City of Tukwila Washington

Urban Tree Canopy Assessment

December, 2012

DAVEY RESOURCE GROUP
A Division of The Davey Tree Expert Company

City of Tukwila, Washington

Urban Tree Canopy Assessment

September, 2012

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Executive Summary

Trees and urban forests are vital to the health and sustainability of any community. Located in the lushly forested Pacific Northwest, Tukwila recognizes the benefits of trees and the value of urban tree canopy. While trees have been long appreciated for their contributions of shade and beauty to our landscapes, science and technology have now made it possible to quantify the environmental benefits to energy savings, cleaner air and water, carbon dioxide reduction, property values, and socio-economics. The Center for Urban Forest Research (CUFR) estimates that over a 40-year period 100 urban trees in the Pacific Northwest provide $202,000 in benefits (Trees in Our City).

Tukwila has been a Tree City, USA for over ten years, developing many programs to restore and maintain the community forest, including sensitive areas restoration, planting trees in parks, and street tree planting, among others. These activities show that the City of Tukwila has made a commitment to protect and manage the community's tree resources. As a part of this commitment, and as preparation for updating the City's Comprehensive Plan to improve urban forest management, the City contracted with Davey Resource Group in June 2012 to carry out an urban tree canopy assessment. The purpose of the assessment is to quantify and map existing urban tree canopy as well as impervious surface, open water, pervious surface, and bare soil.

To accomplish this, high-resolution aerial imagery and infrared technology was used to remotely map tree canopy and land cover over the city limits. The results of the study provide a clear picture of the extent and distribution of urban tree canopy over the Tukwila area. The data developed during the assessment will become an important part of the City's GIS database and provides a foundation for developing community goals and urban forest policies. The primary purpose of the assessment was to establish a benchmark value to measure the success of long-term management strategies over time.

The assessment determined that Tukwila has a current overall average tree canopy cover of 25%, and impervious surface of 51% (Table 1). This may be influenced by the fact that, unlike many communities, Tukwila features more acres of commercial and industrial zoned land than residential areas. While these businesses are vital to the economic well-being and sustainability of the community, commercial and industrial zones are simply less conducive to developing and maintaining tree canopy than residential zones. The residential zones host a range of 33% - 51% canopy across 1,869 acres, while the industrial and commercial zones have a range of 9% - 49% canopy across 2,780 acres.

Land Cover Class	Acres	Percent
Canopy	1,615.77	25%
Impervious	3,241.86	51%
Pervious	1,131.67	18%
Bare Soil	1,07.6	2%
Open Water	299.21	5%
Total	**6,396.11**	**100%**

Table 1 – Percent Land Cover Class Citywide

Introduction

Tukwila lies in the center of the Puget Sound region, sitting 12 miles south of downtown Seattle, 17 miles north of downtown Tacoma, just east of Seattle-Tacoma International Airport, and at the crossroads of two major interstate highways, I-5 and I-405. Located in west King County at an elevation of 138 feet, Tukwila enjoys mild temperatures much of the year, ranging from an average high of 75° F in July to a low of 35° F in January. The average rainfall is 38 inches a year, and the average annual number of days with any measurable precipitation is equal to the number of sunny days (154).

Tukwila includes one of the Northwest's largest concentrations of retail businesses, as well as single and multi-family residences, heavy and light manufacturing, and service-oriented companies. While the residential population of Tukwila is 19,486, it is estimated that over 47,000 people work in the City. Residential zones represent 38% of the land area, about 1,869 acres. The remaining 62% of the city is comprised of Industrial, Commercial, Office, and Mixed Use Zones.

The City of Tukwila recognizes the importance of an urban forest and the value of urban tree canopy. Evidence exists that, to be healthy and sustainable, a community must integrate the natural environment into urban development design. Trees and vegetation provide critical environmental services, which in turn affect the quality of life of residents, visitors, daytime workers, and neighboring communities. A Tree City, USA, since 2002, Tukwila has a tree protection ordinance and requires a permit for tree clearing in sensitive areas on private property. Planning and management of the urban forest is a shared responsibility between the Department of Community Development (tree removal permits, sensitive areas protection, shoreline vegetation protection and restoration), Parks and Recreation (trees in parks), and Public Works (street trees and trees on public rights-of-way).

In an effort to quantify existing urban tree canopy as well as impervious surfaces, surface water, grasslands, and bare soils, the City of Tukwila contracted with Davey Resource Group (DRG) in June 2012 to assess the amount and distribution of tree canopy within the city limits. The primary objective of the assessment was to establish a benchmark value for overall canopy and other land cover.

The amount and distribution of leaf surface area (tree canopy) is the driving force behind the urban forest's ability to produce benefits for the community (Clark, et al., 1997). As canopy cover increases, so do the benefits afforded by leaf area. These benefits, which include energy savings, air quality, water quality, and other socio-economic benefits, can be quantified for their value to the community. The Center for Urban Forest Research (CUFR) estimates that 100 trees in the Pacific Northwest provide $202,000 in benefits over a 40-year period (Trees in Our City).

The Benefits of Urban Tree Canopy

Urban and natural forests work continuously to mitigate the effects of urbanization and development and to protect and enhance life within the community in the following ways:

- **Energy Savings**
- **Air Quality**
- **Water Quality**
- **Carbon Reduction**
- **Aesthetics and Socioeconomics**

> Well-placed trees around a home can save 36% of annual air conditioning costs and 25% of winter heating costs in the Pacific Northwest.
>
> (CUFR, Trees in Our City)

Energy Savings

Urban trees and forests modify climate and conserve energy in three principal ways:

- **Shading dwellings and hardscape**
- **Transpiration**
- **Wind reduction**

Shade from trees reduces the amount of radiant energy absorbed and stored by hardscape and other impervious surfaces, thereby reducing the heat island effect, a term that describes the increase in urban temperatures in relation to surrounding locations. Transpiration releases water vapor from tree canopies, which cools the surrounding area. Through shade and transpiration, trees and other vegetation within an urban setting modify the environment and reduce heat island effects. Temperature differences of more than 9°F (5°C) have been observed between city centers without adequate canopy cover and more vegetated suburban areas (Akbari, et al., 1992).

Trees reduce wind speeds by up to 50% and influence the movement of warm air and pollutants along streets and out of urban canyons. By reducing air movement into buildings and against conductive surfaces (e.g., glass, metal siding), trees reduce conductive heat loss from buildings, translating into potential annual heating savings of 25% (Heisler, 1986).

Reducing energy needs has the added bonus of reducing carbon dioxide (CO_2) emissions from fossil fuel power plants.

Air Quality

Urban trees improve air quality in five fundamental ways:

- **Reducing particulate matter (dust)**
- **Absorbing gaseous pollutants**
- **Shade and transpiration**
- **Reducing power plant emissions**
- **Increasing oxygen levels**

> 100 trees remove 235 pounds of pollutants per year, including 86 lbs of ozone and 84 lbs of particulates.
>
> (CUFR, Trees in Our City)

Trees protect and improve air quality by intercepting particulate matter (PM_{10}), including dust, ash, pollen, and smoke. The particulates are filtered and held in the tree canopy where they are eventually washed harmlessly to the ground. Trees and forests absorb harmful gaseous pollutants like ozone (O_3), nitrogen dioxide (NO_2), and sulfur dioxide (SO_2). Shade and transpiration reduces the formation of O_3, which is brought on by higher temperatures. In fact, scientists are now finding that some trees may absorb more volatile organic compounds (VOCs) than previously thought (Karl, T., et al.; Science NOW). VOCs are a class of carbon-based particles emitted from automobile exhaust, lawnmowers, and other human activities. By reducing energy needs, trees also reduce emissions from the generation of power. And, through photosynthesis, trees and forests increase oxygen levels.

Water Quality

Trees and forests improve and protect the quality of surface waters, such as creeks, rivers, and lakes, by reducing the impacts of stormwater runoff through:

- **Interception**
- **Increasing soil capacity and rate of infiltration**
- **Reducing soil erosion**

Trees intercept rainfall in their canopy, which act as a mini-reservoir (Xiao, et al., 1998). During storm events, this interception reduces and slows runoff. In addition to catching stormwater, canopy interception lessens the impact of raindrops on barren soils. Root growth and decomposition increase the capacity and rate of soil infiltration by rainfall and snowmelt (McPherson, et al., 2002). Each of these processes greatly reduces the flow and volume of stormwater runoff, avoiding erosion and preventing sediments and other pollutants from entering streams, rivers, and lakes.

> 100 mature trees catch 112,000 gallons of rainwater per year.
>
> (CUFR, Trees in Our City)

Urban stormwater runoff is a major source of pollution for surface waters and riparian areas in the Pacific Northwest, threatening salmon and other wildlife as well as human populations. Requirements for stormwater management are becoming more stringent and costly. Reducing runoff and incorporating urban trees in stormwater management planning has the added benefit of reducing the cost of stormwater management, including the expense of constructing facilities necessary to detain and control stormwater, and the cost of treatment to remove sediment and other pollutants.

Carbon Reduction

Trees and forests reduce atmospheric carbon dioxide (CO_2) in two ways:

- **Directly, through growth and sequestration**
- **Indirectly, by lowering the demand for energy**

Trees and forests directly reduce CO_2 in the atmosphere through growth and sequestration of CO_2 as woody and foliar biomass. Indirectly, trees and forests reduce CO_2 by lowering the demand for energy and reducing the CO_2 emissions from the consumption of natural gas and the generation of electric power.

100 trees remove 23 tons of CO_2 per year.

(CUFR, Trees in Our City)

As environmental awareness continues to increase, governments and individuals are paying particular attention to climate change and the effects of greenhouse gas emissions. Two national policy options are currently making headlines, the establishment of a carbon tax and a greenhouse gas cap-and-trade system, aimed at reducing atmospheric CO_2 and other greenhouse gases. A carbon tax would place a tax burden on each unit of greenhouse gas emission and would require regulated entities to pay for their level of emissions. Alternatively, in a cap-and-trade system, an upper limit (or cap) is placed on global (federal, regional, or other jurisdiction) levels of greenhouse gas emissions and the regulated entities would be required to either reduce emissions to required limits or purchase emissions allowances in order to meet the cap (Williams, et al., 2007).

The concept of purchasing emission allowances (offsets) has led to the acceptance of carbon credits as a commodity that can be exchanged for financial gain. The Center for Urban Forest Research Pacific Southwest Research Station and USDA Forest Service recently led the development of Urban Forest Greenhouse Gas Reporting Protocol (McPherson, et al., 2008). The protocol incorporates methods of the Kyoto Protocol and Voluntary Carbon Standard and establishes methods for calculating reductions, provides guidance for accounting and reporting, and guides urban forest managers in developing tree planting and stewardship projects that could be registered for greenhouse gas reduction credits (offsets). The protocol can be applied to urban tree planting projects within municipalities, educational campuses, and utility service areas anywhere in the US.

