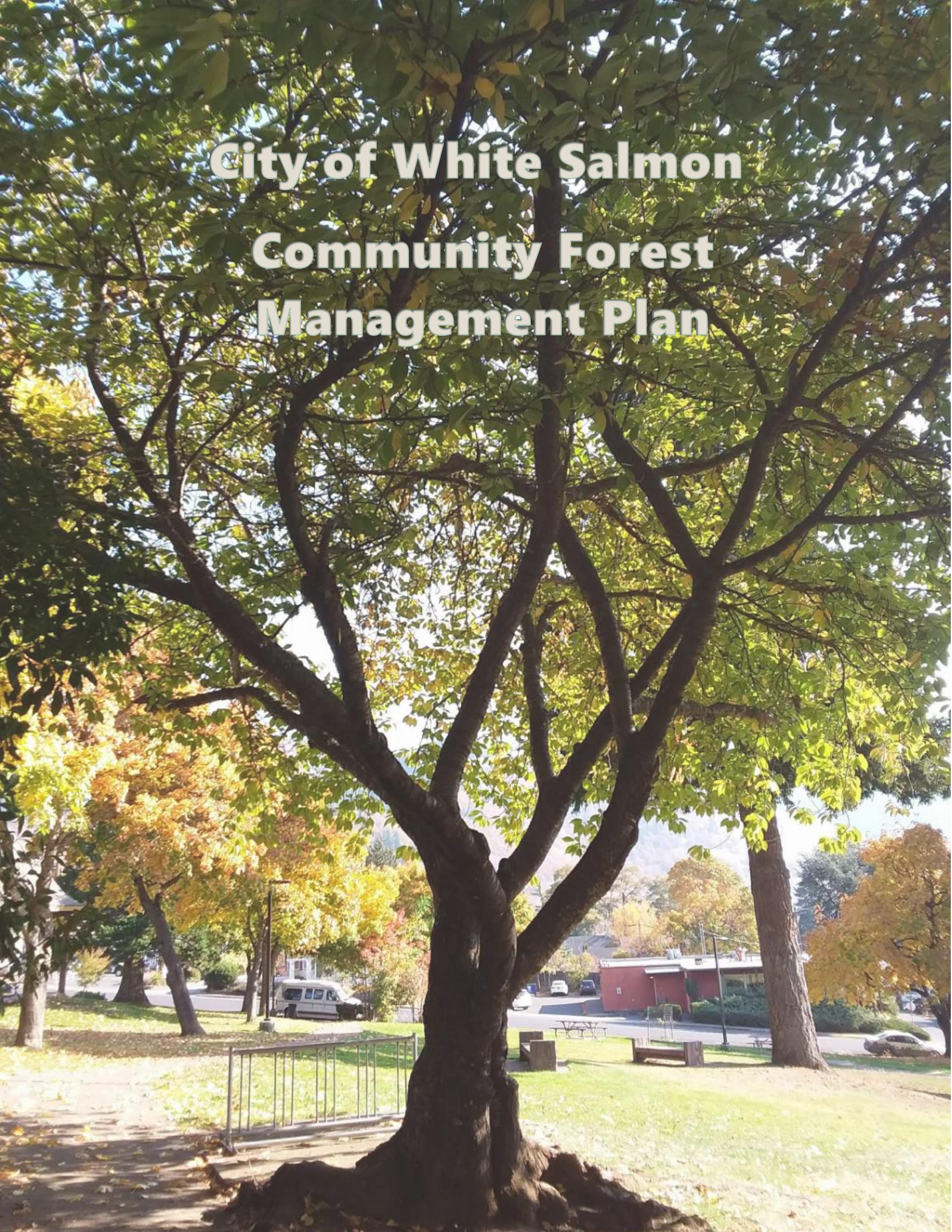


City of White Salmon Community Forest Management Plan

City of White Salmon
White Salmon Community Forest Management Plan

December 2018

Prepared by:

Peninsula Urban Forestry LLC
104 North Laurel Street, Suite 110
Port Angeles, WA 98362
http://www.peninsulauf.com
Office: (360) 504-3825

Consultant Team:

John Bornsworth, Environmental Planner
ISA Board Certified Master Arborist®
#PN-7955BM
ISA Municipal Arborist®
Tree Risk Assessment Qualified®
Registered Consulting Arborist® – Pending
Community Tree Management Institute
john@peninsulauf.com

Micki McNaughton, Urban Forest Planner
Owner, Arborea, LLC
ISA Certified Arborist® #PN-5731AM
ISA Municipal Arborist®
Municipal Foresters Institute Certification
Community Tree Management Institute
Tree Risk Assessment Qualified®

Chelsea Drum, M.S., Forest Ecologist
Candidate Certified Forester®
Tree Risk Assessment Qualified®
chelsea@peninsulauf.com

Courtney Bornsworth, Ecological Arborist
ISA Certified Arborist® #PN-8420A
Tree Risk Assessment Qualified®
courtney@peninsulauf.com

Justin Vendettuoli, GIS Analyst
Wetland Professional In-Training
justin@peninsulauf.com

Community specific,
resource specific planning.

CONTENTS

FIGURES & TABLES

Executive Summary

The City of White Salmon (the "City") is located in the Eastern Cascades Slopes & Foothills ecosystem near the Columbia River Gorge in Klickitat County, Washington. The City of White Salmon formed a Tree Board in 2017 in accordance with ordinance 2017-09-1013 (18.35.020). This City ordinance establishes the importance of trees and urban forest management within the City of White Salmon and meets requirements for recognition as a Tree City USA. It is this tree board, and in turn city ordinance, which sought to amplify the management of the city's urban forest through the development and implementation of an Urban Forest Management Plan. White Salmon has been a Tree City USA, through the Arbor Day Foundation, since 2017.

This Community Forest Management Plan (the "Plan") provides the City of White Salmon city staff and the community with objective analyses and expert management recommendations on the urban forest. Prior to development of the Plan, the Consultants' Certified Arborists inventoried street trees on Jewett Blvd and trees in City Parks throughout White Salmon. This inventory quantified street and park tree distribution, composition, structure, risk and ecosystem services. While this report discusses the benefits, strategies and management of urban forests, only publicly owned street and park trees were inventoried for this project.

Tree Benefits

Urban and community forests are natural resources and as such, require thoughtful planning and management similar to other natural resources. Urban tree canopy, like our native forests, streams and rivers, are a shared natural resource. Research across the nation shows trees and green spaces are essential for healthy, resilient communities. This Plan addresses some of these active and passive benefits trees provide.

Urban and community forests can be defined by individual trees, stands and communities of trees, and all of their associated vegetation, including shrubs and ground covers. These plants can grow within natural forests, forested parks, green spaces, natural areas, streets and sidewalks, outside of businesses and in parking lots. A healthy urban forest creates an interconnected system of green across the urban and suburban landscape.

Street & Park Composition

The City of White Salmon's streets and parks are comprised of 29 different tree species. The top ten species by abundance (the most common species) include Norway maple, Oregon white oak, Northern red oak, London plane tree, apple species, Bigleaf maple, Western redcedar, Douglas-fir, plum species, and paperbark maple. The top 10 trees inventoried are generally of good health and low risk (Table 1).

The urban forest is generally a mix of native and exotic tree species. Therefore, urban forests often have a tree diversity greater than the surrounding native landscape. Urban areas and developed communities generally lack native soils, have altered climate regimes and have

different management needs, exotic trees are often more suited for developed urban sites than native trees. The streets and parks of White Salmon are comprised of ~47% trees native to North America and more specifically, ~29% native to Washington. Species exotic to Washington make up ~53% of the population, with ~33% species from Europe & Asia.

The horizontal and vertical structure of street and park trees is well varied, with tree diameter represented in multiple different diameter classes (horizontal structure) and many different crown classes (height and canopy spread). This information is summarized in Chapter 1.

Street and park tree ecosystem functions and values were analyzed using United States Forest Service i-Tree Eco v6 modeling software. The i-Tree Eco model analysis demonstrated that White Salmon's street and park trees remove 50 pounds per year of pollution, stores 76 tons of carbon, sequesters 2006 tons per year of carbon, produces 2.7 tons per year of oxygen, and buffers 809 cubic feet per year of stormwater runoff. This information in summarized in the i-Tree Eco Valuation section.

Urban Forest Management

Threats to White Salmon's urban forest are primarily future development, climate change and pests. Modern building trends, redevelopment and parcel infill often cause permanent tree cover losses. Climate change and in particular, precipitation concentration, can affect how trees adapt and reconcile drought stress. Climate adaption in developed natural resources requires urban foresters to expand their species palette of urban tree installations. Lastly, White Salmon is susceptible to both plant pests and invertebrate pests actively transported in disturbed and unmanaged landscapes. This report discusses strategies to manage such pests.

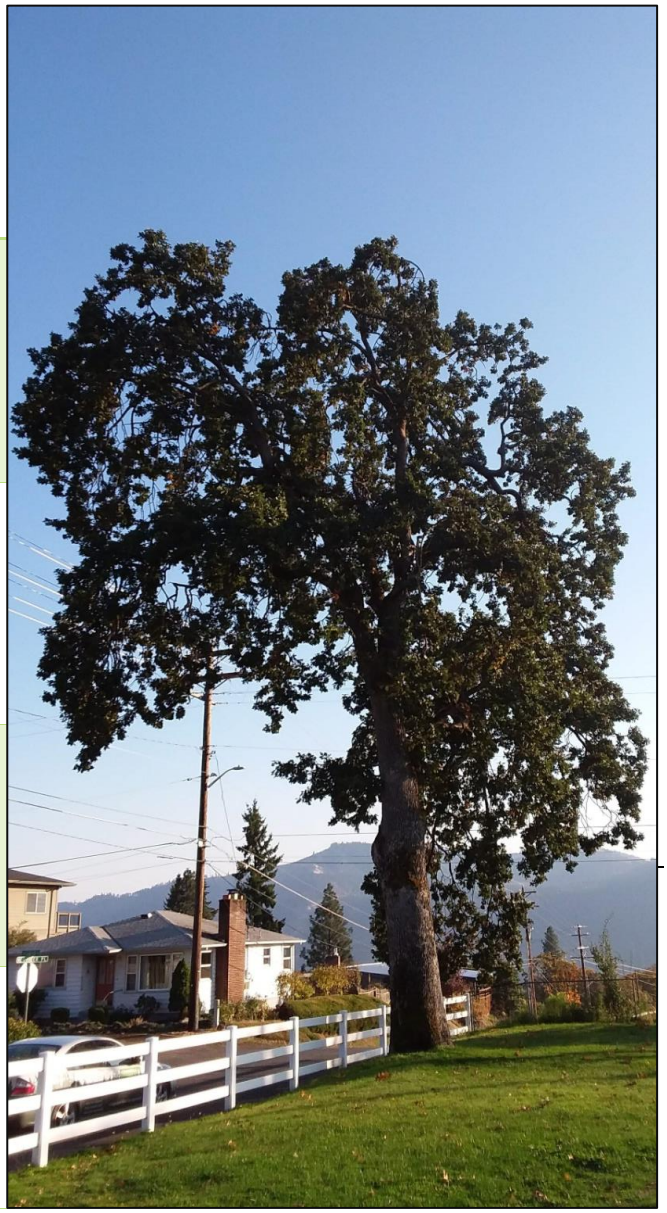
Two major pests are Douglas-fir bark beetle (*Dendoctonus pseudotsugae*) and spotted lanternfly (*Lycorma delicatula*). Douglas-fir bark beetle affects Douglas-fir trees by burrowing into the trees and disrupting the sap stream, eventually killing the tree. Douglas-fir bark beetles are native to the region and are important native forest invertebrates. The spotted lanternfly, a non-native and invasive species, affects hardwood trees rich in tree sap.

The Consultant's street and park tree inventory assessed public parks and street trees for associated tree risk. Fireman's Park, Pioneer Park, and Rheingarten Park were all assessed in this way. Street trees along Jewett Blvd between Garfield and 4th Street were also assessed. Chapter 2 discusses strategies for tree risk management.

This Plan addresses urban and community forest management specific to the City of White Salmon and their current and future natural resources. We have outlined specific goals, strategies, and actions which will support the City in achieving its urban forest resiliency, health, and management.

Executive goals:

Maintain mature tree distribution and structure through maintenance of large trees.
Manage urban forest risk through proactive pruning schedule.
Reduce threat from urban invasive plants and pests.
Recommend Consultant provided White Salmon Street Tree List.
Adopt White Salmon Tree Protection Ordinance



Chapter 1:

Urban & Community Forests

Definition of Urban & Community Forests

An *urban forest* likely means different things to different stakeholders, representing the community, city staff, city council, business owners, and other institutions. This variability in definition emphasizes the different perception those stakeholders have regarding trees in our communities, their benefits and their liabilities.

Urban foresters generally refer to *Urban & Community Forests* as publicly and privately-owned trees, protected and working forests, associated vegetation, landscape shrubs, low-impact-development, green infrastructure, parks, and lawns.

The American Planning Association's 2009 publication, *Planning the Urban Forest: Ecology, Economy and Community Development* offers this description of an urban forest:

> **"A planned and programmatic approach to the development and maintenance of the urban forest, including all elements of green infrastructure, within the community, in an effort to optimize the resulting benefits in social, environmental, public health, economic, and aesthetic terms, especially when resulting from a community visioning and goal-setting process."**

A 2015 publication, *Urban Forestry: Planning & Managing Urban Greenspaces*[1], defines urban forestry more inclusively:

> **"An interdisciplinary approach to the planning and management of all woody and associated vegetation in and around dense human settlements."**

Urban and community forestry generally means the planning, establishment, protection, care, and management of trees and associated plants individually, in small groups, or under forest conditions within landscape scale jurisdictions.

[1] Miller et al. 2015. Urban Forestry: Planning & Managing Urban Greenspaces, 3rd edition, Waveland Press.

Benefits of a Healthy Urban & Community Forest

Urban and community forests provide a vast array of both active benefits, like temperature regulation and air quality improvements, and passive benefits like local crime reduction and improved property values. Benefits of the urban forest are provided via natural processes of plants ecologists call *functions*. Urban forest functions include air quality improvements, stormwater attenuation and enhanced soil wellbeing. Similarly, urban forests have important *values* as defined by the users or community who benefits from these functions. Urban forest values correspond to how people interpret the benefits of the urban forest and can change from community to community. The urban forest ecosystem's functions and values are important when quantifying the role urban forests have in our community. Below we list some fundamental benefits of urban forests and their associates.

Figure 1. City of White Salmon aerial view.

