URBAN TREE CANOPY

ASSESSMENT

SALEM,
OREGON
DECEMBER | 2019

CITY OF Salem
AT YOUR SERVICE

PLANIT GEO™
mapping a greener future

AN ASSESSMENT OF
URBAN TREE CANOPY

SALEM, OREGON

> **To exist as a nation, to prosper as a state, to live as a people, we must have trees.**
>
> **— Theodore Roosevelt**

PREPARED BY
PlanIT Geo, LLC, Arvada, Colorado

PREPARED FOR
City of Salem, Oregon

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9,104 ACRES OF TREE CANOPY

24% OF SALEM WAS TREE CANOPY IN 2018

EXECUTIVE SUMMARY

PURPOSE OF THIS ANALYSIS

The City of Salem is located within Marion County and Polk County in northwest Oregon (Figure 1). The study area for this assessment is the Salem City Limits and the Urban Growth Boundary (UGB) of Salem (excluding Keizer). The Study Area totaled nearly 61 square miles or 38,740 acres of which 37,644 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, interpret the results across a range of geographic boundaries, and evaluate how the City's canopy has changed since 2009, when the last urban tree canopy assessment was conducted. For purposes of this study, the Universal Transverse Mercator (UTM) coordinate system was used for all area (acres) calculations. Every coordinate system is an attempt to accurately represent the earth in two dimensions which causes some level of distortion in shape, size, direction, and distance. The exact area of the official UGB will differ slightly depending on which coordinate system was used. The total area of the UGB in NAD 1983 UTM Zone 10 (used in this study) is 38,740 acres compared to 38,764 using the NAD 1983 Oregon Lambert Conic Conformal coordinate system which is commonly used in other studies in the City of Salem.

URBAN TREE CANOPY IN SALEM

Land cover results of this study indicated that in 2018, 24% of the Salem UGB was tree canopy (or 9,202 acres of the 38,740 total acres); 22% was non-canopy vegetation (8,650 acres), 11% was soil/dry vegetation (4,433 acres), 40% was impervious (15,359 acres); and 3% was water (1,097 acres). Urban tree canopy (UTC) and possible planting area (PPA) results are based on land area which is equal to the total area minus water area (38,740 - 1,097 = 37,644 acres).Trees on tree farms and orchards were removed from the overall canopy cover due to their agricultural and transitional nature (98 acres). The resulting UTC cover was 24% (9,104 acres), 34% (12,763 acres) was suitable for future tree plantings, and 42% (15,778 acres) was unsuitable due to its current land use or other constraint. In further dividing the City's urban tree canopy, 11% was overhanging impervious surfaces, and 89% of all canopy was overhanging pervious surfaces. Salem gained 5% (1,992 acres) urban tree canopy since 2009.

ASSESSMENT BOUNDARIES

This study assessed UTC, PPA, and canopy change metrics 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 geographic scales: the study area boundary (city limits + UGB) (1 unit); zoning types (8 units); sub-basins (13 units); neighborhoods (20 units); parks (90 units); and census block groups (120 units).

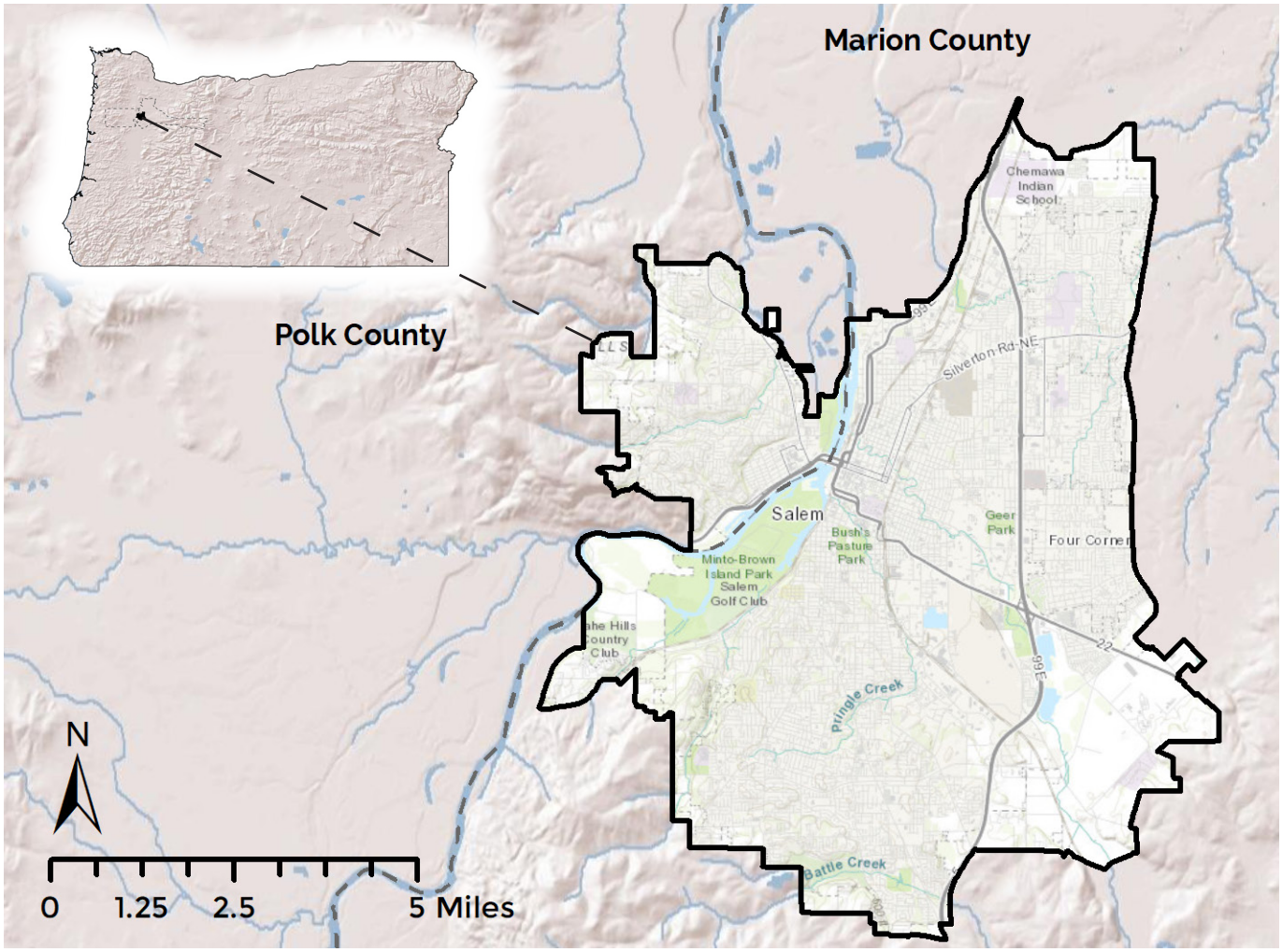


Figure 1. | Salem occupies approximately 61 square miles of Marion and Polk counties in northwest Oregon.

RECOMMENDATIONS

The results of this analysis can be used to develop a continuing strategy to protect and expand the urban forest in Salem. The UTC, PPA, and canopy change 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. Salem should use these results to ensure that their urban forest policies and management practices continue to prioritize its maintenance, health, and growth.

24% URBAN TREE CANOPY

34% POSSIBLE PLANTING AREA

40% IMPERVIOUS SURFACE

Figure 2. | Based on an analysis of 2018 high-resolution imagery and LiDAR, Salem contains 24% tree canopy, 34% areas that could support canopy in the future, and 40% total impervious areas.

PROJECT METHODOLOGY

Land cover, urban tree canopy, and possible planting areas were mapped using the sources and methods described below. These datasets provide the foundation for the metrics reported at the selected geographic assessment scales.

DATA SOURCES

This assessment utilized high-resolution (1-foot) multispectral imagery from the Oregon Statewide Imagery Program (OSIP) collected in July 2018 and Light Detection and Ranging (LiDAR) data from the Oregon LiDAR Consortium collected in 2018 to derive the land cover dataset. Both datasets were resampled to 1 meter for mapping purposes. The OSIP imagery was used to classify all types of land cover whereas the LiDAR data was mostly used to distinguish tree canopy from other types of vegetation. Additional Geographic Information Systems (GIS) layers provided by the City of Salem were also incorporated into the analysis.

MAPPING LAND COVER

An initial land cover dataset was to be created prior to mapping tree canopy. The land cover dataset 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 OSIP imagery and LiDAR to derive five initial land cover classes. These classes are shown in Figure 3 and described in the Glossary on page 34.

After manual classification improvement and quality control were performed on the remote sensing products, additional data layers from the city (such as buildings, roads, sidewalks, trails, and parking lots) were 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 2018 tree canopy assessment: urban tree canopy, other non-canopy vegetation, bare soil and dry vegetation, impervious (paved) surfaces, and water.

IDENTIFYING POSSIBLE PLANTING AREAS AND UNSUITABLE AREAS FOR PLANTING

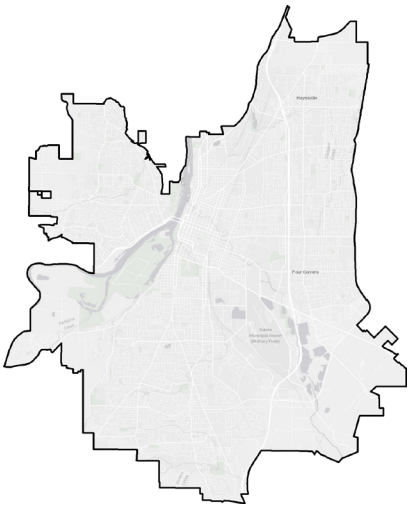
In addition to quantifying Salem's existing tree canopy cover, another metric of interest in this assessment was the area where tree canopy could be expanded. To assess this, all land area in Salem that was not existing tree canopy coverage was classified as either possible planting area (PPA) or unsuitable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

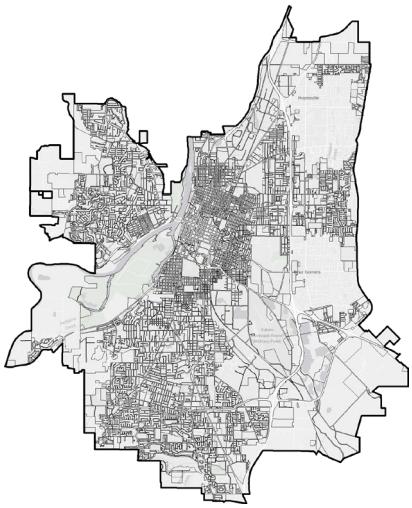
DEFINING ASSESSMENT LEVELS

In order to best inform the City Council and all of Salem's various stakeholders, urban tree canopy and other associated metrics were tabulated across a variety of geographic boundaries (Figure 5). These boundaries include the urban growth boundary, zoning, sub-basins, neighborhoods, parks, and census block groups.

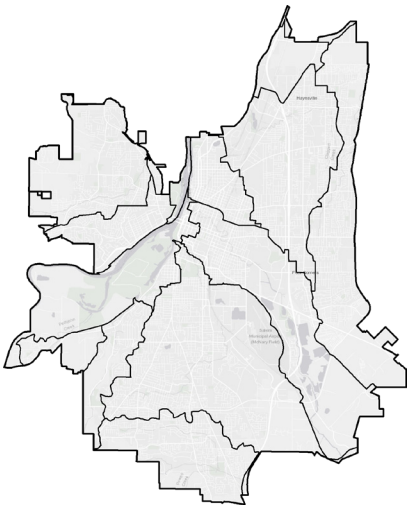
- The City limits of Salem combined with the urban growth boundary is the one (1) main area of interest over which all metrics are summarized.
- Eight (8) unique zoning types were assessed to provide detail on tree canopy within the current human uses of land across the city. These areas are aggregates of the City's zoning categories.
- Thirteen (13) sub-basins were assessed due to the important role trees play in stormwater management.
- Twenty (20) neighborhoods were assessed to quantify tree canopy at an easily-conceptualized scale for local residents and community members. Included in these neighborhoods were two non-neighborhood areas.
- Ninety (90) parks were assessed to determine how tree canopy is distributed in the City's open and green spaces.
- One hundred twenty (120) 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.