Aesthetics and Socioeconomics

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

- **Beautification and comfort**
- **Shade and privacy**
- **Wildlife habitat**
- **Opportunities for recreation**
- **A reduction in violent crime**
- **Creating a sense of place and history**
- **Reduced reliance on medication and quicker recovery from injury or illness**

Each front yard tree adds 1% to the sales price and large specimen trees can add 10% or more to property values.

Shoppers pay up to 12% more for goods when healthy trees are part of the landscape.

(CUFR, Trees in Our City)

Many of these benefits are captured as a percentage of property values through higher sales prices where individual trees and forests are located. While some of the benefits of forests are intangible and/or difficult to quantify, such as impacts on psychological health, crime, and violence, empirical evidence of these benefits does exist (Kaplan, 1989; Ulrich, 1986). However, there is limited knowledge about the physical processes at work and their interactions make quantification imprecise. Exposure to nature, including trees, has a healthy impact on humans, including increased worker productivity, higher test scores, reduced symptoms of ADD, and faster recovery times following surgery. In addition, trees and forests have positive economic benefits for retailers. There is documented evidence that trees promote better business by stimulating more frequent and extended shopping and a willingness to pay more for goods and parking (Wolf, 2007).

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

Methods

As more communities focus attention on environmental sustainability, community forest management has become increasingly dependent on geographic information systems (GIS) for urban tree canopy mapping and analysis. Understanding the extent and location of existing canopy is a key step to identifying various types of community forest management opportunities. Urban forestry research and applications can provide additional guidance for determining a balance between growth and preservation and aid in identifying and assessing existing forestry preservation and planting or restoration opportunities.

Source Data

Davey Resource Group (DRG) used advanced GIS and remote sensing software to identify and map tree canopy and other land cover within the Tukwila project area using 2009 high-resolution aerial imagery from the City of Tukwila and King County, and National Agricultural Imagery Program (NAIP) 4-band imagery acquired by the United States Department of Agriculture (USDA) in 2011. Canopy and land cover summary statistics were developed using GIS layers provided by both the City and the County.

Using both high-resolution aerial imagery and 4-band imagery increases the accuracy of the canopy analysis. The use of 4-band NAIP imagery increases accuracy of the initial feature extraction because the infrared band captures a different set of information not found in the other bands. Using this infrared band, the amount of shadowing is decreased. The infrared band also improves the software's accuracy in separating vegetation from impervious surfaces and bare soils, while also distinguishing differences between low-lying vegetation and tree canopy. Since the initial feature extraction produces better results, the amount of manual editing time is decreased.

While feature extraction is the best way to extract land cover information, the initial classifications can be further refined. When high-resolution submeter imagery is available, this imagery is used to assist in the manual editing process by providing a more accurate impervious layer because editors are able to visually interpret the edges of roads, buildings, parking lots, etc. Since this imagery is normally leaf-off, it is only used for digitizing and editing impervious features.

Remote image analysis is a cost-effective and highly accurate approach to assessing a community's existing tree canopy coverage, in support of responsible tree management, community forest goal-setting, and urban resource planning. The Tukwila urban tree canopy assessment provides the following information:

- **Land Cover.** Using remote image sensing, the project identified and quantified the extent and location of the following land cover classifications:
    - *Urban tree canopy* (including both trees and shrubs)
    - *Impervious surface* (pavement, buildings, etc.)
    - *Pervious surface* (including grass and low-lying shrubs)
    - *Bare soils*
    - *Open water* (lakes, rivers, etc.)
- **Detailed Land Cover.** An additional land cover layer in which the canopy is separated into different classes.

- **Landcover by Land Use.** The assessment identified land cover for the city limits and each zone.
- **Canopy by Parcel.** The percentage of canopy per parcel.

The data developed as a result of this assessment becomes a part of the City's GIS database and provides a foundation for the development of long-term management goals and allows decision-makers and residents to make informed decisions about budgetary and policy support and management priorities. The analysis also establishes benchmarks for measuring the success of future management strategies.

Project Area

The Tukwila urban tree canopy assessment considered all zoned areas within the city limits. This did not include public rights-of-way, because the city lacked up-to-date, complete data for these areas.

Image Analysis

With advanced GIS and remote sensing software capabilities, in addition to advances in image acquisition, a top-down canopy assessment approach using remote sensing data was used to quantify the extent of tree canopy. Davey utilized an *object-based image analysis* (OBIA) semi-automated feature extraction method to process and analyze current high-resolution *color infrared* (CIR) aerial imagery and remotely-sense data to identify tree canopy cover and land cover classifications. The use of imagery analysis is cost-effective and provides a highly accurate approach to assessing the community's existing tree canopy coverage.

The advanced image analysis method was used to classify, or separate, the land cover layers from the overall imagery. The semi-automated extraction process was completed using Feature Analyst®, an extension of ArcGIS®. Feature Analyst ® uses an object-oriented approach to cluster together objects with similar spectral (i.e., color) and spatial/contextual (e.g., texture, size, shape, pattern, and spatial association) characteristics. Secondary source data, 2009 high-resolution aerial imagery provided by King County, and custom ArcGIS® tools were used to aid in the final manual editing and quality checking and quality assurance processes (QA/QC).

i-Tree VUE

The i-Tree suite of tools is free, public software that uses established tree benefit calculations to analyze tree canopy and benefits. DRG uses i-Tree VUE to calculate ecosystem benefits based on the current landscape conditions throughout the City of Tukwila. i-Tree VUE uses the NLCD dataset to assess these benefits. Since the NLCD is far more coarse than the data DRG provides, the City may need to adjust the percentages to receive a more accurate projection of benefits. However, for a quick calculation of tree canopy and other land cover percentages, DRG recommends using the i-Tree Canopy tool to assess land cover percentages to track trends or changes in their future land cover. Detailed literature and methodology can be found on the i-Tree Web site:

i-Tree Applications: **http://www.itreetools.org/applications.php**

i-Tree Literature: **http://www.itreetools.org/resources/manuals.php**

GIS Analysis

All land cover classes were merged into a final 5-class land cover layer and acreage calculations were generated using ArcGIS® geoprocessing, analysis, and data management tools. Land cover acreages and percentages were calculated for the overall project boundary, the City of Tukwila. Figure 1 illustrates how tree canopy cover, which includes both trees and shrubs, is easy to differentiate from other land cover classifications using NAIP, 4-band aerial imagery with color infrared.

Figure 1 – Canopy shown in orange.

Maps

An Urban Tree Canopy Assessment can help city decision makers understand special patterns of canopy in the community and this information can be presented in maps designed to answer specific questions. Beyond the basic canopy distribution, the City of Tukwila was interested in understanding how canopy was distributed among zone classes, in parks and wetlands, and on steep slopes. The possible canopy loss on parcels that are likely to be developed was also examined. The following maps were produced by DRG and provided to Tukwila as companions to this document.

Canopy by Parcels

This map illustrates the canopy cover percent on each land parcel. The parcels with higher canopy percent are a darker green while parcels with lower canopy percent are a lighter green. This map may help managers prioritize tree protection measures on parcels that have high existing canopy and identify parcels that may be ideal locations for canopy development.

Existing Canopy on Steep Slopes

Steep slopes may be strategic locations for tree canopy, both for erosion control provided by tree roots, and because it is often difficult to develop infrastructure on steep slopes. This map shows the steep slopes that have existing canopy in green and other surfaces (impervious, pervious, and bare soil) in red. Engineered fill is shown in blue.

Land Cover

This map illustrates the land cover citywide. The categories include canopy, impervious, pervious, bare soil, and open water. Canopy is vegetative cover excluding lawn. *Impervious* includes cement, asphalt, buildings, or any other surface that would preclude water infiltration into the soil, *pervious* includes lawn, and *bare soil* includes sand, soil, or gravel without vegetation. Often bare soil occurs on land that is in agricultural production or in the process of being developed. Open water includes water bodies and may vary in seasonal wetlands.

Detailed Land Cover

The detailed land cover map further refines the underlying cover of canopied areas. Canopy over impervious areas, parks, and wetlands are identified. This map may assist managers in identifying canopy that is performing important ecosystem services by cooling wetland water temperatures, providing recreational amenities in parks, and shading pavement surfaces. Trees over impervious cover can have a great impact on intercepting stormwater and may provide especially important noise and pollution buffers.

City of Tukwila Zoning

The canopy study examined canopy cover in each of Tukwila's 16 zones. The zone map is provided as a reference so managers can quickly identify the areas of the city covered by each zone.

Possible Urban Tree Canopy

This layer was created by first identifying bare soil and pervious areas without existing canopy. Then, areas determined to be unsuitable locations for canopy were removed (utility rights-of-way, levee walls managed by the Army Corps of Engineers, etc.). This map may help managers identify strategic locations for the development of additional canopy.

Threatened Parcels

This map illustrates the parcels that are likely to be developed in the next 10 to 20 years. Depending on the nature of the development, these parcels may either increase or decrease in canopy. For example, an agricultural field that is converted to a well-treed business park may actually gain canopy, but the same field converted to a large commercial development may become primarily impervious. Tree protection measures and development requirements will influence the outcome.

Accuracy Assessment

A QA/QC process was implemented using ArcGIS® to identify, define, and correct any misclassifications or omission errors in the final land cover layer. The initial land cover layer extractions were edited at a 1:1250 quality control scale in the urban areas to assure that the automated mapping and data analysis performed by GIS specialists accurately reflects the true nature and extent of the canopy cover. To test for accuracy, DRG used the Create Random Points tool to generate a total of 1000 random points for the City of Tukwila. Points were compared with the 2011 NAIP (reference image) and 2009 high-resolution imagery to determine the accuracy of the final land cover layer. Results of the random point assessment were recorded in a classification matrix for further analysis.

To assess accuracy among individual land cover classes, a statistical metric called the *Kappa coefficient* (Khat) was derived from the classification matrix. This metric was chosen because it represents the data more precisely (rather than using an overall accuracy percentage of correct land cover classifications) because it partly accounts for chance, or variance, among random sample sets. The Kappa does not yield a result in percentages but rather in terms of agreement with values ranging from zero to one. Although definitive ranges of the Kappa have not been established, it has been generally accepted that a value of 0.80 or higher results in "very good" agreement between layers. Davey used this statistic to measure agreement between the aerial imagery and extracted land cover. The City of Tukwila was considered statistically significant in terms of agreement according to the Kappa value of 0.9315 (Table 3); therefore, the results of the land cover feature extraction were deemed to sufficiently represent the true nature of the landscape.

As a second quality control process, Davey compared the land cover percentage values with the statistical results generated from i-Tree Canopy. This tool is designed to allow users to easily and accurately estimate tree and other cover classes (e.g., grass, building, roads, etc.) within their city or any area they like. This tool randomly lays points onto Google Earth imagery and the user then classifies what cover class each point falls upon. Point data and results can be exported for use in other programs if desired. The random point locations derived from i-Tree Canopy can be re-imported to produce a statistically valid estimate of land cover for future analysis using new aerial images currently available in Google Maps.

