2016 Seattle Tree Canopy Assessment

Executive Summary

Seattle has a long-standing commitment to its urban trees. Because of the many social, environmental, and economic benefits urban trees provide, they are essential to enhancing the community's quality of life, especially as Seattle grows.

The Urban Forest Stewardship Plan (UFSP), adopted by Council in 2013, has a goal to reach 30% tree canopy cover by 2037. The plan also outlines additional goals for a thriving urban forest that include a healthy diversity of tree species and ages as well as the importance of community participation in caring for and planting trees.

Measuring tree canopy

Tree canopy cover is the layer of branches, stems, and leaves of trees that cover the ground when viewed from above. Canopy cover assessments tell us the extent of Seattle's trees and where they are located; and help us inform urban forestry work planning, management, and investments.

There have been several tree canopy cover assessments in Seattle over the last decade, each using varying methodologies and yielding different results. **Due to the differing technologies and methodologies, results cannot be compared between studies.**

The 2016 LiDAR assessment

The City of Seattle obtained LiDAR (light detection and ranging) data in 2016 to assess progress towards achieving our 30% canopy cover goal. This study represents the most accurate accounting of Seattle's urban canopy to date and shows **Seattle has 28% canopy cover.**

The assessment provides the foundation for understanding the quantity, distribution, and configuration of tree canopy in Seattle. The true value of this study will be realized when the results are used to guide urban forestry policy and management efforts such as establishing localized canopy goals and targeted planting and conservation efforts to maximize limited resources.

The study focused on answering several research questions including: progress achieving Seattle's 30% canopy cover goal citywide, in each of the eight UFSP management units, and in each of the 27 street tree management units; canopy cover levels in Seattle neighborhoods and Equity and Environment Initiative focus areas; coniferous to deciduous tree ratio; location of the city's largest trees and tree groves; heat island effect hot spots; impacts from development; and volume of vegetative material that falls within the minimum 10ft clearance distances of SCL distribution and transmission systems. The results will be analyzed to inform urban forestry priorities and actions moving forward.

2016 LiDAR study findings

The study examined our research questions about Seattle's canopy cover to help inform future urban forestry work and actions. Notable findings include:

- The majority of our urban trees are found in two locations: residential areas (representing 67% of the land with 72% of Seattle's tree canopy), and in the right-of way which is interspersed throughout the city (representing 27% of the land and 22% of the canopy).
- Larger trees and tree groves are often present in parks but are also on residential and institutional lands.
- Canopy exceeds targets in developed parks, natural areas, multi-family, and institutional areas; is close to target in single-family, downtown, and commercial areas; and is below target in industrial areas.

- Canopy cover differs across the city based on land use, the presence of parks and natural areas, and socio-economic factors. Census tracts where the population tends to be residents of color and people with lower than average income also have lower amounts of tree canopy.
- 72% of Seattle's tree canopy is deciduous and 28% is coniferous. Most of the conifers are on single-family land (52%).
- The presence of trees can reduce urban heat island effect (surface temperature), especially inland, and mitigate extreme heat impacts.
- 6% of Seattle's tree canopy is within the clearance distance Seattle City Light maintains for safety and reliability of the power grid.

Impacts of development

In an effort to understand development impacts on Seattle's canopy, our consultant examined additional data using historical Google Earth imagery to do a mini-assessment of 80 random parcels that underwent development comparing before and after images.

Although not statistically valid, this exercise found parcels in the downtown, industrial, single- and multi-family areas saw canopy cover loss while commercial, institutional, and developed parks saw a gain after development (likely a result of retained trees maturing over time).

Canopy cover trend analysis

We had originally requested an analysis of canopy cover change over time comparing 2001 LiDAR to 2016 LiDAR. Unfortunately, the 2001 data, while cutting-edge at the time, is of such low resolution that is unsuitable for comparison to the 2016 data. To get the canopy cover trend we decided to use the i-Tree Canopy protocol, a sample-based approach using historical imagery from Google Earth, to compare canopy cover from 2007, 2010, and 2015. This approach found that Seattle had experienced approximately 2% canopy cover loss over the span of the eight year study period. This method has a +/- 3% margin of error and **canopy cover extent (coverage) is not comparable to the 2016 LiDAR assessment**.

Conclusion

Insights from this study will be used to update the Urban Forest Stewardship Plan and to revisit policies, goals, management efforts, and strategies to grow Seattle's urban forest. The table below shows some of the study findings by Urban Forest Stewardship Plan Management Unit.

Localized canopy goals and targeted planting and conservation efforts will help maximize limited resources. Now that we have a reliable baseline, it will be important to perform another LiDAR-based tree canopy assessment to determine changes to canopy cover over the next five years.

Management Unit	# of acres	Land area (% of city)	% canopy cover	% contribution to city's canopy cover	% conifer contribution
Single-Family Residential	29,918	56%	32%	63%	52%
Multi-family Residential	5,646	11%	23%	9%	5%
Commercial/Mixed-use	4,522	8%	14%	4%	2%
Downtown	815	1%	10%	<1%	0.2%
Industrial	6,191	11%	6%	2%	1.3%
Institutional	1,101	2%	25%	2%	2%
Developed Parks	2,578	4%	34%	6%	7.5%
Parks' Natural Areas	2,356	7%	89%	14%	30%

Introduction

Urban trees in Seattle are an important asset that provides many social, environmental, and economic benefits that enhance the quality of life for the community. Seattle's Urban Forest Stewardship Plan (UFSP), adopted by Council in 2013, has a goal to reach 30% tree canopy cover by 2037. The plan also outlines additional goals for a thriving forest that include a healthy diversity of tree species and ages.

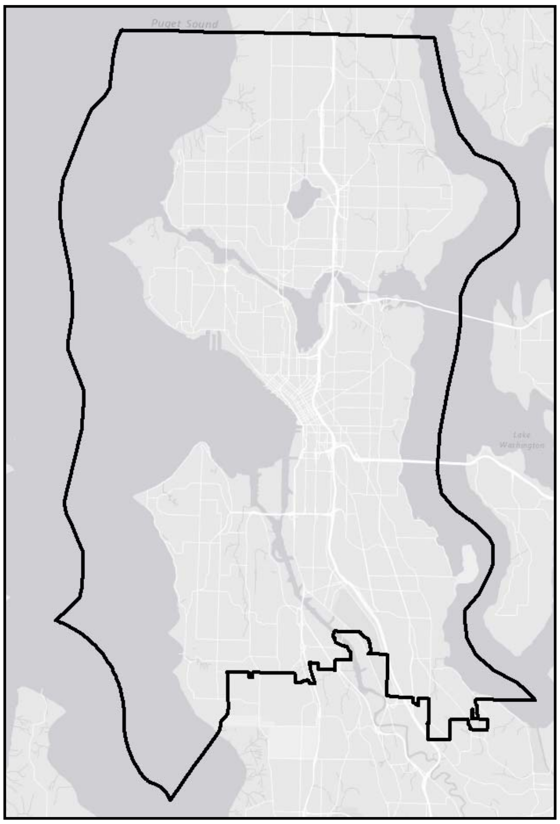

Figure 1. *Study area for this project, which is the full City of Seattle boundary.*

Canopy cover assessments are an important tool for tracking progress. For Seattle to effectively manage our tree canopy and enact policies, plans, and initiatives to help ensure a robust urban forest for generations to come, a comprehensive understanding of our tree canopy is vital.

The Seattle Office of Sustainability & Environment (OSE), commissioned this study to the University of Vermont Spatial Analysis Lab which includes some of the world's foremost experts in urban tree canopy mapping. Although tree canopy for Seattle has been mapped before, the 2016 LiDAR tree canopy assessment represents the most accurate accounting of tree canopy to date.

Many of the benefits urban trees provide are related to the size and structure of the tree canopy, which is the layer of branches, stems, and leaves of trees that cover the ground when viewed from above.

Why is Tree Canopy Important?

Understanding tree canopy is an important step in urban forestry planning. A tree canopy assessment provides an estimate of the amount of tree canopy currently present in a community, where the canopy is located, and the amount of tree canopy that could theoretically be established. The tree canopy assessment can be used by a broad range of stakeholders to help communities plan a greener future.

Project Partners

OSE in partnership with the Urban Forestry Team members (Seattle City Light, Seattle Department of Construction and Inspections, Seattle Department of Transportation, Seattle Parks and Recreation, and Seattle Public Utilities) led the effort to obtain 2016 LiDAR data to perform a canopy cover assessment for the City of Seattle in support of the UFSP goals. At OSE's request, the Spatial Analysis Laboratory analyzed the data to respond to project research questions using the USDA Forest Services' Tree Canopy Assessment protocols.

Figure 2. *Tree Canopy derived from high-resolution imagery and LiDAR.*

How was the Tree Canopy Mapped?

Tree canopy was assessed using the US Forest Service Urban Tree Canopy (UTC) Assessment protocols. Two distinct, complementary remotely sensed datasets were used to map Seattle's canopy: LiDAR (light detection and ranging), acquired under leaf-off conditions in 2016 (Figure 3A) and 2015 leaf-on imagery, obtained through the USDA National Agricultural Imagery Program (NAIP) (Figures 3B and 3C). While slightly less accurate than LiDAR, this imagery has the benefit of providing color information that is useful in separating vegetated from non-vegetated surfaces.

Tree canopy mapping was accomplished using a semi-automated approach in which trees' features were automatically extracted, then manually reviewed and edited at a scale of 1:2500. Any observable errors were corrected and incorporated into the final results. The UTC Assessment protocols are the accepted standard for mapping tree canopy and have been applied by the University of Vermont Spatial Lab to over 80 communities in North America. A formal accuracy assessment was not performed for the study, but similar studies have shows to have a margin of error of +/- 1%.

This 2016 tree canopy assessment represents the most accurate accounting of tree canopy ever done for Seattle, with trees as small as eight feet in height mapped (Figure 3D). Datasets are suitable for summarizing the area and percent area of tree canopy down to the individual property parcel level.

The 2016 LiDAR dataset will serve as the foundation for tracking tree canopy changes over time for the City of Seattle.