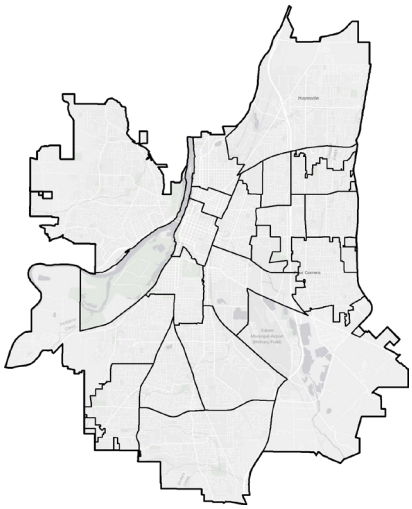
Urban Growth Boundary



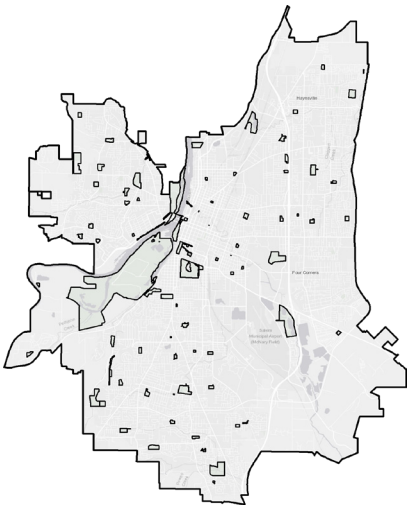
Zoning



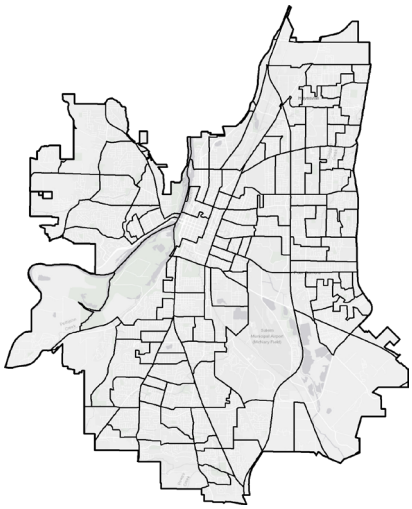
Sub-Basins



Neighborhoods



Parks



Census Block Groups

Figure 5. | Six (6) distinct geographic boundaries were explored in this analysis: the full urban growth boundary, zoning types, sub-basins, neighborhoods, parks, and U.S. Census block groups.

STATE OF THE CANOPY AND KEY FINDINGS

The results and key findings of this study, including the land cover map and canopy analysis results, are presented below. These results, or metrics, help inform a strategic approach to identifying existing canopy and future planting areas. Land cover percentages are based on the total area of interest while urban tree canopy, possible planting area, unsuitable, and canopy change percentages are based on land area only. Water bodies are excluded from land area because they are typically unsuitable for planting new trees without significant modification. All acreages were calculated using the NAD 1983 Universal Transverse Mercator (UTM) Zone 10 coordinate system. All percentages and acres in tables and charts have been rounded.

CITYWIDE LAND COVER

In 2018, tree canopy constituted 24% of Salem's land cover; non-canopy vegetation was 22%; soil/dry vegetation was 11%; impervious was 40%; and water was 3%. These generalized land cover results are presented below in Table 1.

The impervious land cover class was then subdivided into more specific classifications. Approximately 11% of Salem was buildings, 8% was roads, 11% was parking lots, 1% was sidewalks, <1% was trails, and 7% was "other impervious" such as driveways, tennis courts and artificial turf sports fields. The detailed land cover results, including impervious classifications, are presented in Figure 6.

Table 1. | Generalized land cover classification results.

Urban Growth Boundary of Salem	Total Area	Tree Canopy	Impervious Surfaces	Non-Canopy Vegetation	Soil & Dry Vegetation	Water
Acres	38,740	9,202	15,359	8,650	4,433	1,097
% of Total	100%	24%	40%	22%	11%	3%

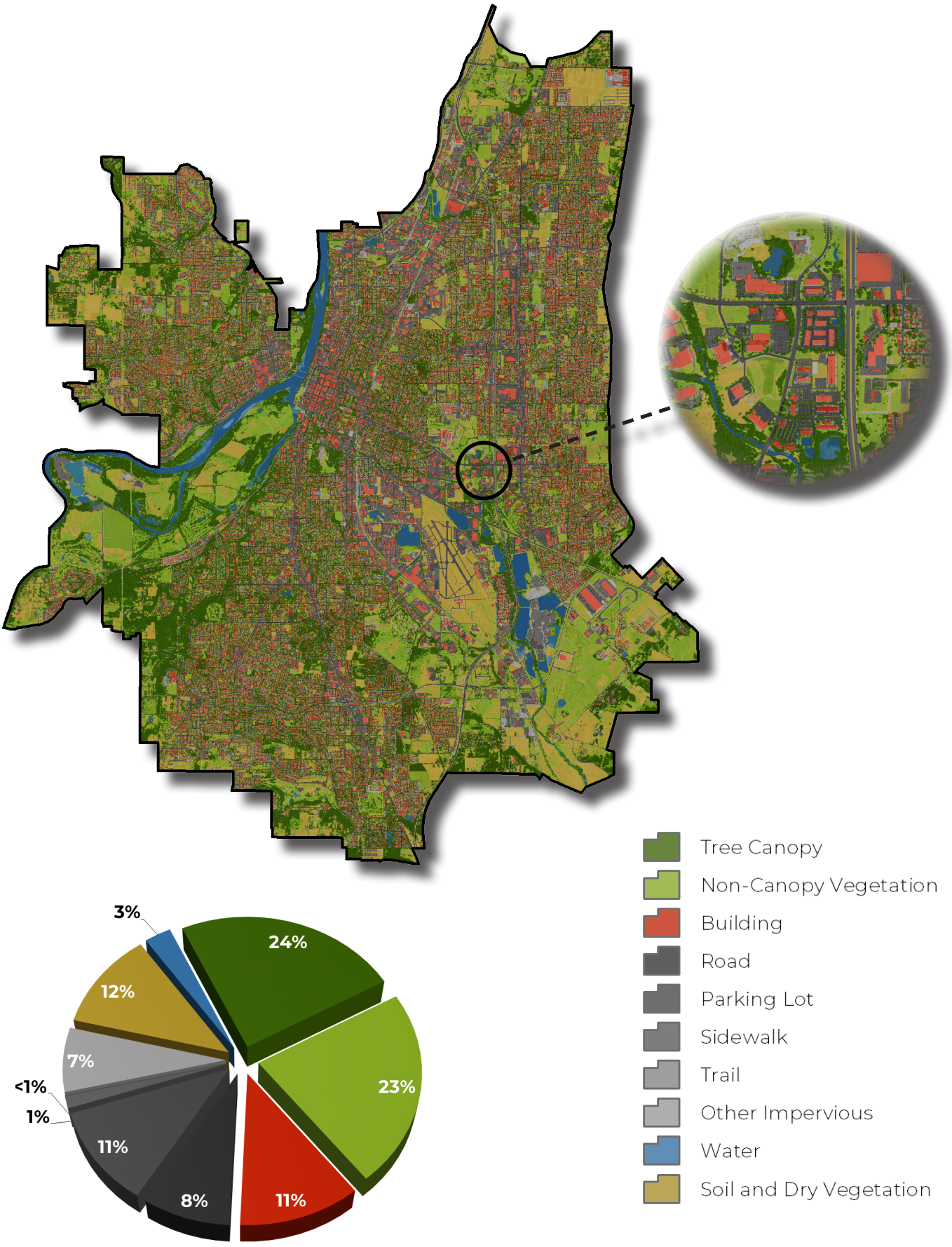


Figure 6. | Land cover classes for Salem, Oregon based on 2018 aerial imagery from the Oregon State Imagery Program and LiDAR from the Oregon State LiDAR Consortium. (Percentages based on total acres.)

URBAN TREE CANOPY IN THE URBAN GROWTH BOUNDARY

This urban tree canopy assessment utilized the land cover map as a foundation to determine possible planting areas throughout the urban growth boundary. Additional layers and information regarding land considered unsuitable for planting were also incorporated into the analysis to identify areas to exclude from PPA. Note that the results of this study are based on land area, which excludes water bodies, as opposed to total area, which includes water bodies (note the difference between Total Acres and Land Acres in Table 2).

Results of this study indicate that within the City of Salem, 9,104 acres (excluding 98 acres of trees on farms and orchards) are covered with urban tree canopy, making up 24% of the UGB's 37,644 land acres; 12,763 acres are covered with other vegetation or impervious surfaces such as parking lots, sidewalks, or trails where it would be possible to plant trees (PPA), making up 34% of the UGB; and the other 15,778 acres were considered unsuitable for tree planting, making up 42% of the UGB. The unsuitable areas include recreational sports fields, golf course playing areas, airports, quarries, buildings, and roads.

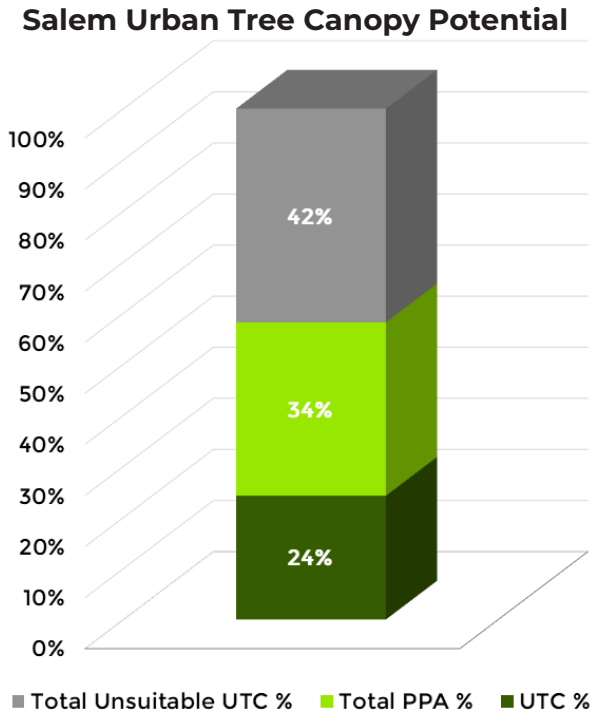


Figure 7. | Urban tree canopy, possible planting area, and area unsuitable for UTC in the City of Salem.