This is an easy way to statistically estimate tree canopy cover, set canopy goals, and keep track of canopy change over time. A comparison of the land cover percentages are displayed in the table below. It is important to note that there was a slight difference in percentages mainly because i-Tree Canopy is a representative statistical sample and, therefore, gives only an approximate land cover percentage. The results from the UTC assessment reflect a more precise measure of Tukwila's land cover, as illustrated in Table 2.

Land Cover	UTC	i-Tree
Canopy	25.26%	23.20%
Impervious	50.68%	49.50%
Pervious	17.69%	19.40%
Bare Soil	1.68%	2.81%
Open Water	4.68%	5.01%

Table 2 – Land cover using UTC assessment vs. i-Tree

Classification Data								
	Pervious	**Canopy**	**Imper-vious**	**Water**	**Bare Soils**	**Row Total**	**Producer's Accuracy**	**Errors of Omission**
Pervious	168	15	6	0	0	189	88.89%	11.11%
Canopy	6	228	2	0	0	236	96.61%	3.39%
Impervious	4	6	502	0	0	512	98.05%	1.95%
Water	0	0	0	40	0	40	100.00%	0.00%
Bare Soils	0	0	5	0	18	23	78.26%	21.74%
Column Total	178	249	515	40	18	1000		
User's Accuracy	94.38%	91.57%	97.48%	100.00%	100.00%		**Overall Accuracy =**	**95.60%**
Errors of Commission	5.62%	8.43%	2.52%	0.00%	0.00%		**Khat* =**	**0.9315**

Table 3 - Accuracy

Results

Landcover Citywide

The city limits of Tukwila encompass an area of 10 square miles (6,396 acres). Land cover classifications within the city limits include the following (Figure 2):

- **25% Canopy,** 1,616 acres
- **51% Impervious surfaces,** 3,242 acres
- **18% Pervious surfaces,** 1,132 acres
- **5% Open water,** 299 acres
- **2% Bare soils,** 108 acres

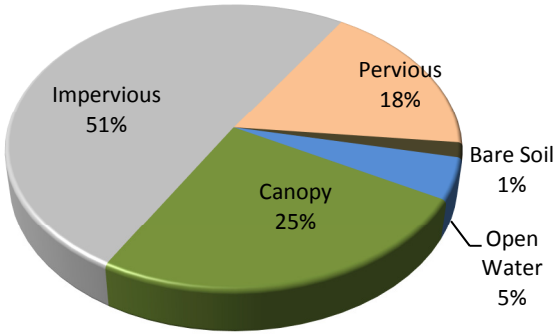

Figure 2 – Citywide Landcover

Landcover in Wetlands and Parks

Wetlands are important habitat areas for native flora and fauna. In Tukwila, wetlands comprise 124 acres, just 1.94% of the city. The overall wetland canopy, in aggregate, covers 72% (89 acres).

Tukwila's parks cover approximately 265 acres with an overall canopy of 38%. The parks' canopy cover ranges widely from 3% to 100%. Southgate Park, Crystal Springs Park, and Pamela Drive Open space feature 97% to 100% canopy cover, while the lowest canopy occurs in North Winds Weir (3%) a shoreline restoration project, which has only recently (2009) been planted with native trees and shrubs. Some parks may have opportunities for canopy protection and development, while others, such as golf courses, pools, and sports fields, may be accommodating other uses.

Park Name	Park Acres	Canopy Acres	Canopy Percentage
Southgate Park	10.9	10.31	95%
Crystal Springs Park	11.03	10.08	91%
Pamela Drive Open Space	0.67	0.65	97%
Tukwila Park	6.39	5.84	91%
Ikawa Park (Japanese Garden)	0.2	0.18	90%
Hazelnut Park	0.6	0.39	65%
Macadam Wetlands & Winter Garden	9.88	6.06	61%
P-17 Pond (Mixed-use area: storm water detention and open space)	3.59	2.14	60%
Duwamish Hill Preserve	8.74	4.41	50%
Bicentennial Park	1.26	0.61	48%

Park Name	Park Acres	Canopy Acres	Canopy Percentage
Riverton Mini Park	0.13	0.06	46%
Crestview Park	10.87	4.82	44%
Cecil Moses Memorial Park	2.98	1.29	43%
Tukwila Pond Park	24.79	10.02	40%
Cascade View Community Park	2.43	0.85	35%
Foster Golf Links	79.29	20.52	26%
Codiga Farm Park	6.75	1.99	29%
Fort Dent Park/Starfire Sports	51.27	13.55	26%
Tukwila Community Center	12.75	3.24	25%
Riverton Park	4.88	1.21	25%
Joseph Foster Memorial/Lee Philips Park	9.31	1.98	21%
Tukwila Pool	1.29	0.24	19%
Duwamish Park	2.11	0.31	15%
57th Ave South Mini Park	0.38	0.05	13%
North Wind's Weir	2.58	0.07	3%
GRAND TOTAL	**265.07**	**100.87**	**38%**

Table 4 – Canopy in Parks

Land Cover by Zone

Tukwila's sixteen zoning districts include the land in parcels owned or controlled by the city or private owners. Although rights-of-way were considered above to calculate citywide canopy, they are not included in this section. The total acreage of zoned parcels within Tukwila is equal to 4,914 acres out of the overall city acreage of 6,396.

When considering canopy, it is useful to look at both percentage of canopy and acreage of canopy across zoning districts. The percent of canopy can indicate if a particular zone has a high or low canopy across the zone and may help decision-makers prioritize canopy protection or planting in a zoning district with a low canopy percent. The acreage can help identify a zoning district with the largest or smallest total acres of canopy and help decision makers determine where canopy protection or restoration activities would have the greatest effect on overall canopy cover.

Percent Canopy

Tukwila's Medium Density Residential zone has the highest percent canopy cover at 51%, followed by Office (49%), and Low Density Residential (47%). The lowest percent of canopy cover (less than 10%) occurs in the Regional Commercial, Manufacturing Industrial Center/Heavy, and Light Industrial zones as shown in Figure 3.

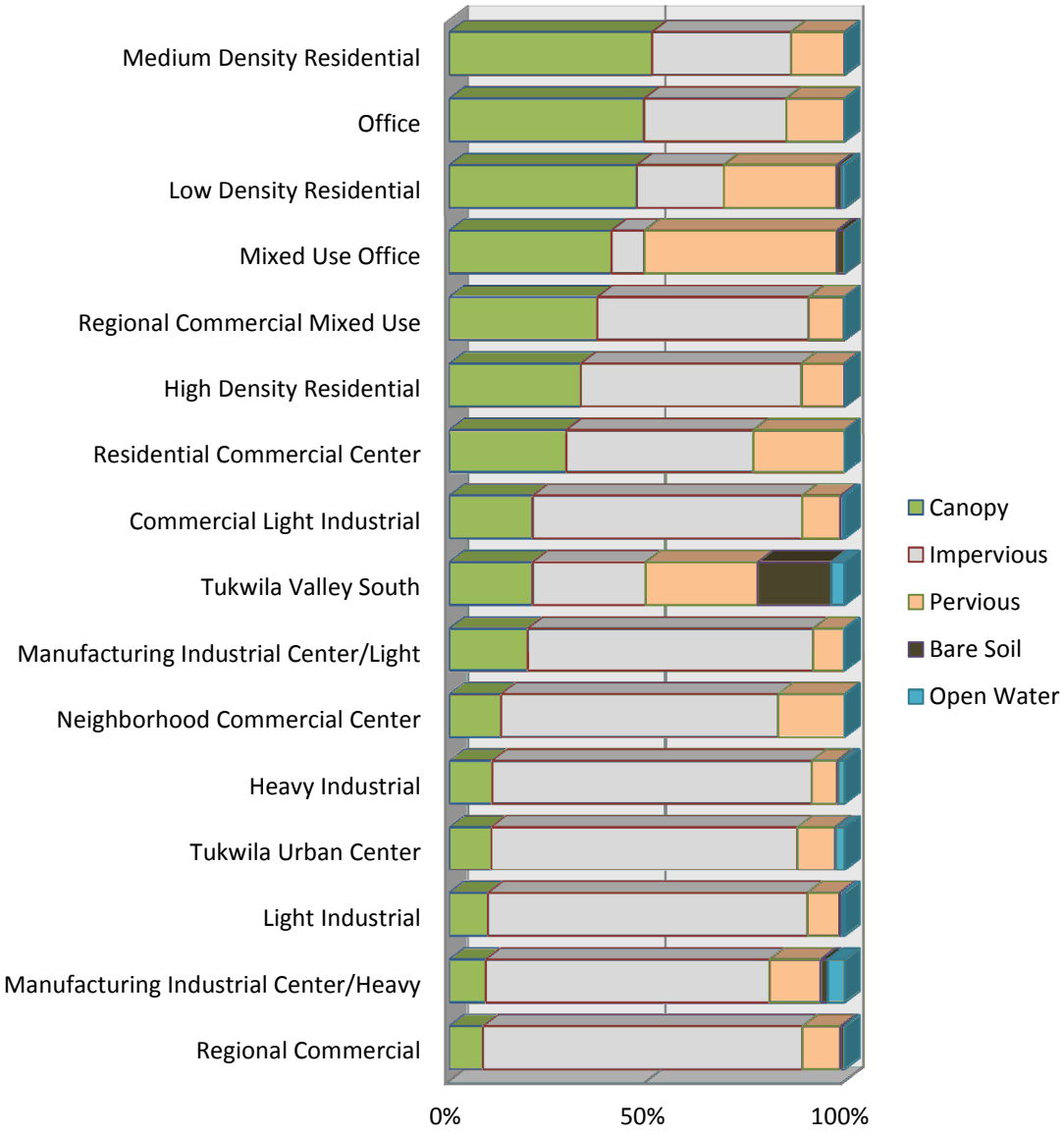

Figure 3 – Land Cover Percent by Zone

Acres of Canopy

Tukwila's Low Density Residential zone hosts most of the canopy acres. In fact, the 777 acres of canopy amount to more than the canopy of all other zones combined (531 acres), as shown in Figure 4.

