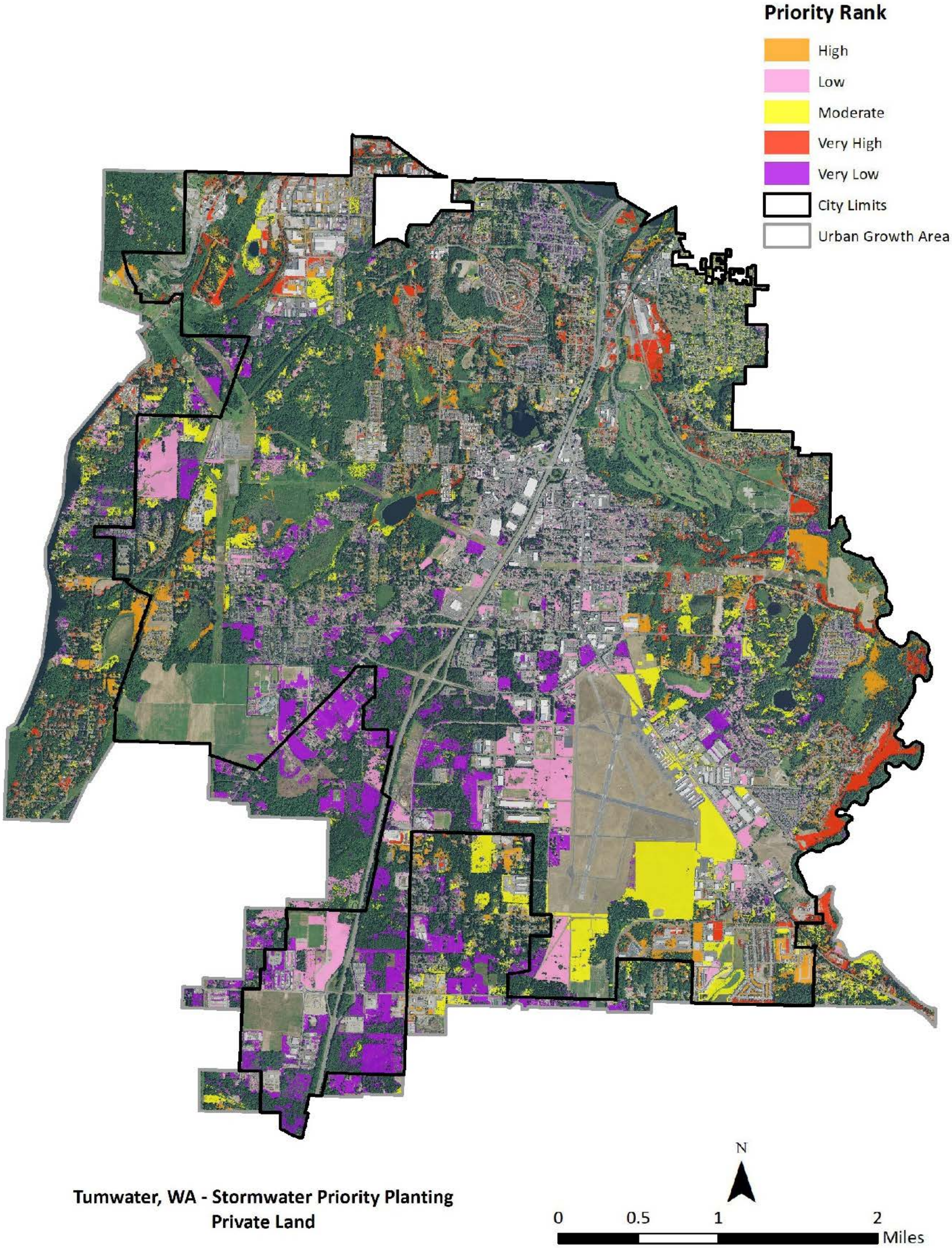
| Priority Rank | Number of Locations | Square Feet | Acres |
|---|---|---|---|
| Very Low | 3,000 | 18,879,040 | 433.40 |
| Low | 4,218 | 17,734,780 | 407.13 |
| Moderate | 3,273 | 18,077,207 | 415.00 |
| High | 3,815 | 8,567,087 | 196.67 |
| Very High | 4,344 | 9,196,704 | 211.13 |
| Total | 18,650 | 72,454,819 | 1,663 |

| Priority Rank | Number of Locations | Square Feet | Acres |
|---|---|---|---|
| Very Low | 14,148 | 31,288,813 | 718.29 |
| Low | 14,483 | 23,867,654 | 547.93 |
| Moderate | 13,631 | 28,434,766 | 652.77 |
| High | 13,263 | 16,334,050 | 374.98 |
| Very High | 11,796 | 18,883,564 | 433.51 |
| Total | 68,321 | 118,808,847 | 2,727 |

Private

*Map 3: Public and Private Priority Planting for Stormwater*






Tumwater, WA - Stormwater Priority Planting
Private Land

## Heat Island

The heat island effect describes the increase in temperatures of urban or metropolitan areas in relation to surrounding suburban and rural areas. Heat islands are associated with an increase in hardscape and impervious surfaces. Trees and other vegetation within an urbanized environment help reduce the heat island effect by lowering air temperatures 5°F (3°C) compared with outside the green space (Chandler, 1965). On a larger citywide scale, temperature differences of more than 9°F (5°C) have been observed between city centers without adequate canopy coverage and more vegetated suburban areas (Akbari et al, 1992). The relative importance of these effects depends upon the size and configuration of trees and other landscape elements (McPherson, 1993). Tree spacing, crown spread, and vertical distribution of leaf area each influence the transport of warm air and pollutants along streets and out of urban canyons. Because trees contribute to reducing the effects of urban heat islands, tree planting can be targeted to reduce urban heat islands.

This analysis isolates the methodology and weighting scheme used to identify and prioritize planting potential for heat islands (Table 11). Areas across the city were ranked from high to low to show at a larger scale where priority planting would mitigate the effects of urban heat islands (Map 3). In the tree placement model to mitigate heat islands, 45.1% of potential planting sites are located within high or very high planting areas for public land (Table 15) and 37.9% for private land (Table 15). Overall, the City of Tumwater would benefit greatly from increased canopy cover.

*Table 20: Potential Planting Priority Sites for Stormwater Management*

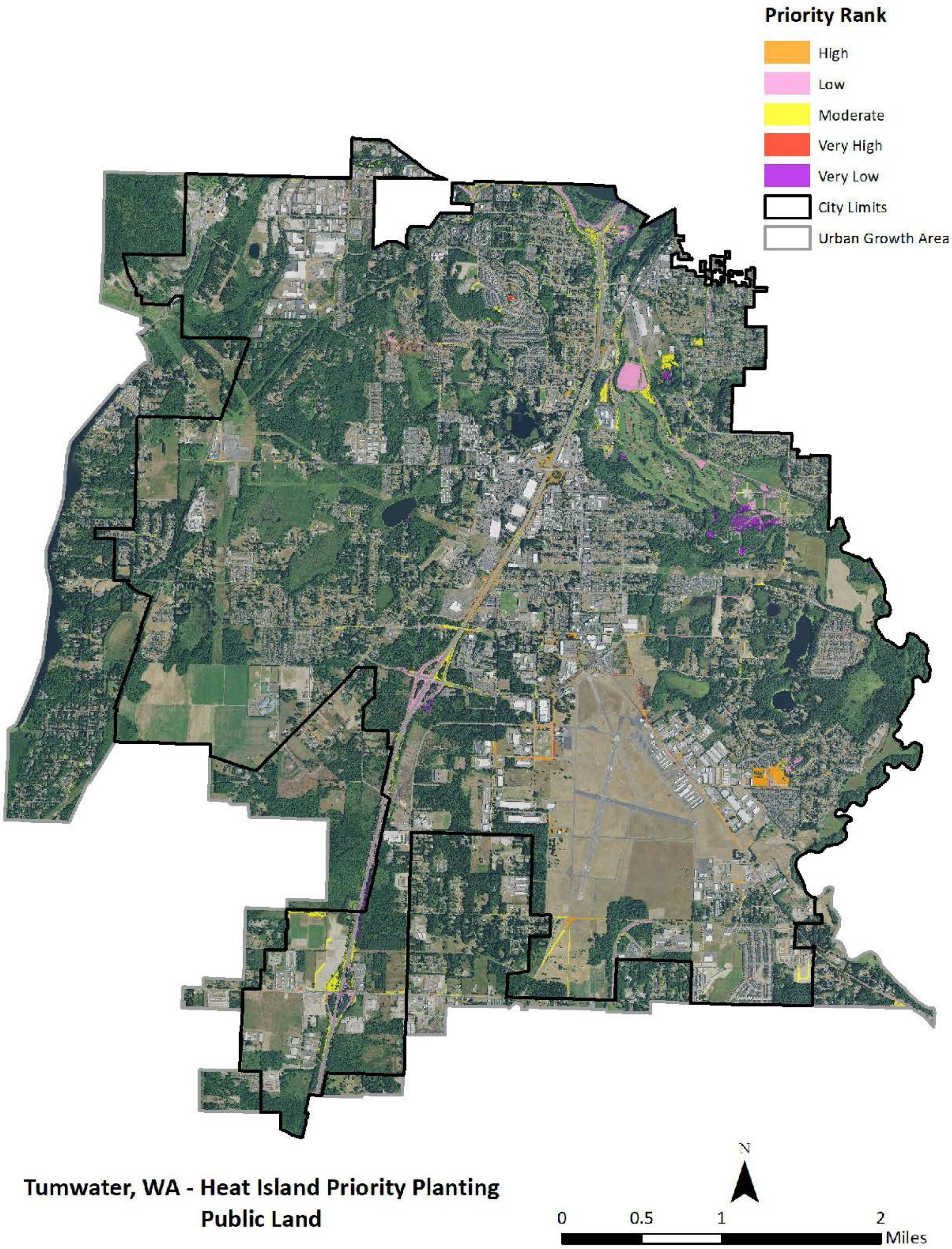
Public

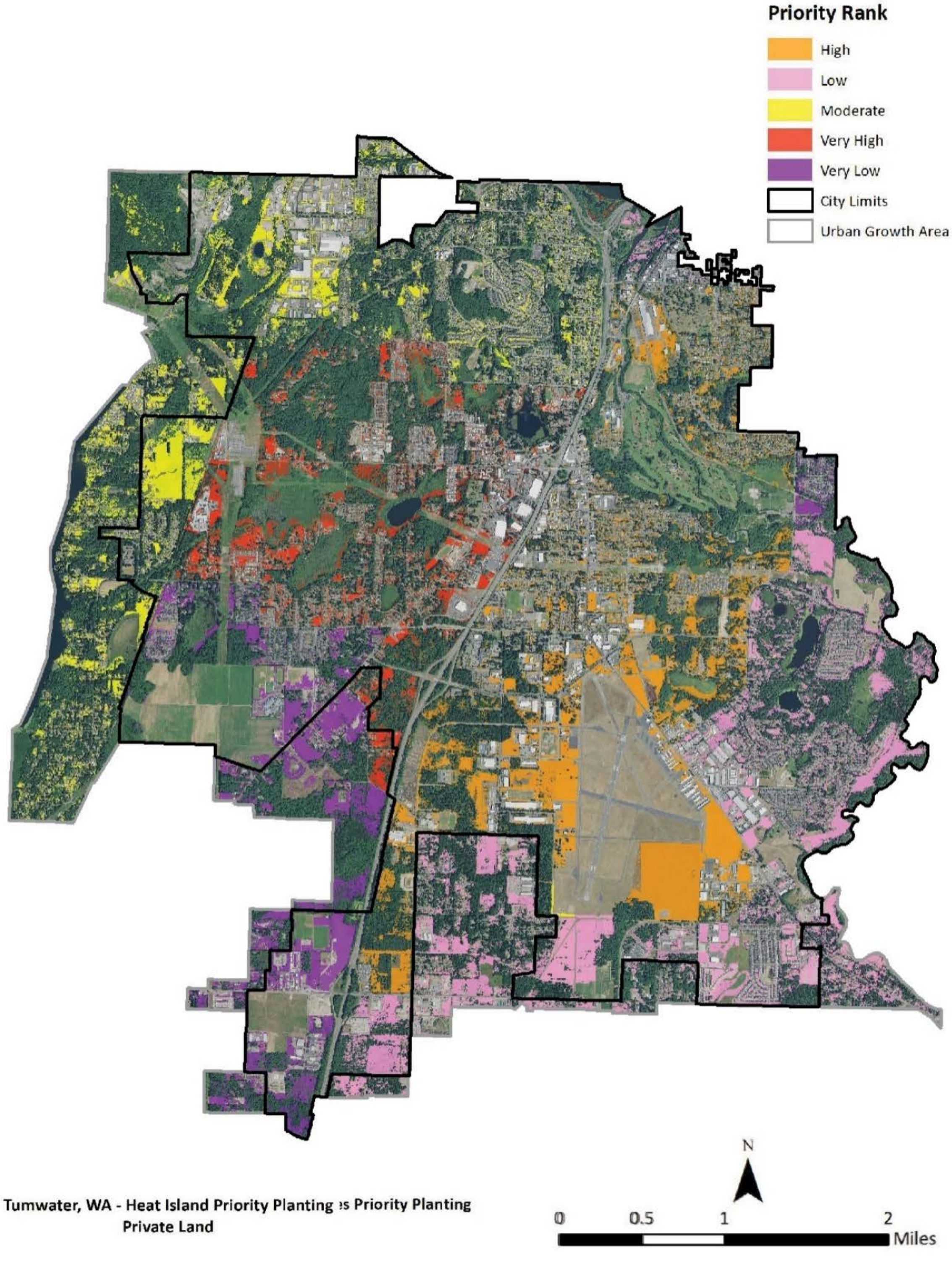
| Priority Rank | Number of Locations | Square Feet | Acres |
|---|---|---|---|
| Very Low | 319 | 3,322,521 | 76.27 |
| Low | 3,293 | 13,276,793 | 304.79 |
| Moderate | 6,628 | 29,296,486 | 672.55 |
| High | 7,080 | 24,663,362 | 566.19 |
| Very High | 1,330 | 1,895,657 | 43.52 |
| Total | 18,650 | 72,454,819 | 1,663.33 |

| Priority Rank | Number of Locations | Square Feet | Acres |
|---|---|---|---|
| Very Low | 3,741 | 8,977,066 | 206.09 |
| Low | 17,245 | 31,900,288 | 732.33 |
| Moderate | 21,414 | 41,964,659 | 963.38 |
| High | 20,794 | 32,000,657 | 734.63 |
| Very High | 5,117 | 3,966,177 | 91.05 |
| Total | 68,321 | 118,808,847 | 2,727 |

Private

*Map 4: Public and Private Priority Planting for Heat Islands*






Tumwater, WA - Heat Island Priority Planting :s Priority Planting
Private Land

69

## Environmental Health Disparities

This analysis isolates the methodology and weighting scheme used to identify and prioritize planting potential for environmental health disparities (Table 16). Areas across the city were ranked from high to low to show at a larger scale where priority planting would mitigate the effects of environmental health disparities (Map 4). In the tree placement model to mitigate environmental health disparities, 46% of potential planting sites are located within high or very high planting areas for public land (Table 16) and 42% for private land (Table 16). Overall, the City of Tumwater would benefit greatly from increased canopy cover.