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

City of Salem	Acres	%
Total Area	38,740	100%
Land Area	37,644	100%
Urban Tree Canopy	9,104	24%
Possible Planting Area - Vegetation	8,146	22%
Possible Planting Area - Impervious	4,617	12%
Total Possible Planting Area	12,763	34%
Unsuitable Vegetation	504	1%
Unsuitable Impervious	10,741	28%
Unsuitable Soil	4,434	12%
Total Unsuitable Area	15,778	42%

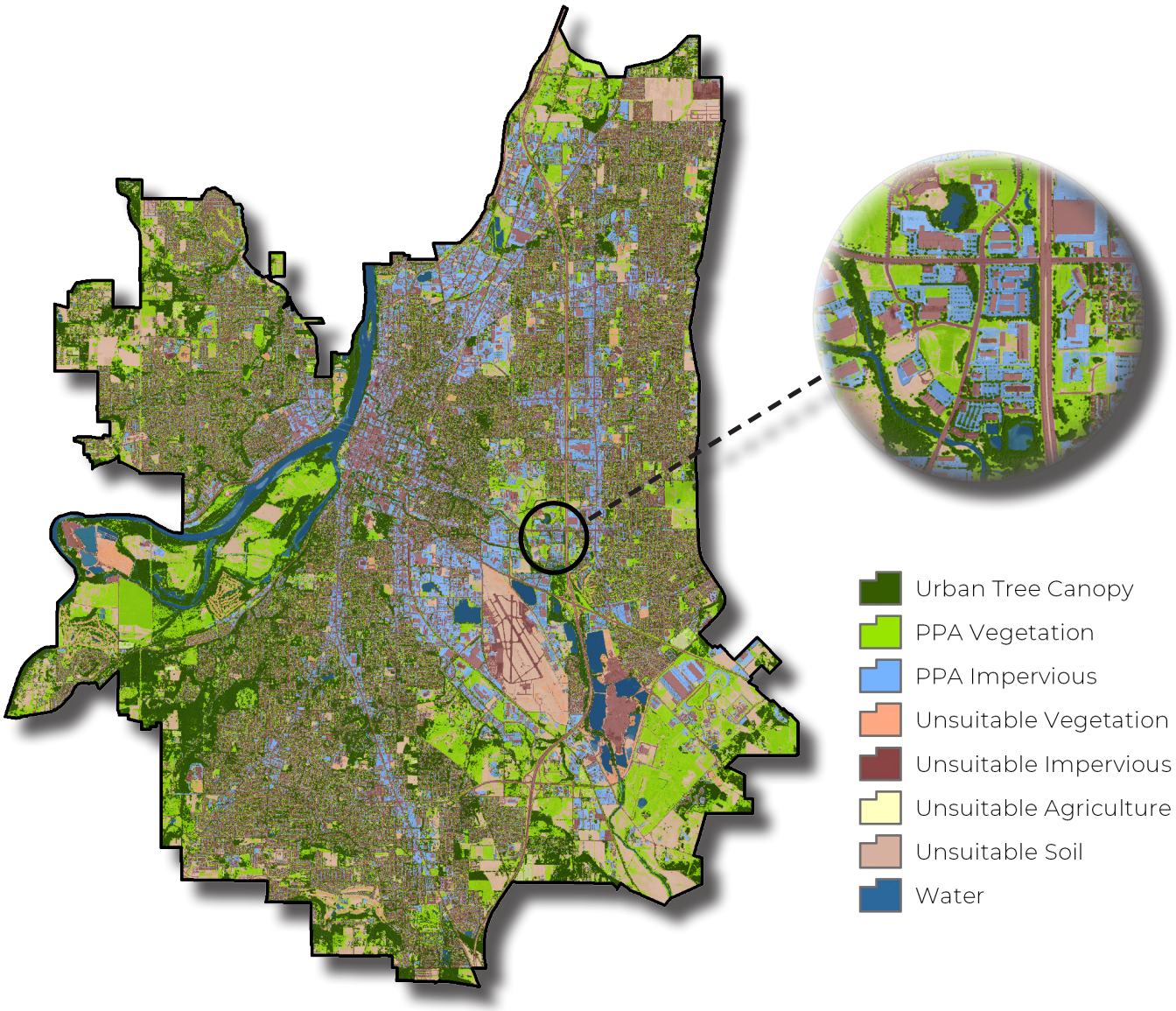


Figure 8. | Urban tree canopy, possible planting area, and unsuitable areas for UTC in the Salem UGB.

All 9,104 acres of urban tree canopy in the City were further divided into two subcategories based on whether the ground underneath the canopy was impervious or pervious. 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 a majority of Salem's UTC was overhanging pervious surfaces, as 89% of all tree canopy had a pervious understory. UTC overhanging impervious surfaces made up 11%.

Table 3. | Detailed urban tree canopy classifications.

City of Salem	Acres	%
UTC with Pervious Understory	8,181	89%
UTC with Impervious Understory	1,018	11%

URBAN TREE CANOPY BY ZONING

UTC and PPA were assessed for eight zoning types in Salem. UTC varied greatly throughout the different zoning types with the lowest UTC found in Downtown (10%) and the highest found in Public Open Space (42%). Residential areas as a whole made up 54% of the UGB, and 65% of all canopy cover is found in these areas. PPA had less variation with the lowest found in Medium Density Residential (29%) and the highest found in Commercial (54%). The greatest opportunity for future canopy expansion was in Medium Density Residential which contained 25% of all PPA in Salem.

Table 4. | Urban tree canopy assessment results by zoning. UTC and PPA results include acres, percent of area covered by UTC or PPA (%), and distribution of the UGB's total UTC or PPA within each zoning type.

Zoning	Land Area		Urban Tree Canopy			Possible Planting Area		
	Acres	*Dist.*	*Acres*	*%*	*Dist.*	*Acres*	*%*	*Dist.*
Commercial	2,142	8%	308	14%	5%	1,151	54%	12%
Downtown	147	1%	15	10%	<1%	51	35%	1%
High Density Residential	2,040	8%	457	22%	7%	649	32%	7%
Industrial	3,620	14%	347	10%	6%	1,870	52%	20%
Low Density Residential	3,298	13%	1,123	34%	18%	1,115	34%	12%
Medium Density Residential	8,183	32%	2,434	30%	40%	2,368	29%	25%
Other Public Land	3,599	14%	512	14%	8%	1,339	37%	14%
Public Open Space	2,227	9%	935	42%	15%	828	37%	9%
Totals	**25,257***	**100%**	**6,131**	**24%**	**100%**	**9,370**	**37%**	**100%**

*Zoning does not include right-of-way areas.

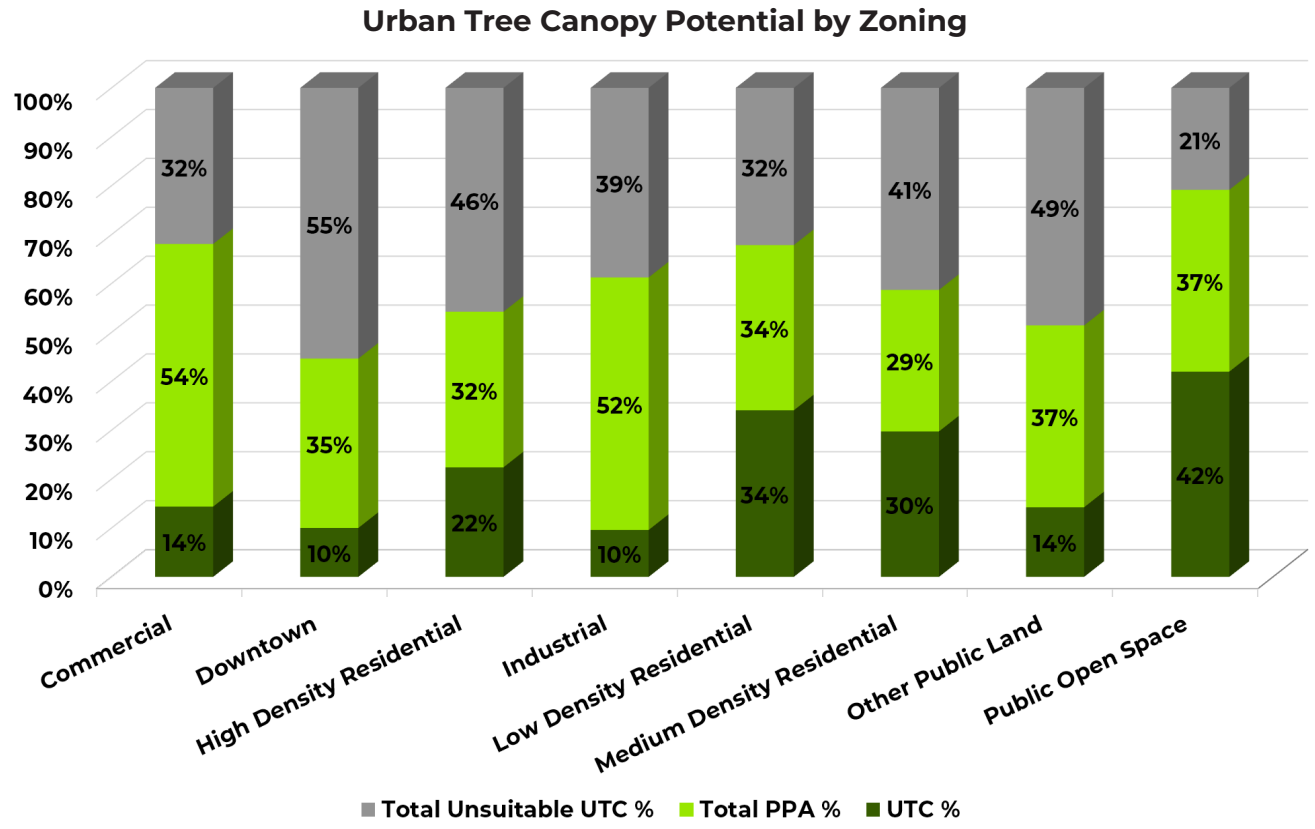


Figure 9. | Urban tree canopy, possible planting area, and area unsuitable by zoning.

URBAN TREE CANOPY BY SUB-BASINS

Since trees play a vital role in regulating runoff, reducing flooding, and maintaining a healthy water cycle, urban tree canopy metrics were assessed by sub-basin. UTC coverage varied greatly ranging from 13% in Lower Clagget to 66% in Willamette Slough West. PPA also varied across sub-basins ranging from 17% in Willamette Slough West to 46% found in Lower Claggett. Pringle Creek, the largest sub-basin within the UGB, added the most to the overall UTC and PPA contributing 21% and 20%, respectively.

Table 5. | Urban tree canopy assessment results by sub-basin. UTC and PPA results include acres, percent of area covered by UTC or PPA (%), and distribution of the UGB's total UTC or PPA within each sub-basin.

Sub Basins	Land Area		Urban Tree Canopy			Possible Planting Area		
	Acres	*Dist.*	*Acres*	*%*	*Dist.*	*Acres*	*%*	*Dist.*
Battlecreek	2,886	8%	808	28%	9%	853	30%	7%
Croisan Creek	1,386	4%	681	49%	7%	357	26%	3%
East Bank	1,228	3%	282	23%	3%	384	31%	3%
Glenn / Gibson	3,500	9%	953	27%	10%	1,158	33%	9%
Little Pudding	4,784	13%	795	17%	9%	1,682	35%	13%
Lower Claggett	967	3%	130	13%	1%	443	46%	3%
Mill Creek	4,855	13%	882	18%	10%	1,835	38%	14%
Pettijohn	718	2%	359	50%	4%	186	26%	1%
Pringle Creek	7,837	21%	1,905	24%	21%	2,484	32%	20%
Upper Claggett	4,724	13%	755	16%	8%	1,785	38%	14%
West Bank	1,449	4%	361	25%	4%	461	32%	4%
Willamette Slough East	2,965	8%	1,074	36%	12%	1,078	36%	8%
Willamette Slough West	144	0%	95	66%	1%	24	17%	0%
Totals	**37,444**	**100%**	**9,080**	**24%**	**100%**	**12,730**	**34%**	**100%**

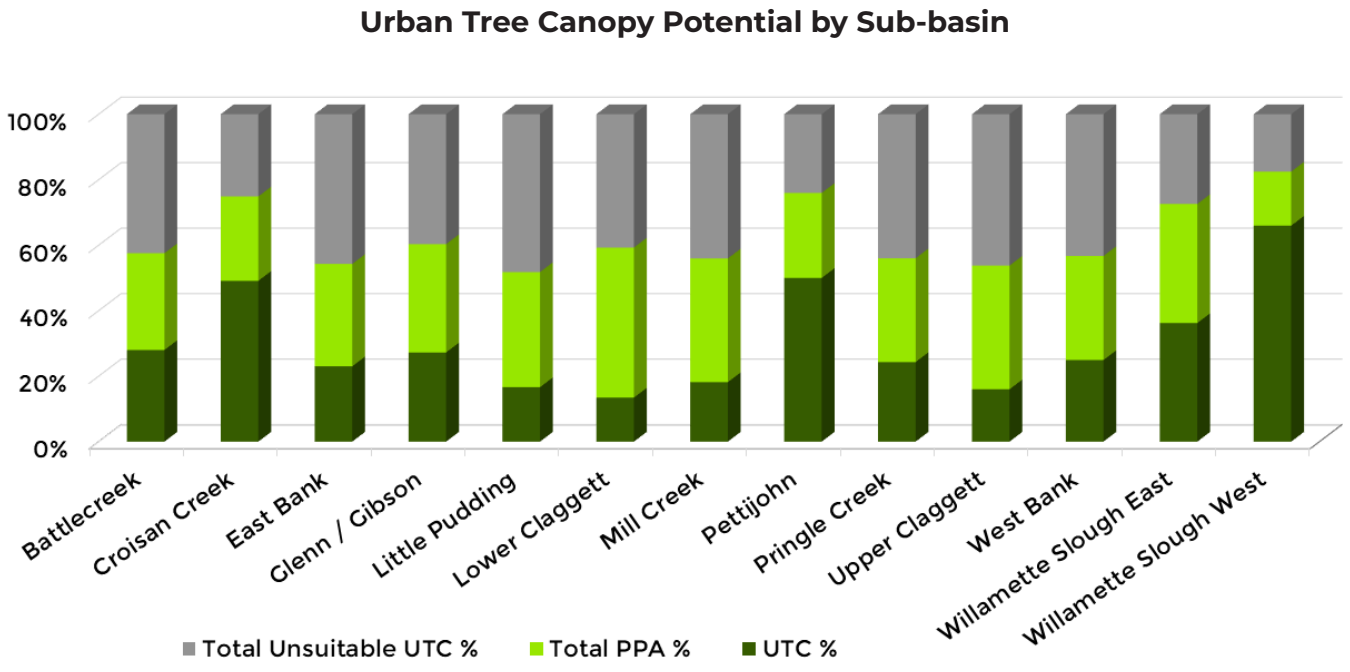


Figure 10. | Urban tree canopy, possible planting area, and area unsuitable by sub-basin.