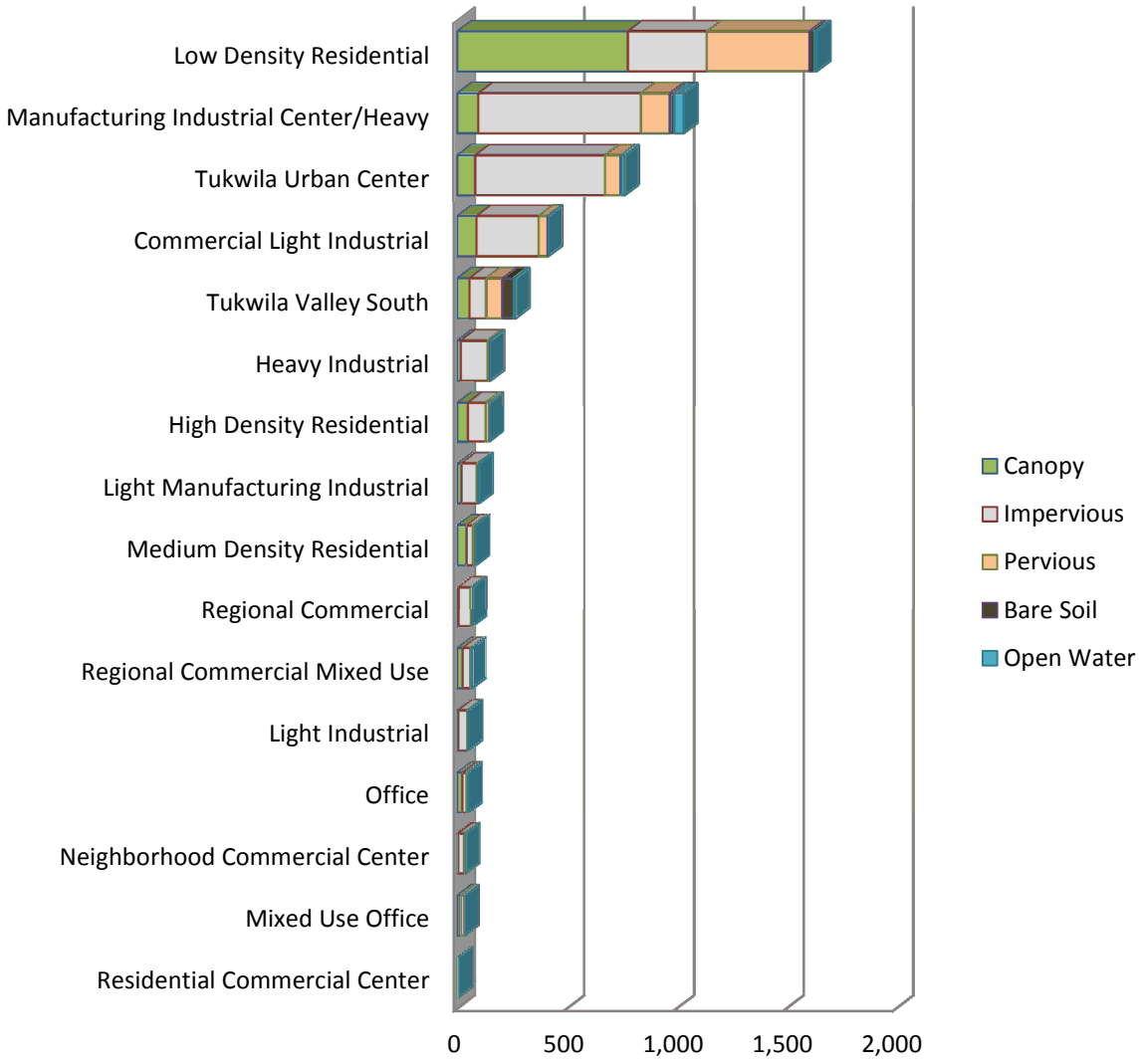

Figure 4 – Landcover Acres by Zone

Landcover: Commercial Light Industrial

Commercial/Light Industrial: allows a mix of commercial, office, or light industrial uses.

Sixty-eight percent (68%) of the Commercial/Light Industrial zone is comprised of impervious surface, and another 10% is pervious. Canopy accounts for 21% of the land cover while bare soil and open water make up approximately 1%.

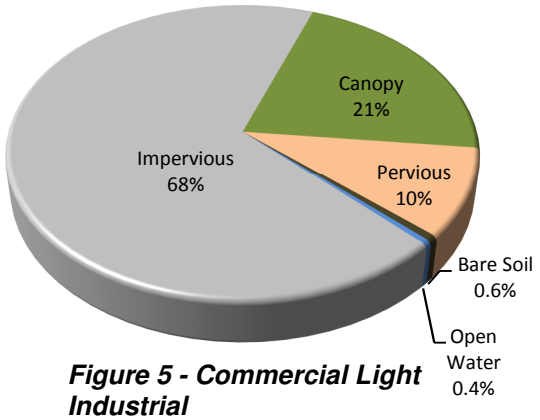

Figure 5 - Commercial Light Industrial

Landcover: Heavy Industrial

Heavy Industrial: allows heavy or bulk manufacturing uses and distributive and light manufacturing uses, with supportive commercial and office uses.

The majority of landcover in the Heavy Industrial zone is comprised of impervious surface (81%), while canopy represents just 11%. Six percent (6%) is pervious, and 2% is open water. Bare soil represents less than one percent (0.3%) of the area.

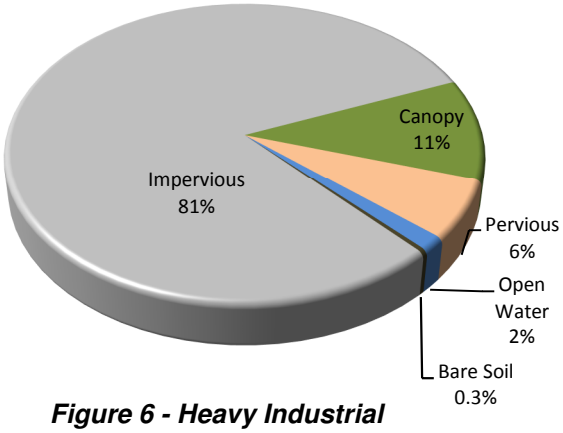

Figure 6 - Heavy Industrial

Landcover: Light Industrial

Light Industrial: allows distributive and light manufacturing uses, with supportive commercial and office uses.

The majority of landcover in the Light Industrial zone is comprised of impervious surface (81%), while canopy represents just 10%. Eight percent (8%) is pervious while one percent (1%) is bare soil. Open water represents less than one percent (0.6%) of the area.

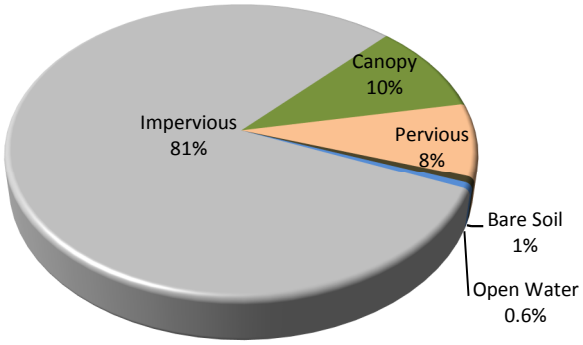

Figure 7 - Light Industrial

Landcover: High Density Residential

High-Density Residential: allows up to 22.0 dwelling units per net acre. Senior citizen housing is allowed up to 60 dwelling units per acre, subject to additional restrictions. The district is intended to provide a high-density, multiple-family district which is also compatible with commercial and office areas.

The majority of High Density Residential land cover is impervious (56%), with 33% canopy. Pervious surface represents 11% while bare soil represents less than one percent (0.1%)

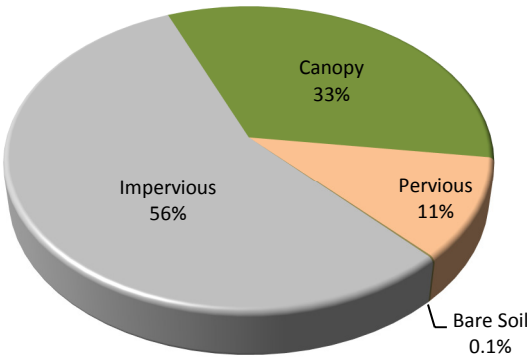

Figure 8 – High Density Residential

Landcover: Medium Density Residential

Medium Density Residential: allows up to 14.5 dwelling units per net acre. The district is intended to provide areas for family and group residential uses, and serves as an alternative to lower density family residential housing and more intensively developed group residential housing and related uses.

Slightly over half of Medium Density Residential landcover is canopy (51%), while 35% is impervious and 14% is pervious. Bare soil represents less than one percent (0.05%).

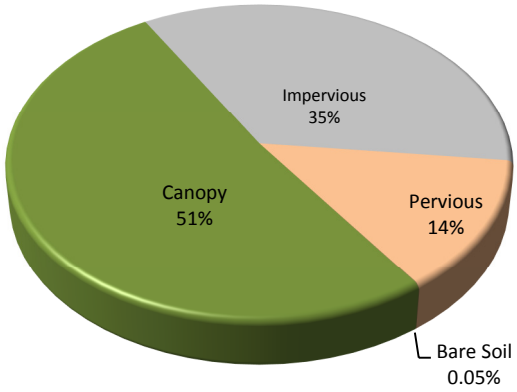

Figure 9 – Medium Density Residential

Landcover: Low Density Residential

Low Density Residential: allows a maximum of 6.7 dwelling units per net acre. It is intended to provide low density family residential areas together with a full range of urban infrastructure services in order to maintain stable residential neighborhoods and to prevent intrusions by incompatible land uses.

Almost half of the landcover in the Low Density Residential zone is canopy (47%) while 29% is pervious. Impervious land cover represents 22% and bare soil and open water represent 1% each.

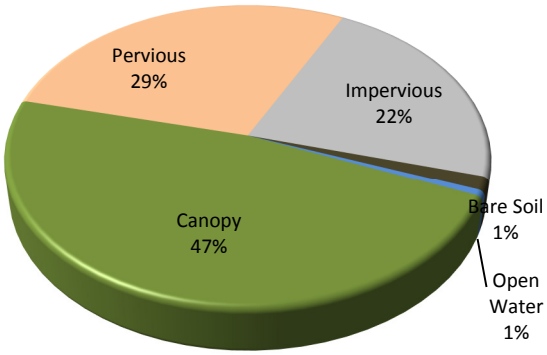

Figure 10 – Low Density Residential

Landcover: Residential Commercial Center

Residential Commercial Center: allows a maximum of 14.5 dwelling units per net acre. The district is intended to create and maintain pedestrian-friendly commercial areas characterized and scaled to serve a local neighborhood, with a diverse mix of residential, retail, service, office, recreational and community facility uses.

The Residential Commercial center zone is almost half impervious (47%), with 30% canopy and 23% pervious.

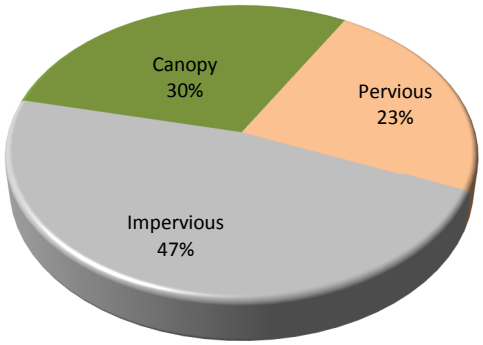

Figure 11 – Residential Commercial Center

Landcover: Neighborhood Commercial Center

Neighborhood Commercial Center: allows small-scale retail, service, office, and automotive uses. The district also allows senior citizen housing up to 60 dwelling units per acre, subject to additional restrictions,

The majority of the Neighborhood Commercial Center zone is comprised of impervious land cover (70%) with 17% pervious and 13% canopy.

