URBAN TREE CANOPY

ASSESSMENT

TACOMA,
WASHINGTON
DECEMBER | 2018

plan-it GEO

SEAL OF THE CITY OF TACOMA 1884

AN ASSESSMENT OF
URBAN TREE CANOPY

TACOMA, WASHINGTON

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

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6,406
ACRES OF TREE CANOPY

EXECUTIVE SUMMARY

PURPOSE OF THIS ANALYSIS

The City of Tacoma is located within Pierce County, Washington, south of the Seattle metropolitan area (Figure 1). It is approximately 49 square miles or 31,607 acres of which 31,476 are land acres. Across the city, trees along streets, in parks, yards, and natural areas constitute a valuable urban and community forest. This resource is a critical element of the region's green infrastructure, contributing to environmental quality, public health, water supply, local economies and aesthetics. The primary goal of this assessment was to provide a baseline and benchmark of the City's tree canopy and interpret the results across a range of geographic boundaries.

URBAN TREE CANOPY IN TACOMA

Results of this study indicated that in 2017, the city of Tacoma contained 20 percent urban tree canopy (or 6,406 of the city's 31,607 total acres); 13 percent non-canopy vegetation (4,257 acres); 14 percent soil/dry vegetation (4,469 acres); 52 percent impervious (16,344 acres); and less than 1 percent water (132 acres). Existing urban tree canopy covers 20 percent of Tacoma's land area (6,406 of the city's 31,476 land acres). Of the city's 80 percent of land area not presently occupied by tree canopy, 13 percent (4,604 acres) was suitable for future tree plantings and 67 percent (21,006 acres) was unsuitable due to its current land use or other restraint. surfaces.

ASSESSMENT BOUNDARIES

This study assessed urban tree canopy (UTC) and possible planting areas (PPA) 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; watersheds (8); land uses (14); and census block groups (202).

RECOMMENDATIONS

The results of this analysis can be used to develop a continuing strategy to protect and expand Tacoma's urban forest. The UTC and PPA metrics should be used as a guide to determine where the city has been successful in protecting and expanding its urban forest resource, while also targeting areas to concentrate future efforts based on needs, benefits, and available planting space. Tacoma can use these results to ensure that their urban forest policies and management practices continue to prioritize its maintenance, health, and growth.

Figure 1. | Tacoma occupies approximately 49 square miles in Pierce County, Washington.

20% URBAN TREE CANOPY

52% IMPERVIOUS SURFACE

13% POSSIBLE PLANTING AREA

Figure 2. | Based on an analysis of 2017 high-resolution imagery, Tacoma contains 20% tree canopy, 13% areas that could support canopy in the future, and 52% 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.

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 2017 LiDAR data from the Washington State Department of Natural Resources to derive the land cover data set. The NAIP imagery is used to classify all types of land cover, whereas the LiDAR is most useful for distinguishing tree canopy from other types of vegetation. Additional GIS layers provided by the City of Tacoma were also incorporated into the analysis.

MAPPING LAND COVER

An initial land cover dataset was to be created prior to mapping tree canopy and assessing change. The land cover data set is the most fundamental component of an urban tree canopy assessment. An object-based image analysis (OBIA) software program called Feature Analyst was used to classify features through an iterative approach. In this process, objects' spectral signatures across four bands (blue, green, red, and near-infrared), textures, pattern relationships, and object height were considered. This remote sensing process used the NAIP imagery and LiDAR to derive five initial land cover classes. These classes are shown in Figure 3.

After manual classification improvement and quality control were performed on the remote sensing products, an additional data layer from the city (buildings) was utilized to capture finer feature detail and further categorize the land cover dataset.

Figure 3. | Five (5) distinct land cover classes were identified in the 2017 tree canopy assessment: urban tree canopy, non-canopy vegetation, bare soil and dry vegetation, impervious (paved) surfaces, and water.

CLASSIFYING URBAN TREE CANOPY

Following the remote sensing classification and final QA/QC of the tree canopy data layer, this output was used as a mask to extract tree height composition using LiDAR height information from a Normalized Digital Surface Model (nDSM). Tree canopy throughout the city was classified into four different height ranges: between 0 and 25 feet tall, 25 to 50 feet, 50 to 100 feet, and greater than 100 feet tall. There were no accuracy standards required or assessed for this classification. Additionally using impervious surface data provided by the city (buildings) and the amount of tree canopy overhanging impervious surfaces was quantified to assist with hydrologic modeling and gain a better understanding of the benefits that the City's trees are providing..

IDENTIFYING POSSIBLE PLANTING AREAS AND UNSUITABLE AREAS FOR PLANTING

In addition to quantifying Tacoma'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 Tacoma that was not existing tree canopy coverage was classified as either possible planting area (PPA) or unsuitable for planting. Possible planting areas were derived from the Non-Canopy Vegetation class. 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.

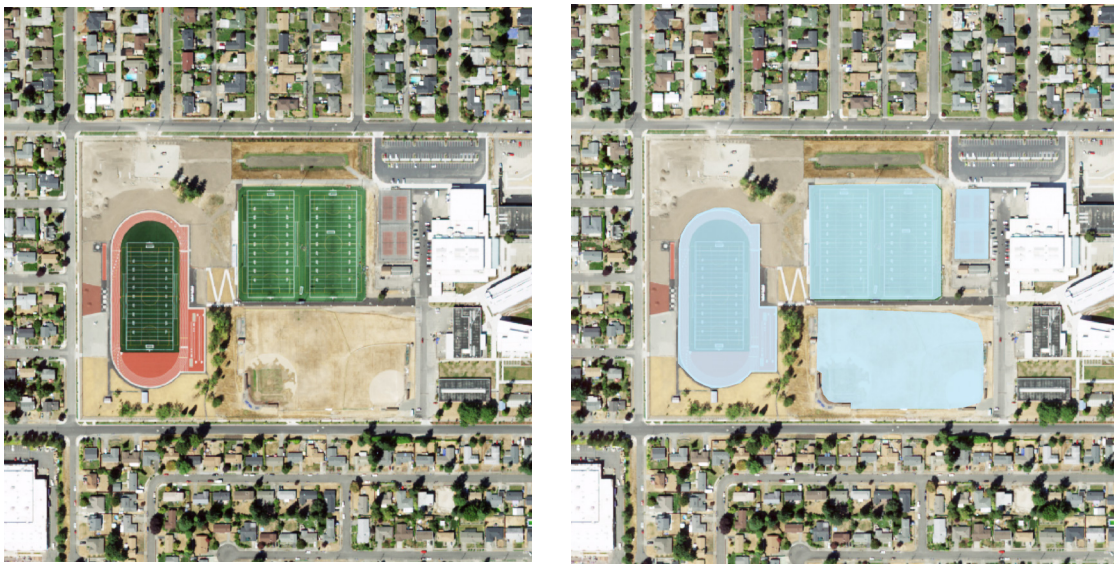
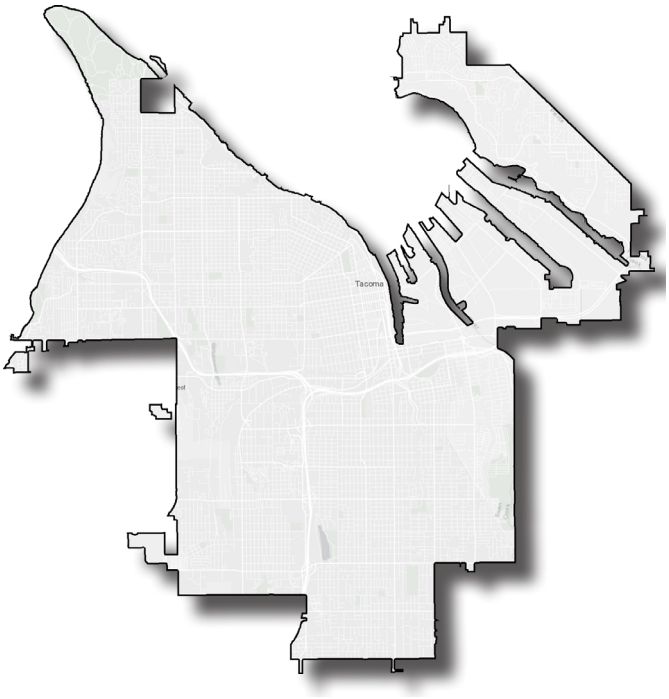


Figure 4. | Vegetated areas where it would be biophysically feasible for tree plantings but undesirable based on their current usage (left) were delineated in the data as "Unsuitable" (right). These areas included recreational sports fields, golf courses, and other open space.

