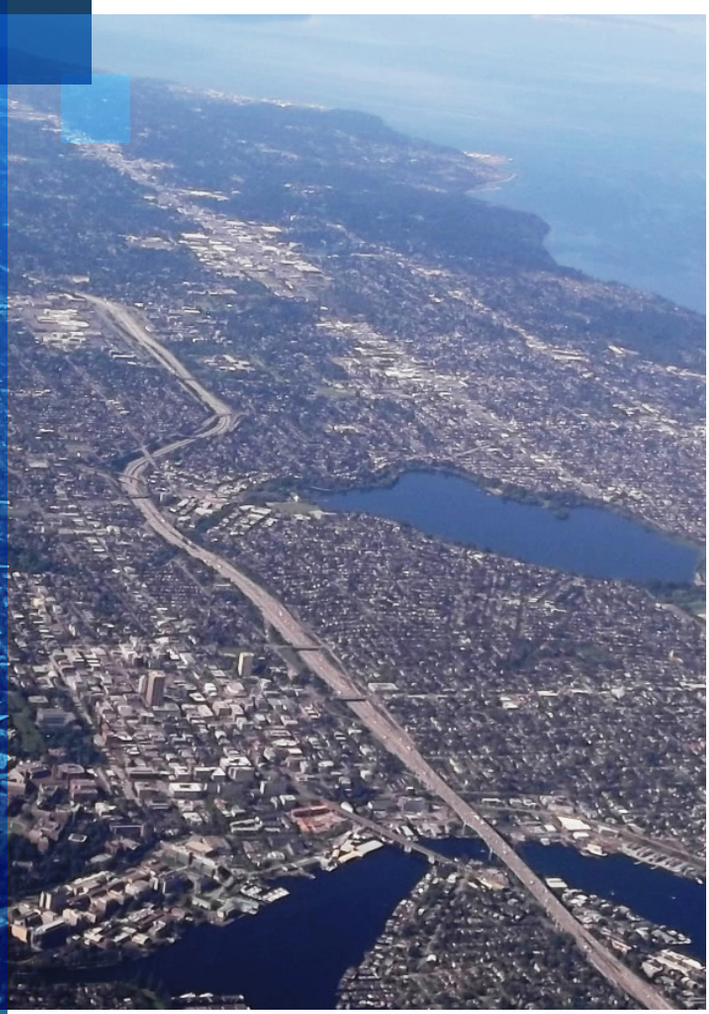
URBAN TREE CANOPY

ASSESSMENT



SHORELINE,
WASHINGTON
JULY | 2018

plan-it GEO

CITY OF SHORELINE

AN ASSESSMENT OF
URBAN TREE CANOPY

SHORELINE, WASHINGTON

Someone is sitting in the shade today because someone planted a tree a long time ago.
-Warren Buffet

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TABLE OF
CONTENTS

2,744
ACRES OF TREE CANOPY

EXECUTIVE SUMMARY

PURPOSE OF THIS ASSESSMENT

The City of Shoreline is located within King County, Washington, in the Seattle metropolitan area along the Puget Sound (Figure 1). It is approximately 12 square miles or 7,416 acres, of which 7,389 are land acres. Shoreline has always placed a high priority on ensuring the long-term health of its urban forest resource, and this assessment demonstrates their continued commitment to protecting, maintaining, and expanding the city's tree canopy.

This analysis is a follow-up to Shoreline's first urban tree canopy assessment, which the City Council commissioned as a part of their City Sustainability Strategy nearly a decade ago. That study, completed by AMEC Earth & Environmental in March 2011, sought to establish a baseline of the city's tree canopy that the City Council could, in turn, utilize to shape important policy decisions regarding Shoreline's urban forest. The City Council also determined that the city's urban tree canopy should be continually monitored at approximately 5-year intervals to assess its status and adjust policies as needed, thereby necessitating this subsequent assessment.

The primary goal of this assessment was to compare tree canopy change over an 8-year time period, to provide an update to the baseline, and to offer insights as to how, where, and why Shoreline's urban tree canopy has been changing since it was originally assessed in 2011 using source data representing conditions in 2009.

URBAN TREE CANOPY IN SHORELINE

Results of this study indicated that in 2017, the city of Shoreline contained 37 percent tree canopy (or 2,744 of the city's 7,416 total acres); 3 percent shrub (238 acres); 12 percent other non-canopy vegetation (922 acres); 6 percent soil/dry vegetation (459 acres); 41 percent impervious (3,026 acres); and a negligible amount of water (28 acres). In further subdividing the impervious areas, 8 percent (625 acres) were roads, 12 percent (901 acres) were buildings, and 20 percent (1,500 acres) were "other impervious" areas such as sidewalks and parking lots. Of the city's 63 percent of land area not presently occupied by tree canopy, 14 percent (1,009 acres) was suitable for future tree plantings, and 49 percent (3,050) was unsuitable due to its current land use or other restraint.

ASSESSMENT BOUNDARIES AND ANALYSIS RESULTS

This study assessed urban tree canopy, possible planting areas, and canopy change since 2009 at multiple geographic scales in order to provide actionable information to a diverse range of audiences. By identifying what resources and opportunities exist at these scales, the City can be more proactive in their approach to protect and expand their urban tree canopy. Metrics were generated at the following geographies: the citywide boundary (1); HUC-12 watersheds (2); city land use classes (14); light rail station sub-areas (3); and census block groups (51).

PREVIOUS STUDY AND CHANGE ANALYSIS

This study was designed to build upon a previous urban tree canopy study conducted in Shoreline in 2011. Some differences in data sources and methodology between the two studies may have slightly exaggerated the canopy change metrics (see Appendix 1), but the results of the change analysis indicated that Shoreline had a 6 percent increase in tree canopy from 2009-2017, with canopy increasing from 31 percent, or 2,270 of the city's 7,389 land acres, to 37 percent or 2,744 acres.

The 2011 study also assessed historical imagery from two additional time periods to get an approximation of canopy change over a longer period of time, but that analysis used 30-meter resolution, offering a less robust comparison to present data. Those results indicated that Shoreline's urban tree canopy was approximately 30 percent in 1992 and 31 percent in 2001, demonstrating a slight upward trend as well.

Figure 1. | Shoreline occupies approximately 12 square miles along the Puget Sound in King County, Washington, just 12 miles north of Seattle.

RECOMMENDATIONS

The results of this analysis can be used to develop a continued strategy to protect and expand Shoreline's urban forest. While it has increased significantly over the last eight years, these increases have not been distributed evenly throughout the city. Therefore, these results are broken up by numerous geographic assessment scales to offer a wide range of actionable information to different audiences and can be used as a basis upon which to focus future tree-related policies and activities. Furthermore, a Sound Transit infrastructure project is planned in which trees will need to be removed. The results can also be used to identify the best strategies for replacing lost tree canopy, engaging the community with greening events, and ensuring a vibrant future for the regions affected by the project. A healthy urban forest benefits practically every sector in Shoreline, so it must be taken into account when envisioning the city's broader goals and planning.

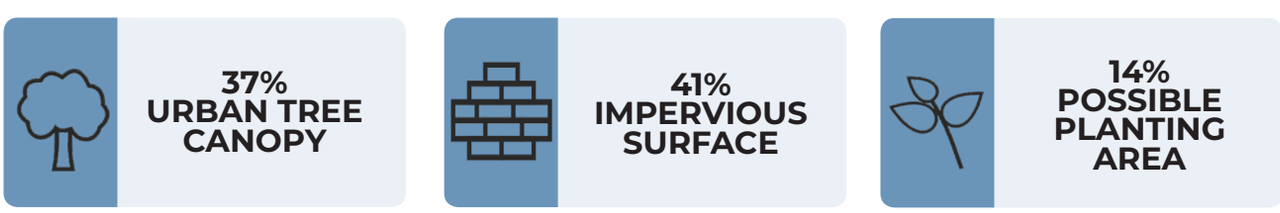


Figure 2. | Based on an analysis of 2017 high-resolution imagery, Shoreline contains 37% tree canopy, 14% areas that could support canopy in the future, and 41% total impervious areas.

PROJECT METHODOLOGY

This section describes the methods through which land cover, urban tree canopy, and possible planting areas were mapped. These datasets provide the foundation for the metrics reported at the selected target geographies, as well as the change in canopy over time.

DATA SOURCES

This assessment utilized 2017 high-resolution (1-meter) multispectral imagery from the U.S. Department of Agriculture's National Agriculture Imagery Program (NAIP) and 2016 LiDAR data from King County, Washington to derive the land cover data set. The NAIP imagery is used to classify all types of land cover, whereas the LiDAR is most useful for distinguishing tree canopy from other types of vegetation. Additional GIS layers provided by the City of Shoreline were also incorporated into the analysis.

MAPPING LAND COVER

The most fundamental component of this urban tree canopy assessment is the creation of an initial land cover data set. The process began with the acquisition of 2013 high-resolution (1-meter) aerial imagery from the USDA's National Agricultural Imagery Program (NAIP). An object-based image analysis (OBIA) software program called Feature Analyst (ArcGIS Desktop) was used to classify features through an iterative approach, where objects' spectral signatures across four bands (blue, green, red, and near-infrared), textures, and pattern relationships were taken into account. This process resulted in six initial land cover classes as shown in Figure 3. After manual classification improvement, additional data layers from the city, such as buildings, roads, and agricultural land, were utilized to capture finer feature detail and further categorize the land cover dataset.

URBAN TREE CANOPY | SCRUB/ SHRUB | OTHER VEGETATION | SOIL AND DRY VEGETATION | IMPERVIOUS | WATER

Figure 3. | Six (6) distinct land cover classes were identified in both the 2009 and 2017 tree canopy assessments: urban tree canopy, shrub, other vegetation (such as grass), bare soil and dry vegetation, impervious (paved) surfaces, and water.

IDENTIFYING POSSIBLE PLANTING AREAS AND UNSUITABLE AREAS FOR PLANTING

In addition to quantifying Shoreline's existing tree canopy cover, another metric of interest in this assessment was the area where tree canopy could be expanded. To assess this, all land area in Shoreline that was not existing tree canopy coverage was classified as either possible planting area (PPA) or unsuitable for planting. Possible planting areas was derived from the Non-Canopy Vegetation and Shrub classes. Unsuitable areas, or areas where it was not feasible to plant trees due to biophysical or land use restraints (e.g. airport runways, golf course playing areas, recreation fields, etc.), were manually delineated and overlaid with the existing land cover data set (Figure 4). The final results were reported as PPA and Unsuitable Vegetation, Unsuitable Impervious, Unsuitable Soil, and Total Unsuitable.

Figure 4. | Vegetated areas where it would be biophysically feasible for tree plantings but undesirable based on their current usage (left) were delineated in the data as "Unsuitable" (right). These areas included recreational sports fields, golf courses, and other open space.

DEFINING ASSESSMENT LEVELS

In order to best inform the City Council and all of Shoreline's various stakeholders, urban tree canopy and other associated metrics were tabulated across a variety of geographic boundaries (Figure 5). These boundaries include the city boundary, watersheds, land use classes, light rail station sub-areas, and census block groups. The tree canopy that would be lost during a proposed Sound Transit construction project was also calculated.

- The City of Shoreline's citywide boundary is the one (1) main area of interest over which all metrics are summarized.
- Two (2) HUC-12 watersheds intersect the city of Shoreline. Delineated by the U.S. Geological Survey, each unique 12-digit identification code represents a different subwatershed. They were analyzed to explore differences in tree canopy across a naturally-occurring geographic boundary.
- Fourteen (14) land use classes were analyzed to assess differences in tree canopy across different human uses of land.
- Three (3) light rail station sub-areas were analyzed to better inform the city's planning efforts during a major infrastructure construction project. One (1) specific area along the future Sound Transit light rail line was also assessed to determine how much of the city's tree canopy would be lost if all trees in that region were removed as a part of this project.
- The smallest unit of analysis was the City's census block groups, totaling fifty-one (51) areas. Census block groups are used by the U.S. Census Bureau to assure statistical consistency when tracking populations across the United States and can be valuable indicators of environmental justice as they are directly linked with demographic and socioeconomic data.

Figure 5. | Five (5) distinct geographic boundaries were explored in this analysis: the full city boundary, watersheds, land use classes, light rail station sub-areas, and U.S. Census block groups.

STATE OF THE CANOPY AND KEY FINDINGS

This section presents the key findings of this study including the land cover base map, canopy analysis, and change analysis results which were analyzed across various geographic assessment boundaries. These results, or metrics, help inform a strategic approach to identifying existing canopy to preserve and future planting areas. All percentages listed are based on land area as opposed to total area.

