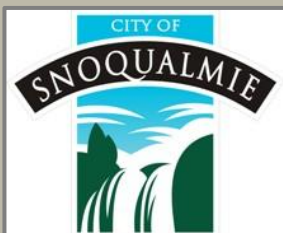# Snoqualmie Tree Canopy Assessment

Completed August 2012

Prepared for the City of Snoqualmie, Washington

by:
Plan-It Geo LLC.

City of Snoqualmie
Tree Canopy Assessment Report
August 2012

Acknowledgements

Snoqualmie Mayor and Council 2012

City Administration 2012

Parks Board 2012

Parks & Recreation Department 2012

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Elizabeth Walker, Terra Firma Consulting

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Snoqualmie Tree Canopy Assessment

Executive Summary

Tree canopy in cities and communities provide numerous social, economic and environmental benefits and services. Trees and natural spaces make the fabric of a community. The City of Snoqualmie's Parks and Recreation Department cares for and manages public trees along streets, in parks and in other public properties. The Parks and Recreation Department is responsible for maintaining the health of the City's street tree canopy comprised of roughly 3,000 trees growing in the street right-of-way, parks and other public spaces.

Land cover mapping is an essential tool to benchmark and monitor forestry, natural resources, development, and planning programs. This report provides results of assessing 2011 and 1998 tree canopy cover to reveal citywide tree canopy, areas for expanding tree canopy, and historical canopy change.

Geographic information systems (GIS) and land use / land cover data provide the basis for this assessment. GIS was used to assess current tree canopy extent, possible planting area (PPA), and areas unsuitable for tree planting citywide, by ownership types, by land use categories, and at the individual parcel (property) level. This report provides statistical canopy results, general recommendations, and examples of ways to use the data for implementation, monitoring, and education/outreach.

Tree Canopy in Snoqualmie

The City of Snoqualmie, Washington, located in King County, was the area of interest (AOI) for this assessment and covered approximately 6.5 square miles (4,159 acres). Based on 4,046 acres of land area (excludes water), Snoqualmie has 1,769 acres (43.7%) of tree canopy based on 2011 summer imagery. Additionally, 706 acres (17.4%) were mapped as possible planting area (PPA) and 803 acres (19.3%) are impervious surfaces such as streets, buildings, and parking area. Mapping forest loss due to development using 1998 aerial photography showed that Snoqualmie's average canopy cover declined by 768 acres or 19.0% over the 13 year time period.

Snoqualmie	1998	2011
Tree Canopy (acres)	2,537	1,769
Tree Cover (percent)	62.7%	43.7%

43.7

Percent of Snoqualmie covered by Tree Canopy in 2011

50.7 | 37.6

Percent Tree Canopy in Historic Downtown vs. the Ridge, respectively

-768 | -19.0

The acres of forest cover lost since 1998 due to development and the percent reduction in citywide canopy cover (from 62.7% to 43.7%)

17.4

Percent of Snoqualmie available for tree planting ("Total PPA") after removing sports fields, utility corridors and golf courses fairways/greens

59 | 29

Percent tree cover on public vs. private property, respectively

Results by ownership show that tree canopy cover is substantially higher on public properties than private properties (59% and 29% respectively) and that tree canopy is higher in Historic Downtown compared to the Ridge (50.7% and 37.6% respectively). Assessing TC by land use revealed that residential properties average 30% canopy cover, that 57% of all TC is on open space property, and the City's street rights of way average 16% canopy cover.

Ecosystem Services

Trees and forests in communities provide many "ecosystem services", or direct and indirect economic and environmental benefits such as removing air pollutants, storing and sequestering carbon, mitigating stormwater runoff, conserving energy through shade and wind block, improving public health, and providing wildlife habitat. In the Pacific Northwest, the main benefits of urban trees include stormwater runoff mitigation, aesthetics, pollution abatement, and fish habitat. The Appendix of this report lists and describes these urban forest benefits.

Setting Canopy Cover Goals

Tree canopy cover is a critical measure of environmental health and sustainability in communities. Setting realistic goals for different land use types and planning scales in a collaborative way creates a shared vision to ensure that resources are allocated effectively and adaptive management can occur over time. This study showed that 17% of the City is available for tree planting and canopy enhancement. With the data from this top-down approach of assessing Snoqualmie's green infrastructure, the City should evaluate tree canopy goals for urban forest management planning, education & outreach, and policy development.

An assessment report and accompanying GIS data may sit on the shelf underutilized if the information isn't made available in diverse ways to a wide audience. Maps and tables in this report demonstrate ways to identify tree planting and preservation opportunities.

Recommendations and Summary

This 2011 tree canopy assessment provides a benchmark for current tree canopy and planting areas. With 43.7% TC in 2011 (50.7% downtown, 37.6% on the Ridge), down 19.0% from 1998, Snoqualmie has seen major landscape change. City officials and residents are working to balance economic development with preservation and management of natural resources. With 57% of all canopy found in Open Space areas, management of those lands will be critical to sustaining forest benefits. The City has 16% tree cover in street rights-of-way (23% Downtown and 14% on the Ridge). Investments in street tree plantings will require maintenance to ensure these trees provide their intended benefits. Over time as canopy trends back upward in Snoqualmie, this will be accompanied by increased social, environmental and economic benefits provided by the urban and community forest. Reaching the public with targeted messages on the benefits of urban trees may foster the greatest amount of stewardship for the urban and community forest. Analyzing tree canopy benefits in a future study would offer compelling arguments to promote and ensure a sustainable, high-performing urban forest.

Introduction

Trees provide many economic, social, and health benefits that form the basis of livability in urban municipalities. Therefore, it is important for planners and community development to work closely with city arborists to develop management goals to maintain community livability. The recent influx of new residents and businesses in the Snoqualmie has created challenges for maintaining existing forest cover. Using 2011 imagery and Google Earth historical imagery, it is clear to see that development places a stress on the City's green infrastructure, including forests, wetlands, and open spaces. This presents unique and significant constraints for the Snoqualmie in providing comprehensive urban forest management services while encouraging and promoting economic development.

A land cover study of the Puget Sound region was performed by American Forests in 1998 (Figure 1) which highlighted a downward trend in forest cover at the regional scale.

Landsat MSS 1972 *80 Meter Pixel Resolution*   **Landsat TM 1986** *30 Meter Pixel Resolution*   **Landsat TM 1996** *30 Meter Pixel Resolution*
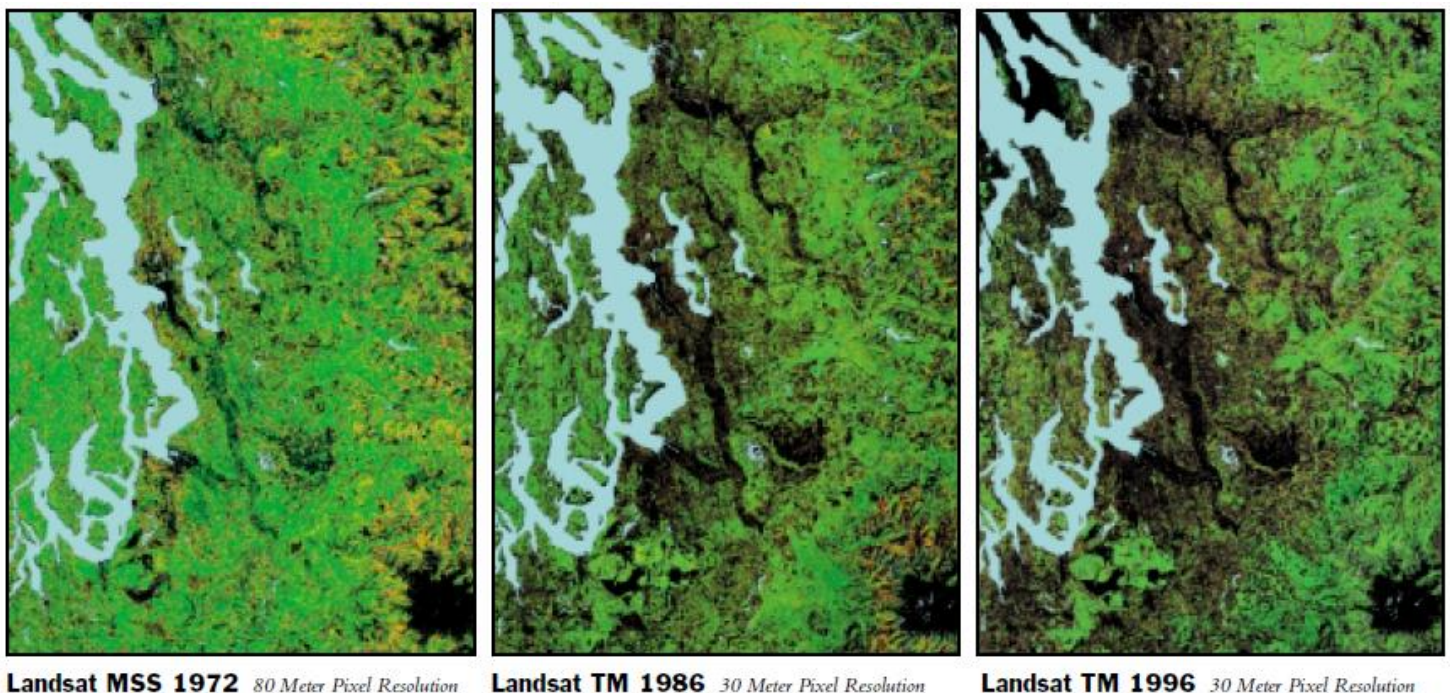
Figure 1. Puget Sound land cover change at a regional scale (American Forests 1998), with green as vegetation types including tree canopy and black as impervious surfaces.

The City of Snoqualmie for the first time recognized the importance of tree canopy cover in the Parks, Recreation and Open Space Plan adopted in 2012. The policy (9.B.8.10) states: *"Develop a citywide canopy cover survey to protect and enhance the current coverage offered by our urban forest and ensure that the forest's air, water quality, water management and economic benefits continue in perpetuity or are enhanced in the future."* The benchmark being provided by this project will serve as the starting point for future surveys and monitoring of the canopy cover.

Snoqualmie has made great strides recently for advancing urban forestry regulations, maintenance, budgeting, certification and education. These include:

- Sustainability initiative: The City launched a "Sustainable Snoqualmie" initiative in 2010 that included surveys of citizens and forums to educate citizens on green practices, including urban forestry best practices.

- Tree regulations: Regulations protecting public trees in Snoqualmie were adopted in 2010 to safeguard trees in parks, street rights-of-way, and historic trees of significance with the City's first landmark tree program.

- Tree maintenance plan: Following adoption of the above regulations, an overall tree maintenance plan was adopted in 2010. The plan lays out a schedule of activities to ensure trees are monitored for health, pruned for their best vitality and properly planted to thrive in the sometimes difficult soil conditions in Snoqualmie.

- Tree budgeting: In 2011, the City allocated $20,000 of its General Fund budget for tree replacements and care—a not insignificant amount for a city with a population of just under 11,000. This funding is before the Council to continue into 2012, in addition to significant staff resources that are expended on tree care.

- Tree expertise: In May 2010, the City hired its first ISA-certified arborist to assist in the proper care of its urban forest and train other employees.

- Tree education: In 2011, the City offered two classes free to residents on proper tree pruning. The intent is to continue the pruning classes and supplement with online information.

