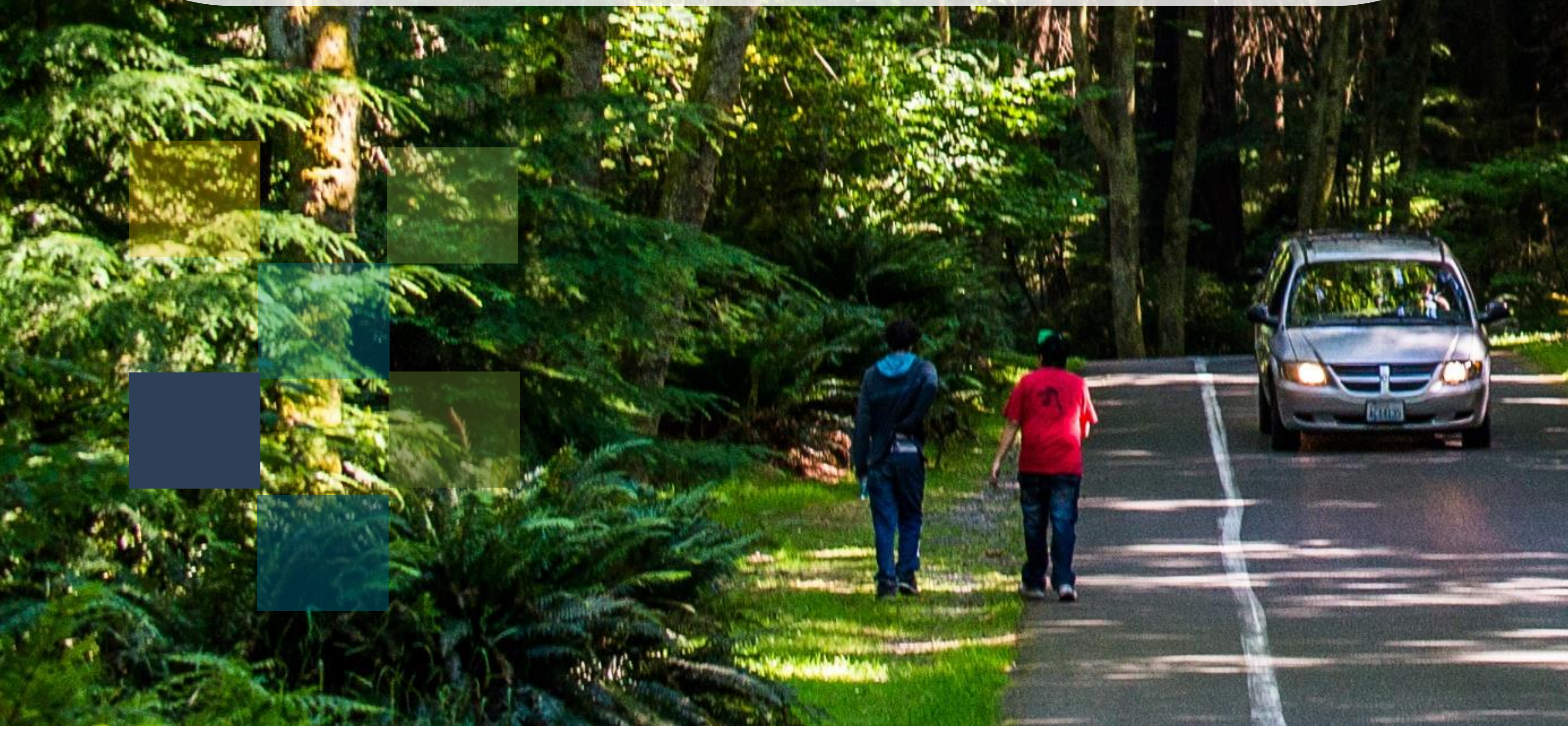
Element 4

High-Level and In-Depth Data Analysis

Purpose

To identify gaps in resourcing and coverage across the entire City's geography and identify urban forest readiness, health, and resilience.



Element #4: High-Level and In-Depth Data Analysis

Purpose

To identify gaps in resourcing and coverage across the entire City's geography using high-level data and identify urban forest readiness, health, and resilience using available inventory data.

Process

The City does not have a comprehensive inventory of all public trees but has high-level data describing the extent and distribution of the Citywide urban forest to conduct coarse analyses and summaries. Multiple in-depth inventory datasets describing various elements of urban forestry exist but, when combined, do not form a comprehensive cumulation of data to represent the entire public tree population.

For this reason, summaries were obtained from the high-level data and the in-depth inventories to appropriately describe the City's tree population where possible. The datasets used in these analyses include data from aerial tree canopy assessments (2011 and 2018), a sample tree inventory project (2019), the Tacoma Mall subsample inventory (2019), the Business Districts tree inventory (2010), MetroParks tree inventory (2019), the City Facilities tree inventory (2015), urban heat island studies (2019), and canopy correlation studies (2019).

Disclaimer: The inventory data only covers a percentage of the City, and although it can be used to decipher general trends, it cannot be used to characterize the entire urban forest.

It cannot be inferred to represent the entire City because there are significant gaps in data (i.e. incomplete or unavailable inventories for various land uses classes).

All tree inventory data except for the MetroParks tree inventory is available and maintained on the City's tree management software application known as TreePlotter (www.pg-cloud.com/TacomaWA). The data analyses and summaries were conducted within TreePlotter and a combination of Microsoft Access, Microsoft Excel, and ArcGIS (Geographic Information System). Supporting charts, graphs, and tables were created in Excel and were provided as a supporting resource as part of the project.

The ecosystem services and benefits of the inventoried tree population were calculated using the U.S. Forest Service's i-Tree suite of tools. Benefits and services are based on the species of tree, its size (diameter), and land use. The totals are summarized as annual amounts.

Each data analysis section includes a description of the purpose and intent of the summary as well as the key findings which are discussed in this planning element's Results section. Results and conclusions will be used to develop the Plan's strategies.

The data were analyzed and summarized in the following formats and approaches to inform the Plan's strategies:

Table 14. Summary of the data analyses conducted as part of the existing conditions audit

Summary	Description	Datasets Used
Tree Distribution	The extent of tree canopy cover and passive open space.	2018 Tree Canopy Assessment, 2011 Tree Canopy Assessment, Strategic 20-Year Passive Open Space Plan.
Urban Heat Islands and the Urban Forest	Correlations between tree canopy, surface temperatures, and public health.	2019 Urban Heat Island Study, 2018 Tree Canopy Assessment.
Environmental Justice and the Urban Forest	Correlations between tree canopy and sociodemographic factors.	2011 Tree Canopy Assessment, 2018 Tree Canopy Assessment, U.S. Census Bureau data
Tacoma Equity Index and the Urban Forest	The Equity Index uses 20 data points to determine where people are not able to access services or where services do not meet the community needs. Tree canopy is an indicator for the "Livability" category.	Various datasets for the Equity Index including the 2011 Tree Canopy Assessment.
Tree Diversity and Composition	The most common, variety, and assortment of public trees.	Aggregation of all tree inventory data.
Distribution of Tree Diameter Size Classes	The relative age classes and structure of public trees.	Aggregation of all tree inventory data.
Tree Condition	The qualitative description of the health of trees based on observations of tree roots, trunk, branches, and canopy.	Aggregation of all tree inventory data.
Tree Observations and Defects	Description of tree and/or site factors potentially impacting tree health, maintenance needs, or corrective actions necessary.	Aggregation of all tree inventory data.
Potential Tree Maintenance Needs	The tree maintenance activity or technique recommended to remediate tree issues and/or improve tree health and public safety.	Aggregation of all tree inventory data.
Cost-Benefit Analysis	Analysis of the tree population's structure to estimate the costs and benefits of that tree population.	Aggregation of all tree inventory data.

Results

Tree Distribution

The focus of this report is to provide summaries of existing conditions to inform the Urban Forest Management Plan's short- and long-term strategies. Understanding the extent and distribution of existing tree cover and opportunities for tree planting across land use boundaries, neighborhoods, ownership type, and various sociodemographic variables enables the City's tree managers to prioritize, target, and plan effective urban forest management and community outreach. A comprehensive understanding provides the framework for an effective Urban Forest Management Plan that addresses resource management, equity and accessibility, canopy health and growth, long-term funding, climate resiliency, enhanced ecosystem services and benefits, and community engagement and stewardship.

Tree canopy is used as an analogy for and measurement of environmental health. In 2010, City Council adopted a new chapter in Tacoma's Comprehensive Plan - the Urban Forestry Policy Element (UFP). This chapter initiated the vision for Tacoma to enhance urban forest resources, including increasing the tree canopy cover from approximately 19% in 2009 to 30% in 2030.

In response to the canopy goal and for effective urban forest management, the UW Remote Sensing & Geospatial Analysis Laboratory completed an analysis of 2009 data (aerial photos and LIDAR) in 2011, with funding support provided by the WA Department of Natural Resources Urban and Community Forestry Program. This assessment provided Tacoma with a baseline approximation of tree canopy cover extent. See Appendix E for a quick summary.

For an updated analysis of canopy extent and opportunities, the City contracted with consultants for a 2018 tree canopy assessment to identify canopy gains and losses using the latest technology and imagery available for even greater assessment accuracy. This assessment allows the City to implement strategies to achieve local and Citywide short- and long-term canopy goals and targets.

2018 Tree Canopy Assessment

In 2018, the City contracted with consultants to assess the extent of tree canopy cover and available planting space Citywide and by various GIS planning boundaries. This assessment utilized 2017 high-resolution (1-meter) multispectral imagery from the USDA's National Agriculture Imagery Program (NAIP) and 2017 LiDAR data from the Washington State Department of Natural Resources to derive the land cover data set. The NAIP imagery is used to classify all types of land cover, whereas the LiDAR is most useful for distinguishing tree canopy from other types of vegetation. The following provides a high-level overview of the results used to inform the Urban Forest Management Plan's short- and long-term strategies. For the full report and assessment metrics, see Appendix D.

Figure 5. Land cover classes for Tacoma based on 2017 NAIP Imagery and 2017 WA State DNR LiDAR

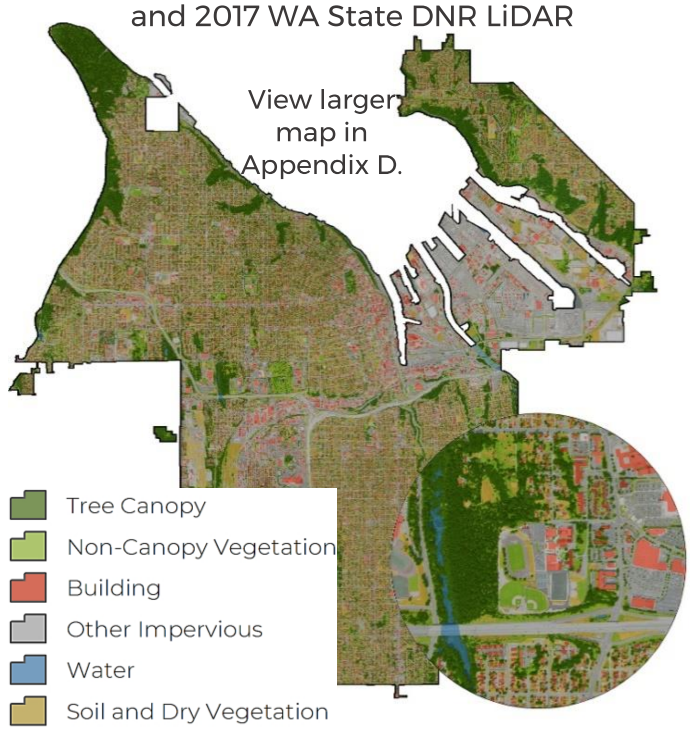


Table 15. Summary of the land cover data from the 2018 Tree Canopy Assessment

<table>
<tr><th>Tree Canopy Assessment Results</th><th>City Boundary</th><th>Tree Canopy</th><th>Impervious Surfaces</th><th>Non-Canopy Vegetation</th><th>Soil & Dry Vegetation</th><th>Water</th></tr>
<tr><td>Acres</td><td>31,607</td><td>6,406</td><td>16,344</td><td>4,257</td><td>4,469</td><td>132</td></tr>
<tr><td>% of Total</td><td>100%</td><td>20%</td><td>52%</td><td>13%</td><td>14%</td><td><1%</td></tr>
<tr><td colspan="4">Land use with the highest tree canopy %</td><td colspan="3">#1 Parks and Open Space (56%)
#2 Shoreline (21%)
#3 Single Family Residential (17%)</td></tr>
<tr><td colspan="4">Land use with the most space for tree plantings (includes vegetative and impervious areas)</td><td colspan="3">#1 Single Family Residential (2,318 acres
#2 Parks and Open Space (784 acres)
#3 Heavy Industrial (235 acres)</td></tr>
<tr><td colspan="4">Count of Census Blocks (CB) with >30% (target) canopy</td><td colspan="3">30 Census Blocks (15% of all CB's)</td></tr>
<tr><td colspan="4">Census Blocks with >10% available planting space</td><td colspan="3">163 Census Blocks (81%)</td></tr>
<tr><td colspan="4">Stormwater Basins with high percentage (~25% or >) of canopy heights over 100 feet</td><td colspan="3">North Tacoma (NT_01)
Western Slopes (WS_02)
Lower Puyallup (LP_05)
North Tacoma (NT_03)
Tideflats (TF_03)</td></tr>
</table>

Information such as the summaries provided in the table above provide meaningful direction for prioritizing tree plantings (available planting space) and tree preservation (existing canopy and greatest tree heights) to achieve canopy goals and targets.