Previous projects have mapped Seattle's tree canopy, but as this project used a combination of superior source data and methodologies, any comparisons between the various studies are not valid. Of particular note is the fact that prior canopy cover estimates should not be used to draw conclusions with respect to changes in tree canopy over time.

Figure 3. *Example of the input data used to extract tree canopy data. LiDAR is on the left, true color imagery, CIR Imagery, and then tree canopy data on the right.*

How is Tree Canopy Calculated?

Tree canopy metrics are generated by the USDA Forest Service's tree canopy metrics tool (Figure 4). This tool takes property parcels and Census tracts and computes the amount of Existing Tree Canopy and Possible Tree Canopy in each geography.

Existing Tree Canopy is the amount of tree canopy that currently exists based on 2016 conditions. It is computed by dividing the amount of tree canopy in each geographic unit by the land area. Possible Tree Canopy is the amount of land that is theoretically available for the establishment of new tree canopy. It is important to note that just because land is available for establishing new tree canopy it does not mean that it would be either socially desirable nor financially feasible to establish tree canopy on such areas.

Figure 5 shows an example of the Tree Canopy metrics computed at the property parcel level. The parcel boundaries (top, black lines) represent the geographic units. The Existing Tree Canopy (middle) is the relative percentage of tree canopy in each parcel. Possible Tree Canopy (bottom) indicates the relative percentage of land in each parcel that is theoretically available for the establishment of new tree canopy.

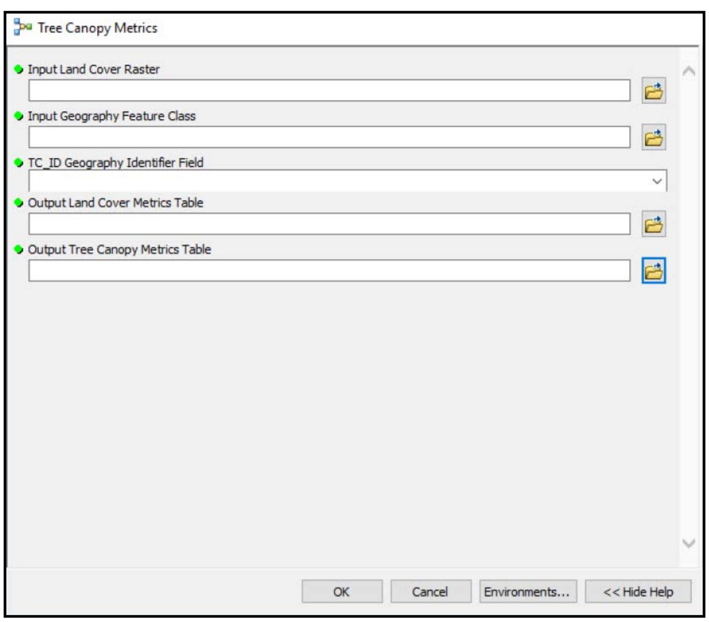

Figure 4. *Graphical user interface for the tree canopy metrics tool. The tree canopy metrics tool is an ArcGIS-based geoprocessing model that summarizes tree canopy information based on the input polygon boundaries*

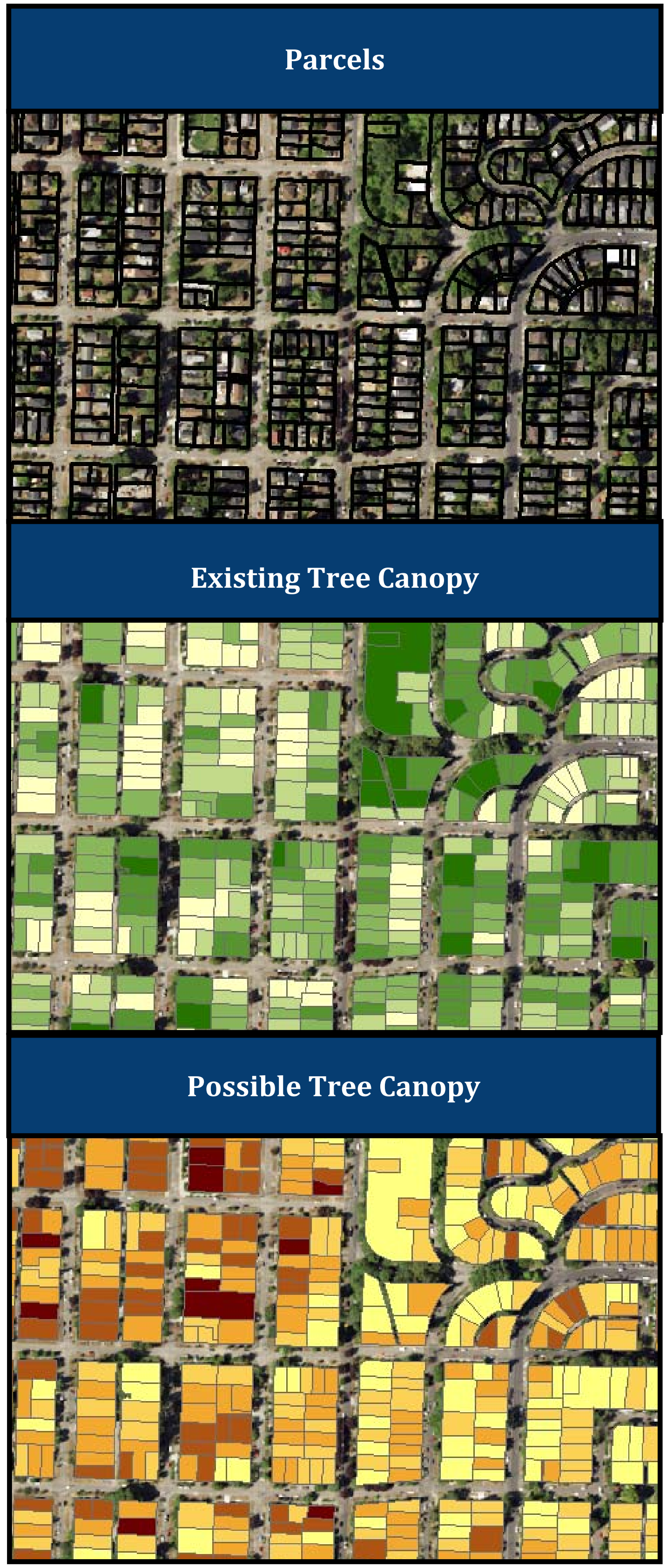

Figure 5. *Parcel-based tree canopy metrics.*

What is our Progress on Achieving 30% Tree Canopy Cover?

Methods

Tree canopy is computed by mapping all land cover then dividing the amount of tree canopy by the amount of land. Excluding water gives a more meaningful percentage that can be compared to other cities.

91,776 acres
Total area of the city (includes water)

38,271 acres
Area of water within the city boundary

15,167 acres
Total area of tree canopy

Results

28%

28% of Seattle's land is covered by tree canopy

91,776 - 38,271 = 53,505 this is the total land area without water
15,167/ 53,505 = 28% dividing the tree canopy area into the land area gives us the percent tree canopy cover