Environmental benefits

Ecosystem services, sometimes referred to *physical services*, are the benefits individual people and communities as a whole receive from the natural processes of our environment. Environmental benefits of trees and urban ecosystems are compelling. The environmental benefits and functions of trees can be grouped into four categories:

Water quality improvements

- Treed and vegetated landscapes interrupt and absorb raindrop energy during storms. Community-wide stormwater attenuation is achieved through a large urban tree canopy (Livesley, 2016)
- Tree roots stabilize slopes by binding to soil and absorbing excess water (Gray, 1982). Water quality is in turn increased by reduced turbidity and soil erosion in our urban and wild streams.
- Both trees and the soils they live in absorb and filter stormwater runoff and sediment, reducing the overall input of pollutants into our aquatic habitats (Tsegave et al., In Press). Through the act of plant transpiration, evapotranspiration and root soil infiltration enhancement, soil saturation is delayed reducing the tendency for landslides.

Air quality improvements

- Through the process of photosynthesis, tree leaves absorb greenhouse gases, including carbon dioxide, and release the oxygen we breath. Trees are the original, natural air purifier (Nowak, 2006).
- Harmful airborne particulates, including automobile brake dust, are intercepted and collected by tree leaves, removing them from the air (Nowak, 2006).

Biodiversity and wildlife habitat enhancement

- Heterogeneous and diverse urban forests promote habitat connectivity for mammals, birds, insects, reptiles, fish and amphibians. Through this act, genetic biodiversity is conserved through an aggregation of urban trees, wildlife corridors and preserved open space (Johnson, 2001).
- Trees beside both freshwater and marine shorelines play a critical role in salmon recovery. Streamside and shoreside trees and associated vegetation provide abundant invertebrate and amphibian foraging (leaf litter) and their shade cools water to appropriate spawning and habitat temperatures (Johnson, 2001).

Climate regulation

- Shade provided by trees provide a cooling effect that can be noticed on a city-wide scale (McPherson, 2010).
- As trees convert carbon dioxide into oxygen, their leaves release fresh water as a byproduct. This water is captured by the local atmosphere and acts to cool the surrounding area, similar to how humans sweat to cool themselves (McPherson, 2010).

Economic benefits

- Urban forests stimulate business growth and increase economic stability by attracting new business, customers, tourists and residents (Wolf 2007).
- Attractive treed landscapes in business districts result in shoppers' willingness to spend for similar goods compared to non-treed business districts (Wolf 2007).
- By buffering stormwater runoff during storms, trees reduce maintenance costs associated with stormwater facilities and stormwater conveyance systems.
- Correctly planted trees can also shelter homes from cold winter gusts and snow storms, reducing the amount of heat those homes require.
- Improved property values (Payton et al., 2008).
- Shade from trees in parking lots and roads can extend the asphalt surface life by up to 20 years, reducing anticipated maintenance costs.
- Individual homes with mature, healthy and safe trees can increase property values by 25%. This property value increase includes neighboring property as well. A single tree in a neighborhood yard can increase property values along the entire street (Donovan & Butry, 2008).
- Retaining mature trees during development can increase property values to a degree that additional costs associated with retaining mature trees are offset.

Social and Human Health benefits

A properly managed, healthy, and functioning urban forest is an indicator of healthy community wellbeing. Social benefits of urban trees used to be an emerging science; today, the science of human physiological response to natural space interactions is astounding. Social scientists have paired with urban foresters and other natural resource scientists to better understand how humans instinctively witness, collaborate and benefit from green spaces, trees, and other natural areas in our communities.

Expressions of nature benefit the lives of humans from birth to old age, offering a full spectrum of life-long interaction and benefit. Beginning in 1984, a landmark study showed a decrease in hospital stay post-surgery if the patient had a view of a natural setting as opposed to no natural setting (Ulrich, 1984). Since then, scientists have uncovered and published scientific research on hundreds of social benefits from urban trees across the world (Wolf, 2014):

- Street trees improve public safety by reducing vehicle speeds, create safer walking areas for pedestrians, and even reduce the occurrence of road rage.
- Urban areas with green spaces, shade from maintained and functioning park and street trees, and open landscapes dramatically reduce rates of crime including domestic violence. Humans connect in these green spaces, increasing community connectivity and reducing opportunities for crime. (Kuo et al., 1998; Donovan and Butry, 2008).
- Healthy urban forests reduce human health issues associated with poor air quality, tree leaves reduce the movement of pollutants via wind, and reduce air temperatures associated with smog.
- Green infrastructure, like street trees, open space gardens and pocket parks, encourages residents to choose active transportation, like walking or biking (Yngve et al., 2016).

Importance of Urban Forest Planning & Protection

The urban & community forest provides many ecosystem services at varying scales, ranging from the individual trees, to street, and entire cities (Livesley et al., 2016). It is these ecosystem services that make protection and preservation of trees worthwhile for the community as a whole and planning for the urban forest essential. Urban foresters and municipal tree managers have long recognized that while the vast majority of community trees reside on private property, they sustain ecosystem services that are measurable and assessable public goods (Mincey et al., 2013). This understanding of community wide shared ecosystem, economic, human health, and social benefits provided by trees requires regulation and protection of trees on private property.

It has been demonstrated tree canopy can be preserved in both an economically and environmentally sound way with effective tree ordinance clauses, zoning ordinances and enacting quality smart growth projects (Hill et al., 2010). However, it has been determined that only having a tree ordinance, designating a management person in charge of tree programs, the existence of a tree board, and multiple communication channels were ineffective ways to increase canopy coverage (Hill et al., 2010; Data set from Greater Metropolitan Atlanta). It is only through active policies that tree canopy cover can be sustained.

Tree protection ordinances require consideration, development, and responsibility; the same as other municipal activities if tree policies are to be effective (Galenieks, 2017). For the urban forest to be effectively preserved, a city must be proactive in its policy strategies toward tree planting and maintenance. Without a proactive plan or policies for tree protection, preservation or retention the municipalities' policies will result in higher total costs over the lifespan of their trees.

Disturbances

Urban and community landscapes are often highly disturbed, highly impacted places, even when these areas were historically healthy, vibrant, diverse landscapes. These impacts from development and land conversion can be offset by an aggregation of urban trees and their associated vegetation. The most notable impacts urban development has on their environment are:

- Compacted and contaminated soils devoid of microbiota.
- Changes in climate, both relative heat, reflective heat and humidity.
- Air pollution.
- Belowground water conveyance disruption.

Street & Park Tree Inventory – Current Conditions

Soils & Topography

A broad overview of soils present within the City of White Salmon can be found in the Natural Resources Conservation Service publication (NRCS, 2009) for Klickitat County and the NRCS Web Soil Survey (2018). While the NRCS mapped soils are useful guides, it is important to recognize that urban soils are highly disturbed and may not have the same characteristics as their parent soils any longer. Nevertheless, the mapped soils in the area provide a useful guide to historical soil types.

The City of White Salmon's Parks and Street trees are primarily underlain by two main soil types:

- Hood loam, 3 to 8 percent slopes
- Hood loam, 8 to 15 percent slopes

The Hood loam, 3 to 8 percent slopes, is a well-drained soil with no restrictive feature within 60in of the surface. It is generally found in an upland landscape setting. The Hood loam, 8 to 15 percent slopes soil, is very similar to the Hood loam, 3 to 8 percent slopes soil, but its slope range is steeper.

Climate

The climate in White Salmon varies drastically between summer and winter, both in precipitation and temperature. In January, temperatures range between 29 degrees F (low) to 41 degrees F (high), with 13 days of rain totaling 5.3 inches and 4 days of snow totaling 11.4 inches (NOAA, 2018). Whereas, in June temperatures range from 74 degrees F to 50 degrees F, with 3 days of rain totaling 0.8 inches (NOAA, 2018).

Climate change is slowly concentrating annual precipitation to narrow temporal windows. Annual precipitation is reducing days of rainfall per year, but not total amount of precipitation. This change is forcing plants to adapt to warmer drier summers, while at the same time, adapting them to wetter, rainy seasons.

Within the next 100 years average annual temperatures in Washington are projected to rise at a rate of 0.1 to 0.6 °C. Precipitation forecasts are generally more uncertain, though, in general, winters are projected to be wetter and summers are projected to be drier.

These changes in our environment will affect forest resilience, regeneration, diversity and spatial distribution over time. Changes are expected in the length of growing season, plant and animal composition and distribution, water availability and duration and an increase in drought conditions during summer and fall. The single greatest forest management action to help sequester carbon is to manage stands for density, regeneration and resiliency to keep trees healthy and foster vigorous growth[2].

[2] Lawler, 2007

Street & Park Tree Inventory Summary

Forest composition identifies the tree species composition across the environment. Below are the top 10 ranked species by their abundance in the streets and park in White Salmon. For a full species list, see Appendix A. For a definition of tree health and tree risk identification, see Appendix E: Street Tree Inventory Definitions & Methods

Table 1. Top ten park and street tree species by abundance with average health, and average risk ratings for canopy, trunk, and roots.

Tree Species	Rank	Count	Average Health	Canopy Average Risk	Trunk Average Risk	Roots Average Risk
Acer platanoides	1	36	Fair	Low	Low	Low
Quercus garryana	2	20	Good	Low	Low	Low
Quercus rubra	3	9	Good	Low	Low	Low
Platanus x acerifolia	4	7	Good	Low	Low	Low
Malus spp.	5	5	Poor	Low	Low	Low
Acer macrophyllum	6	5	Fair	Low	Low	Low
Thuja plicata	7	5	Excellent	Low	Low	Low
Pseudotsuga menziesii	8	4	Good	Moderate	Moderate	Moderate
Prunus spp.	9	4	Poor	Low	Low	Low
Acer griseum	10	4	Good	Low	Low	Low

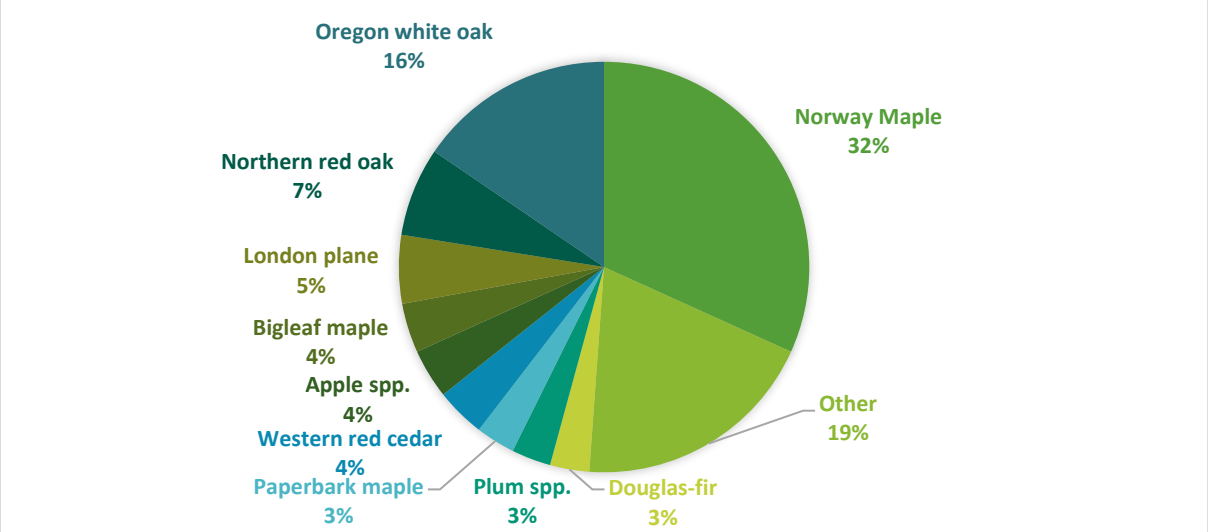


Figure 2. Percent tree species composition.

Forest Structure:

Forest structure is represented by the diameter of trees across a landscape (horizontal structure), and tree height and canopy spread (vertical structure). Classifying urban forest structure gives us spatial information relevant to tree maturity, tree size, tree value and some interpretation to habitat value.

Table 2. Urban forest structure by abundance ranking

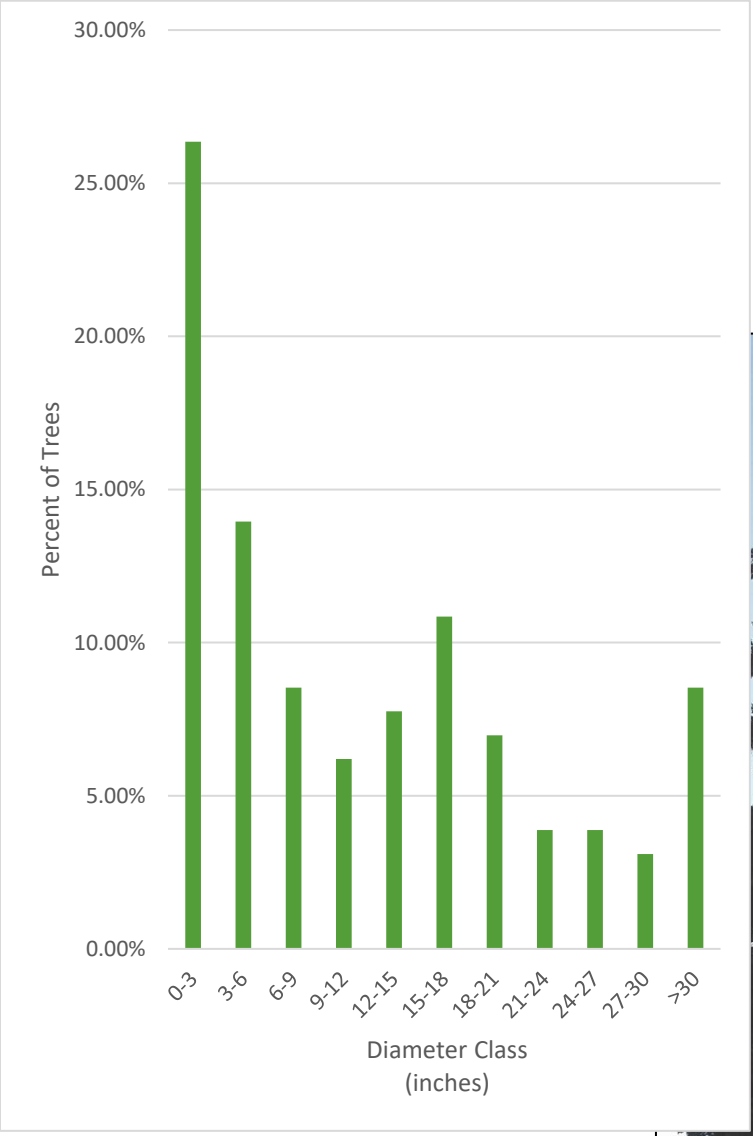
Tree Species	Rank	Average Diameter (in)	Average Canopy Spread (ft)	Average Height (ft)
Acer platanoides	1	15	29	31
Quercus garryana	2	4	8	12
Quercus rubra	3	24	49	52
Platanus x acerifolia	4	8	20	24
Malus Spp.	5	3	22	25
Acer macrophyllum	6	6	10	15
Thuja plicata	7	2	4	8
Pseudotsuga menziesii	8	40	42	94
Prunus Spp.	9	10	18	23
Acer griseum	10	2	3	11

A diameter class distribution examines the horizontal size class (diameter) distribution of the forest, thereby yielding a picture of the horizontal structure of the forest. This distribution is important in that it is a representation of the current conditions of the urban forest.