CITYWIDE LAND COVER

In 2017, tree canopy constituted 37 percent of Shoreline's land cover; shrub was 3 percent; other vegetation was 12 percent; soil/dry vegetation was 6 percent; impervious was 41 percent; and water was a negligible amount. These generalized land cover results are presented below in Table 1.

The impervious land cover class was then subdivided into more specific classifications. Approximately 12 percent was buildings, 8 percent was roads, and 20 percent was "other impervious" (such as sidewalks, parking lots, etc.). Parking lots and sidewalks may offer opportunities for new tree plantings and additional canopy cover, but the data for these opportunistic impervious land classifications would require further analyses to determine their planting suitability.

Table 1. | Generalized land cover classification results

TOTAL ACRES	7,416
TREE CANOPY	2,744 37%
IMPERVIOUS	3,026 41%
SHRUB	238 3%
NON-CANOPY VEGETATION	922 12%
WATER	28 0%
SOIL & DRY VEGETATION	459 6%

The generalized land cover results are presented in Figure 6

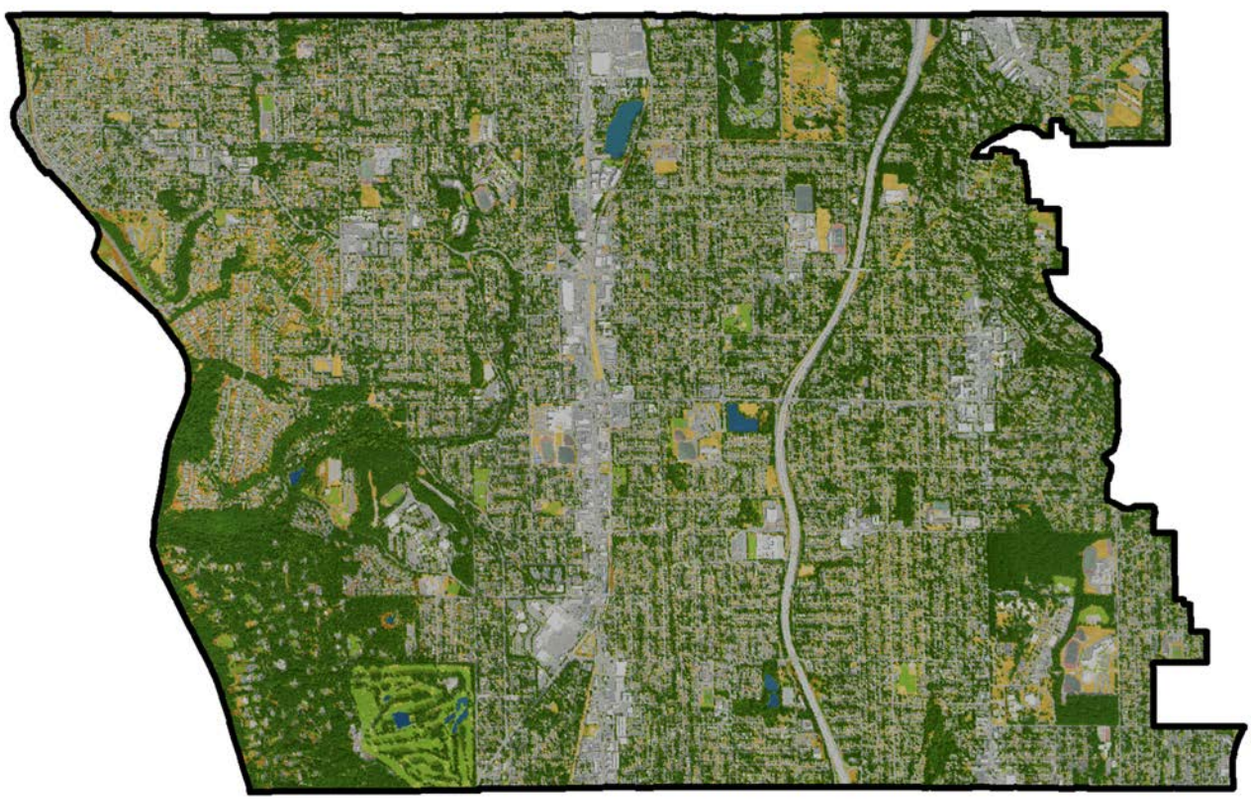
CITYWIDE URBAN TREE CANOPY

This urban tree canopy assessment utilized the land cover map as a foundation to determine Possible Planting Areas throughout the City. Additional layers and information regarding land considered unsuitable for planting were also incorporated into the analysis. Note that the results of this study are based on land area as opposed to total area (note the difference between Total Acres and Land Acres in Table 2).

Table 2. | Urban tree canopy assessment results, by acres

TOTAL ACRES	7,416
LAND ACRES	7,389
UTC	2,744 37%
PPA	1,009 14%
TOTAL UNSUITABLE	3,636 49%
UNSUITABLE VEGETATION	141 2%
UNSUITABLE IMPERVIOUS	3,050 41%

Results of this study indicate that within the city of Shoreline, 2,744 acres are covered with urban tree canopy, making up 37 percent of the city's 7,389 land acres; 1,009 acres are covered with other vegetation where it would be possible to plant trees (PPA), making up 14 percent of the city; and the other 3,636 acres were considered unsuitable for tree planting, making up 49 percent of the city. The unsuitable areas include recreational sports fields, golf course playing areas, buildings, roads, and areas of bare soil and dry vegetation.



GENERALIZED LAND COVER

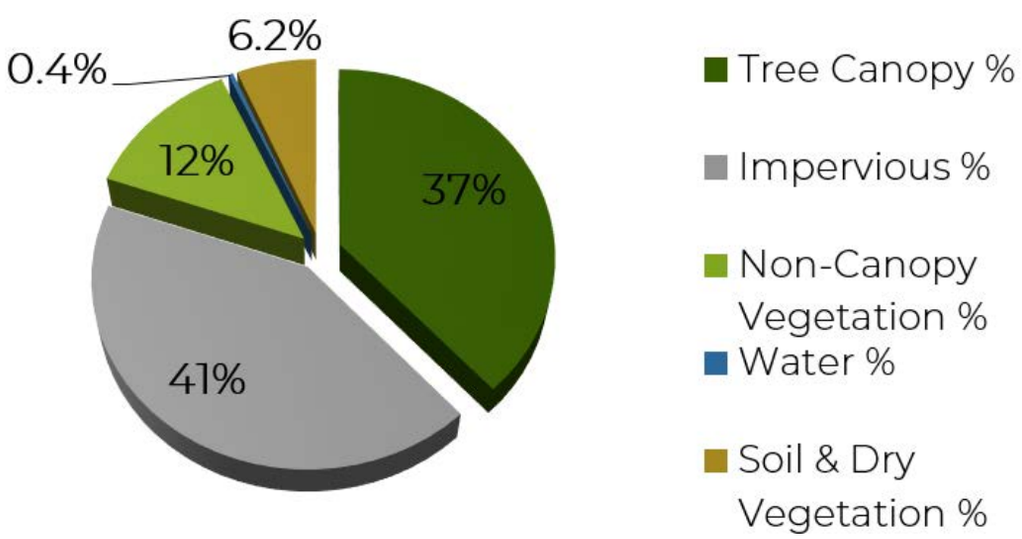


Figure 6. | Generalized land cover classes for Shoreline, Washington based on 2017 NAIP imagery.

URBAN TREE CANOPY BY WATERSHED

Urban tree canopy metrics and possible planting areas were assessed for the two HUC-12 watersheds found within Shoreline (Table 3). These are the Shell Creek-Frontal Puget Sound watershed (roughly the western half of the city) and the Lake Washington-Sammamish River watershed (roughly the eastern half of the city).

While the Shell Creek-Frontal Puget Sound watershed had a slightly higher percentage of canopy cover (40 percent compared to Lake Washington-Sammamish River's 35 percent), the Lake Washington-Sammamish River watershed occupies more of the city's land area and therefore contributed to a greater percentage of the city's total canopy (54 percent compared to Shell Creek-Frontal Puget Sound's 46 percent). Both watersheds had 14 percent PPA in 2017.

Table 3. | Urban tree canopy assessment results by HUC-12 watershed.

WATERSHED	LAND ACRES	UTC	DISTRIBUTION OF UTC	PPA	DISTRIBUTION OF PPA	TOTAL UNSUITABLE
Shell Creek-Frontal Puget Sound	3,184	1,264 40%	46%	440 14%	44%	1,479 46%
Lake Washington-Sammamish River	4,192	1,478 35%	54%	568 14%	56%	2,146 51%
Totals	**7,376**	**2,742 37%**	**100%**	**1,008 14%**	**100%**	**3,625 29%**

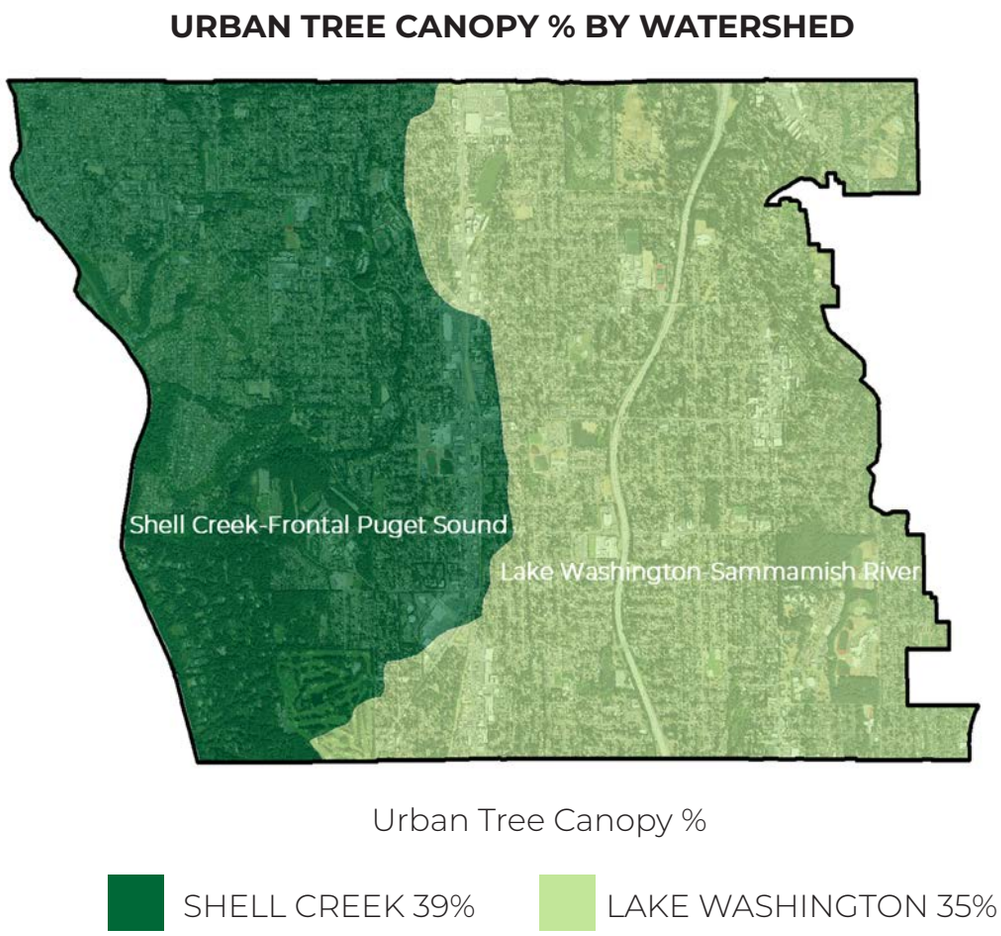
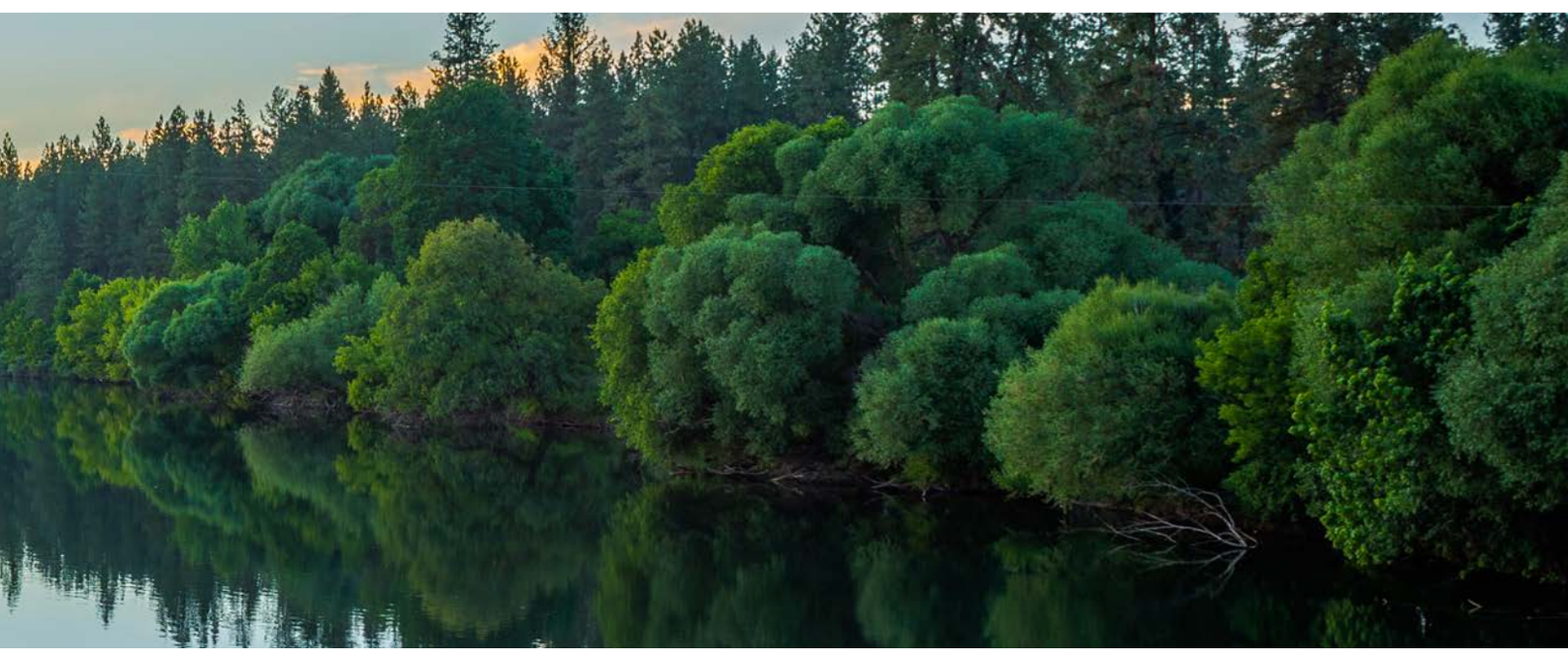