- Tree inventory: In 2011, the City of Snoqualmie started its first partial street tree inventory thanks to funding support from the U.S. Forest Service and Washington State Department of Natural Resources. That data will be used for tree replacement projects and supplemented by updates from City staff.

With funding from the U.S. Forest Service and Washington DNR, the City contracted with Plan-It Geo, LLC to conduct Snoqualmie's first tree canopy assessment project. The assessment was accomplished using geographic information systems (GIS) and aerial photography. A land cover classification process was performed to map tree canopy, shrub cover, impervious surfaces, grass and open space, bare soil, and water. Aerial photography from the 2011 National

Agricultural Imagery Program (NAIP) was used. The NAIP imagery was flown to capture "leaf-on" (summer) conditions at 1-meter pixel resolution. Additionally, loss in tree canopy from new development was assessed by comparing the 2011 results with aerial imagery acquired in 1998 by the U.S. Geologic Survey (USGS).

The specific objectives of this assessment were to:

❖ Map 6 land cover classes across the Snoqualmie: tree canopy, shrub cover, other low-lying vegetation such as grass and open space, impervious surfaces, bare soil / dry vegetation, and water.

❖ Determine existing Tree Canopy (TC) and Possible Planting Area (PPA) percentages for the City, for public and private ownership, street rights-of-way (ROW), 11 generalized land use categories, and individual parcels (property boundaries).

❖ Assess the citywide change in forest cover since 1998 and existing forested areas at risk from development based on land use/zoning.

❖ Present results and opportunities from the analysis in a summary report.

The Snoqualmie Tree Canopy Assessment provides data and tools to develop local and regional urban forestry goals, policies, outreach, and management plans to sustain and enhance the existing urban forest. It provides a sound scientific basis for ongoing regulation and management of the City's urban tree canopy by establishing a tree canopy baseline through GIS analysis. Results should be used as a basis for setting management goals from which to measure progress over time towards those goals.

Major Findings

Based on the analysis of aerial imagery, land cover, and land use data, the following represent the major findings from this assessment:

- *Snoqualmie has 43% tree canopy, 4% shrub, and 19% impervious surface. The remaining 34% is grass, bare soil, and water.*

- *Snoqualmie lost 768 acres of forest cover since 1998 (-19%).*

- *Realistic "Possible Planting Areas" (PPA) such as grass and parking lots cover 606 acres (17.4%) of Snoqualmie.*

- *Public properties average 59% tree cover while private land averages 29%. Consequently, 71% of the City's tree canopy is found on public land, with 25% on private property and 3% in street rights-of-way.*

- *Residential land use makes up 27% of Snoqualmie. With 30% average tree cover, this represents 17% of all tree canopy.*

- *43% of Snoqualmie is Open Space but forest cover in these areas represent 57% of total tree canopy.*

- *Street ROW has 16% canopy cover and 8% Total PPA.*

Methodology

Urban tree canopy assessments include the following main elements: (i) inputs of aerial imagery and GIS data from the community, (ii) land cover mapping using geographic information systems (GIS) and remote sensing analysis, (iii) assessing existing and potential canopy using GIS, and (iv) reporting of the results. The main methods and processes involved in this study are described below.

GIS and Imagery Data

Numerous GIS and imagery data layers were provided by the City in support of this assessment. GIS data layers such as buildings, roads, a prior impervious surface classification, and water polygons were reviewed, edited (as needed), and merged with the automated land cover data to increase accuracy of the final product. See Figure 2 below. Other layers such as parcels, land use/zoning, and ownership were provided by the City and used as TC assessment boundaries. See Table 2 below under Methodology.
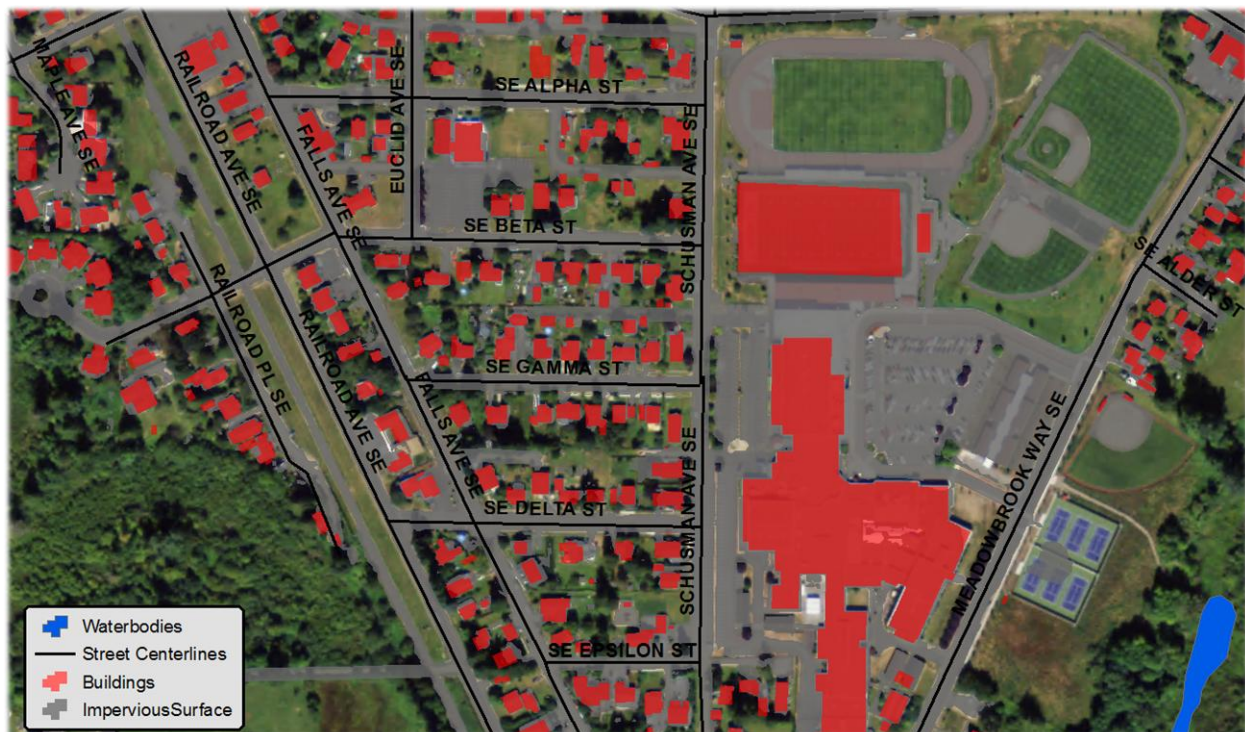

Figure 2. GIS Data Inputs for Land Cover Mapping.

Three imagery data sets were used in this study as described below and in Table 1.

❖ 2011 aerial photography at 1-meter pixel resolution from the National Agricultural Imagery Program (NAIP) which provided summer "leaf-on" imagery;

❖ Spring 2009 "leaf-off" aerial imagery at 6-inch pixel resolution from King County;

❖ 1990 black & white aerial imagery from Google Earth and the USGS which offered a "prior" view to assess TC changes citywide

Table 1. Imagery types used in this assessment

2011 "Leaf-On" NAIP Ortho Aerial Photography (1-meter pixel resolution)	2009 "Leaf-Off" Ortho Aerial Photography (County) (6-inch pixel resolution)	1998 Ortho Aerial Imagery (USGS) (1-meter pixel resolution)

Land Cover Classification

Six (6) land cover types were mapped using the 2011 NAIP imagery. The land cover classes are:

- ❖ <u>Tree canopy</u> – forests and individual trees

- ❖ <u>Shrubs</u> – shrubby, briar, or transitional vegetation

- ❖ <u>Grass and open space</u> – low-lying herbaceous vegetation

- ❖ <u>Impervious surfaces</u> – paved hardscape surfaces such as roads, parking lots, buildings, sidewalks and patios

- ❖ <u>Bare soil and dry vegetation</u> – barren land, unmaintained, or devoid of live vegetation including areas under construction and industrial compacted surfaces

- ❖ <u>Water bodies</u> – all open and exposed water including rivers, lakes, ponds and streams in the city limits visible at the time of aerial imagery capture

An automated remote sensing classification technique known as object-based image analysis (OBIA) was performed to map these classes above. This was followed by a manual Quality Assurance / Quality Control (QA/QC) editing step to improve accuracy of the automated classification. City GIS data including water bodies, buildings, streets, and street tree inventory data were merged into the classification to improve accuracy. Additional land use / land cover classes were mapped to eliminate unrealistic planting areas. Figures 5 and 6 below show results of the detailed tree canopy layer and other land cover classes that were mapped.

A more technical description of the land cover classification methodology is provided in the Appendix of this report.

## Assessing Tree Canopy and Possible Planting Areas

Central to a tree canopy assessment is calculating the area (acres or square feet) and percent of existing TC and possible planting area (PPA) across multiple spatial scales, political boundaries, and ownership types. For Snoqualmie, this was done for:

- ❖ The Snoqualmie City boundary

- ❖ Generalized land use categories: business park/commercial, golf course, office park, open space, planned commercial/industrial, public use, railroad, residential, resource extraction, retail, and utility park.

- ❖ Ownership types: private and public properties and street rights-of-way (ROW)

- ❖ Individual parcel (property) boundaries

Using GIS models, these assessment boundaries were overlaid with the land cover data to calculate area and percent of TC metrics provided in GIS and MS Excel spreadsheet format. Land use zone categories were generalized at the parcel-level by the City and provided in the broad categories listed above. The following definitions were used in the assessment:
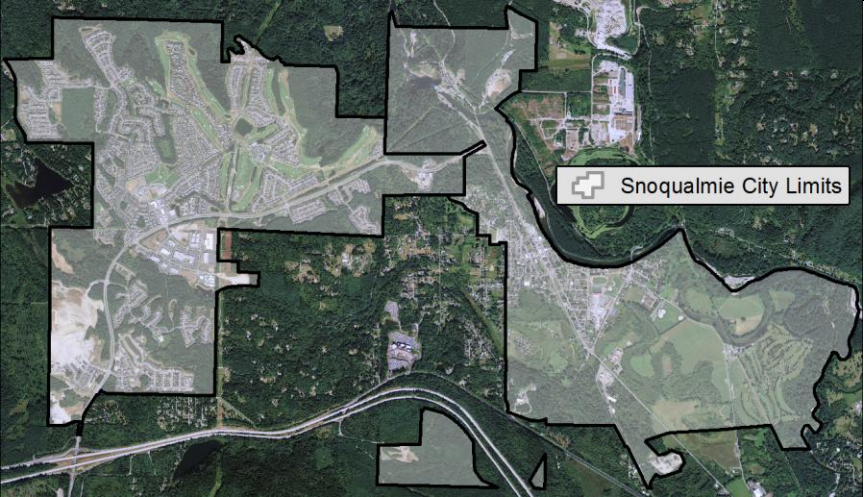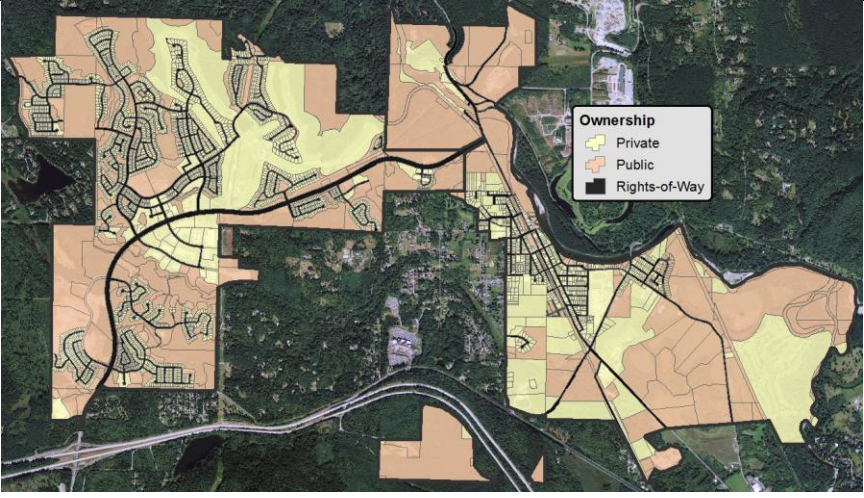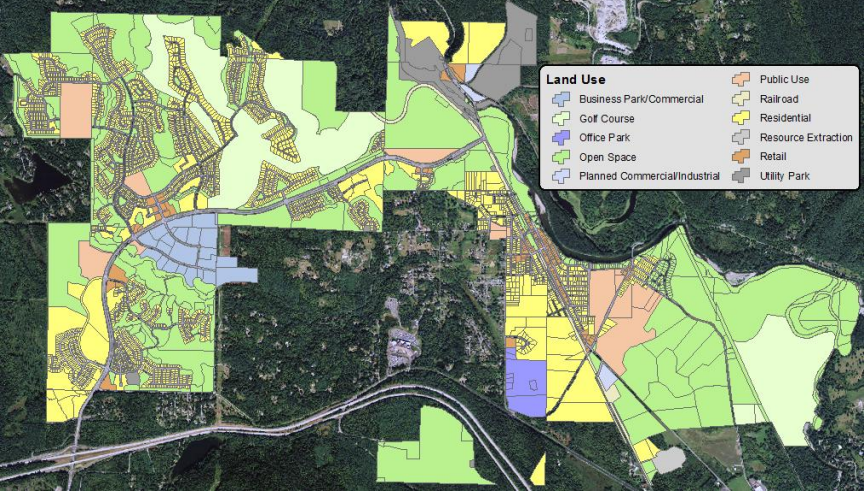
- ❖ *Existing tree canopy (TC)* was defined as areas covered by forest and individual trees.