Large Trees Provide Substantial Benefits Compared To Small Trees

Urban foresters understand that large trees deliver big savings and related benefits compared smaller trees. Small-stature trees, like flowering cherry and plum, deliver far fewer benefits even when extrapolated linearly to the size of a large tree. Research at The Center for Urban Forest Research shows large trees provide up to eight times more benefit than small trees and that their benefit ratio is non-linear.

Strategically placed large trees throughout the city have a much bigger impact on climate regulation, energy conservation, mitigating the urban heat island, attenuating stormwater, intercepting particulates, and other important functions. Cities across the nation spend roughly $13 per year caring for their largest trees, while those same trees provide returns averaging $65 in energy savings (CUFR 2006).



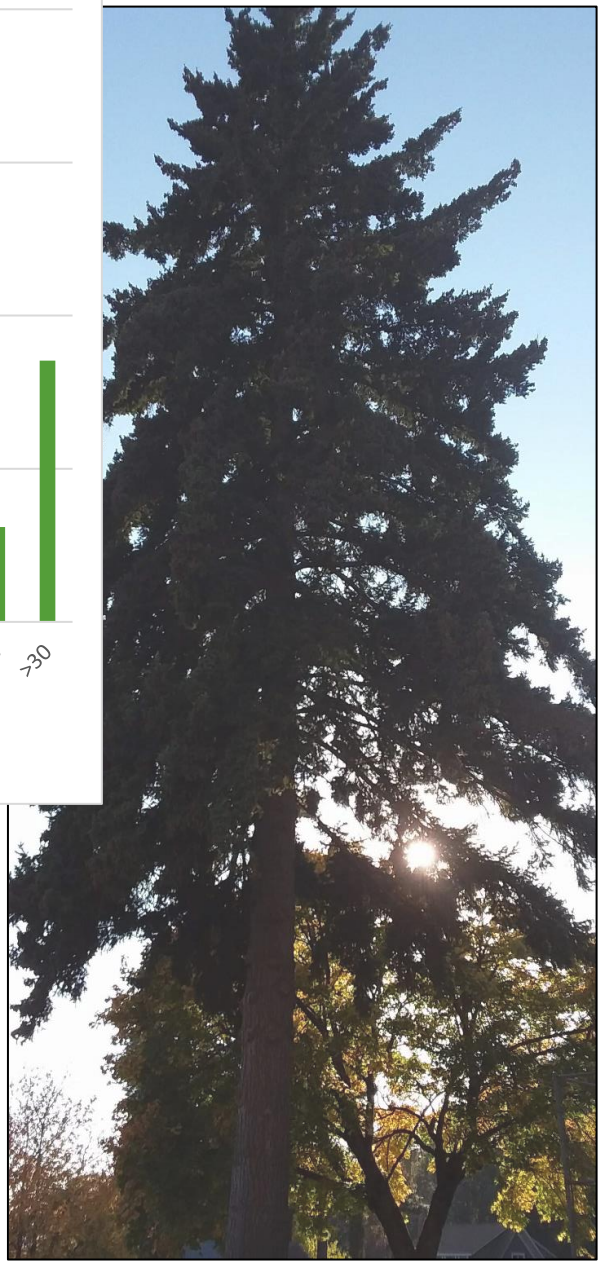


Figure 3. Diameter class distribution of park and street trees, which describes the horizontal structure of the urban forest by distributing the diameters of trees into classes.

Maintenance Tasks

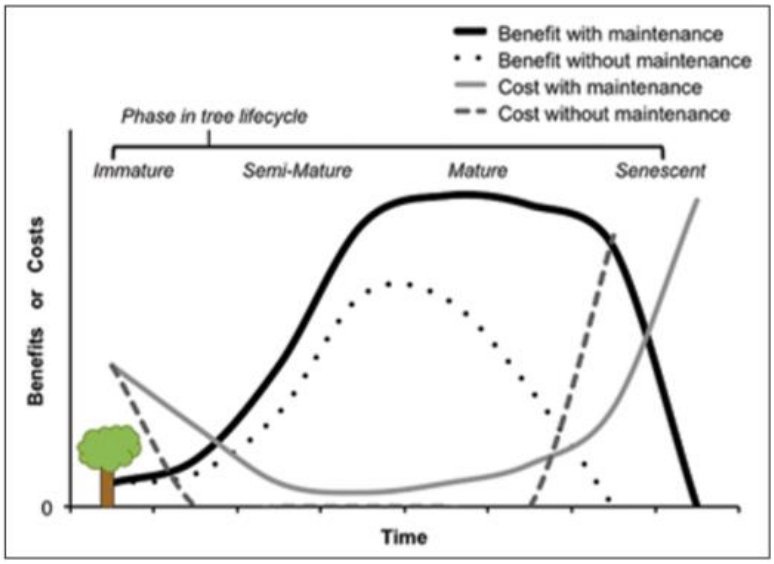
Consultant Certified Arborists who inventoried White Salmon's streets & parks evaluated maintenance tasks for each tree. Each tree was given one of seven different maintenance tasks or was evaluated as no action necessary. Unoccupied planting areas within streets/sidewalks were labeled as planting location. The parks areas were not identified within individual planting locations, as planting areas are more general. For a definition of the below tasks, Appendix E: Street Tree Inventory Definitions & Methods. Maps identifying locations of the trees above are provided to the city supplementing this report.

Table 3. Count of maintenance tasks and priorities.

Maintenance Task	Tree Count	Time Frame
High Priority Pruning	5	1-year
Removal	8	1-year
Routine Pruning	50	End of 5-year rotation
Stump Removal	1	N/A
Training Pruning	24	Beginning of 5-year rotation

The Cost of Not Maintaining the Urban Forest

Over the lifetime of an individual tree, the costs and benefits are displayed in this figure, with (solid lines) and without (dashed lines) acceptable maintenance. During the mature phase of the tree, benefits are maximized. However, costs show an inverse pattern, meaning that without acceptable maintenance practices applied to the tree, costs will increase. Benefits quickly decline with tree senescence. Figure from Hauer et al. 2015: theoretical costs and benefit profiles over the lifetime of an individual tree.



i-Tree Eco Valuation

An i-Tree Eco model was developed using the i-Tree Eco V6 software. This software was designed by the United States Forest Service and other partners to quantity urban forest ecosystem services and their ability to offset municipal and private costs. The software uses field data measurements throughout with local hourly air pollution and meteorological data to quantify forest structure, environmental effects, and value to local communities (i-Tree Eco, 2018).

The Street Tree & Park Tree inventory data from White Salmon was integrated into a format for the i-Tree Eco to process community value of these natural assets. The nearby Dalles Airport weather center was used for climate data required for i-Tree ecosystem service quantification. The following graphs and summary tables are sourced from the i-Tree ecosystem service quantification report. The full i-Tree Eco report is attached to the end of this document.

Table 4. i-Tree Eco ecosystem services data summarization.

Vegetation structure, function, and value measurement	Metric	Value
Number of trees in assessment	129 trees	-
Tree cover	1.736 acres	-
Percent of trees less than 6 inches diameter	38.8%	-
Pollution removal	50.22 lbs.	$41.1/year
Carbon Storage	75.98 tons	$13,000
Carbon Sequestration	2006 lbs.	$171/year
Oxygen production	2.675 tons	-
Avoided runoff	809.1 cubic feet/year	$54.1/year

What are Ecosystem Services?

Ecosystems services are those benefits humans derive from the natural environment or ecosystems. These services generally fall into four categories: supporting (ex: air & water purification); provisioning services (ex: stormwater attenuation); regulating services (ex: energy reduction, pollination); & cultural resources (ex: recreation, science and social services). Ecosystem services are integral in supporting our lives. Native forests provide provisioning services through lumber and supporting services like water purification. Urban forests provide cultural services through recreation and social services, as well as and supporting services like air & water quality improvements.

Table 5. i-Tree Eco tree importance ranking analysis.

Tree Species	Percent Population	Percent Leaf Area	IV[3]
Norway maple	31.8	35.0	66.8
Northern red oak	7.0	20.3	27.2
Oregon white oak	15.5	2.5	18.0
Douglas-fir	3.1	12.5	15.6
London plane	5.4	6.5	11.9
Apple spp.	3.9	2.2	6.1
Bigleaf maple	3.9	1.6	5.4
White ash	1.6	3.4	5.0
Plum spp.	3.1	1.3	4.4
Western redcedar	3.9	0.1	4.0

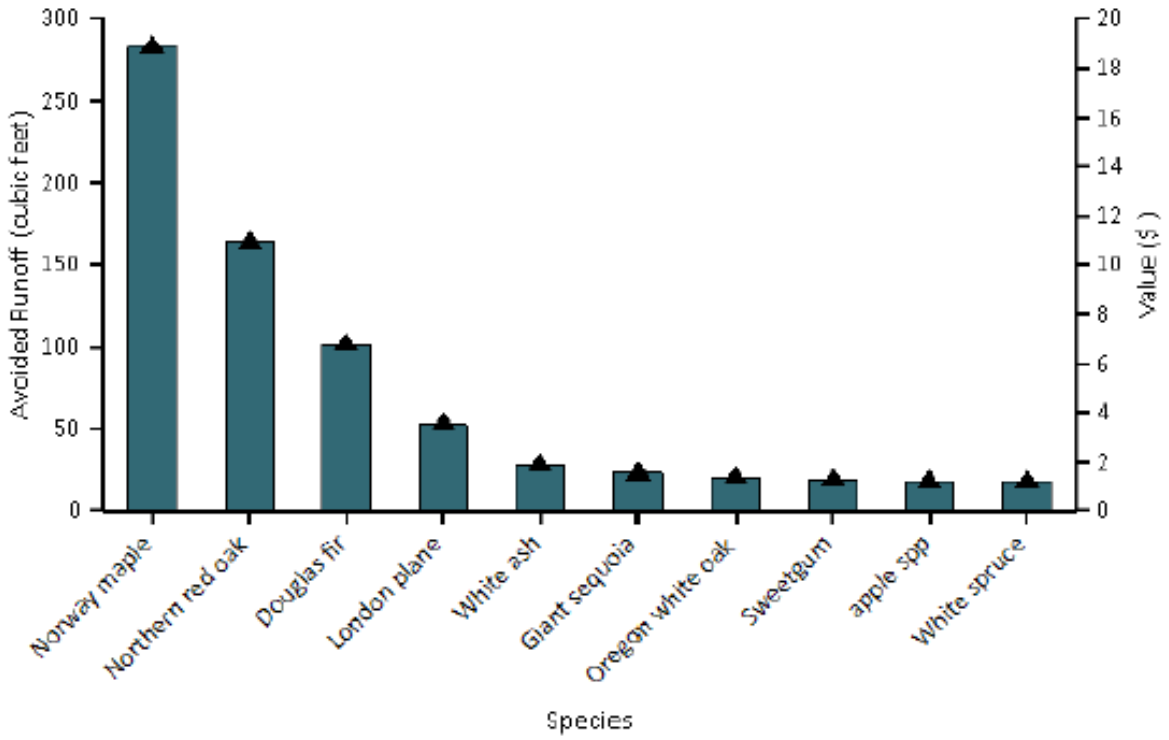


Figure 4. Avoided stormwater runoff attributed to street trees by species.

[3] IV – Importance Values are calculated as the sum of percent population and percent leaf area. IV values do not indicate favoring these tree species in the future, rather, that they currently dominant the urban forest structure.

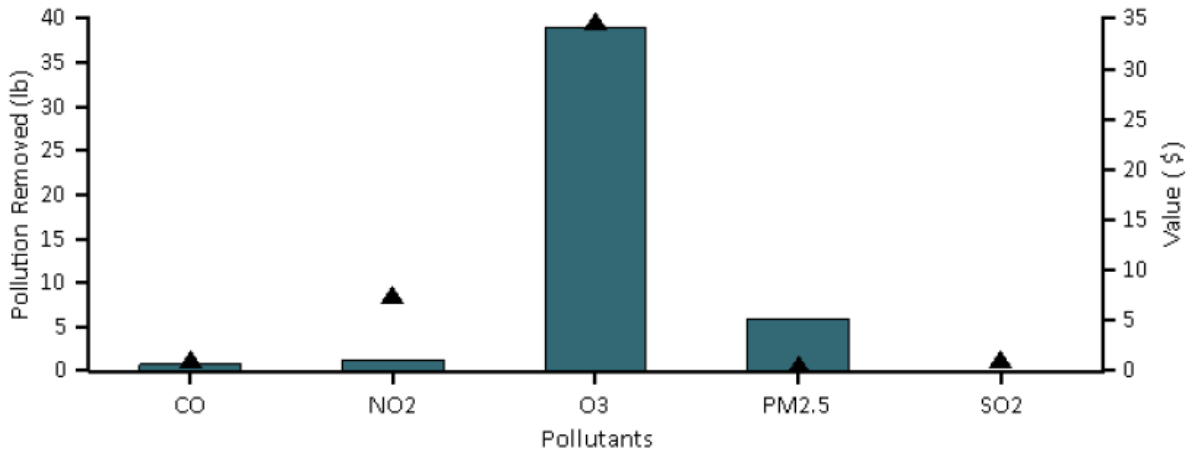


Figure 5. Air pollution removal of street trees, including ozone (O3), carbon monoxide (CO), nitrogen dioxide (NO2), and particulate matter less than 2.5 microns (PM2.5), and sulfur dioxide (SO2).