Figure 7. | Urban tree canopy by HUC-12 watershed.



URBAN TREE CANOPY BY LAND USE

Urban tree canopy metrics and possible planting areas were assessed for the City's 14 different land use categories (Table 4). The highest canopy coverage was seen in the private open space and public open space classes, with 50 percent and 66 percent, respectively. However, these land use classes only occupy a small percentage of Shoreline's total land area, and, therefore, did not contribute greatly to the City's total canopy cover, constituting just 7 and 9 percent.

Low-density residential areas (i.e. single-family homes) contributed the greatest proportion of the city's urban tree canopy, with 43 percent canopy cover making up 63 percent of the City's total. Likewise, low-density residential areas promised the greatest opportunities for canopy expansion with 616 acres available for planting making up 67 percent of the city's total PPA.

The classes with the largest amounts of impervious land cover also had some of the smallest amounts of current canopy cover and PPA. The two mixed-use classes and the Town Center district had 81, 72, and 80 percent impervious land cover, respectively, 12, 17, and 10 percent tree canopy, and just 5, 7, and 5 percent PPA.

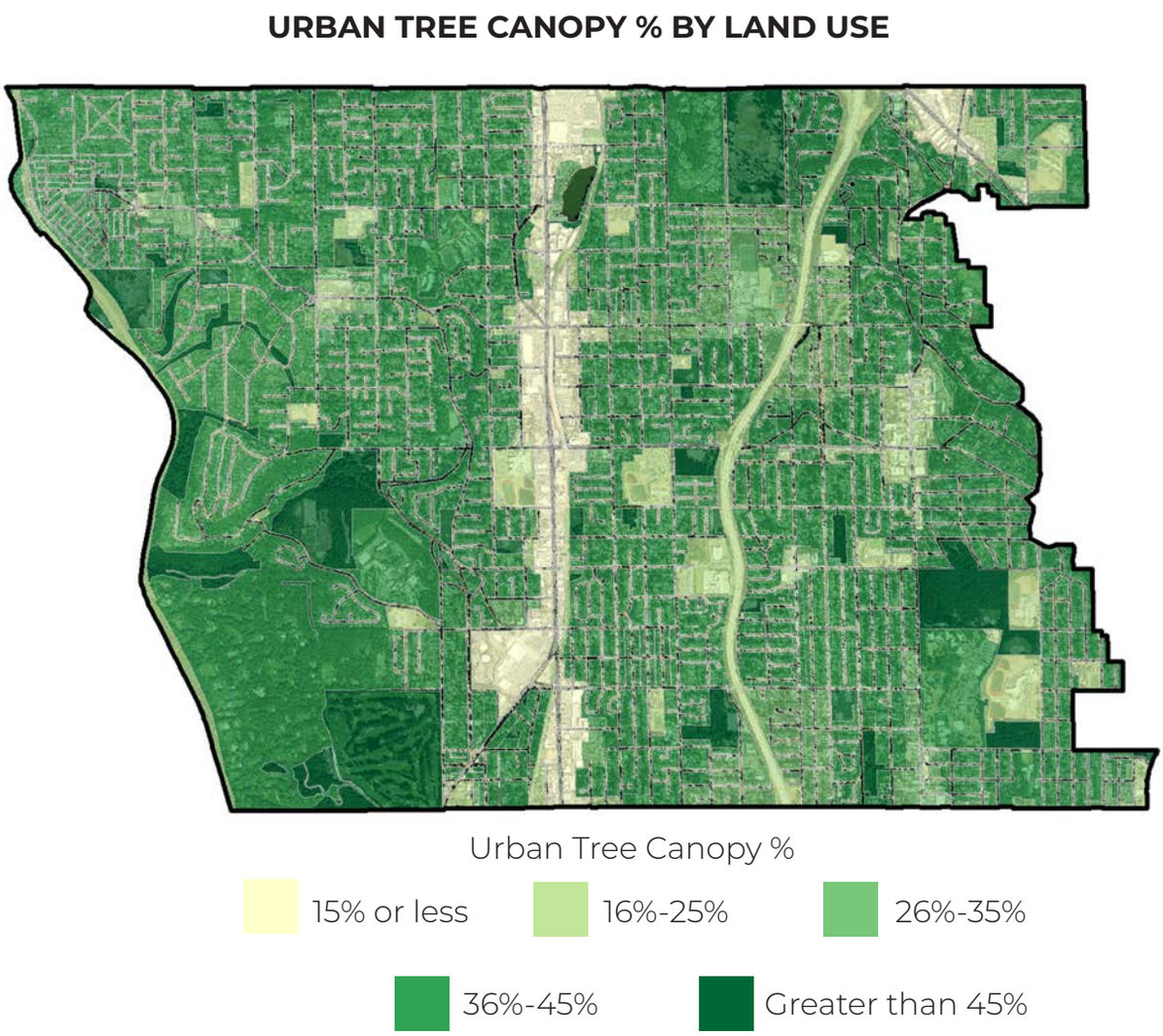


Figure 8. | Urban tree canopy by city land use.

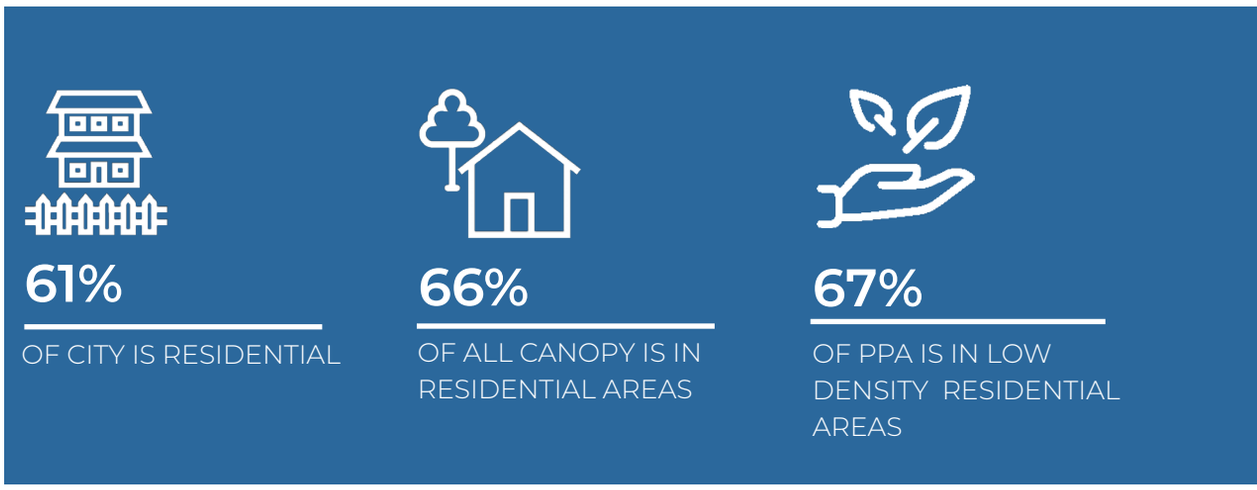


Table 4. | Urban tree canopy assessment results by land use classification

LAND USE	LAND ACRES	UTC	DISTRIBUTION OF UTC	PPA	DISTRIBUTION OF PPA	TOTAL UNSUITABLE
Institution/Campus	224 4%	90 40%	4%	21 10%	2%	112 50%
Low Density Residential	3,607 58%	1554 43%	63%	616 17%	67%	1,437 40%
Medium Density Residential	69 1%	27 39%	1%	10 14%	1%	33 48%
High Density Residential	146 2%	44 30%	2%	15 11%	2%	86 59%
Mixed Use 1	237 4%	29 12%	1%	12 5%	1%	196 83%
Mixed Use 2	118 2%	20 17%	1%	9 7%	1%	89 75%
Planned Area 3	16 0%	2 15%	0%	2 11%	0%	12 74%
Public Facility	507 8%	115 23%	5%	46 9%	5%	346 68%
Private Open Space	321 5%	160 50%	7%	55 17%	6%	106 33%
Public Open Space	349 6%	230 66%	9%	37 11%	4%	83 24%
Station Area 1	200 3%	63 32%	3%	30 15%	3%	107 53%
Station Area 2	139 2%	48 35%	2%	25 18%	3%	66 47%
Station Area 3	157 3%	62 39%	3%	29 18%	3%	66 42%
Town Center District	105 2%	11 10%	0%	5 5%	1%	89 85%
Totals	**6,195 100%**	**2,455 40%**	**100%**	**913 15%**	**100%**	**2,828 46%**

SHORELINE UTC (%) BY LAND USE IN 2017

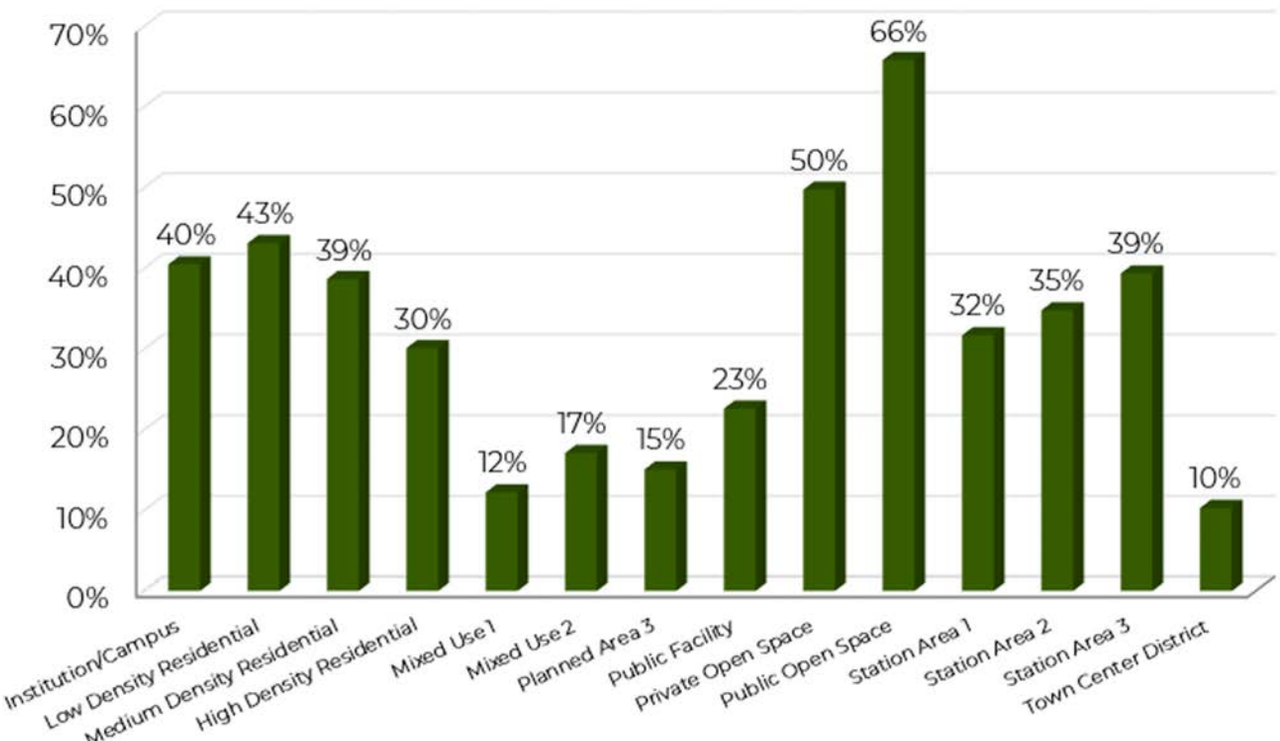


Figure 9. | Urban tree canopy by land use.