For an example of how to establish canopy goals and targets, the City should utilize and implement the canopy cover analysis of the Neighborhood Business Districts (NBD) completed by Tacoma using the 2009 data. In order to assist the Urban Forestry Program with achieving canopy goals, particularly in the NBDs which were identified as priority planting areas by the Urban Forest Policy Element, the City further analyzed canopy cover data to give approximations of the canopy cover in each NBD to determine what amount of growth is needed in each District. The table below shows canopy cover by NBD in both actual and needed cover for the entire NBD and for the rights-of-way (ROW) within each Neighborhood Business District. This information ties in with the Strategic Urban Forest Management Plan (SUFMP) for Neighborhood Business Districts and the strategies in the Citywide Urban Forest Management Plan.

Tacoma is comprised of 20% tree canopy cover. Single-Family Residential land use has over 2,300 acres of space available for tree plantings. To increase tree canopy and achieve a 30% canopy goal, the City needs the support from its residents. **Use the canopy data to prioritize tree planting and preservation.**

Table 16. Canopy by Neighborhood Business District and canopy cover targets (2009 data)

Neighborhood Business District (NBD)	Percentage of Right-of-Way (ROW) in NBD	Actual NBD Cover	NBD Cover Needed	Actual NBD ROW Cover	NBD ROW Cover Needed
Portland Avenue	42.2%	2.4%	12.6%	0%	30%
South Tacoma	39.7%	0%	15%	0%	30%
Stadium	49.6%	4.9%	10.1%	4.5%	25.5%
6th Ave	41.3%	2.1%	12.9%	2.3%	27.7%
Proctor	41.2%	4%	11%	7.3%	22.7%
Oakland/Madrona	41.3%	7.1%	7.9%	0.2%	29.8%
Fern Hill	34.4%	7.3%	7.7%	2.8%	27.2%
Lincoln	37.7%	0%	15%	0%	30%
McKinley	48.1%	1.1%	13.9%	1.2%	28.8%
Narrows	43.9%	3.3%	11.7%	2.7%	27.3%
Dome	36.1%	1.9%	13.1%	1.8%	28.2%
Hilltop	43%	0.9%	14.1%	1.1%	28.9%
Ruston/Pt. Defiance	41.2%	2.6%	12.4%	0%	30%
Old Town	44.8%	2.8%	12.2%	1.2%	28.8%
Pacific	40.7%	3.4%	11.6%	0.9%	29.1%

The distribution of existing canopy cover and possible planting space across geographies is just one component of a multi-faceted approach to the urban forest strategies presented in this Plan.

To inform strategies in this Plan, the extent of canopy and available planting spaces were cross-examined with the tree inventory datasets and other studies such as the Urban Heat Island (UHI) study and the City's Equity Index.

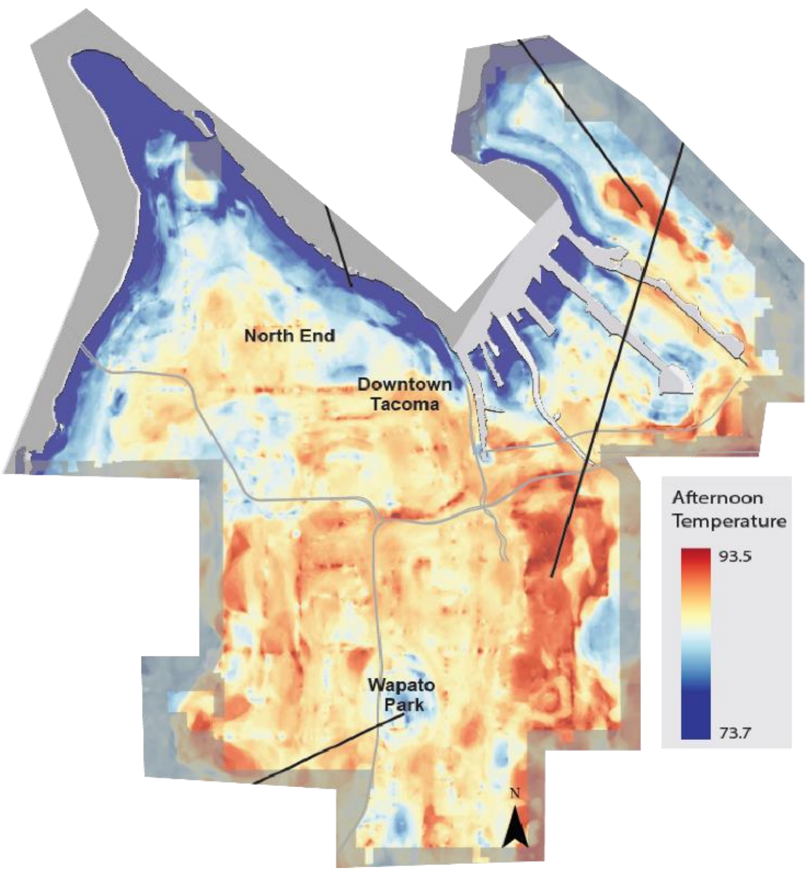
Establishing small-scale canopy goals and targets provides incremental steps in achieving a Citywide canopy goal of 30%. **In addition to Business Districts, canopy goals for other areas throughout the City will be established to achieve improvements in tree and human health equity.**

Tacoma Urban Heat Islands and the Urban Forest

In 2018, researchers from the Sustaining Urban Places Research (SUPR) Lab at Portland State University visited Tacoma to collect high resolution urban heat data with the help of local volunteers. Tacoma is one of the five cities chosen for the Canopy Continuum study, which examines the implications of landscape conditions, extreme heat events, and human health. Of the five cities that are part of the study, Tacoma contains the highest canopy cover, middle value of impervious surface cover, and is located in a dry-summer, wet-winter climate – all of which makes it a very important point of study. For more information on the purpose, approach, and results visit www.canopycontinuum.org.

The following maps provide an overview of how the tree canopy assessment data, tree inventory data, UHI data, and other supporting data can be utilized to inform tree planting and preservation approaches.

Figure 6. An urban heat island map showing afternoon temperatures



Also, in response to urban heat islands and the changing climates, the City's Environmental Services Department completed the Tacoma Climate Change Resilience Study in 2016. Information from this study is used to inform strategies in this Plan.

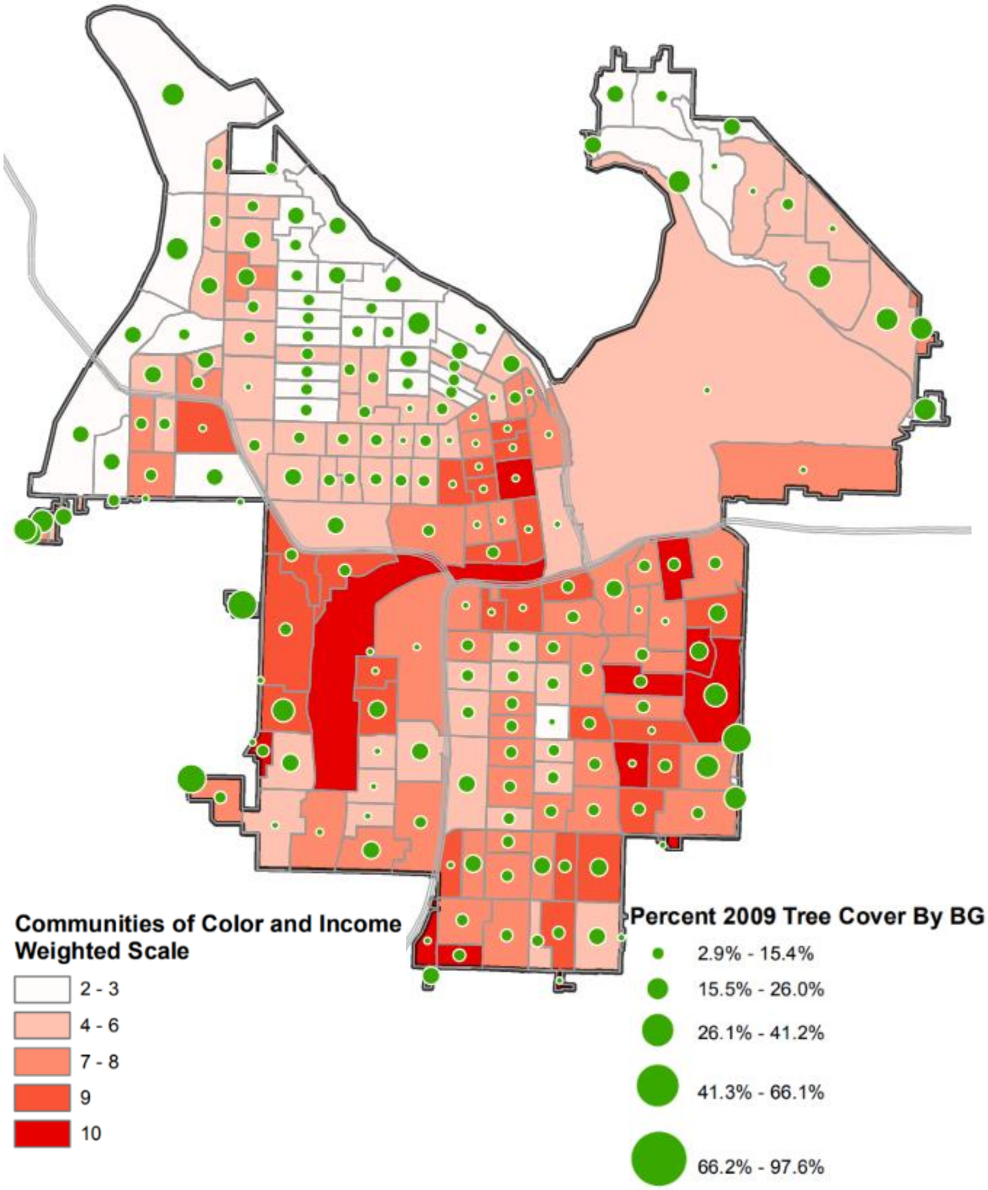
Trees provide many environmental benefits that have a direct positive effect on human health. Some of these benefits include cooling, air filtration, sun protection, and improved mental health. Yet, for all this to work, a host of challenges — funding constraints, lack of City tree maintenance responsibility, the design of Tacoma's streets, resident indifference or even resistance, the demands of utility companies — make it challenging to design a future with true tree equity in Tacoma. Trees are more than just scenery, they are critical infrastructure for the health, wealth, and well-being of communities. Distributing the cooling shade of trees more equitably across Tacoma is an essential strategy. Improving the City's tree equity improves the City's health equity.

Trees provide benefits in terms of cooling, air filtration, and sun protection.
Dense clusters of large trees with expansive canopies reduce the sun's heat energy.
Use the data to prioritize areas where trees can mitigate urban heat.