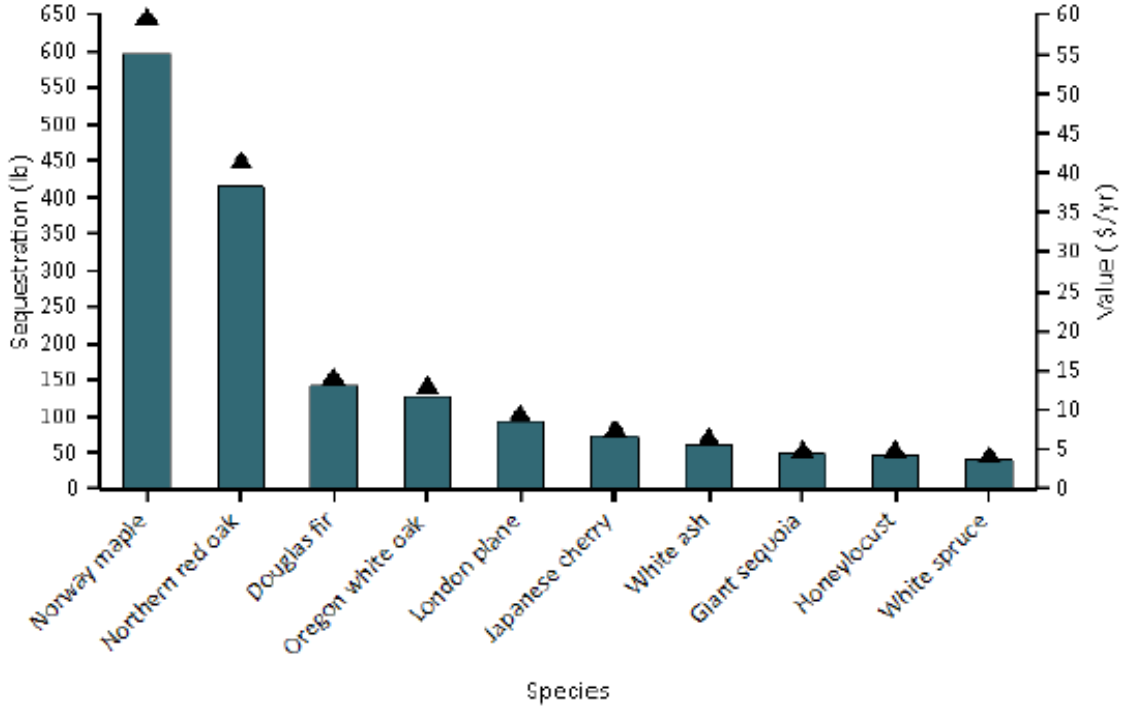


Figure 6. Estimated annual gross carbon sequestration (points) and value (bars) for urban tree species with the greatest sequestration.

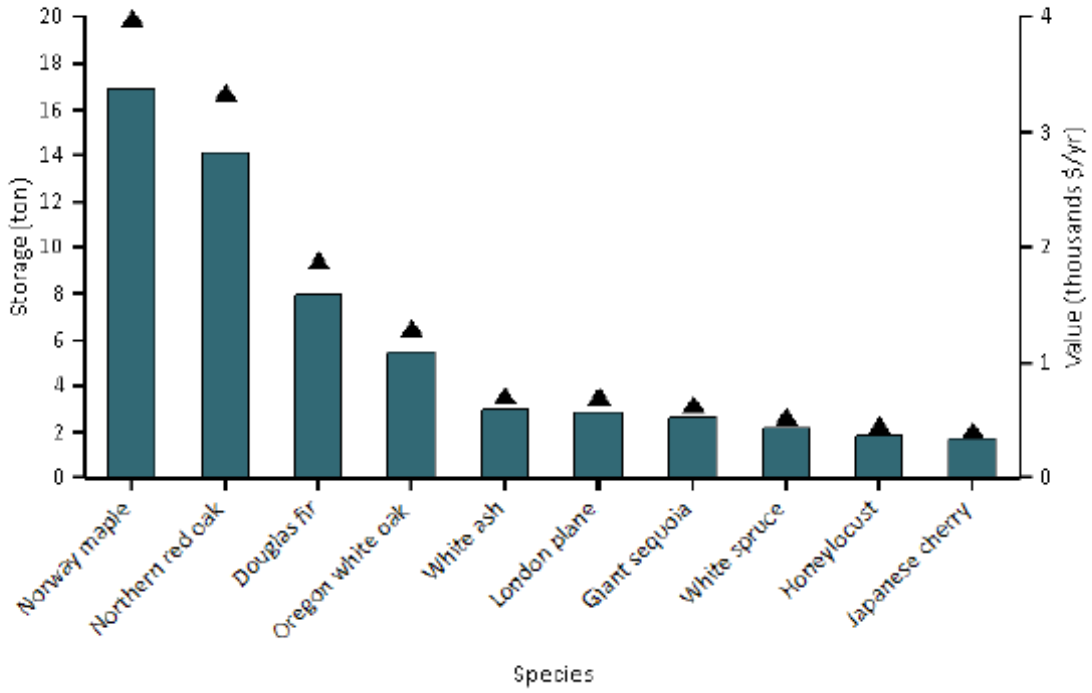


Figure 7. Estimated carbon storage (points) and values (bars) for urban tree species with the greatest storage.

Table 6. Top ten oxygen producing species and their associated gross carbon sequestration and leaf area.

Tree Species	Number of trees	Oxygen (lbs.)	Gross carbon Sequestration (lbs./year)	Leaf Area (acre)
Norway maple	41	1721.23	645.46	2.02
Northern red oak	9	1195.65	448.37	1.17
Douglas-fir	4	406.44	152.42	0.73
Oregon white oak	20	369.61	138.60	0.15
London plane	7	267.71	100.39	0.38
Japanese cherry	2	209.19	78.45	0.08
White ash	2	179.84	67.44	0.20
Giant sequoia	1	138.36	51.89	0.17
Honey locust	2	133.71	50.14	0.06
White spruce	1	117.54	44.08	0.13

Chapter 2:

Guiding Principles

Principles of Urban Forest Management in White Salmon

This chapter discusses strategies in urban and community forest management. Some of these topics were identified by the Consultants as important for White Salmon, and other topics were presented to us by the Tree Board and City Staff.

Understanding Tree Risk

A tree is a repository of its entire natural history; this gives arborists the urban foresters a glimpse into their past health. Trees are self-optimizing mechanical structures whose new wood growth tends to maintain a uniform stress distribution. Understanding of this mechanism, and other important biological factors, allows Tree Risk Assessment Qualified individuals to make informed judgements on the expressed risk of trees. A common evaluation paradigm taking into account tree biological health, mechanical structure and environmental conditions is labeled the visual tree assessment (VTA) method. A tree's risk is a dynamic concept based on subjective interpretations of this information.

The International Society of Arboriculture provides training and testing for Tree Risk Assessment Qualified (TRAQ) individuals. Without this specific training, Certified Arborists, Certified Forester and their allied professionals are not in a position to qualify tree risk.

TRAQ evaluates tree risk as either "Low", "Moderate", "High", or "Extreme". Tolerance of that interpreted tree risk is entirely decided by the tree owner. The only way to eliminate tree risk entirely is to remove all trees within an area of impact of a target. Almost all trees have some aggravating circumstances such as foliar loss, wood branch dieback, nutrient depletion, drought stress, overwatering, root disturbance, fungi, internal decay, bacteria, insects and more. It's the task of the tree risk evaluator to identify these aggravating circumstances and grade them and their influences using an integrated fashion, looking at the ecology of the tree and surrounding environment.

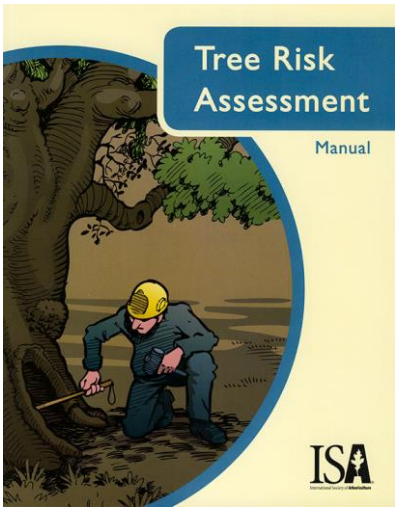


Figure 8. Tree Risk Assessment Qualification is the national standard qualification in tree risk assessment.

For trees to have a risk, they must have a target to impact. Targets are the structures, thoroughfares, utility boxes, parking areas, steep slopes, other trees and any other object which could potentially become damaged or conflicted with tree-part failure. We evaluate likelihood of impact and likelihood of damage associated with trees and their targets.

The potential risk a tree owner is willing to accept is the sole responsibility of the tree owner/manager and any applicable governing laws. The best course of action when managing large quantities of potential tree risk (either low, medium or high risk) is to actively participate and encourage biennial Level 1 monitoring of trees by a TRAQ qualified professional. Additional information on Tree Risk Methodology in Appendix A.

Distribution of Private to Public Trees

While the majority of trees in White Salmon reside on private property, their benefits support the community significantly, as community trees sustain ecosystem services that are measurable and assessable public goods (Mincey et al., 2013). This relationship between the trees on private property and the ecosystem, economic, human health, and social benefits they provide necessitates regulation and protection of trees on private property.

For White Salmon to further equitably distribute the community's trees between public and private property, the City should improve design standards for streets to include more street trees installed in capital development projects. In turn, this will reduce the distribution from private trees to public trees.

Low Impact Development (LID) is an alternative comprehensive approach to stormwater management in which urban retrofits, re-development projects, and new development sites can be used to meet regulatory water protection program goals. LID specifically denotes systems and practices that use or reproduce natural processes that result in the infiltration, evapotranspiration, or use of stormwater in order to protect water quality and the associated aquatic habitat (EPA, 2018). Green infrastructure, like street trees, can be used in LID as an approach to management stormwater and protect aquatic habitat.

Tree Protection Guidelines

In order to protect both public and private trees, regulations are necessary. For private trees, if modern development continues trends of building large homes on small lots, redevelopment and infilling of parcels to achieve high-density zoning, a permanent loss of tree cover will follow (Daniel et al., 2016). High-density urban planning often facilitates the removal of or is a causation of decline for large, dominant trees within urban environments.

Providing tree permit education, access and low-cost or free removal permits influences canopy height in cities (Sung, 2012). While canopy height is not a linear expression of tree age, tree height is an effective and often used proxy for tree age. Free tree related permits are common throughout Washington State and common in small to large cities. Free tree permits also reduces need for enforcement, as more property owners will submit permits prior to carrying out tree actions.

The development of tree protection code, especially for the native Oregon white oak, will increase community forest functionality and increase ecological biodiversity in the area. The Oregon white oak is a pillar of both community recognition and a large and important component of the surrounding Eastern Cascades Slopes & Foothills ecosystem.

Regulation within critical areas often stipulates a 3-to-1 ratio of removed to reinstalled trees. In some cities, developed non-critical areas share this replacement ratio. This technique in tree regulation often results in the removal of significant, mature native trees while being replaced with small trees which lack the overall tree capabilities of the tree they're replacing.

This regulatory discrepancy across Washington & Oregon has focused many cities to adopt regulations requiring calculating replacement trees based on diameter in inches of tree removed. Again, this results in an undesirable setting, creating a highly overcompetitive environment where trees are struggling for resources and not establishing themselves.

We recommend not requiring a high ratio of reinstallation trees to offset tree removal during single family development or redevelopment. Instead, single, large capacity trees should be planted, irrigated for a number of years, and allowed to establish into a large tree. This regulatory technique will take less time to replace lost ecosystem services of the removed tree.

Performance standards used in natural resource management can be used in community tree protection ordinances. These performance standards can include tree replacement selection, placement (right tree in the right place), correct planting, mulching, irrigation until establishment, and replacement if the tree declines.

Community tree protection codes should reside in the Environmental Chapter of local municipal code, outside of other environmentally sensitive areas and critical areas.

Included at the end of this report is a simple "Tree Protection Worksheet" White Salmon can evaluate, reinterpret and redesign to fit their desire to protect trees during development.

Introduced and Indigenous Trees in Urban Areas

The goal of those who design, build and maintain our urban landscapes and treescapes is not what historically has grown here, but instead what will grow here now and in the future. Strictly defined, a "native" plant is one that is living, growing, and reproducing naturally in a particular region. The urban environment is not a natural or native environment. Therefore, it is difficult to transplant our native plants and trees into a non-native, urban condition and expect them to thrive. Additionally, our native plants and trees have rarely been selected to be bred to adapt to the urban ecosystem. Site specific planting is required in any situation, and the urban environment is no different. Furthermore, when planted in the urban environment, often our native plants and trees create issues for municipalities, like sidewalk lift, etc., in addition to often not thriving as street trees, as they have been removed from a forest setting.

Non-native trees that have been specially selected for your locale can avoid the introduction of non-native, invasive species; which are different than simply non-native species. Selected non-native species can be planted under the correct conditions to prevent

their introduction as an invasive species. Recommendations for these trees can be found in Appendix C.

According to the i-Tree Eco report, about 47% of the trees are species native to North America, while 29% are native to Washington. Species exotic to North America make up 53% of the population. Most exotic tree species have an origin from Europe & Asia (33% of the species). Zero of the 27 tree species in urban forest inventory are identified as invasive on the state invasive species list (Oregon Invasive Species Council, 2014).

Some native trees can successfully reside in open areas, medium to large parks and other natural areas. The tree below, in Figure 9, is a native, big leaf maple tree. This tree has the potential to grow into a 150-foot-wide canopy, and 100 feet tall. These trees are adapted for wide open areas, with plenty of nutrients and water availability. Planting them in streets, or anything less than 500 square feet will likely cause hardscape damage.

Figure 9. Native bigleaf maple tree with room to grow in Rheingarten Park.

Evergreen and Deciduous Tree Benefits

Trees are integral within the urban hydrologic cycle because they arrest and buffer precipitation, deplete soil moisture, improve soil infiltration, and act in concert with natural ecosystems and installed green infrastructure.

Evergreen trees provide these stormwater attenuation benefits year-round, as their needles or leaves persist, while deciduous trees provide those benefits for only a portion of the of the year. Trees serve as crucial green infrastructure components by attenuating stormwater across a landscape. In the Pacific Northwest region, we receive most our precipitation during winter months, this is amplified by climate change models' prediction and recent weather patterns indication of higher intensity storms with higher intensity rainfall.

While many deciduous trees are important components for habitat, pollinators, food supply, aquatic resources and nutrient cycling, they lack the ability to attenuate stormwater during our rainy seasons. Populations of evergreen trees are far more effective at stormwater attenuation in our region.