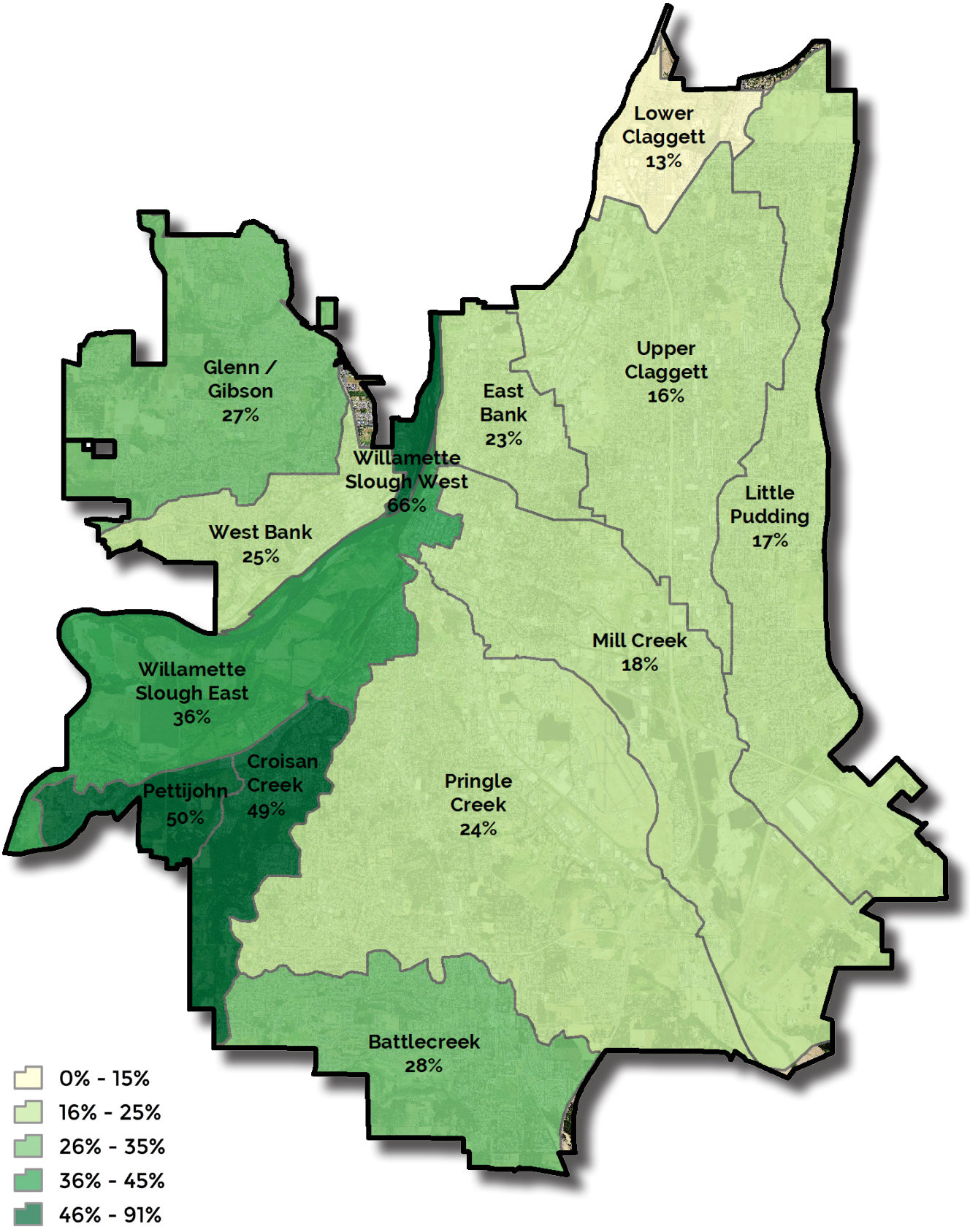


Figure 11. | Urban tree canopy in Salem by sub-basins.

URBAN TREE CANOPY BY NEIGHBORHOODS

UTC and PPA were assessed for 20 neighborhoods (18 Associations plus State Fairgrounds and State Hospital/ Penitentiary) across Salem. UTC varied greatly throughout neighborhoods ranging from 10% in State Fairgrounds to 41% in South West Association of Neighbors. PPA ranged from 26% in South Central Association of Neighbors to 50% in State Hospital and Penitentiary. South East Mill Creek Association offered the most opportunity for future canopy expansion in Salem as it contains 17% of all PPA in the UGB or over 2,000 acres.

Table 6. | Urban tree canopy assessment results by neighborhood. UTC and PPA results include acres, percent of area covered by UTC or PPA (%), and distribution of the UGB's total UTC or PPA within each neighborhood.

Neighborhoods	Land Area		Urban Tree Canopy			Possible Planting Area		
	Acres	*Dist.*	*Acres*	*%*	*Dist.*	*Acres*	*%*	*Dist.*
Central Area	621	2%	122	20%	1%	190	31%	2%
East Lancaster	932	3%	146	16%	2%	359	38%	3%
Faye Wright	1,141	3%	358	31%	4%	304	27%	3%
Grant	269	1%	64	24%	1%	72	27%	1%
Highland	773	2%	152	20%	2%	271	35%	2%
Lansing	493	1%	101	21%	1%	159	32%	1%
Morningside	2,098	6%	549	26%	7%	812	39%	7%
North East Salem	688	2%	100	15%	1%	261	38%	2%
North Lancaster	646	2%	106	16%	1%	219	34%	2%
Northeast Neighbors	754	2%	222	29%	3%	202	27%	2%
Northgate	4,579	13%	721	16%	9%	1,666	36%	14%
South Central	849	2%	302	36%	4%	222	26%	2%
South Gateway	3,315	10%	924	28%	11%	964	29%	8%
Southeast Mill Creek	5,486	16%	788	14%	10%	2,004	37%	17%
Southeast Salem	1,499	4%	267	18%	3%	622	41%	5%
South West	3,349	10%	1,386	41%	17%	959	29%	8%
State Fairgrounds	173	1%	17	10%	0%	80	46%	1%
State Hospital and Penitentiary	354	1%	46	13%	1%	176	50%	2%
Sunnyslope	1,247	4%	346	28%	4%	361	29%	3%
West Salem	5,227	15%	1,448	28%	18%	1,689	32%	15%
Totals	**34,491**	**100%**	**8,166**	**24%**	**100%**	**11,593**	**34%**	**100%**

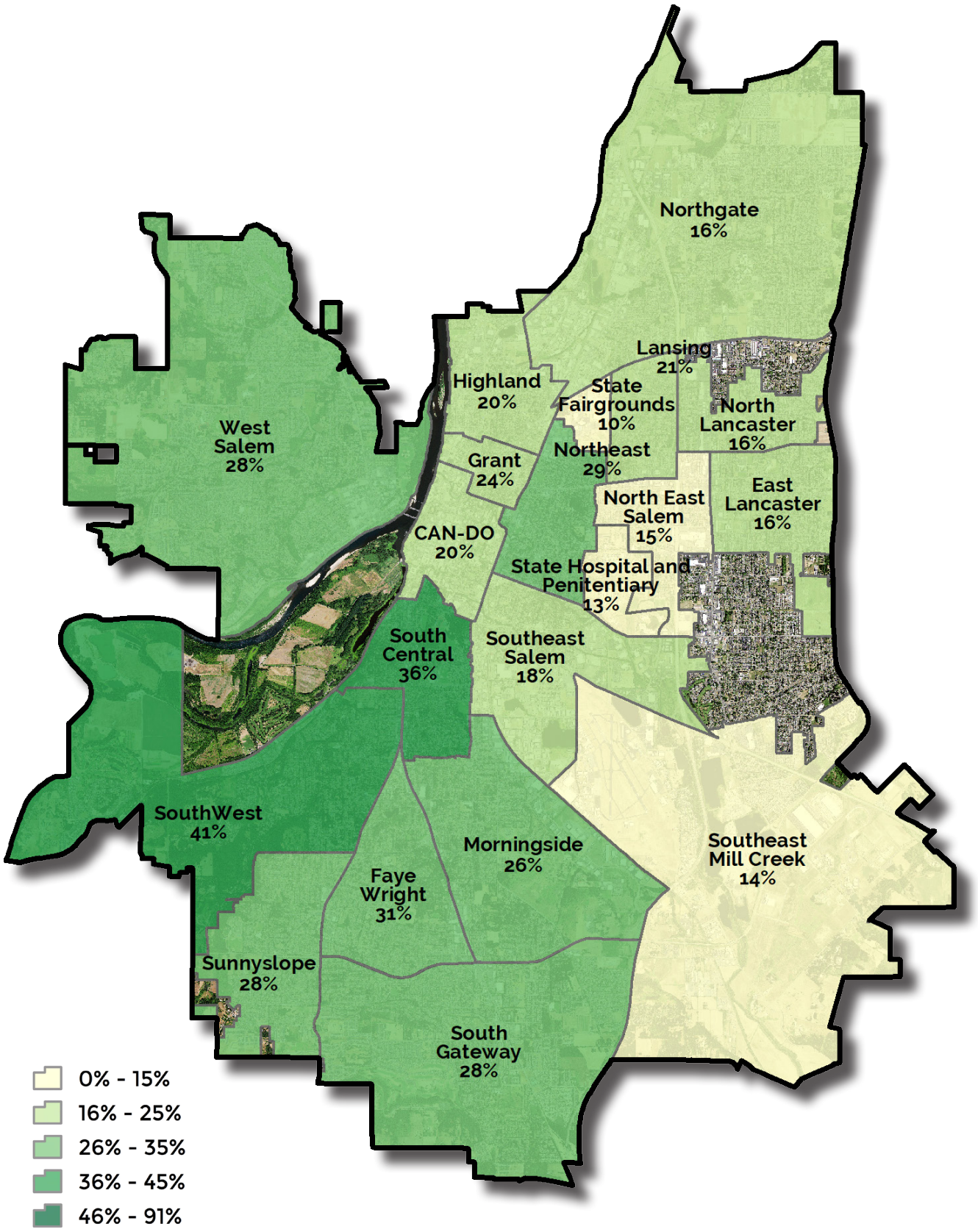


Figure 12. | Urban tree canopy in Salem by neighborhoods.

URBAN TREE CANOPY BY PARKS

UTC and PPA were assessed for the 90 parks located within Salem. UTC varied greatly within the City's parks as some contained less than 5% UTC whereas others were completely covered by tree canopy. PPA in parks had a similar variance with some parks containing less than 1% PPA while others contained over 80% PPA. Salem's largest park, Minto-Brown Island Park, contained the most UTC and PPA, containing 53% of all UTC and 62% of all PPA found in Salem's parks. For more detailed UTC metrics for individual parks within Salem refer to the UTC Results spreadsheet separate from this report.