Environmental Justice and the Urban Forest

In a City where addressing inequity is a primary goal, canopy cover has been historically distributed in unequal measure. The City's impoverished areas tend to have less tree canopy than wealthier areas, a pattern that is especially pronounced in concrete-dense neighborhoods. The City is actively addressing canopy equity and the question of whether these trees will ever provide enough shade is critical to the health of people in Tacoma's hottest neighborhoods, as they face a future of increasingly intense summers, driven by the climate crisis. The urban heat island effect makes Tacoma hotter than surrounding suburbs. A major reason: many of the materials that define Tacoma's urban landscape — brick rowhouses, concrete sidewalks, black tar roofs, asphalt streets — are very effective at trapping, storing and then radiating heat. To cool neighborhoods, these materials could be removed or replaced with heat-repellent versions. Or some of the sun's heat energy could be prevented from reaching those materials in the first place by planting trees — especially dense clusters of large trees with expansive canopies.

Figure 7. Map showing communities of concern (2014) each symbolized by the percent of existing tree canopy (2009)



The City is actively addressing canopy equity because more shade is critical to the health of people in Tacoma's hottest neighborhoods, as they face a future of increasingly intense summers, driven by the climate crisis.

Improving the City's tree equity improves the City's health equity.

Tacoma Equity Index and the Urban Forest

The Equity Index is comprised of 20 indicators within the 2025 Strategic Plan goals; Accessibility, Economy, Education, and Livability. Tacoma 2025 represents Tacoma's vision for the future. With defined indicators and other ways to measure progress, it is a plan that guides where the City of Tacoma – as both a local government organization and a community – is going over the next 10 years. It is also a plan that helps the City direct its efforts and resources in ways that reflect the growing community's evolving needs. This Phase 1 Research Summary and the Urban Forest Management Plan are vital components to Tacoma 2025's vision as urban tree canopy cover is an indicator for the Livability category.

This Plan's strategies for prioritizing tree preservation and plantings will consider the Equity Index among other criteria such as population density and Tacoma's capacity and rate of growth. The following provides an illustration of the prioritization process for consideration.

Figure 8. Tacoma Equity Index showing equity opportunities and livability scores

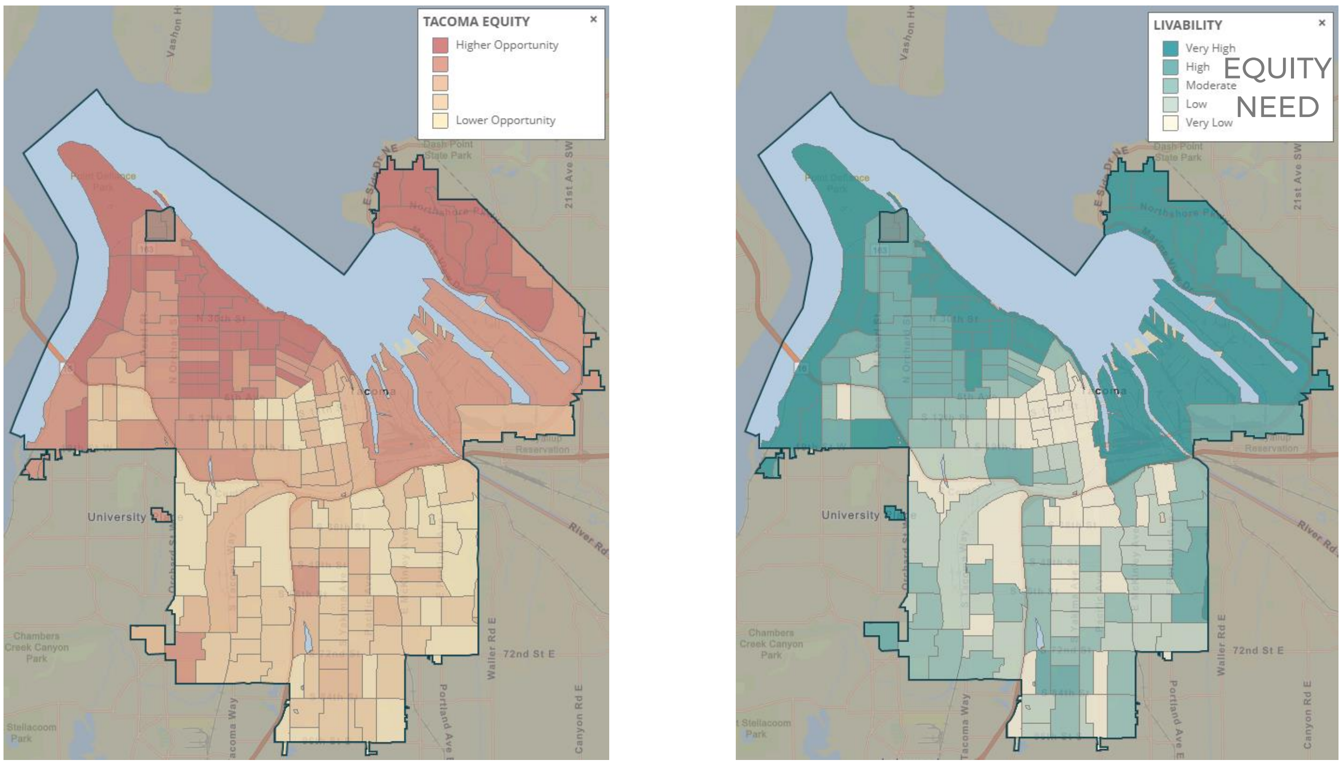
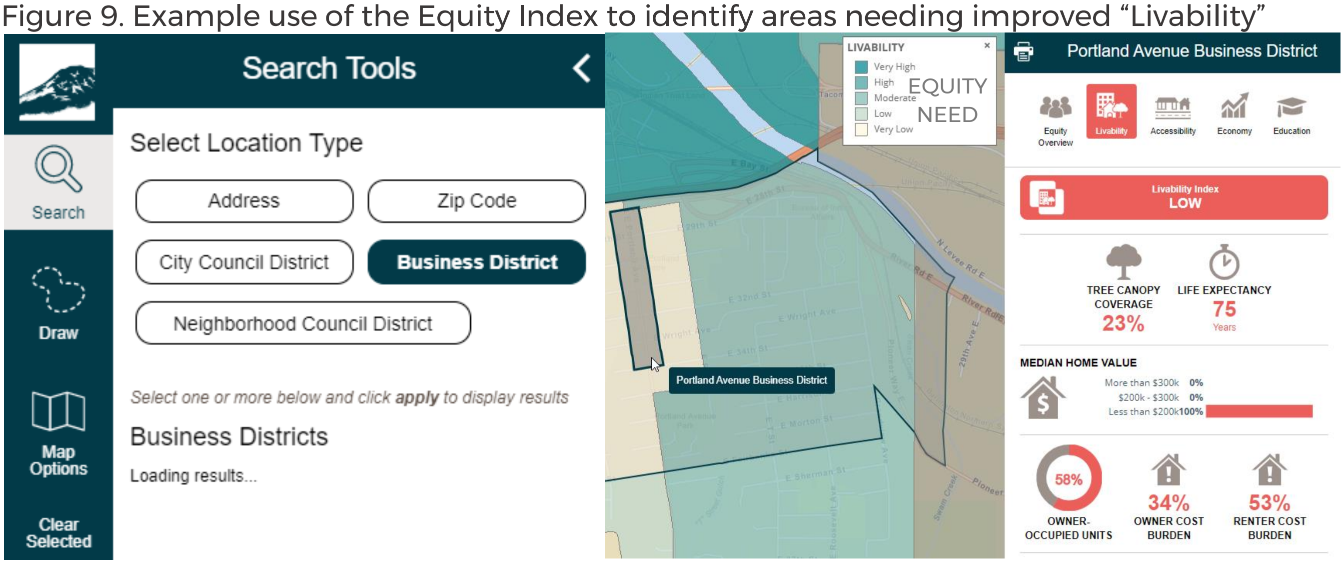


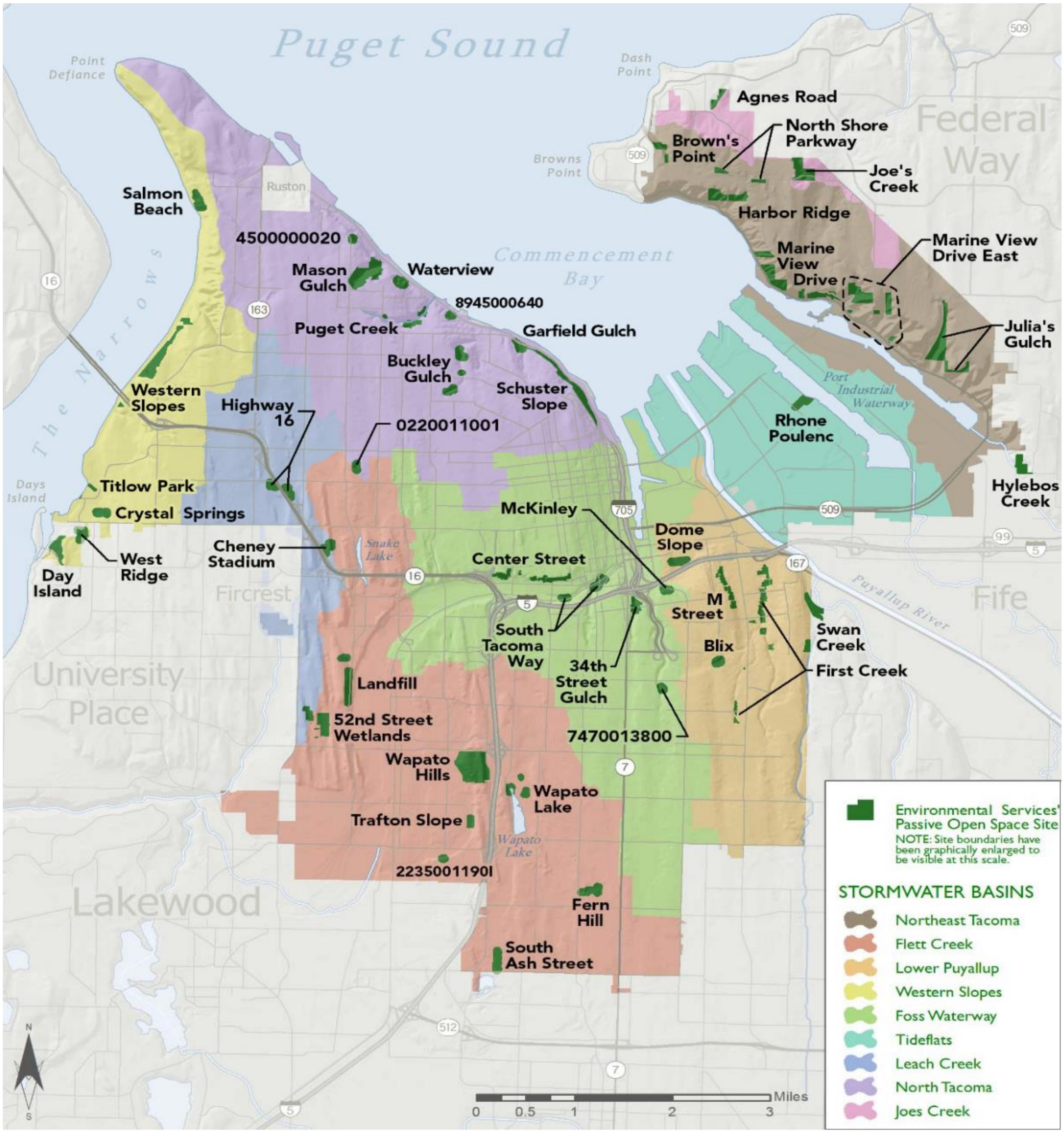
Figure 9. Example use of the Equity Index to identify areas needing improved "Livability"



Tacoma's Open Space and Critical Areas

In 2017, the City of Tacoma's Environmental Services Department, in partnership with Forterra and American Forest Management consulting firms, developed the Strategic 20-Year Passive Open Space Plan to provide a path forward for the active restoration and management of 496 acres of open space land. As described in the Passive Open Space Plan, many of the City's natural resources are held within open space properties. Open spaces, whether associated with active parks, passive natural areas or even non-publicly accessible spaces provide numerous public benefits to the City and its residents.