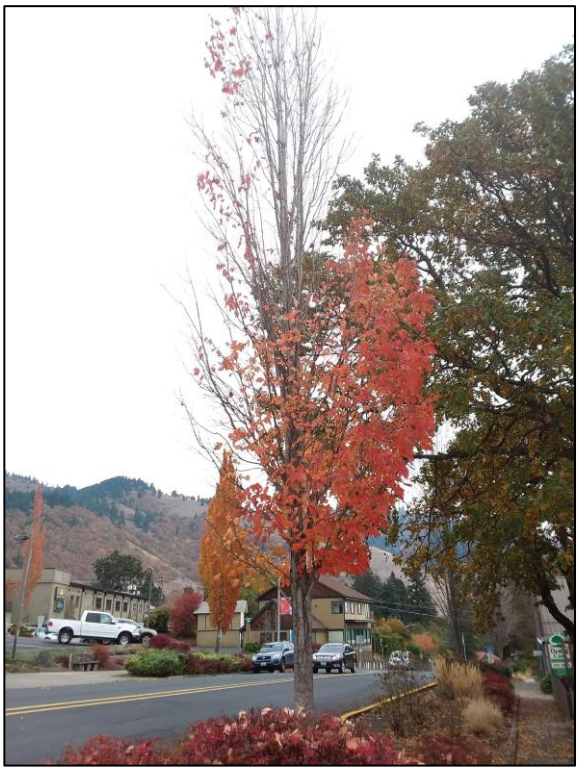


Figure 10. Deciduous trees lose leaves in winter, reducing their ability to manage stormwater

Wildfire Resiliency in Wildland Urban Interfaces

In 2017, a state of emergency was declared in Washington due to wildfire activity. It is essential communities plan ahead for wildfire activity while situated in the wildland-urban interface, or where unoccupied land transitions to human development and occupancy. White Salmon is situated in the wildland-urban interface, and as such, should be active in planning for wildland fires.

Klickitat County is developing an updated Community Wildland Fire Protection Plan this year. However, it is recommended that White Salmon proactively prepare individuals, neighborhoods, and the community-at-large in order to become a fire-adapted community.

The Washington State Wildland Fire Protection Strategic Plan Draft, drafted by Washington State Department of Natural Resources, outlines ways for individuals, neighborhoods, and communities to be prepared for wildland fire (WA DNR, 2018). The table below summarizes the practices recommended by WA DNR to create fire-adapted communities.

Practices that create a fire-adapted community		
Individual	**Neighborhood**	**Community**
• Ignition-resistant building • Home ignition zone preparation • Evacuation kits • Business continuity plans • Home assessments	• Firewise USA® program (Consultant recommends community-specific analyses explicitly adapted to each neighborhood) • Ingress/egress routes	• Fuel breaks • Proper addressing and signage • Ingress/egress route • Wildland Urban Interface (WUI) codes • Land use planning • Fire-adapted communities • Community Wildfire Protection Plans • Home assessment training for responders • Ready, Set, Go! Program for responders.

Weather Conditions

Weather conditions, along with other environmental conditions, play a major role in fire risk and behavior. The National Oceanic and Atmospheric Administration (NOAA)'s National Weather Service created a website to predict wildfire risk conditions (https://www.weather.gov/safety/wildfire). Additionally, Washington State Department of Natural Resources (WA DNR) has a fire danger website (https://fortress.wa.gov/dnr/protection/firedanger/). These websites should be monitored and used in decision making for the community.

Defensible Space

While staying alert of weather conditions, it is also important to take precautions and preventative measures. According to WA DNR, studies have shown that up to 80% of homes lost to wildland fire may have been saved if defensible space was created around the home and brush was cleared (Syphard et al., 2014; Cheney et al., 2001). Defensible space is a zone around a home or structure where plants or trees are altered to increase the probability of structure survival if a wildfire transpires. Defensible space mitigates home loss via reduction in radiative heating, dropping chances of ignitions from embers, decreasing direct contact with fire, and allowing for a safe space for firefighters to combat fire (Gill and Stephens, 2009; Cheney et al., 2001).

Common mitigation strategies to reduce fuel loads can include: stand thinning, tree pruning, reduction of diseased stands, prescribed fires, fuel breaks, and fire resilient or resistant plantings. Scientific evidence demonstrates that the most effective distances with reduced vegetation from the structure vicinity were anywhere from 16-58ft (Syphard et al., 2014). In this study, the most effective actions were reducing vegetative cover up to 40% immediately adjacent to structures and making sure that vegetation does not touch the structure (Syphard et al., 2014). Washington

State DNR recommends thinning a 15ft space between crowns and removing limbs within 15ft of the ground. Also, removing dead branches that extend over the roof is recommended by WA DNR.

Maintaining Forested and Treed Residences

There are mitigation and risk reduction strategies that can be put into place to reduce the risk of wildfire affecting a primary residence while preserving a safe landscape and community forest. As discussed in the 'Defensible Space' section, pruning of trees away from the roof and primary structure are essential. Additionally, branches overhanging powerlines can create additional hazards and should be pruned or trees removed.

By removing trees and pruning others, reducing canopy contact and probably reducing the likelihood of fire transferring via canopy. The goal of pruning should be to reduce crown overlap and reduce branches that overhang the road, as roads can be used as fire breaks.

Part of fire safety is also making sure an address is well labelled with reflective metal signage and that fire trucks can come down the drive. Pruning of trees and shrubs that may overhang the drive or crowd the entrance to the primary residence will make it difficult for firefighters to fight the fire. Steps should be taken to prune back shrubs at the entrance to the drive to the primary residence, including the entrance to the parking area of homes.

Bare or unpainted wood on the premises as well as missing shingles increase the risk of fire transfer to the home. It is important to maintain the home by keeping the house and deck painted, if possible, with fire retardant lacquer. Furthermore, in homes, the vents should have small mesh screen, and follow California Fire codes to prevent fire ember entry into homes (Quarles, 2017). Homes may need to be retrofit. Gutters should be kept clean of debris. The surrounding landscape should be well-watered to maintain healthy plants.

Community Specific Planning

Every neighborhood, every community requires community specific planning. White Salmon is unique, and therefore merits community specific recommendations and planning for wildland fire safety.

Shared Trees

Trees often will grow large enough to extend branches, and roots, onto two or more properties. At times, trees can grow large enough so the tree trunk itself is located on two or more properties. Commonly, there is not discrete legal definition in city ordinances or law regarding legal definitions of tree ownership. Tree ownership is often defined by case law experience and common law. In Alaska as of 2018, if a tree trunk at ground level is 50% or more in a protected environmentally sensitive area, that tree is owned by the sensitive area jurisdiction.

Generally, in Washington State, a *boundary tree* is a tree whose trunk is located on the property line of at least two adjoining landowners. This property line can intersect any part of the tree trunk and a tree, planted on a single property, can grow into this property line intersection and become jointly owned. Boundary trees are owned by both landowners as tenants in common (Merullo and Valentine, 1992). The judicial system has taken the stance that trees positioned on the boundary line between adjoining landowners are jointly owned by both parties (Merullo and Valentine, 1992). *Border trees* on the other hand, are trees where branches or roots extend over property lines. According to Washington State common law, border trees are not jointly owned.

Figure 11. Large sweetgum tree on Jewett Boulevard.

Urban Forest Pests & Diseases

Douglas-Fir Bark Beetles

Douglas-fir bark beetle (*Dendroctonus pseudotsugae*) outbreaks are usually prompted by disturbance. The beetles burrow into the tree bark, leaving 'frass' on the outside of the tree. Pitch-tubes and/or pitch streaming may occur, running down the tree from the beetles' bored holes. The beetles lay their eggs inside 'galleries' and the larvae feed underneath the bark. With 1-year life cycles, the Douglas-fir bark beetles usually emerge when the temperature is 60 degrees (in the spring normally). Most Douglas-fir bark beetles make a single attack, but about 20% of the population make a second attack. Insect outbreaks last 2-4 years (Kegley, 2011).

Figure 12. Larvae of wood boring insect.

The Douglas-fir bark beetles favor trees that are wounded by fire, defoliation, windthrow, root disease, or other pathogens. Stand density and weather conditions can also affect beetle populations. For example, the denser the stand, the more vulnerable the forest is to a Douglas-fir bark beetle attack. Additionally, larger diameter trees are more likely to be affected than intermediate or suppressed trees (Negron et al., 1999). Furthermore, there is a relationship between root-diseased Douglas-fir and native populations of beetles (Wright and Lauterbach, 1958).

Douglas-fir bark beetle associated mortality was observed on ~30,600 acres statewide in 2016, the highest since 2009, when wind storms battered the coast (WA DNR, 2017). Washington State DNR believes the 2016 increase may be due to the drought and defoliation by the western spruce budworm (*Choristoneura occidentalis*) in some areas (WA DNR, 2017).

One option to combat Douglas-fir bark beetle damage is the use of beetle pheromones. These are pheromones that the beetles use naturally to communicate with each other. One such pheromone is used by the beetles to interrupt their aggregation. Therefore, beetles' attacks can be prevented by using bubble capsules filled with the pheromone to prevent beetle aggregation on certain trees. This can avert the attacks on high value trees (Ross et al., 2015).

Spotted Lanternfly

The Washington State Department of Agriculture's (WSDA) Plant Protection unit has determined the colorful exotic spotted lanternfly as an important invasive species, specifically detrimental to agricultural lands. The WSDA's Pest Program classifies this pest as a "target pest" and in September of 2018 the Washington Invasive Species Council added the pest to the top priority species list, to join the agricultural invasive pest ranks of apple maggots, gypsy moths and brown marmorated stink bugs.

A native of China, the spotted lanternfly first arrived in Pennsylvania in 2014. Since that time, it has migrated south and west substantially. Pennsylvania's spotted lanternfly infestation continues to spread, despite $20 million dollars appropriated into control and eradication research.

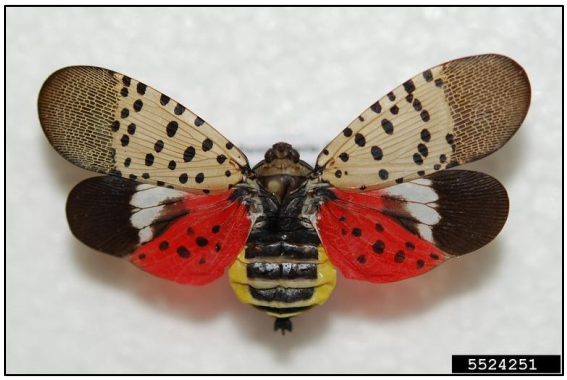


Figure 13. Spotted lanternfly, sourced from Pennsylvania Department of Agriculture

Habitat for the spotted lanternfly (*Lycorma delicatula*) is hardwood trees rich in tree sap. Commercial and private grape vines, fruit trees, and nut trees are all susceptible hosts for the insect. A widely used and seemingly favorable host of the pest is the tree of heaven (*Alianthus altissima*), another prolific invasive plant pest which grows in disturbed areas. Tree of heaven is non-obligate habitat for the pest, though the pest prefers tree of heaven to most other hardwoods.

A concern in Washington State is the spotted lanternfly migrating west along transit corridors which often contain ample tree of heaven habitat. Disturbed areas like highways and rail ways could be used as a direct thoroughfare for the spotted lanternfly. To date, spotted lanternfly has not been directly observed in Washington State.

Trees and the Community

White Salmon's community forest includes more than park and street trees, therefore a big picture approach in its management is warranted. Private trees must be incorporated into the City's tree management purview. Through focused education about the benefits of community trees and its ecosystem, economic human and social services, a seed can be planted within the community that will grow into an appreciation of the community forest and all of its components.

Urban forestry relies on a community of engaged citizens for its success. Citizens are sometimes reluctant to plant a tree or get involved with urban forestry due to concerns about time, cost, or risk. However, through education, about the beneficial effects the community forest provides, the community is willing to participate.

Arbor Day can be used as a method of education and as a way to plant trees in White Salmon. Tree planting should occur in the fall or winter months in the White Salmon environment, while educational presentations or invasive tree management events can be orchestrated in the spring and summer.

Recommendations

Goal 1:
Maintain mature tree distribution and structure through maintenance and preservation of established city trees.

Strategy 1:
Retain large trees safely, through proactive tree maintenance.

Actions:

- Use ISA Certified Arborists to prune street trees, and other public trees in White Salmon, according to the maintenance tasks and maps provided by the Consultant.
- Maintain large, mature trees through targeted risk reduction.
- City owned tree pruning should be implemented in a way to reduce risk via the *least destructive method* possible.
    - Least destructive method implies individual tree parts will be managed for risk, and pruned, cabled or otherwise as determined by a Certified Arborist.
    - Tree removal should only be executed when no other feasible option is available.
- Increase tree pruning standards, implement pruning routines, treat tree risk where it's expressed, not via whole tree removal.
- Use only Tree Risk Qualified Assessors (TRAQ) to evaluate future potential risk and threat of tree parts.

Strategy 2:
Reduce infrastructure damage on street trees.

Actions:

- Reassess design standards on new development and urban roads.
- When redesigning sidewalks, roads, utility lines, trenches, etc., and street tree damage is expected, follow Consultants recommendations to protect trees during development.

Goal 2:
Manage community forest risk through proactive pruning routine.

Strategy 1:
Use Consultant Street & Park Tree List to identify high-risk tree parts and tree features to be mitigated.

Actions:
- Contract with a local ISA Certified Arborist for tree pruning requirements.
- High-risk trees or trees with high-risk tree parts (like canopies or trunks) should be addressed first.

Strategy 2:
Begin city owned tree pruning program and schedule pro-active tree pruning.

Actions:
- Either encourage and fund a member of your City staff interested in arboriculture and urban forest management to study and take the ISA Certified Arborist test -OR-Contract with a local ISA Certified Arborist for tree pruning requirements.
    - We recommend pursuing internal accreditation of City staff as opposed to a contractor. This could be an additional job responsibility to someone who already works with trees, or a new part-time job description.
- Budget for routing pro-active pruning every 5 years. Concentrate on structural pruning of young trees and reducing moderate/high risk on mature trees.

Strategy 3:
Plan for emergency weather events which can cause street tree failure throughout the city.

Actions:
- Contract with a tree removal service to provide emergency services in cases of extreme wind, extreme ice or other potential weather event.
- Contract with services well before the need for emergency services.
- Identify and map out emergency service road corridors and focus tree cleanup on those roads.
    - Emergency services should include medical and police emergency services, and utility management emergency services.

Goal 3:
Reduce threat from urban invasive plants and pests.

Strategy 1:
Educate community on disruptive and invasive nature of Tree of Heaven (*Ailanthus altissima*), both on private and public lands.