*Table 21: Potential Planting Priority Sites for Health Disparities*

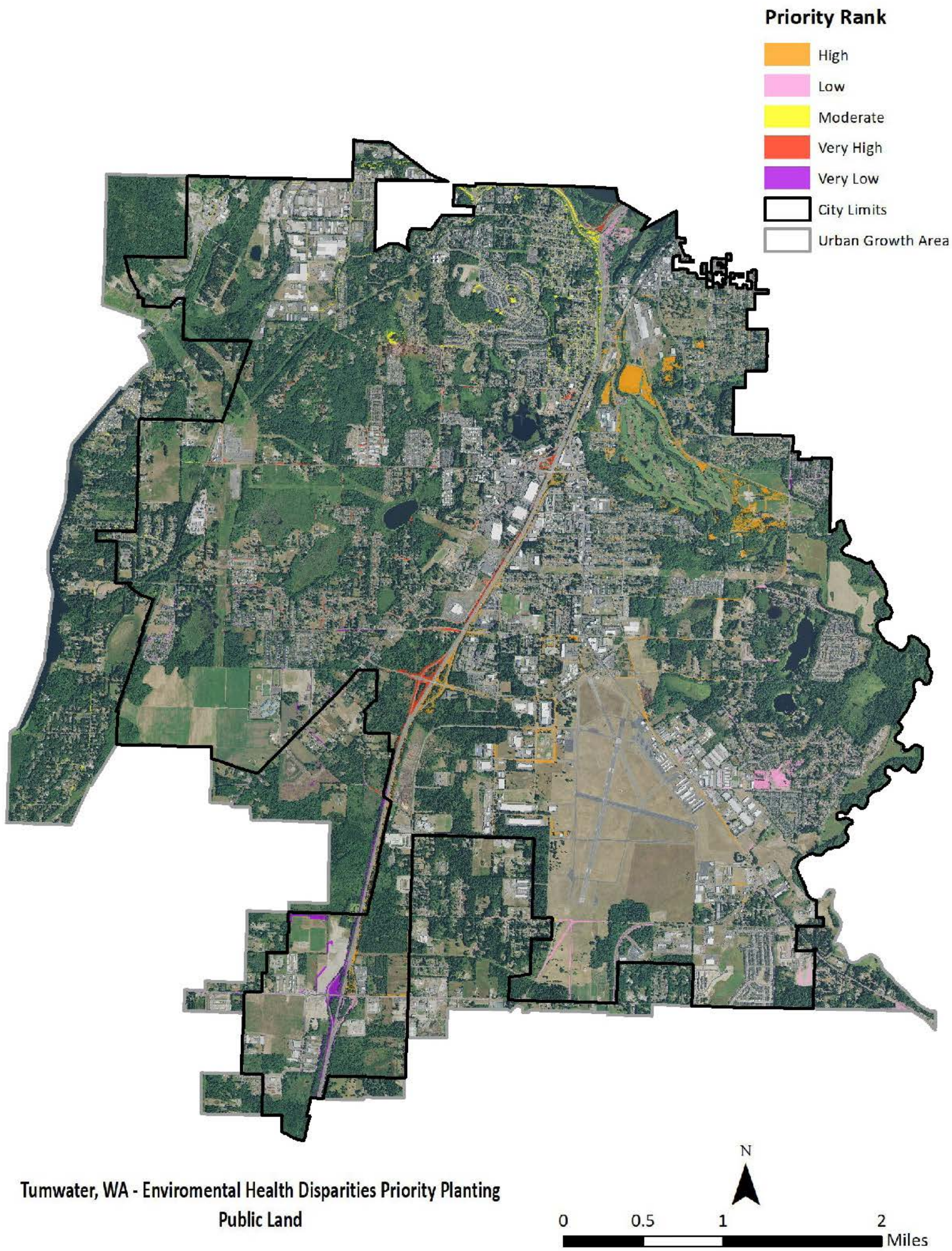
Public

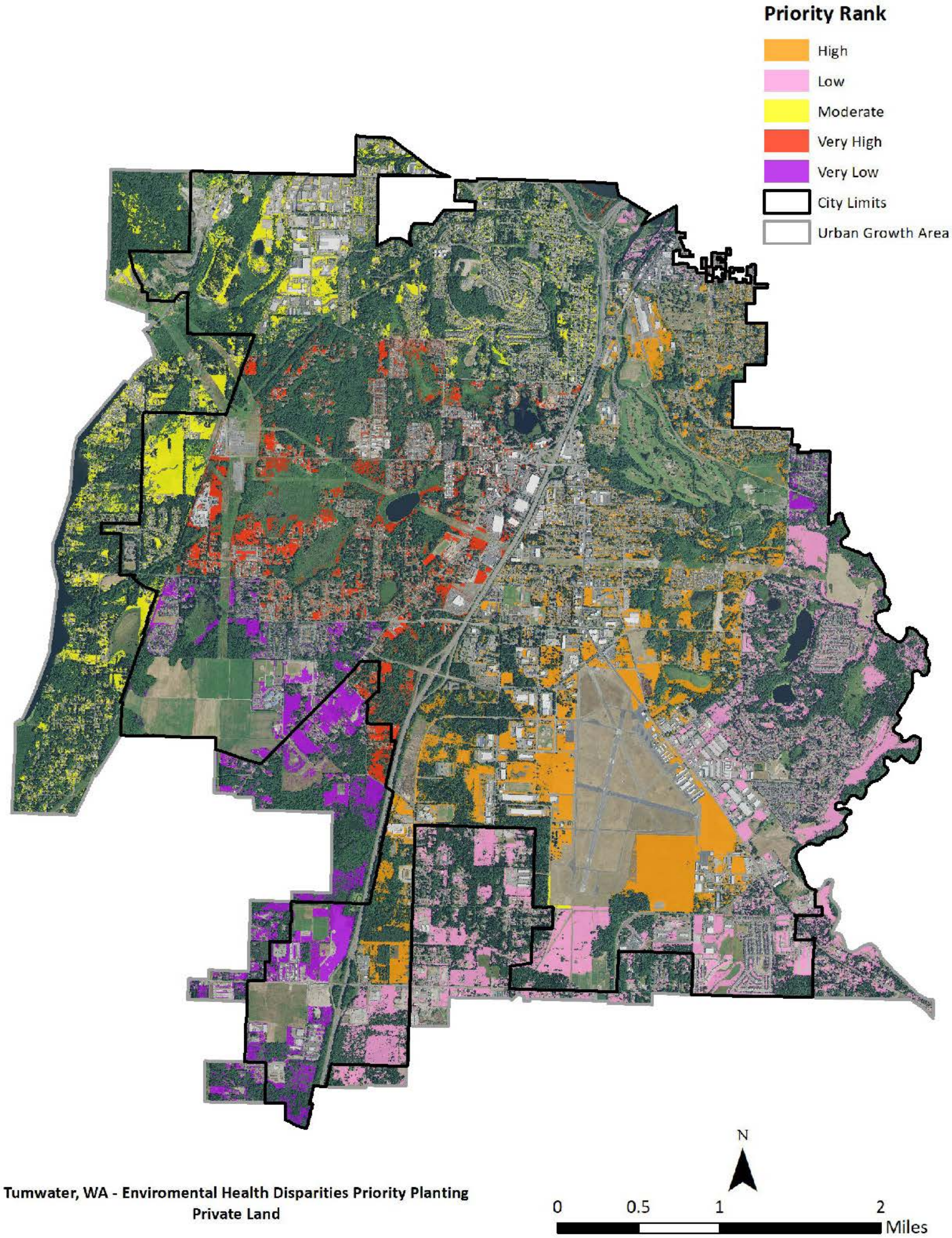
| Priority Rank | Number of Locations | Square Feet | Acres |
|---|---|---|---|
| Very Low | 1,357 | 10,341,638 | 237.41 |
| Low | 3,866 | 20,619,348 | 473.36 |
| Moderate | 4,809 | 9,469,303 | 217.39 |
| High | 5,628 | 26,391,586 | 605.87 |
| Very High | 2,990 | 5,632,945 | 119.31 |
| Total | 18,650 | 72,454,819 | 1,663 |

| Priority Rank | Number of Locations | Square Feet | Acres |
|---|---|---|---|
| Very Low | 6,767 | 15,839,045 | 363.61 |
| Low | 14,348 | 35,726,111 | 820.16 |
| Moderate | 18,393 | 20,303,410 | 466.10 |
| High | 15,801 | 34,211,718 | 785.42 |
| Very High | 13,011 | 11,727,563 | 292.18 |
| Total | 68,321 | 118,808,847 | 2,727 |

Private

*Map 5: Public and Private Priority Planting for Environmental Health Disparities*






Tumwater, WA - Enviromental Health Disparities Priority Planting
Private Land

## Tree Equity

This analysis isolates the methodology and weighting scheme used to identify and prioritize planting potential for tree equity (Table 17). Areas across the city were ranked from high to low to show at a larger scale where priority planting would mitigate the effects of low tree canopy (Map

5). In the tree placement model to mitigate low tree canopy 8.2% of potential planting sites are located within high planting areas for public land (Table 17) and 9.2% for private land (Table 17). Overall, the City of Tumwater has fairly even canopy cover throughout the city and other factors may have greater impact on the inventoried tree resource.

*Table 22: Potential Planting Priority Sites for Tree Equity*

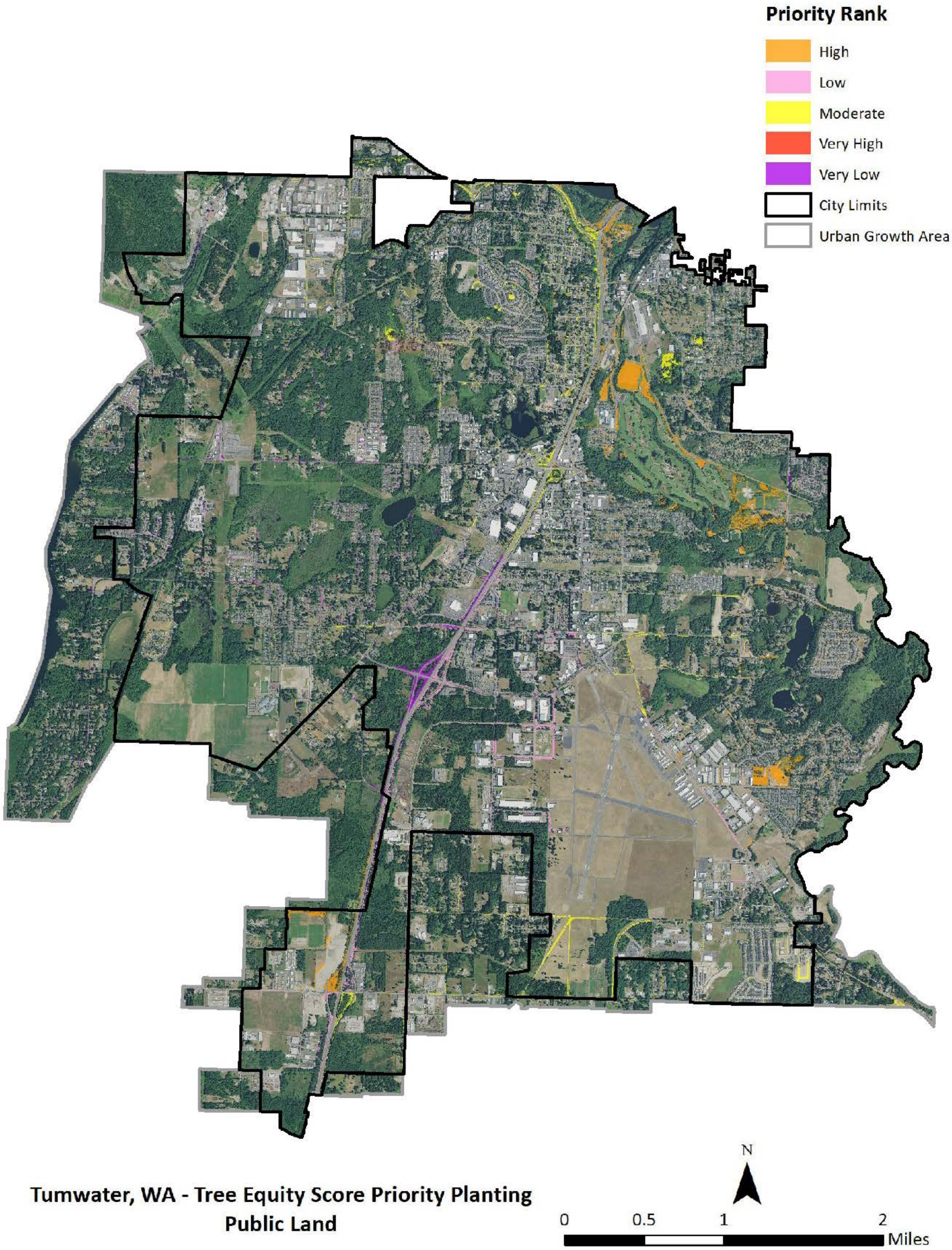
Public

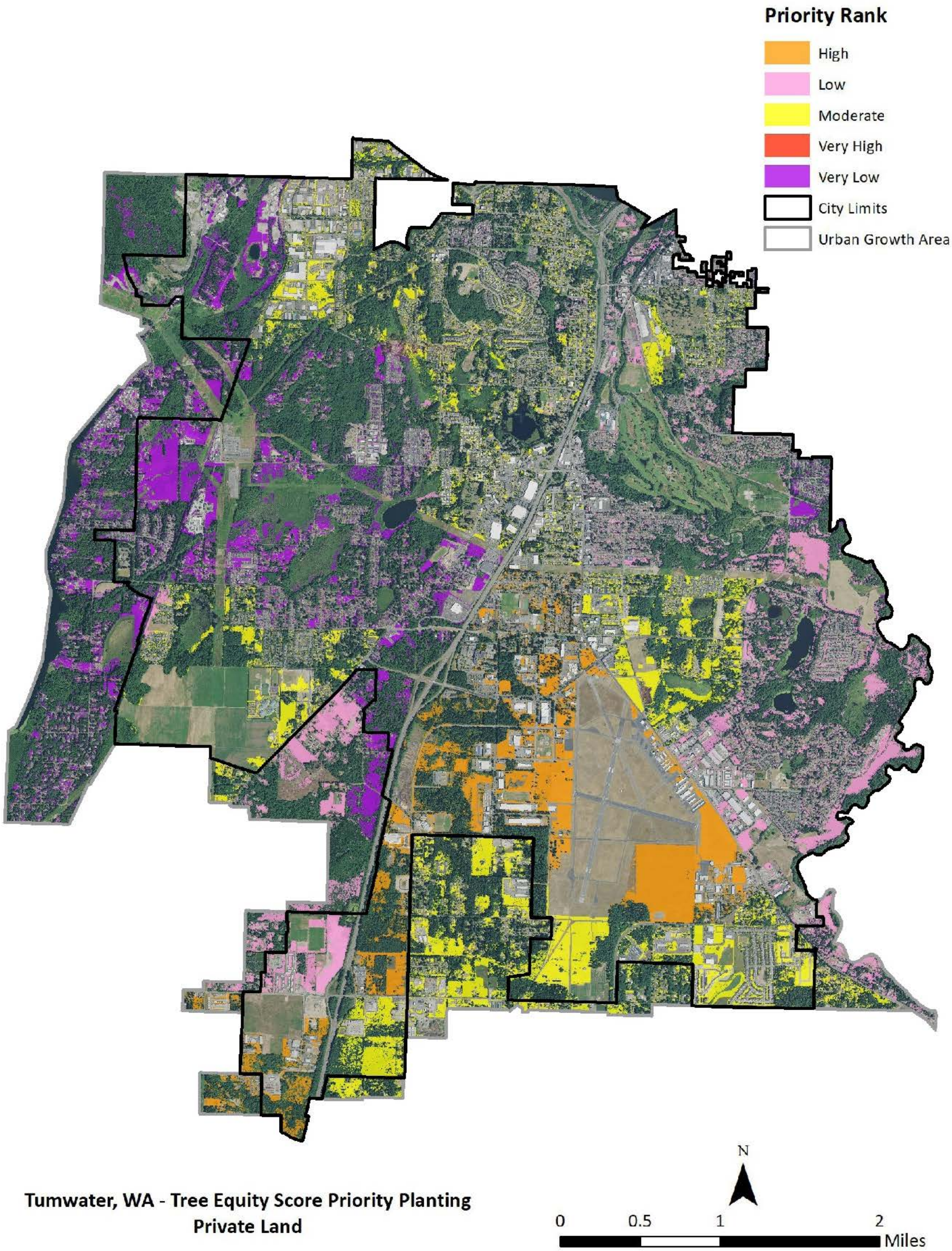
| Priority Rank | Number of Locations | Square Feet | Acres |
|---|---|---|---|
| Very Low | 3,550 | 11,176,529 | 256.58 |
| Low | 5,783 | 17,961,705 | 411.34 |
| Moderate | 7,793 | 25,184,892 | 578.17 |
| High | 1,524 | 18,131,693 | 416.25 |
| Very High | 0 | 0 | 0 |
| Total | 18,650 | 72,454,819 | 1,663 |

| Priority Rank | Number of Locations | Square Feet | Acres |
|---|---|---|---|
| Very Low | 19,178 | 25,589,959 | 587.46 |
| Low | 16,957 | 31,550,627 | 724.30 |
| Moderate | 25,887 | 38,506,447 | 883.99 |
| High | 6,299 | 23,161,814 | 531.72 |
| Very High | 0 | 0 | 0 |
| Total | 68,321 | 118,808,847 | 2,727 |

Private

*Map 6: Public and Private Priority Planting for Tree Equity*






**Tumwater, WA - Tree Equity Score Priority Planting Private Land**

## Social Equity

To prioritize planting areas based on social equity, a model was produced comparing tree canopy cover and median household income, while stormwater was excluded from the analysis. Areas with low canopy cover were prioritized over areas with high canopy cover, as well as areas with low median income were prioritized over those with higher median income. Areas with very high priority for planting are areas where both the tree canopy cover is low, and the median household income is also low (Map 6).