POSSIBLE PLANTING AREA (%) BY LAND USE

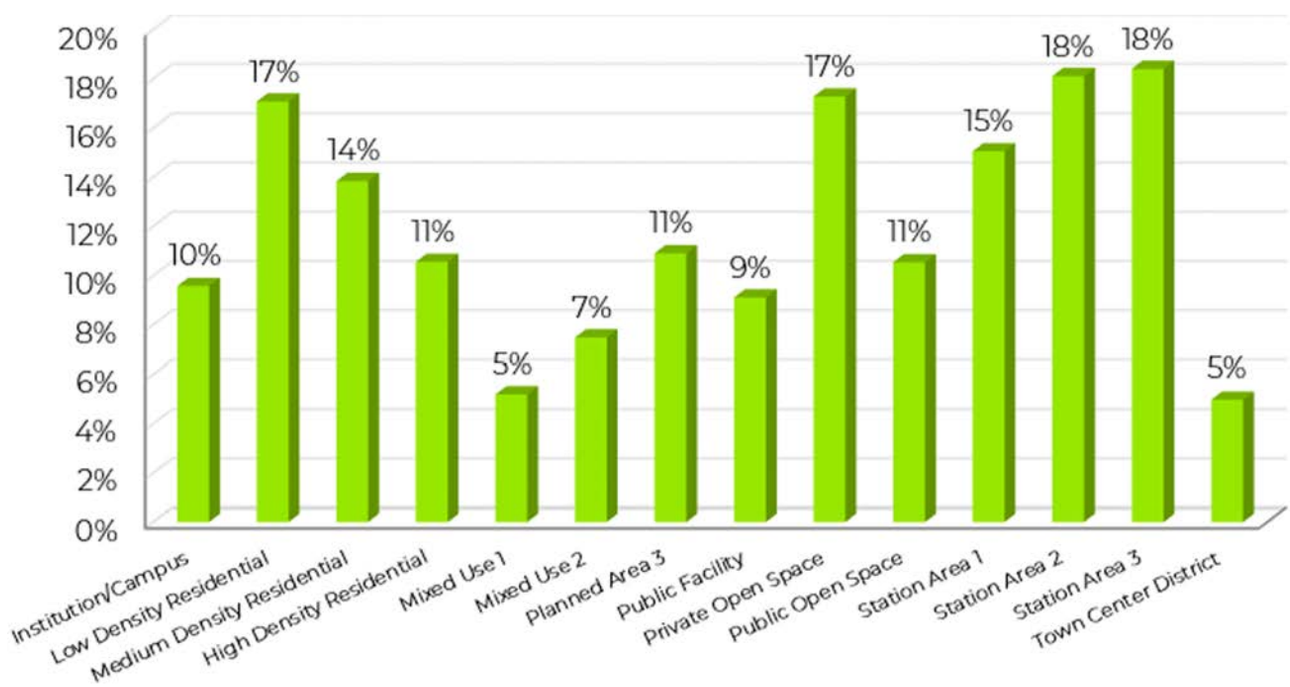
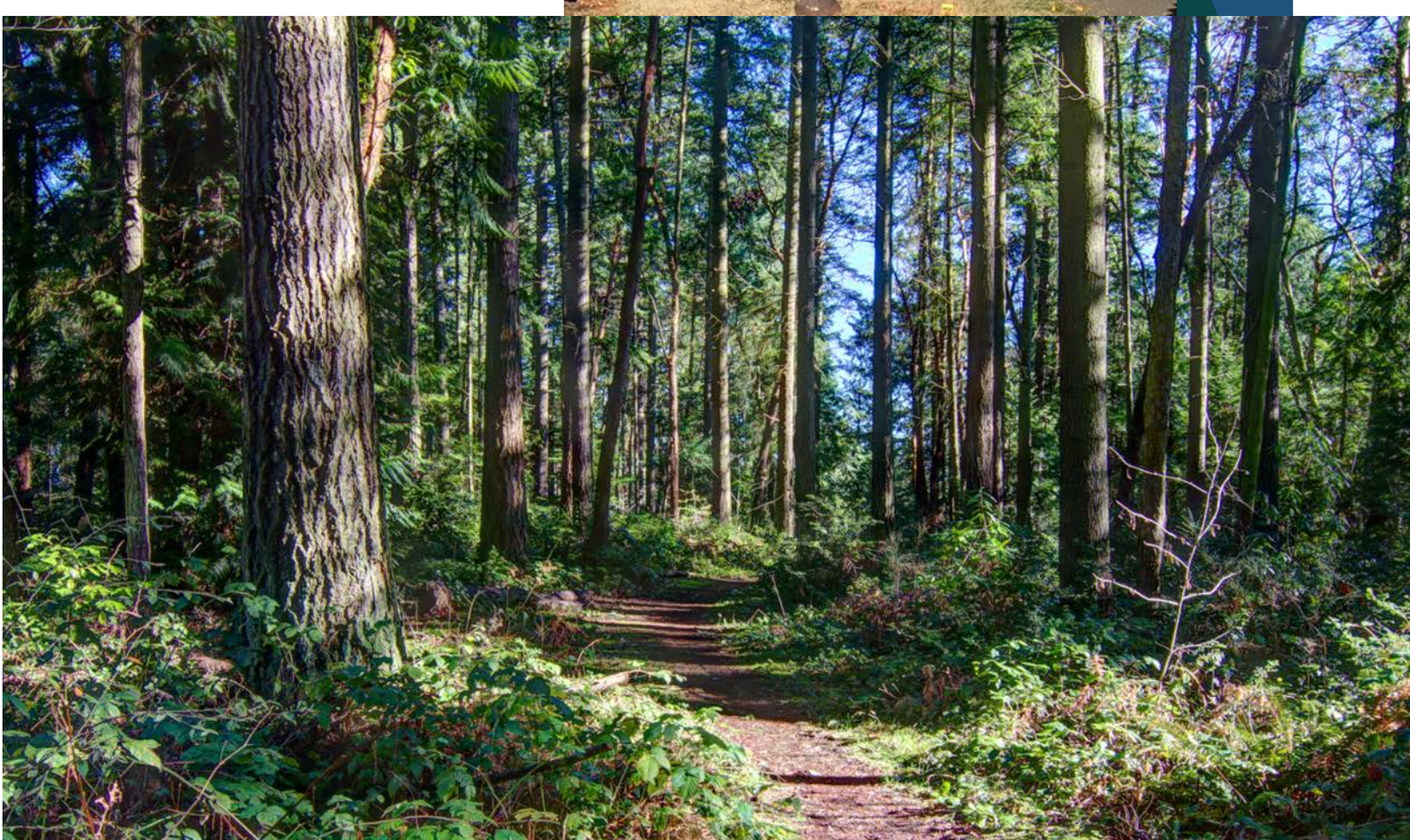


Figure 10. | Potential planting area by land use.



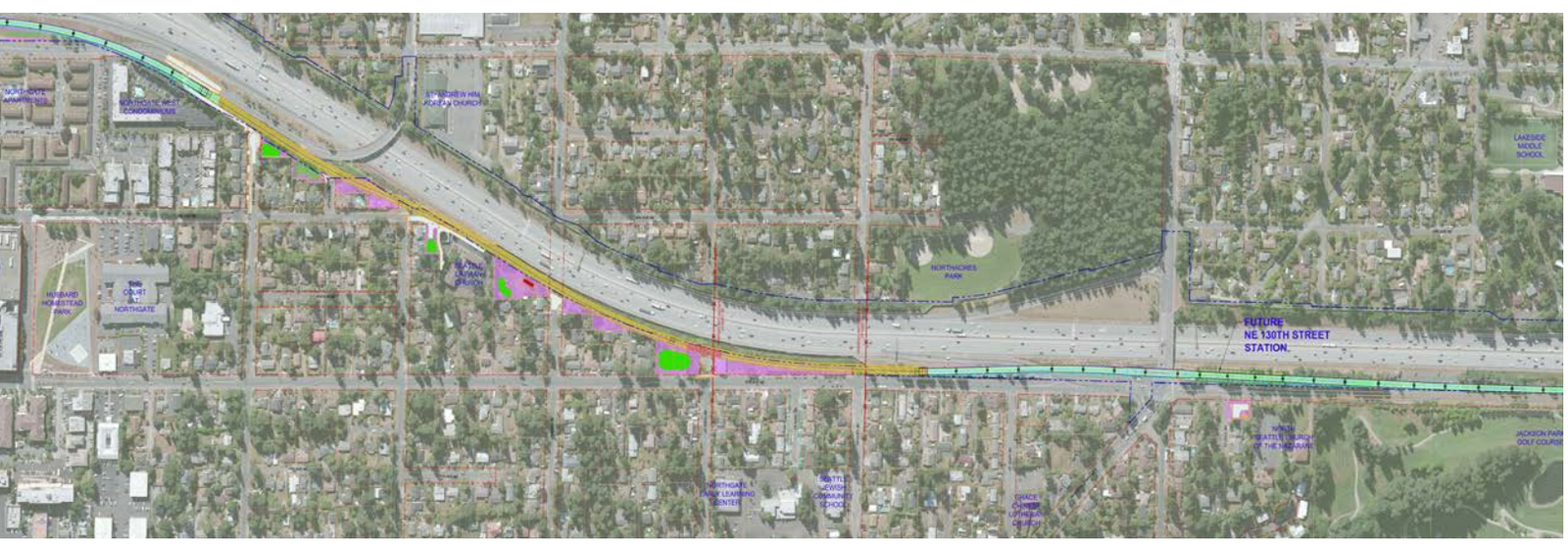
URBAN TREE CANOPY BY SOUND TRANSIT LIGHT RAIL STATION SUB-AREAS

A development project (Sound Transit 2) was approved by voters in 2008 which involves extending Sound Transit light rail service through Shoreline along the east side of Interstate 5. Two new stations will be created—one in the northern end of town (185th St.) and one in the southern (145th St.). The city has identified three tiers of "sub-areas" surrounding the two stations for the purposes of city planning, future zoning, and community engagement during the project's launch. Urban tree canopy and possible planting area were assessed for these three categories of light rail station sub-areas (Table 5).

Results indicated that all three of the sub-areas had relatively high amounts of canopy cover but contributed only a small fraction to the city's overall canopy due to their size. Sub-area 1 had 32 percent canopy cover and contributed 3 percent to the city's total; Sub-area 2 had 35 percent cover and contributed to 2 percent to the total; and Sub-area 3 had 39 percent cover and contributed 3 percent of the total. The same trend was evident for PPA within the 3 sub areas: they ranged from 15-18 percent possible planting area individually and each contributed 3 percent to the city's total PPA.

Table 5. | Urban tree canopy assessment results by light rail station sub-area.