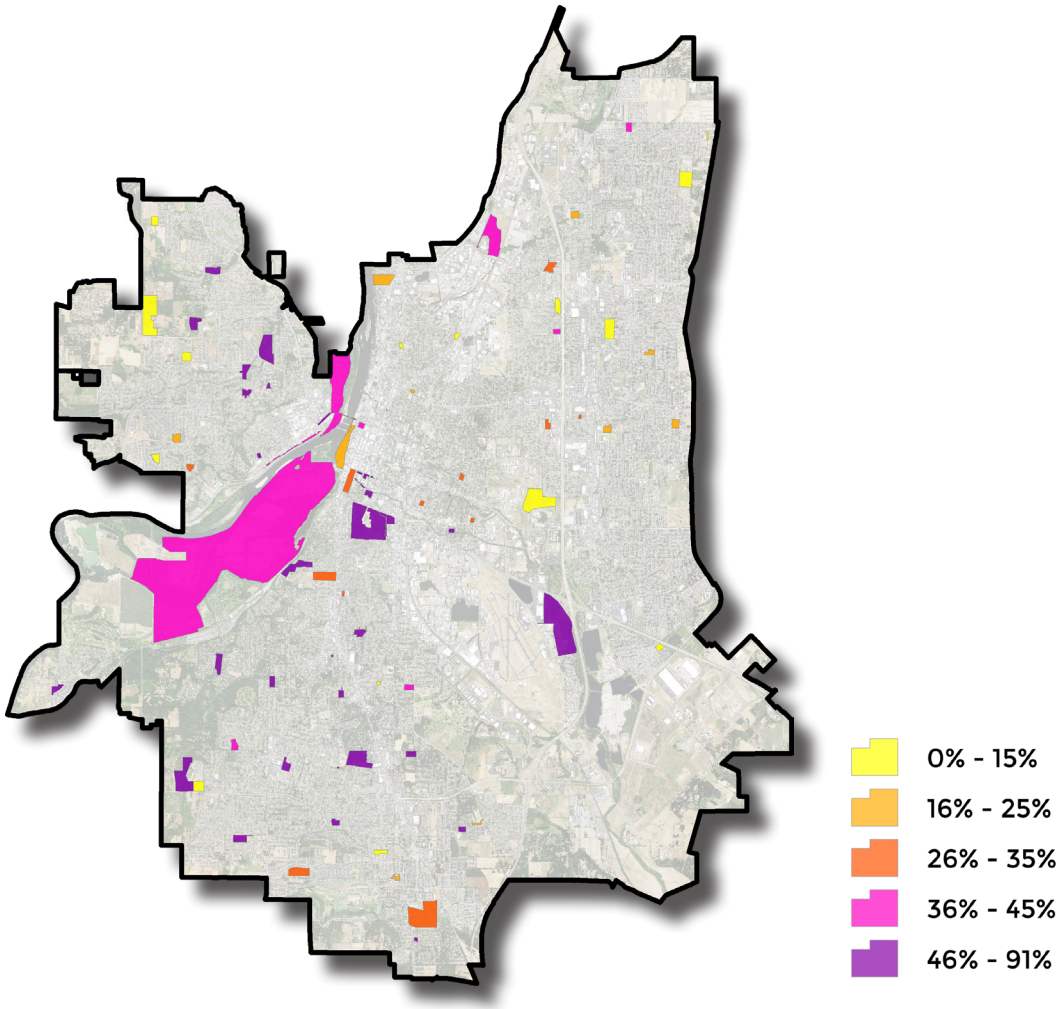


Figure 13. | Urban tree canopy in Salem by parks.

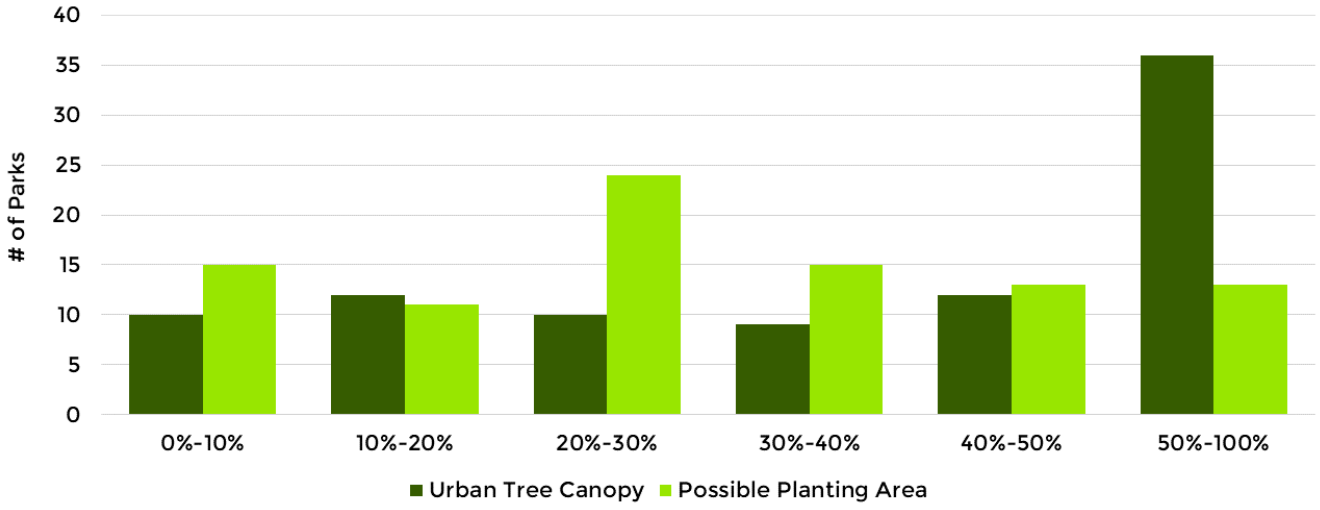


Figure 14. | Urban tree canopy and possible planting area in Salem by parks.

URBAN TREE CANOPY BY CENSUS BLOCK GROUPS

Census block groups are linked to all demographic and socioeconomic U.S. Census data which makes them useful for assessing the equitable distribution of tree canopy. Results indicated that UTC in Salem is not uniformly distributed throughout the City. Some of the City's 120 census block groups contained less than 10% cover while others contained over 40%. The average canopy cover for a census block group in Salem was 24%. PPA was also varied and ranged from 22% to 50%. The average PPA across all census block groups was 32%. For the complete results by census block group, refer to the UTC Results spreadsheet. TreePlotter CANOPY, a customized browser based software, can also be used to explore correlations between tree canopy, possible planting area, and various environmental, socioeconomic, and demographic factors at the census block group level.

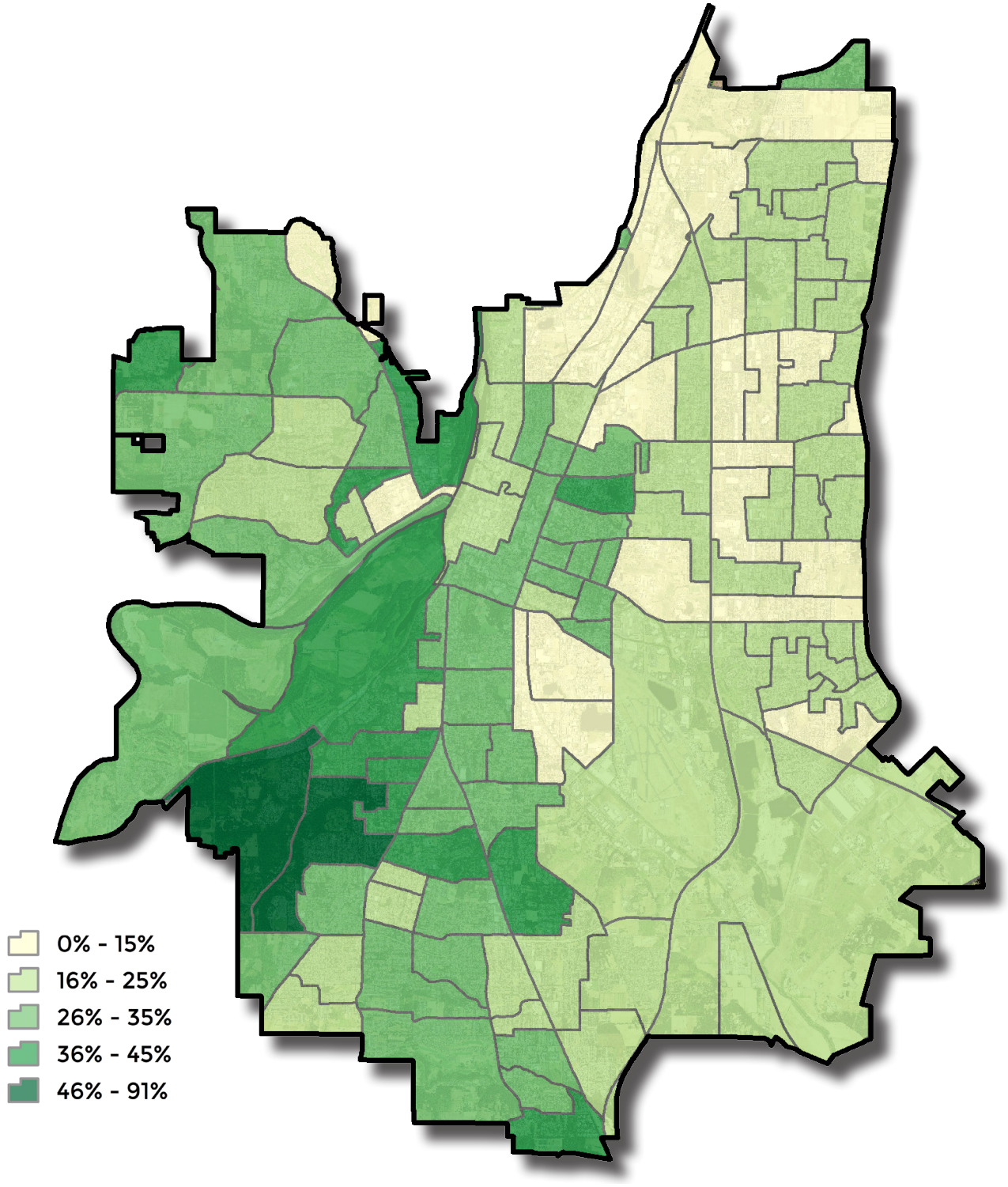


Figure 15. | Urban tree canopy in Salem by census block groups.

URBAN TREE CANOPY CHANGE ANALYSIS

In addition to assessing Salem's current urban tree canopy, this study also quantified changes in urban tree canopy using data from the previous 2009 assessment. Nearly identical methods were used in both studies. However, data sources did vary. In 2009, 1-meter resolution National Agriculture Imagery Program (NAIP) aerial imagery was the sole data source. In 2018, 1-meter OSIP aerial imagery and LiDAR elevation data from the Oregon LiDAR Consortium were used in conjunction. LiDAR data were not available at the time when the 2009 canopy coverage was mapped.

For clarity and consistency with the 2009 assessment findings, the 2009 tree canopy percentage in the study area is reported as 18.3% despite minor differences with the 2018 boundary and the coordinate system used for area calculations. With the region continuing to experience population increases and associated development, it is increasingly important to measure the extent of canopy and monitor changes that occur.

URBAN TREE CANOPY CHANGE IN THE URBAN GROWTH BOUNDARY

Current urban tree canopy coverage in the UGB is 24% with 9,104 acres. In 2009, urban tree canopy covered 18.3% of the 2018 land area in Salem with 7,120 acres. A net total of 1,984 acres of canopy were gained equating to a change of +5% throughout the UGB.

The change in canopy coverage is a result of several factors. In 2009, LiDAR data were not available. The availability of LiDAR in 2018 allowed us to determine the extent of true urban tree canopy versus areas with low-lying shrub species such as invasive blackberry. These transitional vegetation types cover large areas and led to the largest differences in canopy cover between the two time periods. Additionally, agricultural areas such as tree farms and orchards were excluded in both the 2009 and 2018 canopy analyses. However, the extent of these areas in 2009 may have differed from those used in 2018. In addition, the imagery and mapping show that significant canopy growth occurred over

Table 7. | Urban tree canopy change for the Salem UGB.