- ❖ *Possible Planting Area – Vegetation* was defined as shrub and grassy vegetated areas where no TC exists and it is possible to plant trees. Sports fields, transmission corridors, golf courses, (greens/fairways), barren soil, and other unrealistic areas were removed.

- ❖ *Possible Planting Area – Impervious* was defined as paved surfaces where it is possible to plant trees, primarily in and around parking lots. Buildings, roads, tennis courts, and other unrealistic paved surfaces were removed.

- ❖ *Total PPA* was the combination of PPA – Vegetation and PPA – Impervious.

- ❖ *Unsuitable TC* was defined as all remaining areas (water, bare soil, buildings, roads, etc.)

Examples are provided in the photographs below. *Note: TC metrics were calculated based on percentage of land area which excludes area in the City covered by water.*
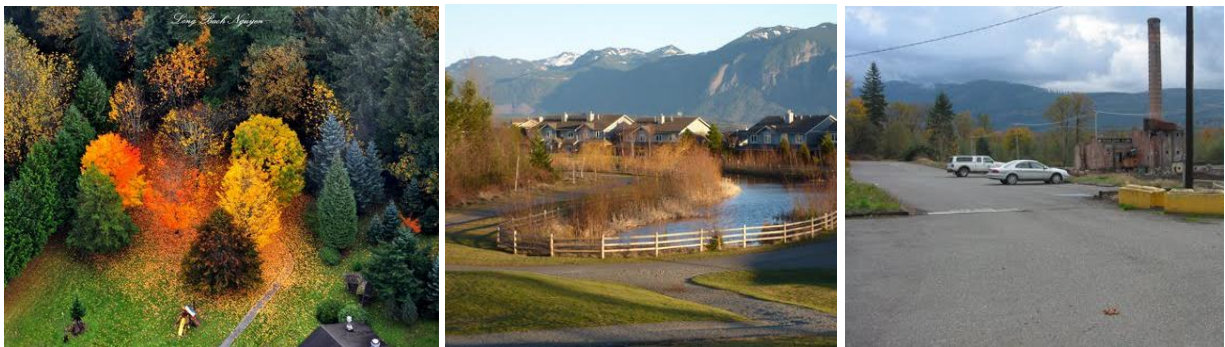
Figures 3a – 3c. Local area photos (from left to right) of Existing TC, Possible Planting Area – Vegetation and Possible Planting Area – Impervious.

Table 2. List of TC Assessment Boundaries

Boundary	Description	Map
City Limits	Study area boundary	
Land Ownership & Street ROW	Private and public properties and street rights-of-way (ROW) where the City has the most direct influence on tree planting and maintenance.	
Land Use and Parcels	16 land use types were categorized into 11 broad classes at the parcel-level for this assessment. Data was manipulated and provided by the City.	

Results

This section of the report presents the mapping and assessment results beginning with an overview of Snoqualmie's land cover. Results are then presented for tree canopy (TC) and Possible Planting Areas (PPA) at the citywide scale, by ownership types including the rights-of-way (ROW), by land use categories, and finally at the individual parcel level. Results from assessing forest change in Snoqualmie (1998 to 2011) and remaining forested areas at risk from development are presented at the end.

Snoqualmie Land Cover

The predominant land cover in the City is comprised of forests and individual trees (1,770 acres / 43.7%), followed by grass and open space (1,035 acres / 24.9%) and then impervious surfaces (803 acres / 19.3%). As additional development occurs and recently developed areas mature, canopy cover from individual trees as well as impervious surfaces will likely increase while bare soil and grass/open space land cover will decrease.

Snoqualmie Land Cover Distribution

113 · 288 · 148

1,035 · 803 · 1,770

- Tree Canopy (ac)
- Impervious (ac)
- Grass / Open Space (ac)
- Water (Acres)
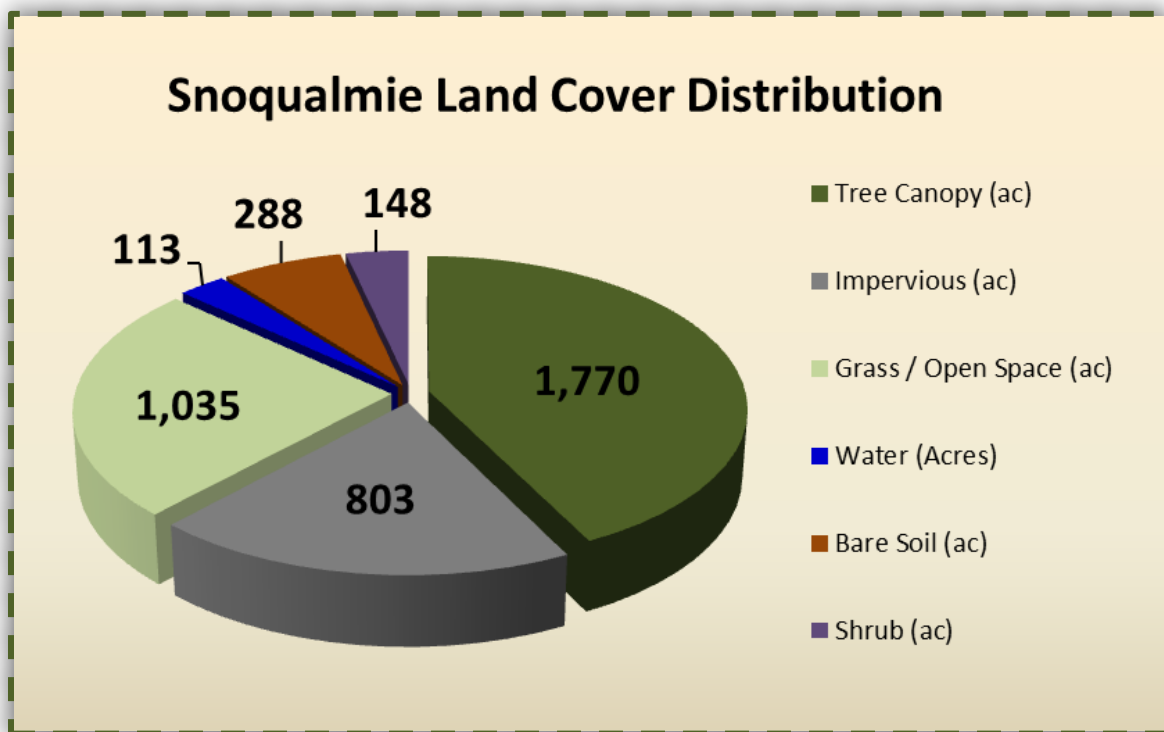- Bare Soil (ac)
- Shrub (ac)

Figure 4. Distribution of Snoqualmie's Land Cover in Acres
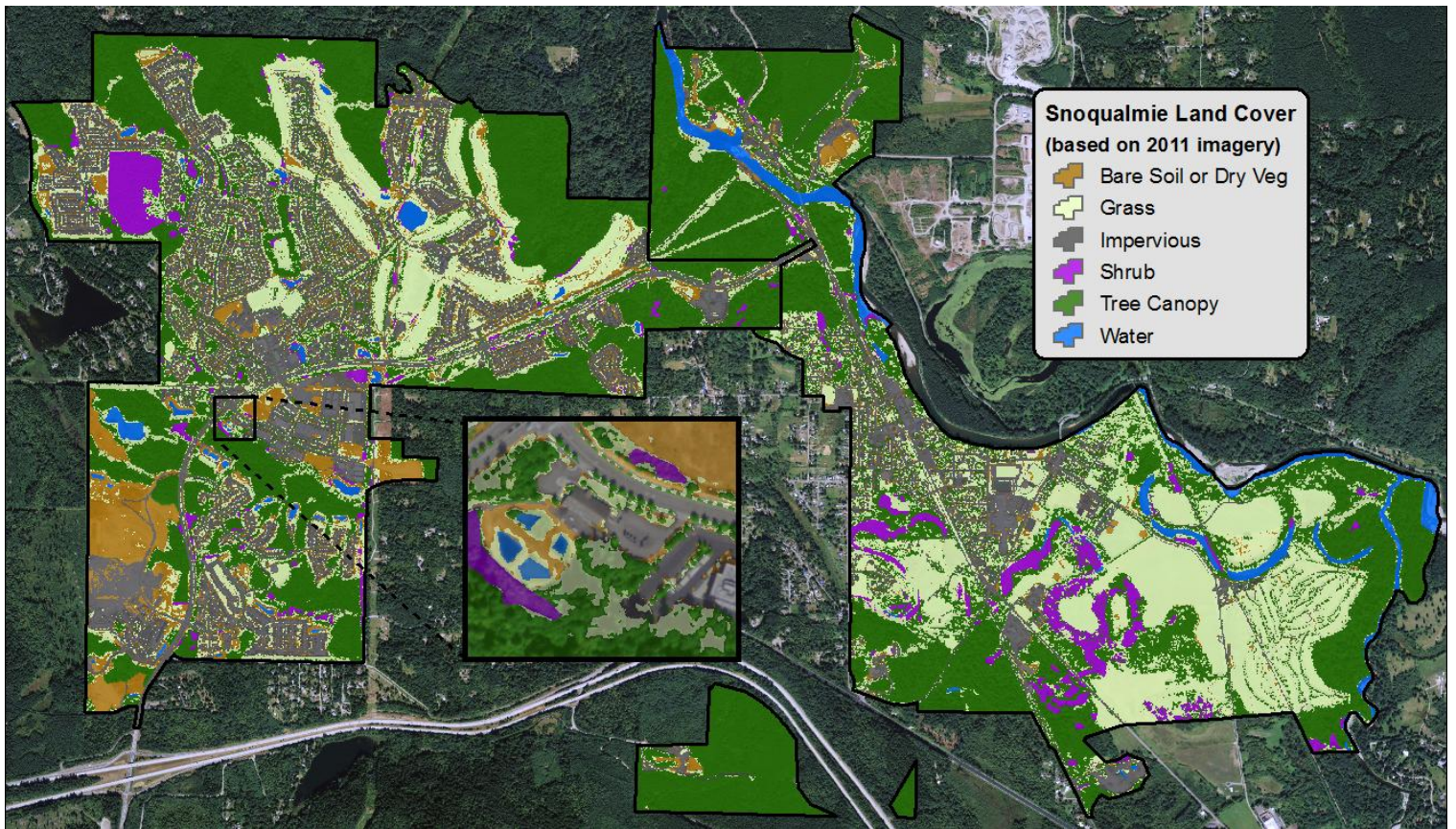
Figure 5. Classified Land Cover Data in the Snoqualmie and Example Inset Map.