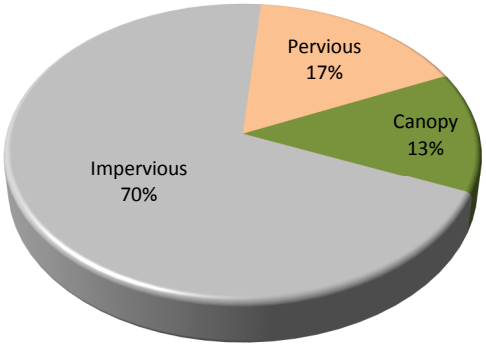

Figure 12– Neighborhood Commercial Center

Landcover: Regional Commercial

Regional Commercial: allows commercial services, offices, lodging, entertainment, and retail activities with associated warehousing, and accessory light industrial uses, along a transportation corridor and intended for high-intensity regional uses.

The Regional Commercial zone is primarily impervious (81%) with 10% pervious and 8% canopy. One percent (1%) is bare soil.

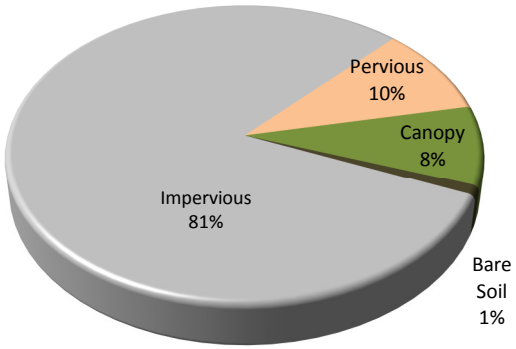

Figure 13 – Regional Commercial

Landcover: Regional Commercial Mixed Use

<u>Regional Commercial Mixed Use:</u> allows commercial services, offices, lodging, entertainment, and retail activities with associated warehousing, and accessory light industrial uses along a transportation corridor and intended for high-intensity regional uses. Residential uses up to 14.5 dwelling units per net acre mixed with certain commercial uses are allowed at second story or above. Senior citizen housing is allowed up to 60 dwelling units per acre, subject to additional restrictions

The Regional Commercial Mixed Use zone is primarily impervious (53%) with 38% canopy and 9% pervious surface. Open water comprises less than one percent (0.06%)

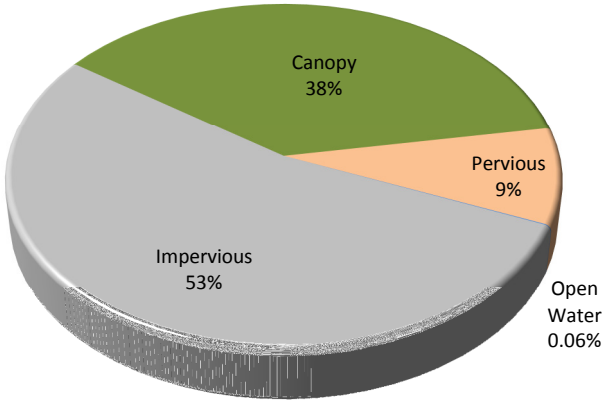

Figure 14 – Regional Commercial Mixed Use

Landcover: Office

Office: allows professional and administrative offices, mixed with certain retail uses. Because of the generally light environmental and traffic impacts and daytime use characteristics of offices, it is further intended that the Office district may serve as a buffer between residential districts and commercial and/or industrial areas.

These light-use areas have a relatively high percent canopy of 49% with impervious surface of 36% and pervious cover of 15%.

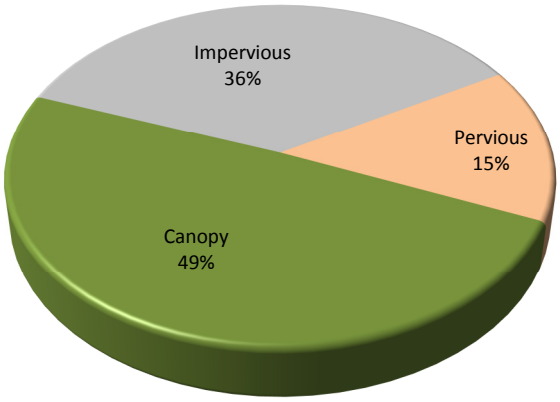

Figure 15- Office

Landcover: Mixed Use Office

Mixed-Use Office: allows professional and commercial office structures, mixed with certain complementary retail and residential uses up to 14.5 dwelling units per net acre. Senior citizen housing is allowed up to 60 dwelling units per acre, subject to additional restrictions.

Mixed Use Office has a relatively high percent pervious cover (49%) with 41% canopy and 8% impervious. Bare soil covers 2% of the zone.

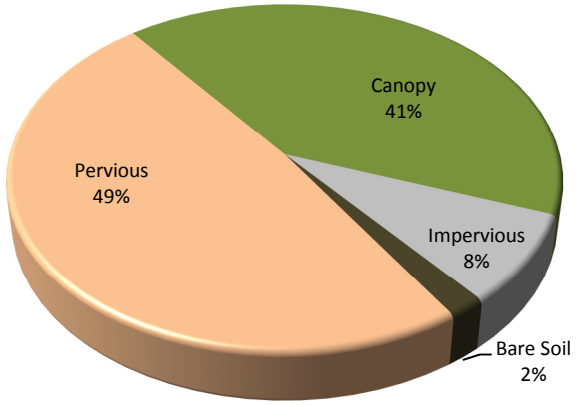

Figure 16 – Mixed Use Office

Landcover: Tukwila Urban Center

Tukwila Urban Center: allows high-intensity regional uses that include commercial services, offices, light industry, warehousing and retail uses. Development is intended to be pedestrian friendly, with a strong emphasis on a safe and attractive streetscape.

The Tukwila Urban Center is a high use area with 77% impervious surface and 11% canopy. Ten percent (10%) is pervious while open water covers 2%. Bare soil represents less than one percent (0.23%)

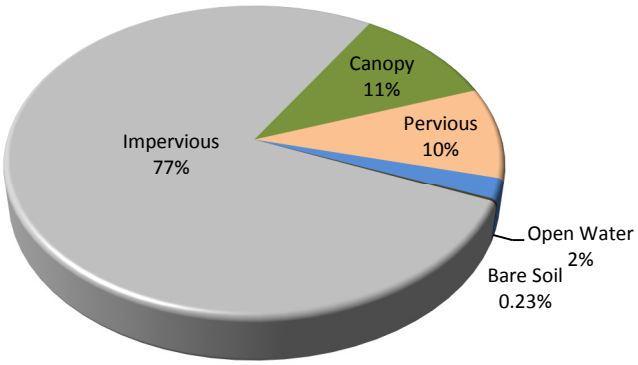

Figure 17 – Tukwila Urban Center

Landcover: Manufacturing Industrial Center/Heavy

Manufacturing Industrial Center/Heavy: allows heavy or bulk manufacturing and industrial uses, distributive and light manufacturing and industrial uses, and other uses that support those industries. This district's uses and standards are intended to enhance the redevelopment of the Duwamish Corridor.

The Manufacturing Industrial Center/ Heavy zone is comprised of 72% impervious, 13% pervious, and 9% canopy cover. Open water represents 4% and bare soil is 2%.

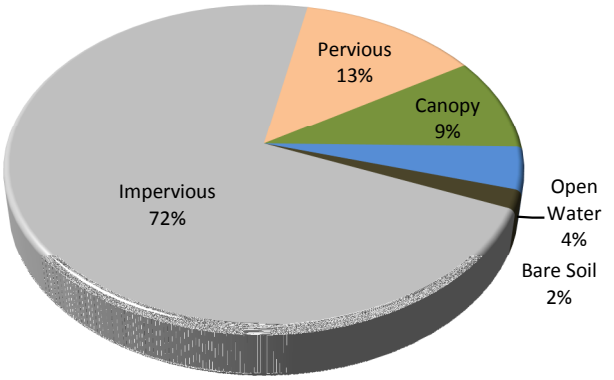

Figure 18 – Manufacturing Industrial Center/Heavy

Landcover: Manufacturing Industrial Center/Light

Manufacturing Industrial Center/ Light: allows distributive light manufacturing and industrial uses and other uses that support those industries. This district's uses and standards are intended to enhance the redevelopment of the Duwamish Corridor.

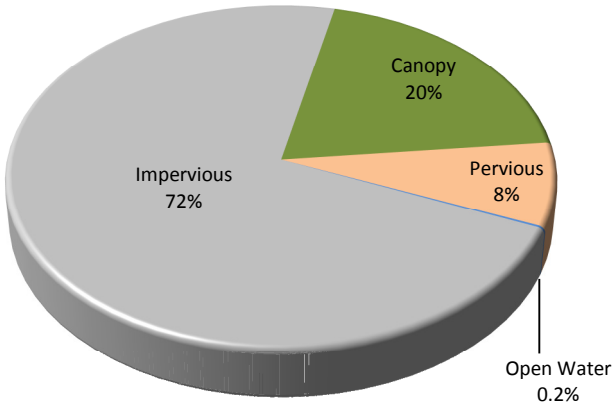

Figure 19 – Manufacturing Industrial Center/Light

Similar to the Manufacturing Industrial Center/ Heavy zone, Light is comprised of 72% impervious, but canopy is higher at 20% and pervious surface is 8%. Open water is less than one percent (0.2%).

Landcover: Tukwila Valley South

Tukwila Valley South: allows high-intensity regional uses that include commercial services, offices, light industry, warehousing and retail.

Tukwila Valley South is a transitional zone that is expected to change significantly over the next 10 years as the Tukwila South Master Plan, which covers almost 500 acres, is implemented. The impervious (29%) and pervious (28%) cover are nearly equal and there is 21% canopy. This zone has the highest percent bare soil (19%) due in part to the on-going construction of infrastructure that will support future development. Open water represents 3%.

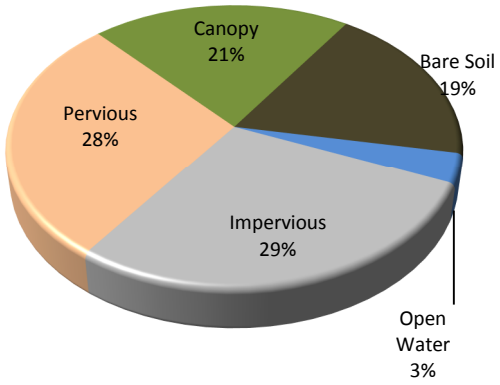

Figure 20 – Tukwila Valley South

Threatened Canopy

Tukwila is comprised of several areas at different stages of development. As parcels are developed, canopy is sometimes lost. However, agricultural land that becomes residential or another low-intensity use may substantially increase in canopy. Until 1980, the population of Tukwila was less than 4,000. The population doubled from 1980 to 1985, and reached over 12,000 in 1990, due almost entirely to annexation, rather than new housing construction. The next 10 years saw an increase to over 17,000, and population growth has leveled since 2000, as only minor infill development has occurred. The last major annexation occurred in 2009, consisting mostly of vacant, industrial, and environmentally sensitive land.