LIGHT RAIL STATION SUB-AREA	LAND ACRES	UTC	DISTRIBUTION OF UTC	PPA	DISTRIBUTION OF PPA	TOTAL UNSUITABLE
Sub-Area 1	200	63 32%	37%	30 15%	36%	107 53%
Sub-Area 2	139	48 35%	28%	25 18%	30%	66 47%
Sub-Area 2	157	62 39%	36%	29 18%	34%	66 42%
Totals	**496**	**174 35%**	**100%**	**84 17%**	**100%**	**239 48%**



URBAN TREE CANOPY % BY LIGHT RAIL STATION SUB AREAS

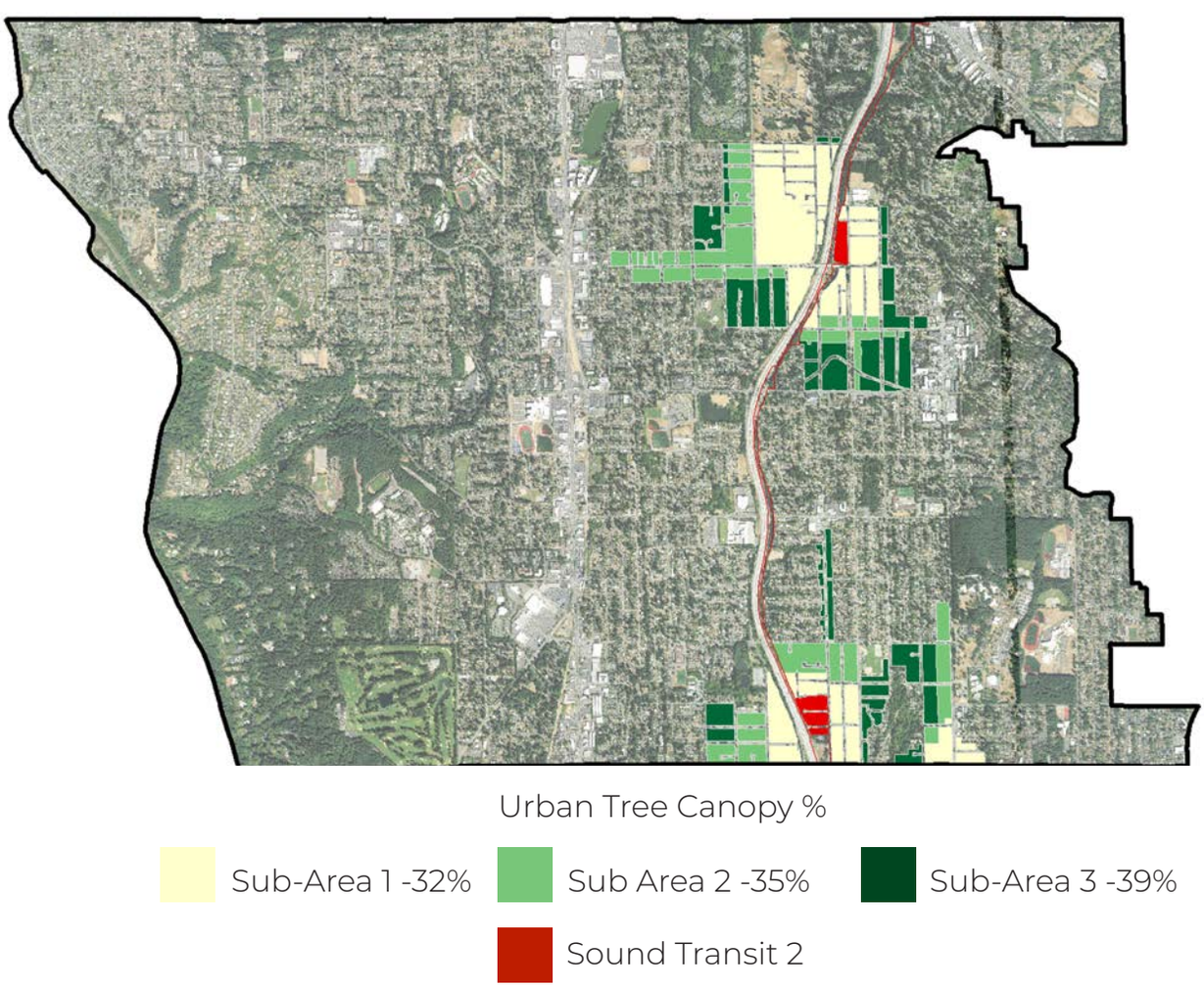


Figure 11. | Urban tree canopy by light rail station sub-area along future light rail line..

URBAN TREE CANOPY BY CENSUS BLOCK GROUPS

Lastly, urban tree canopy and possible planting areas were assessed at the census block group level. This was the smallest geographic area unit analyzed and is particularly valuable for assessing the equitable distribution of tree canopy throughout the city as the block groups are linked to all demographic and socioeconomic U.S. census data. Results indicated that urban tree canopy varies substantially throughout the city, with some census block groups containing only 21 percent cover and one containing as much as 65 percent. PPA also varied somewhat across the various block groups, with some containing only 6 percent PPA and others as much as 20 percent PPA. For the complete results by census block group, refer torefer to the UTC Results spreadsheet or the Census Block Groups shapefile.

POSSIBLE PLANTING AREA (%) BY CENSUS BLOCK GROUPS

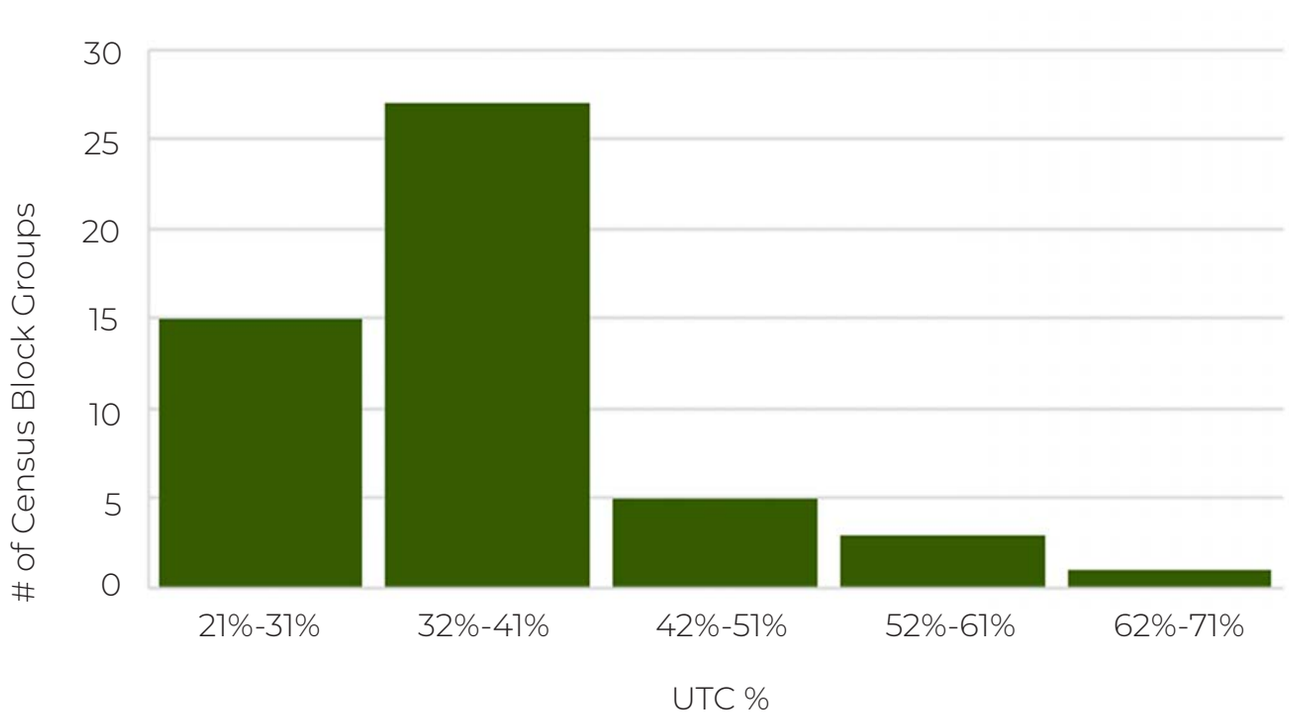


Figure 12. | Number of census block groups within urban tree canopy ranges.

25% of Shoreline census block groups have **40%** or higher canopy cover

URBAN TREE CANOPY % BY CENSUS BLOCK

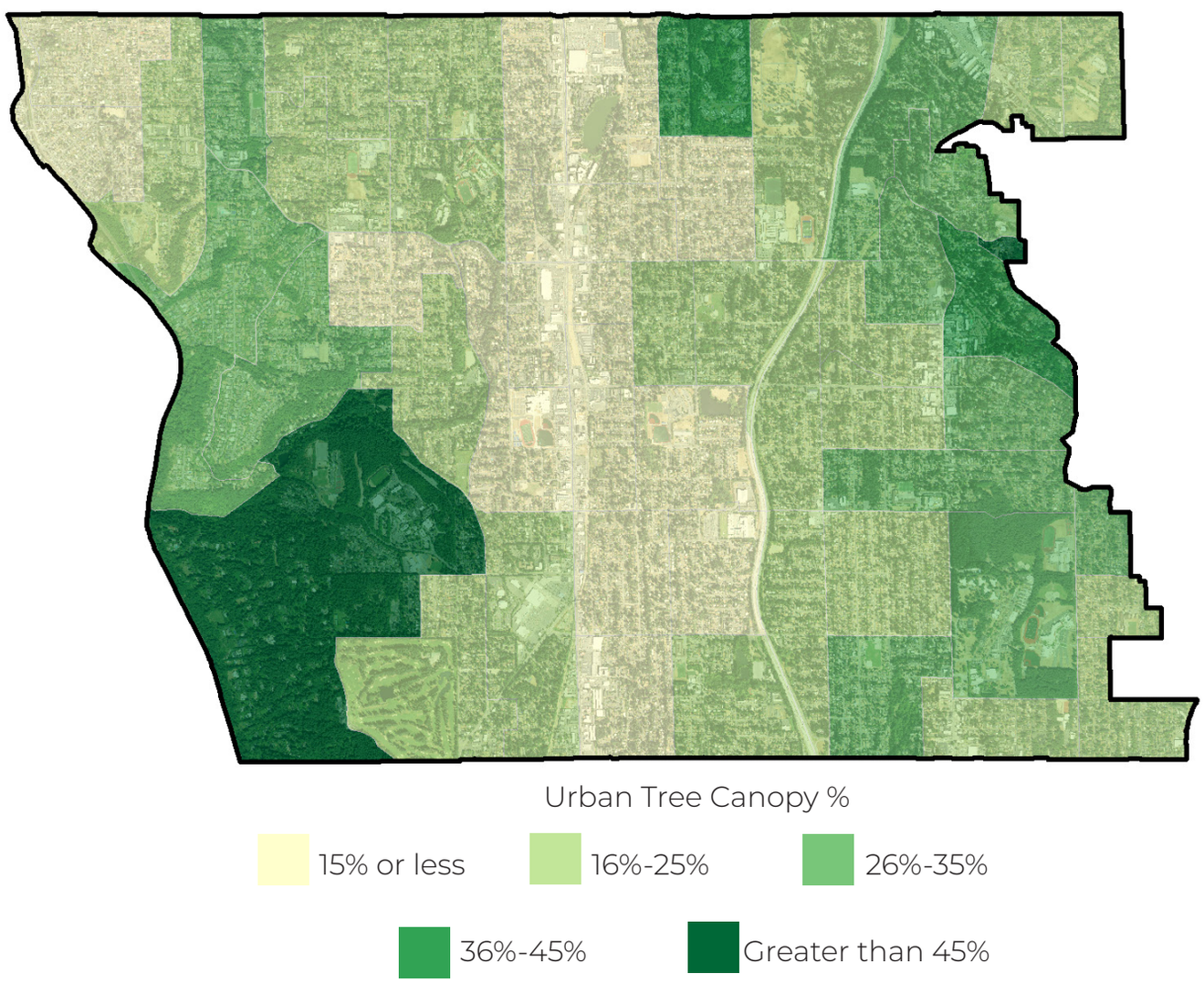


Figure 13. | Urban tree canopy by census block group.

73% of Shoreline census block groups have **30%** or higher canopy cover

URBAN TREE CANOPY CHANGE ANALYSIS

In addition to quantifying Shoreline's current tree canopy with the most recently available data, this analysis also included an additional component—comparing present data to the results of the 2011 study based on 2009 imagery. The two studies needed to yield results that were statistically comparable in order to derive meaningful information on changes that have occurred between 2009 and 2017. Therefore, the same six land cover classes were used in 2017 that had been used in the original study (tree canopy, shrub, other vegetation, soil/dry vegetation, impervious, and water). Canopy change was also assessed across all of the different geographic boundaries included in the tree canopy assessment, and those results are described in their respective subsections.

Furthermore, the imagery used in the remote sensing portion of the analyses needed to have a similar resolution. The 2011 study used a 2009 2-foot resolution satellite orthophoto, whereas this study used a 2017 1-meter (approximately 3-foot) resolution NAIP aerial image. The differences in imagery sources (Figure 14) and accuracy of the two assessments (Appendix 1) may have resulted in the canopy metrics being slightly underreported in the previous study, but still offered results that were statistically similar enough to compare.