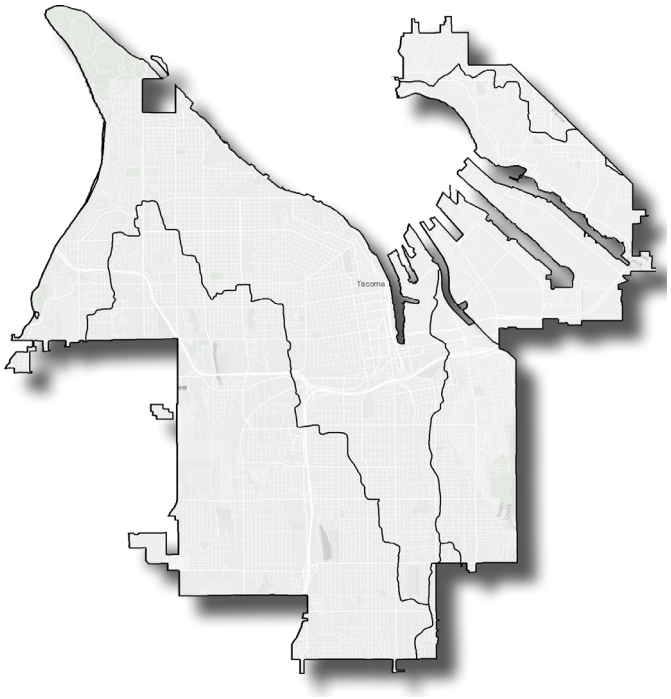
DEFINING ASSESSMENT LEVELS

In order to best inform the City Council and all of Tacoma'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, and census block groups.

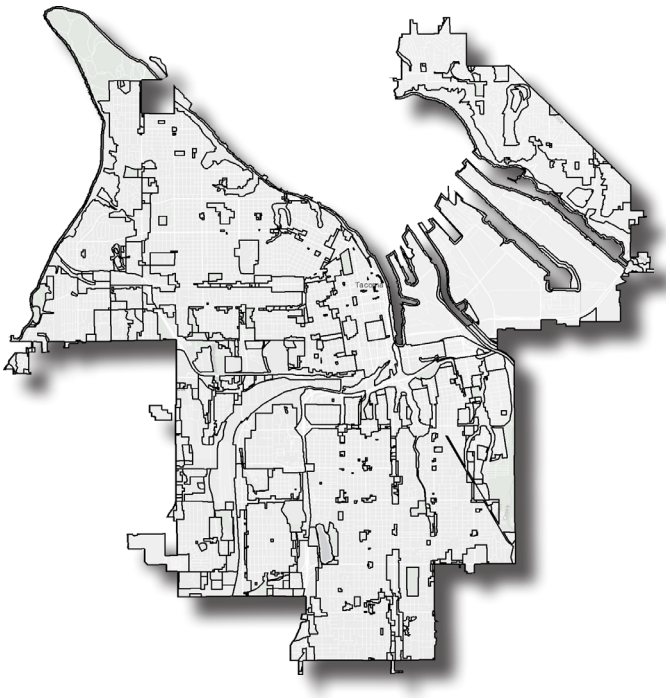
- The City of Tacoma's citywide boundary is the one (1) main area of interest over which all metrics are summarized.
- Eight (8) HUC-12 watersheds intersect the city of Tacoma. Delineated by the U.S. Geological Survey, each unique 12-digit identification code represents a different subwatershed. They were analyzed to explore differences in tree canopy across a naturally-occurring geographic boundary.
- Fourteen (14) land use classes provided by the City were analyzed to assess differences in tree canopy across different human uses of land.
- Two hundred and two (202) census block groups were assessed to provide information at a small geographic scale. Census block groups (CBGs) 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.



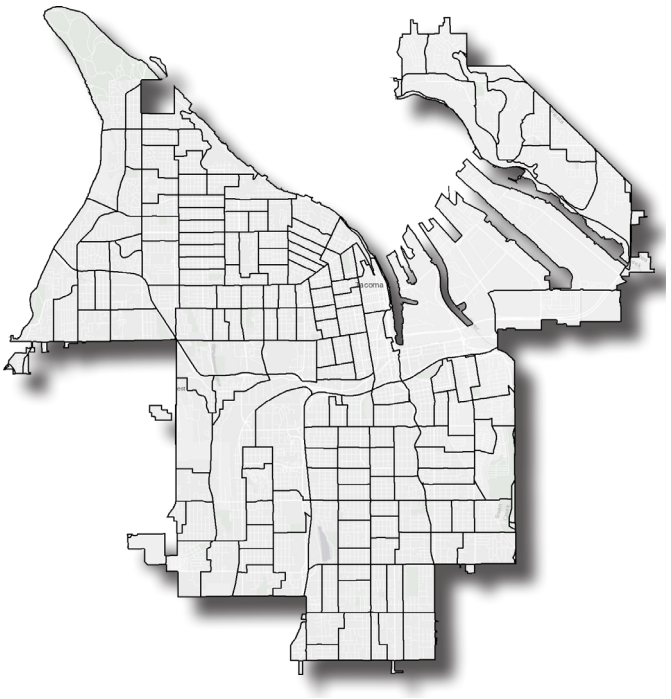
City of Tacoma



Watersheds



Land Use



Census Block Groups

Figure 5. | Four distinct geographic boundaries were explored in this analysis: the full city boundary, watersheds, land use classes, and 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 and canopy 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. Land cover percentages are based on the total area of interest while urban tree canopy, possible planting area, and unsuitable percentages are based on land area. Water bodies are excluded from land area because they are typically unsuitable for planting new trees without significant modification.

CITYWIDE LAND COVER

In 2017, tree canopy constituted 20 percent of Tacoma's land cover; non-canopy vegetation was 13 percent; soil/dry vegetation was 14 percent; impervious was 52 percent; and water was less than 1 percent. These generalized results are presented in Table 1 below. In further dividing the impervious surfaces, 12 percent of Tacoma's total area was buildings and 40 percent was "other impervious" (such as roads, sidewalks, and parking lots). These detailed results are presented in Figure 6 on the next page.

Table 1. | Generalized land cover classification results for the City of Tacoma, Washington.

Tacoma	City Boundary	Tree Canopy	Impervious Surfaces	Non-Canopy Vegetation	Soil & Dry Vegetation	Water
Acres	31,607	6,406	16,344	4,257	4,469	132
% of Total	100%	20%	52%	13%	14%	<1%