The result identified the following acres for priority planting that would positively contribute to equitable distribution of canopy cover for social equity 37.9% of potential planting sites are located within high or very high planting areas for public land (Table 18) and 54.9% for private land (Table 18). Overall, the City of Tumwater would benefit greatly from increased canopy cover.

*Table 23: Potential Planting Priority Sites for Social Equity*

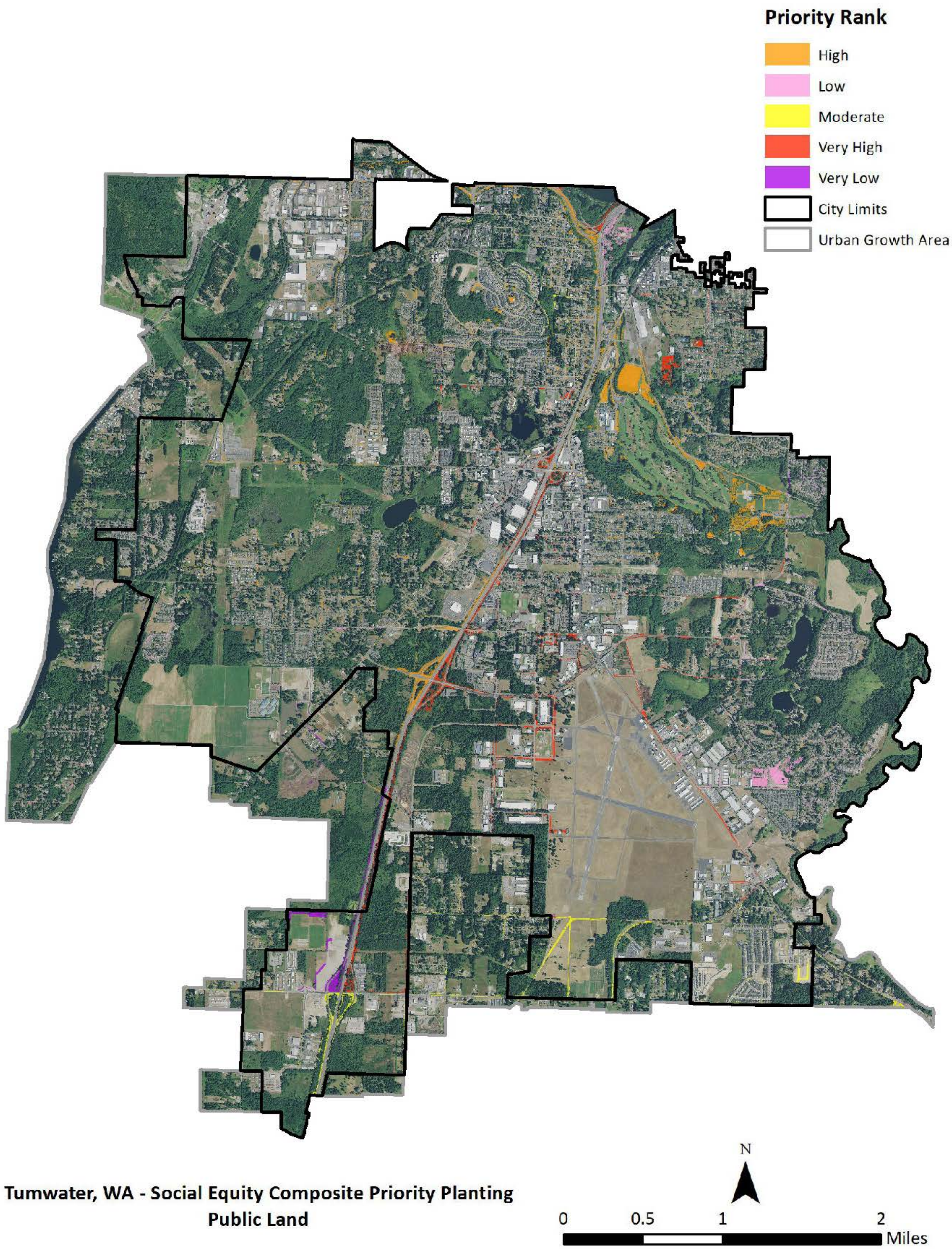
Public

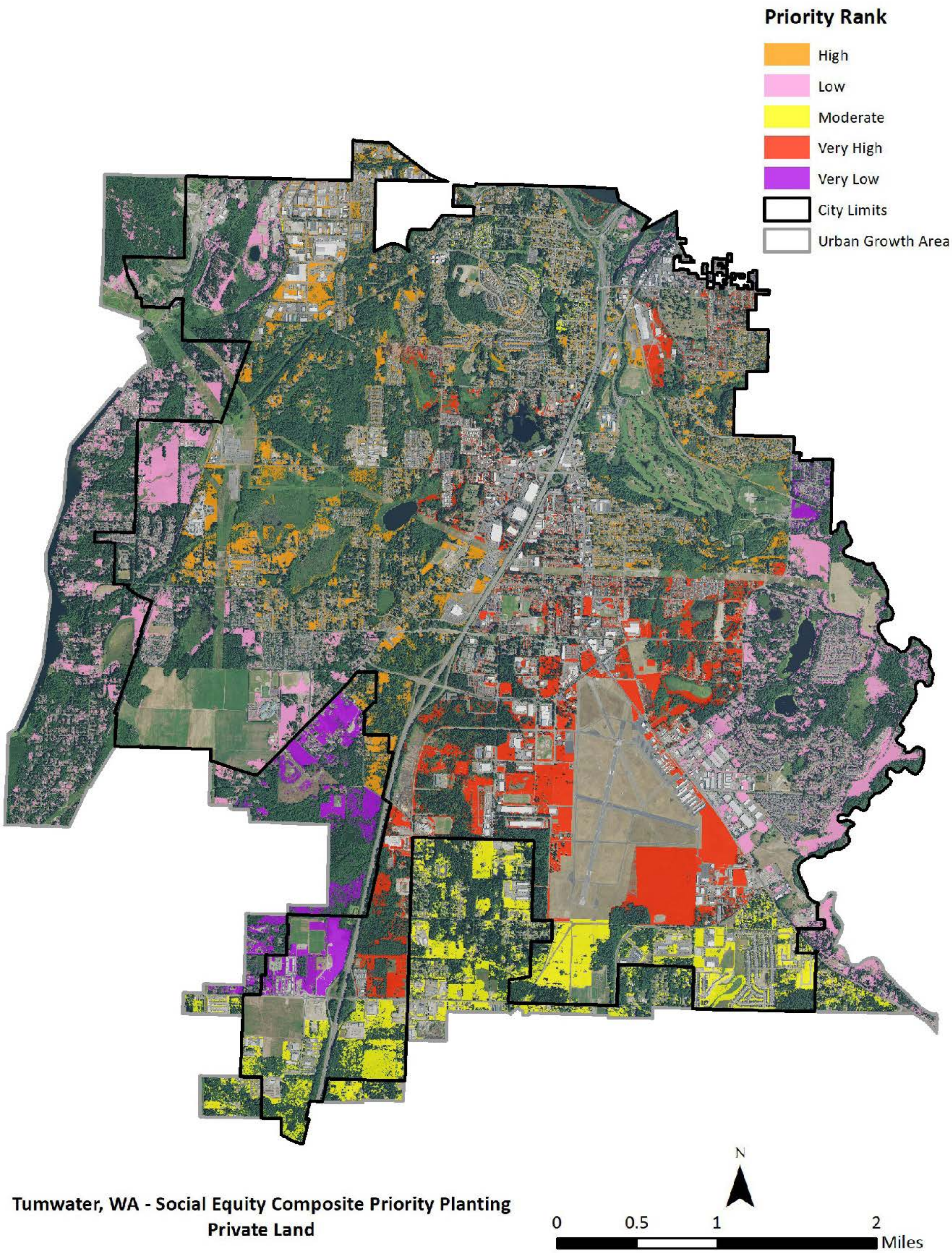
| Priority Rank | Number of Locations | Square Feet | Acres |
|---|---|---|---|
| Very Low | 642 | 7,026,411 | 161.30 |
| Low | 3,829 | 14,326,158 | 328.88 |
| Moderate | 2,098 | 14,945,936 | 343.11 |
| High | 8,542 | 11,909,734 | 296.37 |
| Very High | 3,539 | 23,246,581 | 533.67 |
| Total | 18,650 | 72,454,819 | 1,663 |

| Priority Rank | Number of Locations | Square Feet | Acres |
|---|---|---|---|
| Very Low | 2,876 | 9,659,576 | 221.75 |
| Low | 19,316 | 34,111,474 | 783.09 |
| Moderate | 8,596 | 21,638,172 | 496.74 |
| High | 24,114 | 22,117,977 | 507.76 |
| Very High | 13,409 | 31,281,647 | 718.13 |
| Total | 68,321 | 118,808,847 | 2,727 |

Private

*Map 7: Public and Private Priority Planting for Social Equity*






Tumwater, WA - Social Equity Composite Priority Planting
Private Land

# Appendix C: Inventoried Tree Tables

*Table 24: Botanical and Common Names of All Inventoried Tree Species*

| Species | | # of Trees | % of Trees |
|---|---|---|---|
| Norway maple | *Acer platanoides* | 747 | 15.28 |
| Callery pear | *Pyrus calleryana* | 466 | 9.53 |
| red maple | *Acer rubrum* | 451 | 9.22 |
| Douglas-fir | *Pseudotsuga menziesii* | 417 | 8.53 |
| Japanese flowering cherry | *Prunus serrulata* | 286 | 5.85 |
| little-leaf linden | *Tilia cordata* | 239 | 4.89 |
| bigleaf maple | *Acer macrophyllum* | 235 | 4.81 |
| northern red oak | *Quercus rubra* | 155 | 3.17 |
| sweetgum | *Liquidambar styraciflua* | 154 | 3.15 |
| balsam poplar | *Populus balsamifera* | 135 | 2.76 |
| cherry plum | *Prunus cerasifera* | 134 | 2.74 |
| apple spp | *Malus* | 133 | 2.72 |
| European ash | *Fraxinus excelsior* | 119 | 2.43 |
| green ash | *Fraxinus pennsylvanica* | 104 | 2.13 |
| Kousa dogwood | *Cornus kousa* | 82 | 1.68 |
| red alder | *Alnus rubra* | 77 | 1.57 |
| western red cedar | *Thuja plicata* | 77 | 1.57 |
| flowering dogwood | *Cornus florida* | 65 | 1.33 |
| Katsura tree | *Cercidiphyllum japonicum* | 61 | 1.25 |
| plum spp | *Prunus* | 58 | 1.19 |
| incense cedar | *Calocedrus decurrens* | 52 | 1.06 |
| black tupelo | *Nyssa sylvatica* | 38 | 0.78 |
| European hornbeam | *Carpinus betulus* | 27 | 0.55 |
| bigtooth maple | *Acer grandidentatum* | 25 | 0.51 |
| black locust | *Robinia pseudoacacia* | 23 | 0.47 |
| Nootka cypress | *Xanthocyparis nootkatensis* | 23 | 0.47 |
| hedge maple | *Acer campestre* | 21 | 0.43 |
| narrow-leafed ash | *Fraxinus angustifolia* | 21 | 0.43 |
| serviceberry spp | *Amelanchier* | 18 | 0.37 |
| western white pine | *Pinus monticola* | 18 | 0.37 |
| black hawthorn | *Crataegus douglasii* | 17 | 0.35 |
| English elm | *Ulmus procera* | 17 | 0.35 |
| juniper spp | *Juniperus* | 15 | 0.31 |
| lodgepole pine | *Pinus contorta* | 14 | 0.29 |
| Oregon white oak | *Quercus garryana* | 14 | 0.29 |
| Himalayan white birch | *Betula utilis ssp. jacquemontii* | 13 | 0.27 |

| Species | | # of Trees | % of Trees |
|---|---|---|---|
| quaking aspen | *Populus tremuloides* | 13 | 0.27 |
| western hemlock | *Tsuga heterophylla* | 13 | 0.27 |
| European white birch | *Betula pendula* | 11 | 0.25 |
| London planetree | *Platanus x hybrida* | 11 | 0.25 |
| sweet cherry | *Prunus avium* | 11 | 0.25 |
| Japanese maple | *Acer palmatum* | 11 | 0.22 |
| Acer truncatum x A. platanoides | *Acer truncatum x platanoides* | 11 | 0.22 |
| eastern service berry | *Amelanchier canadensis* | 11 | 0.22 |
| hawthorn spp | *Crataegus* | 11 | 0.22 |
| bitter cherry | *Prunus emarginata* | 9 | 0.18 |
| Atlas cedar | *Cedrus atlantica* | 8 | 0.16 |
| tulip tree | *Liriodendron tulipifera* | 8 | 0.16 |
| American sycamore | *Platanus occidentalis* | 8 | 0.16 |
| common pear | *Pyrus communis* | 8 | 0.16 |
| grand fir | *Abies grandis* | 7 | 0.14 |
| boxelder | *Acer negundo* | 7 | 0.14 |
| Leyland cypress | *x Hesperotropsis leylandii* | 7 | 0.14 |
| loquat tree | *Eriobotrya japonica* | 7 | 0.14 |
| Austrian pine | *Pinus nigra* | 7 | 0.14 |
| giant sequoia | *Sequoiadendron giganteum* | 7 | 0.14 |
| Norway spruce | *Picea abies* | 6 | 0.11 |
| Bur oak | *Quercus macrocarpa* | 6 | 0.11 |
| willow spp | *Salix* | 6 | 0.11 |
| vine maple | *Acer circinatum* | 5 | 0.10 |
| Amur maple | *Acer tataricum ssp. ginnala* | 5 | 0.10 |
| horse chestnut | *Aesculus hippocastanum* | 5 | 0.10 |
| paper birch | *Betula papyrifera* | 5 | 0.10 |
| Italian cypress | *Cupressus sempervirens* | 5 | 0.10 |
| English holly | *Ilex aquifolium* | 5 | 0.10 |
| white spruce | *Picea glauca* | 5 | 0.10 |
| Japanese snowbell | *Styrax japonicus* | 5 | 0.10 |
| sycamore maple | *Acer pseudoplatanus* | 4 | 0.08 |
| ash spp | *Fraxinus* | 4 | 0.08 |
| Oregon ash | *Fraxinus latifolia* | 4 | 0.08 |
| black poplar | *Populus nigra* | 4 | 0.08 |
| European buckthorn | *Rhamnus cathartica* | 4 | 0.08 |
| Scouler willow | *Salix scouleriana* | 4 | 0.08 |
| lilac spp | *Syringa* | 4 | 0.08 |
| Japanese zelkova | *Zelkova serrata* | 4 | 0.08 |
| silver maple | *Acer saccharinum* | 3 | 0.06 |
| sugar maple | *Acer saccharum* | 3 | 0.06 |