Figure 10. Tacoma's passive open space map (2017 Strategic 20-Year Passive Open Space Plan)



Map originally created by Forterra in partnership with the City of Tacoma

Restoring these lands is considered critical to the health and welfare of the citizens of Tacoma. Specifically, the Department is charged with managing passive open space (including many forested lands) for purposes of air quality, water quality and quantity benefits to the public. The intent of the plan is to articulate measurable goals and objectives, strategies for achieving these goals, and establish benchmarks for evaluating success and timing. To accomplish this, a complete analysis of all 496 acres of land managed by the Department was conducted. The results of the analysis provide the foundation for prioritizing restoration actions. To further guide prioritization and to ensure the ultimate success of this effort, a cost model was developed to determine the total cost of restoration and ongoing management of the City's passive open space lands.

Key Concerns Relating to the Urban Forest

Critical Areas

Historically, many passive open space areas have remained undeveloped and dedicated to open space because of terrain, the lack of development feasibility, or utility corridors. These areas are now threatened due to increased pressure to infill to meet the demands of increases in population and density. Many of Tacoma's passive open space properties consist of wetlands, buffers, and/or steep and unstable slopes. The Critical Areas Preservation Ordinance of the Tacoma Municipal Code (TMC 13.11) guides activities within critical areas (e.g., steep slopes, wetlands, wetland buffers, streams, stream buffers, and biodiversity areas/corridors.).

Past Tree Management Practices

In the past, many passive open space areas have been neglected and subject to mismanagement. In some areas, historic vegetation management techniques included the topping of trees which is currently prohibited within critical areas (TMC 13.11.210). This management technique was often used to enhance views and to reduce the height of a tree with minimal time or skill. However, this method starves the tree and leads to weaker and dense re-growth, and opportunities for pathogen and disease entry. This technique is not sustainable or healthy for the tree and where the tree is located on a steep slope, these actions increase the likelihood of slope instability by reducing soil binding root mass.

A host of other concerns exist for passive open spaces and are detailed in the Strategic 20-Year Passive Open Space Plan.

Assessment and Planning

Effective and efficient passive open space management can only be accomplished if planners, field staff and decision makers have the environmental information on which to prioritize and guide restoration actions. In 2015, the consulting firm, Forterra, conducted a forest habitat assessment to characterize habitat conditions across 496 acres of passive open space under management of the Environmental Services Department.

Baseline ecological data was collected using a rapid assessment data collection protocol called the Forest Landscape Assessment Tool (FLAT) developed by the Green Cities Research Alliance in collaboration with the U.S. Forest Service (www.fs.fed.us/pnw/research/gcra; see "Urban Landscape Assessment"). FLAT is based on the "Tree-iage" model, originally developed by the Green Seattle Partnership. Tree-iage is a prioritization tool, based on the concept of medical triage that uses habitat composition (e.g., canopy cover or native plant cover) and invasive plant cover as the two parameters to prioritize restoration.

Figure 11. Distribution of HMU acres across the Tree-iage Matrix established in the Passive Open Space Plan

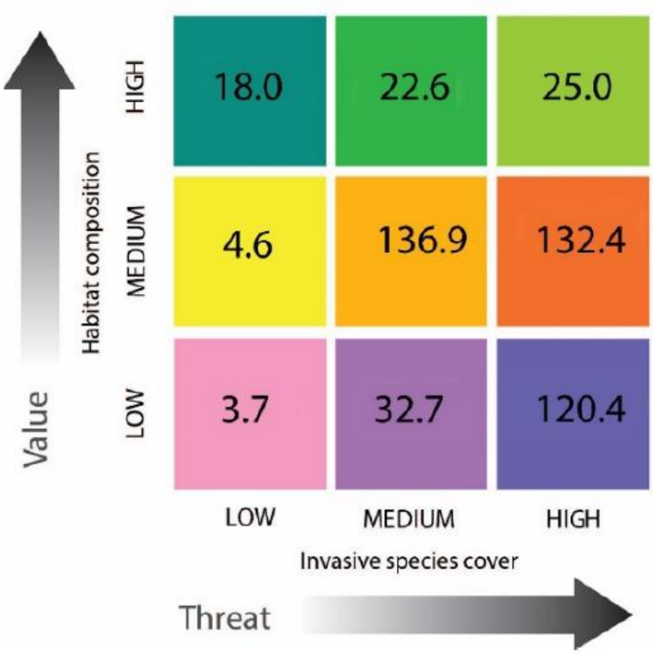
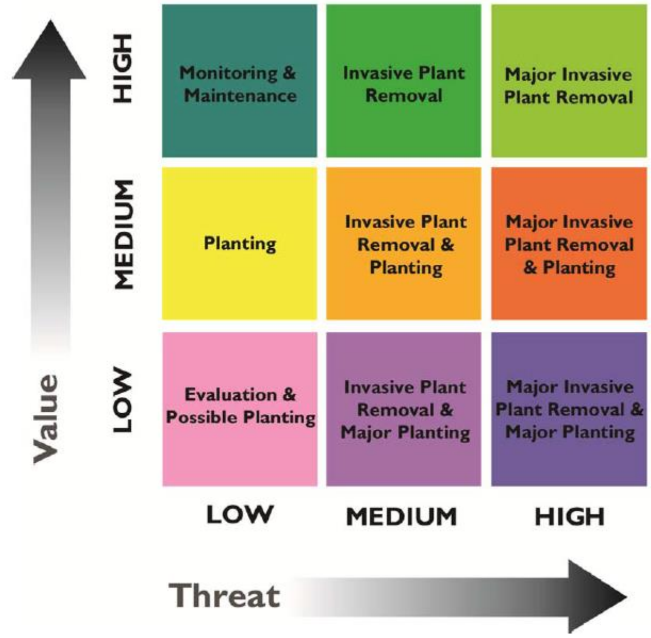


Figure 12. Restoration strategies and Tree-iage categories established in the Passive Open Space Plan



Prior to field data collection, passive open space areas were classified through digital orthophoto interpretation, dividing each tract of open space land area into one of five categories—forested, natural, open water, hardscaped, or landscaped Habitat Management Units (HMUs).

HMUs were assigned a value of High, Medium, or Low for habitat composition as well as for invasive species threats. Using the data gathered on all HMUs during the FLAT assessment, Tacoma's open space forest conditions were described. As seen in the figure, over 136 acres are in the medium category of habitat value and invasive species concerns.

As seen in the figure above, management strategies were established based on each HMU's assessment results. This assessment was used to provide prioritized restoration strategies over the 20-year planning and management horizon for each HMU comprising the 496 total acres of passive open space.

Implementation of the strategies are supported by extensive cost modeling provided in the Passive Open Space Plan. Passive open space areas identified in the plan will continue to face threats from invasive species, habitat fragmentation, adjacent land impacts and other influences that prevent native species from regenerating. To maintain the overall health and ecosystem functions of these passive open space areas, the Department should engage in active management and restoration. These activities will be guided by the plan and supported by this Plan and ensure that these lands are managed for stormwater quantity and quality benefits for the citizens of Tacoma and as charged in the mission of the Environmental Services Department.

Passive open space is a component of Tacoma's urban forest and provides substantial environmental, social, and economic benefits.
Strategies for maintaining these ecosystems are being implemented using the assessment, supported by this Plan.

In-Depth Analysis of Tacoma's Public Trees Using Aggregated Data

All available, current, and relevant data pertaining to Tacoma's urban forest was gathered and aggregated as part of the Urban Forest Management Plan's auditing processes. Data for trees in public rights-of-way, parks, Business Districts, City facilities, Tacoma Mall Subarea, and Metro Parks was attained from the City and/or collected by the project consultants. The collection of data was provided in Microsoft Excel spreadsheets or accessed via the City's tree inventory management software, TreePlotter (www.pg-cloud.com/TacomaWA).

Since each dataset contains varying degrees of attributes, completion, accuracy, and maintenance, the information was carefully examined to determine relevant data summaries for this report and data to be applied to the Urban Forest Management Plan. The following provides the summaries of the aggregated datasets.

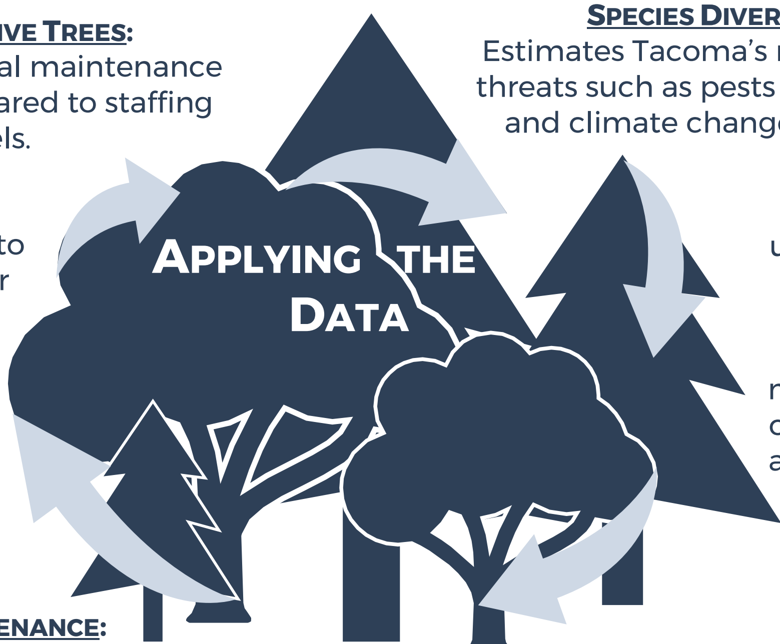
The following summaries use an aggregated tree inventory dataset to provide generalized urban forestry trends Citywide. These summaries describe Tacoma's urban forest structure, condition, potential maintenance needs but are not assumed to depict exact characteristics of Tacoma's urban forest. Comprehensive accurate data assessments can only be made through statistical analyses or a complete inventory of all public trees.

Figure 13. Summary of methods for applying the in-depth data analysis results

The following provides suggested applications of the data as presented in this section.

COUNT OF LIVE TREES: Estimate potential maintenance demands compared to staffing levels.

SPECIES DIVERSITY: Estimates Tacoma's resiliency to threats such as pests and disease and climate change impacts.



TREE BENEFITS: Use these values to build support for urban forestry, acquire tree planting grants, and ensure equitable distribution is pursued.

SIZE CLASS: An uneven-aged urban forests balance and normalize tree maintenance costs while providing the most sustainable flow of ecosystem benefits and services. Prevents surges of maintenance demands.

TREE MAINTENANCE: Though no comprehensive data exists, maintenance needs and costs can be extrapolated for a given area or used as an example of the need on a small scale the potential projection of the Citywide need.

TREE DEFECTS: Defects are indicators of tree issues and the type and frequency can inform urban forest management needs.

CONDITION: A healthy urban forest provides more benefits, reduces costs, and indicates sustainable urban forestry.