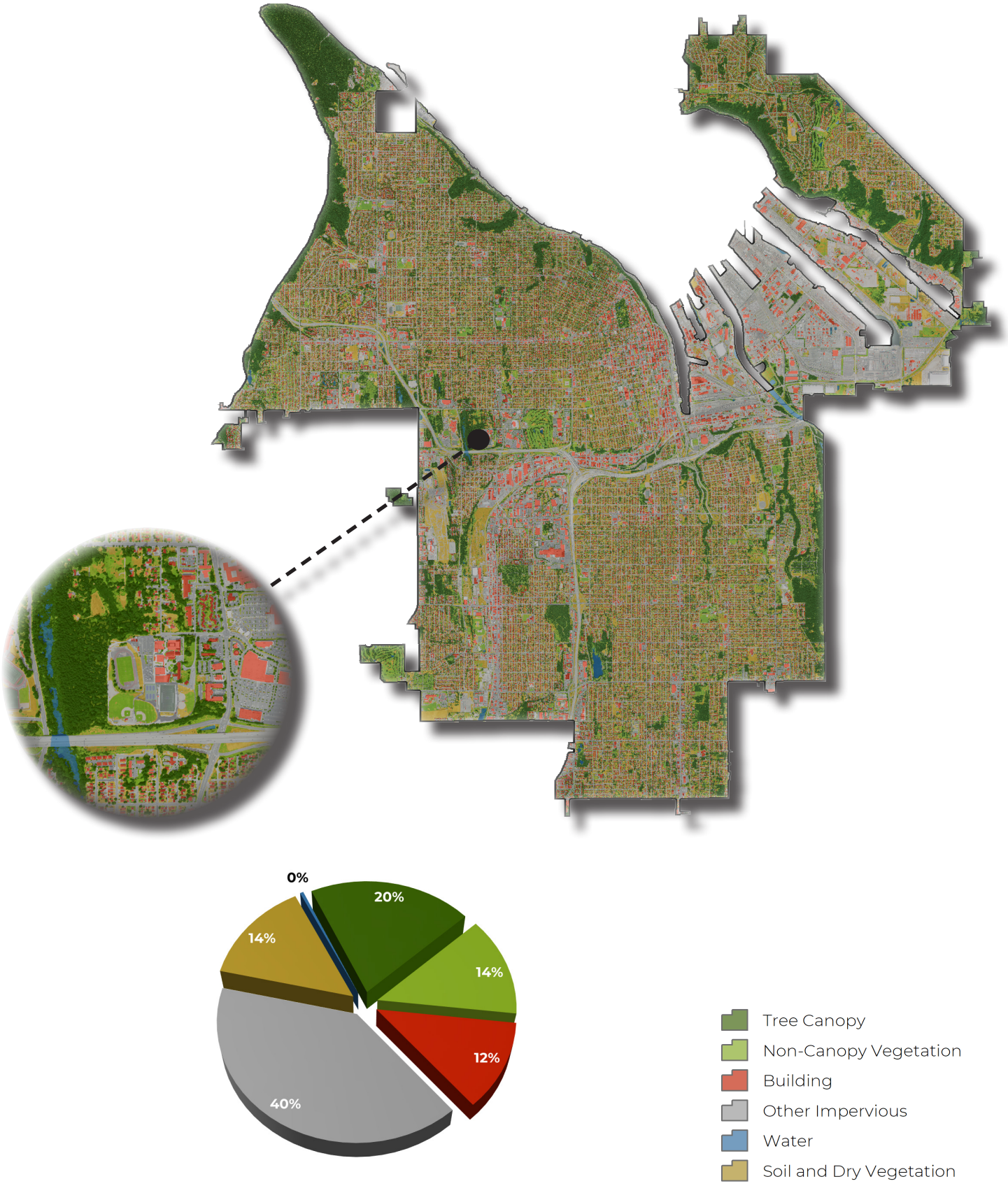


Figure 6. | Land cover classes for Tacoma, Washington based on 2017 NAIP imagery and 2017 Washington State DNR LiDAR data. (Percentages based on total acres.)

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).

Results of this study indicate that within the city of Tacoma, 6,406 acres are covered with urban tree canopy, 4,064 acres are covered with other vegetation where it would be possible to plant trees (PPA), making up 13 percent of the city, 4,604 acres, or 13 percent, are areas where it would be possible to plant trees (PPA), and the other 21,006 acres were considered unsuitable for tree planting, making up 67 percent of the city. The unsuitable areas include recreational sports fields, golf course playing areas, impervious surfaces, and areas of bare soil and dry vegetation.

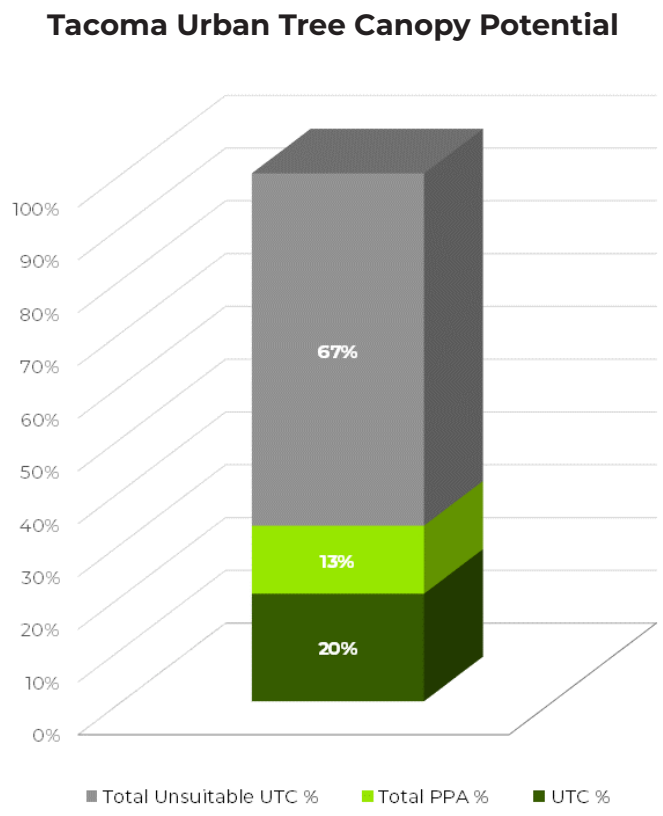


Figure 7. | Urban tree canopy, potential planting area, and area unsuitable for UTC in the City of Tacoma.

Table 2. | Urban tree canopy assessment results, by acres and percent. (Percentages based on land acres.)

City of Tacoma	Acres	%
Total Area	31,607	100%
Land Area	31,476	100%
UTC	6,406	20%
Total PPA	4,064	13%
Total Impervious	16,344	52%
Total Unsuitable UTC	21,006	67%