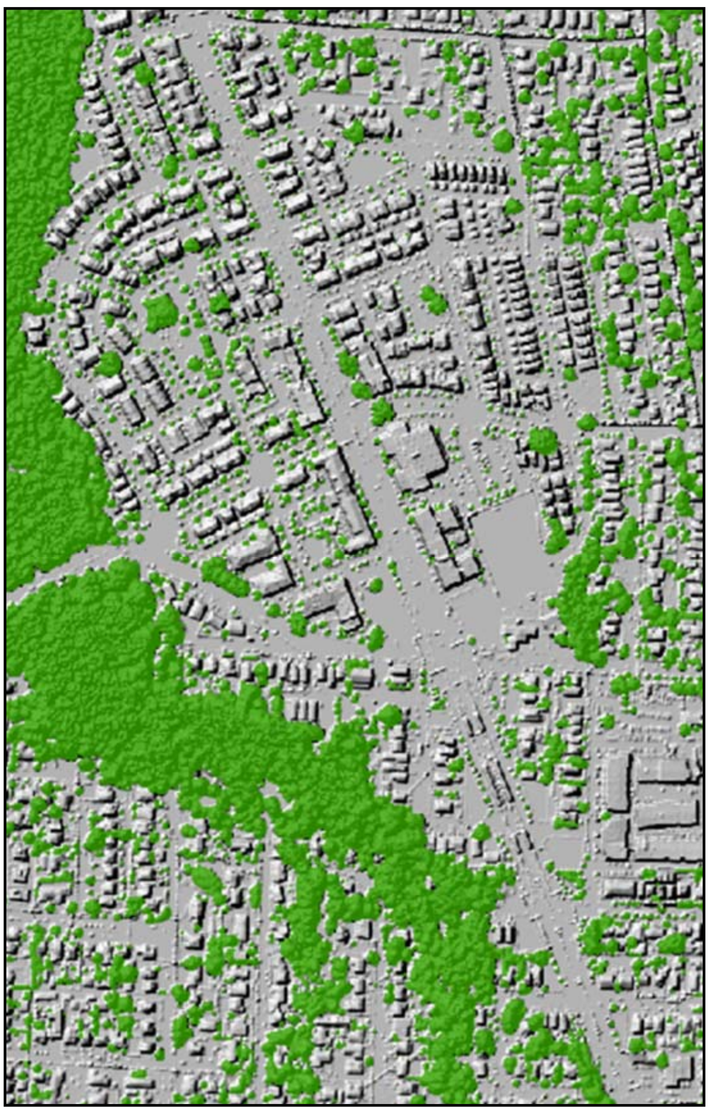

Figure 6. *Tree Canopy derived from high-resolution imagery and LiDAR.*

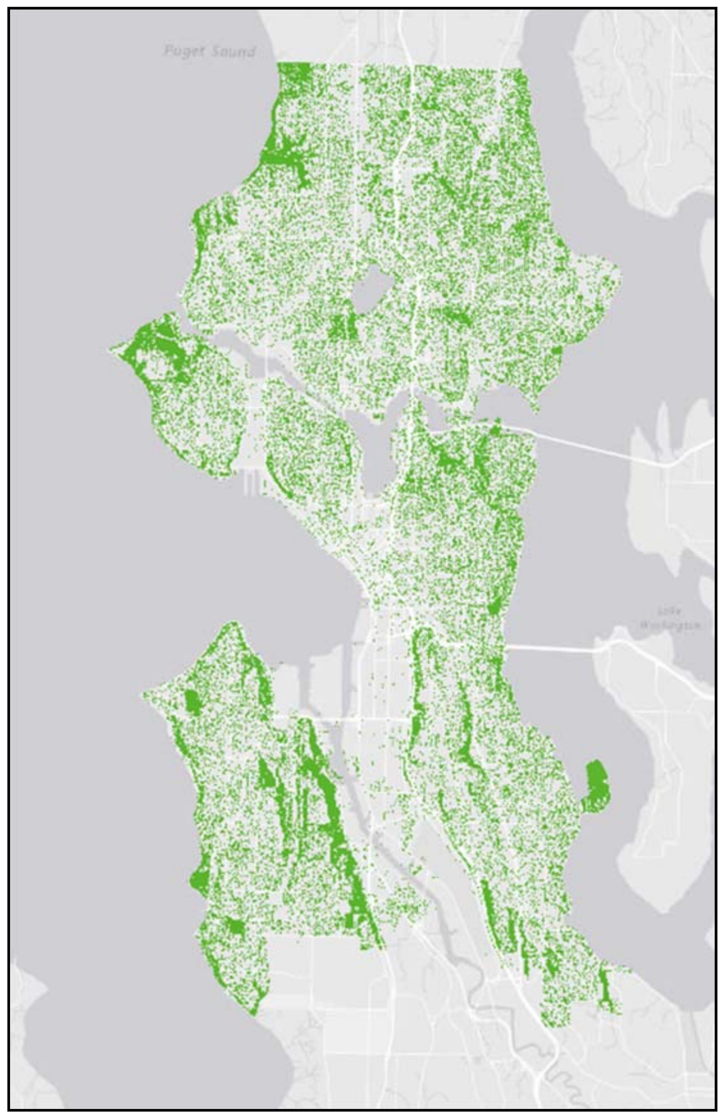

Figure 7. *Tree Canopy at the city-scale derived from high-resolution imagery and LiDAR*

What is our Progress on Achieving Canopy Cover Targets on the Urban Forest Stewardship Plan Management Units?

Methods

Because of the differences between developed property, streetscapes, parklands, remnant forests, and other areas, Seattle's urban forest cannot be viewed as a single unit for management purposes. The UFSP defines eight management units (MUs) that cover all the land types in the city. Using these land-use types allows for easy coordination of GIS mapping layers and for related planning initiatives. The units include eight distinct areas that were selected based upon physical characteristics. A ninth MU, the right-of-way, overlays the eight units so is not a separate land area.

Canopy cover is a major indicator of the breadth of the urban forest and its overall health and vitality. To determine the canopy cover of each MU, their individual land area was determined and the tree canopy percent in each MU was calculated. Tree canopy was computed both in terms of total area and as a percentage of the land area within each MU.

Results

Table 1 identifies the percentage of the city's landmass, current canopy cover, targets by MU, as well as each MU's contribution to the city's overall canopy cover. Figure 8 shows MUs contribution to overall canopy cover.

Canopy cover exceeds targets in Developed Parks, Parks' Natural Areas, Multif-family Residential, and Institutional management units; is close to target in the Single-family Residential, Downtown, and Commercial/Mixed-use management units; and is below target in the Industrial management unit.

The majority of our urban trees reside in two locations: residential areas (representing 67% of the land and housing 72% of Seattle's tree canopy), and in the Right-of-way (ROW), which represents 27% of the land that is interspersed throughout all Management Units, and houses 22% of the canopy.

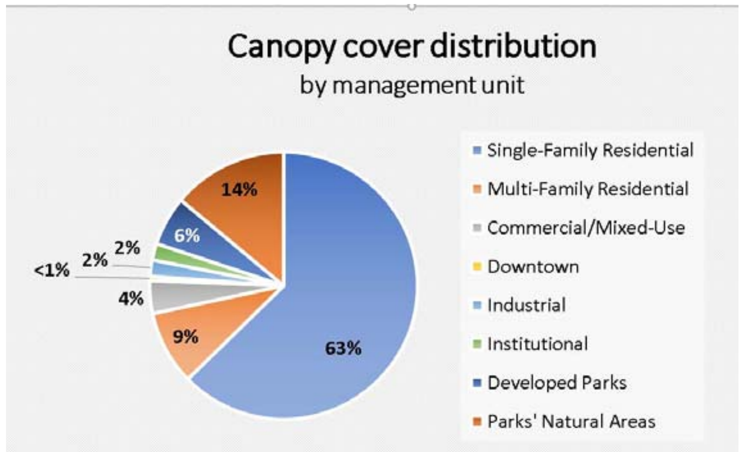

Figure 8. *Contribution to the city's overall canopy cover by Management Unit.*

Management Unit	Land area (% of city)	2016 canopy cover	2037 canopy goal (set in 2007)	% contribution to city's canopy cover
Single-Family Residential	56%	32%	33%	63%
Multi-family Residential	11%	23%	20%	9%
Commercial/Mixed-use	8%	14%	15%	4%
Downtown	1%	10%	12%	<1%
Industrial	11%	6%	10%	2%
Institutional	2%	25%	20%	2%
Developed Parks	4%	34%	25%	6%
Parks' Natural Areas	7%	89%	80%	14%
City total	100%	28%	30%	100%
Right-of-way (runs through all other MUs)	27%	23%	24%	22%

Table 1. *Percentage of city's landmass,, current canopy cover, targets by MU and MU contribution to city's canopy cover*

What is the Canopy Cover in Different Areas of Seattle?

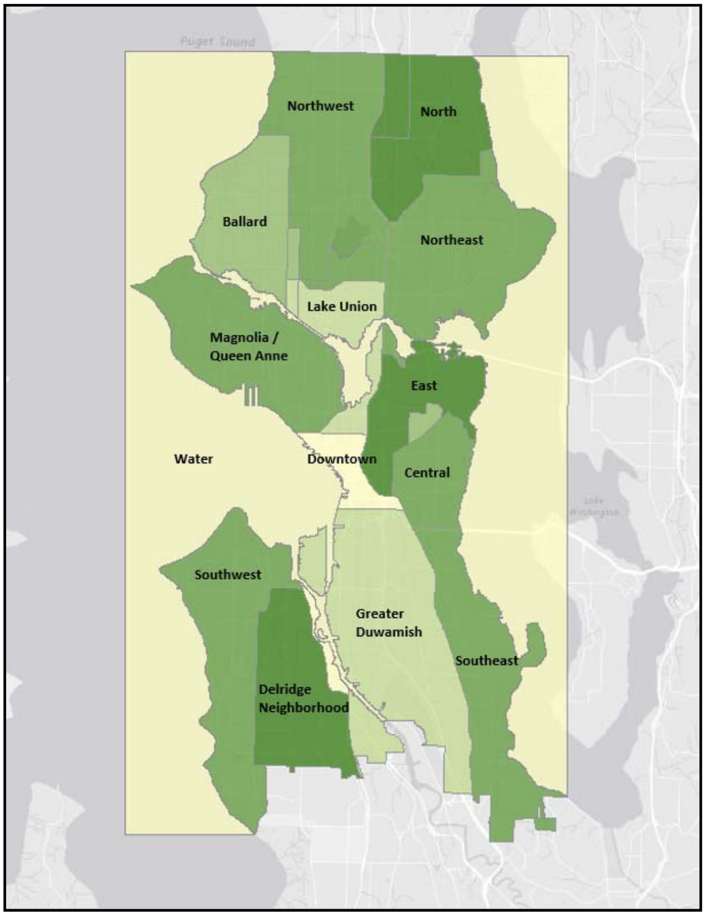

Figure 9. *Map of existing tree canopy for each of Seattle's neighborhoods.*

Methods

The amount of Existing Tree Canopy was computed for thirteen neighborhoods, whose boundaries do not precisely align with the actual land area. This results in the "water" neighborhood having a small amount of tree canopy due to the presence of trees along the water's edge.

Results

The amount of tree canopy in each area is reflective of land use and urbanization, with industrial areas and the urban core having the least amount of tree canopy (Figure 9). Downtown has 10% canopy cover, mostly in the ROW. Greater Duwamish, the most heavily industrial area, has 15% canopy cover. Delridge, with its large patches of connected tree canopy is above the city average with 38% canopy cover. The North neighborhood has a robust amount of tree canopy within its residential areas (35%). The Central, East, Northeast, Northwest, Southeast, and Southwest neighborhoods all have at least 30% canopy cover. This can largely be traced to robust tree canopy of residential lands coupled with larger expanses of tree canopy in parks, the ROW, and other protected areas (Figure 10).

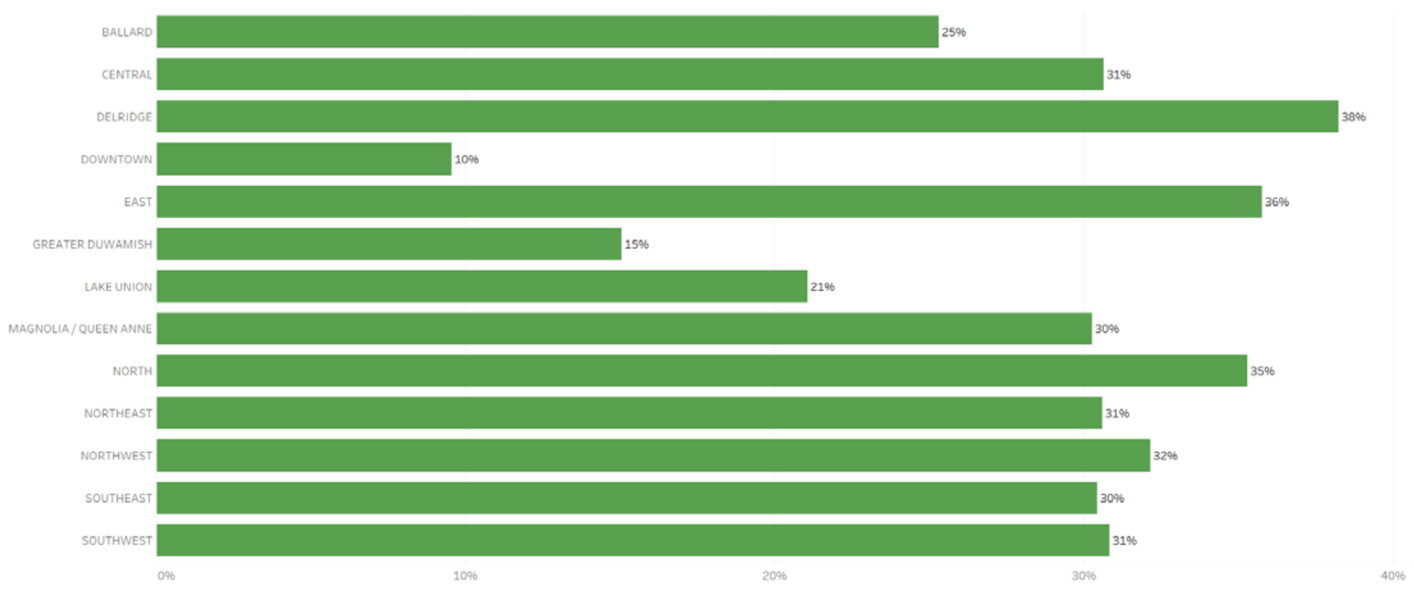

Figure 10 *Percent of neighborhoods' land that is covered by tree canopy.*

What are the Canopy Cover levels in SDOT's Street Tree Management Units and the Right-of-Way?