Tree Inventory Data Overview

Table 17. Summary of key attributes from the various tree and planting site inventories for Tacoma

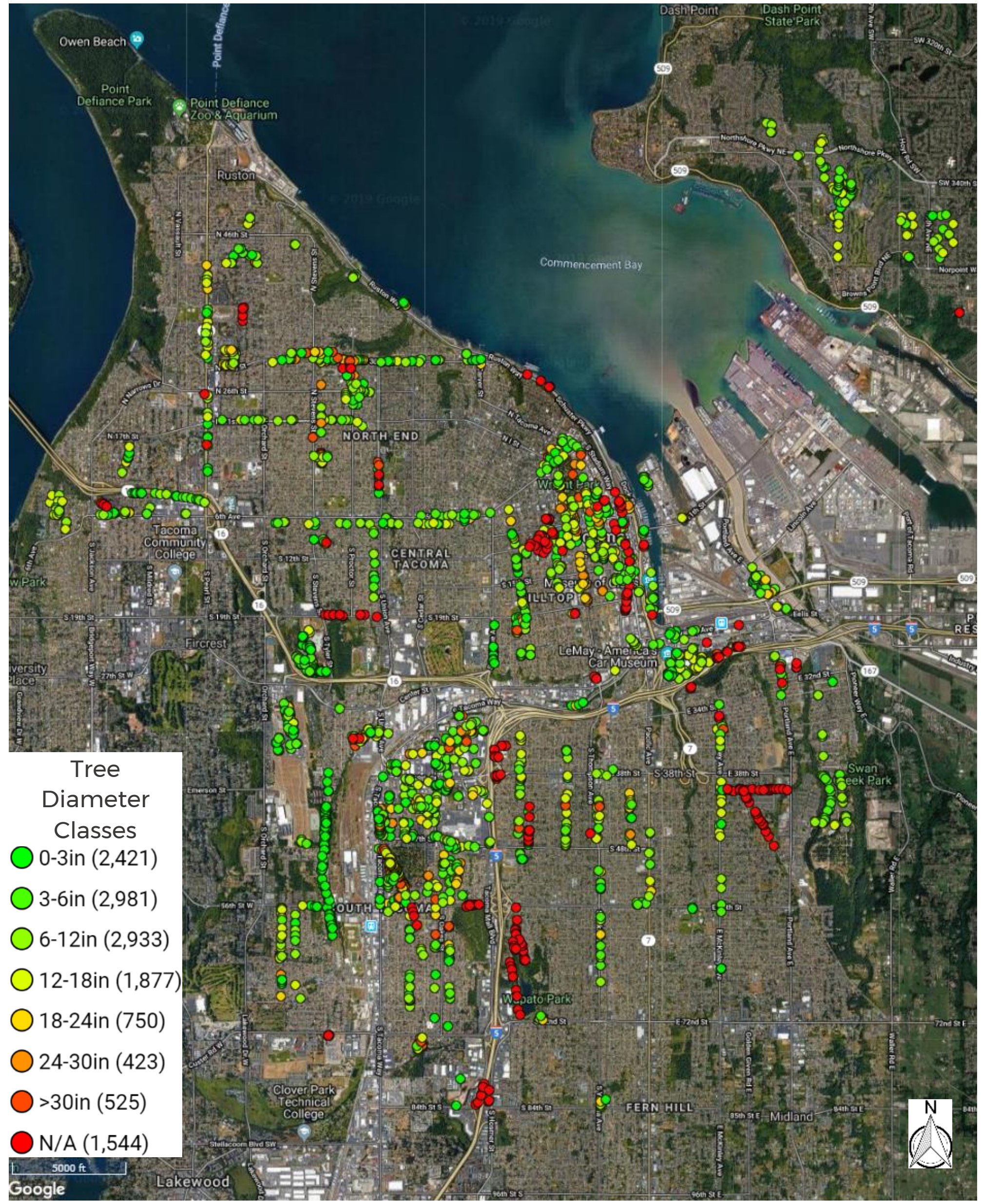
	2019 Sample	Tacoma Mall Public	Tacoma Mall Private	Business Districts	City Facilities	Metro Parks
Data Points	4,143	3,555	2,081	2,131	1,962	9,016
Live Trees	4,121	2,011	2,051	1,221	1,948	6,505
Planting Sites	N/A	1,517 Large (41%) Small (37%) Medium (22%)	N/A	906 Large (21%) Medium (40%) Small (39%)	N/A	N/A
Genera Count	68	62	45	37	57	129
Common Genera	*Acer* (22%) *Prunus* (19%) *Fraxinus* (7%)	*Acer* (17%) *Pseudotsuga* (15%) *Quercus* (12%)	*Acer* (14%) *Pseudotsuga* (11%) *Thuja* (7%)	*Pyrus* (21%) *Acer* (15%) *Prunus* (14%)	*Acer* (18%) *Chamaecyparis* (10%) *Prunus* (9%)	*Acer* (15%) *Pseudotsuga* (14%) *Quercus* (6%)
Species Count	165	123	89	64	112	431
Common Species	Cherry plum (11%) Nor. maple (9%) Green ash (6%)	Douglas fir (15%) OR white oak (10%) Red maple (5%)	Douglas fir (11%) Red maple (7%) Arborvitae (5%)	Flowering pear (21%) Cherry plum (13%) American sweetgum (7%)	Japanese cherry (7%) Red maple (5%) Hinoki cypress (5%)	Douglas fir (14%) Western red cedar (4%) Red maple (3%)
Common Size Class	3-6-inch (26%)	3-6-inch (23%)	3-6-inch (46%)	7-12-inches (36%)	3-6-inch (32%)	N/A
Average Diameter	10.1 inches	12.3 inches	6.4 inches	7.6 inches	8.9 inches	N/A
Largest Diameter	68 inches	84 inches	40 inches	56 inches	63 inches	N/A
Common Condition	Good (46%)	Good (50%)	Good (53%)	Good (70%)	Fair (59%)	N/A
Poor/Dead Condition	Poor (7%) Dead (1%)	Poor (7%) Dead (1%)	Poor (5%) Dead (1%)	Poor (10%) Dead (2%)	Poor (3%) Dead (1%)	N/A
Tree Work Priorities	Clearance Prune (8%) Sidewalk Damage (5%) Remove (3%) Routine Prune (3%)	Clearance Prune (19%) Remove (4%) Sidewalk Damage (2%)	(N/A) Observations: Co-dominant stems (44%) Dieback (31%) Trunk decay (28%)	Routine Prune (65%) Removal (27%)	Routine Prune (52%) Remove (3%) Stake Removal (1%)	(N/A) Reason for Removals: Unknown (26%) Construction (15%) Disease/Pests (14%)
Appraisal				$1,642,550	$4,176,170	N/A

Summary of Aggregated Tree Inventory Data

Table 18/Figure 14. Summary of all tree and planting site data available for the City of Tacoma and a location of the data points

Data Points*+	17,870 trees
Live Trees**	13,452 trees
Planting Sites	2,423
Genera Count*	137
Common Genera*	*Acer* (17%), *Prunus* (9%) *Pseudotsuga* (9%), *Quercus* (5%) *Pyrus* (4%), *Fraxinus* (4%) *Thuja* (4%), *Pinus* (4%) *Chamaecyparis* (3%), *Betula* (3%)
Species Count*	525
Common Species*	Douglas fir (9%) Red maple (5%) Norway maple (4%) Flowering pear (4%) Cherry plum (4%)
Common Size Class*	3-6-inch (31%)
Common Condition	Good (48%)
Poor/Dead Condition**	Poor (5%) Dead (0.4%)
Land Use Distribution**	Single Family (26%) Industrial (24%) Park/Vacant (20%) Small Commercial (10%) Multi Family (6%) Not Specified (14%)
Grow Space**	Large – 8ft+ (25%)
Average Diameter	9.4 inches
Tree Task** **Tree Defect****	Clearance Prune (1,734) Co-dominant stems (2,571)
Appraisal*	$6,215,610***

*From spreadsheet databases
**From TreePlotter online reports
***Values in spreadsheet obtained from the Council of Tree and Landscape Appraiser's Trunk-Formula method for appraisals. Does not represent the entire 13,452 trees in spreadsheet databases.
+Not in this summary: Univ. of Puget Sound's 1,500 tree database (32% Douglas fir, 11% western redcedar, 22% 3 to 6" DBH.



Tree Diversity and Composition

Tree species composition data are essential since the species and size of trees present in a city greatly affect the level of benefits produced, tree maintenance activities, budgets, planting goals, canopy connectivity, and the City's ability to respond to threats from invasive pests and diseases. Low species diversity (large proportion of the population consisting of trees of the same species) can lead to severe losses in the event of species-specific epidemics such as the devasting results of tree pests and diseases. Tree species diversity is crucial to the resilience of the urban forest from these and future unknown threats.

Figure 15. Tree genera diversity (all data)

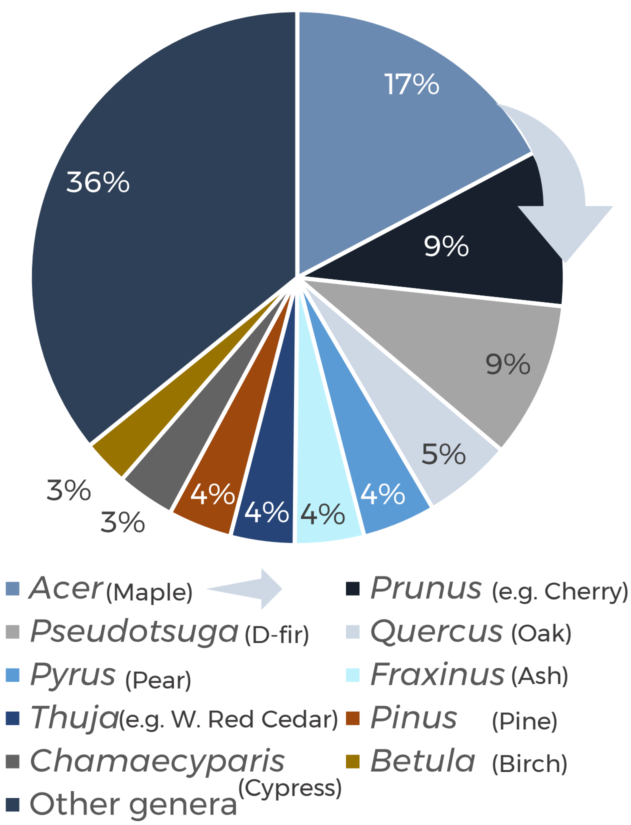
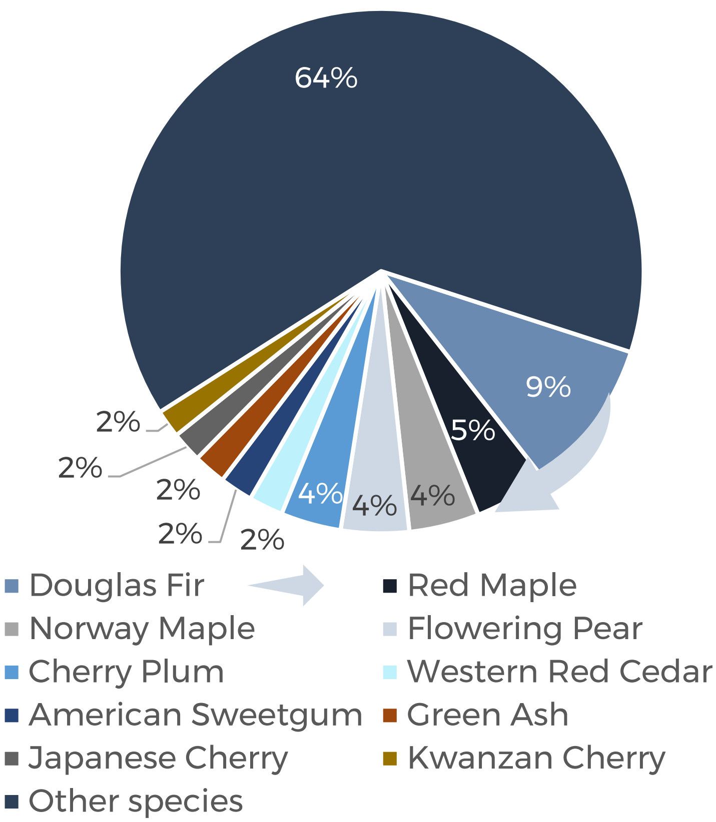


Figure 16. Tree species diversity (all data)



Findings

Based on the aggregated datasets, there exists a total of 137 unique tree genera across this City. The top five most common genera include *Acer* (17%), *Prunus* (9%), *Pseudotsuga* (9%), *Quercus* (5%), and *Pyrus* (4%). Tree species within these five genera amount to a total of 8,214 trees or 46% of the population.

Regarding tree species diversity, there exists a total of 525 unique tree species, an impressive statistic for an urban forest. The most prevalent species are comprised of 9% (1,688) Douglas firs, 5% (808) red maples, 4% (771) Norway maples, 4% (749) flowering pears, and 4% (664) cherry plums.

It should be noted that this is based on the 17,870 live trees summarized from the April 2019 sample inventory, the Tacoma Mall Subarea inventory, City facilities, Business Districts, and Metro Parks datasets, so it is not necessarily representative of the entire City.