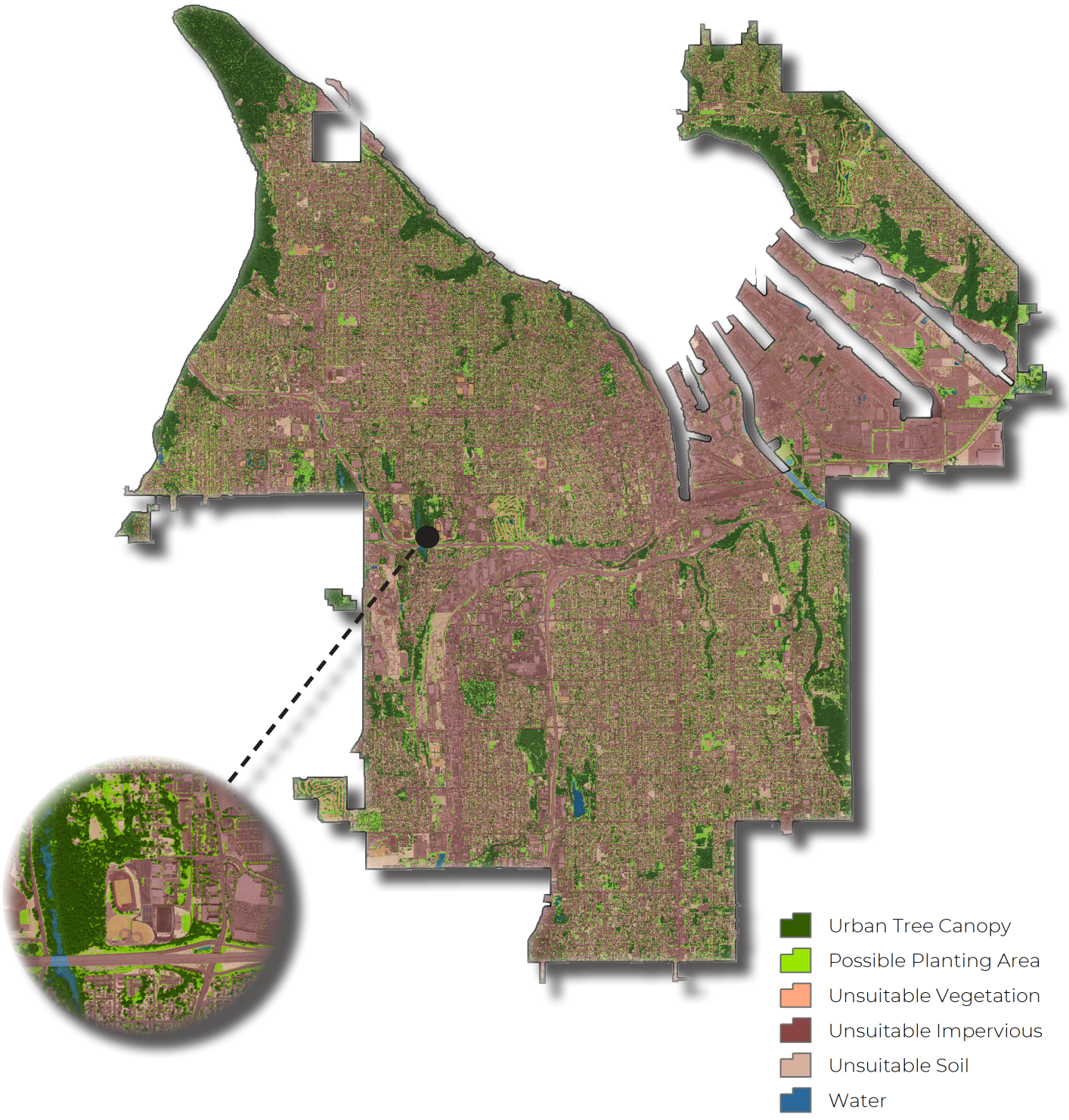


Figure 8. | Urban tree canopy, possible planting area, and area unsuitable for UTC in the city of Tacoma.

The city's 6,406 acres of urban tree canopy were further divided into two subcategories based on whether the trees' canopy had an impervious or pervious understory. Tree canopy overhanging an impervious surface can provide many benefits through ecosystem services such as localized cooling provided by shading of impervious surfaces and increased stormwater absorption. Results indicated that 4 percent of Tacoma's 6,406 acres of UTC had an impervious understory. Data on other impervious surface types such as roads and parking lots were not available at the time of this study. Inclusion of such datasets in future studies may indicate a higher percentage of impervious understory.

URBAN TREE CANOPY HEIGHT ANALYSIS

Tree canopy height across Tacoma's urban forest was analyzed. This analysis was conducted by clipping the LiDAR nDSM to the tree canopy layer. A smoothing filter was then applied to the nDSM to remove small discrepancies in the height data. The canopy height data were then grouped into four height classes: 0-25 feet, 25-50 feet, 50-100 feet, and taller than 100 feet. The analysis showed that 36 percent of Tacoma's canopy was between 0 and 25 feet tall, 24 percent was between 25 and 50 feet, 33 percent was between 50 and 100 feet, and 8 percent was taller than 100 feet.

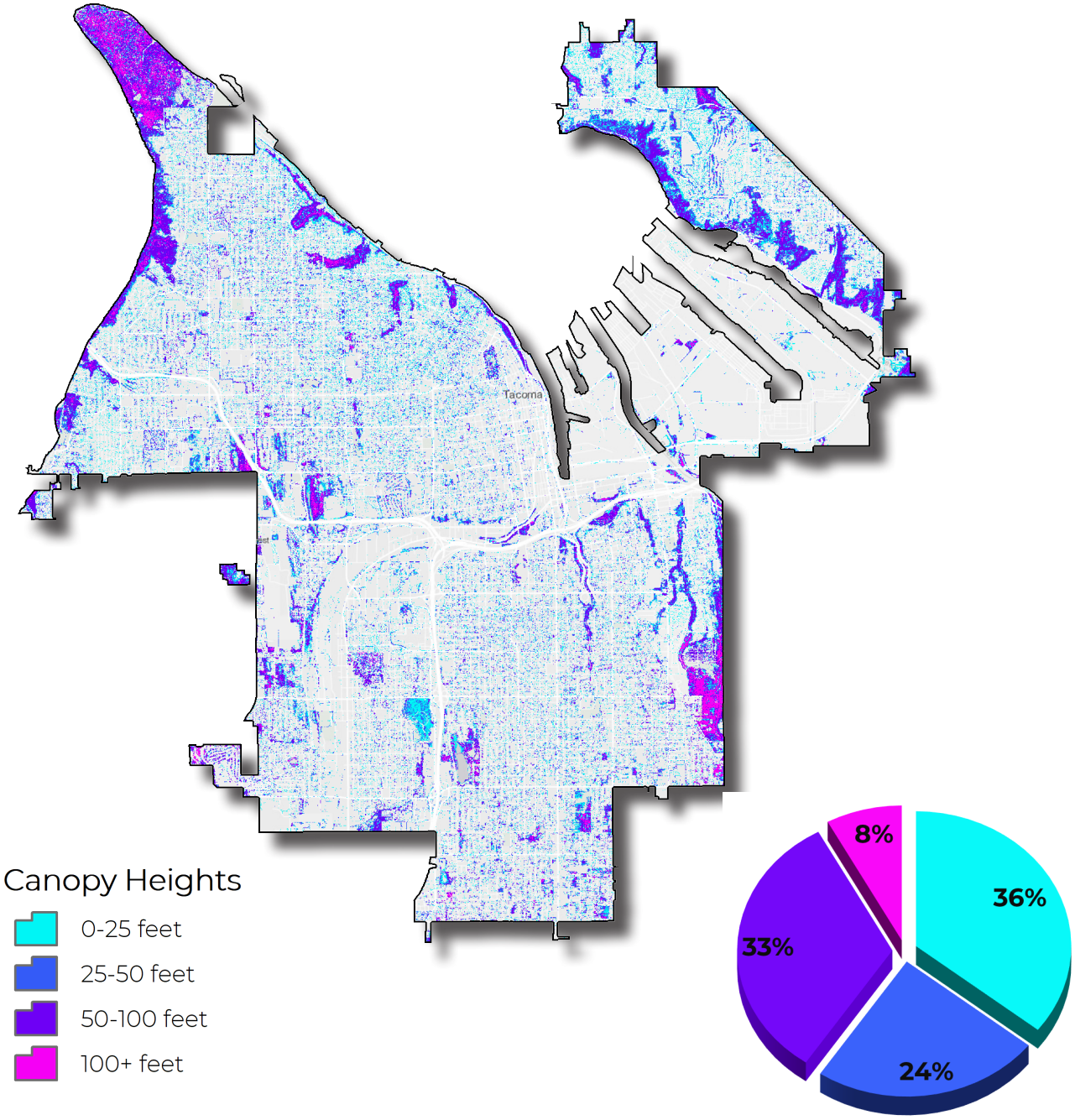


Figure 9. | Urban tree canopy height in the City of Tacoma.

URBAN TREE CANOPY BY WATERSHEDS

UTC and PPA were also assessed for the HUC-12 watersheds found within Tacoma. Watersheds are commonly analyzed to explore differences in tree canopy across a naturally-occurring geographic boundary. The watershed with the lowest existing canopy cover was the highly industrial and impervious Hylebos Creek Frontal Comencement Bay watershed with 19 percent UTC. The watershed with the highest canopy cover was the Miller Creek Frontal East Passage watershed with 30 percent UTC. PPA ranged from 11 percent in Hylebos Creek Frontal Comencement Bay to 21 percent in Miller Creek Frontal East Passage. The largest watershed, City of Tacoma Frontal Commencement Bay, did not have the highest percentage of either UTC or PPA but contained the greatest proportion of the city's overall UTC (42 percent) and PPA (39 percent).