City of Salem	Land Area 2009	UTC 2009		Land Area 2018	UTC 2018		UTC Change	
	Acres	*Acres*	*%*	*Acres*	*Acres*	*%*	*Acres*	*%*
Urban Tree Canopy	37,644	7,120	18%	37,644	9,104	24%	1,984	6%

UTC LOSS

UTC GAIN

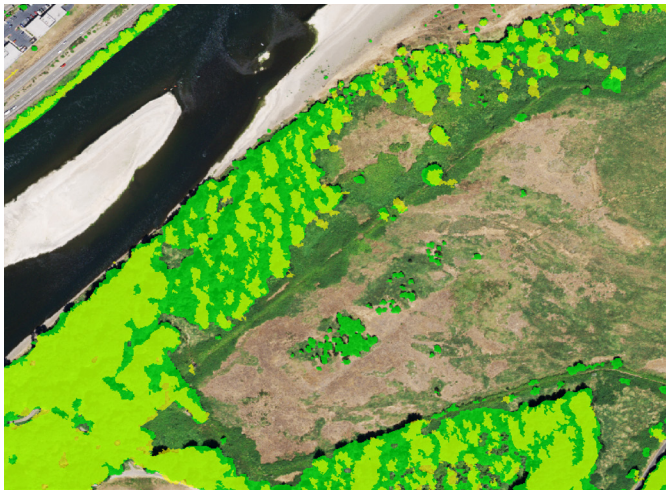


Figure 16. | Examples of urban tree canopy loss (red) (left) and gain (green) (right) in Salem.

the last nine years, leading to further increases in canopy cover. Finally, while the UGB has experienced significant development, many of the larger development areas were farmland or other low canopy areas prior to development.

This study achieved 92% overall accuracy (see Appendix). With a 95% confidence interval, there was a 1.8% margin of error equating to 24.2% canopy cover +/- 1.8% or a range of 22.4% to 26.0%. Therefore, compared to 2009 coverage (18.3%), there could have been a change ranging from +7.1% to +3.5% taking into account the 2018 margin of error. Accuracy was not calculated for the 2009 tree canopy data.

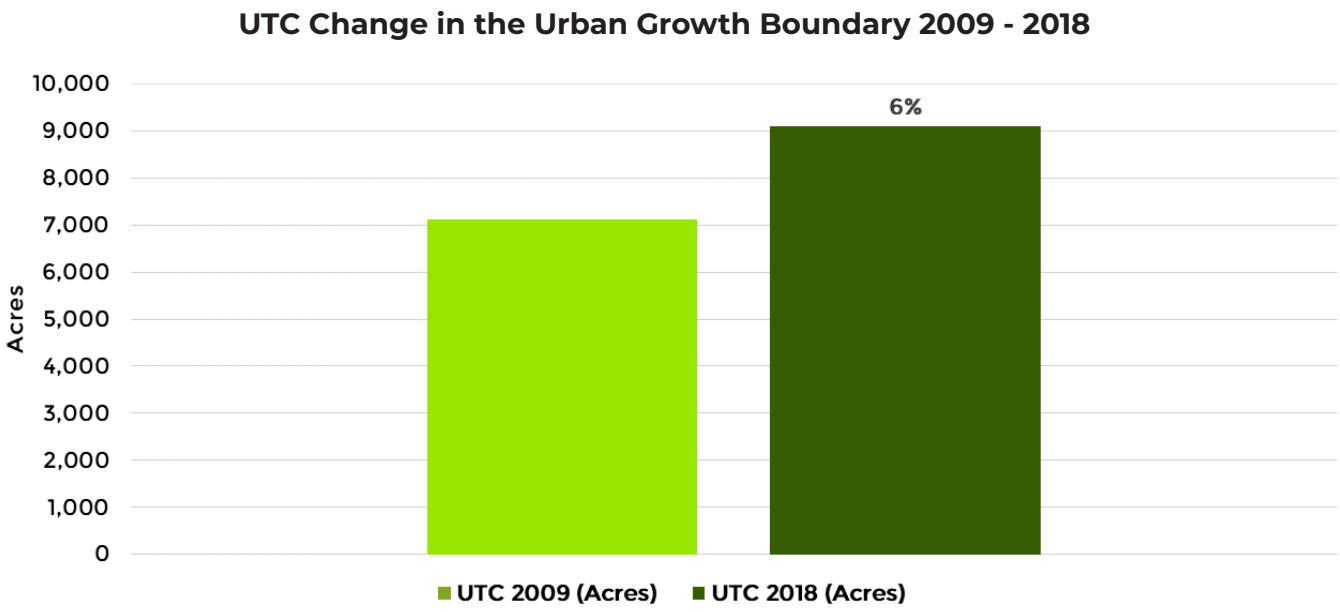


Figure 17. | Urban tree canopy change by Salem UGB.

URBAN TREE CANOPY CHANGE BY ZONING

UTC change was assessed for the eight different zoning types in Salem. All zoning types experienced gains in overall UTC. The lowest was in Downtown with a 1% (1 acre) increase, and the highest was in Public Open Space with 11% (245 acres). Industrial areas gained 3% (120 acres) of canopy cover which, compared to canopy cover in 2009, is a 53% relative gain (120/228). Canopy cover in residential areas, as a whole, increased by 777 acres or a gain of 5%.

Table 8. | Urban tree canopy change by zoning.

Zoning	Land Area	UTC 2009		UTC 2018		UTC Change	
	Acres	*Acres*	*%*	*Acres*	*%*	*Acres*	*%*
Commercial	2,142	238	11%	308	14%	69	3%
Downtown	147	14	9%	15	10%	1	1%
High Density Residential	2,040	369	18%	457	22%	88	4%
Industrial	3,620	228	6%	347	10%	120	3%
Low Density Residential	3,298	871	26%	1,123	34%	253	8%
Medium Density Residential	8,183	1,998	24%	2,434	30%	436	5%
Other Public Land	3,599	364	10%	512	14%	148	4%
Public Open Space	2,227	689	31%	935	42%	245	11%
Totals	**25,257***	**4,771**	**18%**	**6,131**	**24%**	**1,360**	**6%**

*Zoning does not include areas in the right of way.

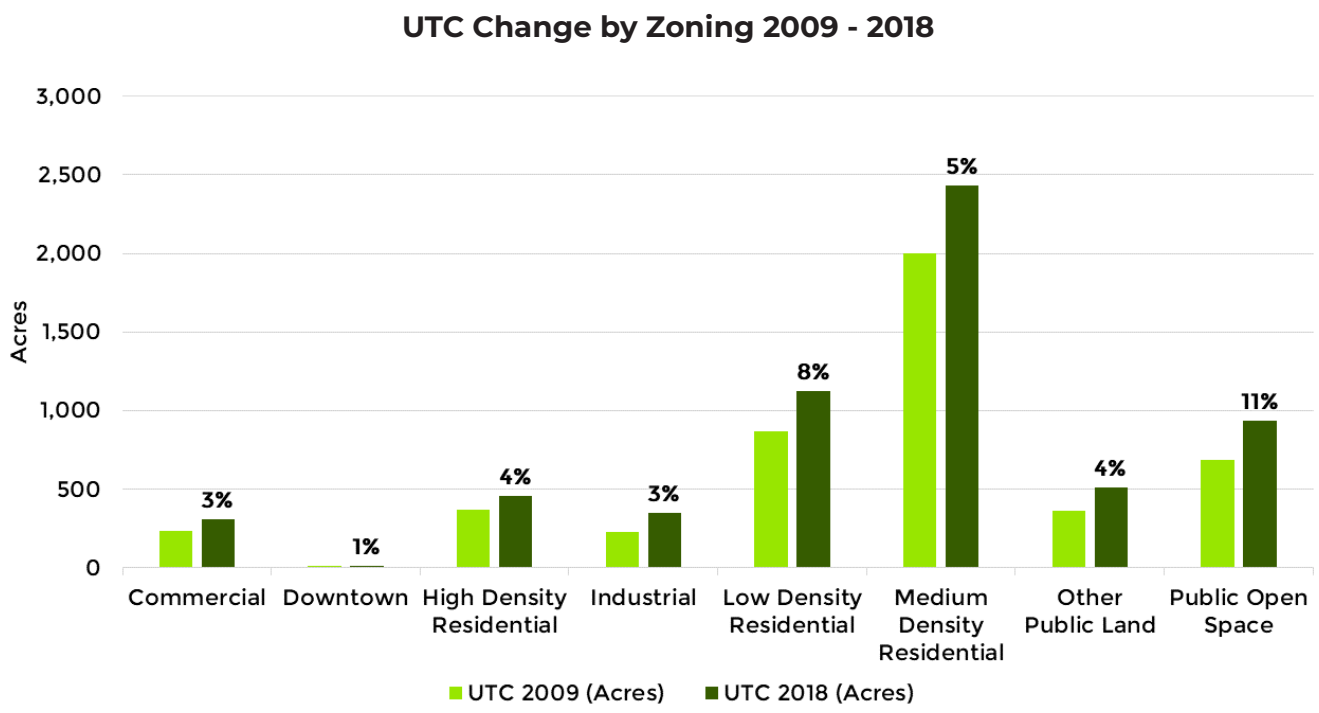


Figure 17. | Urban tree canopy change in Salem by zoning.

URBAN TREE CANOPY CHANGE BY SUB-BASINS

All 13 sub-basins in Salem experienced a gain in UTC. These gains ranged from 3% to 11%. The largest canopy gain was 11% within the Willamette Slough East sub-basin which includes Minto Brown Island. The smallest gains were found in East Bank and Upper Claggett which both gained 3% UTC.

Table 9. | Urban tree canopy change by sub-basins.

Sub-Basins	Land Area	UTC 2009		UTC 2018		UTC Change	
	Acres	*Acres*	*%*	*Acres*	*%*	*Acres*	*%*
Battlecreek	2,886	617	21%	808	28%	191	7%
Croisan Creek	1,386	570	41%	681	49%	111	8%
East Bank	1,228	247	20%	282	23%	35	3%
Glenn / Gibson	3,500	741	21%	953	27%	213	6%
Little Pudding	4,784	549	11%	795	17%	247	5%
Lower Claggett	967	102	11%	130	13%	28	3%
Mill Creek	4,855	657	14%	882	18%	224	5%
Pettijohn	718	297	41%	359	50%	62	9%
Pringle Creek	7,837	1,529	20%	1,905	24%	376	5%
Upper Claggett	4,724	624	13%	755	16%	132	3%
West Bank	1,449	288	20%	361	25%	73	5%
Willamette Slough East	2,965	750	25%	1,074	36%	324	11%
Willamette Slough West	144	85	59%	95	66%	10	7%
Totals	**37,444**	**7,055**	**18%**	**9,080**	**24%**	**2,026**	**6%**

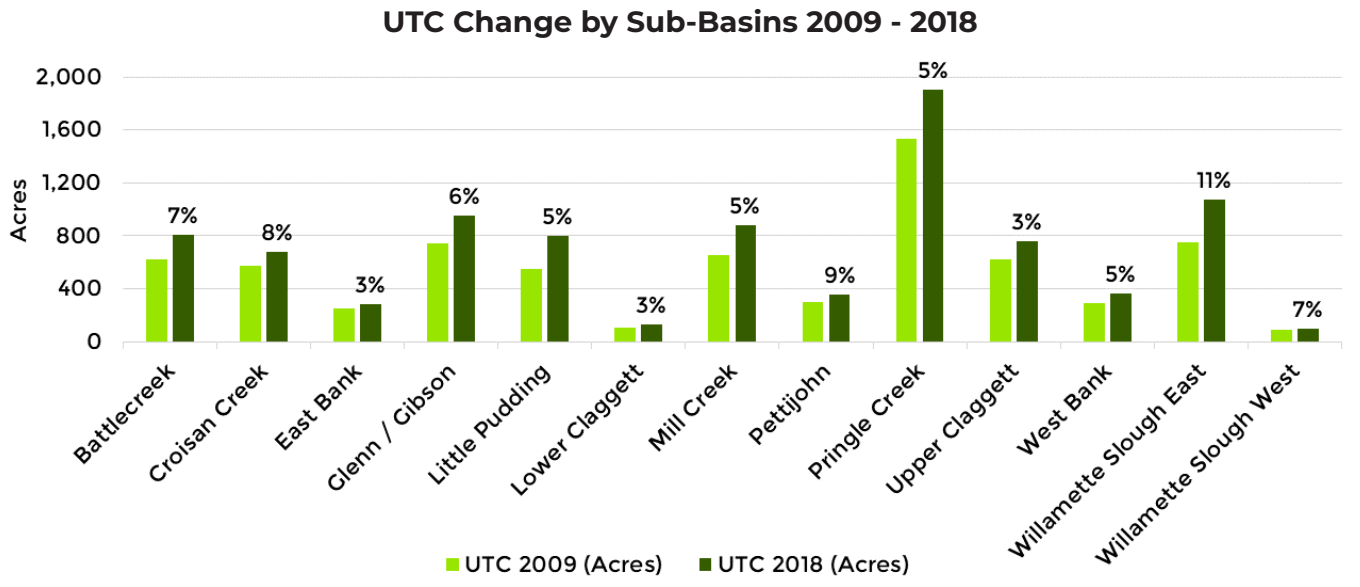


Figure 18. | Urban tree canopy change in Salem by sub-basins.