Methods

The Seattle Department of Transportation (SDOT) is inventorying street trees as part of the Street Tree Management Plan. SDOT divided the city into 27 Street Tree Management Units. Having clear geographic boundaries supports establishment and tracking of performance measures. Inventory data will inform tree maintenance and replacement efforts and will help balance resources more equitably.

Canopy cover was calculated for each unit and further subdivided into whether or not it fell within the ROW. It is important to note that a limitation of LiDAR analysis is that the location of the tree stem can be obscured due to the top down nature of the technology, making the analysis of trees within the ROW less precise.

Results

The amount of tree canopy in each SDOT Street Tree Management Unit, along with the proportion of the tree canopy that falls within the ROW, differ substantially from unit to unit (Figures 11 and 12). Unit 18 has the highest percent of tree canopy at 39%, with 15% being in the ROW. At the low end, Unit 27 has the lowest tree canopy at 10% with the 70% of the canopy being in the ROW.

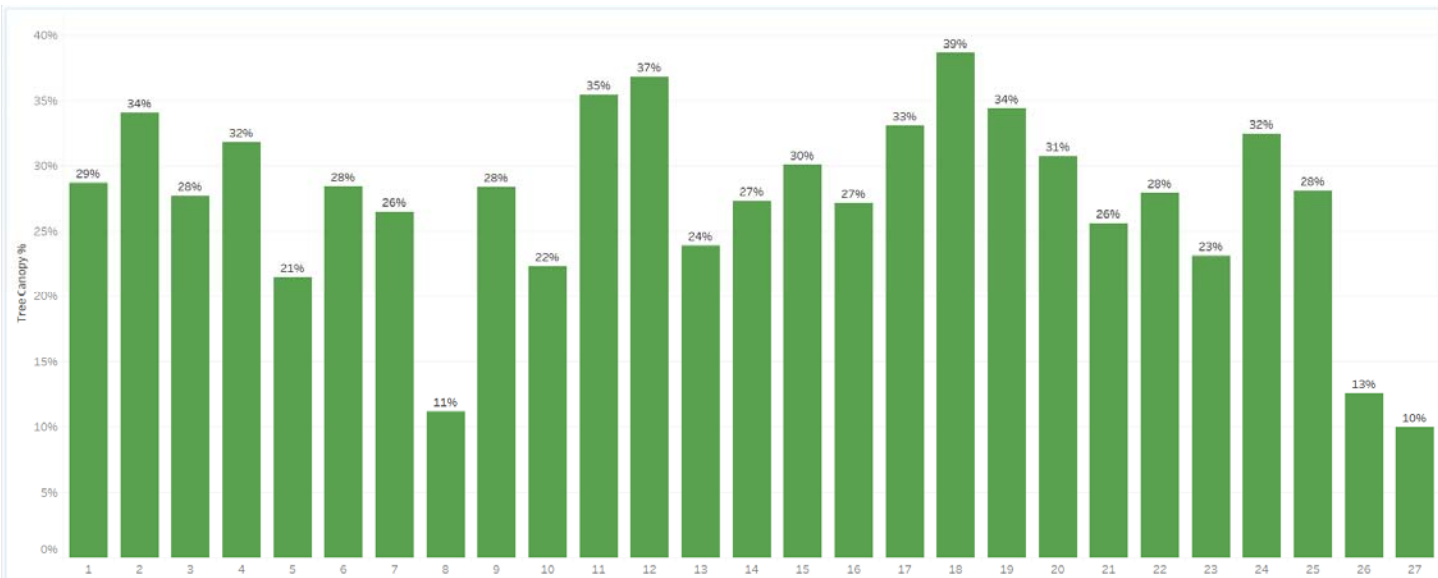

Figure 11. *Percent of existing tree canopy for each of the SDOT's 27 street tree management units.*

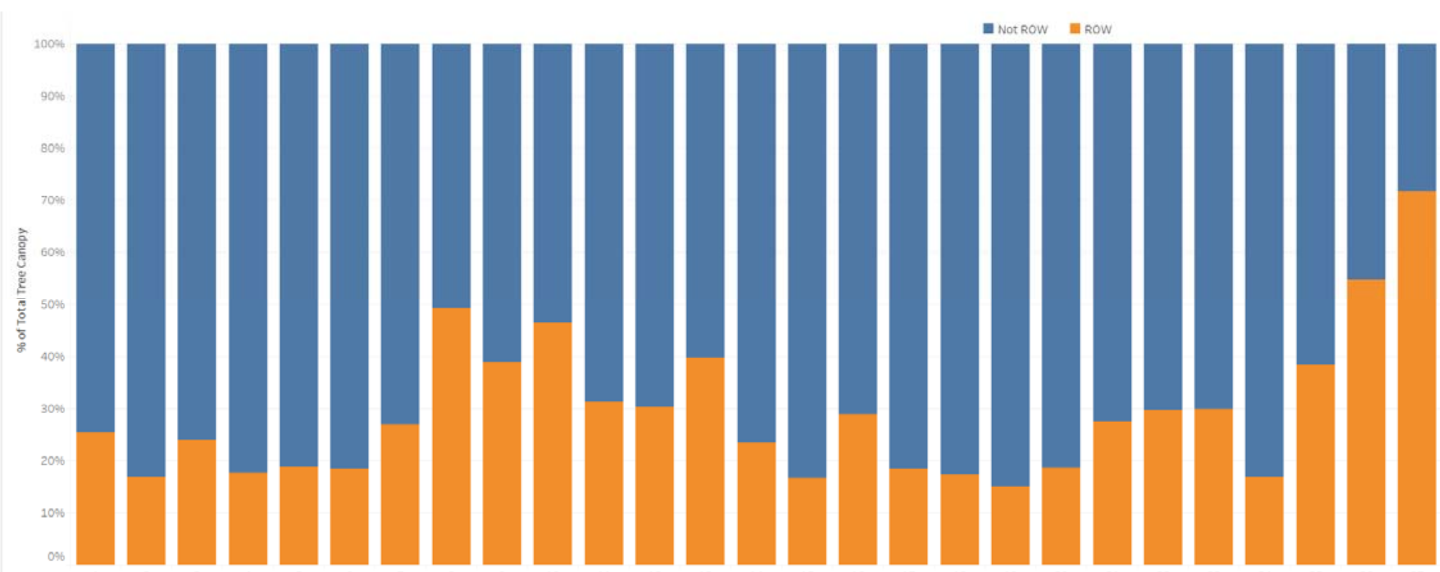

Figure 12. *Percent of tree canopy as ROW or Not ROW in relation to each of the SDOT's 27 street tree management units.*

What is the Relationship Between Tree Canopy and Environmental Equity?

Methods

In 2015, Mayor Ed Murray launched the Equity and Environment Initiative (EEI) to deepen Seattle's commitment to race and social justice in environmental work also creating the Environmental Action Agenda (EEA). The EEA is a series of community-developed goals and strategies that address environmental inequities and create opportunities for communities of color, refugees, people with low incomes, and limited English proficiency individuals to become leaders in Seattle's environmental movement.

Two environmental equity measures were selected for analysis: people of color and people within 200% of the poverty level. These two factors were analyzed, mapped, and graphed alongside tree canopy. It should be noted that although demographic factors may be correlated with tree canopy, these correlations do not necessarily equal causation.

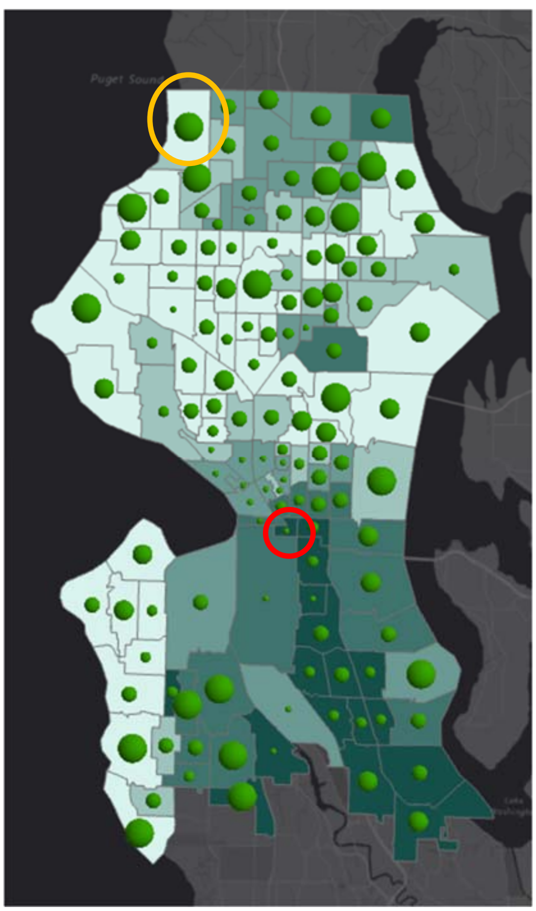

Figure 13. Map of percent people of color and percent tree canopy for each Census tract.