Figure 6. Classified TC and PPA Analysis Data in the Snoqualmie and Example Inset Map. Note the addition of classes to help derive meaningful assessment statistics for planting potential.

Citywide Tree Canopy (TC) Results

The total land area assessed in this study covered 4,046 acres (excluding water), of which 1,769 acres are tree canopy (43.7% average tree cover). Results were broken out by Historic Downtown Snoqualmie ('Town') vs. Snoqualmie Ridge ('Ridge'), illustrating that average canopy cover is currently higher in Town vs. the Ridge (50.7% and 37.6% respectively). Planting potential is higher in Town as well (22.3% vs. 13.2%).

Table 3. Canopy assessment results citywide and by Historic Downtown vs. the Ridge

Tree Canopy (TC) Metrics	Total Acres	Acres (excludes water)	2011 TC (Ac)	2011 TC (%)	PPA Veg. (Ac)	PPA Veg. (%)	PPA Imp. (Ac)	PPA Imp. (%)	Total Possible Planting (Ac)	Total Possible Planting (%)
City of Snoqualmie	4,159	4,046	1,769	43.7%	606	15.0%	100	2.5%	706	17.4%
Historic Downtown	1,979	1,892	959	50.7%	368	19.5%	54	2.8%	422	22.3%
Ridge	2,180	2,155	809	37.6%	237	11.0%	47	2.2%	284	13.2%

* Note: "Veg." is short for vegetation and "Imp." is short for impervious

Snoqualmie Tree Canopy, *at a glance*

Tree Canopy Percent (43.7% overall)
Historic Downtown (50.7%)
Ridge (37.6%)

Possible Planting Area (17.4%)
Historic Downtown (22.3%)
Ridge (13.2%)

Tree Canopy by Ownership and Street Rights-of-Way

Results were broken out by two ownership types: private and public lands. Public lands were further categorized by street rights-of-way (ROW) given the City's influence on tree planting, maintenance and canopy cover in streets. See maps in Figures 8-11 on the following pages.

Table 4. TC Results in Snoqualmie by Ownership.

Area of Snoqualmie	Ownership Type	Total Acres	Land Acres (excludes water)	2011 TC (Ac)	2011 TC (%)	PPA Veg. (Ac)	PPA Veg. (%)	PPA Imp. (Ac)	PPA Imp. (%)	Total Possible Planting (Acres)	Total Possible Planting (%)	Unsuitable TC (Acres)	Unsuitable TC (%)	Distribution of TC	Distribution of Ownership
Historic Downtown	Public -	1,204.7	1,131.1	656	58%	246	22%	13	1%	259	23%	290	26%	37%	29%
	Private -	653.0	642.8	265	41%	110	17%	34	5%	144	22%	244	38%	15%	16%
	ROW -	98.8	98.8	22.3	23%	10.9	11%	5.9	6%	16.8	17%	59.7	60%	1%	2%
Ridge	Public -	1,011.2	992.5	595	60%	82	8%	7	1%	89	9%	328	33%	48%	46%
	Private -	920.9	914.2	181	20%	147	16%	38	4%	185	20%	555	61%	14%	42%
	ROW -	253.7	253.7	34.5	14%	8.5	3%	2.1	1%	10.6	4%	208.6	82%	3%	11%
Citywide	Public -	2,215.9	2,123.6	1,251	59%	328	15%	20	1%	348	16%	618	28%	71%	53%
	Private -	1,573.9	1,556.9	446	29%	256	16%	72	5%	329	21%	799	51%	25%	38%
	ROW -	352.6	352.1	57	16%	19	6%	8	2%	27	8%	268	76%	3%	9%
Total or Average		**4,142**	**4,033**	**1,753**	**43%**	**604**	**15%**	**100**	**2%**	**704**	**17%**	**1,685**	**41%**	**100%**	**100%**
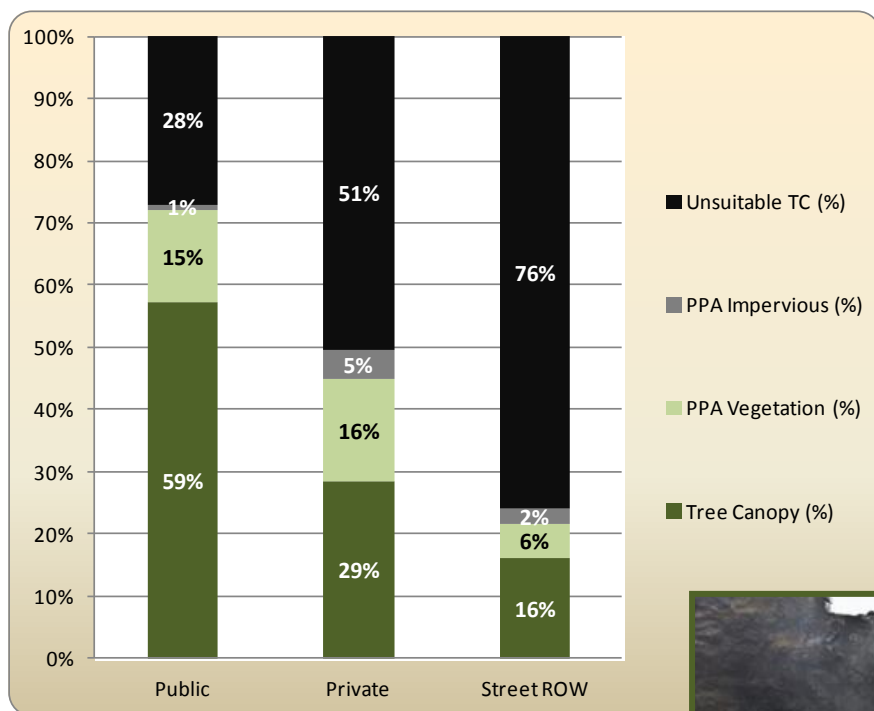
Figure 7. Citywide tree canopy and planting area results in percent in Snoqualmie by Ownership type.

Important Numbers for Ownership:

- Citywide there are 256 acres of PPA on private land; approximately 105 acres (41%) is in golf courses (excludes fairways and greens)

- Private land on the Ridge has 20% average canopy cover; Downtown private land averages 41% canopy

- Downtown ROW has higher Total PPA than the Ridge (16.8 % vs. 10.6%)

Ownership, *at a glance…*

Public
Portion of Total Canopy (71%)

Private
Plantable Space (21%)

Street Rights-of-Way (ROW)
Average Tree Cover (16%)
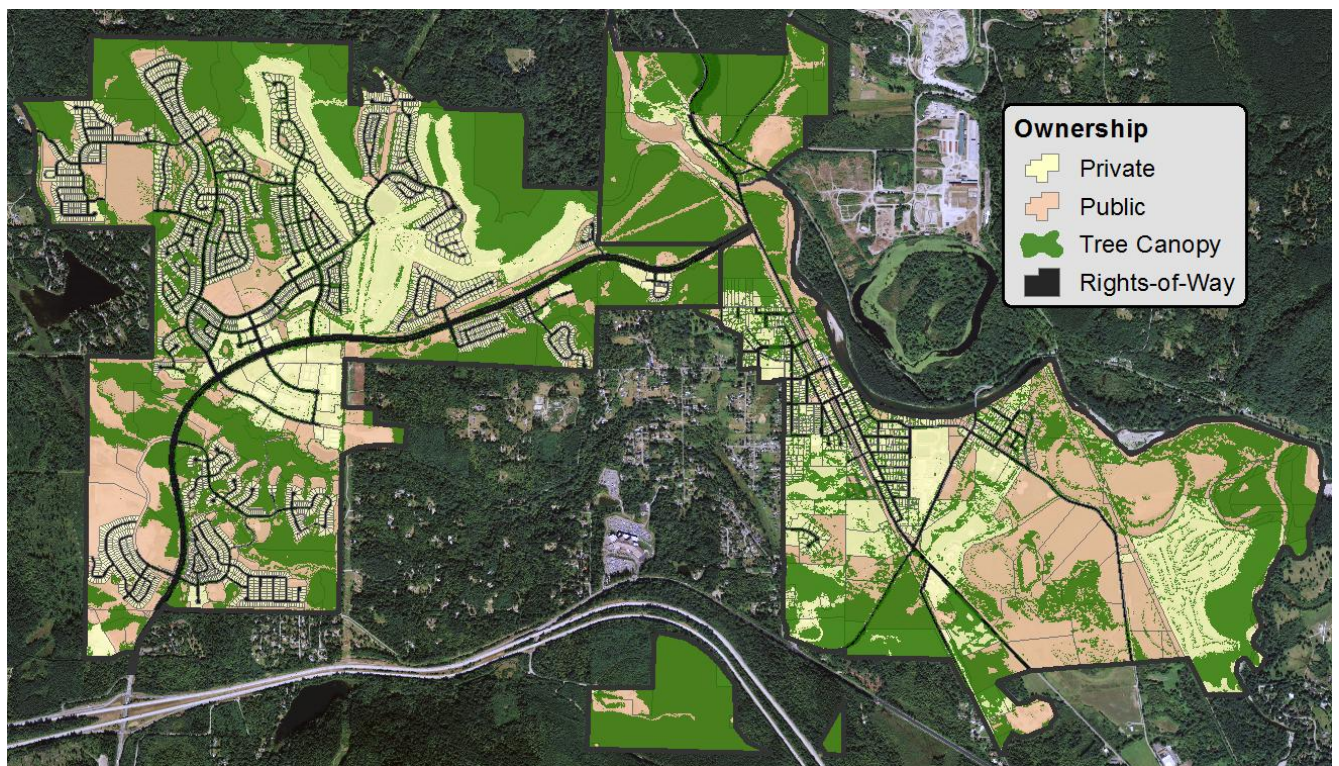
Figure 8. Three (3) types of ownership in Snoqualmie with tree canopy overlaid in green.

Figure 9. Three (3) types of ownership in Snoqualmie with Possible Planting Areas overlaid in bright green (PPA – Vegetation) and dark blue (PPA – Impervious).

Figure 10. Possible Planting Areas specifically within the street rights-of-way (ROW).