The slope along the eastern side of I-5 and some isolated vacant parcels are the only parts of the city where development would remove significant amounts of tree canopy, unless the canopy were protected by easements, regulation, or another mechanism. The rest of the city is largely built out, and new construction would likely be the result of redevelopment of existing sites to a higher intensity. The landcover of parcels identified as having a high likelihood of canopy loss in the next ten years are shown in Table 5 for each land use type. In these parcels, there is a total of 46.86 acres of canopy. If that canopy is lost from the city's total canopy area (1615.77 acres) 1,569 acres remain and the overall canopy for the city would drop from 25.26% to 24.50%, a difference of 0.76%.

Zone	Zone Acres	Existing Canopy	Existing Impervious	Existing Pervious	Existing Bare Soil	Existing Water
Commercial Light Industrial	1.48	1.48	0.00	0.00	0.00	0.00
High Density Residential	1.02	1.01	0.01	0.00	0.00	0.00
Low Density Residential	27.93	22.96	0.88	3.74	0.35	0.00
Medium Density Residential	4.61	3.12	0.05	1.44	0.00	0.00
Office	0.84	0.32	0.14	0.38	0.00	0.00
Tukwila Valley South	28.97	17.78	5.00	1.80	4.38	0.01
Other	0.20	0.19	0.00	0.01	0.00	0.00
Total Citywide	**65.06**	**46.86**	**6.06**	**7.40**	**4.73**	**0.01**

Table 5 – Threatened Canopy

Discussion: Canopy Goals

Influencing Urban Tree Canopy

Trees have natural lifespans that vary by species, climate, and local conditions. Each year, in every community, trees are planted, grow, are pruned, and are removed. Even a conservative estimate, that 1% of the tree population dies each year, necessitates a robust tree replacement plan in order to acomplish no net loss of canopy. Communities may track tree removals and endevour to replace trees 1:1 or at an even greater ratio. While the city may not have substantial control over canopy loss on private property, a city goal of planting at least the number of trees that are removed demonstrates to the public the City's commitment to maintaining community canopy. There are three kinds of canopy gain and loss to consider: natural, private, and public.

In natural areas, when trees fail, they may be retained in the landscape because they provide habitat value, or they may be removed, if they present a hazard to the public. Planting trees in natural areas may not be necessary because regeneration is common in functional ecosystems, unless they have many invasive species that would inhibit native tree regeneration. Natural tree loss and regeneration does not typically require substantial city management, except to abate hazards, such as unstable trees on fringes or where people or property can be harmed by tree failure. Managers may also consider tree planting in natural areas if an area has been disturbed or overrun with invasive species, or to achieve specific management goals, such as stream or wetland shading or improving urban wildlife habitat.

Private trees are lost and planted by private property owners. City regulations can influence the retention or loss of trees at the time of development, and any time remodeling or redevelopment may occur, but often these trees are outside the perview of current city regulations. Decision makers may impact the preservation of private property trees through education, by creating policies that favor tree retention, and by regulating the business of tree pruning and removal. Often, tree rebates or incentives can be aimed at increasing tree canopy on private property.

Trees in parks, at city facilities, and along the public right-of-way (ROW) are considered public trees. Public trees typically represent a smaller portion of the urban canopy than private trees. The city can often excersize substantial control over the instalation, maintenance, preservation, removal, and replacement of these trees. An inventory of public trees, including stumps and vacant sites can assist managers in determining planting locations for additional new trees. In Tukwila, there may be an opportunity to partner with other agencies to fully stock the areas available for public tree planting, such as tree planting along freeways and interchanges in partnership with the Washington State Department of Transportation.

Canopy policies should recognize that these segments of canopy are unique and should attempt to address canopy in both the public and private arenas, while monitoring natural areas.

The following types of policies and activities are aimed at preserving and maintaining existing tree canopy:

- Require tree protection during construction
- Require permits for tree pruning and removal
- Require tree workers to obtain a city licence

- Have potentially hazardous trees evaluated by Certified Tree Risk Assessors and rated before removal.

These strategies may increase canopy:

- Develop an annual tree planting plan
- Provide trees or rebates for tree planting on private property
- Incorporate substantial canopy requirements into parking lot and perimeter or interior redevelopment regulations
- Plant large-stature trees where appropriate on public property and in the right-of-way

Considering Canopy Goals

Setting a canopy goal is an important step in urban forest management and in ensuring the quality of life and sustainability of a community. Canopy can be expanded and maintained through a variety of means, including preservation, conservation, and new tree plantings on public and/or private lands. Canopy goals can be broad based, or specific to land use, but they should be determined based on the ability of a community to accomplish and sustain the goal. When setting canopy goals, a community should consider how trees and forests contribute to quality of life and how tree and forest canopy can help achieve environmental goals, including federal and local regulations for clean air, water, and stormwater runoff.

Many communities set canopy goals by land use or zoning districts. This distinction allows different goals for areas of the city that require different densities and intensities of use. When setting canopy goals, there is no single nationwide standard. Goals should be set by each individual city considering climate, budget considerations, distribution of land uses, and community vision.

American Forests, the oldest national nonprofit conservation organization in the country, advocates for the protection and expansion of America's forests, including urban forests (American Forests, 2012). The organization pursues a science-based approach to their work and has worked with the Forest Service to develop early urban tree canopy assessments for communities such as Bellevue, Washington. The following values were recommended by American Forests' as general goals for cities east of the Mississippi.

General Tree Canopy Goals

- 40% citywide
- 50% in suburban residential
- 35% in urban residential
- 25% in commercial and mixed use
- 25% in industrial
- 15% in central business districts

These goals were later removed from American Forests' platform in recognition that every city should find goals that suit their individual area, however, they may still be useful to consider as decision makers begin the discussion about canopy goal setting.

Regional Canopy

Several communities in the Pacific Northwest have conducted canopy studies as part of their urban forestry strategic planning. These cities recognize the value in documenting the quantity of urban canopy and some are also tracking how canopy changes over time. It should be noted that the total canopy coverage percentages shown in the following graphic for various cities in the Pacific Northwest are not directly comparable to Tukwila due to the different land use make up of each community (as explained in the next sub-section of this report), however, they are useful for providing an idea of the range of total canopy coverage found in the region.

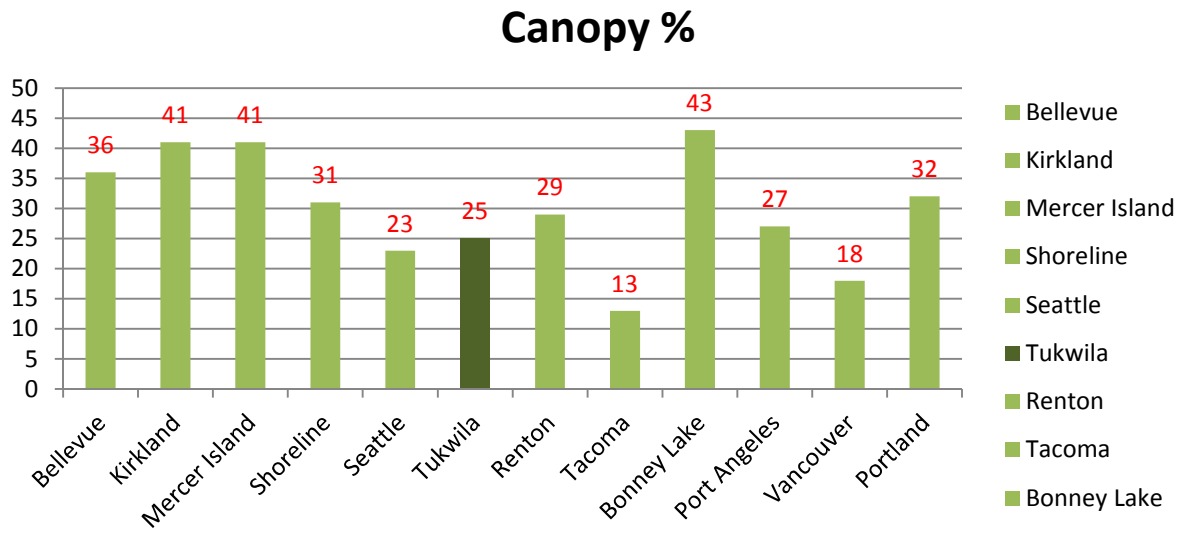

Figure 21 – Regional Canopy Percent

Regional Canopy by Zone

Tukwila's canopy was compared to three Pacific Northwest reference cities: Seattle, Renton, and Portland. The figures in Table 6 are the values reported in urban tree canopy studies in each city. It is important to note that the zone categories do not align precisely, and each city has different distributions of zone coverage. Still, looking at Tukwila's canopy alongside these reference cities' canopy by zone can be informative to provide some context.

Based on Table 6, Tukwila has the highest residential, commercial, and industrial canopy percent among the cities, and the lowest canopy percent in parks or open spaces. Many factors contribute to this distribution, and each city features its own unique mosaic of zones. Renton and Seattle excluded rights of way, while Portland's canopy study included rights of way, roads and two rivers. Moreover, Portland's open space includes 5,100 acres of open space in Forest Park alone, and open space comprises 17% of the city, compared to Tukwila's 4%. Thus it is reasonable that Tukwila's parks include a smaller portion of canopy when important recreational uses such as sports fields and courts are accommodated.

While this table provides context, decision makers should ideally develop canopy goals based on Tukwila's unique local community attributes including zone distribution, and possible canopy.

	Tukwila	Renton	Seattle	Portland
Low Density Residential	47	33		-
High Density Residential	33	33		-
All Residential	**46**	**33**	**17 - 26**	**34**
Commercial	**29**	**16**	**10**	**14**
Industrial & Manufacturing	**13**	**17**	**4**	**9**
Natural Areas	-	68	80	-
Developed Park	-	-	26	-
All Park & Open Space	**38**	**-**	**-**	**68**
Urban Center	**11**	**-**	**5**	**-**
Citywide	**25**	**29**	**23**	**33**

Table 6 – Regional Canopy Percent by Zone

Economic Development and Urban Tree Canopy Preservation

Unlike many communities, Tukwila features more acres of commercial, office, mixed use and industrial-zoned land (2,780 acres, 62% of the zone areas) than residential areas (1,869 acres, 38% of the zone areas). While these business areas are vital to the economic well-being and sustainability of the community, commercial and industrial zones are generally less conducive to developing and maintaining tree canopy than residential zones. Many industrial land uses, such as rail yards, are incompatible with tree canopy, and commercial buildings tend to require larger building footprints and larger paved parking lots. This unusual distribution of zoning means that any approach to maintaining or enhancing canopy will need to take into account the logistical needs of commercial, industrial, and office infrastructure.