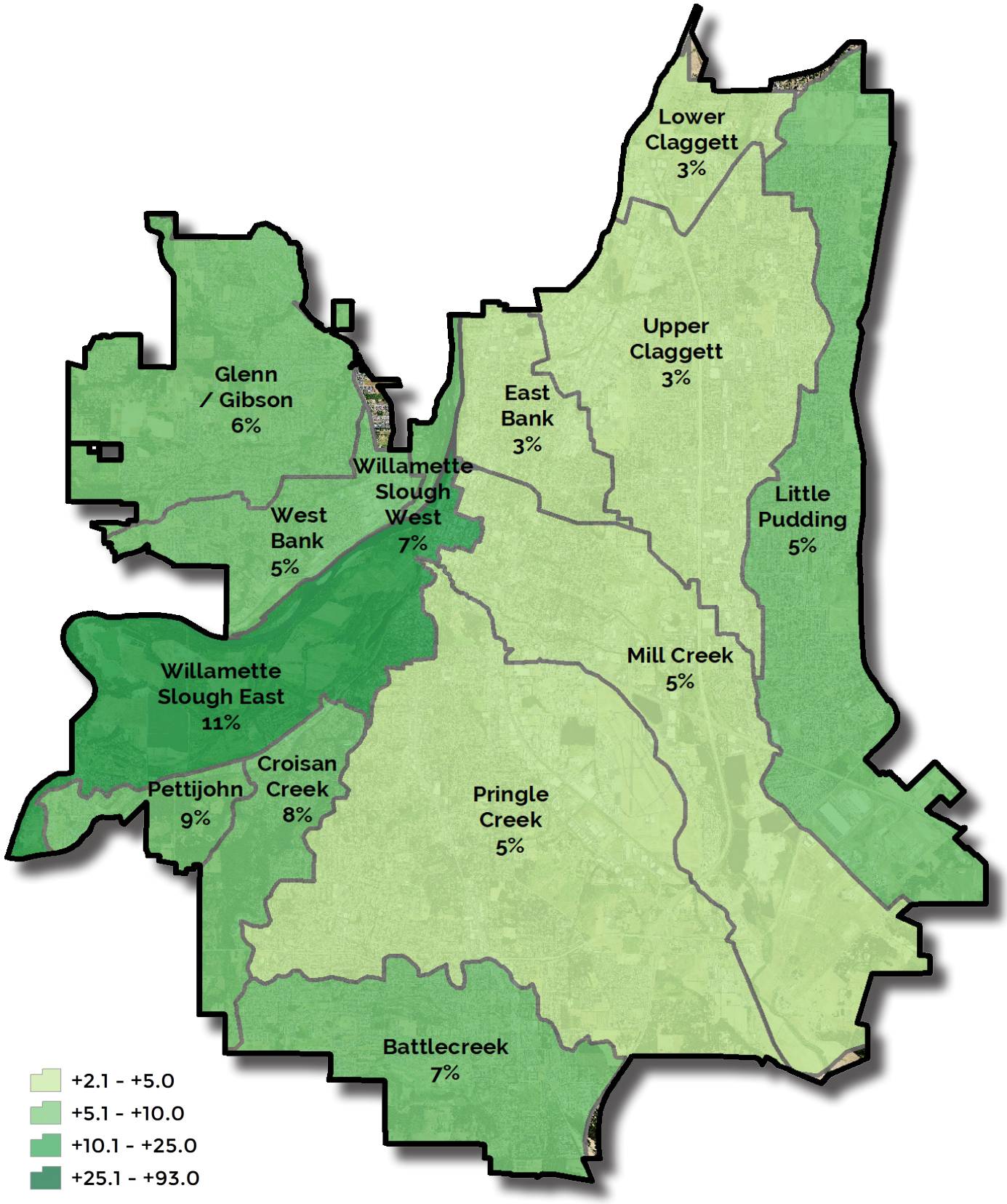


Figure 19. | Urban tree canopy change in Salem by sub-basins.

URBAN TREE CANOPY CHANGE BY NEIGHBORHOODS

Every neighborhood within Salem saw an increase in UTC, ranging from 2% in Lansing Neighborhood Association to 8% in the South West Association of Neighbors. State Fairgrounds, technically not a neighborhood, had the smallest gains of 3 acres and under 2%. After that, the smallest gain by acreage was Grant Neighborhood Association which gained 6 acres of UTC. The largest canopy gain by acreage was the West Salem Neighborhood Association (299 acres).

Table 10. | Urban tree canopy change by neighborhoods.

Neighborhoods	Land Area	UTC 2009		UTC 2018		UTC Change	
	Acres	*Acres*	*%*	*Acres*	*%*	*Acres*	*%*
Central Area	621	105	17%	122	20%	17	3%
East Lancaster	932	115	12%	146	16%	32	3%
Faye Wright	1,141	322	28%	358	31%	36	3%
Grant	269	54	20%	64	24%	9	3%
Highland	773	128	17%	152	20%	24	3%
Lansing	493	90	18%	101	21%	11	2%
Morningside	2,098	406	19%	549	26%	142	7%
North East Salem	688	80	12%	100	15%	20	3%
North Lancaster	646	78	12%	106	16%	28	4%
Northeast Neighbors	754	199	26%	222	29%	23	3%
Northgate	4,579	561	12%	721	16%	160	3%
South Central	849	273	32%	302	36%	29	3%
South Gateway	3,315	698	21%	924	28%	226	7%
Southeast Mill Creek	5,486	517	9%	788	14%	271	5%
Southeast Salem	1,499	199	13%	267	18%	68	5%
South West	3,349	1,133	34%	1,386	41%	253	8%
State Fairgrounds	173	14	8%	17	10%	3	2%
State Hospital and Penitentiary	354	36	10%	46	13%	10	3%
Sunnyslope	1,247	285	23%	346	28%	61	5%
West Salem	5,227	1,149	22%	1,448	28%	299	6%
Totals	**34,491**	**6,443**	**18%**	**8,166**	**24%**	**1,722**	**6%**

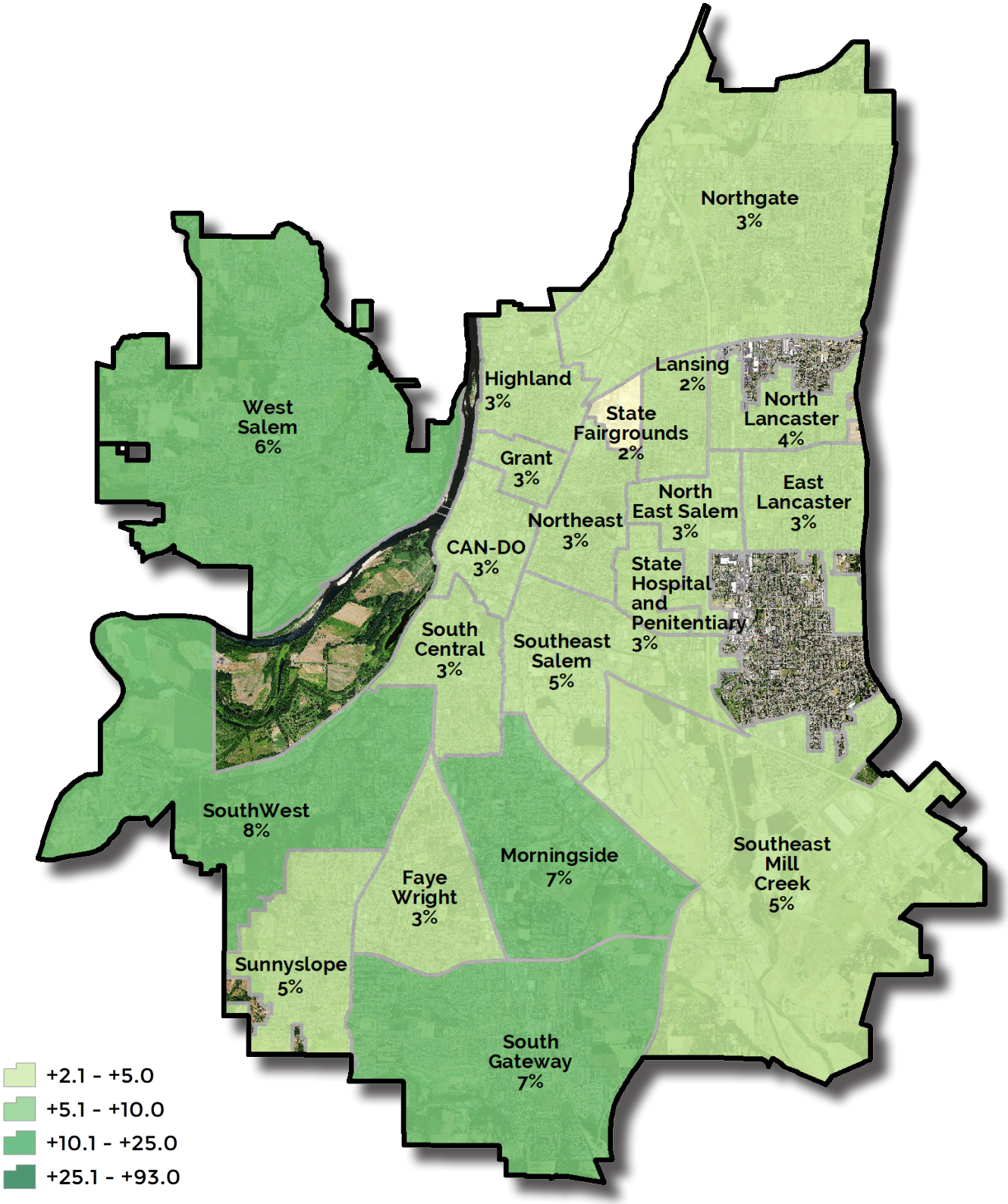


Figure 20. | Urban tree canopy change in Salem by neighborhoods.

URBAN TREE CANOPY CHANGE BY PARKS

Out of 90 parks assessed in this study, 13 experienced no gain or a loss of canopy. The largest acreage gain was in Salem's largest park Minto-Brown Island Park which gained 174 acres of canopy. The amount of canopy gain in Minto-Brown Island Park is due to growth of previously planted restoration areas and inclusion of former tree plantations in the overall canopy.