Figure 11. A zoomed in view of Possible Planting Areas in Historic Downtown Snoqualmie's street ROW with current tree canopy percent per parcel overlaid.

Tree Canopy by Land Use

Eleven (11) categories of land use within Snoqualmie were assessed for tree canopy (TC) and possible planting area (PPA). In addition to TC and PPA cover percentages, the distribution of canopy by land use type was also calculated (see far right columns, Table ## be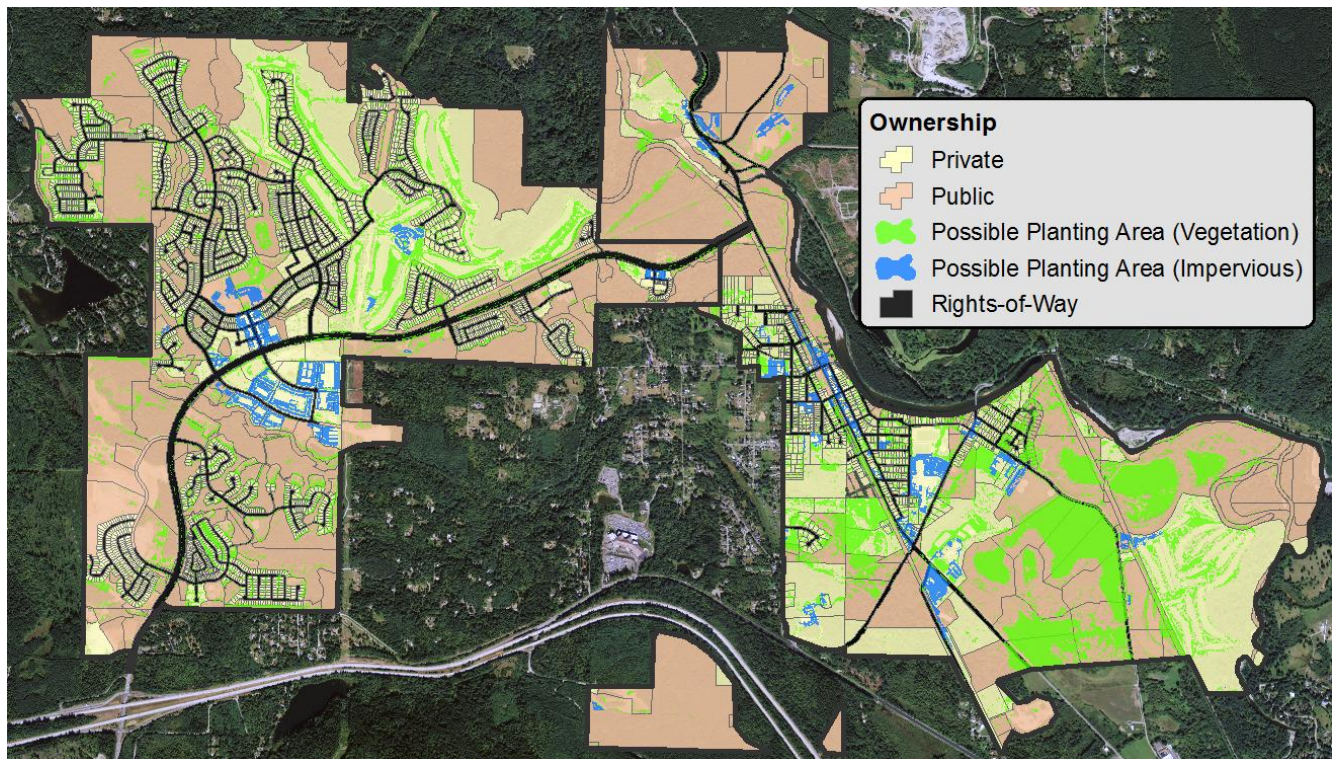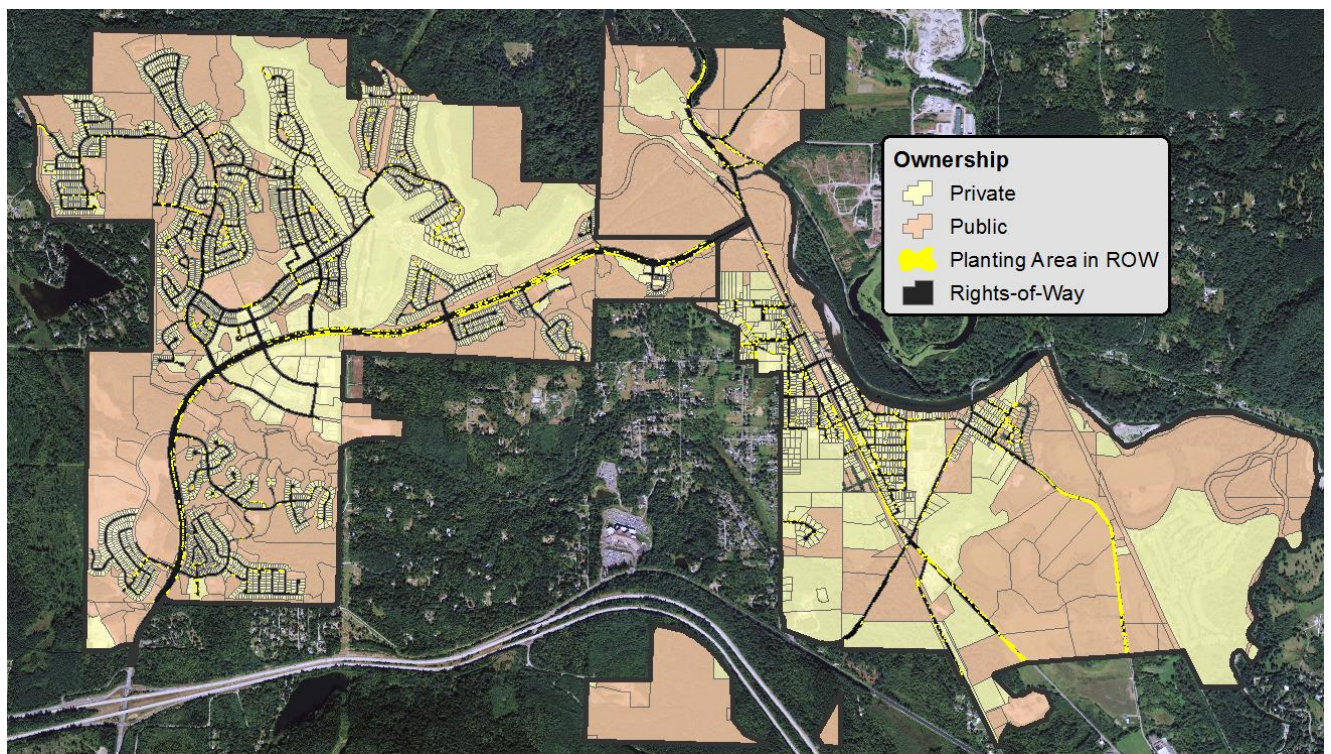low). Residential areas average 30% canopy cover. This represents 17% of all total canopy yet this land use occupies 27% of the City. Additionally, while 14% average PPA on residential property appears low, these areas offer a cost-effective way to achieve higher tree canopy cover. Commercial, business, and retail properties also have high potential for tree planting and canopy growth (all 30% PPA or higher) due to available grass near parking areas where tree shade provides many benefits. Results by land use type can be used for canopy goal setting.

Table 5. Snoqualmie TC Results by Land Use

Land Use Categories	Total Acres	Acres (excludes water)	2011 TC (Ac)	2011 TC (%)	PPA Veg. (Ac)	PPA Veg. (%)	PPA Imp. (Ac)	PPA Imp. (%)	Total Possible Planting (Acres)	Total Possible Planting (%)	Distribution of TC by LU	Distribution of Land Use
Business Park/Commercial	107	107	15	14%	6	5%	26	25%	32	30%	1%	3%
Golf Course	511	498	206	41%	105	21%	6	1%	110	22%	12%	13%
Office Park	53	52	36	69%	5	10%	2	4%	7	14%	2%	1%
Open Space	1,642	1,570	974	62%	278	18%	7	0%	286	18%	57%	43%
Planned Commercial/Industrial	14	14	8	53%	0	3%	5	32%	5	36%	0%	0%
Public Use	198	196	54	28%	30	15%	19	10%	49	25%	3%	5%
Railroad	37	37	16	43%	5	14%	2	6%	7	20%	1%	1%
Residential	1,003	1,002	296	30%	139	14%	3	0%	142	14%	17%	27%
Resource Extraction	15	15	3	18%	1	4%	0	0%	1	4%	0%	0%
Retail	58	58	15	26%	6	10%	16	27%	21	37%	1%	2%
Utility Park	147	125	75	60%	10	8%	6	4%	16	13%	4%	4%
TOTALS / AVERAGES	**3,784**	**3,674**	**1,696**	**46.2%**	**584**	**15.9%**	**92**	**2.5%**	**676**	**18.4%**	**100%**	**100%**

Land Use, *at a glance…*

Tree Canopy
Low – Business Park/Comm. (14%)
High – Office Park (69%)

Total Possible Planting Area
Low – Resource Extraction (4%)
High – Retail (37%)
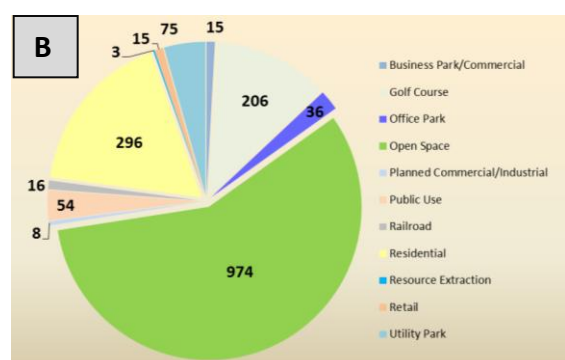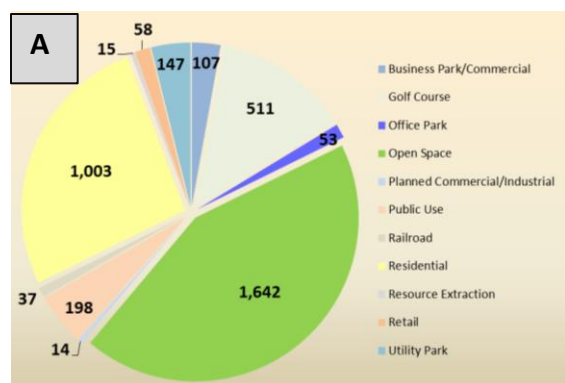
Figure 12A and 12B: Distribution of Land Use and Distribution of TC and PPA by Land Use

Tree Canopy for Parcels

At the finest scale of analysis in this study, individual parcels (property boundaries) were assessed for existing TC and PPA. Results are seen below in Figures 13 and 14.

Tree Canopy by Parcel
- 0 - 10%
- 10 - 20%
- 20 - 40%
- 40 - 70%
- 70 - 100%

Figure 13. Tree canopy percent by parcel

Tree Canopy Opportunities by Parcel
- > 25% Vegetated Planting Area
- > 25% Impervious Planting Area
- < 10% Tree Canopy Cover

Figure 14. Sample GIS queries to locate planting opportunities and monitor canopy growth from new development landscaping. Note many areas will require space for other uses (gardens, play areas, etc.)