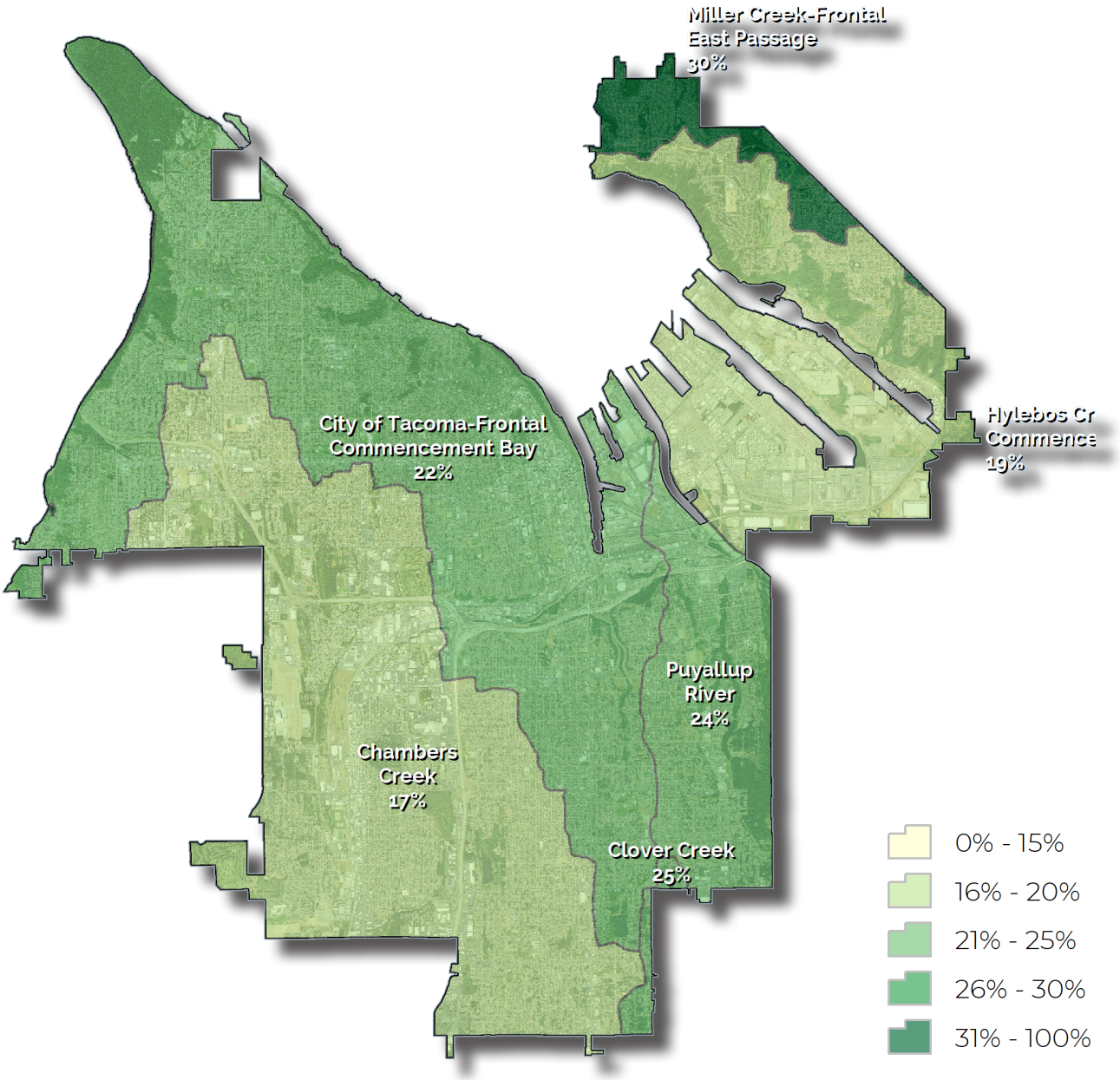


Figure 10. | Urban tree canopy (UTC) by watersheds in the City of Tacoma.

Table 3. | Urban tree canopy in Tacoma by watersheds. UTC and PPA results include acres, percent of area covered by UTC or PPA (%), and distribution of the city's total UTC or PPA within each watershed (dist.).

Watershed	Land Area		Urban Tree Canopy			Possible Planting Area		
	Acres	*Dist.*	*Acres*	*%*	*Dist.*	*Acres*	*%*	*Dist.*
Chambers Creek	10,333	33%	1,720	17%	27%	1,264	12%	31%
City of Tacoma Frontal Commencement Bay	11,956	38%	2,673	22%	42%	1,589	13%	39%
Clover Creek	225	1%	56	25%	1%	37	17%	1%
Hylebos Creek Frontal Commencement Bay	5,282	17%	983	19%	15%	578	11%	14%
Miller Creek Frontal East Passage	890	3%	269	30%	4%	186	21%	5%
Puyallup River	2,858	9%	688	24%	11%	403	14%	10%
Totals	**31,607**	**100%**	**6,406**	**20%**	**100%**	**4,064**	**13%**	**100%**

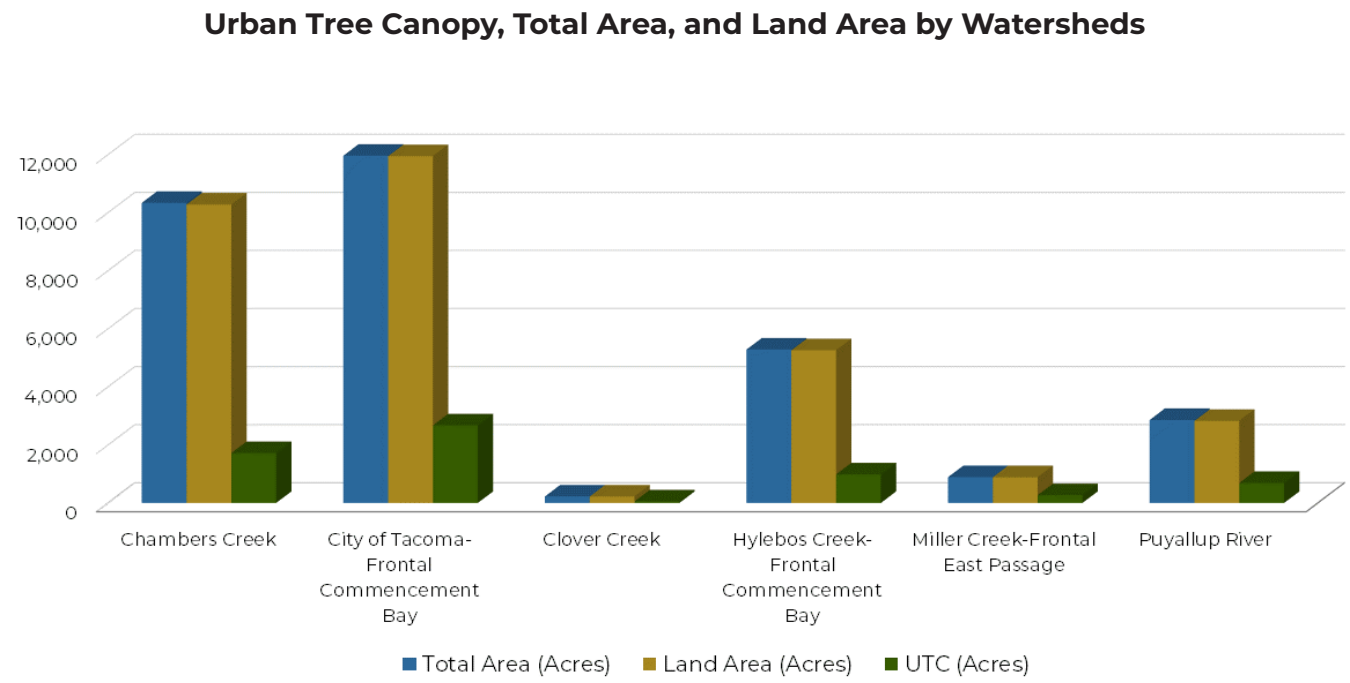


Figure 11. | Urban tree canopy compared to land area and total area for HUC-12 watersheds in the City of Tacoma.