5 tree genera account for 46% of the population (8,214 trees).
Tacoma boasts a diverse urban forest (525 unique species).
Use this data to inform selection of tree species for new plantings.
(Based on available data, not all public trees represented)

Distribution of Tree Diameter Size Classes (Relative Age)

The distribution of tree ages influences the structure of the urban forest as well as the present and future costs to the City or property owners. An uneven-age urban forest offers continued flow of benefits and a more uniform workflow allowing managers to more accurately allocate annual maintenance funds. For instance, large mature trees may require more maintenance to keep them in a healthy condition, so a population made of all large trees could be more expensive. The aggregated dataset of trees was categorized into the following diameter size classes: young trees (0-3 and 3-6 inches DBH or diameter at breast height measured at 4.5 feet), established (6-12 inches DBH), maturing (12-18 and 18-24 inches DBH), and mature trees (24-30 and >30 inches). Since tree species have different lifespans and mature at different diameters, heights, and crown spreads, actual tree age cannot be determined from diameter size class alone. However, general classifications of size can be extrapolated into relative age classes.

Figure 17. Tacoma's diameter distribution (all datasets*) compared to the McPherson Ideal Distribution

*Metro Parks data not included

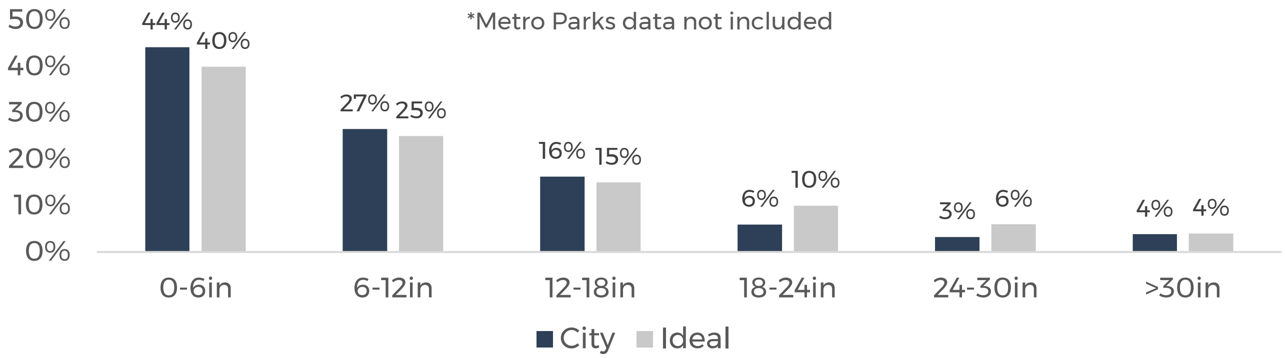
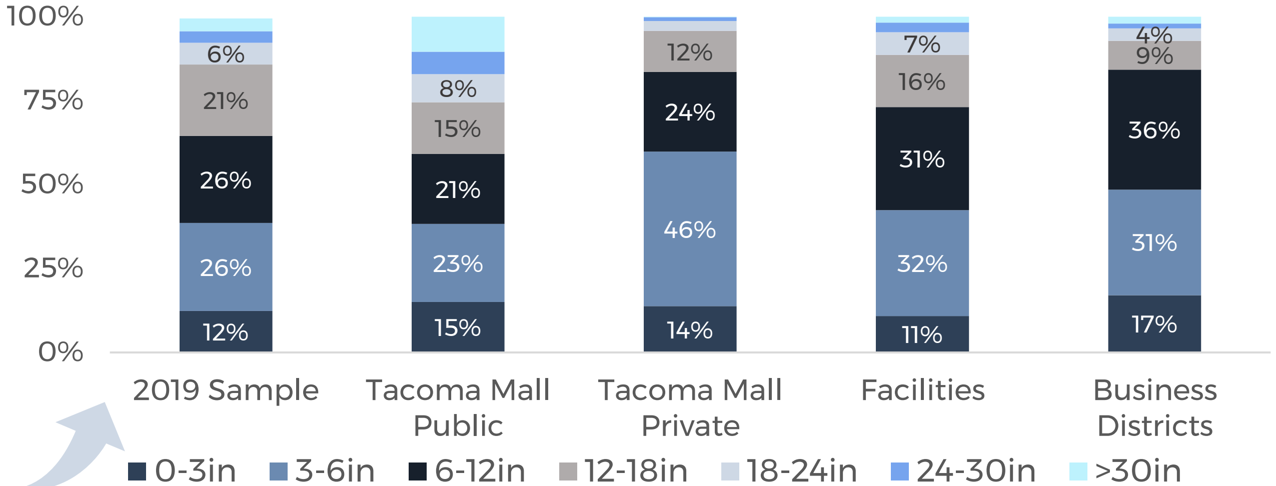


Figure 18. Diameter distribution for each inventory dataset



Findings

The diameter classes were chosen so that the tree population could be analyzed according to the McPherson ideal distribution (McPherson, Soares et al. 2011). Based on the analysis, the distribution trends towards the ideal; there is an adequate distribution of young trees (44%) and established trees (27%). The City's level of maturing trees (trees in the 18-24-inch range) is below the ideal distribution levels.

Most trees are in trees in the 0-6 inch size class (44%).
Young tree pruning may reduce future maintenance costs.
(Based on available data, not all public trees represented)

Condition of the Public Trees

Tree characteristics and outside forces affect the management needs for urban trees. An analysis of the condition enables managers to plan the urban forest and target outreach to property owners and the community as a whole. Tree condition indicates how well trees are managed and how well they perform given site-specific conditions.

The condition of individual trees was summarized based on the information available in the 2019 sample inventory, Tacoma Mall Subarea inventory, Business Districts, City facilities, and Metro Parks datasets. Commonly, several factors are considered for assessing a tree's condition including root characteristics, branch structure, trunk, canopy, foliage condition, and the presence of pests. The condition values consist of Excellent, Good, Fair, Poor, or Dead.

Figure 19. Summary of tree condition Citywide (all data)

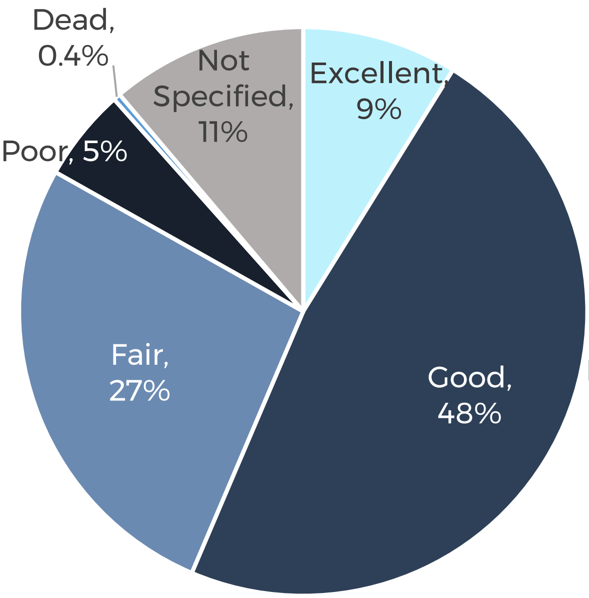
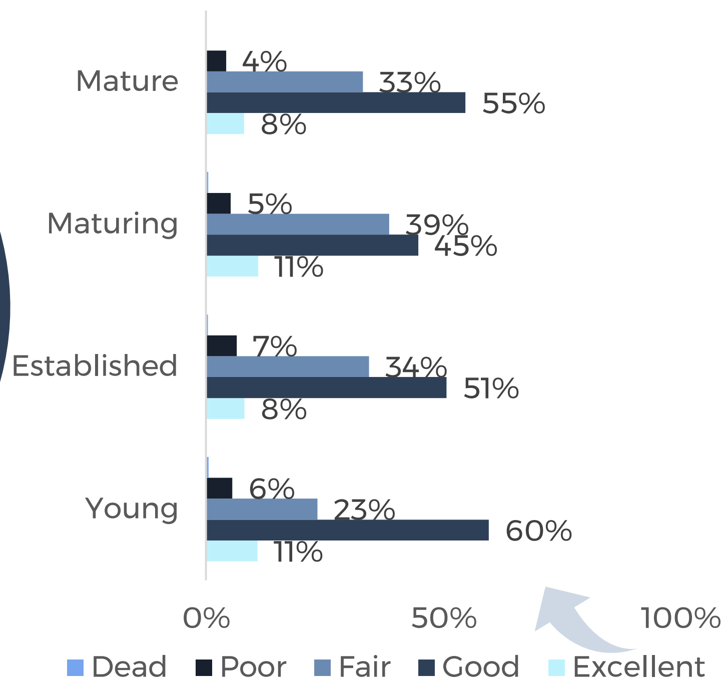


Figure 20. Summary of tree condition by age classes



Findings

Tree condition summaries were performed using the City's TreePlotter application rather than the Excel spreadsheets since the software application provides the means to more frequently update and maintain tree condition values. It should be noted that the condition of trees may have changed since the drafting of this report.

Of the 13,452 trees in the City's TreePlotter, nearly half of the trees are in Good condition with a total of 6,400 trees or 48%. There are a total of 3,596 (27%) trees in Fair condition and 1,189 (9%) trees in Excellent condition. Only 5% were reported in Poor condition and less than 1% are Dead. There are 1,505 trees without a condition rating specified.

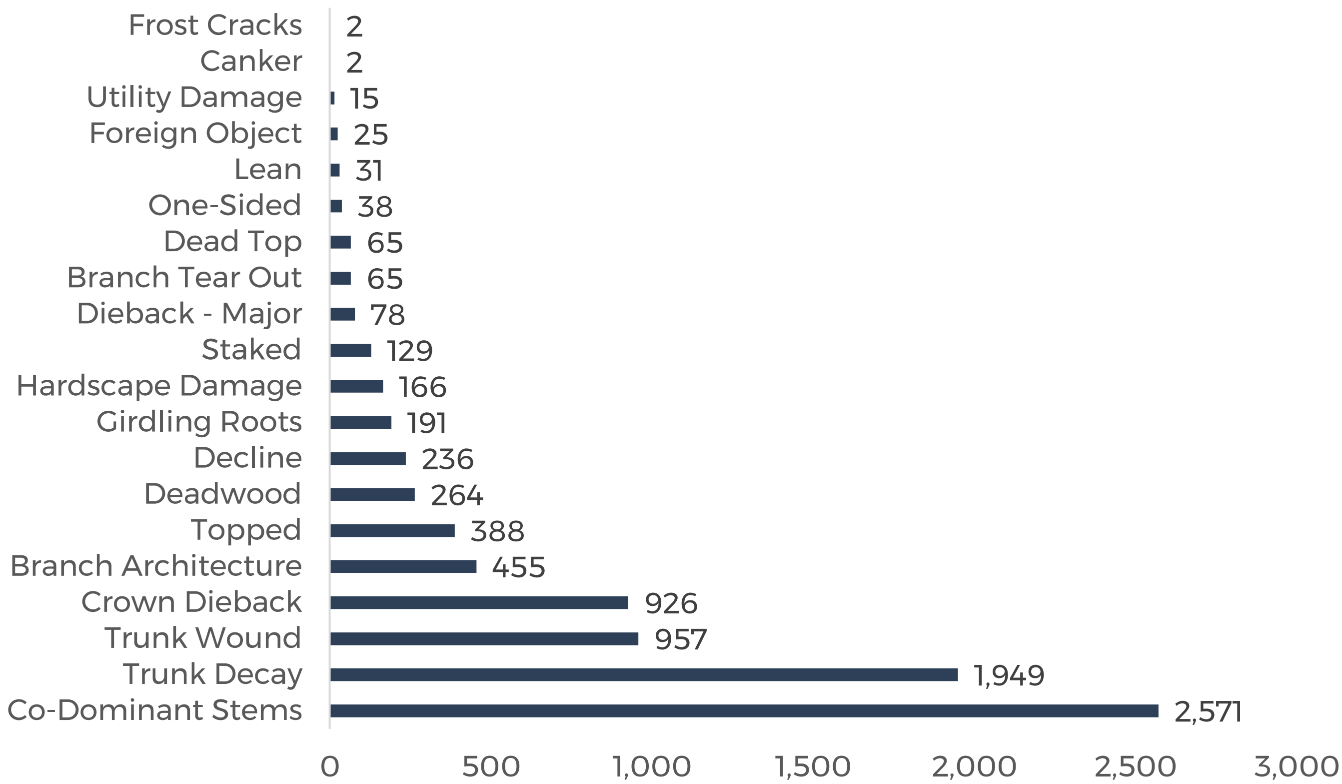
In addition, the condition was summarized by relative age classes. Most trees in all age classes are in Good condition. A higher distribution of Fair trees (39%) exists in the maturing age class and the established age class has the highest distribution of Poor conditioned trees with 7%.