Historical Tree Canopy in Snoqualmie

Historical black & white aerial photos provided for free by the U.S. Geologic Survey (USGS) were acquired in 1998 which provided an opportunity to map forest change in Snoqualmie. The City experienced significant growth on the 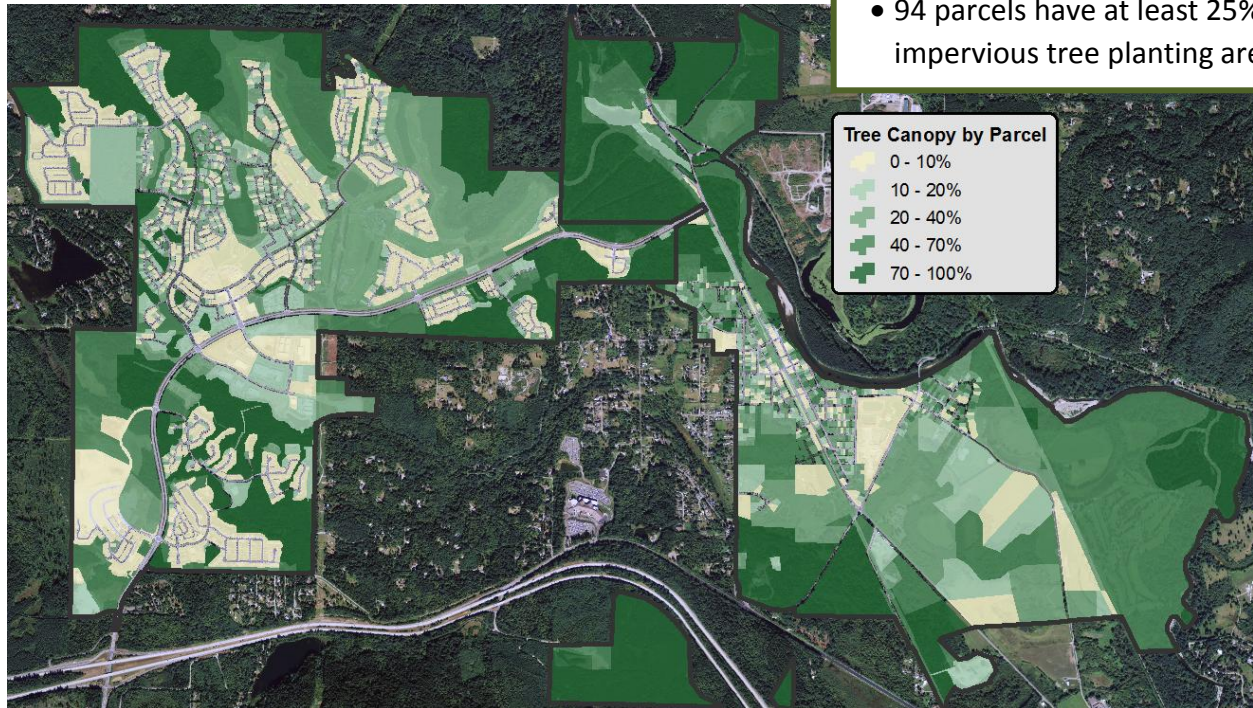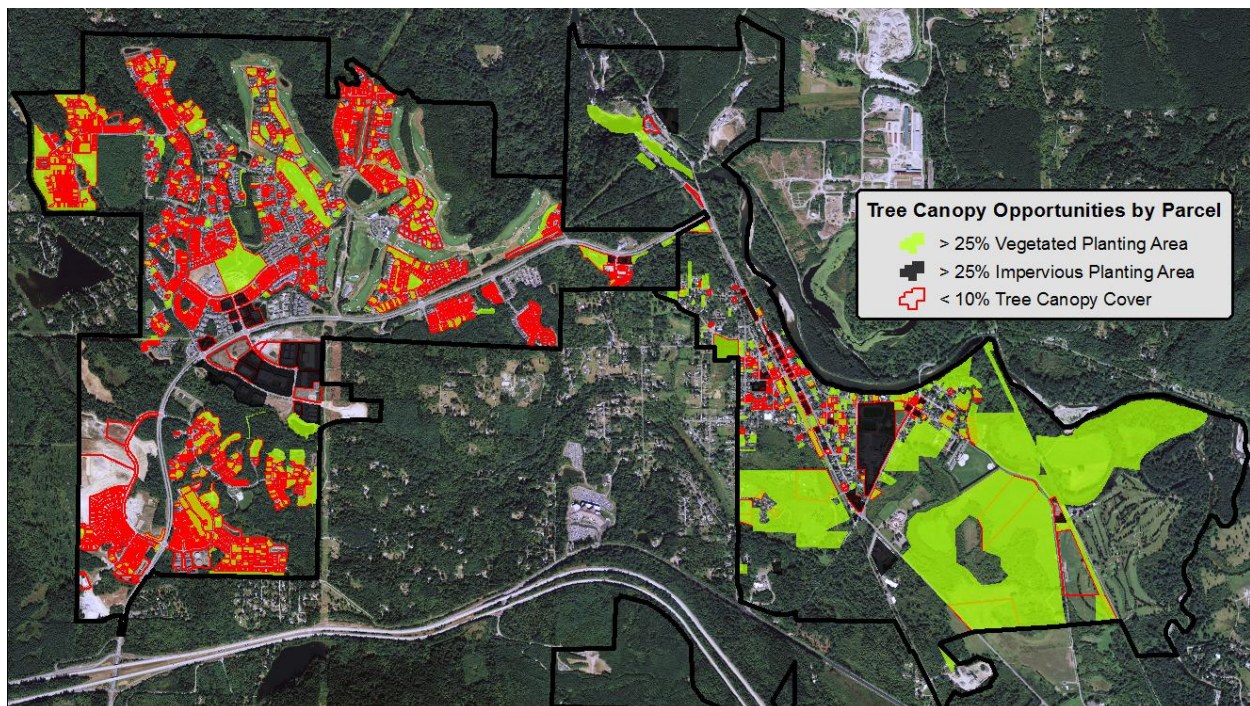Ridge development area which resulted in approximately 768 acres of forest loss. This decreased the City's canopy cover by 19%, from 62.7% in 1998 to its present cover of 43.7%. This represents a 30.3% reduction in canopy cover. Areas in red in Figure 15 below illustrate the locations of forested areas in 1998 that were cleared for development.

Table 6. Acres and percent of tree canopy change (1998-2011) citywide in Snoqualmie.

Tree Canopy (TC) Metrics	Total Acres	Acres (excludes water)	1998 TC (Acres)	1998 TC (%)	2011 TC (Acres)	2011 TC (%)	TC Change (Acres)	TC Change (%)
City of Snoqualmie	4,159	4,046	2,537	62.7%	1,769	43.7%	768	-19.0%
Historic Downtown	1,979	1,892	N/A	N/A	959	50.7%	N/A	N/A
Ridge	2,180	2,155	N/A	N/A	809	37.6%	N/A	N/A
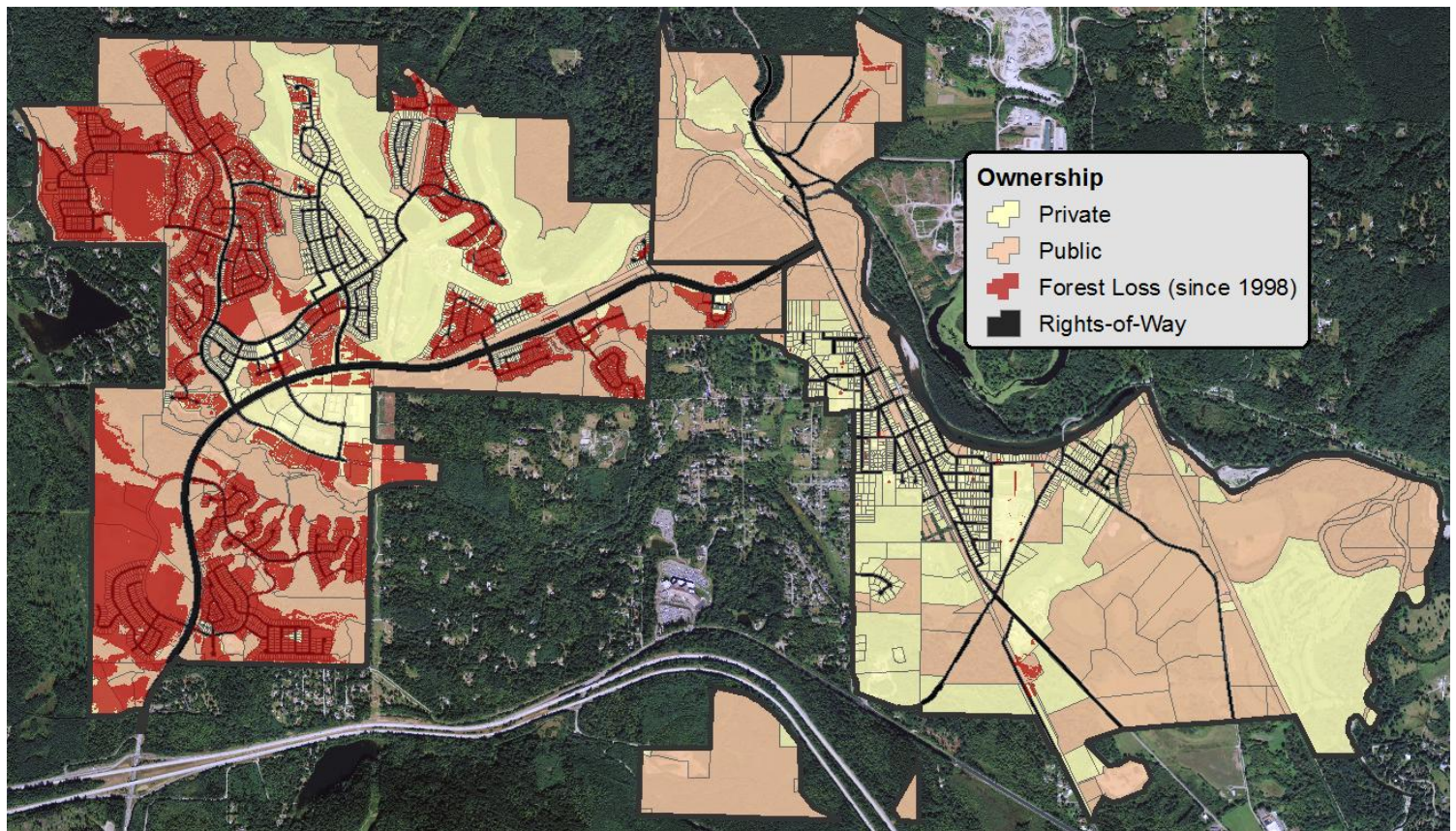
Figure 15. Areas of forest loss between 1998 and 2011 are shown in red in Snoqualmie, overlaid on City ownership and street rights-of-way.

Forested Areas at Risk from Development

An analysis was conducted to locate and quantify forested areas in the City where zoning or land use indicates a property is at risk of forest loss due to potential future development. Criteria for this analysis were:

- ❖ Only undeveloped parcels with high tree canopy cover applied, and;
- ❖ Residential and open space land use types were excluded

This resulted in 39 parcels with forested area at risk from future development. The total area on these 39 properties is 426.8 acres with total forested area of 304.6 acres. If these properties were developed and all forest area was cleared, this would decrease Snoqualmie's citywide canopy cover from 43.7% to 36.2% (-7.5%). This not insignificant impact underscores the importance of retaining canopy during development and reliance upon new tree plantings and tree growth to maintain current percent tree cover. The map below in Figure 16 shows the locations of these properties.