| Species | | # of Trees | % of Trees |
|---|---|---|---|
| Port Orford cedar | *Chamaecyparis lawsoniana* | 3 | 0.06 |
| Hinoki cypress | *Chamaecyparis obtusa* | 3 | 0.06 |
| hazelnut spp | *Corylus* | 3 | 0.06 |
| Pacific dogwood | *Cornus nuttallii* | 3 | 0.06 |
| Arizona cypress | *Cupressus arizonica* | 3 | 0.06 |
| pin oak | *Quercus palustris* | 3 | 0.06 |
| paperbark maple | *Acer griseum* | 2 | 0.04 |
| American chestnut | *Castanea dentata* | 2 | 0.04 |
| deodar cedar | *Cedrus deodara* | 2 | 0.04 |
| ginkgo | *Ginkgo biloba* | 2 | 0.04 |
| butternut | *Juglans cinerea* | 2 | 0.04 |
| dawn redwood | *Metasequoia glyptostroboides* | 2 | 0.04 |
| pine spp | *Pinus* | 2 | 0.04 |
| scarlet oak | *Quercus coccinea* | 2 | 0.04 |
| European mountain ash | *Sorbus aucuparia* | 2 | 0.04 |
| fir spp | *Abies* | 1 | 0.02 |
| Nordmann fir | *Abies nordmanniana* | 1 | 0.02 |
| birch spp | *Betula* | 1 | 0.02 |
| camellia | *Camellia japonica* | 1 | 0.02 |
| dogwood spp | *Cornus* | 1 | 0.02 |
| Japanese red cedar | *Cryptomeria japonica* | 1 | 0.02 |
| blue Chinese fir | *Cunninghamia lanceolata* | 1 | 0.02 |
| beech spp | *Fagus* | 1 | 0.02 |
| holly spp | *Ilex* | 1 | 0.02 |
| black walnut | *Juglans nigra* | 1 | 0.02 |
| golden-chain tree | *Laburnum anagyroides* | 1 | 0.02 |
| southern magnolia | *Magnolia grandiflora* | 1 | 0.02 |
| star magnolia | *Magnolia stellata* | 1 | 0.02 |
| eastern cottonwood | *Populus deltoides* | 1 | 0.02 |
| Lombardy poplar | *Populus nigra v. italica* | 1 | 0.02 |
| oak spp | *Quercus* | 1 | 0.02 |
| swamp white oak | *Quercus bicolor* | 1 | 0.02 |
| Babylon weeping willow | *Salix babylonica* | 1 | 0.02 |
| Total | | 4,890 | 100% |

*Table 25: Population Summary for All Inventoried Tree Species*

| Species | # of Trees | DBH Class (inches) 0 – 4 | 4 – 6 | 6 – 11 | 11 – 18 | 18 – 24 | 24 – 30 | 30 – 36 | 36 – 42 | 42 – 48 | 48+ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *Acer platanoides* | 747 | 194 | 160 | 303 | 75 | 10 | 5 | 0 | 0 | 0 | 0 |
| *Pyrus calleryana* | 466 | 187 | 113 | 161 | 4 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Acer rubrum* | 451 | 157 | 173 | 93 | 27 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Pseudotsuga menziesii* | 417 | 0 | 5 | 62 | 75 | 70 | 73 | 61 | 39 | 16 | 16 |
| *Prunus serrulata* | 286 | 143 | 55 | 61 | 21 | 5 | 0 | 1 | 0 | 0 | 0 |
| *Tilia cordata* | 239 | 89 | 68 | 79 | 3 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Acer macrophyllum* | 235 | 0 | 13 | 43 | 53 | 26 | 22 | 18 | 11 | 8 | 41 |
| *Quercus rubra* | 155 | 38 | 30 | 67 | 11 | 6 | 2 | 0 | 1 | 0 | 0 |
| *Liquidambar styraciflua* | 154 | 11 | 15 | 104 | 22 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Populus balsamifera* | 135 | 0 | 27 | 85 | 15 | 2 | 1 | 2 | 1 | 1 | 1 |
| *Prunus cerasifera* | 134 | 22 | 6 | 54 | 39 | 11 | 0 | 0 | 1 | 0 | 0 |
| *Malus* | 133 | 68 | 13 | 41 | 1 | 1 | 7 | 0 | 2 | 0 | 0 |
| *Fraxinus excelsior* | 119 | 72 | 11 | 34 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Fraxinus pennsylvanica* | 104 | 67 | 15 | 19 | 3 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cornus kousa* | 82 | 61 | 19 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Alnus rubra* | 77 | 0 | 4 | 29 | 21 | 10 | 5 | 5 | 0 | 1 | 2 |
| *Thuja plicata* | 77 | 3 | 2 | 21 | 14 | 9 | 10 | 10 | 5 | 2 | 1 |
| *Cornus florida* | 65 | 47 | 11 | 5 | 1 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Cercidiphyllum japonicum* | 61 | 2 | 2 | 56 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Prunus* | 58 | 0 | 3 | 29 | 14 | 6 | 2 | 3 | 0 | 0 | 1 |
| *Calocedrus decurrens* | 52 | 0 | 26 | 10 | 10 | 2 | 4 | 0 | 0 | 0 | 0 |
| *Nyssa sylvatica* | 38 | 15 | 20 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Carpinus betulus* | 27 | 15 | 3 | 2 | 7 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Acer grandidentatum* | 25 | 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Robinia pseudoacacia* | 23 | 0 | 0 | 14 | 3 | 1 | 3 | 1 | 0 | 0 | 1 |
| *Xanthocyparis nootkatensis* | 23 | 4 | 9 | 8 | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Acer campestre* | 21 | 16 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Fraxinus angustifolia* | 21 | 21 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Amelanchier* | 18 | 0 | 1 | 9 | 1 | 2 | 2 | 1 | 1 | 0 | 1 |
| *Pinus monticola* | 18 | 0 | 0 | 0 | 2 | 2 | 13 | 1 | 0 | 0 | 0 |
| *Crataegus douglasii* | 17 | 0 | 2 | 7 | 2 | 4 | 2 | 0 | 0 | 0 | 0 |
| *Ulmus procera* | 17 | 0 | 2 | 11 | 1 | 2 | 0 | 1 | 0 | 0 | 0 |
| *Juniperus* | 15 | 0 | 3 | 7 | 3 | 0 | 1 | 1 | 0 | 0 | 0 |
| *Pinus contorta* | 14 | 1 | 3 | 2 | 4 | 3 | 1 | 0 | 0 | 0 | 0 |

| Species | # of Trees | DBH Class (inches) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0 - 4 | 4 - 6 | 6 - 11 | 11 - 18 | 18 - 24 | 24 - 30 | 30 - 36 | 36 - 42 | 42 - 48 | 48+ |
| *Quercus garryana* | 14 | 0 | 1 | 0 | 2 | 2 | 1 | 1 | 4 | 2 | 1 |
| *Betula utilis ssp. jacquemontii* | 13 | 1 | 3 | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Populus tremuloides* | 13 | 0 | 1 | 8 | 4 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Tsuga heterophylla* | 13 | 0 | 0 | 5 | 2 | 1 | 2 | 0 | 2 | 1 | 0 |
| *Betula pendula* | 11 | 0 | 0 | 5 | 5 | 1 | 1 | 0 | 0 | 0 | 0 |
| *Platanus x hybrida* | 11 | 2 | 2 | 1 | 0 | 4 | 1 | 1 | 0 | 1 | 0 |
| *Prunus avium* | 11 | 0 | 1 | 3 | 5 | 1 | 2 | 0 | 0 | 0 | 0 |
| *Acer palmatum* | 11 | 2 | 0 | 1 | 4 | 4 | 0 | 0 | 0 | 0 | 0 |
| *Acer truncatum x platanoides* | 11 | 10 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Amelanchier canadensis* | 11 | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Crataegus* | 11 | 0 | 1 | 4 | 1 | 3 | 1 | 1 | 0 | 0 | 0 |
| *Prunus emarginata* | 9 | 0 | 0 | 1 | 3 | 4 | 1 | 0 | 0 | 0 | 0 |
| *Cedrus atlantica* | 8 | 0 | 0 | 1 | 5 | 2 | 0 | 0 | 0 | 0 | 0 |
| *Liriodendron tulipifera* | 8 | 0 | 0 | 0 | 3 | 3 | 0 | 2 | 0 | 0 | 0 |
| *Platanus occidentalis* | 8 | 0 | 2 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pyrus communis* | 8 | 5 | 0 | 0 | 1 | 2 | 0 | 0 | 0 | 0 | 0 |
| *Abies grandis* | 7 | 0 | 0 | 1 | 0 | 0 | 4 | 2 | 0 | 0 | 0 |
| *Acer negundo* | 7 | 4 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Eriobotrya japonica* | 7 | 3 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pinus nigra* | 7 | 0 | 0 | 2 | 5 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sequoiadendron giganteum* | 7 | 0 | 0 | 1 | 0 | 2 | 2 | 2 | 0 | 0 | 0 |
| *x Hesperotropsis leylandii* | 7 | 0 | 0 | 1 | 2 | 3 | 0 | 0 | 0 | 0 | 1 |
| *Picea abies* | 6 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Quercus macrocarpa* | 6 | 0 | 0 | 2 | 1 | 0 | 1 | 2 | 0 | 0 | 0 |
| *Salix* | 6 | 0 | 0 | 1 | 2 | 1 | 0 | 2 | 0 | 0 | 0 |
| *Acer circinatum* | 5 | 1 | 0 | 0 | 1 | 3 | 0 | 0 | 0 | 0 | 0 |
| *Acer tataricum ssp. ginnala* | 5 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Aesculus hippocastanum* | 5 | 0 | 0 | 0 | 2 | 0 | 1 | 0 | 1 | 0 | 1 |
| *Betula papyrifera* | 5 | 1 | 3 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cupressus sempervirens* | 5 | 1 | 3 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ilex aquifolium* | 5 | 0 | 1 | 1 | 2 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Picea glauca* | 5 | 0 | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Styrax japonicus* | 5 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Acer pseudoplatanus* | 4 | 0 | 0 | 0 | 0 | 1 | 2 | 0 | 1 | 0 | 0 |
| *Fraxinus* | 4 | 0 | 0 | 3 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |

| | | DBH Class (inches) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Species | # of Trees | 0 - 4 | 4 - 6 | 6 - 11 | 11 - 18 | 18 - 24 | 24 - 30 | 30 - 36 | 36 - 42 | 42 - 48 | 48+ |
| *Fraxinus latifolia* | 4 | 0 | 0 | 0 | 1 | 2 | 0 | 0 | 1 | 0 | 0 |
| *Populus nigra* | 4 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 0 |
| *Rhamnus cathartica* | 4 | 0 | 0 | 3 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Salix scouleriana* | 4 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| *Syringa* | 4 | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 |
| *Zelkova serrata* | 4 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Acer saccharinum* | 3 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 |
| *Acer saccharum* | 3 | 0 | 0 | 2 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| *Chamaecyparis lawsoniana* | 3 | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Chamaecyparis obtusa* | 3 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| *Cornus nuttallii* | 3 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Corylus* | 3 | 0 | 0 | 0 | 0 | 1 | 2 | 0 | 0 | 0 | 0 |
| *Cupressus arizonica* | 3 | 0 | 1 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Quercus palustris* | 3 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Acer griseum* | 2 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Castanea dentata* | 2 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 |
| *Cedrus deodara* | 2 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 |
| *Ginkgo biloba* | 2 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Juglans cinerea* | 2 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Metasequoia glyptostroboides* | 2 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Pinus* | 2 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Quercus coccinea* | 2 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Sorbus aucuparia* | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Abies* | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Abies nordmanniana* | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Betula* | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Camellia japonica* | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| *Cornus* | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Cryptomeria japonica* | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Cunninghamia lanceolata* | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| *Fagus* | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Ilex* | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Juglans nigra* | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Laburnum anagyroides* | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Magnolia grandiflora* | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Magnolia stellata* | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Populus deltoides* | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Populus nigra v. italica* | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Quercus* | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| Species | # of Trees | DBH Class (inches) 0 - 4 | 4 - 6 | 6 - 11 | 11 - 18 | 18 - 24 | 24 - 30 | 30 - 36 | 36 - 42 | 42 - 48 | 48+ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *Quercus bicolor* | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| *Salix babylonica* | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| all other species | 643 | 164 | 80 | 150 | 87 | 65 | 50 | 20 | 11 | 6 | 9 |
| Total | 4,890 | 1,326 | 852 | 1,507 | 498 | 226 | 183 | 110 | 72 | 34 | 72 |

*Table 26: Importance Values for All Inventoried Tree Species*

| Species | # of Trees | % of Trees | % Leaf Area | IV |
|---|---|---|---|---|
| *Acer platanoides* | 747 | 15.28 | 27.23 | 42.50 |
| *Pyrus calleryana* | 466 | 9.53 | 17.13 | 26.66 |
| *Acer rubrum* | 451 | 9.22 | 7.92 | 17.15 |
| *Pseudotsuga menziesii* | 417 | 8.53 | 3.54 | 11.07 |
| *Prunus serrulata* | 286 | 5.85 | 3.53 | 9.38 |
| *Tilia cordata* | 239 | 4.89 | 3.18 | 8.07 |
| *Acer macrophyllum* | 235 | 4.81 | 2.67 | 7.48 |
| *Quercus rubra* | 155 | 3.17 | 2.64 | 5.81 |
| *Liquidambar styraciflua* | 154 | 3.15 | 2.41 | 5.56 |
| *Populus balsamifera* | 135 | 2.76 | 2.22 | 4.98 |
| *Prunus cerasifera* | 134 | 2.74 | 2.11 | 4.86 |
| *Malus* | 133 | 2.72 | 1.80 | 4.52 |
| *Fraxinus excelsior* | 119 | 2.43 | 1.60 | 4.04 |
| *Fraxinus pennsylvanica* | 104 | 2.13 | 1.45 | 3.58 |
| *Cornus kousa* | 82 | 1.68 | 1.32 | 3.00 |
| *Alnus rubra* | 77 | 1.57 | 1.17 | 2.74 |
| *Thuja plicata* | 77 | 1.57 | 1.11 | 2.70 |
| *Cornus florida* | 65 | 1.33 | 0.92 | 2.25 |
| *Cercidiphyllum japonicum* | 61 | 1.25 | 0.87 | 2.11 |
| *Prunus* | 58 | 1.19 | 0.86 | 2.05 |
| *Calocedrus decurrens* | 52 | 1.06 | 0.76 | 1.83 |
| *Nyssa sylvatica* | 38 | 0.78 | 0.75 | 1.53 |
| *Carpinus betulus* | 27 | 0.55 | 0.60 | 1.16 |
| *Acer grandidentatum* | 25 | 0.51 | 0.55 | 1.06 |
| *Robinia pseudoacacia* | 23 | 0.47 | 0.55 | 1.02 |
| *Xanthocyparis nootkatensis* | 23 | 0.47 | 0.45 | 0.92 |
| *Acer campestre* | 21 | 0.43 | 0.41 | 0.84 |
| *Fraxinus angustifolia* | 21 | 0.43 | 0.38 | 0.81 |
| *Amelanchier* | 18 | 0.37 | 0.37 | 0.74 |
| *Pinus monticola* | 18 | 0.37 | 0.37 | 0.74 |
| *Crataegus douglasii* | 17 | 0.35 | 0.35 | 0.70 |
| *Ulmus procera* | 17 | 0.35 | 0.33 | 0.68 |
| *Juniperus* | 15 | 0.31 | 0.33 | 0.64 |
| *Pinus contorta* | 14 | 0.29 | 0.33 | 0.61 |
| *Quercus garryana* | 14 | 0.29 | 0.32 | 0.61 |