Most trees are in Good condition (48%).
Young trees in Fair Condition (23%) may improve with maintenance.
(Based on available data, not all public trees represented)

Tree Observations and Defects

Observing and recording tree defects and features during tree inventory activities help to inform managers of existing and potential issues facing trees as well as the possible causes of defects observed. Understanding the cause of these defects can inform managers of future communications, management, protection, and planning needs.

Figure 21. Summary of observed defects (all data)



Findings

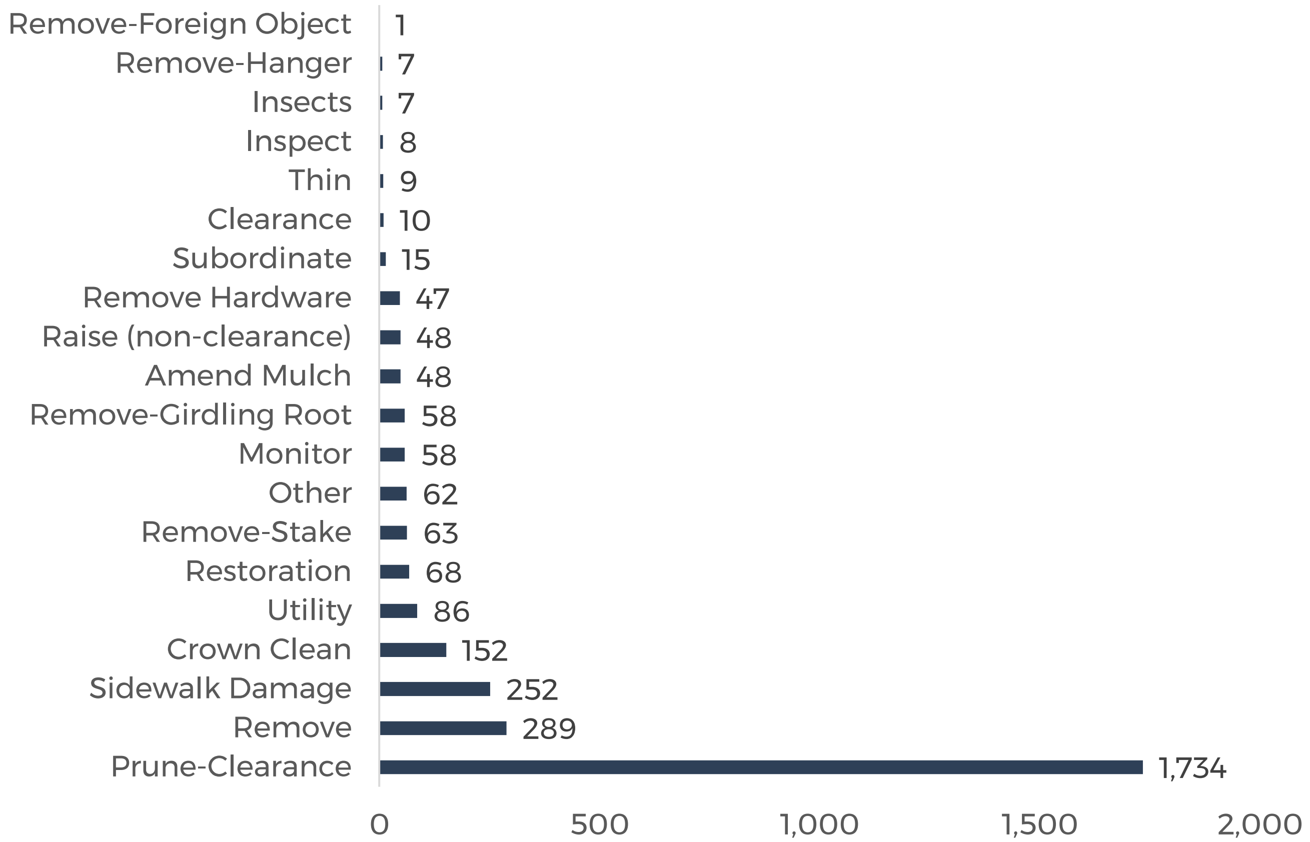
A total of 4,908 trees (36%) were recorded as having a defect. The most common defect observed was the presence of co-dominant stems (2,571 trees). A total of 1,949 trees were recorded as having trunk decay. Over 900 defects were recorded for both trunk wounds and crown dieback. The total number of defects recorded was 8,553 records meaning some trees had multiple defects. It should be noted that this information is based on the 13,452 living trees in the City's TreePlotter software application.

5,161 (60%) of recorded defects could potentially have been avoided.
These include utility damage, hardscape damage, girdling roots, topped, branch architecture, and trunk wounds.
Use this data to enforce best practices in tree care.
(Based on available data, not all public trees represented)

Potential Tree Maintenance Needs

An analysis of the potential maintenance requirements enables managers to plan the urban forest and target outreach to property owners and the City as a whole. Tree maintenance needs are inventoried for public safety reasons and for the health and longevity of the trees though a complete and comprehensive dataset is not available at this time. The following summaries provide an overview of potential maintenance needs based on the data available in the City's TreePlotter software application. It should be noted that as the City and adjacent property owners actively maintain trees, these values may change, and may have done so since the writing of this report. For cities with the responsibility of maintaining trees in the public rights-of-way, data such as maintenance needs provides tree managers with an understanding of the demands, frequency, and concentration to establish daily work plans and prioritize maintenance and planting.

Figure 22. Recommended tree maintenance tasks (all data)



Findings

A total of 2,715 trees were given a recommended tree maintenance task and a total of 3,022 tree tasks were assigned, meaning some trees have multiple recommended tasks. Clearance pruning is the most recommended maintenance task with 1,734 trees (57%). A total of 289 trees are recommended for removal.

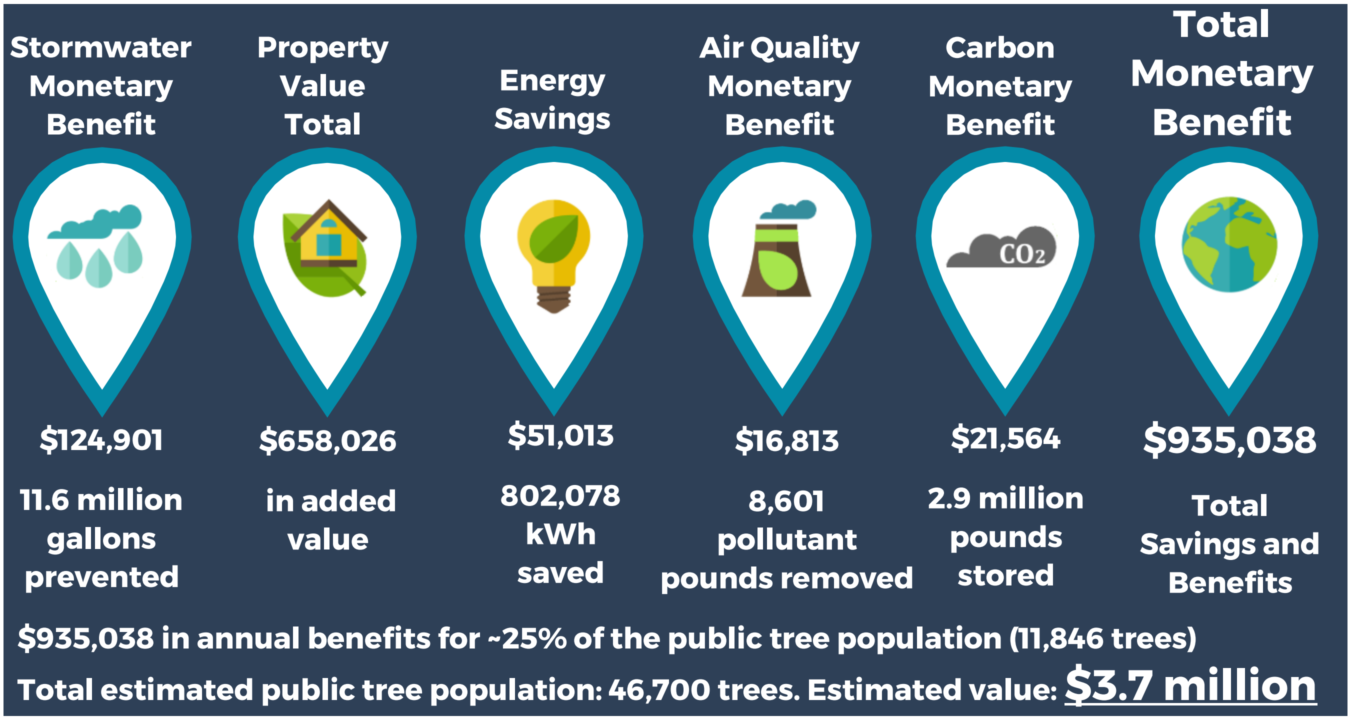
Most trees require pruning for clearance (57%)
or a routine pruning (11%).

A complete inventory will provide a comprehensive understanding of the maintenance needs.

(Based on available data, not all public trees represented)

Cost-Benefit Analysis of Tacoma's Urban Forest

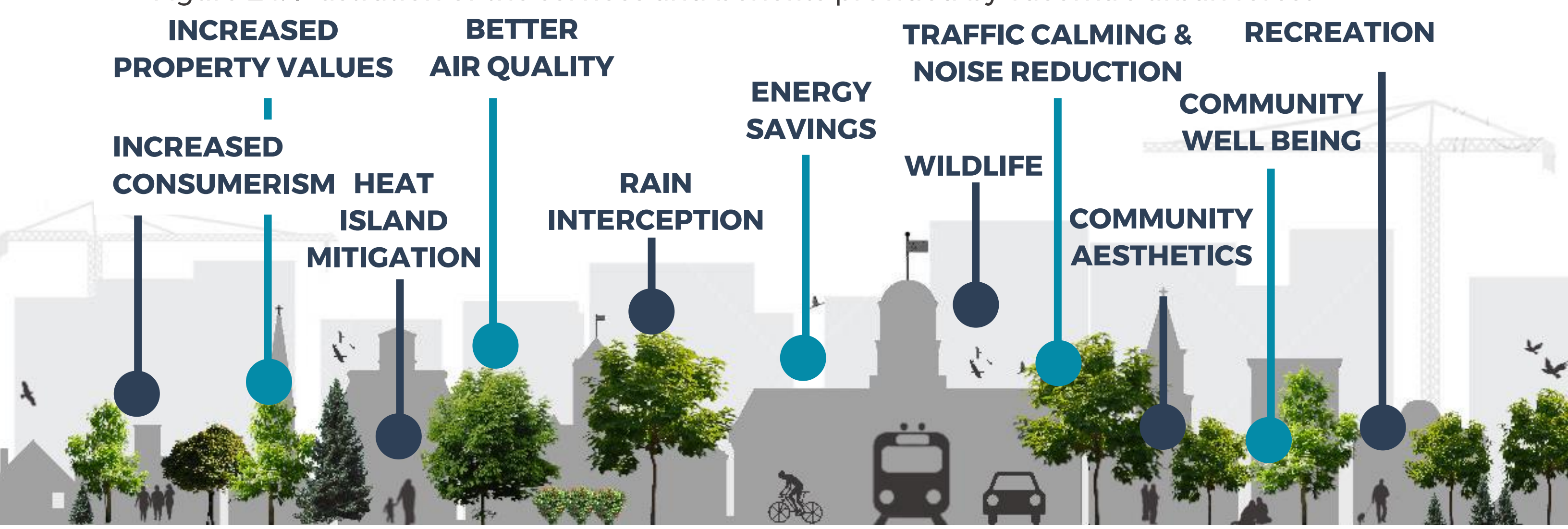
Figure 23. Summary of annual ecosystem services and benefits of Tacoma's trees (sample)



A total of 11,846 (88%) of the 13,452 total trees in the City's tree inventory management software, TreePlotter, have data to enable calculations of ecosystem services and benefits. In addition to the summaries provided in the figure above, the inventoried trees provide over $72,700 in annual natural gas savings by preventing heat use by 80,235 Therms. Nearly 1.4 million pounds of carbon are sequestered annually and nearly 1.8 million pounds of carbon are avoided. Based on the estimated population of Tacoma in 2017 and the number of trees with ecosystem benefit values, the inventoried trees in the City provide nearly $4.40 in benefits per capita and average $79 in annual benefits per tree. With an estimated total public tree population of 46,700 trees, this equates to approximately $3.7 million in total benefits.