Actions:
- White Salmon Tree Board or City Staff can partner with Klickitat County Noxious Weed Department to create an education outlet on Tree of Heaven in the community.
  - Education should focus on City & County website upgrades, information brochures, mailing opportunities and volunteer parties.
- Reduce presence of downtown invasive presence and threat by coordinating volunteer events hosted by the Noxious Weed Department in conjunction with White Salmon Tree Board.
  - Events should focus on control methods from published best-management-practices on both private and public lands.

Strategy 2:
Partner with Washington State Department of Agriculture & Underwood Conservation District on the spotted lanternfly (*Lycorma delicatula*) threat directly associated with *A. altissima*.

Actions:
- Communicate with Underwood Conservation District and WSDA on programs and funding opportunities related to *A. altissima* control nearby agricultural centers.

Strategy 3:
Educate on distinction between similar plants: Sumac (*Rhus spp.*), black walnut (*Juglans nigra*) & Tree of Heaven (*Alianthus altissima*)

Actions:
- Create a brochure on the distinction between *Rhus spp.*, *Juglans nigra* & *Alianthus altissima*.
  - Sumac, black walnut and Tree of Heaven are similar in appearance and difficult to tell apart. In the process of removal and control of the invasive plant, collateral damage of the others should be reduced.

Goal 4:
Recommend Consultant provided White Salmon Street Tree List

Strategy 1:
Adopt White Salmon Street Tree list as required in 18.35.070 of the White Salmon Ordinance 2017-09-1013.

Actions:

- The White Salmon Tree Board should recommend to the White Salmon City Council, the White Salmon Street Tree list as supplied by Consultant in Appendix C of this plan.
- Enforce street tree list through proper regulations in city code.
    - We encourage the use of follow-up inspections by City staff, or proof requirements showing the right tree has been installed in the right place.

Goal 5:
Adopt White Salmon Tree Protection Ordinance

Strategy 1:
Adopt a community specific tree protection ordinance tailored to White Salmons desire to protect native trees during development.

Actions:
- Redesign the Consultant draft Tree Protection Worksheet for use in Official City Permits for development or redevelopment only.
- Require all new developments, redevelopments and infill projects complete the Tree Protection Worksheet and complete required mitigation if tree removal is necessary.

Strategy 2:
Prioritize, encourage and incentivize preserving native trees, especially native Oregon white oak, in all new developments.

Actions:
- Offer development incentives for retaining and protecting established Oregon white oak trees during development.
- During single family residential redevelopment and infill, encourage placement of the development and its footprint outside of tree roots.
- Enforce native tree protection standards recommend by Consultant.

Resources Cited

Allen, E., Morrison, D. & Wallis G. (1996). *Common Tree Diseases of British Columbia*, Natural Resources Canada, Canadian Forest Service. Victoria, BC.

American National Standard for Tree Care Operations – Tree, Shrub, and Other Woody Plant Maintenance – Standard Practices (Tree Risk Assessment a. Tree Structure Assessment) (A300, Part 9) 2017. Tree Care Industry Association, Manchester, NH. 14pp.

Berlund, Adam; Shiflett, Sheri A.l Shurster, William D.; Garmestani, Ahjondi, S.; Goddard, Haynes, C.; Hermann, Dustin L.; Hopton, Matthew E. The role of trees in urban stormwater management. Landscape and Urban Planning (2017) 162:167-177.

Burns, Russell M., and Barbara H. Honkala, tech. coords. 1990. Silvics of North America: 1. Conifers; 2. Hardwoods. Agriculture Handbook 654. U.S. Department of Agriculture, Forest Service, Washington, DC. vol.2, 877 p.

Cheney P, Gould J, McCaw L (2001) The dead-man zone – a neglected area of firefighter safety. Australian Forestry 64, 45–50.

Daniel, Claire; Morrison, Tiffany H.; Phinn, Stuart. 2016. The governance of private residential land in cities and spatial effects on tree cover. Environmental Science & Policy 62, 79-89.

Donovan, G.H. and Butry, D.T. "Market Based Approaches to Tree Valuation." Arborist News. August 2008

Dunster & Associates Environmental Consultants Ltd. 2006 *Assessing Trees in Urban Areas and the Urban-Rural Interface, US Release 1.0*. Silverton: Pacific Northwest Chapter ISA.

Dunster, Julian A., E. Thomas Smiley, Nelda Matheny, and Sharon Lilly. 2013. *Tree Risk Assessment Manual*. Champaign, Illinois: International Society of Arboriculture.

Dwyer, J.F., D.J. Nowak, M.H. Noble, and S.M. Sisinni. 2000. Assessing our Nation's Urban Forests: Connecting People with Ecosystems in the 21st Century. *USDA Forest Service Gen. Tech. Rep.* PNW-460. 540p

Environmental Protection Agency (EPA). 2018. Urban Runoff: Low Impact Development. https://www.epa.gov/nps/urban-runoff-low-impact-development. Accessed 12/12/2018.

Evergreen Communities Act: Technical Advisory Committee Web Page-Tree Inventories and Assessments. www.dnr.wa.gov/ResearchScience/Topics/UrbanForestry/Pages/rp_urban_eca_tac.aspx. Partnership Task Force Web Page-Urban Forestry Programming www.commerce.wa.gov/site/1131/Default.aspx

Franklin, J.F., Shugart, H.H. and Mark E. Harmon. 1987. Tree Death as an ecological Process. BioScience Vol 37. No. 8.

Galenieks, Andrejs. Importance of urban street tree policies: A comparison of neighboring Southern California cities. Urban Forestry & Urban Greening 22 (2017) 105-110.

Gill AM, Stephens SL (2009) Scientific and social challenges for the management of fire-prone wildland–urban interfaces. Environmental Research Letters 4, 034014.

Gray, D. H. and A.T. Leiser, Biotechnical Slope Protection and Erosion Control: Van Nostrund Reinhold, New York, © 1982. Print.

Hauer, R.; Vogt, J.; B.C. Fisher; 2015. The Cost of Not Maintaining the Urban Forest; Arborist News 24(1):12-17

Hauer, Richard J.; Vogt, Jessica M.; Fischer, Burnell C. The costs of maintaining and not maintaining the urban forest: a review of the urban forestry and arboriculture literature. Arboriculture and Urban Forestry. 41 (2015) 6, 293-323.

Hill, Elizabeth; Dorfman, Jeffrey H.; Kramer, Elizabeth. 2010. Evaluating the impact of government land use policies on tree canopy coverage. Land Use Policy. 27 (2010) 407-414.

i-Tree Eco. v6. 2018. https://www.itreetools.org/eco/

Johnson, David H., and Thomas A. O'Neil. Wildlife-Habitat Relationships in Oregon and Washington. Oregon State University Press, 2001.

Kegley, Sandra. 2011. Douglas-fir Beetle Management. Forest Health Protection and State Forestry Organizations. https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5187396.pdf

Kuo, F.E., Sullivan, W.C., Coley, R.L., and Brunson, L. 1998. Fertile ground for community: Inner-city neighborhood common spaces. *American Journal of Community Psychology*, 26(6), 823-851. www.lhhl.uiuc.edu/download.php?article=1_article_Fertile%20ground%20for%20 community.pdf.)

Lawler J.J. and M. Mathias. 2007. Climate Change and the Future of Biodiversity in Washington. Report prepared for the Washington Biodiversity Council.

Lewis, Charles. *Green Nature/Human Nature: The Meaning of Plants in Our Lives.* Urbana: University of Illinois Press, 1996.

Livesley, S.J.; McPherson, E.G.; Calfapietra, C. The Urban Forest and Ecosystem Services: Impacts on Urban Water, Heat, and Pollution Cycles at the Tree, Street, and City Scale. Journal of Environmental Quality. 45 (2016) 119-124.

Mattheck C & Breloer H, 1994, *The Body Language of Trees: A handbook for failure analysis.* The Stationary Office. London, UK.

McPherson, E.G., S.E. Maco, J.R. Simpson, P.J. Peper, Q. Xiao, A.M. VanDerZanden and N. Bell. 2002. Western Washington and Oregon Community Tree Guide: Benefi ts, Costs, and Strategic Planting. Silverton, OR: International Society of Arboriculture, Pacifi c Northwest.

Mincey, Sarah K.; Schmitt-Harsh, Mikeala; Thurau, Richard. Zoning, land use, and urban tree canopy cover: The importance of scale. Urban Forestry & Urban Greening 12 (2013) 191-199.

National Oceanic & Atmospheric Administration (NOAA). National Centers for Environmental Information. Local Climatological Data: DALLESPORT AIRPORT, WA. Accessed December 15, 2018.

Natural Resources Conservation Service, National Water and Climate Center. (2017). Retrieving Climate Data and Summary Reports from AgACIS. United States Dept. of Agriculture. https://www.wcc.nrcs.usda.gov/climate/navigate_wets.html

Natural Resources Conservation Service. (2017). Web Soil Survey. United States Department of Agriculture, USA. http://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm

Negron, J.F., W.C. Schaupp, Jr., K.E. Gibson, J. Anhold, D. Hansen, R. Thier, and P. Mocettini. 1999. Estimating extent of mortality associated with the Douglas-fir beetle in the central and northern Rockies. W.J. App. For. Vol. 14, No. 3, p. 121-127.

Nowak, David J., Crane, Daniel E., Stevens, Jack C. 2006. Air pollution removal by urban trees and shrubs in the United States. USDA Forest Service, Northeastern Research Station, Syracuse, NY. Urban Forestry & Urban Greening 4 (2006) 115-123.

Oregon Invasive Species Council. 2014. 100 Worst List. OR: Oregon Invasive Species Council. https://www.oregoninvasivespeciescouncil.org/100-worst-list/

Payton, Seth; Lindsey, Greg; Wilson, Jeff; Ottensmann, John R.; Man, Joyce. Valuing the benefits of the urban forest: a spatial hedonic approach. Journal of Environmental Planning and Management 51 (2008) 6:717-736.

Quarles, Stephen L. 2017. Vulnerability of Vents to Wind-Blown Embers. IBHS

Ross, Darrell W. K. Gibson, and Gary E. Daterman. 2015. Using MCH to Protect Trees and Stands from Douglas-fir Beetle Infestation. USDA Forest Service. Morgantown, WV

Smiley, E. T., N. Matheny, and S.J. Lilly. 2017. *Best Management Practices: Tree Risk Assessment.* International Society of Arboriculture, Champaign, IL. 81 pp.

Sung, Chan Yong. 2012. Evaluating the efficacy of a local tree protection policy using LiDAR remote sensing data. 104(1): 19-25.

Syphard, A. D., Brennan, T. J., & Keeley, J. E. (2014). The role of defensible space for residential structure protection during wildfires. International Journal of Wildland Fire, 23(8), 1165-1175.

Tsegaye, Seneshaw; Singleton, Thomas L.; Koeser, Ander K.; Lamb, David S.; Landry, Shawn M.; Lu, Shen; Barber, Joshua B.; Hilbert, Deborah R.; Hamilton, Keir O.; Northrop, Robert J.; Ghebremichael, Kebreab. Tranitioning from gray to green (G2G)- A green infrastructure planning tool for the urban forest. Urban Forestry & Urban Greening. 2018: Article in Press.

Ulrich, R.S. 1984. View Through A Window May Influence Recovery From Surgery. *Science* 224:420-421.

Washington State Department of Natural Resources. 2017. Forest Health Highlights-2016. USDA.

Washington State Department of Natural Resources. September, 21 2018. Washington State Wildland Fire Protection Strategic Plan: Participant Review Draft.

Wolf, K.L., S. Krueger, and K. Flora. 2014. Healing and Therapy - A Literature Review. In: Green Cities: Good Health (www.greenhealth.washington.edu). School of Environmental and Forest Resources, College of the Environment, University of Washington.

Wright K. H Lauterbach P. G . Ten year study of mortality in a Douglas-fir saw-timber stand in Coos and Douglas Counties, Oregon. Research Paper PNW-RP-27. Portland, OR, USDA Forest Service, Pacific Northwest and Range Experiment Station , 1958.

Yngve, L., K. Beyer, K. Malecki, AND L. Jackson. The association between green neighborhood environments and active transportation. International Conference on Transport and Health, San Jose, CA, June 13 - 15, 2016.

Appendix A: Tables & Figures

Table 7. Street and Park Trees and their abundance.

Common Name	*Scientific Name*	Count
Norway maple	*Acer platanoides*	36
Oregon white oak	*Quercus garryana*	20
Northern red oak	*Quercus rubra*	9
London plane tree	*Platanus x acerifolia*	7
Flowering apple species	*Malus Spp.*	5
Bigleaf maple	*Acer macrophyllum*	5
Western redcedar	*Thuja plicata*	5
Douglas-fir	*Pseudotsuga menziesii*	4
Flowering cherry species	*Prunus spp.*	4
Paperbark maple	*Acer griseum*	4
Freeman maple	*Acer freemanii 'Armstrong'*	3
Norway maple 'sunset'	*Acer platanoides 'Sunset'*	3
Nootka Falsecypress	*Chamaecyparis nootkatensis 'fastigiate'*	3
Norway maple 'crimson moon'	*Acer platanoides 'Crimson moon'*	2
Japanese cherry	*Prunus serrulata*	2
Dawn redwood	*Sequoia sempervirens*	2
Sweetgum	*Liquidambar styraciflua*	2
Honey locust	*Gleditsia triacanthos*	2
American ash	*Fraxinus americana*	2
Tulip tree	*Liriodendron tulipifera*	1
Eastern black walnut	*Juglans nigra*	1
Atlas cedar	*Cedrus atlantica*	1
Giant sequoia	*Sequoiadendron giganteum*	1
Ponderosa pine	*Pinus ponderosa*	1
White spruce	*Picea glauca*	1
Flowering dogwood	*Cornus florida*	1
Common hawthorn	*Crataegus monogyna*	1
Red maple 'fastigiate'	*Acer rubrum 'fastigiate'*	1
Weeping Japanese cherry	*Acer palmatum 'pendula'*	1

Table 8. Overall condition of tree species, with count of trees in each category

Tree Species	Overall Condition				
	Excellent	Good	Fair	Poor	Dead
Alaska cedar of Nootka Falsecypress	3	-	-	-	-
American ash	-	-	2	-	-
Atlas cedar	-	-	-	1	-
Bigleaf maple	-	3	1	-	1
Common hawthorn	-	1	-	-	-
Dawn redwood	-	2	-	-	-
Douglas-fir	1	2	1	-	-
Eastern black walnut	-	-	-	1	-
Apple spp.	-	-	1	1	-
Flowering dogwood	-	1	-	-	-
Freeman maple	-	1	-	-	-
Giant sequoia	1	-	-	-	-
Honey locust	-	-	2	-	-
Japanese cherry	1	1	-	-	-
London plane	1	6	-	-	-
Northern red oak	3	5	1	-	-
Norway maple	2	12	17	5	-
Norway maple "Crimson Moon"	2	-	-	-	-
Norway maple "Sunset"	-	2	1	-	-
Oregon white oak	5	6	9	-	-
Paperbark maple	1	3	-	-	-
Ponderosa pine	-	1	-	-	-
Red maple 'fastigiate'	1	-	-	-	-
Sweetgum	-	1	1	-	-
Tulip tree	-	1	-	-	-
Weeping Japanese cherry	-	-	-	1	-
Western redcedar	3	2	-	-	-
White spruce	-	1	-	-	-

Table 9. Average tree heights, average crown spread (ft), average diameter at breast height (DBH; 4.5ft above grade) of park and street trees.