Results

There is a statistically significant inverse relationship between tree canopy and both people of color and people within 200% of the poverty level. The analysis found that in Census tracts with lower amounts of tree canopy more of the population tends to be people of color and have lower incomes. In census tracts with high numbers of people of color, tree canopy is as low as 11% while in areas with not many people of color there is 55% canopy cover (Figure 14). It is important to note that although there is a general inverse relationship, there are numerous exceptions. Some locations within Seattle that have the highest concentrations of people of color and residents under 200% of the poverty level have a relatively high percentage of tree canopy due to the presence of parks and street trees.

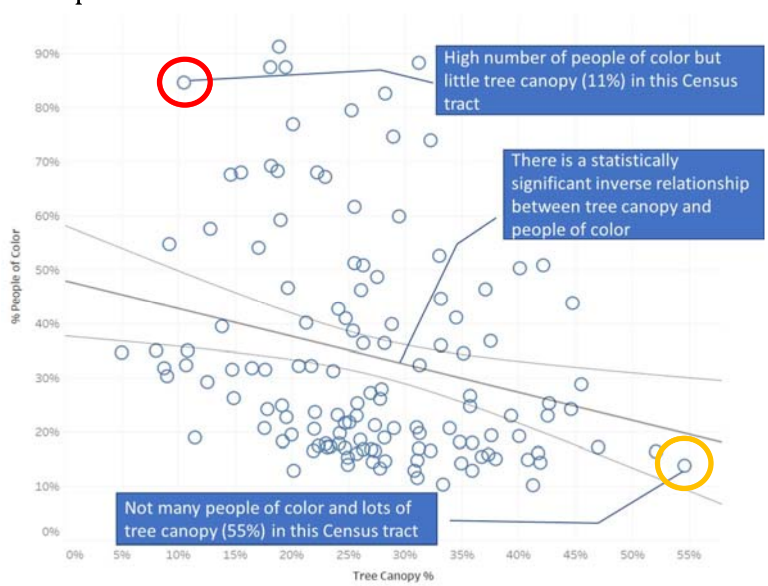

Figure 14. Figure describing percent tree canopy in relation to people of color. Each dot represents an EEA polygon.

The analysis found that in Census tracts with lower amounts of tree canopy more of the population tends to be people of color and have lower incomes.

What is the Deciduous to Coniferous Tree Ratio Citywide, by Management Unit, and the Right-of-Way?

Methods

Coniferous trees provide greater environmental benefits because they tend to maintain their canopy year-round, including during the rainy season, helping slow down and reduce storm water run-off. They also absorb more carbon dioxide and air pollutants. A challenge conifers present is that due to their longer life spans, they tend to achieve greater size rending them not viable in many locations. Home owners are often reluctant to plant conifers in their yards and they are not always a good fit for street trees.

To calculate the deciduous to coniferous tree ratio, tree canopy was separated into approximate individual tree canopies using a tree canopy segmentation routine developed for this project. Each tree canopy shape was then classified as either deciduous or coniferous based on its morphological properties in the LiDAR data.

Conifers tend to be conical in shape, while deciduous species, more rounded. The optimal method of separating out evergreen species is to use a combination of LiDAR and leaf-off imagery, but no such imagery was available to be used in the project. The project team decided to account for coniferous as a proxy for evergreen species. The deciduous/coniferous breakdown was then summarized for each Management Unit and then based on whether or not the canopy was inside or outside of the ROW.

Results

Citywide, 72% of trees are deciduous and 28% are coniferous. 17% of the conifers are in the ROW. Parks' Natural Areas is the only management unit with a majority of conifers (60%). Downtown had the lowest percent of coniferous trees at only 10%, which demonstrates the challenge we face accommodating conifers in the right-of-way.

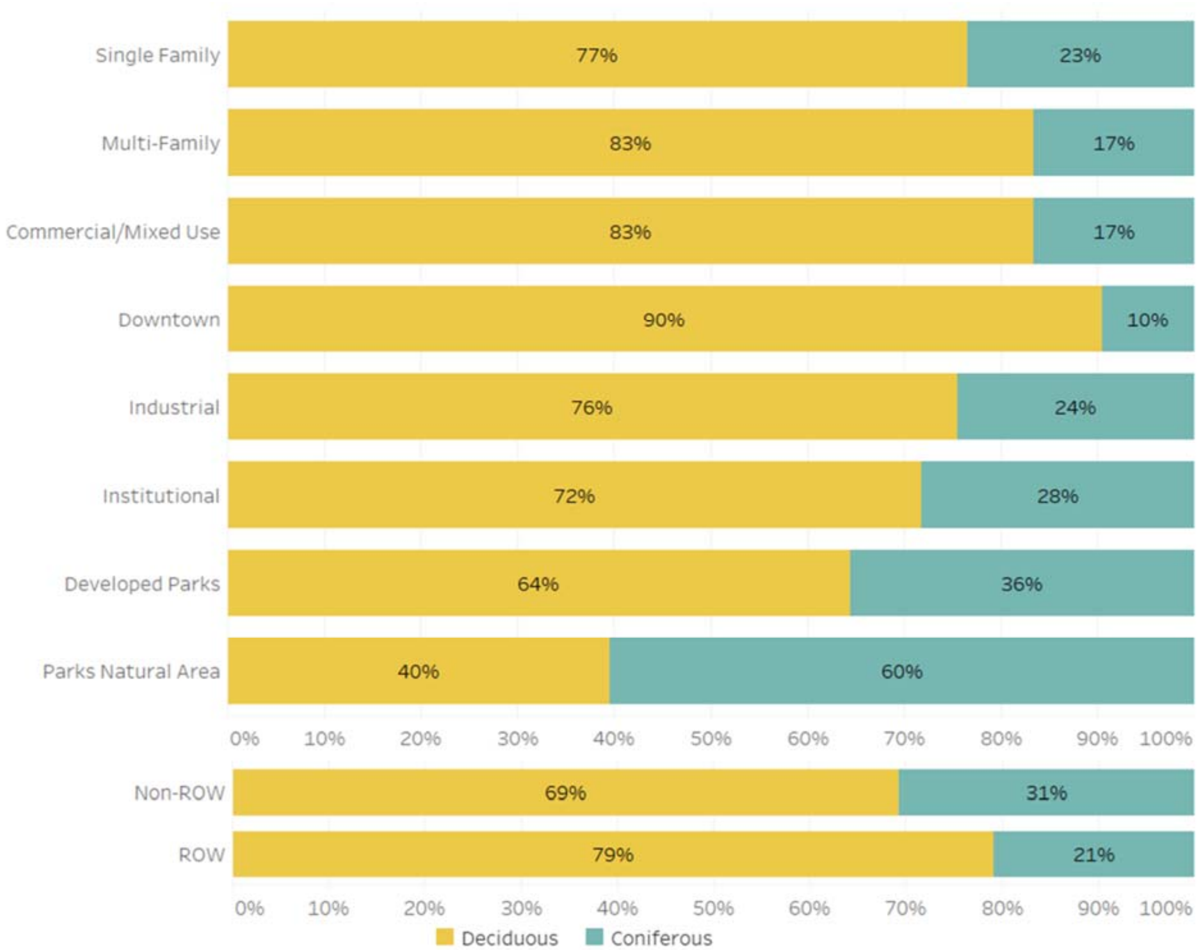

Figure 15. *Percent of deciduous to coniferous tree ratio by each UFSP Management Unit*

Where are the Largest Trees and Tree Groves Located?

Methods

The project team defined large trees and tree groves based on diameter at breast height (DBH). For the purpose of this study, large trees must have at least a 30-inch DBH and tree groves have to contain a minimum of eight trees, each with a 12-inch minimum DBH and forming a contiguous canopy (excluding street trees). As DBH cannot be directly measured from overhead remote sensing data, we used height information from the LiDAR dataset as a proxy based on equations developed by Jenkins et al (2003).

Results

Seattle is estimated to have 6,338 large trees (Figure 17) and 3,188 tree groves (Figure 18). Not surprisingly, the large trees and tree groves are often present in parks and other forested areas throughout the city. Although the large trees and tree groves are largely absent from the most urbanized areas some do exist on residential and institutional lands.

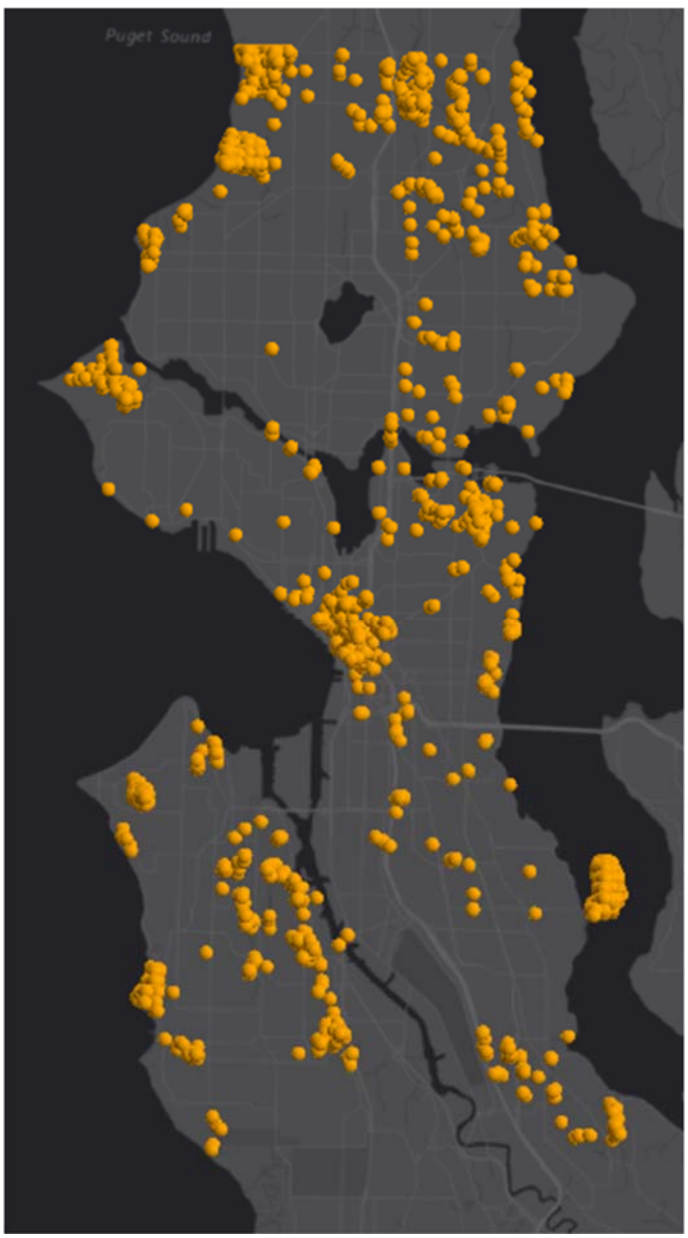

Figure 16. *Locations of the largest trees at the city scale.*

Figure 17. *Locations of tree groves at the city scale.*

How has Seattle's Canopy Cover Changed since 2007?