Canopy Goals Recommended for Tukwila

This canopy study is the first step in establishing canopy goals by zone and citywide for Tukwila. In considering possible canopy goals, decision-makers should take into consideration Tukwila's unusual composition with just 38% of the city zoned residential and 62% zoned commercial, office, industrial, and mixed use. Because of this, recommended goals were created by zone, and a citywide percent was extrapolated. Table 7 provides an overview of the canopy potential if a 1-3% increase is projected in select zones.

Zone Class	Zone Acres	Zone Canopy Acres	Zone Canopy Percent	Goal Acres	Percent Increase Goal	Goal
Commercial Light Industrial	416.7	88.1	21%	92.3	1%	22%
Heavy Industrial	151.1	16.5	11%	18.0	1%	12%
Light Industrial	51.6	5.1	10%	5.6	1%	11%
Manufacturing Industrial Center/Heavy	1,033.7	95.9	9%	106.3	1%	10%
Manufacturing Industrial Center/Light	99.3	19.7	20%	20.7	1%	21%
Industrial Total	**1,752.5**	**225.4**	**13%**	**242.9**	**1%**	**14%**
High Density Residential	145.7	48.5	33%	145.7	0%	33%
Medium Density Residential	84.0	43.1	51%	84.0	0%	51%
High - Medium Residential Total	**229.6**	**91.6**	**40%**	**91.6**	**0%**	**40%**
Low Density Residential Total	**1,639.0**	**777.0**	**47%**	**777.0**	**0%**	**47%**
Mixed Use Office	34.2	14.0	41%	14.4	1%	42%
Neighborhood Commercial Center	38.3	5.1	13%	5.4	1%	14%
Office	49.7	24.5	49%	25.0	1%	50%
Regional Commercial	69.3	6.0	9%	6.6	1%	10%
Regional Commercial Mixed Use	66.8	25.0	37%	25.7	1%	38%
Residential Commercial Center	5.7	1.7	30%	1.7	1%	31%
Office and Commercial Total	**264.0**	**76.2**	**29%**	**78.8**	**1%**	**30%**
Tukwila Urban Center	763.5	81.8	11%	104.7	3%	14%
Tukwila Valley South	265.8	56.2	21%	64.2	3%	24%
Urban Center and South Total	**1,029.3**	**138.0**	**13%**	**168.8**	**3%**	**16%**
Citywide Total	**4,914.0**	**1,309.0**	**27%**	**1,359.2**	**1%**	**28%**
**Canopy Percent does not match citywide total because this table only shows zoned parcels, not rights-of-way. Parks, wetlands, and storm water detention areas are not included in zoned parcels.*						

Table 7 – Canopy Goals

A no-net-loss strategy is recommended for Residential zones. Commercial and Office zones may have an opportunity to increase canopy with additional tree planting in parking lots, along street rights-of-way and with increased perimeter or interior landscape tree requirements for redeveloped parcels. Industrial areas have planting opportunities along the river and in rights-of way, so a 1% increase in tree canopy goal is recommended. A more substantial 3% increase may be achieved in Tukwila Valley South and the Urban Center if planned redevelopment occurs. This goal is contingent on redevelopment and the subsequent establishment and growth of landscape and street trees in newly-developed land that was previously mostly agricultural in the

case of Tukwila South. While the 1% increases may be seen within 10 years, 20 years, or more may be required to achieve the 3% goal.

These goals were based on identifying possible planting locations, as provided in the map titled Possible Urban Tree Canopy. The map was developed by identifying areas with low canopy that were bare ground and pervious surfaces (impervious, open water, and canopy were not considered plantable areas). These possible planting locations were further refined by City staff to exclude areas that have already recently been planted through restoration activities and areas where the land use is incompatible with additional planting. For example, on the west side of the river from I-405 south to the city limits, no tree planting on federally certified levees is permitted by federal regulations, unless levee sections are set back and mid-slope benches are installed for planting. Table 8 illustrates the acreage available for tree canopy in Tukwila at present.

Citywide

City Acres	Existing Acres	Existing %	Possible Additional Acres	Possible%
6,396	1,616	25%	928	40%

By Zone

Zone Class	Zone Acres	Existing Acres	Existing %	Possible Additional Acres	Possible%
Commercial Light Industrial	417	88	21%	36	30%
Heavy Industrial	151	17	11%	6	15%
High Density Residential	146	49	33%	13	42%
Light Industrial	52	5	10%	1	11%
Low Density Residential	1,639	777	47%	344	68%
Manufacturing Industrial Center/Heavy	1,034	96	9%	58	15%
Manufacturing Industrial Center/Light	99	20	20%	6	26%
Medium Density Residential	84	43	51%	10	63%
Mixed Use Office	34	14	41%	17	91%
Neighborhood Commercial Center	38	5	13%	6	29%
Office	50	24	49%	7	62%
Regional Commercial	69	6	9%	7	19%
Regional Commercial Mixed Use	67	25	37%	5	45%
Residential Commercial Center	6	2	30%	1	51%
Tukwila Urban Center	764	82	11%	65	19%
Tukwila Valley South	266	56	21%	116	65%

Table 8 – Possible Canopy

Conclusion

Tree canopy is a vital community resource that provides ecological, economic and social benefits to residents, businesses, visitors, and wildlife. Considering the extent and distribution of canopy can help decision-makers protect and enhance this resource. This Urban Tree Canopy (UTC) assessment determined that Tukwila has a current overall average tree canopy cover of 25%, and impervious surface of 51%. It established that the largest acreage of canopy is in the Low Density Residential zone, and the highest percent canopy is found in the Medium Density Residential zone.

This canopy study is the first step in establishing canopy goals by areas or zones and city-wide for Tukwila. In considering a possible canopy goal, decision-makers should consider Tukwila's unique zoning composition with just 38% residential and 62% zoned commercial, office, industrial, and mixed use. Initiating the goal-setting process by developing zone-based canopy goals can help inform the development of a realistic citywide canopy goal that is unique and appropriate to Tukwila.

Providing space for commerce is vital to the economic well-being and sustainability of the community. Compared to residential and office zones, commercial and industrial zones are simply less conducive to developing and maintaining tree canopy. However, Tukwila has an opportunity to consider creative approaches to engaging commercial and industrial parcel owners in promoting urban forestry while protecting and enhancing the canopy in residential and office zones.

Appendix A: References

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Appendix B: Land Cover Percentage

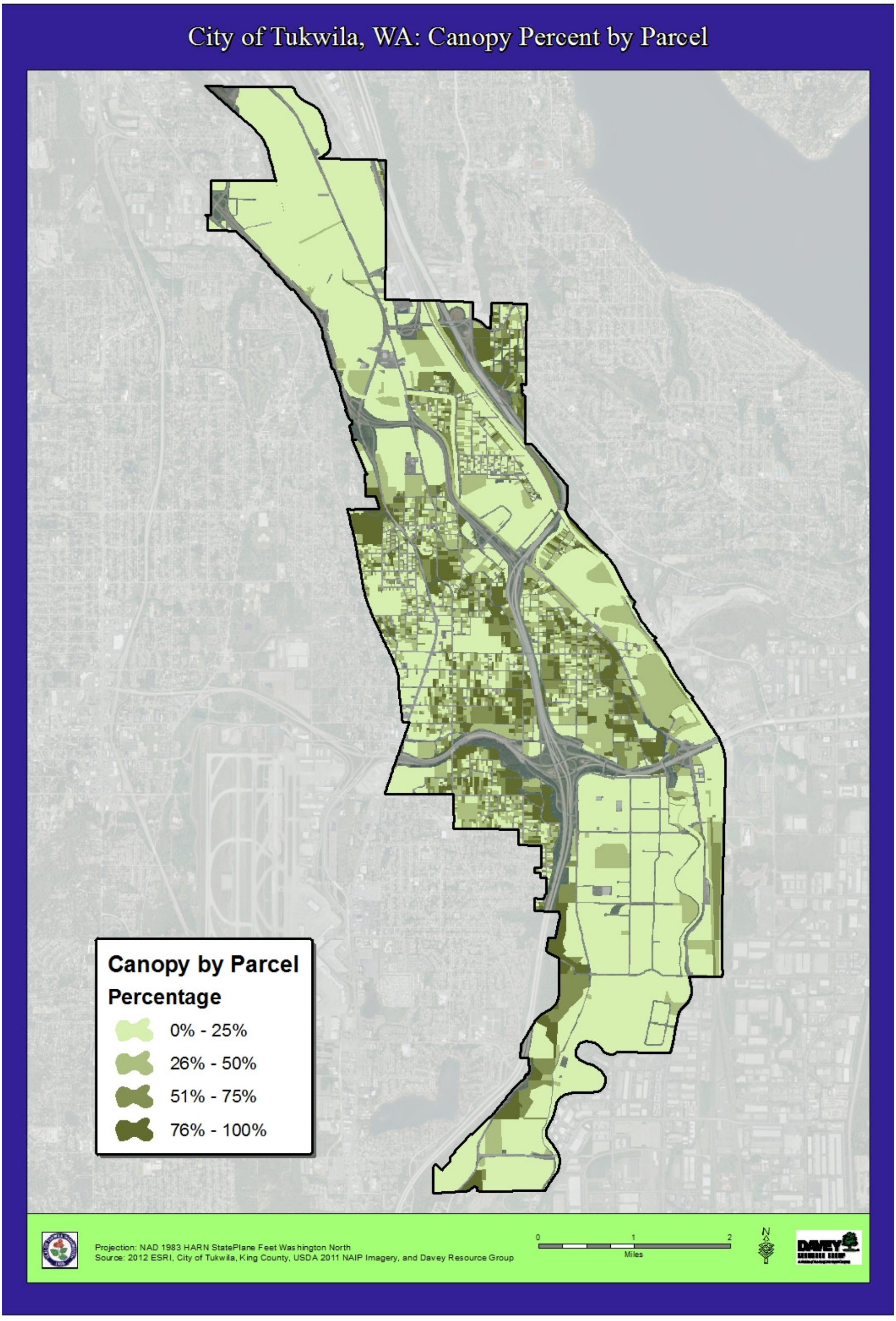
	Percent (%)				
Zone Class	**Canopy**	**Impervious**	**Pervious**	**Bare Soil**	**Open Water**
Medium Density Residential	51.33	35.10	13.50	0.05	-
Office	49.24	35.90	14.72	-	-
Low Density Residential	47.44	21.95	28.51	1.43	0.60
Mixed Use Office	41.02	8.39	48.65	1.93	-
Regional Commercial Mixed Use	37.47	53.45	9.02	-	0.06
High Density Residential	33.30	55.76	10.81	0.14	-
Residential Commercial Center	29.63	47.27	23.10	-	-
Commercial Light Industrial	21.15	67.98	9.74	0.60	0.42
Tukwila Valley South	21.14	28.55	28.34	18.55	3.41
Manufacturing Industrial Center/Light	19.84	71.85	7.82	-	0.16
Neighborhood Commercial Center	13.19	69.91	16.77	-	-
Heavy Industrial	10.92	80.78	6.44	0.34	1.51
Tukwila Urban Center	10.71	77.42	9.47	0.23	2.18
Light Industrial	9.89	80.71	8.12	0.68	0.60
Manufacturing Industrial Center/Heavy	9.28	71.61	12.87	1.84	4.23
Regional Commercial	8.58	80.52	9.60	1.01	-

Totals may not add to 100% due to rounding.