It is important to note that due to the different data sources and remote sensing methods employed in the two different studies, the canopy increase may be slightly exaggerated for several reasons. The differences in angles, shading, etc. may have caused the canopy to appear lesser in 2009 and greater in 2017. Additionally, when reviewing the previous project data, many instances of underestimation in canopy were observed by GIS technicians, leading to the belief that the 31 percent figure generated in that analysis may have been lower than the true canopy percentage in 2009. Nevertheless, many examples of canopy growth and new tree plantings were evident when comparing the imagery, which gives merit to the case for an overall increase in canopy. Figure 15 contains some examples of underestimation in the 2009 study. (Refer to Appendix 1 for a detailed accuracy assessment of both 2009 and 2017 data.)

2009 SATELLITE IMAGERY
2-FOOT RESOLUTION

2017 NAIP AERIAL IMAGERY
1-METER RESOLUTION

Figure 14. | Different imagery sources were used in the 2009 versus 2017 assessments, but the spatial and spectral imagery resolutions were similar enough to compare change over time.

2009 TREE CANOPY

2017 TREE CANOPY

TREE CANOPY COMPARISON

CITYWIDE UTC CHANGE

Results indicated that canopy had increased since 2009 across all geographic boundaries, with the citywide total increasing from 2,270 acres, or 31 percent of the city's total, to 2,744 acres, or 37 percent. This yields an increase of 437 acres, or a 6 percent raw (or change divided by total city area) and 21 percent relative (change divided by the original UTC area) increase in canopy over the 8 year period. Changes in canopy are displayed in Table 6 and Figure 16 and 17.

Figure 15. | at left |Tree canopy identified in Shoreline in 2009 (top, yellow) appears to be underestimated when compared to the 2009 imagery (top, underneath). The 2017 tree canopy (center, yellow) seems to have been more fully captured when compared to the 2017 imagery. Comparing both the 2009 and 2017 imagery together (bottom) reveals large discrepancies in what was recorded as canopy.

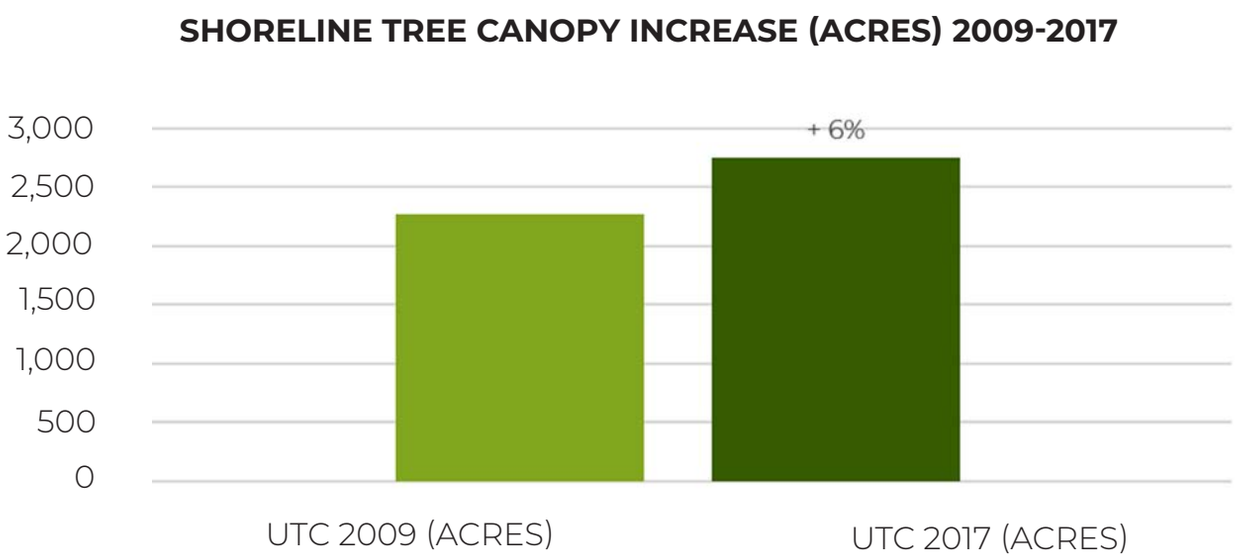


Figure 16. | Citywide change in urban tree canopy.

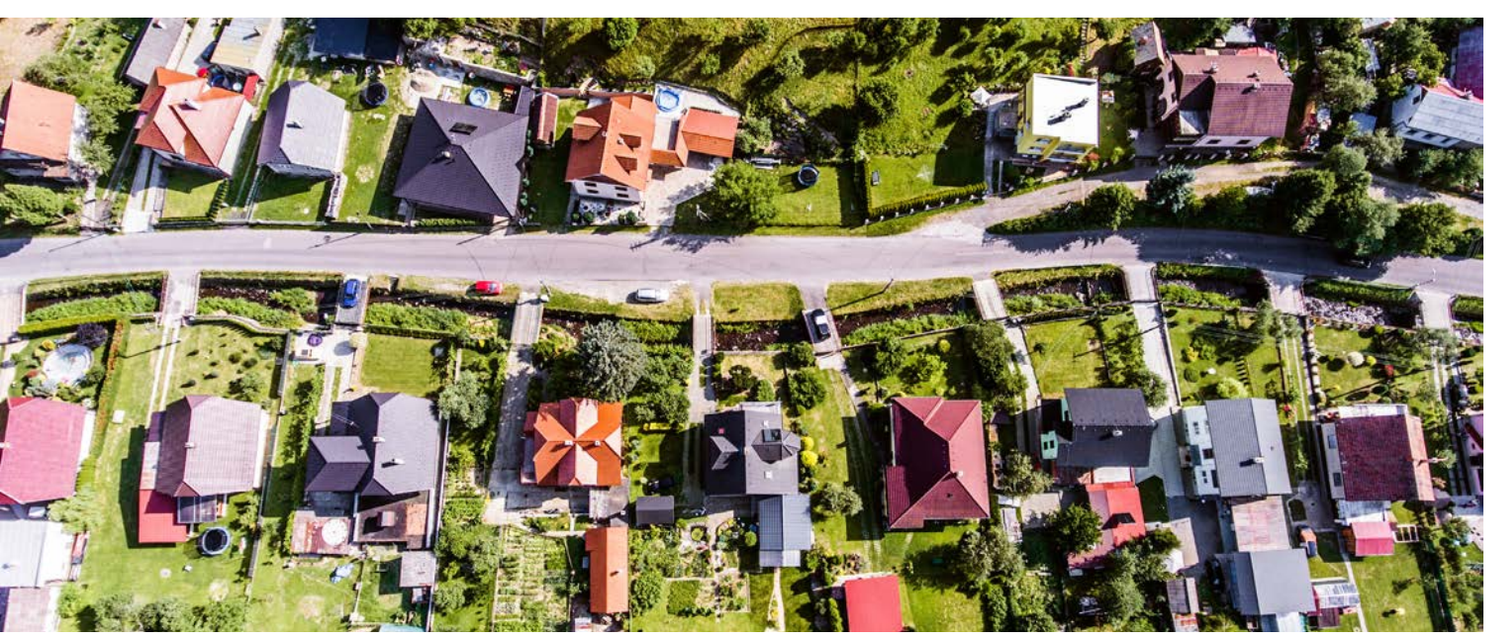


Table 6. | Canopy change from 2009-2017.

TOTAL ACRES	LAND ACRES	UTC 2009	UTC 2017	UTC CHANGE 2009-2017
7,416	7,389	2,270 31%	2,744 37%	+473 +6%

UTC CHANGE BY WATERSHED

Both watersheds also saw a noticeable increase in canopy from 2009-2017. Interestingly, in 2009, the two watersheds each contained 50 percent of the city's total tree canopy. However, the Lake Washington-Sammamish River watershed's canopy increased by 8 percent while the Shell Creek-Frontal Puget Sound watershed only increased by 4 percent, leading to Lake Washington-Sammamish River containing a greater proportion of the city's overall canopy in 2017.

Table 7. | Urban tree canopy change since 2009 by HUC-12 watersheds.

WATERSHED	LAND ACRES	UTC 2017	UTC CHANGE (SINCE 2009)
Shell Creek-Frontal Puguet Sound	3,184	1,264 40%	+123 + 4%
Lake Washington-Sammamish River	4,192	1,478 35%	+350 + 8%
TOTALS	**7,376**	**2,742 37%**	**3,625 49%**

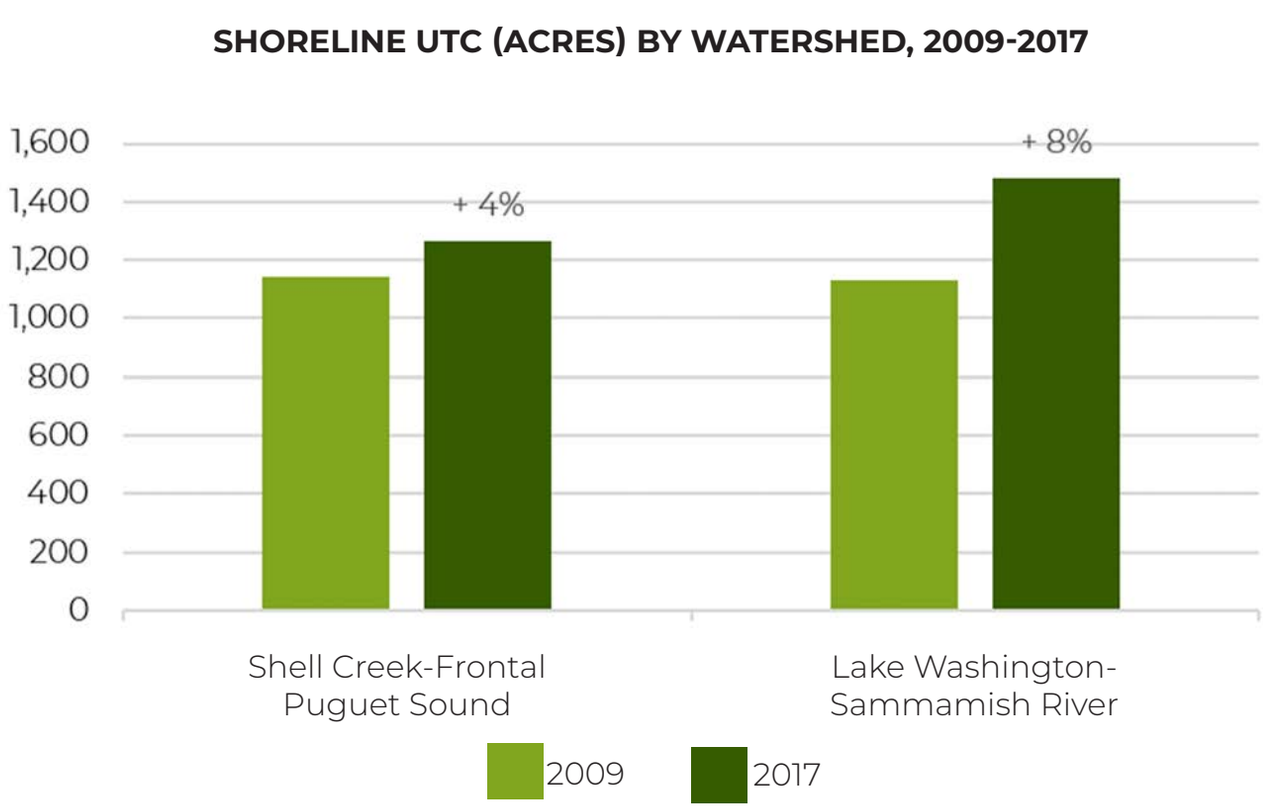


Figure 17. | Urban tree canopy by HUC-12 watershed.

UTC CHANGE BY LAND USE

The same trend in UTC and PPA that was observed when results were assessed by land use was evident in the UTC change results by land use as well. In other words, low-density residential areas contributed the greatest overall increase in canopy at 230 acres, but this was due more to the large land area of that class than the class having a high UTC increase (6 percent). Notably, the areas that had the highest increase in UTC over the study period were the three light rail station sub-areas, at 9, 9, and 10 percent. This is good news for the City's goal of maintaining a healthy urban forest presence in the areas where trees will have to be removed to make way for the Sound Transit 2 project.

In Shoreline's low-density residential areas, which make up 58% of the city's total land area, urban tree canopy increased by 6% since 2009.

Table 8. | Urban tree canopy change since 2009 by land use.