Methods

Mapping tree canopy change over time requires consistent, high-quality data, without which it is not possible to determine if the resulting trend is due to actual canopy change or due to anomalies in the source data. The original study scope included comparing 2001 LiDAR with 2016 LiDAR to determine canopy cover change over time. Unfortunately, the 2001 dataset, while considered cutting-edge technology at the time, is of very low resolution which prevented reliable comparison to the new, higher-quality data from 2016.

However, in 2015, OSE commissioned an analysis using USDA Forest Service i-Tree Canopy protocols, which consist of a sample-based approach that estimates canopy by determining the presence/absence of tree canopy at a given location using aerial or satellite imagery. The amount of change was determined through the manual interpretation of 4,000 stratified random points generated for three years: 2007, 2010 and 2015.

Results

The 2015 analysis estimated a 2% loss over the span of the eight-year study period with a +/- 3% margin of error (Figure 18). The 2016 LiDAR dataset will serve as the foundation for tracking tree canopy changes over time for the City of Seattle moving forward.

A number of factors could cause differences in canopy estimates including limitations of using a sample-based approach and that historical imagery from Google Earth is not collected at the same time of day, causing shifts of tree canopy location.

Tree canopy loss could initially be caused by increase of impervious surface due to development. Natural growth of mature trees and tree plantings tend to offset canopy loss.

The differences in the 2015 approach and the 2016 LiDAR makes the studies' results not directly comparable to one another. Prior estimates of tree canopy should not be used to draw conclusions with respect to changes in tree canopy over time.

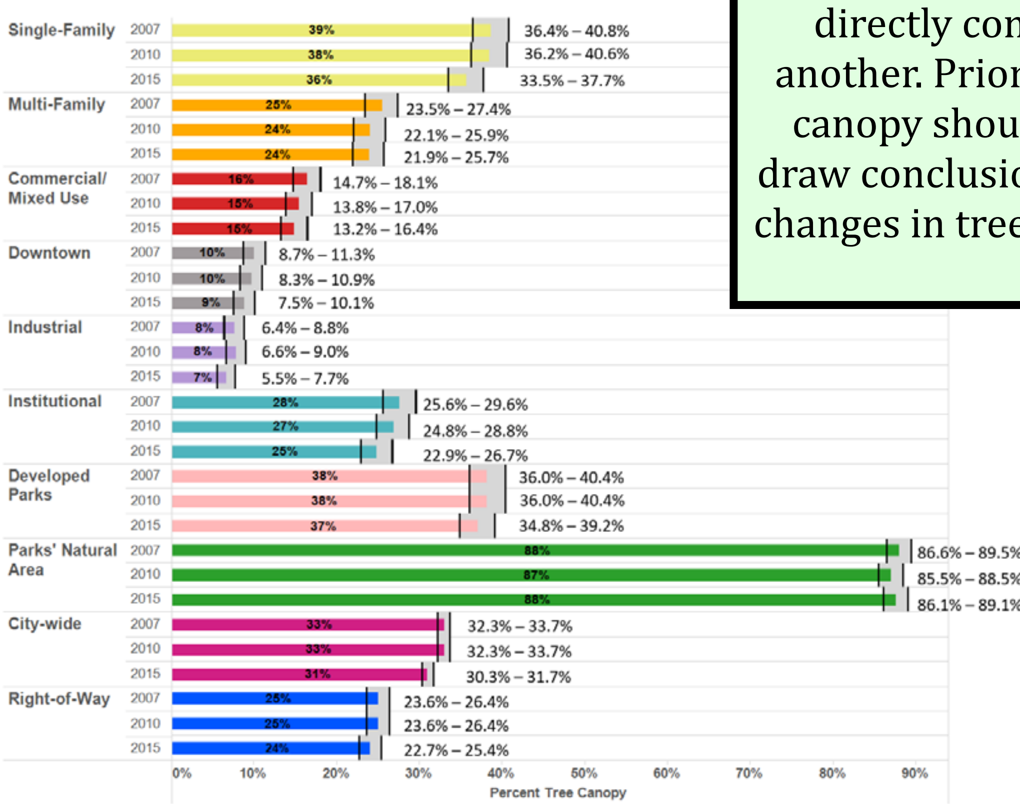

Figure 18. *Percent tree canopy cover for each UFSP Management Unit in 2007, 2010 and 2015. The gray area represents the standard error.*

What Impact can Development Have on Tree Canopy?

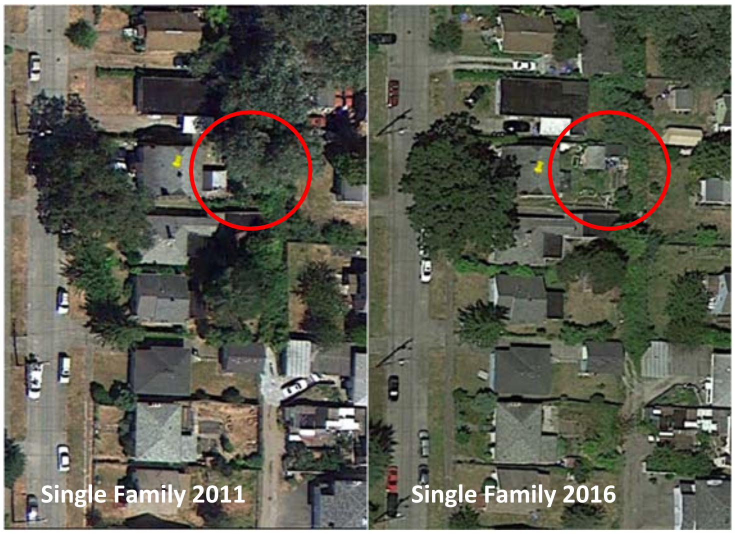

Figure 19. *Example of the impacts of development in a single family management unit parcel. The left image is from 2011 and the right is 2016.*

Methods

Development impact on tree canopy was explored by randomly selecting 10 development points from each UFSP Management Unit totaling 80 points. Using 2007-2017 historical imagery from Google Earth, tree canopy was mapped by parcel for before and after development (Figure 19). Percent tree canopy was calculated by dividing the total area of tree canopy by the total area of the parcels.

Results

Although this piece is not statistically valid, it is a detailed analysis of how development impacted tree canopy at each identified point and provides general insights into how development can impact canopy cover over time.. Downtown and Single Family had the most tree canopy loss. (Figure 20).

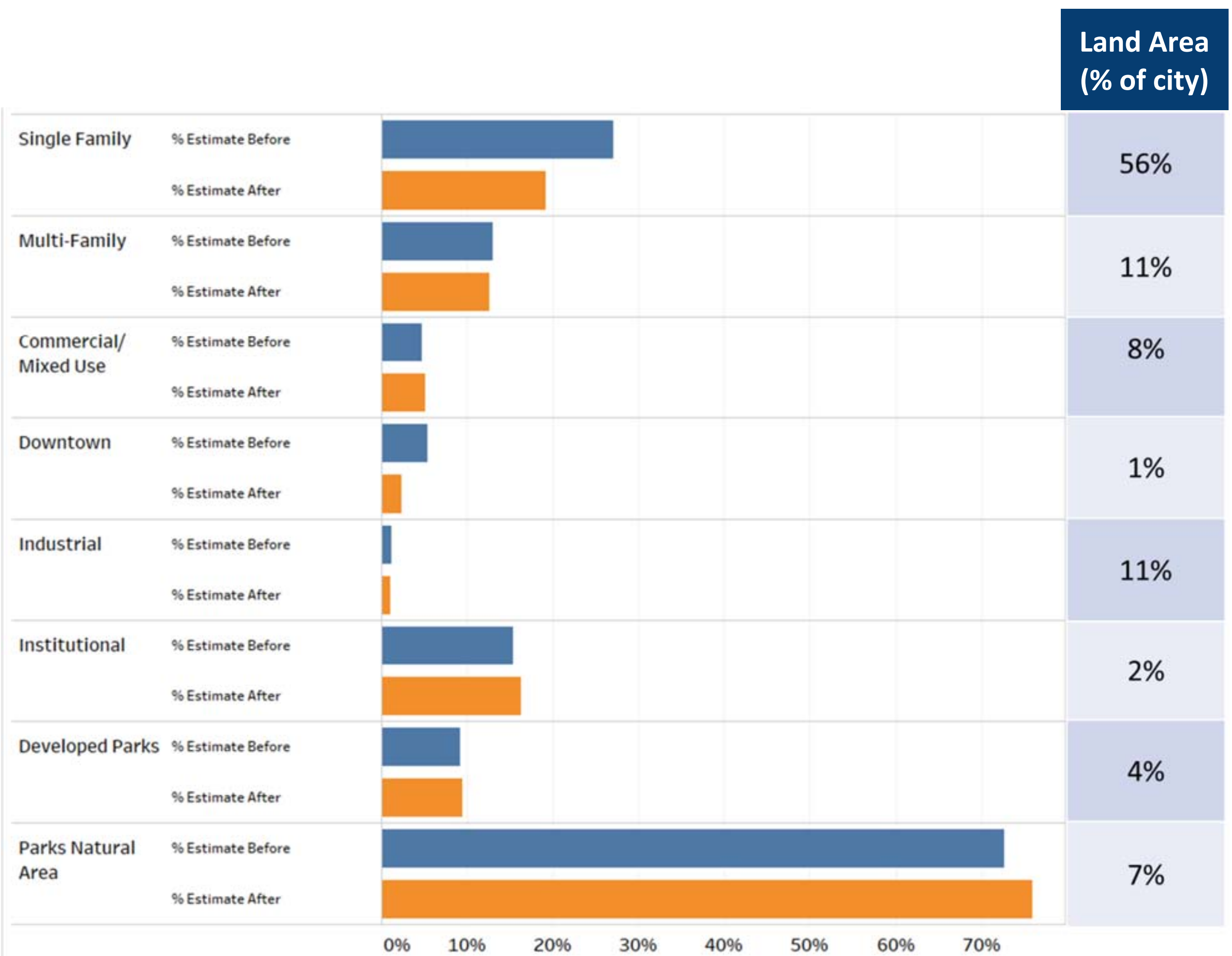

Figure 20. *Percent tree canopy cover for each management unit before and after development occurred.*

How does Tree Canopy Reduce the Urban Heat Island Effect?