| Species | # of Trees | % of Trees | % Leaf Area | IV |
|---|---|---|---|---|
| *Betula utilis ssp. Jacquemontii* | 13 | 0.27 | 0.30 | 0.56 |
| *Populus tremuloides* | 13 | 0.27 | 0.30 | 0.56 |
| *Tsuga heterophylla* | 13 | 0.27 | 0.29 | 0.56 |
| *Betula pendula* | 11 | 0.25 | 0.29 | 0.54 |
| *Platanus x hybrida* | 11 | 0.25 | 0.29 | 0.53 |
| *Prunus avium* | 11 | 0.25 | 0.29 | 0.53 |
| *Acer palmatum* | 11 | 0.22 | 0.28 | 0.51 |
| *Acer truncatum x platanoides* | 11 | 0.22 | 0.28 | 0.50 |
| *Amelanchier canadensis* | 11 | 0.22 | 0.27 | 0.50 |
| *Crataegus* | 11 | 0.22 | 0.21 | 0.43 |
| *Prunus emarginata* | 9 | 0.18 | 0.20 | 0.39 |
| *Cedrus atlantica* | 8 | 0.16 | 0.20 | 0.36 |
| *Liriodendron tulipifera* | 8 | 0.16 | 0.19 | 0.36 |
| *Platanus occidentalis* | 8 | 0.16 | 0.19 | 0.35 |
| *Pyrus communis* | 8 | 0.16 | 0.18 | 0.35 |
| *Abies grandis* | 7 | 0.14 | 0.18 | 0.33 |
| *Acer negundo* | 7 | 0.14 | 0.18 | 0.32 |
| *Eriobotrya japonica* | 7 | 0.14 | 0.17 | 0.31 |
| *Pinus nigra* | 7 | 0.14 | 0.16 | 0.30 |
| *Sequoiadendron giganteum* | 7 | 0.14 | 0.16 | 0.30 |
| *x Hesperotropsis leylandii* | 7 | 0.14 | 0.14 | 0.28 |
| *Picea abies* | 6 | 0.11 | 0.14 | 0.26 |
| *Quercus macrocarpa* | 6 | 0.11 | 0.14 | 0.26 |
| *Salix* | 6 | 0.11 | 0.13 | 0.25 |
| *Acer circinatum* | 5 | 0.10 | 0.13 | 0.23 |
| *Acer tataricum ssp. Ginnala* | 5 | 0.10 | 0.13 | 0.23 |
| *Aesculus hippocastanum* | 5 | 0.10 | 0.11 | 0.21 |
| *Betula papyrifera* | 5 | 0.10 | 0.11 | 0.21 |
| *Cupressus sempervirens* | 5 | 0.10 | 0.10 | 0.20 |
| *Ilex aquifolium* | 5 | 0.10 | 0.09 | 0.20 |
| *Picea glauca* | 5 | 0.10 | 0.09 | 0.20 |
| *Styrax japonicus* | 5 | 0.10 | 0.09 | 0.19 |
| *Acer pseudoplatanus* | 4 | 0.08 | 0.09 | 0.17 |
| *Fraxinus* | 4 | 0.08 | 0.08 | 0.17 |
| *Fraxinus latifolia* | 4 | 0.08 | 0.08 | 0.17 |
| *Populus nigra* | 4 | 0.08 | 0.06 | 0.14 |
| *Rhamnus cathartica* | 4 | 0.08 | 0.06 | 0.14 |
| *Salix scouleriana* | 4 | 0.08 | 0.06 | 0.14 |
| *Syringa* | 4 | 0.08 | 0.06 | 0.14 |
| *Zelkova serrata* | 4 | 0.08 | 0.06 | 0.14 |
| *Acer saccharinum* | 3 | 0.06 | 0.06 | 0.11 |
| *Acer saccharum* | 3 | 0.06 | 0.06 | 0.11 |
| *Chamaecyparis lawsoniana* | 3 | 0.06 | 0.06 | 0.11 |
| *Chamaecyparis obtusa* | 3 | 0.06 | 0.05 | 0.11 |

| Species | # of Trees | % of Trees | % Leaf Area | IV |
|---|---|---|---|---|
| *Cornus nuttallii* | 3 | 0.06 | 0.05 | 0.11 |
| *Corylus* | 3 | 0.06 | 0.05 | 0.11 |
| *Cupressus arizonica* | 3 | 0.06 | 0.05 | 0.11 |
| *Quercus palustris* | 3 | 0.06 | 0.05 | 0.11 |
| *Acer griseum* | 2 | 0.04 | 0.04 | 0.08 |
| *Castanea dentata* | 2 | 0.04 | 0.04 | 0.08 |
| *Cedrus deodara* | 2 | 0.04 | 0.04 | 0.08 |
| *Ginkgo biloba* | 2 | 0.04 | 0.04 | 0.08 |
| *Juglans cinerea* | 2 | 0.04 | 0.04 | 0.08 |
| *Metasequoia glyptostroboides* | 2 | 0.04 | 0.03 | 0.07 |
| *Pinus* | 2 | 0.04 | 0.02 | 0.06 |
| *Quercus coccinea* | 2 | 0.04 | 0.02 | 0.06 |
| *Sorbus aucuparia* | 2 | 0.04 | 0.02 | 0.06 |
| *Abies* | 1 | 0.02 | 0.02 | 0.04 |
| *Abies nordmanniana* | 1 | 0.02 | 0.01 | 0.03 |
| *Betula* | 1 | 0.02 | 0.01 | 0.03 |
| *Camellia japonica* | 1 | 0.02 | 0.01 | 0.03 |
| *Cornus* | 1 | 0.02 | 0.01 | 0.03 |
| *Cryptomeria japonica* | 1 | 0.02 | 0.01 | 0.03 |
| *Cunninghamia lanceolata* | 1 | 0.02 | 0.01 | 0.03 |
| *Fagus* | 1 | 0.02 | 0.01 | 0.03 |
| *Ilex* | 1 | 0.02 | 0.00 | 0.03 |
| *Juglans nigra* | 1 | 0.02 | 0.00 | 0.03 |
| *Laburnum anagyroides* | 1 | 0.02 | 0.00 | 0.03 |
| *Magnolia grandiflora* | 1 | 0.02 | 0.00 | 0.03 |
| *Magnolia stellata* | 1 | 0.02 | 0.00 | 0.03 |
| *Populus deltoides* | 1 | 0.02 | 0.00 | 0.03 |
| *Populus nigra v. italica* | 1 | 0.02 | 0.00 | 0.02 |
| *Quercus* | 1 | 0.02 | 0.00 | 0.02 |
| *Quercus bicolor* | 1 | 0.02 | 0.00 | 0.02 |
| *Salix babylonica* | 1 | 0.02 | 0.00 | 0.02 |
| Total | 4,890 | 100% | 100% | 200 |

*Table 27: Condition and RPI for All Inventoried Tree Species*

| Species | % Excellent | % Very Good | % Good | % Fair | % Poor | % Critical | % Dead | RPI | # of Trees | % of Trees |
|---|---|---|---|---|---|---|---|---|---|---|
| *Acer platanoides* | 6.0 | 85.5 | 5.8 | 1.7 | 0.5 | 0.0 | 0.4 | 1.05 | 747 | 15.28 |
| *Pyrus calleryana* | 3.4 | 83.5 | 10.7 | 2.1 | 0.2 | 0.0 | 0.0 | 1.04 | 466 | 9.53 |
| *Acer rubrum* | 11.9 | 74.3 | 10.2 | 1.8 | 0.9 | 0.0 | 0.0 | 1.06 | 451 | 9.22 |
| *Pseudotsuga menziesii* | 0.0 | 65.2 | 31.7 | 1.7 | 0.0 | 0.0 | 1.4 | 0.99 | 417 | 8.53 |
| *Prunus serrulata* | 3.5 | 73.8 | 16.1 | 4.9 | 1.4 | 0.0 | 0.3 | 1.01 | 286 | 5.85 |
| *Tilia cordata* | 21.8 | 54.0 | 16.7 | 5.4 | 1.3 | 0.0 | 0.8 | 1.04 | 239 | 4.89 |
| *Acer macrophyllum* | 0.0 | 35.7 | 57.0 | 4.7 | 0.4 | 0.0 | 2.1 | 0.92 | 235 | 4.81 |
| *Quercus rubra* | 1.9 | 80.6 | 11.6 | 3.2 | 1.9 | 0.0 | 0.6 | 1.02 | 155 | 3.17 |

| Species | % Excellent | % Very Good | % Good | % Fair | % Poor | % Critical | % Dead | RPI | # of Trees | % of Trees |
|---|---|---|---|---|---|---|---|---|---|---|
| *Liquidambar styraciflua* | 3.2 | 53.2 | 37.7 | 4.5 | 1.3 | 0.0 | 0.0 | 0.98 | 154 | 3.15 |
| *Populus balsamifera* | 0.0 | 56.3 | 11.6 | 31.1 | 0.0 | 0.0 | 0.0 | 0.93 | 135 | 2.76 |
| *Prunus cerasifera* | 0.7 | 39.6 | 40.3 | 18.7 | 0.7 | 0.0 | 0.0 | 0.92 | 134 | 2.74 |
| *Malus* | 7.5 | 39.8 | 42.1 | 9.8 | 0.8 | 0.0 | 0.0 | 0.96 | 133 | 2.72 |
| *Fraxinus excelsior* | 1.7 | 83.2 | 5.9 | 5.0 | 4.2 | 0.0 | 0.0 | 1.02 | 119 | 2.43 |
| *Fraxinus pennsylvanica* | 0.0 | 62.5 | 37.5 | 0.0 | 0.0 | 0.0 | 0.0 | 1.00 | 104 | 2.13 |
| *Cornus kousa* | 0.0 | 57.3 | 32.9 | 3.7 | 3.7 | 0.0 | 2.4 | 0.95 | 82 | 1.68 |
| *Alnus rubra* | 0.0 | 22.1 | 55.8 | 10.4 | 0.0 | 0.0 | 11.7 | 0.82 | 77 | 1.57 |
| *Thuja plicata* | 0.0 | 48.1 | 41.6 | 2.6 | 7.8 | 0.0 | 0.0 | 0.94 | 77 | 1.57 |
| *Cornus florida* | 0.0 | 46.2 | 38.5 | 6.2 | 6.2 | 0.0 | 3.1 | 0.91 | 65 | 1.33 |
| *Cercidiphyllum japonicum* | 11.5 | 72.1 | 14.8 | 1.6 | 0.0 | 0.0 | 0.0 | 1.05 | 61 | 1.25 |
| *Prunus* | 0.0 | 5.2 | 72.4 | 17.2 | 1.7 | 0.0 | 3.4 | 0.83 | 58 | 1.19 |
| *Calocedrus decurrens* | 0.0 | 36.5 | 55.8 | 7.7 | 0.0 | 0.0 | 0.0 | 0.94 | 52 | 1.06 |
| *Nyssa sylvatica* | 36.8 | 55.3 | 5.3 | 2.6 | 0.0 | 0.0 | 0.0 | 1.11 | 38 | 0.78 |
| *Carpinus betulus* | 0.0 | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.06 | 27 | 0.55 |
| *Acer grandidentatum* | 0.0 | 92.0 | 8.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.05 | 25 | 0.51 |
| *Robinia pseudoacacia* | 0.0 | 43.5 | 43.5 | 13.0 | 0.0 | 0.0 | 0.0 | 0.94 | 23 | 0.47 |
| *Xanthocyparis nootkatensis* | 4.3 | 91.3 | 4.3 | 0.0 | 0.0 | 0.0 | 0.0 | 1.06 | 23 | 0.47 |
| *Acer campestre* | 14.3 | 57.1 | 28.6 | 0.0 | 0.0 | 0.0 | 0.0 | 1.04 | 21 | 0.43 |
| *Fraxinus angustifolia* | 42.9 | 33.3 | 19.0 | 4.8 | 0.0 | 0.0 | 0.0 | 1.09 | 21 | 0.43 |
| *Amelanchier* | 0.0 | 5.6 | 94.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.90 | 18 | 0.37 |
| *Pinus monticola* | 0.0 | 38.9 | 55.6 | 0.0 | 0.0 | 0.0 | 5.6 | 0.92 | 18 | 0.37 |
| *Crataegus douglasii* | 0.0 | 0.0 | 52.9 | 29.4 | 5.9 | 0.0 | 11.8 | 0.73 | 17 | 0.35 |
| *Ulmus procera* | 0.0 | 35.3 | 47.1 | 17.6 | 0.0 | 0.0 | 0.0 | 0.92 | 17 | 0.35 |
| *Juniperus* | 0.0 | 0.0 | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.89 | 15 | 0.31 |
| *Pinus contorta* | 0.0 | 50.0 | 35.7 | 14.3 | 0.0 | 0.0 | 0.0 | 0.95 | 14 | 0.29 |
| *Quercus garryana* | 7.1 | 57.1 | 35.7 | 0.0 | 0.0 | 0.0 | 0.0 | 1.01 | 14 | 0.29 |
| *Betula utilis ssp. jacquemontii* | 7.7 | 84.6 | 7.7 | 0.0 | 0.0 | 0.0 | 0.0 | 1.06 | 13 | 0.27 |
| *Populus tremuloides* | 0.0 | 61.5 | 38.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.99 | 13 | 0.27 |
| *Tsuga heterophylla* | 0.0 | 46.2 | 23.1 | 7.7 | 0.0 | 0.0 | 23.1 | 0.79 | 13 | 0.27 |
| *Betula pendula* | 0.0 | 83.3 | 16.7 | 0.0 | 0.0 | 0.0 | 0.0 | 1.03 | 11 | 0.25 |
| *Platanus x hybrida* | 16.7 | 58.3 | 16.7 | 8.3 | 0.0 | 0.0 | 0.0 | 1.03 | 11 | 0.25 |
| *Prunus avium* | 0.0 | 91.7 | 8.3 | 0.0 | 0.0 | 0.0 | 0.0 | 1.05 | 11 | 0.25 |
| *Acer palmatum* | 0.0 | 63.6 | 18.2 | 18.2 | 0.0 | 0.0 | 0.0 | 0.97 | 11 | 0.22 |
| *Acer truncatum x platanoides* | 0.0 | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.06 | 11 | 0.22 |
| *Amelanchier canadensis* | 0.0 | 0.0 | 90.9 | 9.1 | 0.0 | 0.0 | 0.0 | 0.87 | 11 | 0.22 |
| *Crataegus* | 0.0 | 9.1 | 81.8 | 9.1 | 0.0 | 0.0 | 0.0 | 0.89 | 11 | 0.22 |
| *Prunus emarginata* | 0.0 | 0.0 | 88.9 | 11.1 | 0.0 | 0.0 | 0.0 | 0.87 | 9 | 0.18 |
| *Cedrus atlantica* | 0.0 | 62.5 | 37.5 | 0.0 | 0.0 | 0.0 | 0.0 | 1.00 | 8 | 0.16 |
| *Liriodendron tulipifera* | 0.0 | 75.0 | 25.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.02 | 8 | 0.16 |
| *Platanus occidentalis* | 0.0 | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.06 | 8 | 0.16 |
| *Pyrus communis* | 0.0 | 11.5 | 75.0 | 11.5 | 0.0 | 0.0 | 0.0 | 0.89 | 8 | 0.16 |
| *Abies grandis* | 0.0 | 57.1 | 42.9 | 0.0 | 0.0 | 0.0 | 0.0 | 0.99 | 7 | 0.14 |
| *Acer negundo* | 0.0 | 71.4 | 0.0 | 28.6 | 0.0 | 0.0 | 0.0 | 0.96 | 7 | 0.14 |