This information, in conjunction with tree maintenance costs and costs for replacement, provide summaries of the costs-to-benefits of the City's public (partial) tree inventory population.

Figure 24. Illustration of the services and benefits provided by Tacoma's urban forest



Conclusion

The analysis of existing tree inventory datasets has been presented in this section. As noted, not all data can be used to represent the Citywide urban forest. The following provides an interpretation of the data as presented in this section.

Tree Canopy, Urban Heat Islands, and Environmental Justice

The results of the 2011 and 2018 tree canopy assessments can be used to develop a continuing strategy to protect and expand Tacoma's urban forest. The existing canopy and possible planting area data can be used as a guide to determine where the City has been successful in protecting and expanding its urban forest resource, while also targeting areas to concentrate future efforts based on needs, benefits, and available planting space. Tacoma can use these results to ensure that their urban forest policies and management practices continue to prioritize its maintenance, health, and growth.

This Plan's recommendations and strategies for achieving a 30% canopy goal by 2030 will use the data from these studies to prioritize tree plantings while addressing urban heat island issues and environmental justice. To plant for the future, trees need to be chosen that can cope with hotter, drier summers, wetter winters with more extreme storms, less snowpack and smaller water reserves.

Trees, planted to achieve the canopy goal, are most susceptible to disease or drought in their first years. Anything Tacoma plants will need adequate care or be tolerant to salt, pollution, wind, and drought, especially if City water restrictions come into effect as they have in the past.

In order to get to the 30% canopy by 2030 goal, the City and its partners must engage the community. As the data shows, most tree canopy and available planting space resides on residential land. In a sense, community residents are the wardens of the urban forest and its associated benefits. Preserving and enhancing the urban forest must be a collaborative effort.

Tree Diversity and Composition

The aggregated dataset is not a complete dataset of all public trees but is adequately comprehensive to provide meaningful results to inform future urban forest management. Based on the data, the City is at several diversity thresholds. It is generally recommended that an urban forest not be comprised of more than 20% of any tree genus and no more than 10% of any tree species. While this guidance may be an umbrella recommendation, it does provide information for selection of tree species for future plantings. There are an abundant number of maples (*Acer*) and Douglas fir (*Pseudotsuga*). The abundance of these species in the urban forest makes it a limiting species. For a sustainable and resilient urban forest these tree species should be limited in new tree installations outside of natural areas where they may be performing a specific ecosystem function in their natural environment.

Maintaining and improving tree species diversity should also consider existing and potential tree pests and diseases, changing climates, enhancing ecosystem benefits, and equitable distribution Citywide. Diversity and potential threats can be properly managed with routine monitoring of the urban forest, routine pruning cycles, adequate tree plantings, and an engaged community.

Distribution of Tree Diameter Size Classes (Relative Age)

McPherson et. al. proposed an ideal diameter size class distribution for street trees based on observations of well-adapted trees in urban environments. McPherson's ideal distribution suggests that the largest fraction of trees (approximately 40% of the population) should be young (less than six inches DBH), while a smaller fraction (approximately 10%) should be in the large-diameter size class (greater than 24 inches DBH). A tree population with an ideal distribution would have an abundance of newly planted and young trees, and lower numbers of established, maturing, and mature trees. Based on the aggregated dataset, Tacoma is trending towards this ideal distribution.

Appropriate distribution of tree sizes and age classes can be achieved if trees are properly maintained and preserved. Proper urban forest management will allow the maturing trees to mature as the younger trees transition to established.

A goal for Tacoma's urban forest should be an uneven-aged distribution of trees at the street, park, and Citywide levels. An aging tree population poses a potential increase in maintenance and removal demands and may leave a void in tree canopy and associated benefits if tree planting levels are not elevated. The City should increase its tree planting efforts to prevent a loss of ecosystem services provided by the mature trees that reach senescence or early mortality.

It is recommended that Tacoma support a strong planting and maintenance program to ensure that young, healthy trees are in place to fill in gaps in tree canopy and replace older declining trees. The City must promote tree preservation and proactive tree care to ensure the long-term survival of older trees. Additionally, tree planting and tree care will allow the distribution to normalize over time.

The distribution of individual tree ages within a tree population influences present and future costs as well as the flow of benefits. Cities with the responsibility of tree maintenance within public rights-of-way experience an ideal age/size distribution in the tree population that allows managers to allocate annual maintenance costs uniformly over many years and assures continuity in overall tree canopy coverage and associated benefits which are often dependent on the growing space of individual trees (e.g. open grown versus restricted growing areas).

The relative age classes of trees per dataset can inform future maintenance needs and tree planting decisions.

Condition of the Public Trees

Comparing the condition of the inventoried tree population with relative tree age (or size class distribution) can provide insight into the stability of the population. The condition of Tacoma's tree population based on the aggregated datasets is typical for a Citywide tree population and specifically for the age classes. The data analysis has provided the following insight into maintenance needs and historical maintenance practices.

The similar trend in condition across the tree population reveals that growing conditions and/or past management of trees were consistent.

- Younger trees rated in Fair or Poor condition may benefit from improvements in structure that may improve their health over time. Pruning should follow ANSI A300 (Part 1) standards.[1] Young tree pruning is less costly and has some significant impacts on the health outcomes of trees as they mature. Generally, as trees grow in size, the cost for maintenance increases. Some future maintenance costs can be prevented by conducting proper young tree pruning.

[1] ANSI, American National Standards Institute. 2017. ANSI A300 (Part 1)-2017 Pruning

- Poor condition ratings among mature trees may be due to visible signs of decline and stress, including decay, dead limbs, sparse branching, or poor structure. These trees would require corrective pruning, regular inspections, and possible intensive plant health care to improve their vigor.
- Proper tree care practices are needed for the long-term general health of the urban forest. Following guidelines developed by ISA and those recommended by ANSI A300 (Part 5) standards[2] will ensure that tree maintenance practices ultimately improve the health of the urban forest.

Tree Observations and Defects

5,161 (60%) recorded defects could potentially have been prevented. These defects include utility damage, foreign object, staked, hardscape damage, girdling roots, topped, branch architecture, trunk wound, and co-dominant stems. Defects such as branch tear out, major dieback, girdling roots, decline, topping, poor branch architecture, crown dieback, trunk wounds, trunk decay, and co-dominant stems can have long-term effects on the health and longevity of the tree and pose a potential risk to the public and property. This information should be used to enhance tree best management practices ("BMPs"). Proper young tree maintenance, tree protection, and monitoring will reduce these defects over time.

Corrective actions should be taken when warranted. If the tree's condition worsens, removal may be required. The costs for treating deficient trees must be considered to determine whether removing and replacing the tree is the more viable option.

Potential Tree Maintenance Needs

Tasks such as crown cleaning, utility, restoration, monitor, raise, reduce, clearance, thin, inspect, remove-hanger, remove-foreign object can be addressed during clearance pruning activities or during a routine pruning cycle if the City moves in this direction. Tasks such as remove-stake, monitor, remove-girdling root, amend mulch, raise, remove hardware, and inspect may apply to young trees which can be addressed by implementing a routine young tree training cycle which could possibly be administered by trained volunteers. Training of volunteers and tree stewards would reduce future tree maintenance demands within the public rights-of-way.

Cost-Benefit Analysis of Tacoma's Urban Forest

The trees growing along the public streets constitute a valuable community resource. They provide numerous tangible and intangible benefits such as pollution control, energy reduction, stormwater management, property value increases, wildlife habitat, education, and aesthetics.

The services and benefits of trees in the urban setting were once considered to be unquantifiable. However, by using extensive scientific studies and practical research, these benefits can now be confidently calculated using tree inventory information. The results of applying a proven, defensible model and method that determines tree benefit values for the City of Tacoma's tree inventory data are summarized in this report. The results of Tacoma's tree inventory provide insight into the overall health of the City's public trees and the management activities needed to maintain and increase the benefits of trees into the future.

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[2] ANSI A300 (Part 5)-2012: Management of Trees and Shrubs During Site Planning, Site Development, and Construction

Based on U.S. Forest Research, on average the monetary cost-benefit ratio in dollars ($) of urban trees is 1:2. For every dollar invested in tree planting, the community realizes a two dollar return in investment based on the ecosystem services and benefits provided.[3]

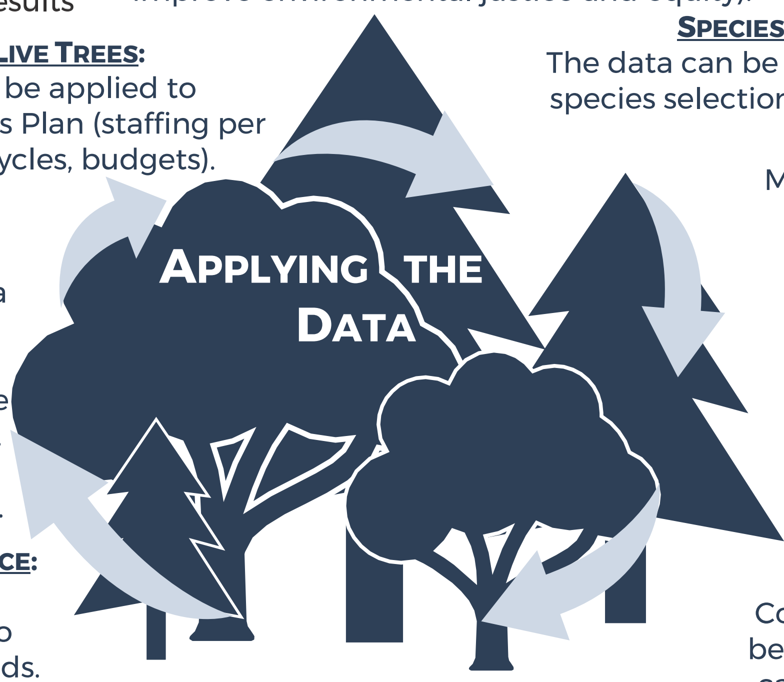
The total annual value and savings provided by Tacoma's inventoried trees is over $935,000, or approximately $4.40 per capita (2017). A complete inventory of all public trees in Tacoma will provide greater and more accurate estimates of the value and benefits of the City's trees. In addition, the benefits can be estimated for the future tree planting targets and canopy goals established in this Plan. This information can be used to build support for the implementation of this Plan, demonstrating the City's efforts to improve the equity of distribution of trees and associated benefits.

Final Conclusion

The summaries provided in this section use an aggregated tree inventory dataset to provide generalized urban forestry trends Citywide. These summaries describe Tacoma's urban forest structure, condition, potential maintenance needs but do not depict exact characteristics of Tacoma's urban forest. Comprehensive accurate data assessments can only be made through statistical analyses or a complete inventory of all public trees.

Generalized summaries of tree diversity, relative age, condition, and potential maintenance can inform tree species for new tree installations, ecosystem services and benefits of the public trees, and maintenance requirements of priority maintenance corridors recommended in this Plan.

Figure 25. Summary of methods for applying the data analysis results



[3] U.S. Forest Service, Urban & Community Forestry Program and Vibrant Cities Lab 1-pager. February 2018, www.fs.fed.us/ucf/supporting_docs/UCF-Brief-Feb2018.pdf