Methods

The urban heat island effect is produced by dense concentrations of buildings, pavement, and other surfaces that absorb and retain heat. This increases air pollution, costs related to air conditioning, and heat-related health conditions disproportionally impacting vulnerable populations. Tree canopy helps reduce heat island effect mitigating impacts.

Surface temperature obtained from Landsat 8 satellite thermal imagery collected on September 20, 2016 was used to estimate the urban heat island effect. Landsat 8 senses thermal energy at a resolution of 60-meters. Surface temperature was integrated with the 2016 LiDAR tree canopy data to analyze how the presence of tree canopy affects the urban heat island.

Results

Determining the urban heat island in Seattle is challenging given that much of the city is surrounded by water, which dampens the urban heat island effect. Nevertheless, in the inland areas trees clearly help reduce surface temperature, thereby reducing the urban heat island.

This study produced GIS shapefiles for existing tree canopy, thermal imagery, and possible tree canopy (Figure 21) that can be used to identify tree planting locations to minimize the impacts of urban heat island hot spots by reducing surface temperatures, as well as to prioritize tree planting efforts to mitigate equity issues.

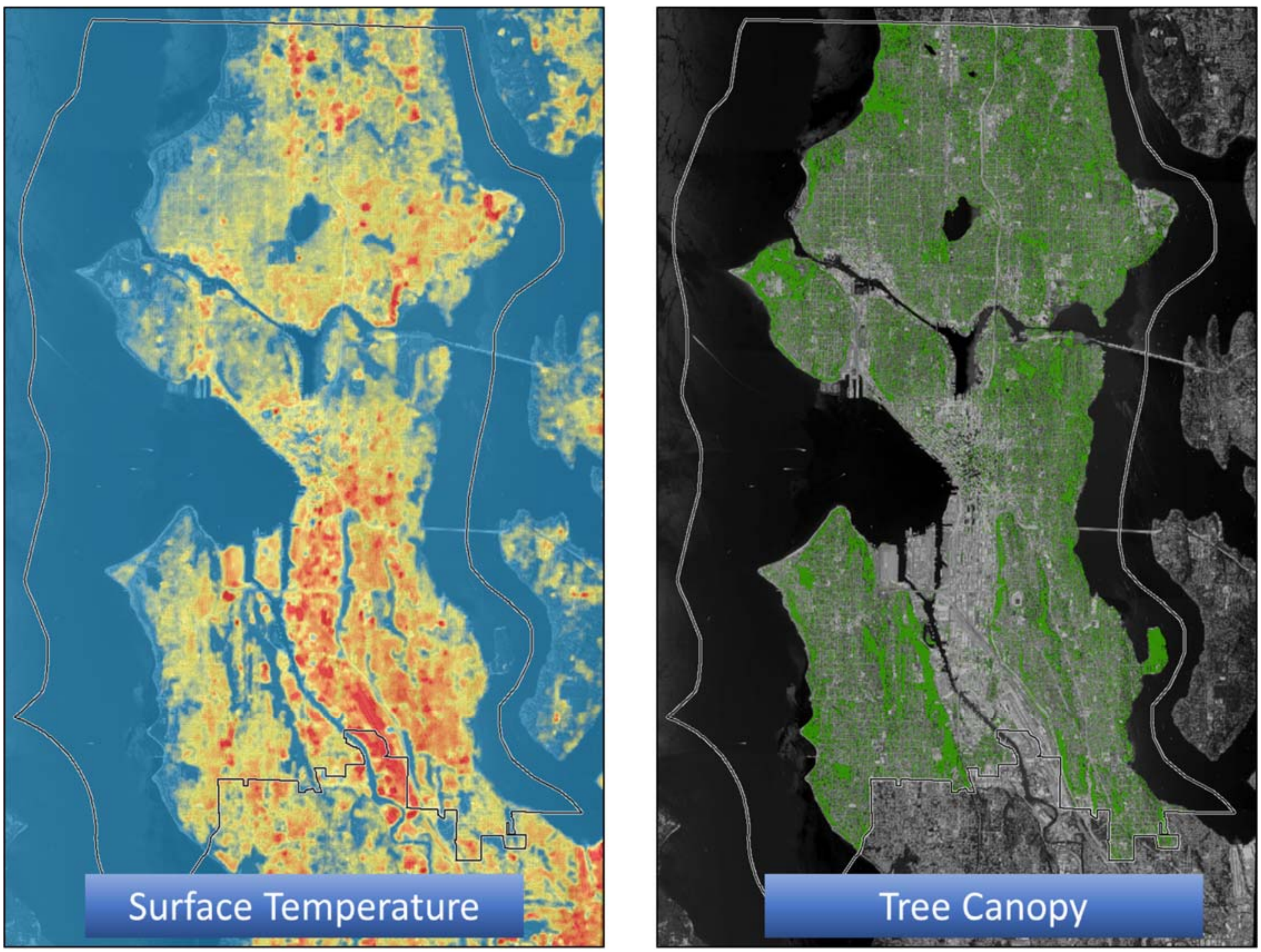

Figure 21. *Seattle's urban heat island hot spots correspond to low tree canopy areas..*

What is the Volume of Tree Canopy that Intersects the Minimum 10ft Clearance Distances for SCL's Electrical System?

Methods

Seattle City Light maintains vegetation clearances (pruning trees away from power lines) for safety and electrical service system reliability. SCL maintains clearances in accordance with utility best management practices and tree-industry standards.

To isolate canopy that intersects SCL's electrical infrastructure, a 10-foot buffer was created around all primary and secondary distribution lines, transmission support structures, and 115kV-

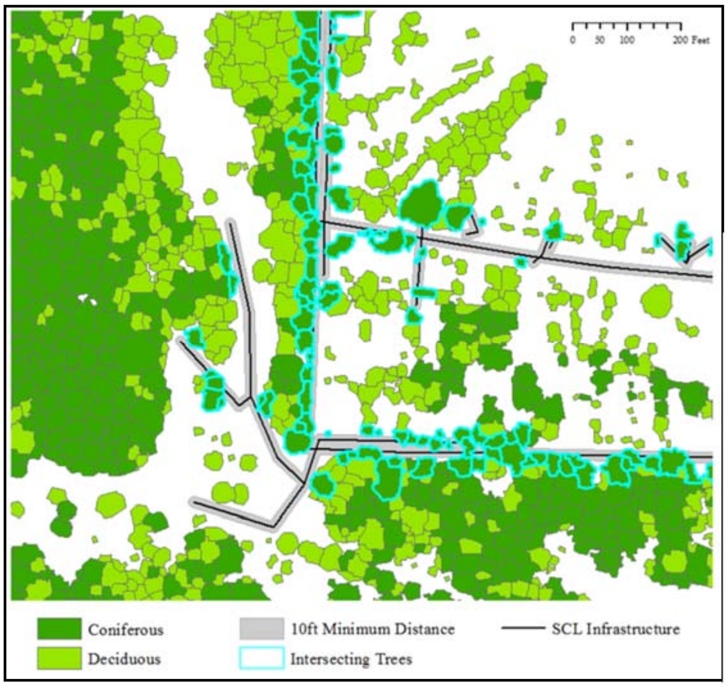

Figure 22. *Coniferous and deciduous trees intersecting the 10ft minimum distance of SCL infrastructure.*

230kV overhead wires (Figure 22).
Biomass equations from Jenkins et al. (2003), were used to compute volume. The biomass equations requires a consideration of tree diameter at breast height (DBH) and species. As DBH was not available, height was used as proxy. Averages were obtained for the most common coniferous and deciduous species: black cottonwood, red alder, western red cedar, Douglas Fir, bigleaf maple, Scouler's willow, western hemlock, and beaked hazelnut. Densities were 540 kg/m³ and 470 kg/m³ for deciduous and coniferous trees, respectively. Diameter-at-breast-height to tree height models (Figure 23) was created by combining minimum, maximum, and mean data for each parameter from several journals (Fierke and Kauffman, 2005; Garman et al., 1995; and Hanus et al. 1999).

Results

The volume of tree canopy that intersects the minimum 10-foot clearance distances for Seattle City Light's distribution and transmission systems is 1,328,000 ft³ or 6% of Seattle's total tree canopy volume (Table 2).

SCL will use this information and additional analysis that is being performed outside the scope of this study to inform vegetation management efforts.