Figure 16. Parcels with forest cover at risk from future development based on land use.

Recommendations

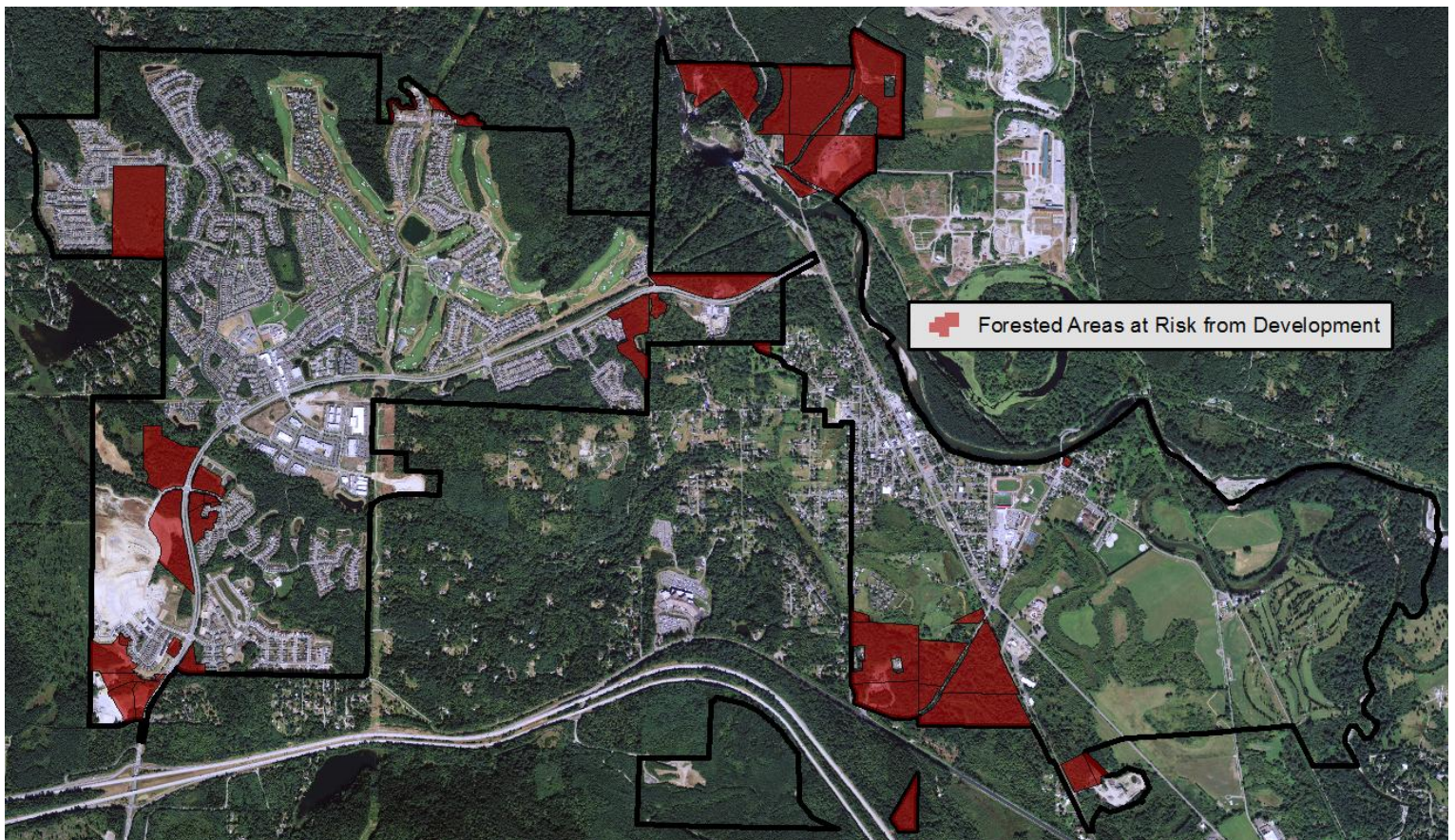The City should be complemented on their 2012 Parks & Opens Space plan policy statement "to protect and enhance the current [canopy] coverage and ensure that the [benefits] continue in perpetuity or are enhanced in the future". Recommended ways to maintain current coverage are provided below. Some of the benefits of doing so include:

❖ Infiltration, abatement, and management of stormwater runoff through natural systems (street trees, yard trees, and forests)

❖ Provide quality habitat for native fish and animal species that also promotes recreation

❖ Absorb and filter air pollutants

❖ Ensure livable communities with a high quality of life, in turn fostering local sustainable economic development

Based on this assessment, the following general recommendations are offered for achieving or maintaining tree canopy cover goals and urban forest management objectives in Snoqualmie. Recommendations generally apply at the citywide scale with others applying more specifically to Historic Downtown vs. on the Ridge.

Citywide Recommendations

1. Preserve and protect open space; this is where 57% of the City's tree cover resides.

2. Use this report to guide:

   o Review of the effectiveness of tree planting ordinances (new development, public street and park trees, tree protection) in meeting other environmental, planning, and sustainability goals;

   o Development of best management practices (BMPs) integrating trees with low impact development (LID) approaches meeting multiple environmental goals.

   o Updates to the street tree inventory and Comprehensive Plan

3. Maintaining mature, healthy trees should be the City's highest priority given larger trees provide the greatest environmental and economic benefits. Beginning with "Right Tree – Right Place" approaches can also help ensure success and cost-effectiveness.

4. Prioritize enhancements to tree cover in and around parking lots on commercial land uses, where benefits include improved water quality, shade, and retail/tourism.

5. Use the canopy cover and available planting space data to target tree planting projects in the street ROW, parks, and other high visibility areas.

6. Conduct an ecosystem services analysis to quantify urban forest benefits using data from this study and software such as CITYgreen and i-Tree. Incorporate benefits into an education/outreach Public Service Announcement (PSA) with targeted messages that are relevant for residents, businesses and decision-makers.

7. Develop regulations for forest conservation for properties identified through this project as having the highest threat for development to ensure canopy with high ecological value is retained on site where feasible and safe.

8. Utilize the land cover data from this project while it is current for other applications such as water supply and water conservation analysis and stormwater modeling.

9. Create an education, outreach and incentive program to assist in planting trees in private land like golf courses, schools, churches, and commercial properties.

10. Explore partnerships to achieve urban forest goals: public/private including corporate and academic sponsors, council representatives, stormwater managers, volunteers, non-profit organizations, and neighborhood associations.

11. Assess tree canopy every 5 to 10 years to monitor trends and assess the effectiveness of public education & outreach campaigns, policies, codes, and ordinances.

    o If feasible, utilize aerial LiDAR data to help differentiate between trees and shrub cover that may convert to canopy over time through natural forest regeneration.

12. Update the 2010 tree maintenance plan to reflect management tactics applied in Historic Downtown vs. the Ridge including unique tree species lists given differences in:

    o Age of development and therefore age, health, and risk of trees;

    o Development density and the associated amount of plantable area;

    o Appropriate species based on soils, floodplain areas, and site characteristics

13. For a sustainable urban forest on the Ridge:

    o Focus on proper installation, selection, and young tree maintenance, especially important given the area's poor soils, tight spacing, and construction compaction in the ROW, to ensure healthy trees that provide increased benefits.

    o Proactively manage potential risk of the mature forest tracts near homes.

Summary

With 43.7% tree canopy cover in 2011 (50.7% downtown and 37.6% on the Ridge), down 19% citywide from 62.7% in 1998, Snoqualmie's land cover, urban forest, and residents have seen significant change recently due to a surge of development on the Ridge. Tree canopy created through new development landscaping ordinances, preservation, and additional new tree planting will be needed to regain ecological and economic forest benefits. Figure 17 below compares Snoqualmie's tree canopy cover to other cities in Washington State with comparable analyses and development opportunities.

There are many positive trends to highlight regarding urban forestry in Snoqualmie. Recent implementation of tree regulations, education, inventory, and maintenance planning show that Snoqualmie has made their commitment to trees and the natural environment clear. With much of the City's development being new, canopy cover and associated environmental benefits should increase rapidly with these programs and initiatives in place. Analyzing the data in this way underscores the importance of tree maintenance and forest preservation during development.

Results from Historic Downtown vs. the Ridge show the impact of land use patterns; Downtown has higher canopy cover and higher planting space in large part due to denser residential development on the Ridge. Specifically (after removing some outliers), average residential lot size is 6,900 sq.ft. on the Ridge and 11,000 sq.ft. in Town. Canopy results at the parcel-level should be used to identify strategic tree planting to maximize benefits while balancing the needs for gardens, solar access, views and recreation in high-density development in particular.

This report identifies areas to preserve and enhance tree canopy during and after development. It provides a benchmark of existing tree canopy and realistic planting areas for the City to use moving forward. The data from this study provides opportunities for education, management, implementation and planning of Snoqualmie's current and future urban and community forest.
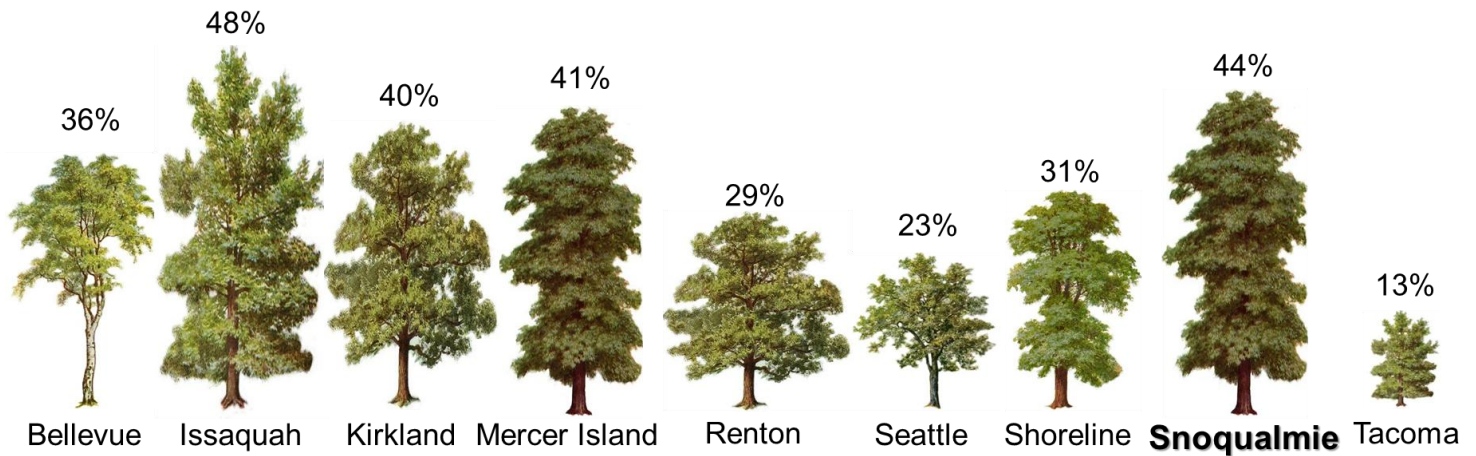
Figure 17: Comparing Urban Tree Canopy (TC) Percent in Snoqualmie to Similar Areas

Appendix

Included in the Appendix of this report are additional details on urban forest benefits, the data and methods used in this analysis, and a list of deliverables.