URBAN TREE CANOPY BY LAND USES

UTC and PPA were assessed for 13 different land use categories (Table 4) provided by the City of Tacoma. Land use classes with the lowest UTC included Heavy Industrial (4 percent), Light Industrial (6 percent), Downtown Regional Growth Center (7 percent), and General Commercial (7 percent), while the highest were Parks and Open Space (56 percent), Shoreline (21 percent) and Single Family Residential (17 percent). Single Family Residential areas offered the greatest opportunities for future canopy expansion, with 16 percent PPA contributing 57 percent of the city's total PPA. Parks and Open Space also had 16 percent PPA, but the suitability and human uses of these areas for new tree plantings must be evaluated to determine whether or not they are actually good candidates for urban forest expansion. Heavy Industrial areas only contain 6 percent PPA but make up 6 percent of all PPA throughout the city. These 235 acres provide great opportunities for mitigating stormwater runoff, air pollution, and urban heat island effect from planting new trees in these highly industrial and impervious landscapes.

Table 4. | Urban tree canopy assessment results by land uses. UTC and PPA results include acres, percent of area covered by UTC or PPA (%), and distribution of the city's total UTC or PPA within each land use (dist.).

Land Use	Land Area		Urban Tree Canopy			Possible Planting Area		
	Acres	*Dist.*	*Acres*	*%*	*Dist.*	*Acres*	*%*	*Dist.*
Crossroads Mixed-Use Center	644	2%	80	12%	1%	59	9%	1%
Downtown Regional Growth Center	978	3%	73	7%	1%	63	6%	2%
General Commercial	818	3%	56	7%	1%	52	6%	1%
Heavy Industrial	4,015	13%	147	4%	2%	235	6%	6%
Light Industrial	538	2%	34	6%	1%	36	7%	1%
Major Institutional Campus	626	2%	65	10%	1%	69	11%	2%
Multi-Family (High Density)	389	1%	56	14%	1%	54	14%	1%
Multi-Family (Low Density)	1,480	5%	226	15%	4%	178	12%	4%
Neighborhood Commercial	597	2%	59	10%	1%	44	7%	1%
Neighborhood Mixed-Use Center	386	1%	33	9%	1%	24	6%	1%
Parks and Open Space	5,006	16%	2,805	56%	44%	784	16%	19%
Shoreline	1,048	3%	208	21%	3%	110	11%	3%
Single Family Residential	14,499	46%	2,507	17%	39%	2,318	16%	57%
Tacoma Mall Regional Growth Center	483	2%	48	10%	1%	33	7%	1%
Totals	**31,508**	**100%**	**6,399**	**20%**	**100%**	**4,060**	**13%**	**100%**



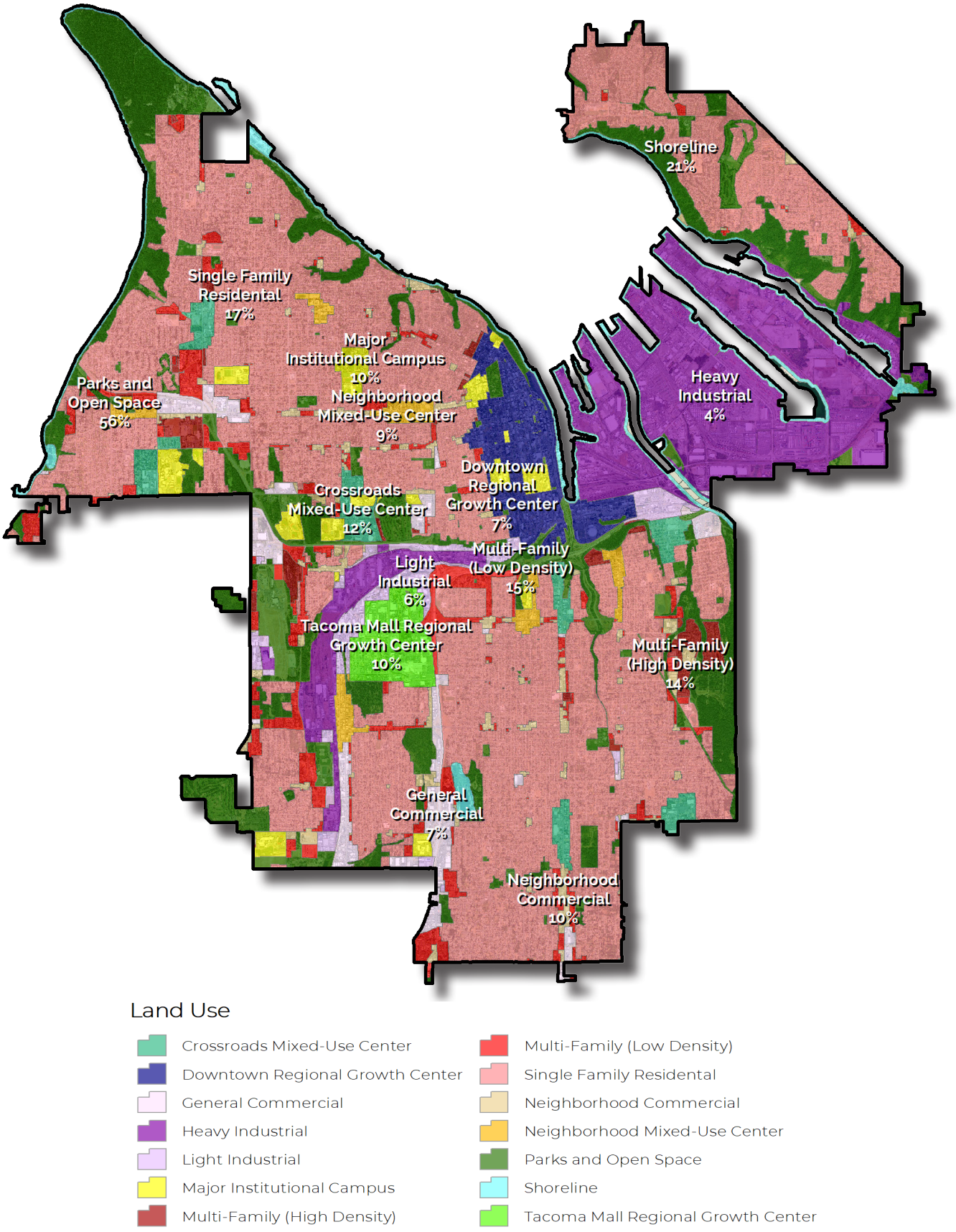


Figure 12. | Urban tree canopy in Tacoma by city land uses.

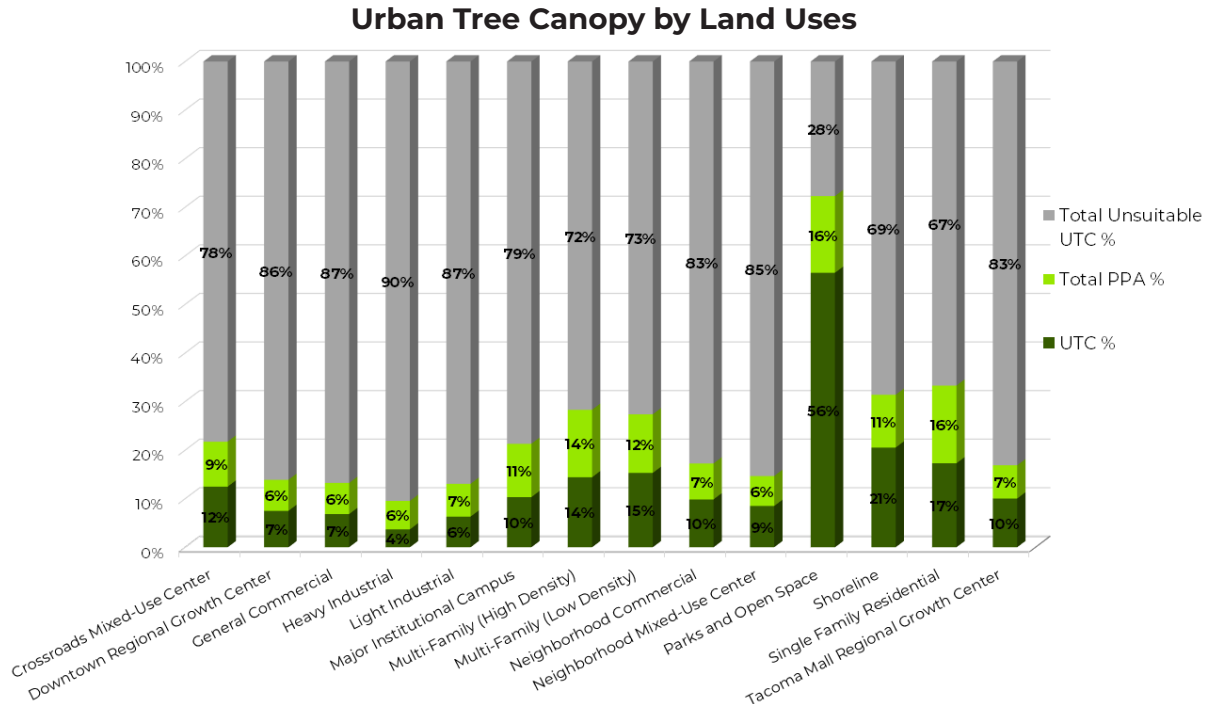


Figure 13. | Urban tree canopy, potential planting area, and area unsuitable for UTC by land uses.