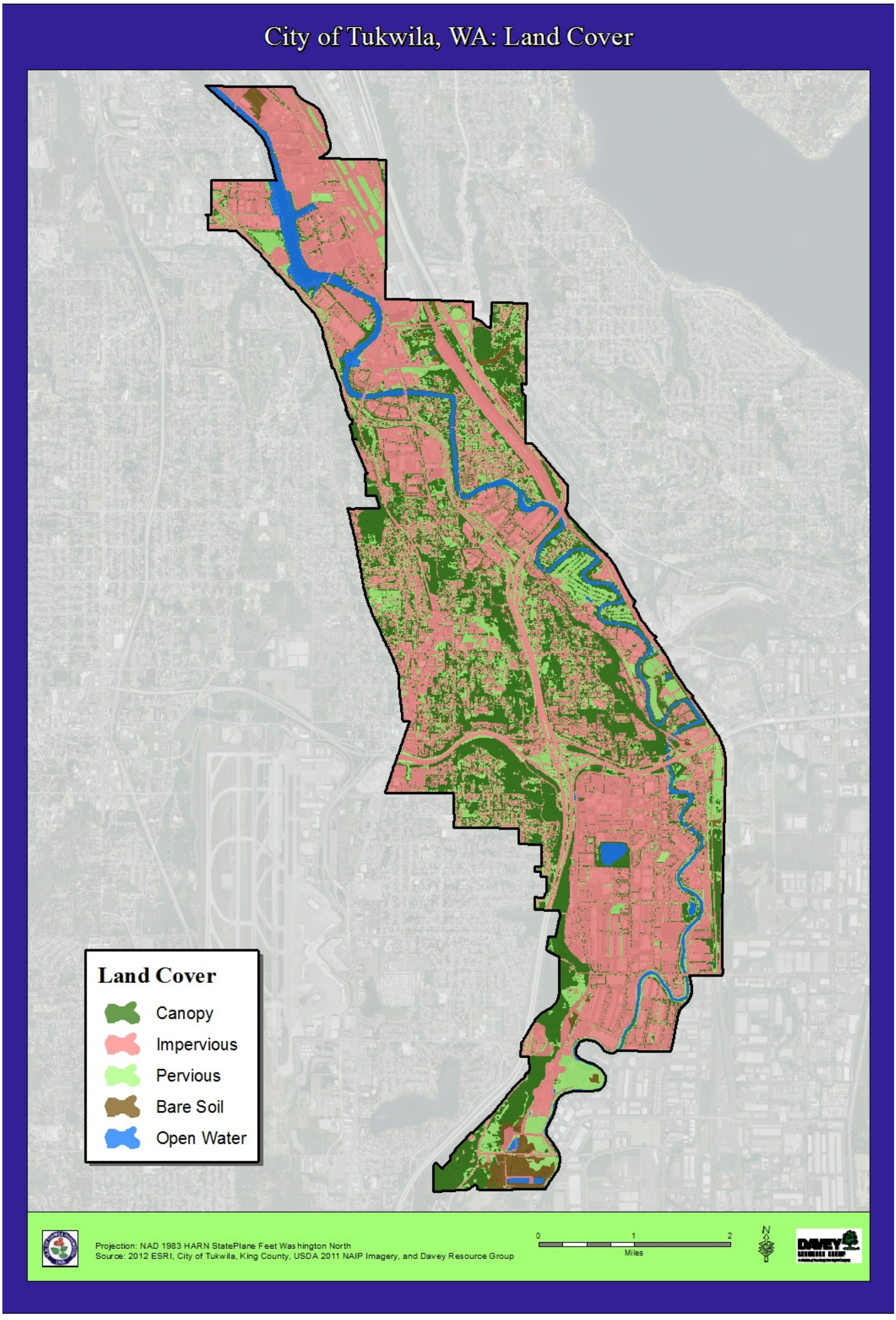
Appendix C: Land Cover Acreage

Zone Class	Canopy	Impervious	Pervious	Bare Soil	Open Water	Total Zone Acres
Residential Commercial Center	1.68	2.68	1.31	-	-	5.67
Mixed Use Office	14.03	2.87	16.64	0.66	-	34.20
Neighborhood Commercial Center	5.05	26.77	6.42	-	-	38.24
Office	24.48	17.85	7.32	-	-	49.65
Light Industrial	5.10	41.64	4.19	0.35	0.31	51.59
Regional Commercial Mixed Use	25.02	35.69	6.02	-	0.04	66.77
Regional Commercial	5.95	55.83	6.66	0.70	-	69.14
Medium Density Residential	43.09	29.47	11.33	0.04	-	83.93
Light Manufacturing Industrial	19.71	71.38	7.77	-	0.16	99.02
High Density Residential	48.50	81.22	15.74	0.20	-	145.66
Heavy Industrial	16.51	122.08	9.73	0.52	2.28	151.12
Tukwila Valley South	56.20	75.89	75.34	49.31	9.06	265.80
Commercial Light Industrial	88.14	283.25	40.57	2.52	1.74	416.22
Tukwila Urban Center	81.75	591.09	72.27	1.72	16.68	763.51
Manufacturing Industrial Center/Heavy	95.94	740.24	133.09	19.07	43.71	1,032.05
Low Density Residential	777.48	359.70	467.19	23.48	9.87	1,637.72
All Zones	**1,308.63**	**2,537.65**	**881.59**	**98.57**	**83.85**	**4,910.29**

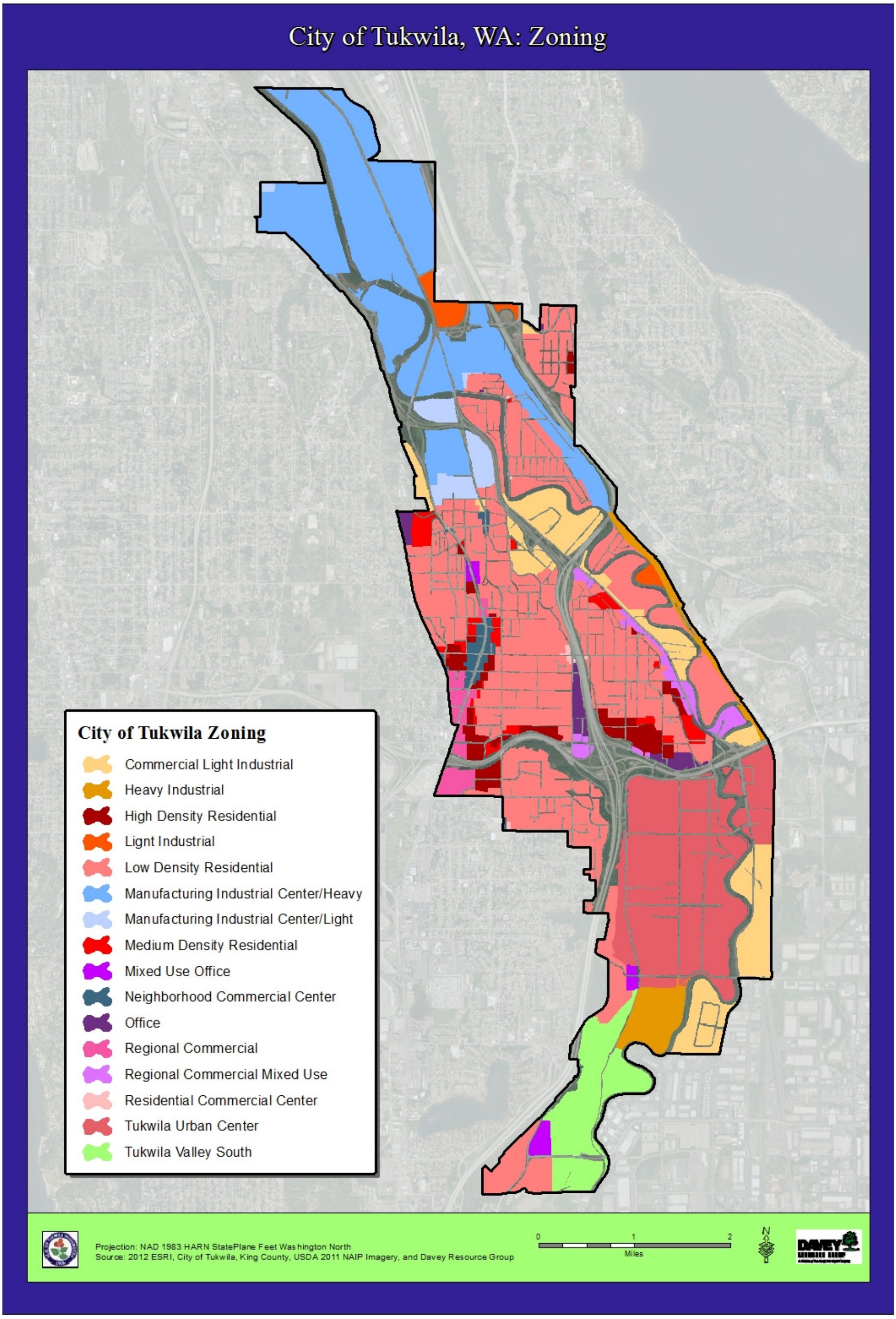
Appendix D: Maps



Map 1 – Canopy by Parcel Percentage



Map 2 – Land Cover


City of Tukwila, WA: Zoning
City of Tukwila Zoning
Commercial Light Industrial
Heavy Industrial
High Density Residential
Lignt Industrial
Low Density Residential
Manufacturing Industrial Center/Heavy
Manufacturing Industrial Center/Light
Medium Density Residential
Mixed Use Office
Neighborhood Commercial Center
Office
Regional Commercial
Regional Commercial Mixed Use
Residential Commercial Center
Tukwila Urban Center
Tukwila Valley South
Projection: NAD 1983 HARN StatePlane Feet Washington North
Source: 2012 ESRI, City of Tukwila, King County, USDA 2011 NAIP Imagery, and Davey Resource Group
0
1
2
Miles
N

Map 3 – Zoning