LAND USE	LAND AREA (ACRES)	UTC (2017)	UTC CHANGE (SINCE 2009)
Institution/Campus	224	90 40%	+17 8%
Low Density Residential	3,607	1554 43%	+230 6%
Medium Density Residential	69	27 39%	+6 8%
High Density Residential	146	44 30%	+10 +7%
Mixed Use 1	237	29 12%	+8 +3%
Mixed Use 2	118	20 17%	+6 (+5%)
Planned Area 3	16	2 15%	+1 (+6%)
Public Facility	507	115 23%	+23 (+5%)
Private Open Space	321	160 50%	+15 (+5%)
Public Open Space	349	230 66%	+13 (+4%)
Station Area 1	200	63 32%	+19 (+9)
Station Area 2	139	48 35%	+13 (+9%)
Station Area 3	157	62 39%	+15 (+10%)
Town Center District	105	11 10%	+3 (+3%)
Totals	**6,195**	**2,455 40%**	**+381 (+6%)**

UTC CHANGE BY SOUND TRANSIT LIGHT RAIL STATION SUB-AREA & REMOVAL AREA

In addition to assessing the UTC change of the three light rail station sub-areas, changes resulting from another area were also assessed. As a part of the Sound Transit 2 project, all trees will need to be removed along the immediate corridor where the track will be built. The impacts on the city's overall tree canopy caused by this removal were explored. It was determined that this removal area occupies 61 acres of the city's land area, of which 25 acres were tree canopy, yielding 41 percent cover in 2017. This number had jumped approximately 7 percent since 2009, when it contained 20 acres or 33 percent cover. However, since the removal area makes up such a small fraction of the city's land area, this analysis revealed that removing these trees would have a negligible impact on the city's overall canopy cover, decreasing it by only 0.3 percent. This less than one percent change could easily be recovered by planting new trees within the light rail station sub-areas' PPA if maintaining tree canopy cover in those immediate areas is a priority.

Table 9. | Urban tree canopy change since 2009 by light rail station sub-areas.

LIGHT RAIL STATION SUB-AREA	LAND AREA (ACRES)	UTC (2017)	UTC CHANGE (SINCE 2009)
Sub-Area 1	200	63 32%	+19 + 9%
Sub-Area 2	139	48 35%	+13 + 9%
Sub-Area 3	157	62 39%	+15 +10%
TOTALS	**496**	**174 35%**	**+47 +9%**

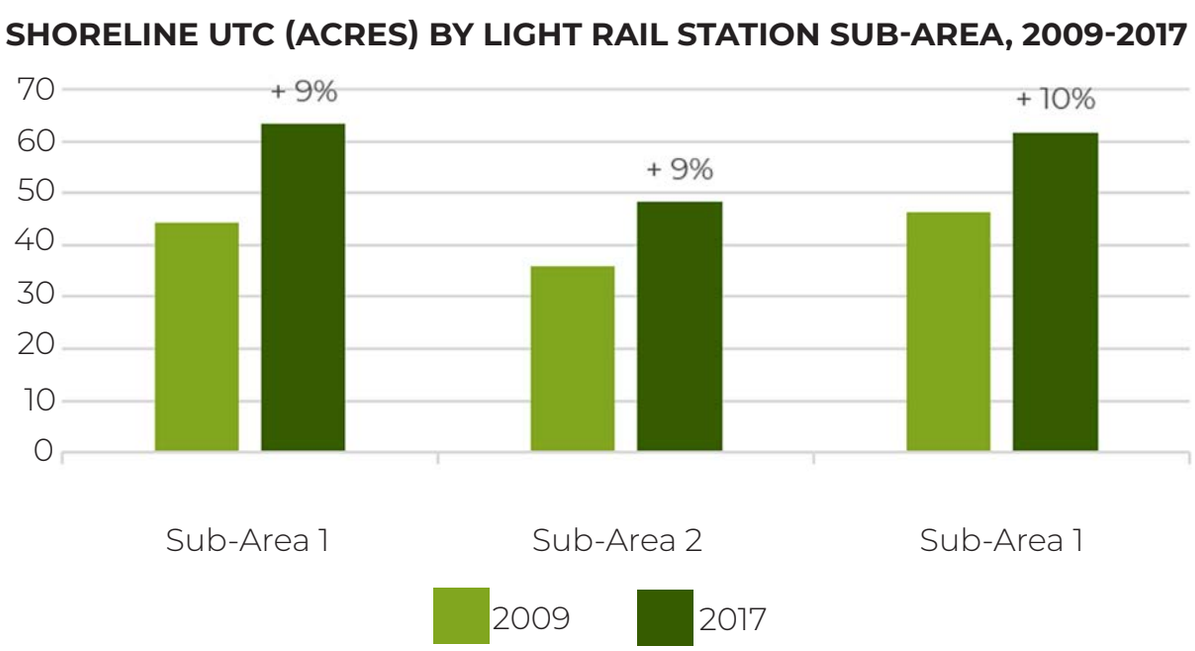


Figure 18. | Urban tree canopy by light rail station sub-area.

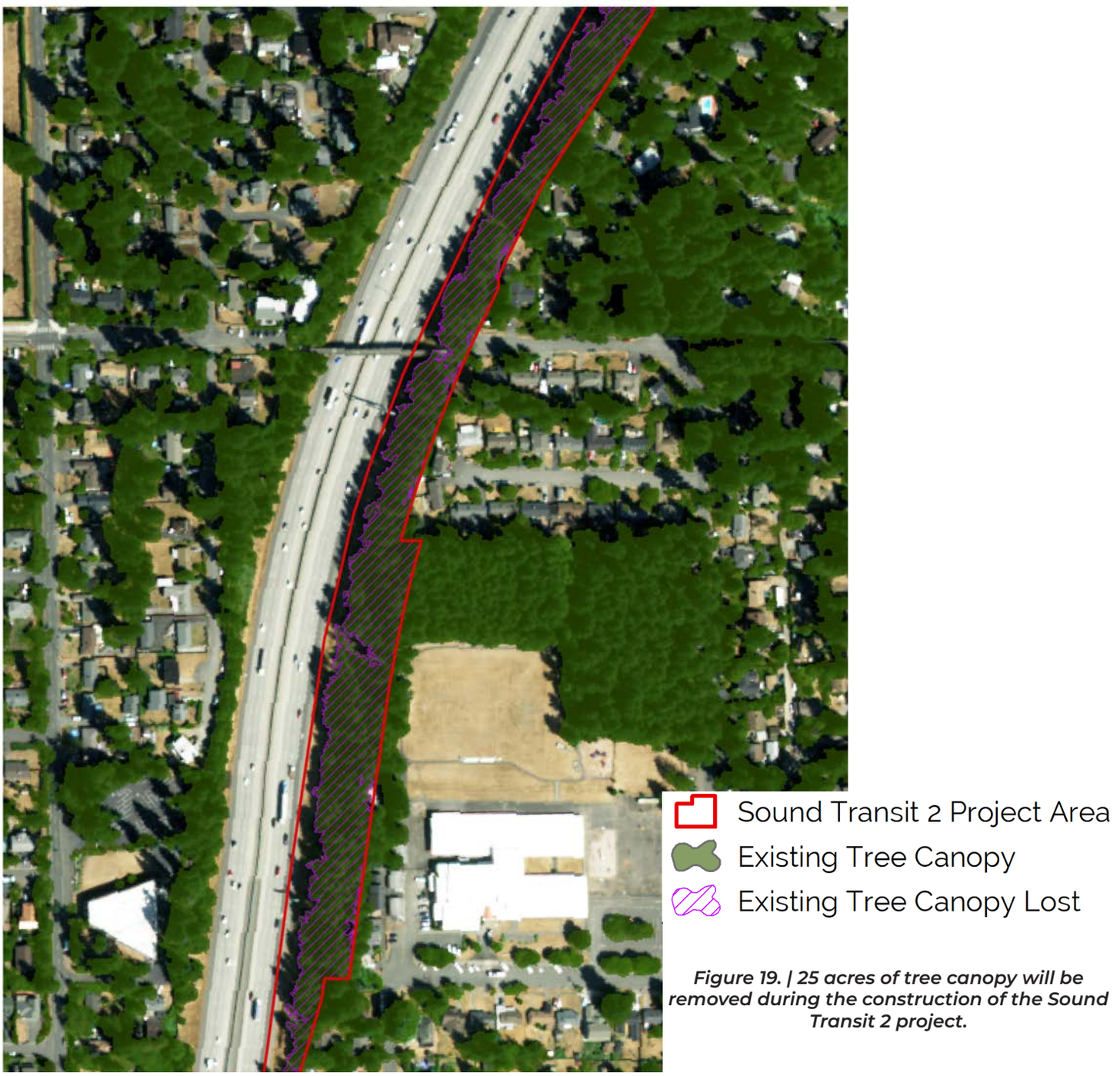


Figure 19. | 25 acres of tree canopy will be removed during the construction of the Sound Transit 2 project.

UTC CHANGE BY CENSUS BLOCK GROUPS

Canopy change since 2009 amongst Shoreline's census block groups had a wide variance as well. While some census block groups only had a 1 percent increase in canopy from 2009-2017, others had as high as 18 percent raw (53 percent relative). Fortunately, only one of the city's 51 census block groups had a decrease in canopy, with a 3 percent raw (7 percent relative) loss. Again, for the complete results by census block group, refer to the UTC Results spreadsheet or the Census Block Groups shapefile.

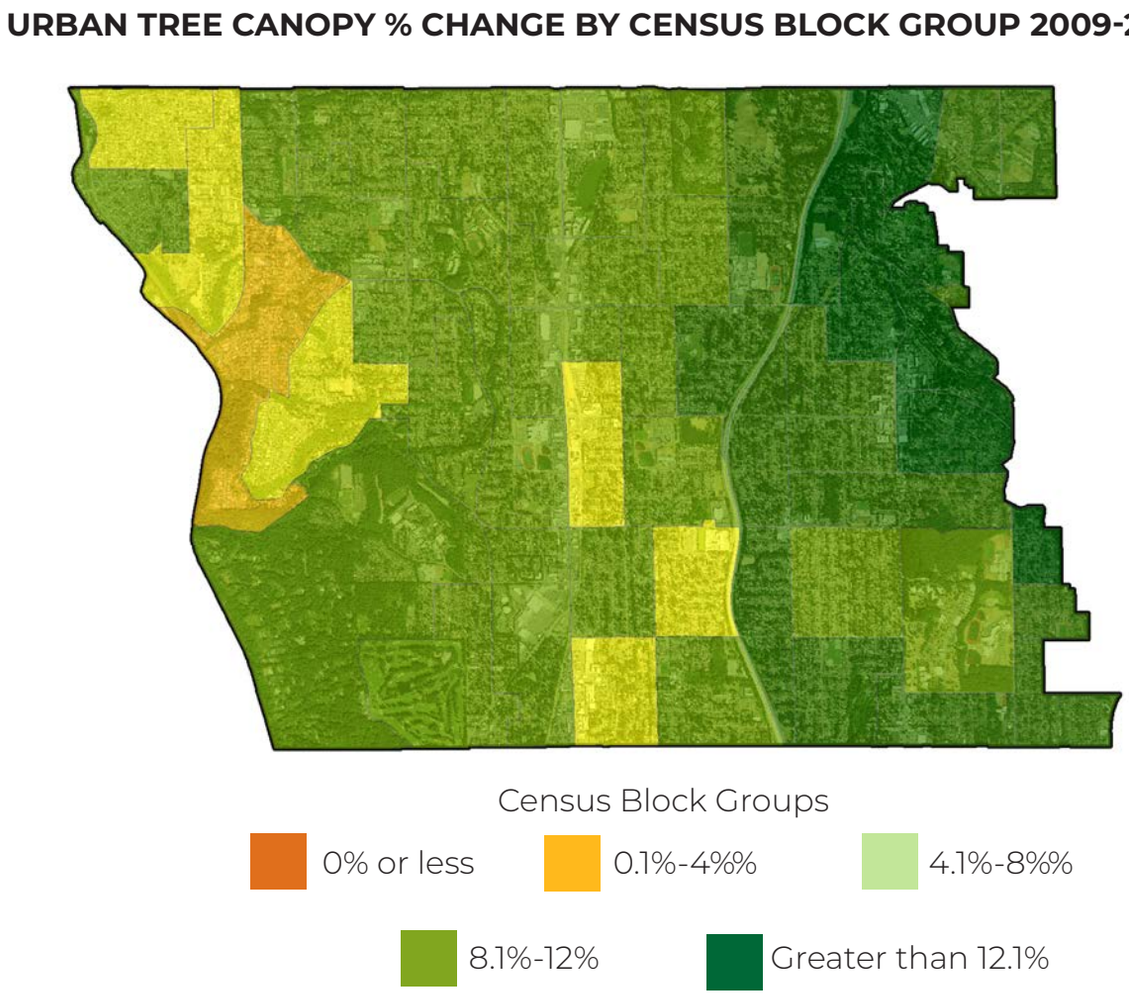


Figure 20. | Urban tree canopy change by census block group.