| Species | % Excellent | % Very Good | % Good | % Fair | % Poor | % Critical | % Dead | RPI | # of Trees | % of Trees |
|---|---|---|---|---|---|---|---|---|---|---|
| *Eriobotrya japonica* | 0.0 | 85.7 | 0.0 | 0.0 | 14.3 | 0.0 | 0.0 | 0.99 | 7 | 0.14 |
| *Pinus nigra* | 0.0 | 71.4 | 28.6 | 0.0 | 0.0 | 0.0 | 0.0 | 1.01 | 7 | 0.14 |
| *Sequoiadendron giganteum* | 0.0 | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.06 | 7 | 0.14 |
| *x Hesperotropsis leylandii* | 0.0 | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.06 | 7 | 0.14 |
| *Picea abies* | 0.0 | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.06 | 6 | 0.11 |
| *Quercus macrocarpa* | 0.0 | 83.3 | 16.7 | 0.0 | 0.0 | 0.0 | 0.0 | 1.03 | 6 | 0.11 |
| *Salix* | 0.0 | 50.0 | 50.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.97 | 6 | 0.11 |
| *Acer circinatum* | 0.0 | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.06 | 5 | 0.10 |
| *Acer tataricum ssp. ginnala* | 0.0 | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.06 | 5 | 0.10 |
| *Aesculus hippocastanum* | 0.0 | 0.0 | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.89 | 5 | 0.10 |
| *Betula papyrifera* | 0.0 | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.06 | 5 | 0.10 |
| *Cupressus sempervirens* | 0.0 | 80.0 | 20.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.03 | 5 | 0.10 |
| *Ilex aquifolium* | 0.0 | 60.0 | 40.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.99 | 5 | 0.10 |
| *Picea glauca* | 0.0 | 80.0 | 20.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.03 | 5 | 0.10 |
| *Styrax japonicus* | 0.0 | 80.0 | 0.0 | 20.0 | 0.0 | 0.0 | 0.0 | 0.99 | 5 | 0.10 |
| *Acer pseudoplatanus* | 0.0 | 75.0 | 25.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.02 | 4 | 0.08 |
| *Fraxinus* | 0.0 | 75.0 | 25.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.02 | 4 | 0.08 |
| *Fraxinus latifolia* | 0.0 | 0.0 | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.89 | 4 | 0.08 |
| *Populus nigra* | 0.0 | 25.0 | 75.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.93 | 4 | 0.08 |
| *Rhamnus cathartica* | 0.0 | 25.0 | 75.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.93 | 4 | 0.08 |
| *Salix scouleriana* | 0.0 | 0.0 | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.89 | 4 | 0.08 |
| *Syringa* | 0.0 | 0.0 | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.89 | 4 | 0.08 |
| *Zelkova serrata* | 0.0 | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.06 | 4 | 0.08 |
| *Acer saccharinum* | 0.0 | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.06 | 3 | 0.06 |
| *Acer saccharum* | 0.0 | 66.7 | 33.3 | 0.0 | 0.0 | 0.0 | 0.0 | 1.00 | 3 | 0.06 |
| *Chamaecyparis lawsoniana* | 0.0 | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.06 | 3 | 0.06 |
| *Chamaecyparis obtusa* | 0.0 | 66.7 | 33.3 | 0.0 | 0.0 | 0.0 | 0.0 | 1.00 | 3 | 0.06 |
| *Cornus nuttallii* | 0.0 | 33.3 | 66.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.94 | 3 | 0.06 |
| *Corylus* | 0.0 | 0.0 | 66.7 | 33.3 | 0.0 | 0.0 | 0.0 | 0.83 | 3 | 0.06 |
| *Cupressus arizonica* | 0.0 | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.06 | 3 | 0.06 |
| *Quercus palustris* | 33.3 | 33.3 | 0.0 | 33.3 | 0.0 | 0.0 | 0.0 | 1.00 | 3 | 0.06 |
| *Acer griseum* | 0.0 | 50.0 | 0.0 | 50.0 | 0.0 | 0.0 | 0.0 | 0.89 | 2 | 0.04 |
| *Castanea dentata* | 0.0 | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.06 | 2 | 0.04 |
| *Cedrus deodara* | 0.0 | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.06 | 2 | 0.04 |
| *Ginkgo biloba* | 0.0 | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.06 | 2 | 0.04 |
| *Juglans cinerea* | 0.0 | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.06 | 2 | 0.04 |
| *Metasequoia glyptostroboides* | 0.0 | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.06 | 2 | 0.04 |
| *Pinus* | 0.0 | 0.0 | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.89 | 2 | 0.04 |
| *Quercus coccinea* | 0.0 | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.06 | 2 | 0.04 |
| *Sorbus aucuparia* | 0.0 | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.06 | 2 | 0.04 |

| Species | % Excellent | % Very Good | % Good | % Fair | % Poor | % Critical | % Dead | RPI | # of Trees | % of Trees |
|---|---|---|---|---|---|---|---|---|---|---|
| *Abies* | 0.0 | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.06 | 1 | 0.02 |
| *Abies nordmanniana* | 0.0 | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.06 | 1 | 0.02 |
| *Betula* | 0.0 | 0.0 | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.89 | 1 | 0.02 |
| *Camellia japonica* | 0.0 | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.06 | 1 | 0.02 |
| *Cornus* | 0.0 | 0.0 | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.89 | 1 | 0.02 |
| *Cryptomeria japonica* | 0.0 | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.06 | 1 | 0.02 |
| *Cunninghamia lanceolata* | 0.0 | 0.0 | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.89 | 1 | 0.02 |
| *Fagus* | 0.0 | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.06 | 1 | 0.02 |
| *Ilex* | 0.0 | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.06 | 1 | 0.02 |
| *Juglans nigra* | 0.0 | 0.0 | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.89 | 1 | 0.02 |
| *Laburnum anagyroides* | 0.0 | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.06 | 1 | 0.02 |
| *Magnolia grandiflora* | 0.0 | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.06 | 1 | 0.02 |
| *Magnolia stellata* | 0.0 | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.06 | 1 | 0.02 |
| *Populus deltoides* | 0.0 | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.06 | 1 | 0.02 |
| *Populus nigra v. italica* | 0.0 | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.06 | 1 | 0.02 |
| *Quercus* | 0.0 | 0.0 | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.89 | 1 | 0.02 |
| *Quercus bicolor* | 0.0 | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.06 | 1 | 0.02 |
| *Salix babylonica* | 0.0 | 100.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.06 | 1 | 0.02 |
| Total | 4.9% | 65.1% | 23.4% | 4.8% | 0.9% | 0% | 0.8% | 1.00 | 4,890 | 100% |

*Table 28: Annual Benefits for All Inventoried Tree Species*

| Species | # of Trees | % of Pop. | Carbon Storage ($) | Gross Carbon Sequestration ($/yr.) | Avoided Runoff ($/yr.) | Pollution Removal ($/yr.) |
|---|---|---|---|---|---|---|
| *Acer platanoides* | 747 | 15.28 | 22,368 | 887.46 | 594.87 | 472.18 |
| *Pyrus calleryana* | 466 | 9.53 | 5,529 | 271.52 | 198.13 | 157.27 |
| *Acer rubrum* | 451 | 9.22 | 6,903 | 375.05 | 265.40 | 210.67 |
| *Pseudotsuga menziesii* | 417 | 8.53 | 60,845 | 513.03 | 1185.76 | 1020.59 |
| *Prunus serrulata* | 286 | 5.85 | 8,592 | 198.14 | 110.19 | 95.40 |
| *Tilia cordata* | 239 | 4.89 | 2,307 | 110.77 | 135.25 | 107.36 |
| *Acer macrophyllum* | 235 | 4.81 | 92,572 | 562.62 | 2043.34 | 1621.92 |
| *Quercus rubra* | 155 | 3.17 | 6,304 | 156.77 | 238.56 | 189.36 |
| *Liquidambar styraciflua* | 154 | 3.15 | 2,577 | 107.56 | 181.15 | 143.79 |
| *Populus balsamifera* | 135 | 2.76 | 6,283 | 113.24 | 200.82 | 159.40 |
| *Prunus cerasifera* | 134 | 2.74 | 9,645 | 113.81 | 166.43 | 132.11 |
| *Malus* | 133 | 2.72 | 6,186 | 59.25 | 56.20 | 44.61 |
| *Fraxinus excelsior* | 119 | 2.43 | 2,328 | 61.45 | 87.89 | 69.76 |
| *Fraxinus pennsylvanica* | 104 | 2.13 | 833 | 39.14 | 57.20 | 45.41 |
| *Cornus kousa* | 82 | 1.68 | 385 | 15.43 | 9.77 | 7.75 |
| *Alnus rubra* | 77 | 1.57 | 6,008 | 70.17 | 159.25 | 116.40 |
| *Thuja plicata* | 77 | 1.57 | 6,432 | 30.34 | 264.75 | 210.15 |
| *Cornus florida* | 65 | 1.33 | 754 | 22.47 | 13.90 | 11.03 |

| Species | # of Trees | % of Pop. | Carbon Storage ($) | Gross Carbon Sequestration ($/yr.) | Avoided Runoff ($/yr.) | Pollution Removal ($/yr.) |
|---|---|---|---|---|---|---|
| *Cercidiphyllum japonicum* | 61 | 1.25 | 677 | 27.87 | 109.04 | 86.55 |
| *Prunus* | 58 | 1.19 | 10,039 | 61.51 | 98.96 | 78.55 |
| *Calocedrus decurrens* | 52 | 1.06 | 2,211 | 27.75 | 65.23 | 51.77 |
| *Nyssa sylvatica* | 38 | 0.78 | 222 | 15.78 | 13.34 | 10.59 |
| *Carpinus betulus* | 27 | 0.55 | 785 | 19.38 | 28.80 | 22.86 |
| *Acer grandidentatum* | 25 | 0.51 | 5 | 1.68 | 0.52 | 0.41 |
| *Robinia pseudoacacia* | 23 | 0.47 | 4,132 | 53.37 | 40.97 | 32.52 |
| *Xanthocyparis nootkatensis* | 23 | 0.47 | 2,254 | 31.11 | 15.40 | 11.23 |
| *Acer campestre* | 21 | 0.43 | 84 | 4.90 | 6.95 | 5.52 |
| *Fraxinus angustifolia* | 21 | 0.43 | 18 | 2.81 | 2.89 | 2.29 |
| *Amelanchier* | 18 | 0.37 | 4,875 | 13.88 | 24.77 | 19.66 |
| *Pinus monticola* | 18 | 0.37 | 2,699 | 38.93 | 69.31 | 55.01 |
| *Crataegus douglasii* | 17 | 0.35 | 1,909 | 5.84 | 11.80 | 10.16 |
| *Ulmus procera* | 17 | 0.35 | 1,240 | 25.91 | 21.27 | 16.88 |
| *Juniperus* | 15 | 0.31 | 1,206 | 9.21 | 21.80 | 17.30 |
| *Pinus contorta* | 14 | 0.29 | 596 | 11.66 | 22.42 | 17.80 |
| *Quercus garryana* | 14 | 0.29 | 7,502 | 26.86 | 84.30 | 66.92 |
| *Betula utilis ssp. jacquemontii* | 13 | 0.27 | 218 | 10.28 | 13.86 | 11.00 |
| *Populus tremuloides* | 13 | 0.27 | 354 | 14.21 | 7.48 | 5.94 |
| *Tsuga heterophylla* | 13 | 0.27 | 1,407 | 8.75 | 41.49 | 32.93 |
| *Betula pendula* | 11 | 0.25 | 1,078 | 31.36 | 33.94 | 26.94 |
| *Platanus x hybrida* | 11 | 0.25 | 1,883 | 19.77 | 45.16 | 35.85 |
| *Prunus avium* | 11 | 0.25 | 1,904 | 11.58 | 22.00 | 17.46 |
| *Acer palmatum* | 11 | 0.22 | 1,082 | 2.54 | 21.52 | 17.08 |
| *Acer truncatum x platanoides* | 11 | 0.22 | 65 | 3.63 | 4.43 | 3.51 |
| *Amelanchier canadensis* | 11 | 0.22 | 9 | 1.34 | 0.40 | 0.32 |
| *Crataegus* | 11 | 0.22 | 1,649 | 5.71 | 14.99 | 11.90 |
| *Prunus emarginata* | 9 | 0.18 | 2,142 | 7.02 | 20.36 | 16.16 |
| *Cedrus atlantica* | 8 | 0.16 | 758 | 11.91 | 14.62 | 11.61 |
| *Liriodendron tulipifera* | 8 | 0.16 | 1,804 | 31.61 | 64.62 | 51.30 |
| *Platanus occidentalis* | 8 | 0.16 | 71 | 4.26 | 8.23 | 6.53 |
| *Pyrus communis* | 8 | 0.16 | 636 | 2.73 | 6.69 | 5.31 |
| *Abies grandis* | 7 | 0.14 | 1,151 | 11.26 | 27.61 | 21.92 |
| *Acer negundo* | 7 | 0.14 | 60 | 3.63 | 3.54 | 2.81 |
| *x Hesperotropsis leylandii* | 7 | 0.14 | 2,967 | 31.60 | 24.59 | 19.52 |
| *Eriobotrya japonica* | 7 | 0.14 | 89 | 3.84 | 1.70 | 1.35 |
| *Pinus nigra* | 7 | 0.14 | 242 | 5.50 | 9.85 | 7.82 |
| *Sequoiadendron giganteum* | 7 | 0.14 | 3,107 | 28.68 | 30.44 | 24.16 |
| *Picea abies* | 6 | 0.11 | 9 | 0.49 | 0.48 | 0.38 |
| *Quercus macrocarpa* | 6 | 0.11 | 1,504 | 13.84 | 27.86 | 22.11 |
| *Salix* | 6 | 0.11 | 1,513 | 9.22 | 22.23 | 17.65 |
| *Acer circinatum* | 5 | 0.10 | 856 | 1.98 | 24.92 | 19.78 |
| *Acer tataricum ssp. ginnala* | 5 | 0.10 | 9 | 1.11 | 0.94 | 0.75 |