URBAN TREE CANOPY BY CENSUS BLOCK GROUPS

UTC and PPA were assessed at the census block group level. This geographic unit of measure is linked to all demographic and socioeconomic U.S. Census data which makes it useful for assessing the equitable distribution of tree canopy within a city. Results indicated that Tacoma's UTC is not uniformly distributed throughout the city boundary. Some of the City's 202 census block groups contained less than 10 percent cover while others contained up to 87 percent. PPA also varied greatly and ranged from less than 1 percent to 39 percent. For the complete results by census block groups, refer to the UTC Results spreadsheet.

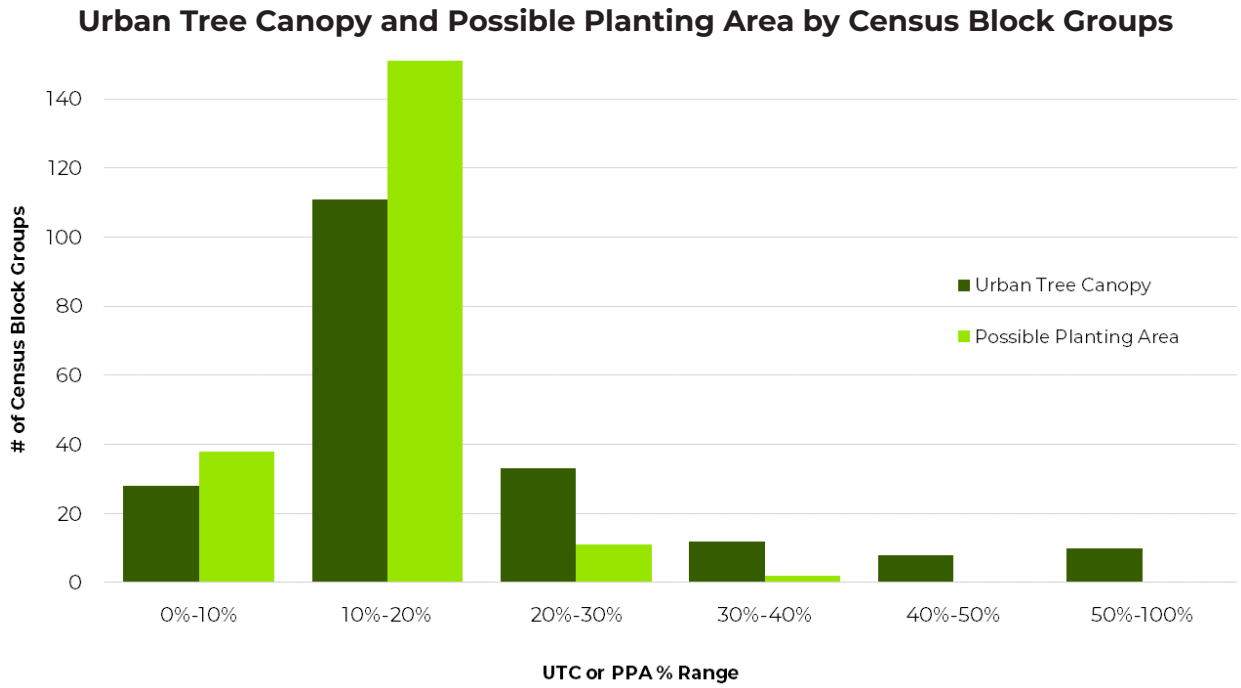


Figure 14. | Urban tree canopy and possible planting area in Tacoma by U.S. census block groups.

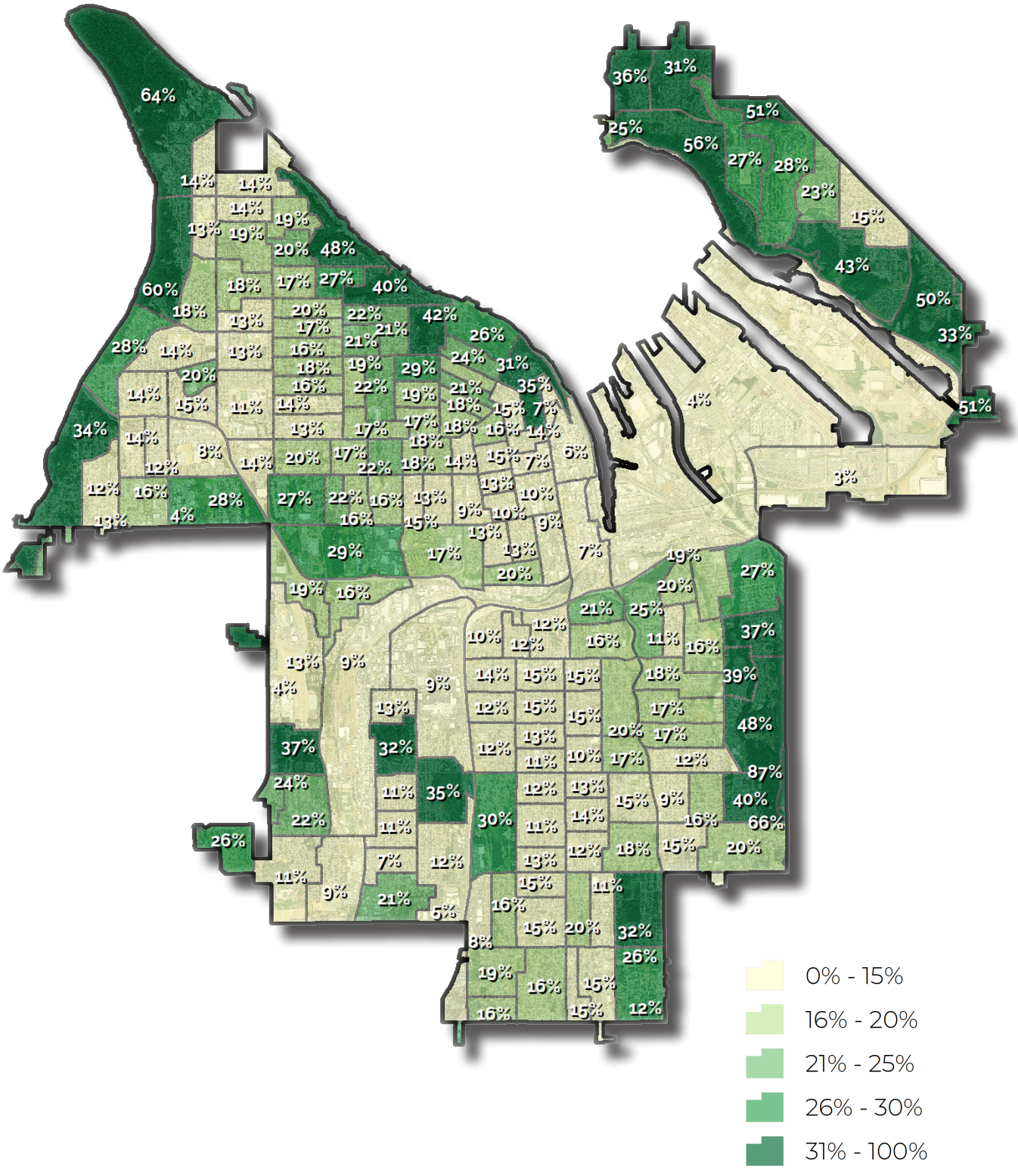


Figure 15. | Urban tree canopy in Tacoma by U.S. Census block groups.