Tree Species	Average Height (ft)	Average Crown Spread (ft)	Average DBH (in)
Pinus ponderosa	115	26	35
Pseudotsuga menziesii	94	42	40
Sequoiadendron giganteum	69	36	47
Cedrus atlantica	55	45	25
Quercus rubra	52	49	24
Liquidambar styraciflua	45	36	19
Gleditsia triacanthos	43	35	22
Picea glauca	40	35	37
Fraxinus americana	38	49	25
Acer freemanii 'Armstrong'	37	11	10
Acer platanoides	31	29	15
Acer rubrum 'fastigiate'	30	7	6
Acer platanoides 'Sunset'	29	9	7
Chamaecyparis nootkatensis 'fastigiate'	25	6	5
Malus spp.	25	22	3
Platanus x acerifolia	24	20	8
Prunus spp.	23	18	10
Prunus serrulata	21	28	16
Sequoia sempervirens	20	18	16
Crataegus monogyna	15	15	4
Liriodendron tulipifera	15	8	2
Acer macrophyllum	15	10	6
Quercus garryana	12	8	4
Acer griseum	11	3	2
Juglans nigra	10	9	3
Acer platanoides 'Crimson moon'	10	2	2
Thuja plicata	8	4	2
Cornus florida	6	2	1
Acer palmatum 'pendula'	5	6	3

Table 10. Maintenance tasks by tree species.

Tree Species	High Priority Pruning	Removal	Routine Pruning	Stump Removal	Training Pruning
Acer freemanii 'Armstrong'	-	-	-	-	-
Acer griseum	-	-	-	-	1
Acer macrophyllum	1	1	-	-	1
Acer palmatum 'pendula'	-	-	-	-	1
Acer platanoides	1	4	29	-	-
Acer platanoides 'Crimson moon'	-	-	-	-	1
Acer platanoides 'Sunset'	-	1	-	-	2
Acer rubrum 'fastigiate'	-	-	1	-	1
Cedrus atlantica	-	-	1	-	-
Chamaecyparis nootkatensis 'fastigiate'	-	-	-	-	-
Cornus florida	-	-	-	-	1
Crataegus monogyna	-	1	-	-	-
Fraxinus americana	-	-	-	-	-
Gleditsia triacanthos	-	-	2	-	-
Juglans nigra	-	-	-	1	-
Liquidambar styraciflua	-	-	-	-	-
Liriodendron tulipifera	-	-	-	-	1
Malus Spp.	-	-	-	-	-
Picea glauca	-	-	1	-	-
Pinus ponderosa	-	-	-	-	-
Platanus x acerifolia	-	-	4	-	-
Prunus serrulata	-	-	1	-	1
Prunus Spp.	-	1	1	-	-
Pseudotsuga menziesii	1	-	2	-	-
Quercus garryana	-	-	1	-	6
Quercus rubra	2	-	6	-	-
Sequoia sempervirens	-	-	2	-	-
Sequoiadendron giganteum	-	-	-	-	-
Thuja plicata	-	-	-	-	2

Appendix B:
Tree Protection Survey Form

We do not recommend using the Homeowner Tree Protection Survey Form verbatim, but instead as a guideline to be integrated into White Salmon administrative forms. This document is a guide and a framework. Tree Protection Ordinances are complex and require community specific planning to function and provide results. For more information regarding tree protection guidelines during development, read the 2009 publication Tree Protection on Construction and Development Sites: A Best Management Practices Guidebook for the Pacific Northwest, published by the Oregon State University, Oregon Department of Forestry and Washington State Department of Natural Resources and Washington State University.

For all developments, redevelopments, and other land use actions potentially impacting trees and their roots, landowners shall conduct the following inventory and basic evaluation. All established trees within the parcel boundaries shall be identified, numbered and marked on a site plan (rendered or hand-drawn). An established tree shall be defined as all native trees greater than 6 inches in diameter at ground height and all non-native trees greater than 18 inches at 4.5 feet above soil grade (DBH). Impacted trees shall be defined as trees planned for removal, or trees where soil disturbance, compaction, or loading is planned to occur within their Critical Root Zone.

Mitigation is required for all trees potentially impacted during construction given:

- Project construction calls for tree removal,
- Project construction area results in a 15% or larger disturbance into a tree's Critical Root Zone,
- Impacted tree scores over 10 points on the Tree Protection Survey Form,
- Tree has NOT been assessed as high-risk by a Tree Risk Assessment Qualified (TRAQ) professional. (Requires TRAQ report with packet submission.)

Other construction requirements that should be added to Definitions & Performance Standards section of Tree Protection Ordinance:

- Critical Root Zone (CRZ) of a tree is measured at 1.5 feet radius from trunk per inch of tree diameter at 4.5 feet above soil grade (DBH). A Certified Arborist can evaluate this and recommend changes on a site-by-site case.
- Impacts from construction are defined as tree removal, root disturbance, root compaction, movement or storage of trucks, equipment, materials, or anything else over critical root zones.
- Tree Reinstallation Mitigation Points are a last resort, and only available to mitigate tree removal or tree impact if homeowners cannot alter development plans or use tree protection fencing.
- Tree Protection Plans from a Certified Arborist with plans and actions to protect trees and reduce impact from construction can be used instead of the Homeowner Tree Protection Survey Form.

Homeowner Tree Protection Survey Form				
			Trees	
			1	2
		Diameter of trees	24"	18"
		Calculated CRZ	36'	27'
Tree Conditions & Features		Points		
Diameter	6 – 10 inches	3		
	11 – 16 inches	8		
	17 – 24 inches	12		X
	24 – 32 inches	28	X	
	32 + inches	42		
Crown & Leaves (identified in summer only)	Normal, Green, Vibrant	14	X	
	Missing leaves, tree canopy is half to ¾ of normal summer-time appearance.	7		X
	10% or less normal leaf presence in in summer.	2		
Nearby trees	There are 4+ OTHER established and native trees unimpacted by project per 1/2 acre, that 20 total or more points individually.	-18		
Tree Protection & Aftercare	Homeowners agrees to install tree protection fencing around CRZ of potentially impacted tree(s).	Zero out all points		
	Alter development plans to not remove trees and remain outside of CRZ.	Zero out all points		
	Annual monitoring & aftercare treatment plan by Certified Arborist.	-6 annually		
CURRENT TOTAL TREE POINTS				

Tree Reinstallation Mitigation Points: (Points must balance out with total tree points above.)	
All replacement trees must be native or on the Tree Planting List:	10 mitigation points
Newly installed tree is over 2 inches caliper at time of installation:	8 mitigation points
Reinstalled tree is long-lived as defined in Tree Planting List:	8 mitigation points
Reinstalled tree grows to 60-foot spread:	8 mitigation points
Reinstalled tree grows to 40-foot spread:	3 mitigation points
Reinstalled tree grows to 20-foot spread:	1 mitigation point
Each year of planned aftercare monitoring, mulching & summer irrigation. Monitoring must include electronic photos to city and replacement if dead:	3 mitigation points

Appendix C: Tree Planting List

Species Name	Common Name	USDA Hardiness Zone	Drought Tolerant	Mature Height x Spread	Minimum Planting Width[4]	Benefits[5]	Recommended For
Abies koreana	Horstmann's Korean fir	4-7	Yes	15'x15'	6ft	LL, EG	Pocket parks, LID, Streets
Acer griseum	Paperbark maple	2-9, 14-21	No	25'x25'	2ft	LL, BF	MUTC Streets
Acer saccharum	Sugar maple	1-10, 14-20	Yes	60'x40'	8ft+	LL, BF	Large parks, Mitigation
Amelanchier grandiflora	Autumn Brilliance Serviceberry	4-9	Yes	20'x15'	2ft	SL, FL, FR	Pocket parks, Streets
Betula utilis	Himalayan birch	3-11, 14-17	No	40'x30'	4ft	LL, BF	Parks, Streets
Calocedrus decurrens	Incense cedar	4-8	Yes	40'x15'	8ft+	LL, EG	ROW, Parks
Catalpa speciosa	Northern catalpa	4-8	Yes	60'x40'	8ft	LL, FL	Parkway Streets, Parks
Cedrus libani	Cedar of Lebanon	5b-9	Yes	100'x80'	8ft	LL, EG	ROW, Parkway Streets, Parks
Cercidiphyllum japonicum	Katsura tree	2-6, 14-16, 18-20	No	40'x40'	4ft	LL, AR	Streets, Parks
Chionanthus retusus	Chinese Fringe tree	5-9	Yes	20'x20'	2ft	LL, FL, AR	MUTC Streets
Cladrastis kentukea	Yellowwood	2-9, 14-16	Yes	40'x35'	4ft	LL, AR, FL	MUTC Streets, Parks
Cornus florida	Eastern dogwood	2-9, 14-16	No	25'x30'	2ft	SL, FR, FL	MUTC Streets

[4] 2 ft – 4 ft – 6 ft – 8ft+

[5] Fruits/food, Flowers/Pollinators, Shade producing, Evergreen, Bark features, Aroma, Long-lived, Short-lived.

Species Name	Common Name	USDA Hardiness Zone	Drought Tolerant	Mature Height x Spread	Minimum Planting Width[4]	Benefits[5]	Recommended For
Cupressus glabra 'Sulphuera'	Sulphuera Arizona cypress	7-9	Yes	10'x4'	2ft	LL, EG, BF	Pocket parks, Streets
Davidia involucrate	Dove tree	6-7(8)	No	30'x30'	2ft	SL, FL	MUTC Streets, Parks, LID
Gleditsia triacanthos inermis	Thorn-less Honey locust	4-9	Some	70'x40'	6ft	LL, SH	Parkway Streets, Parks
Gymnocladus dioica	Kentucky coffee tree	1-3, 7-10, 12-16, 18-21	Yes	60'x50'	6ft	LL, BF	Large parks, ROW, LID
Juniperus scopulorum 'Sky Rocket'	Sky Rocket juniper	4-9	Yes	14'x2'	2ft	LL, FR, EG	MUTC Streets, Pocket Parks
Koelreuteria paniculata	Goldenrain tree	2-24	Some	30'x25'	4ft	SL, FL	MUTC Streets, Parks
Laurus nobilis	Bay laurel	1-8	No	30'x20'	4ft	SL, FL, FR, EG	Streets, ROW, LID
Lithocarpus densiflorus	Tanbark oak	4-7, 14-24	No	60'x50'	6ft	LL, EG	Parkway Streets, Parks
Picea omorika	Serbian spruce	4-7	Yes	30'x8'	6ft	SL, FR, EG	LID, ROW, Parks
Picea pungens 'Hoopsii'	Hoopsii Colorado blue spruce	2-7	Yes	50'x20x	6ft	LL, FR, EG	LID, ROW, Parks
Pinus cembra	Columnar Swiss Stone pine	4-7	Yes	35'x15'	4ft	LL, EG	LID, ROW, Parks
Pinus contorta	Shore pine	1-7	Yes	45'x30'	6ft	LL, FR, EG	ROW, Mitigation
Pinus flexilis	Limber pine	4-7	Yes	60'x35'	6ft	LL, EG	LID, Parks
Sophora japonica	Japanese Pagoda tree	2-24	No	60'x60'	8ft	LL, AR	Large parks

Species Name	Common Name	USDA Hardiness Zone	Drought Tolerant	Mature Height x Spread	Minimum Planting Width[4]	Benefits[5]	Recommended For
Stewartia pseudocamellia	Japanese stewartia	5-8	No	30'x30'	6ft	LL, FL	Parkway streets, ROW, Parks
Styrax japonicus	Japanese snowbell	5-8	No	20'x20'	6ft	SL, FL, BF	Parkway streets, ROW, Parks
Thuja occidentalis 'Smargaard'	Emerald Green arborvitae	4-8	Yes	20'x5'	6ft	SL, EG	LID, ROW, MUTC Streets
Tilia Americana	American basswood	3	Yes	45'x30'	8ft+	LL, FL	Large parks, Parkway Streets, Mitigatoin
Zelkova serrata 'Musashino	Columnar Japanese zelkova	5-8	No	45'x15'	4ft	LL, FL, BF	ROW, MUTC Streets, Parks
Quercus rubra	Red oak	3-8	Yes	65'x75'	8ft	LL, SP	Large parks, Parkway streets
Quercus garryana	Oregon white oak	7-9	Yes	80'x80'	8ft+	LL	Large Pakrs, ROW, Mitigation
Acer macropyllum	Bigleaf Maple	5-9	No	80'x100'	8ft+	LL	Large Parks, ROW, Mitigation
Quercus latifolia	Laurel oak	7-9	Yes	40'x50'	6ft+	LL	Large Parks, Parkway Streets
Pseudtosuga menziesii	Douglas-fir	3b-7b	Yes	200'x80'	8ft+	LL	Large Parks, Mitigation

Appendix D: Tree Risk Evaluation Methodology

The tree risk methodology used for this report was developed by the ISA in 2013. *Tree Risk Assessment Manual* authored by Dr. Julian Dunster and published by the ISA is the industry standard for the assessment of tree risk. This systematic approach to quantifying tree risk incorporates likelihood of failure, likelihood of impact and consequence of failure to measure the tree risk of specific targets. See Table 1 for details. The ANSI standard for risk assessment and ISA's *Best Management Practices: Tree Risk Assessment* defines three levels of tree risk assessment.

Level 1: Limited visual
Level 2: Basic
Level 3: Advanced

For this project, we utilized a Level 2 Basic assessment. This assessment level involves a full spectrum visual evaluation of an individual tree near specified targets. The perspective is 360° fully around the tree from grade level. A Basic assessment allows the assessor the ability to fully identify all conspicuous and some inconspicuous defects, conditions, and diseases present on a tree. Tree reactions and compensatory growth, morphological plasticity and external influences are all outlined in a Basic assessment. When a question cannot be answered using the Basic assessment, an Advanced assessment can be recommended.