| Species | # of Trees | % of Pop. | Carbon Storage ($) | Gross Carbon Sequestration ($/yr.) | Avoided Runoff ($/yr.) | Pollution Removal ($/yr.) |
|---|---|---|---|---|---|---|
| *Aesculus hippocastanum* | 5 | 0.10 | 2,923 | 14.97 | 23.92 | 18.99 |
| *Betula papyrifera* | 5 | 0.10 | 67 | 4.27 | 4.26 | 3.38 |
| *Cupressus sempervirens* | 5 | 0.10 | 77 | 3.31 | 1.53 | 1.21 |
| *Ilex aquifolium* | 5 | 0.10 | 434 | 2.33 | 7.18 | 5.70 |
| *Picea glauca* | 5 | 0.10 | 75 | 1.91 | 3.92 | 3.11 |
| *Styrax japonicus* | 5 | 0.10 | 2 | 0.27 | 0.22 | 0.17 |
| *Acer pseudoplatanus* | 4 | 0.08 | 1,892 | 17.23 | 26.53 | 21.06 |
| *Fraxinus* | 4 | 0.08 | 196 | 4.87 | 9.92 | 7.88 |
| *Fraxinus latifolia* | 4 | 0.08 | 950 | 9.47 | 15.18 | 11.05 |
| *Populus nigra* | 4 | 0.08 | 1,330 | 14.33 | 14.10 | 11.19 |
| *Rhamnus cathartica* | 4 | 0.08 | 114 | 3.80 | 1.52 | 1.21 |
| *Salix scouleriana* | 4 | 0.08 | 2,727 | 3.36 | 21.53 | 17.09 |
| *Syringa* | 4 | 0.08 | 949 | 2.55 | 6.80 | 5.40 |
| *Zelkova serrata* | 4 | 0.08 | 2 | 0.34 | 0.40 | 0.32 |
| *Acer saccharinum* | 3 | 0.06 | 889 | 11.22 | 20.91 | 16.60 |
| *Acer saccharum* | 3 | 0.06 | 650 | 6.24 | 10.75 | 8.54 |
| *Chamaecyparis lawsoniana* | 3 | 0.06 | 37 | 1.62 | 1.08 | 0.86 |
| *Chamaecyparis obtusa* | 3 | 0.06 | 1,422 | 4.84 | 10.52 | 8.35 |
| *Corylus* | 3 | 0.06 | 718 | 6.74 | 10.48 | 8.32 |
| *Cornus nuttallii* | 3 | 0.06 | 216 | 4.10 | 2.86 | 2.27 |
| *Cupressus arizonica* | 3 | 0.06 | 160 | 3.72 | 2.73 | 2.17 |
| *Quercus palustris* | 3 | 0.06 | 316 | 6.31 | 11.87 | 9.42 |
| *Acer griseum* | 2 | 0.04 | 34 | 0.72 | 0.95 | 0.75 |
| *Castanea dentata* | 2 | 0.04 | 994 | 5.91 | 11.81 | 9.37 |
| *Cedrus deodara* | 2 | 0.04 | 311 | 5.49 | 6.44 | 5.11 |
| *Ginkgo biloba* | 2 | 0.04 | 30 | 0.64 | 3.01 | 2.39 |
| *Juglans cinerea* | 2 | 0.04 | 74 | 2.69 | 4.69 | 3.73 |
| *Metasequoia glyptostroboides* | 2 | 0.04 | 57 | 2.00 | 6.36 | 5.05 |
| *Pinus* | 2 | 0.04 | 118 | 2.19 | 4.77 | 3.79 |
| *Quercus coccinea* | 2 | 0.04 | 70 | 3.25 | 3.49 | 2.77 |
| *Sorbus aucuparia* | 2 | 0.04 | 3 | 0.49 | 0.17 | 0.13 |
| *Abies* | 1 | 0.02 | 38 | 0.85 | 1.24 | 0.99 |
| *Abies nordmanniana* | 1 | 0.02 | 2 | 0.13 | 0.09 | 0.07 |
| *Betula* | 1 | 0.02 | 20 | 0.79 | 0.90 | 0.71 |
| *Camellia japonica* | 1 | 0.02 | 1,401 | 0.18 | 3.07 | 2.44 |
| *Cornus* | 1 | 0.02 | 1 | 0.11 | 0.04 | 0.03 |
| *Cryptomeria japonica* | 1 | 0.02 | 111 | 2.23 | 4.14 | 3.28 |
| *Cunninghamia lanceolata* | 1 | 0.02 | 181 | 1.79 | 4.13 | 3.27 |
| *Fagus* | 1 | 0.02 | 50 | 1.57 | 3.93 | 3.11 |
| *Ilex* | 1 | 0.02 | 29 | 1.01 | 0.77 | 0.61 |
| *Juglans nigra* | 1 | 0.02 | 165 | 3.41 | 3.74 | 2.97 |
| *Laburnum anagyroides* | 1 | 0.02 | 28 | 1.65 | 0.72 | 0.57 |
| *Magnolia grandiflora* | 1 | 0.02 | 47 | 1.32 | 2.30 | 1.82 |
| *Magnolia stellata* | 1 | 0.02 | 268 | 0.06 | 4.35 | 3.45 |
| *Populus deltoides* | 1 | 0.02 | 8 | 0.66 | 0.58 | 0.46 |
| *Populus nigra v. italica* | 1 | 0.02 | 1,410 | 0.45 | 8.27 | 6.56 |

| Species | # of Trees | % of Pop. | Carbon Storage ($) | Gross Carbon Sequestration ($/yr.) | Avoided Runoff ($/yr.) | Pollution Removal ($/yr.) |
|---|---|---|---|---|---|---|
| *Quercus* | 1 | 0.02 | 17 | 0.72 | 0.49 | 0.39 |
| *Quercus bicolor* | 1 | 0.02 | 158 | 3.19 | 4.75 | 3.77 |
| *Salix babylonica* | 1 | 0.02 | 0 | 0.09 | 0.08 | 0.06 |
| Total | 4,890 | 100% | $335,667 | $4,548 | $7,505 | $5,957 |

# Appendix D: Plot Sampled Park Trees

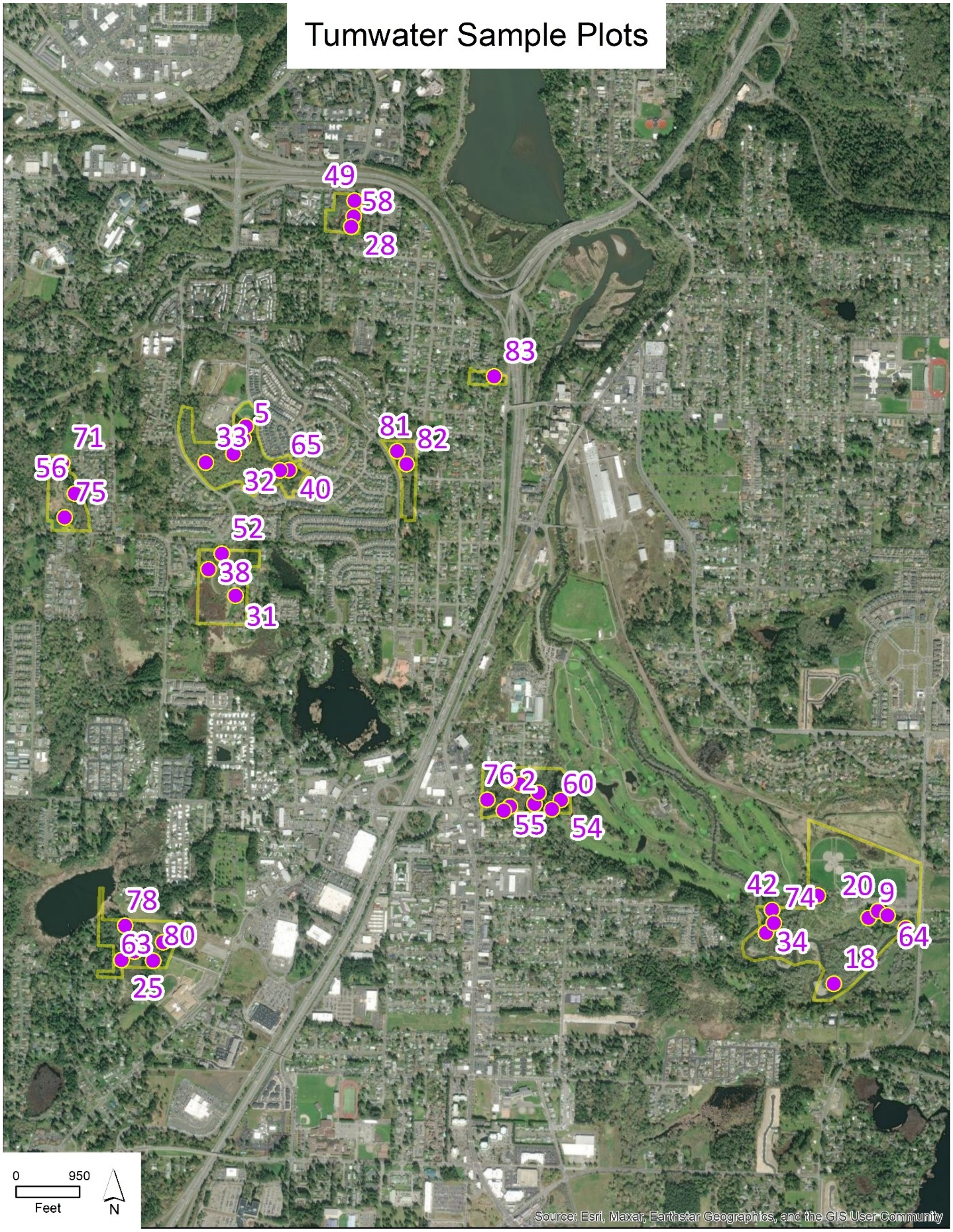
*Table 29: Primary Defects of Plot Sampled Trees*

| Defects of Plot Sampled Trees in Natural Areas | | | |
|---|---|---|---|
| **Plot 2** | **9** | **Plot 47** | **7** |
| Cavity/Decay/Nest hole | 1 | Cavity/Decay/Nest hole | 1 |
| Dieback/Deadwood | 1 | Included Bark/Weak Union(s) | 1 |
| Included Bark/Weak Union(s) | 1 | None | 3 |
| None | 2 | Previous Failure(s) | 2 |
| Uncorrected Lean | 4 | **Plot 49** | **45** |
| **Plot 5** | **10** | Cavity/Decay/Nest hole | 2 |
| Cankers/Galls/Burls | 4 | Dieback/Deadwood | 16 |
| Dieback/Deadwood | 4 | None | 4 |
| Poor Structure/Taper | 1 | Poor Structure/Taper | 14 |
| Serious Decline | 1 | Previous Failure(s) | 1 |
| **Plot 9** | **25** | Serious Decline | 1 |
| Dieback/Deadwood | 8 | Suppressed | 4 |
| Fungal Fruiting Bodies | 1 | Unbalanced Crown | 2 |
| None | 2 | Uncorrected Lean | 1 |
| Poor Structure/Taper | 14 | **Plot 52** | **13** |
| **Plot 15** | **6** | Dieback/Deadwood | 11 |
| Cavity/Decay/Nest hole | 1 | Poor Structure/Taper | 2 |
| None | 3 | **Plot 54** | **5** |
| Poor Structure/Taper | 1 | Dieback/Deadwood | 4 |
| Unbalanced Crown | 1 | None | 1 |
| **Plot 17** | **11** | **Plot 55** | **9** |
| Dieback/Deadwood | 1 | Dieback/Deadwood | 2 |
| Included Bark/Weak Union(s) | 1 | Included Bark/Weak Union(s) | 1 |
| Mechanical Damage | 1 | None | 1 |
| None | 4 | Poor Structure/Taper | 3 |
| Poor Structure/Taper | 1 | Serious Decline | 1 |
| Previous Failure(s) | 2 | Unbalanced Crown | 1 |
| Signs of Stress | 1 | **Plot 56** | **30** |
| Uncorrected Lean | 1 | Dieback/Deadwood | 17 |
| **Plot 18** | **11** | Included Bark/Weak Union(s) | 1 |
| Dieback/Deadwood | 1 | Poor Structure/Taper | 4 |
| Mechanical Damage | 2 | Previous Failure(s) | 3 |
| None | 1 | Suppressed | 5 |
| Poor Structure/Taper | 2 | **Plot 57** | **19** |
| Previous Failure(s) | 2 | Dieback/Deadwood | 11 |
| Serious Decline | 1 | Poor Structure/Taper | 7 |
| Unbalanced Crown | 2 | Previous Failure(s) | 1 |
| Uncorrected Lean | 1 | **Site 58** | **19** |
| **Plot 20** | **11** | Dieback/Deadwood | 9 |

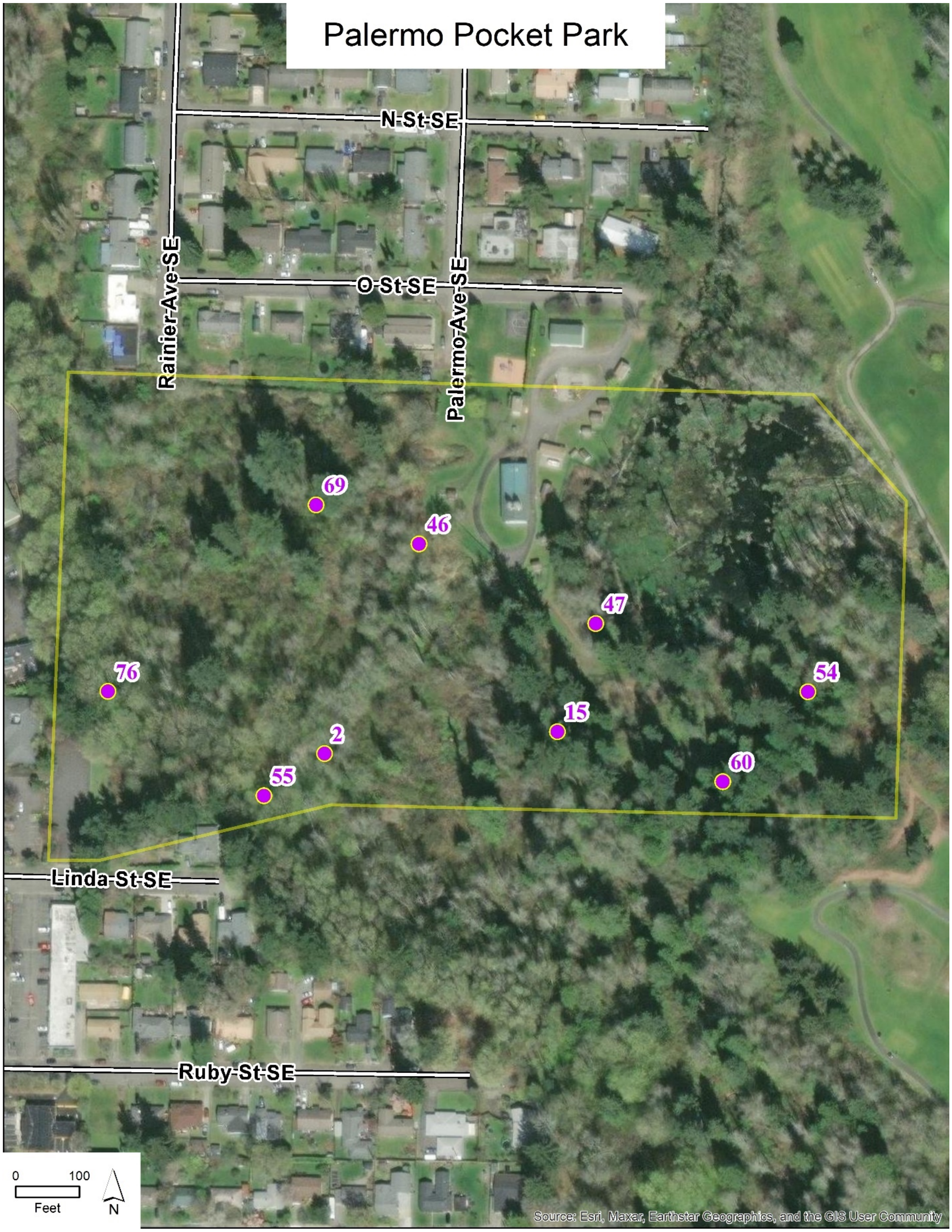
| | |
|---|---|
| Dieback/Deadwood | 2 |
| None | 1 |
| Poor Structure/Taper | 1 |
| Root Plate Lifting | 1 |
| Serious Decline | 1 |
| Signs of Stress | 5 |
| Plot 21 | 17 |
| Dieback/Deadwood | 7 |
| Fungal Fruiting Bodies | 1 |
| Mechanical Damage | 1 |
| None | 1 |
| Poor Structure/Taper | 3 |
| Serious Decline | 3 |
| Unbalanced Crown | 1 |
| Plot 22 | 17 |
| Dieback/Deadwood | 3 |
| None | 6 |
| Poor Structure/Taper | 3 |
| Signs of Stress | 1 |
| Suppressed | 4 |
| Plot 24 | 19 |
| Cankers/Galls/Burls | 1 |
| Dieback/Deadwood | 15 |
| Poor Structure/Taper | 1 |
| Previous Failure(s) | 2 |
| Plot 25 | 15 |
| Dieback/Deadwood | 14 |
| Uncorrected Lean | 1 |
| Plot 28 | 20 |
| Dieback/Deadwood | 1 |
| None | 2 |
| Poor Structure/Taper | 8 |
| Serious Decline | 6 |
| Signs of Stress | 1 |
| Suppressed | 2 |
| Plot 31 | 28 |
| Dieback/Deadwood | 5 |
| None | 1 |
| Poor Structure/Taper | 16 |
| Previous Failure(s) | 1 |
| Serious Decline | 4 |
| Suppressed | 1 |
| Plot 32 | 5 |
| Dieback/Deadwood | 5 |
| Plot 33 | 8 |
| Dieback/Deadwood | 4 |
| None | 1 |
| Poor Structure/Taper | 3 |
| Serious Decline | 1 |
| Suppressed | 4 |
| Uncorrected Lean | 1 |
| Plot 60 | 11 |
| Dieback/Deadwood | 5 |
| None | 3 |
| Poor Structure/Taper | 2 |
| Suppressed | 1 |
| Plot 63 | 22 |
| Cavity/Decay/Nest hole | 1 |
| Dieback/Deadwood | 16 |
| Poor Structure/Taper | 3 |
| Suppressed | 1 |
| Uncorrected Lean | 1 |
| Plot 64 | 11 |
| Dieback/Deadwood | 8 |
| Included Bark/Weak Union(s) | 2 |
| None | 1 |
| Plot 65 | 11 |
| Crack/Seams | 1 |
| Dieback/Deadwood | 2 |
| Fungal Fruiting Bodies | 1 |
| Poor Structure/Taper | 6 |
| Serious Decline | 1 |
| Plot 69 | 8 |
| Cavity/Decay/Nest hole | 1 |
| Dieback/Deadwood | 1 |
| Included Bark/Weak Union(s) | 1 |
| Poor Structure/Taper | 2 |
| Suppressed | 2 |
| Unbalanced Crown | 1 |
| Plot 71 | 16 |
| Dieback/Deadwood | 5 |
| Poor Structure/Taper | 3 |
| Suppressed | 8 |
| Plot 74 | 8 |
| Dieback/Deadwood | 6 |
| Poor Structure/Taper | 1 |
| Previous Failure(s) | 1 |
| Plot 75 | 7 |
| Cavity/Decay/Nest hole | 1 |
| Dieback/Deadwood | 1 |
| Suppressed | 1 |
| Unbalanced Crown | 4 |