RECOMMENDATIONS

An important step in preserving, protecting, and maintaining a city's valuable urban forest resource is to have a canopy assessment performed on a regular interval. The City of Tacoma has started this process by assessing their canopy in 2017. As the City continues to grow and change, they will be able to use these recommendations to ensure that their urban forest policies and management practices prioritize its maintenance, health, and growth. A nation-wide analysis conducted by USFS researchers stated that under ideal conditions, forested states such as Washington could achieve a canopy cover of 40-60 percent. With an existing canopy cover of 20 percent and PPA of 13 percent, Tacoma will need to be strategic with its future planning and development to ensure the sustained health of its trees if it hopes to meet this goal. The City can put these results to work to preserve, promote, and expand its tree canopy.

Over 200 acres of plantable space are found in Heavy Industrial areas

The results of this assessment 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 and refine canopy cover goals for the short- and long-term.

The City of Tacoma and its various stakeholders can utilize the results of the UTC and PPA analyses to identify the best locations to focus future tree planting and canopy expansion efforts. The City's canopy coverage varies throughout its entire area and breaking up the results by several different geographic boundaries demonstrated where the areas containing dense and sparse tree canopy are located. For example, Tacoma's Downtown Regional Growth Center land use had one of the lowest canopy covers in the city at 7 percent, whereas other land uses such as Single-Family Residential and Parks and Open Space had more than twice that. City should look to use planting opportunities in downtown areas where it is viable as trees will benefit a greater number of people in a densly populated area. However, a majority of Tacoma's planting opportunities are found outside of the downtown area, so the City should focus the majority of its efforts elsewhere. Parks and Open Spaces contained more than double the UTC percentage of the next highest land use category, but they also contained the highest PPA percentage of any land use. The City should take efforts to maintain or expand this concentration of UTC within its parks and open spaces by conducting field surveys of the plantable space available to determine actual suitability for new tree plantings. Also, Heavy Industrial areas contain over 200 acres of PPA. Trees planted in industrial areas have potential to make big impacts in these

areas through ecosystem services such as stormwater mitigation, air quality improvement, and localized cooling through shade.

SINGLE FAMILY RESIDENTIAL AREAS CONTIAN THE MOST POSSIBLE PLANTING AREA.

To maximize citywide canopy expansion, Tacoma's residential areas are a great place to prioritize as they cover the majority of the City's area and contain the vast majority of its PPA. The City should conduct public outreach in residential areas to engage residents interested in working together to improve the neighborhoods where they live. The Single Family Residential land use has below average existing UTC (17 percent) abut contains over half of all PPA throughout the city (57 percent), so existing tree maintenance and planting efforts should be evaluated to preserve and enhance tree canopy in these areas. The results by geographic area (such as census block groups) can also be overlaid with the land use layer to determine which residential areas have the greatest need.

Finally, Tacoma should integrate these data into its larger citywide planning efforts. While valuable, this assessment is only the first step in protecting, preserving, and expanding Tacoma's valuable urban forest resource. The City must establish set policies and guidelines for the preservation of tree canopy amidst future development and planning. The UTC data can assist implementation of the City Comprehensive Plan, VISION 2040, and environmental goals mentioned in Chapter 4, 'Enviornment + Watershed Health', of the One Tacoma Plan. Specifically, the City should take action to achieve its goal of 30 percent citywide tree canopy coverage by 2030 (30-by-30). Tacoma'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. The City should use these UTC and PPA metrics in combination with the results of the recent i-Tree Hydro analysis that was also performed in Tacoma to interpret where tree canopy gains would be 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.

The classification accuracy error matrix illustrated in Table A1 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 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. Seven hundred and thirty seven (737) sample points, or approximately 15 points per square mile area in Tacoma (49 sq. miles), were randomly distributed across the study area and assigned a random numeric value.
2. Each sample point was then referenced using the NAIP aerial photo 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.[1]

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 Tacoma's landscape. The error matrices shown in Table A1 represent the intersection of reference pixels manually identified by a human observer (columns) and classification 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

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.

reported in the matrix (142 + 90 + 383 + 81 + 3 = 699 / 737 = 95 percent), and the matrix can be used to calculate per class accuracy percent's. For example, 146 points were manually identified in the reference map as Tree Canopy, and 142 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: (142/146 = .97), meaning that we can expect that ~97 percent of all 2017 tree canopy in the Tacoma, 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, 142 classification pixels intersecting reference pixels were classified as Tree Canopy, but one pixel was identified as Vegetation in the reference map. Therefore, the User's Accuracy for Tree Canopy is calculated as: (142/145 = 0.98), meaning that ~98 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 Tacoma in 2017. The largest sources of classification confusion exist between tree canopy and vegetation.

Table A1. | Error matrix for land cover classifications in Tacoma, WA (2017).

Classification Data	Reference Data: Tree Canopy	Vegetation	Impervious	Soil / Dry Veg.	Water	Total Reference Pixels
Tree Canopy	142	2	1	0	0	145
Vegetation	1	90	2	3	1	97
Impervious	0	2	383	9	0	394
Soil / Dry Veg.	3	2	11	81	0	97
Water	0	0	1	0	3	4
Total	146	96	398	93	4	737

Overall Accuracy = 95%

Producer's Accuracy	
Tree Canopy	97%
Veg./ Open Space	94%
Impervious	96%
Bare Ground / Soil	87%
Water	0%

User's Accuracy	
Tree Canopy	98%
Veg./ Open Space	93%
Impervious	97%
Bare Ground / Soil	84%
Water	75%

ACCURACY ASSESSMENT RESULTS

Interpretation of the sample error matrix offers some important insights when evaluating Tacoma's urban tree canopy coverage and how land cover reported by the derived rasters and the human eye. The high accuracy of the 2017 data indicates that Tacoma's current tree canopy can be safely assumed to match the figures stated in this report (approximately 20 percent).

GLOSSARY/KEY TERMS

Land Acres: Total land area, in acres, of the assessment boundary (excludes water).

Non-Canopy Vegetation: Areas of grass and open space where tree canopy does not exist.

Possible Planting Area - Vegetation: Areas of grass and open space where tree canopy does not exist, and it is biophysically possible to plant trees.

Possible Planting Area - Impervious: Paved areas void of tree canopy, excluding buildings and roads, where it is biophysically possible to establish tree canopy. Examples include parking lots and sidewalks.

Possible Planting Area - Total: The combination of PPA Vegetation area and PPA Impervious area.

Shrub: Low-lying vegetation that was classified based on interpretation of shadows and texture in vegetation. Shrubs produce little to no shadow and appeared smooth in texture compared to tree canopy.

Soil/Dry Vegetation: Areas of bare soil and/or dried, dead vegetation.

Total Acres: Total area, in acres, of the assessment boundary.

Unsuitable Impervious: Areas of impervious surfaces that are not suitable for tree planting. These include buildings and roads.

Unsuitable Planting Area: Areas where it is not feasible to plant trees. Airports, ball fields, golf courses, etc. were manually defined as unsuitable planting areas.

Unsuitable Soil: Areas of soil/dry vegetation considered unsuitable for tree planting. Irrigation and other modifiers may be required to keep a tree alive in these areas.

Unsuitable Vegetation: Areas of non-canopy vegetation that are not suitable for tree planting due to their land use.

Urban Tree Canopy (UTC): The “layer of leaves, branches and stems that cover the ground” (Raciti et al., 2006) when viewed from above; the metric used to quantify the extent, function, and value of Tacoma’s urban forest. Tree canopy was generally taller than 10-15 feet tall.

Water: Areas of open, surface water not including swimming pools.

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DECEMBER | 2018

URBAN TREE CANOPY

ASSESSMENT

TACOMA, WASHINGTON

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SEAL OF THE CITY OF TACOMA 1884