Urban Tree Benefits

The benefits of urban trees, sometimes called "ecosystem services", include environmental, economic, and social values. These are direct or indirect benefits provided by urban forests and individual trees that are often dismissed or underrepresented when valuing infrastructure because they don't readily have an associated dollar value. Types of tree benefits are listed and briefly described below. While none alone are a "silver bullet", when combined, trees and the collective urban forest are an impressive part of the solution for sustainability during urban planning and community development.

Environmental "Services" of Urban Trees:

- Air Quality – trees absorb, trap, offset and hold air pollutants such as particulate matter, ozone, sulfur dioxide, carbon monoxide, and CO^2.
- Greenhouse Gases (GHGs) and Carbon – trees store and sequester carbon through photosynthesis as well as offset carbon emissions at the plant due to energy conservation.
- Water Quality and Stormwater Runoff Mitigation – trees infiltrate, evapotranspire, and intercept stormwater while also increasing soil permeability and ground water recharge.
- Erosion control – tree roots hold soil together along stream banks and steep slopes, stabilizing soils and reducing sedimentation issues in water bodies.
- Urban heat island effect – trees cool the air directly through shade and indirectly through transpiration, reducing day and nighttime temperatures in cities.
- Increased wildlife habitat – Trees create local ecosystems that provide habitat and food for birds and animals, increasing biodiversity in urban areas.

Economic "Services" of Urban Trees:

- Property value – numerous studies across the country show that residential homes with healthy trees add property value (up to 15%).
- Energy conservation – trees lower energy demand through summer shade and winter wind block, additionally offsetting carbon emissions at the power plant.
- Retail and Economic Development – trees attract businesses, tourists, and increase shopping.
- Stormwater facilities – trees and forests reduce the need for or size of costly gray infrastructure.
- Pavement – tree shade increases pavement life through temperature regulation (40-60% in some studies).

Social "Services" of Urban Trees:

- 🍁 <u>Public health</u> – trees help reduce asthma rates and other respiratory illnesses.
- 🍁 <u>Safe walking environments</u> – trees reduce traffic speeds and soften harsh urban landscapes.
- 🍁 <u>Crime and domestic violence</u> – urban forests help build stronger communities. Places with nature and trees provide settings in which relationships grow stronger and violence is reduced.
- 🍁 <u>Connection to nature</u> – trees increase our connection to nature.
- 🍁 <u>Noise pollution</u> – Trees reduce noise pollution by acting as a buffer and absorbing up to 50% of urban noise (U.S. Department of Energy study).

Data Inputs, Land Cover Methodology, and Accuracy

Land Use

The City's original land use data included 16 classes. The City categorized these into 11 generalized classes. Below lists how the original classes were categorized before providing to Plan-It Geo.

- ❖ Open Space was comprised of Wetland Buff, LB/OS1, and LB/OS
- ❖ Residential was comprised of NCRES and Residential
- ❖ Public Use was comprised of School Districts and Muni Campus
- ❖ Retail was comprised of Downtown Business and NCRETAIL
- ❖ Railroad, golf course, Office Park, Business Park/Commercial, Planned Commercial/Industrial, Utility Park, and Resource Extraction were not grouped with other categories

Land Cover Classification

The land cover classification task was conducting using a remote sensing process known as geographic object-based image analysis (OBIA). Feature Analyst version 5.0 was used to classify forested areas, individual trees, pervious and impervious surfaces, and bare soil / dry vegetation using separate, specific algorithms. See Figure 18 below. OBIA technology leverages the texture, shape, pattern and color of features in satellite and aerial imagery to produce highly accurate and cost-effective geospatial feature data. It involves an iterative process where results are trained, reviewed, and re-trained to produce better results with each pass. Plan-It Geo performed a rigorous quality assurance/quality control (QA/QC) process to further improve the accuracy of the land cover data. This involved manually reviewing and deleting or adding polygons to appropriate land cover classes with primary focus on tree canopy and impervious surfaces. Shrubs and water bodies were manually digitized in ESRI ArcMap. ESRI geoprocessing and data management tools were then used in scripting models to

compile and resolve overlap between classes. The City reviewed and approved of the final land cover data prior to assessing tree canopy and PPA metrics.
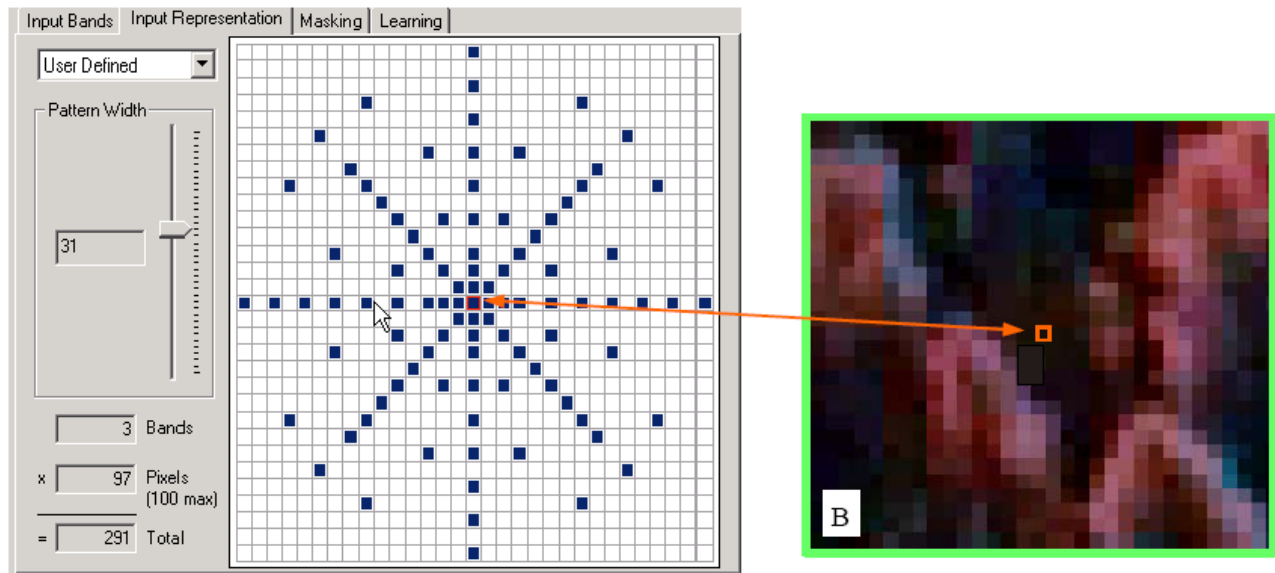

Figure 18. Example of an input representation algorithm overlaid on color-infrared imagery using Feature Analyst (OBIA) software.

TC GIS Database Format

Assessment boundaries (parcels, ownership and generalized land use) were delivered with fields that include land cover and tree canopy metrics seen in Figure 19. Acronyms are:

- ❖ Pct = percent
- ❖ SqFt = square feet (only for smaller scale geographies like parcels; not shown below)
- ❖ TC = tree canopy
- ❖ PPA = possible planting area
- ❖ Veg = short for PPA – Vegetation
- ❖ Imp = short for PPA – Impervious
- ❖ TP = total possible planting area

LU_Descrip	TC_Acres	TC_Pct	PPA_Veg_Acres	PPA_Veg_Pct	PPA_Imp_Acres	PPA_Imp_Pct	TP_Acres	TP_Pct	Land_Acres	SHRUB	WATER	TREE_CANOPY	IMPERVIOUS	BARE_SOIL_OR_DRY	PPA_VEGETATION	PPA_IMPERVIOUS
Business Park/Commer	14.700735	13.726129	5.56405	5.195173	26.280046	24.537775	31.844096	29.732948	107.100365	154515.315	0	640363.997047	916575.597401	1228986.083689	242370.00137	1144758.821589
Golf Course	206.12633	41.365979	104.587181	20.988833	5.887756	1.181571	110.474938	22.170404	498.299173	287427.550	538247.187	8978862.945014	495030.259937	607114.410769	4555817.624457	256470.667613
Office Park	36.276408	69.211996	5.037223	9.610551	2.325747	4.437307	7.36297	14.047858	52.413468	57597.4542	11119.0749	1580200.311815	123924.404928	49998.163892	219421.436156	101309.519603
Open Space	973.631587	62.006036	278.250419	17.720466	7.497641	0.47749	285.748061	18.197956	1570.220661	2950580.55	3138044.07	42411391.913149	1590673.554757	2653648.512136	12120588.258772	326597.263471
Planned Commercial/Ind	7.518892	52.925981	0.47617	3.351793	4.590953	32.316018	5.067123	35.667811	14.20643	5468.04461	0	327522.956064	19267.322576	8438.872011	20741.972405	199981.891702
Public Use	54.007877	27.550321	29.835137	15.219402	19.053231	9.719372	48.888369	24.938774	196.033565	1866562.23	80255.3950	2352583.142046	719112.450661	384388.467333	1299618.581313	829958.756746
Railroad	15.786264	43.069438	5.189934	14.159621	2.174024	5.93136	7.363958	20.090981	36.653054	9504.49488	0	687649.666364	370761.411253	82440.460119	226073.506185	94700.505043
Residential	296.163264	29.565188	138.506954	13.826779	3.037654	0.303241	141.544609	14.13002	1001.729683	940482.146	48921.7771	12900871.767647	14519003.94804	5524382.701211	6033362.933249	132320.22147
Resource Extraction	2.586689	17.699502	0.605406	4.142509	0	0	0.605406	4.142509	14.614472	21344.7489	16694.7582	112676.163536	387639.155276	10301.021065	26371.475035	0
Retail	15.061507	26.049949	5.776312	9.990544	15.619469	27.014984	21.395781	37.005527	57.817798	17469.7567	32.291602	656079.243394	593465.826955	130598.002692	251616.163433	680384.055896
Utility Park	74.633681	59.522509	10.465859	8.346824	5.565285	4.438475	16.031145	12.785299	125.387324	36737.0793	920988.783	3251043.150678	557557.565438	581474.878714	455892.838212	242423.820707

Figure 19: TC Assessment GIS Database Field Key

Complete List of Deliverables

The following products were provided to the City on DVD.

- Land cover data (GIS vector and raster formats, ArcGIS v10 geodatabase) including a "6-class" file with 6 land cover classes, a "9-class" file including the addition of (i) tree buffers, (ii) PPA unsuitable and (iii) PPA (Vegetation vs. Impervious), and individual layers for tree canopy and impervious surface area

- 2011 National Agricultural Imagery Program (NAIP) imagery

- Areas of forest loss in Snoqualmie since 1998

- TC assessment boundaries (GIS vector format, ArcGIS v10 geodatabase): city limits, zoning by land use at the parcel-level, zoning by summarized land use, and ownership

- TC assessment spreadsheet (MS Excel)

- Supporting maps including an ArcMap session (.mxd file)

- Report summarizing the results, methods, goals and recommendations (MS Word and Adobe PDF format)

About Plan-It Geo, LLC.

Plan-It Geo is a geospatial analysis, technology consulting, and planning firm specializing in natural resource management and related fields. We provide a full range of services involving GIS, remote sensing, cost/benefit analysis, urban forestry planning, water resources analysis, decision support systems, and web-based solutions. Our clients and partner affiliations include local, state and federal government as well as non-profits, private industry, academia, and utilities. Plan-It Geo staff members have conducted more than 40 urban tree canopy assessment projects and ecosystem benefits analyses across the country.