For a tree to have associated risks, there must be a target present and there must be a chance for damage to occur. Targets can include houses, vehicles and driveways, park users and walkways, electrical wires, infrastructure, and other trees and plants.

Using the below matrices, we identify a likelihood of tree part failure. This can be root based failure, trunk failure, or branch failure. Then, we evaluate the likelihood of this failure impacting a predetermined target. Matrix 1 gives us a likelihood of failure and impact which we use along with predetermined consequences of a failure to arrive at a risk rating.

Matrix 1. Likelihood of Failure and Impact (Dunstser, 2013)

Likelihood of Failure	*Likelihood of Impacting Target*			
	Very Low	Low	Medium	High
Imminent	Unlikely	Unlikely	Likely	Very likely
Probable	Unlikely	Unlikely	Somewhat likely	Likely
Possible	Unlikely	Unlikely	Unlikely	Somewhat likely
Improbable	Unlikely	Unlikely	Unlikely	Unlikely

Matrix 2. Risk Rating (Adapted from Dunster 2013 and Matheny 1994)

Likelihood of Failure and Impact	*Consequences of Failure*			
	Negligible	Minor	Significant	Severe
Very likely	Low	Moderate	High	Extreme
Likely	Low	Moderate	High	High
Somewhat likely	Low	Low	Moderate	Moderate
Unlikely	Low	Low	Low	Low

As the matrices show, a tree can have *Moderate* risk of failure by either a "minor consequence" which is "very likely" to occur, or a "significant consequence" that is "somewhat likely" to occur. A real-life scenario is a native black cottonwood normally shedding small branches over a parking lot and oppositely, a large, over-extended oak branch over a parking lot. These scenarios offer similar risk ratings, yet the management of these risks is very different. This is where an Arborist expertly trained in managing tree risk is necessary to differentiate risks and offer remedial opportunities.

Some options for mitigation of tree risk include:
Acceptance of risk: All vegetation comes with some inherit risk. Most often this risk is tolerable and will have no significant effects on risk potential. Normally, tree benefits far outweigh associated risks.

Retain and monitor for changes: When a tree has some level of potential risk but not enough to warrant a more extensive mitigation. Most Tree Protection and Monitoring plans recommend a return time-frame of 1-3 years.

Move offending target from damage radius: If target is not fixed, this can be the simplest of mitigation techniques.

Modify probability of failure: This mitigation includes techniques like stress-load-reductions, propping, cabling, bracing and habitat conversions.

Full removal of tree risk: Full removal of offending tree or tree parts (branches).

Roles and Responsibilities of Managing Tree Risk:
The proper roles of Tree Risk Assessors (Certified Arborists with additional qualification as a Qualified Tree Risk Assessor) and Tree Risk Managers (owners of trees) are very different. These roles are clearly delineated in two publications which are generally accepted guidelines for tree risk assessment in the arboricultural industry:

- Tree Care Industry Association. 2011. *American National Standard for Tree Care Operations – Tree, Shrub, and Other Woody Plant Maintenance – Standard Practices (Tree Risk Assessment a. Tree Structure Assessment)* (A300, Part 9) Tree Care Industry Association, Manchester, NH. 14pp.

- Smiley, E. T., N. Matheny, and S.J. Lilly. 2011. *Best Management Practices: Tree Risk Assessment.* International Society of Arboriculture, Champaign, IL. 81 pp.

The Tree Risk Assessor's role includes the following responsibilities, as defined in a scope of work or project assignment:
- Evaluate and classify the likelihood of a tree failure impacting a target.
- Evaluate the potential consequences of a tree failure.
- Record and explain findings to the client;
- Determine tree risk; and
- Provide options for treatment to mitigate risk.

The role of the Tree Risk Manager (the tree owner, property manager, or controlling authority) includes the following responsibilities:
- Meet a duty of care;
- Determine the scope of work;
- Specify the desired level of assessment;
- Choose among risk mitigation options;
- Decide the level of acceptable risk, and
- Prioritize work.

Appendix E: Street Tree Inventory Definitions & Methods

Category	Field Name	Data Type	Definition	Methods	Instruments	Rationale
Base Data	**Geospatial ID**	Hex	Database identifier	Automatic	None	Automated
Base Data	**TreeNumber**	Integer	Tree ID Number	Analysis	Tablet	Individual tree identifier.
Base Data	**DateInspected**	Date/Time	Date of data collection	GIS	GPS	Date of inspection.
Base Data	**CollectionPersonnel**	Text, Dropdown Menu	Crew leader involved with collecting the data List Choices: *John B* *Courtney B* *Micki M*	Field	Tablet	ISA Certified Arborist with the Tree Risk Assessment Qualification performing tree inspection.
Location Data	**TreeGroup**	Text, Dropdown Menu	Name of tree group. List Choices: *1. Rheingarten Park* *2. Pioneer Park* *3. Fireman's Park* *4. Street*	Field	Tablet	General location of tree within City.
Location Data	**ParkLocal**	Text, Free Form	General area located in the park if park tree Predetermined Options (Not a Pick-List) : *Descriptive Free Form Text Notes or* *Central, North, Northeast, East, Southeast, South, Southwest, West, Northwest*	Field	Tablet	General area of the tree within the park.
Location Data	**Street**	Text, Free Form	Street tree is located on.	Field	GPS	Identify location of tree using non-GPS methods.
Location Data	**CrossStreet**	Text, Free Form	Nearest cross street.	Analysis	GPS	Identify location of tree using non-GPS methods.
Location Data	**CrossStreetDist**	Integer, Free Form	Distance to identified cross street.	Analysis	GPS	Identify location of tree using non-GPS methods.
Location Data	**LATCOORDX**	Decimal degrees	Latitude, global positioning system point.	Field	GPS	Sub meter coordinates of tree location.
Location Data	**LATCOORDY**	Decimal degrees	Longitude, global positioning system point.	Field	GPS	Sub meter coordinates of tree location.
Tree Data	**Photo**	Photo	Photo of the tree	Field	Tablet	Photo of each tree associated with its individual tree ID
Tree Data	**TreeGenus**	Text, Free Form	iTree compatible species as identified by genus and species using both botanical and common names and by cultivars where appropriate	Field	Tablet	Tree genus identification.
Tree Data	**TreeSpecies**	Text, Free Form	iTree compatible species as identified by genus and species using both botanical and common names and by cultivars where appropriate	Field	Tablet	Tree species identification.
Tree Data	**KnownAge**	Integer	Known age of tree, when applicable. Derived from permit submissions, park and street renovations and other known planting dates.	Research	None	Knowing age of trees allows for further future planning of eventual removal/replacement, and identifies tree age throughout city, and tree's that age well in city. Height and tree diameter are not an accurate proxy to assess tree age.

Category	Field Name	Data Type	Definition	Methods	Instruments	Rationale
Tree Data	**GrowthStage**	Text, Dropdown Menu	Physio-morphological stage of tree growth. List Choices: ***Sapling*** *– Very young tree, 1-3 inches in diameter. First lowest branches still present on trunk. Pre-establishment.* ***Juvenile*** *– Established young tree, actively growing at a fast rate and equal proportion of wood tissue and foliage.* ***Primary Growth*** *– Established actively growing tree. Rate of foliage and wood tissue production becoming dissimilar.* ***Mature*** *– Established tree. Not actively growing in height or canopy spread. Slower diameter accumulation. Wood tissue growing more than foliage.* ***Over-mature*** *– Tree entering beginning phases of retrenchment. Tree canopy height and spread reducing. Wood tissue accumulation significantly more than foliage production.* ***Ancient*** *– Wood tissue accumulation significantly more than foliage production. Tree actively colonized by wood decay organisms, heavily reduced in canopy height and spread. Active use as cavity nesting habitat.*	Field	Arborist	Physiomorphological condition of trees identifies their current growth stage. This rating is not parallel with age of urban trees. Allows planners to identify landmark and legacy trees, identify growth class of urban forest.
Tree Data	**TrunkDiameter1-4 (4 repeating fields)**	Decimal	Diameter at standard height (4.5 feet above grade) measured to the nearest 0.5in	Field	Diameter Tape	Tree diameter is a standard measurement used to assess tree size
Tree Data	**CrownSpreadNS**	Integer	Crown spread north - south to the nearest foot	Field	Logger's Tape	Crown spread is a standard measurement used in assessment of tree canopy size
Tree Data	**CrownSpreadEW**	Integer	Crown spread east - west to the nearest foot	Field	Logger's Tape	Crown spread is a standard measurement used in assessment of tree canopy size
Tree Data	**PercentCrownMissing**	Percent	Percent of crown missing *In ten percent intervals.*	Field	Arborist	Percent crown missing is a standard measurement used in assessment of tree canopy size
Tree Data	**Height**	Integer	Height of tree to the nearest foot.	Field	Range finder	Tree height is a standard measurement used to assess tree size

Category	Field Name	Data Type	Definition	Methods	Instruments	Rationale
Tree Data	**OverallCondition**	Text, Dropdown Menu	The general condition of each tree evaluated according to ISA standards List Choices: ***Excellent*** *- Trees in this class are judged to be exceptional trees possessing the best qualities of the species. They have excellent form, very minor maintenance issues, with virtually no dead branches, deformation or nutritional problems. These trees are in an acceptable location and can be expected to achieve a full mature shape and life expectancy. (**ISA Rating 100%**)* ***Good*** *- Trees in this class are judged to be desirable and with proper maintenance can be returned in excellent classification. They may be interfering with utility lines, planted in an overcrowded location, or have minor insect, pathogen or national deficiencies. (**ISA Rating 80%+**)* ***Fair*** *- Trees in this category have some or all of the following problems: large dead limbs representing less than one third of the canopy, large-cavities in the trunk, major deformities, girding roots, obvious insect, pathogen or nutritional problems. (**ISA Rating 60%**)* ***Poor*** *- Trees in this group are in degraded condition with irreversible problems. These can include dead branches representing 50% or more of the canopy, drastic deformities, multiple trunk cavities, and severe insect, pathogen or nutritional problems. (**ISA Rating 40%**)* ***Removal*** *- Trees in this category are either already dead or in such poor condition that removal is required. These trees have over 90% dead branches and/or have completely succumbed to insects, pathogens or nutritional deficiencies. (**ISA Rating of Less than 40%**)*	ISA TRAQ	Variety of instruments	Matheny, Clark, "Arboriculture" ISA BMP Tree Inventories 2014
Tree Risk Assessment – *(Following TRA field will repeat for Canopy, Truck, & Roots)*	**TRA-LoF**	Text, Dropdown Menu	Likelihood of Failure List Choices: *Imminent* *Probable* *Possible* *Improbable*	ISA TRAQ	Variety of instruments	Identifies the most probable failure and rates the likelihood that structural defect(s) will result in failure based on observed current conditions
Tree Risk Assessment	**TRA-LIT**	Text, Dropdown Menu	Likelihood of Impacting Target List Choices: *Very Low* *Low* *Medium* *High*	ISA TRAQ	Variety of instruments	The rate of occupancy of targets within the target zone and any factors that could affect the failed tree as it falls toward the target. Dunster, TRA Manual, 2014
Tree Risk Assessment	**TRA-LoFIT**	Text	Likelihood of Failure Impacting a Target *Matrix*	Analysis	Variety of Instruments	The likelihood of failure and target impact are combined in the matrix to determine the likelihood of tree failure impacting a target.
Tree Risk Assessment	**TRA-CoF**	Text, Dropdown Menu	Consequence of Failure List Choices: *Negligible* *Minor* *Significant* *Severe*	ISA TRAQ	Variety of instruments	The consequences of tree failure are based on the level of target and potential harm that may occur. Consequences can vary depending upon the size of defect, distance of fall for the tree or limb, and any other factors that may protect a target from harm. Target values are subjective, but efforts will be made to assess them from the City's perspective.

Category	Field Name	Data Type	Definition	Methods	Instruments	Rationale
Tree Risk Assessment	**TRA-RiskRating**	Text	Risk Rating *Matrix*	Analysis	Variety of instruments	The tree's risk rating is determined based on combining the likelihood of tree failure impacting a target and the consequences of failure in the matrix.
Tree Risk Assessment	**TRA-TargetNotes**	Text	Target Notes	ISA TRAQ	Variety of instruments	Any specific notes that may be necessary for the City in addition to the Risk Rating for tree and target management.
Maintenance	**MaintenanceNeeds**	Text, Dropdown Menu	Different maintenance categories will be collected List Choices: ***Immediate removal*** *- Trees designated as immediate removals are dead or have one or more defects that cannot be cost-effectively remedied.* ***Removal*** *- Trees designated as removals should be removed, but do not pose a liability as great as the immediate priority or pose minimal liability.* ***Immediate Priority Pruning*** *- Trees in this category require pruning to remove deadwood and/or broken branches that pose a potential risk to people or property. These trees have broken and/or hanging limbs, hazardous deadwood and dead, dying or diseased limbs or leaders greater than four inches in diameter.* ***High Priority Pruning*** *- Trees in this category require pruning to remove deadwood and/or broken branches that pose a potential risk to people or property. These trees have broken and/or hanging limbs, hazardous deadwood and dead, dying or diseased limbs or leaders greater than two but less than four inches in diameter.* ***Routine Pruning*** *- Trees in this category have characteristics that could become risks if not corrected. Deadwood is less than two inches in diameter.* ***Training Pruning*** *- This category includes trees less than 20 feet in height with correctable structural problems or minor amounts of deadwood that pose little or no threat of personal injury or property damage. Pruning at this stage is relatively inexpensive but can have significant effects in the future.* ***Stump Removal*** *- Tree stumps which are recommended for grinding to allow for future planting or to improve the appearance of the site.* ***Planting Location*** *- Locations where no tree exits but fit with current city standards for a tree location. Parameters include minimum 25 linear feet to the trunk of the nearest tree, minimum of 10 feet from fire hydrants, water lines, driveways and alley entrances, 25 feet from street light poles, 25 feet from street intersections, parkway must be at least three feet wide.*	Field	Tablet	Maintenance that needs to be undertaken by the City to maintain the trees health and also the vitality of the Urban Forest as a whole.
Overhead	**OverheadObstructions**	Integer, Free Form	Type of overhead conductors or other utilities that are present at the tree site *Free Form Number*	Field	Range finder	The type and location of the utility lines in reference to where the tree is located for management of the tree.