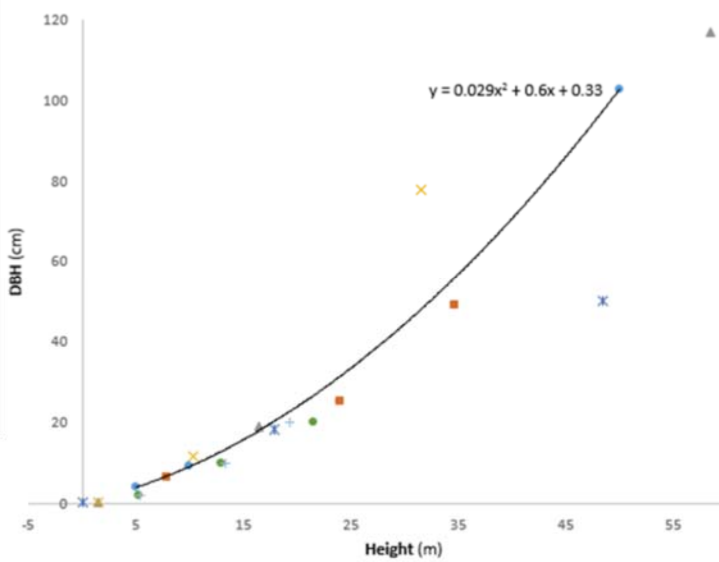

Figure 23. *DBH by height regression to produce a simple polynomial to best fit the model. This model incorporates data of all species before coniferous/deciduous differentiation.*

	Seattle		Intersecting Trees	
	Tree count	Volume (ft³)	Tree count	Volume (ft³)
Coniferous	199,463	15,210,821.04	19,263	930,216.74
Deciduous	750,332	5,836,428.33	136,029	397,997.73
Total	949,795	21,047,249.37	155,292	1,328,214.12

Table 2. *Volume (cubic feet) of Seattle trees and trees that intersect within 10ft of SCL infrastructure.*

Conclusions

Tree canopy in Seattle is a vital asset that provides multiple ecosystem services such as stormwater runoff reduction, improved air quality, decreased carbon footprint, enhanced quality of life, savings on energy bills, and habitat for wildlife.

The 2016 LiDAR assessment represents the most accurate, comprehensive, and detailed accounting of Seattle's canopy cover to date. It provides the foundation for understanding the quantity, distribution, and configuration of tree canopy within Seattle and establishes the baseline for future canopy cover change analysis.

Study findings

- The majority of Seattle's urban trees are found in two locations: residential areas (representing 67% of the land with 72% of Seattle's tree canopy), and in the right-of-way, interspersed throughout the city (representing 27% of the land with 22% of the canopy).
- Larger trees and tree groves are often present in parks but are also on residential and institutional lands.
- Canopy exceeds targets in developed parks, natural areas, multi-family, and institutional areas; is close to target in single-family, downtown, and commercial areas; and is below target in industrial areas.
- Canopy cover differs across the city based on land use, the presence of parks and natural areas, and socio-economic factors. Census tracts where the population tends to be residents of color and people with lower than average income also have lower amounts of tree canopy.
- 72% of Seattle's tree canopy is deciduous and 28% is coniferous. Most of the conifers are on single-family areas.
- The presence of trees can reduce urban heat island (surface temperature), especially inland.
- 6% of Seattle's tree canopy is within the clearance distance Seattle City Light maintains for safety and reliability of the power grid.
- Although not statistically valid, a mini-assessment of 80 random parcels found that development led to canopy cover loss.
- A separate sample-based satellite imagery trend analysis done in 2015 suggests an overall canopy cover loss of around 2% from 2010 to 2015, with a margin of error of +/- 3%.

Using the findings

1. The value of this study will be realized when the results are used to guide urban forestry policy and management efforts.
2. Preserving tree canopy is as important as new tree planting initiatives. Established mature tree growth contributes to canopy cover gain.
3. Study data can be used to establish localized canopy goals and targeted plantings and conservation efforts to maximize limited resources. Selecting a specific benefit to build an engagement campaign can increase the success in tree planting and conservation actions, particularly when an audience is already galvanized around a particular issue (e.g. engaging residents concerned about air quality issues in a specific neighborhood in tree planting efforts in that area).
4. It is recommend that the City of Seattle update its Urban Forestry Stewardship Plan with information derived from this study. The information can be used to revisit existing goals and targets.
5. Another LiDAR-based assessment should be planned to determine changes to the tree canopy in Seattle within the next five years. Such assessment can provide information on how effective tree planting and preservation efforts have been, in addition to understanding how other factors (e.g. development, drought, pests, etc.) may be impacting tree canopy. Future assessments will only be made possible if continued investments in high-resolution remote imagery and LiDAR data acquisition are made. Undertaking LiDAR-based assessments in the future will allow for trend analysis with comparable tree canopy data to be made.

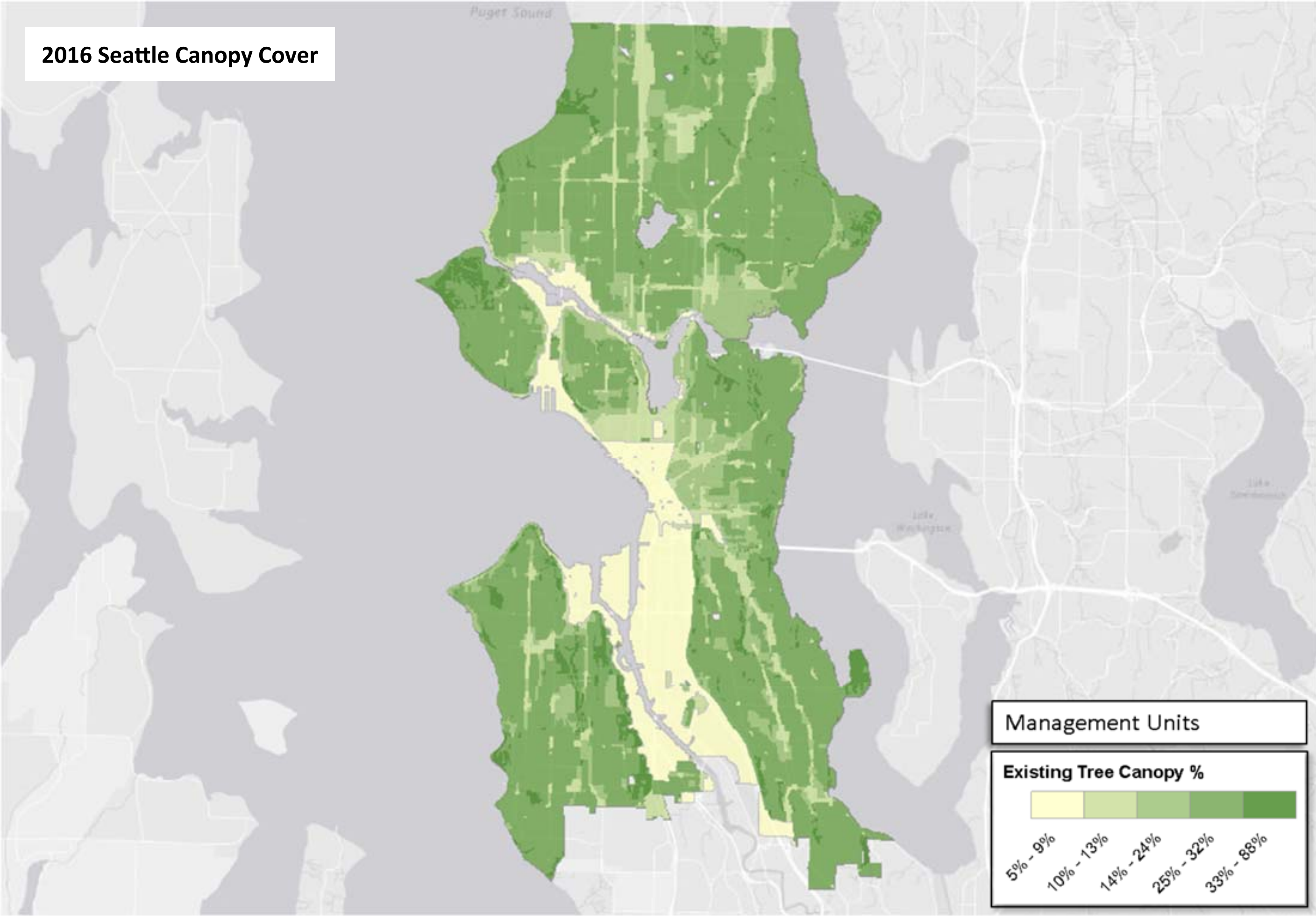

Figure 24. *Seattle canopy cover by Urban Forest Stewardship Plan management unit..*

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Jenkins, J.C., Chojnacky, D.C., Heath, L.S. and R.A. Birdsey. 2003. National-Scale Biomass Estimators for United States Tree Species. Forest Science, 49: 12-35.

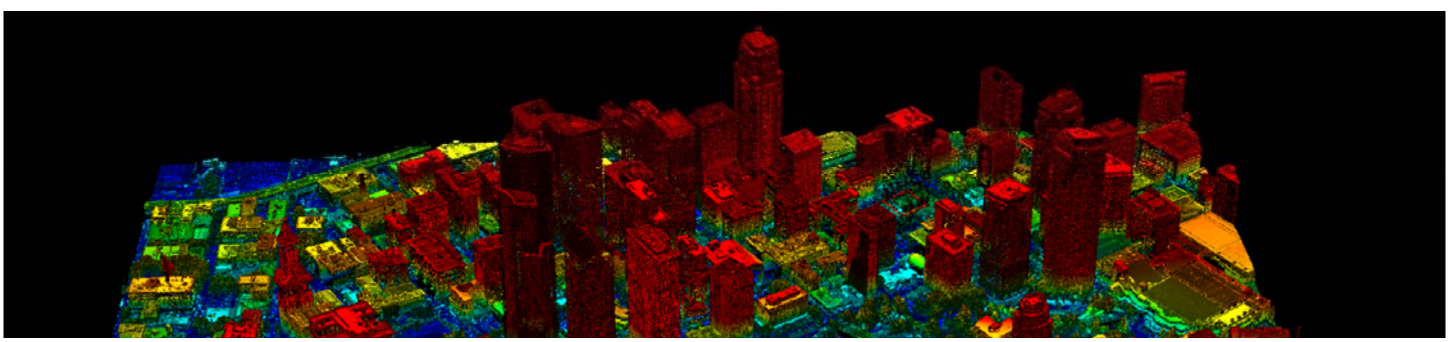

Figure 25. *2016 LiDAR for Seattle. The acquisition of such data in the future will be crucial for tracking tree canopy change over time.*

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Additional Information

For more info on the Urban Tree Canopy Assessment please visit **http://nrs.fs.fed.us/urban/UTC/**

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trees for seattle

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