| | |
|---|---|
| Serious Decline | 4 |
| Plot 34 | 10 |
| Dieback/Deadwood | 3 |
| None | 2 |
| Poor Structure/Taper | 2 |
| Uncorrected Lean | 3 |
| Plot 38 | 19 |
| Cankers/Galls/Burls | 2 |
| Crack/Seams | 1 |
| Dieback/Deadwood | 7 |
| None | 1 |
| Poor Structure/Taper | 5 |
| Previous Failure(s) | 2 |
| Serious Decline | 1 |
| Plot 40 | 14 |
| Dieback/Deadwood | 6 |
| None | 1 |
| Poor Structure/Taper | 4 |
| Serious Decline | 1 |
| Unbalanced Crown | 1 |
| Uncorrected Lean | 1 |
| Plot 42 | 10 |
| Crack/Seams | 1 |
| Dieback/Deadwood | 6 |
| Fungal Fruiting Bodies | 1 |
| Poor Structure/Taper | 1 |
| Previous Failure(s) | 1 |
| Plot 46 | 8 |
| Dieback/Deadwood | 2 |
| Mechanical Damage | 1 |
| None | 2 |
| Serious Decline | 1 |
| Soil heaving | 1 |
| Unbalanced Crown | 1 |
| Plot 76 | 11 |
| Dieback/Deadwood | 3 |
| None | 2 |
| Poor Structure/Taper | 4 |
| Unbalanced Crown | 1 |
| Uncorrected Lean | 1 |
| Plot 78 | 17 |
| Dieback/Deadwood | 11 |
| Poor Structure/Taper | 1 |
| Suppressed | 4 |
| Uncorrected Lean | 1 |
| Plot 80 | 13 |
| Cankers/Galls/Burls | 1 |
| Dieback/Deadwood | 8 |
| Poor Structure/Taper | 4 |
| Site 81 | 14 |
| Dieback/Deadwood | 9 |
| Included Bark/Weak Union(s) | 1 |
| Poor Structure/Taper | 4 |
| Site 82 | 14 |
| Dieback/Deadwood | 8 |
| None | 1 |
| Poor Structure/Taper | 5 |
| Site 83 | 8 |
| Dieback/Deadwood | 6 |
| None | 1 |
| Poor Structure/Taper | 1 |

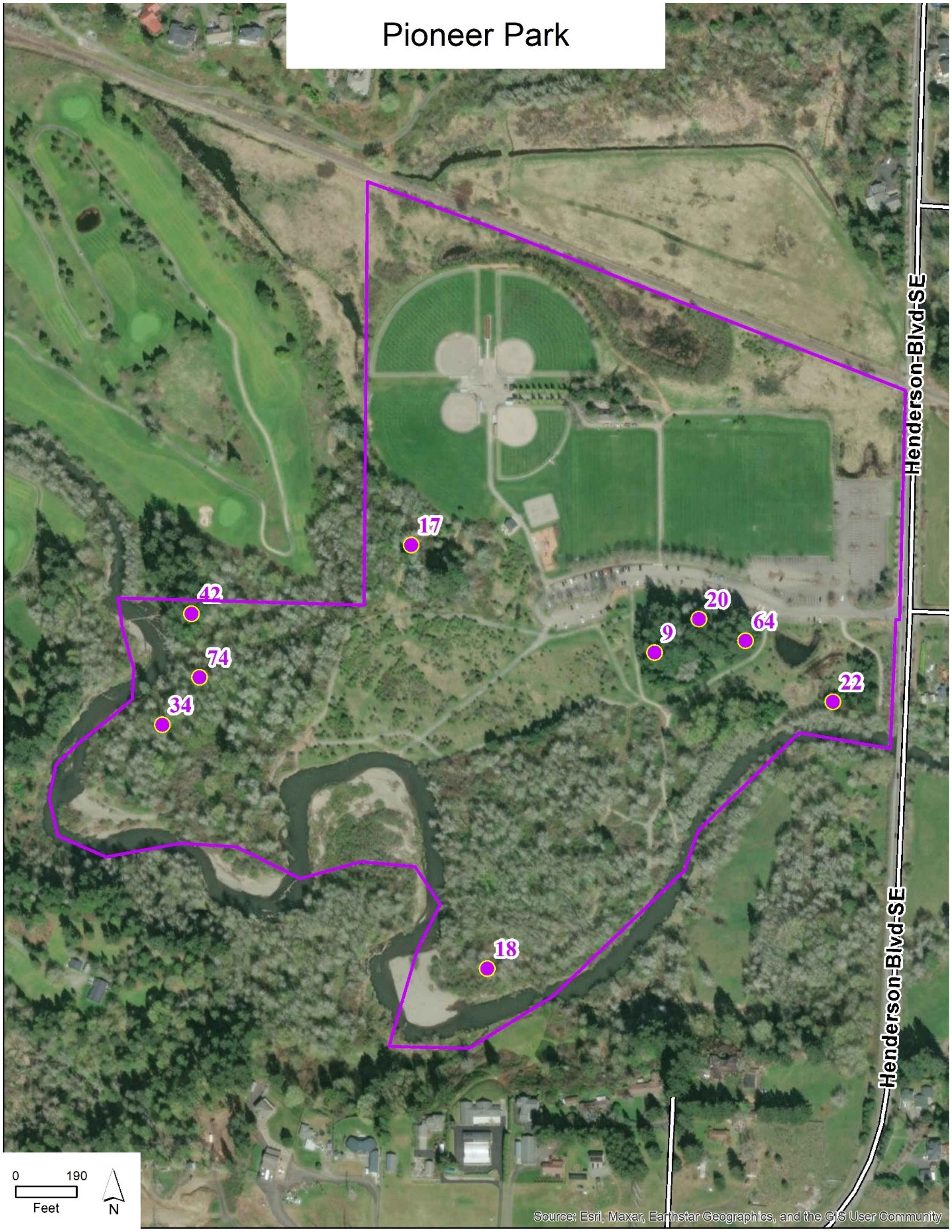
*Appendix C (Map 7): Overview location of Tumwater Sample Plots*



*Appendix C (Map 8): Sample Plots in Palermo Pocket Park*

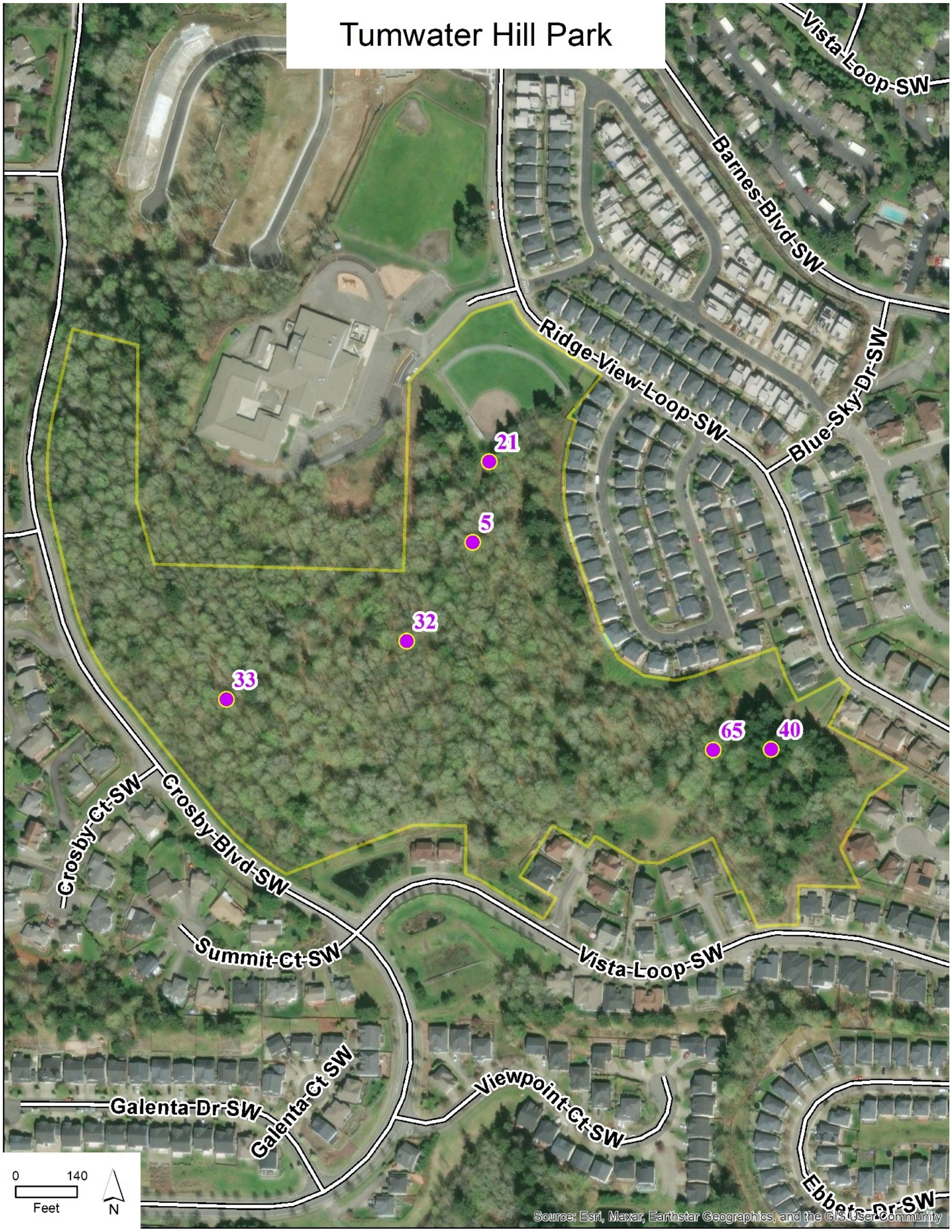


*Appendix C (Map 9): Sample Plots in Pioneer Park*



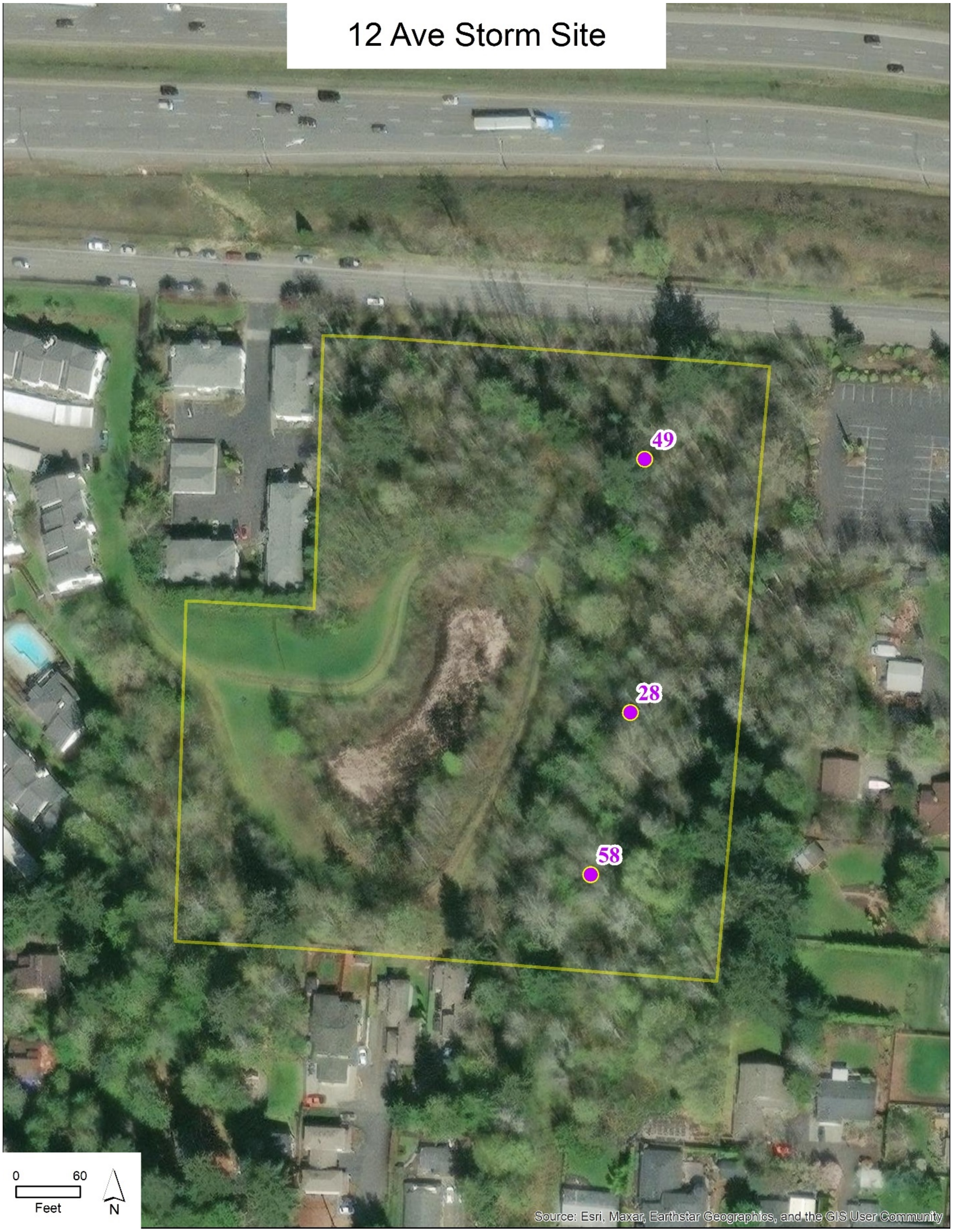
*Appendix C (Map 10): Sample Plots in Trosper Lake Park*

*Appendix C (Map 11): Sample Plots in Tumwater Hill Park*



*Appendix C (Map 12): Sample Plots in Isabella Bush Park*

*Appendix C (Map 13): Sample Plots in 12th Ave Storm Site*



*Appendix C (Map 14): Sample Plots in 2332 SW Sapp Dr*

*Appendix C (Map 15): Sample Plots in Barnes Blvd Park*

*Appendix C (Map 16): Sample Plots in N 4th Ave SW*