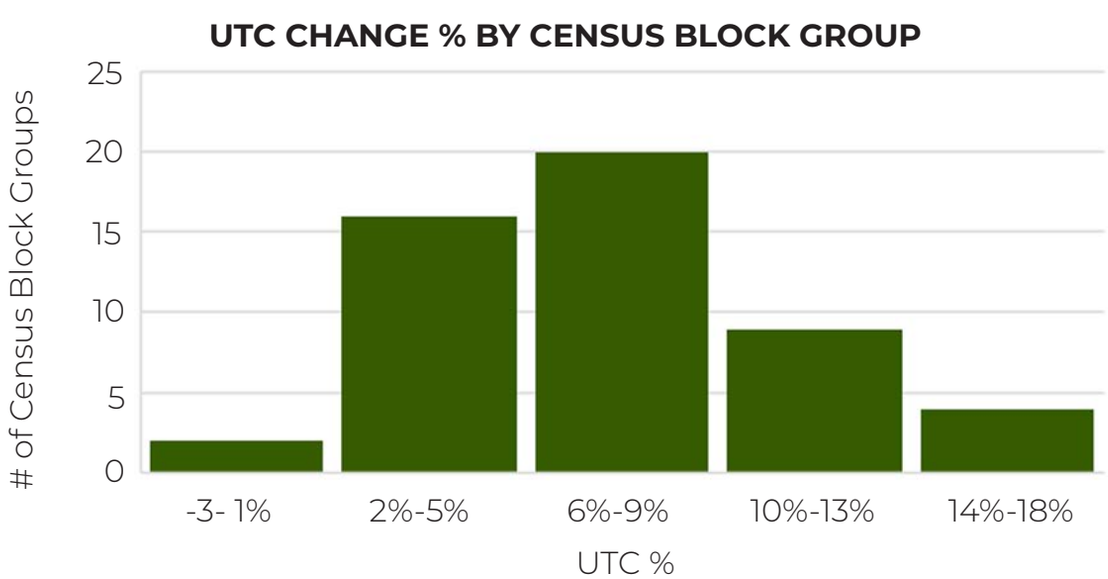


Figure 21. | Number of census block groups within urban tree canopy change ranges.

RECOMMENDATIONS

It is clear that the City of Shoreline values its urban forest resource and wants to preserve, protect, and maintain it. One way to do this is to have a canopy assessment performed on a regular interval. The City of Shoreline has achieved this by assessing their canopy in 2009 and again in 2017. As the City changes, they will be able to use these recommendations to ensure that their urban forest policies and management practices continue to prioritize its maintenance, health, and growth.

First and foremost, the City must put these results to work to preserve and promote its tree canopy.

The results of this assessment can and should be used to encourage investment in forest monitoring, maintenance, and management; to prepare supportive information for local budget requests/grant applications; and to develop targeted presentations for city leaders, planners, engineers, resource managers, and the public on the functional benefits of trees in addressing environmental issues. The land cover data should be disseminated to diverse partners for urban forestry and other applications while the data is current and most useful for decision-making and implementation planning. The information from this study can help establish canopy cover goals for the short- and long-term.

Additionally, the City and its various stakeholders can utilize the results of the UTC, PPA, and change analyses to identify the best locations to focus future tree planting and canopy expansion efforts. While the City has seen an overall upward trend in canopy cover throughout the years assessed, breaking up the results by several different geographic boundaries demonstrated that this growth has not been evenly distributed. For example, while some of Shoreline's 51 census block groups have increased their canopy by more than 50 percent relative to their previous amounts, others have seen gains as small as 1 percent, and others have even lost canopy. These results can be used as a guide to determine which areas would receive the greatest benefits from the investment of valuable time and resources into Shoreline's urban forest.

98% OF CENSUS BLOCK GROUPS IN SHORELINE HAD AN INCREASE IN CANOPY SINCE 2009

Furthermore, as the City prepares to welcome its new light rail line, the UTC results will be vital in determining how to counter the canopy losses that will result from the major increase in development. The residents of the adjacent communities value Shoreline's trees and green spaces and are concerned about the impending removal necessary for this infrastructure project. The results of the UTC assessment by light rail station sub-areas can be used to identify the places with the least remaining canopy and/or most available planting space to target community plantings and quell these apprehensions.

The 2011 tree canopy assessment performed for Shoreline by AMEC identified 40% as the overall canopy goal for Pacific Northwest communities, as set forth by American Forests. With the increases in canopy that Shoreline has seen since that report was published, the City is well on its way to meeting that goal. Shoreline's urban forest provides the City with a wealth of environmental, social, and even economic benefits which relate back to greater community interest in citywide initiatives and priorities. These updated results can be used to interpret where these gains have been felt most significantly and where there is still work to be done in accordance with the city's broader goals and vision for its future.

APPENDIX

ACCURACY ASSESSMENT

Classification accuracy serves two main purposes. Firstly, accuracy assessments provide information to technicians producing the classification about where processes need to be improved and where they are effective. Secondly, measures of accuracy provide information about how to use the classification and how well land cover classes are expected to estimate actual land cover on the ground. Even with high resolution imagery, very small differences in classification methodology and image quality can have a large impact on overall map area estimations. Accuracy assessments were performed on both the 2011 study results (based on 2009 imagery) and current study results (based on 2017 imagery) to determine both their own respective accuracy and how they compare.

The classification accuracy error matrix illustrated in Figures 22 and 23 contain confidence intervals that report the high and low values that could be expected for any comparison between the classification data and what actual, on the ground land cover was in 2009 and 2017. This accuracy assessment was completed using high resolution aerial imagery, with computer and manual verification. No field verification was completed.

THE INTERNAL ACCURACY ASSESSMENT WAS COMPLETED IN THESE STEPS

1. One hundred seventy-five (175) sample points, or 15 points per square mile area in Shoreline (11.7 sq. miles), were randomly distributed across the study area and assigned a random numeric value.
2. Each sample point was then referenced using the satellite photo (2009) or NAIP aerial photo (2017) and assigned one of five generalized land cover classes (“Ref_ID”) mentioned above by a technician.
3. In the event that the reference value could not be discerned from the imagery, the point was dropped from the accuracy analysis. In this case, no points were dropped.
4. An automated script was then used to assign values from the classification raster to each point (“Eval_ID”). The classification supervisor provides unbiased feedback to quality control technicians regarding the types of corrections required. Misclassified points (where reference ID does not equal evaluation ID) and corresponding land cover are inspected for necessary corrections to the land cover .

Accuracy is re-evaluated (repeat steps 3 & 4) until an acceptable classification accuracy is achieved.

SAMPLE ERROR MATRIX INTERPRETATION

Statistical relationships between the reference pixels (representing the true conditions on the ground) and the intersecting classified pixels are used to understand how closely the entire classified map represents Shoreline’s landscape. The error matrices shown in Figures 22 and 23 represent the intersection of reference pixels manually identified by a human observer (columns) and classification

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(1) Note that by correcting locations associated with accuracy points, bias is introduced to the error matrix results. This means that matrix results based on a new set of randomly collected accuracy points may result in significantly different accuracy values.

category of pixels in the classified image (rows). The gray boxes along the diagonals of the matrix represent agreement between the two-pixel maps. Off-diagonal values represent the number of pixels manually referenced to the column class that were classified as another category in the classification image. Overall accuracy is computed by dividing the total number of correct pixels by the total number of pixels reported in the matrix (69 + 16 + 67 + 10 + 1 = 163 / 175 = 93 percent), and the matrix can be used to calculate per class accuracy percent's. For example, 71 points were manually identified in the reference map as Tree Canopy, and 69 of those pixels were classified as Tree Canopy in the classification map. This relationship is called the "Producer's Accuracy" and is calculated by dividing the agreement pixel total (diagonal) by the reference pixel total (column total). Therefore, the Producer's Accuracy for Tree Canopy is calculated as: (69/71 = .97), meaning that we can expect that ~97 percent of all 2017 tree canopy in the Shoreline, WA study area was classified as Tree Canopy in the 2017 classification map. Conversely, the "User's Accuracy" is calculated by dividing the total number of agreement pixels by the total number of classified pixels in the row category. For example, 69 classification pixels intersecting reference pixels were classified as Tree Canopy, but three pixels were identified as Vegetation and one pixel was identified as Impervious in the reference map. Therefore, the User's Accuracy for Tree Canopy is calculated as: (69/73 = 0.95), meaning that ~95 percent of the pixels classified as Tree Canopy in the classification were actual tree canopy. It is important to recognize the Producer's and User's accuracy percent values are based on a sample of the true ground cover, represented by the reference pixels at each sample point. Interpretation of the sample error matrix results indicates this land cover, and more importantly, tree canopy, were accurately mapped in Shoreline in 2017. The largest sources of classification confusion exist between tree canopy and vegetation.

Reference Data

Classification Data	Tree Canopy	Shrub	Vegetation	Impervious	Soil /Dry Veg.	Water	Total Reference Pixels
Tree Canopy	69	0	3	1	0	0	73
Shrub	0	0	0	0	0	0	0
Vegetation	1	0	16	0	2	0	19
Impervious	1	0	1	67	0	0	69
Soil /Dry Veg.	0	0	1	2	10	0	13
Water	0	0	0	0	0	1	1
Total	71	0	21	70	12	1	175

Overall Accuracy =	93%

Producer's Accuracy	
Tree Canopy	97%
Shrub	N/A
Vegetation	76%
Impervious	96%
Soil/Dry Veg	83%
Water	100%

User's Accuracy	
Tree Canopy	95%
Shrub	N/A
Vegetation	84%
Impervious	97%
Soil/Dry Veg	77%
Water	100%

Figure 22. | Error matrix for land cover classifications in Shoreline, WA (2017).

In addition to analyzing the accuracy of Plan-It Geo's current canopy assessment against the 2017 NAIP imagery, the 2011 AMEC results were also analyzed against the 2009 satellite orthophoto used in that study using the same methods. This was deemed necessary due to the conspicuously large increase in canopy derived from the change analysis (a 6 percent increase over an 8-year time period). Qualitatively speaking, GIS technicians also expressed concerns about the apparent underestimation of canopy in the previous study's data when they reviewed it for reference during the 2017 assessment. Therefore, another random one hundred seventy-five points were created, and the entire process described above was repeated.

Results indicated an overall accuracy of 82 percent, which is substantially lower than the current study's data. Additionally, the low Producer's Accuracy of tree canopy (76 percent), in particular, effectively means that as many as a quarter of the trees that were present in Shoreline's true land cover in 2009 were left out of the 2009 classification map.

Reference Data

Classification Data	Tree Canopy	Shrub	Vegetation	Impervious	Soil /Dry Veg.	Water	Total Reference Pixels
Tree Canopy	44	2	4	0	0	0	50
Shrub	1	0	2	1	0	0	4
Vegetation	10	6	17	3	2	0	38
Impervious	3	0	1	66	3	0	73
Soil /Dry Veg.	0	0	1	0	10	0	11
Water	0	0	0	0	0	0	0
Total	58	8	25	70	15	0	176

Overall Accuracy =	78%

Producer's Accuracy	
Tree Canopy	76%
Shrub	0%
Vegetation	68%
Impervious	94%
Soil/Dry Veg	67%
Water	N/A

User's Accuracy	
Tree Canopy	88%
Shrub	0%
Vegetation	45%
Impervious	90%
Soil/Dry Veg	91%
Water	N/A

Figure 23. | Error matrix for land cover classifications in Shoreline, WA (2009).

ACCURACY ASSESSMENT RESULTS

Interpretation of the two sample error matrices offers some important insights when evaluating Shoreline's urban tree canopy coverage and how it has changed over time. Most significantly, it indicates that the tree canopy was more than likely underestimated in the initial study. Therefore, rather than increasing by such a substantial amount in a relatively short period of time, the true UTC was likely higher than reported in 2009 and increased by a less extreme figure to 2017. However, the high accuracy of the 2017 data indicates that regardless of how and when it was achieved, Shoreline's current tree canopy can be safely assumed to match the figures stated in this report (approximately 37 percent).

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JULY | 2018

URBAN TREE CANOPY

ASSESSMENT

SHORELINE, WASHINGTON

plan-it GEO

CITY OF SHORELINE