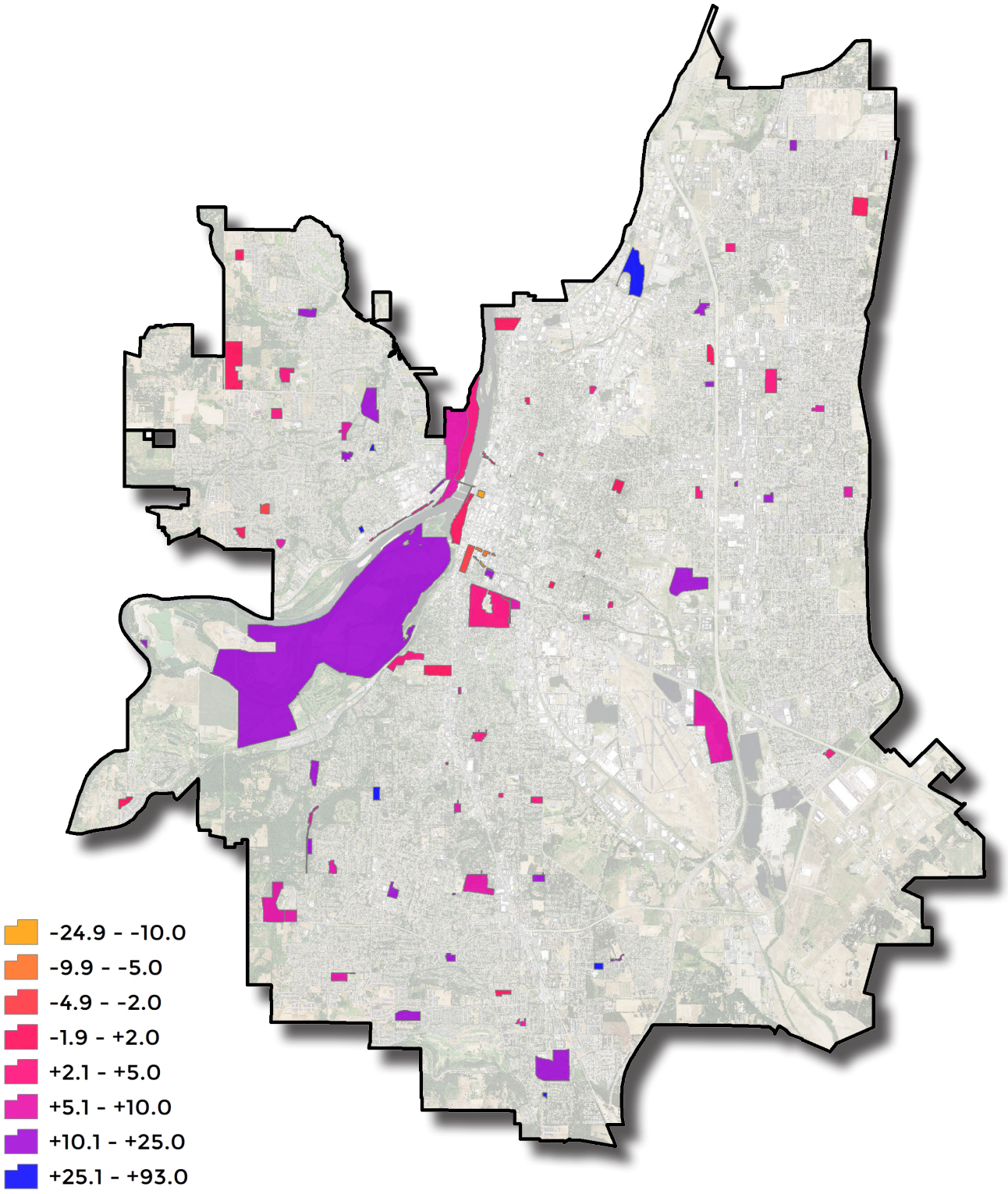


Figure 21. | Urban tree canopy change in Salem by parks.

URBAN TREE CANOPY CHANGE BY CENSUS BLOCK GROUPS

As one of the smaller geographic units, census block groups provide an additional measure for understanding canopy change in Salem. Nearly all block groups gained tree canopy while four had no change or lost canopy. The largest gain was 12% UTC, while the greatest loss was -3%. Throughout the UGB, the average change by census block group was a gain of about 5%. Refer to the UTC Results spreadsheet for complete change analysis results by census block groups.

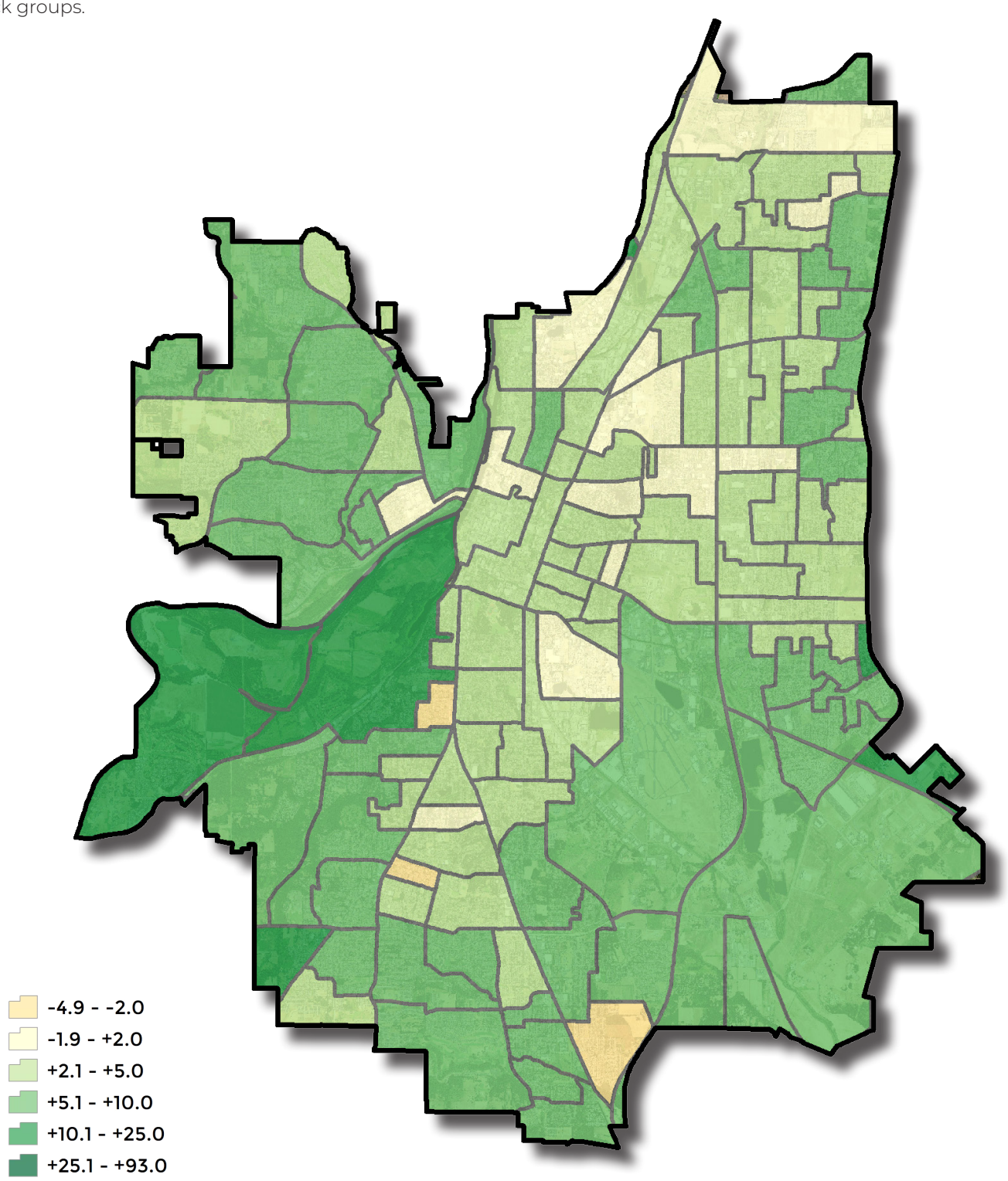


Figure 22. | Urban tree canopy change in Salem by census block groups.

QUANTIFYING ECOSYSTEM BENEFITS

Using the best available science from i-Tree tools, values were calculated for some of the benefits and functions provided by trees and forests in Salem. The urban forest holds millions of dollars of savings in avoided infrastructure costs, pollution reduction , and stored carbon.

AIR QUALITY

Trees produce oxygen, indirectly reduce pollution by lowering air temperatures, and improve public health by reducing air pollutants which cause death and illness.

- The existing tree canopy in Salem removes 274 tons of air pollution annually, valued at $4.2 Million

STORMWATER AND WATER QUALITY

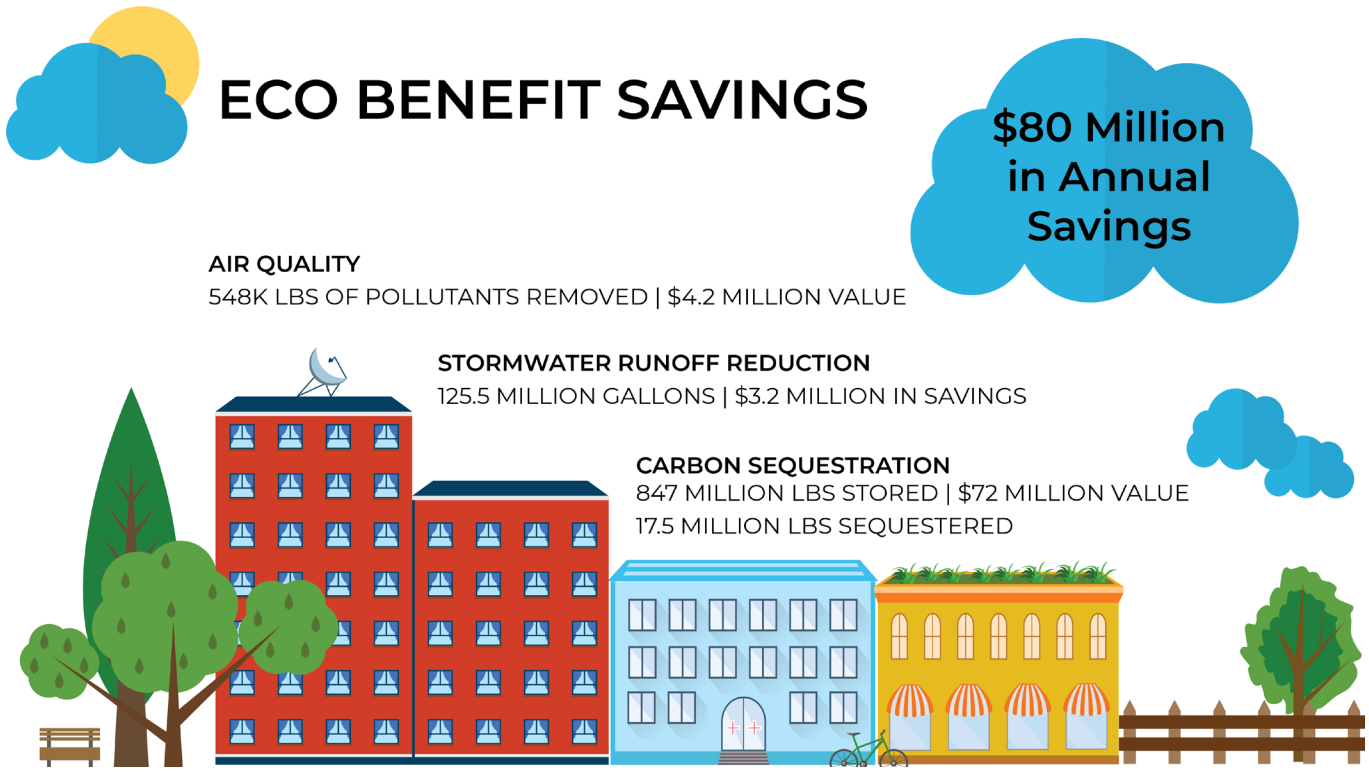
Trees and forests mitigate stormwater runoff which minimizes flood risk, stabilizes soil, reduces sedimentation in streams and riparian land, and absorbs pollutants, thus improving water quality and habitats.

- On average, each acre of tree canopy in Salem absorbs 40 thousand gallons of water. This benefit of avoided runoff is valued at roughly $350 per acre/per year. Extrapolated citywide, this means that Salem's existing tree canopy provides $3.2 million annually in stormwater benefits.

CARBON STORAGE AND SEQUESTRATION

Trees accumulate carbon in their biomass; with most species in a temperate forest, the rate and amount increase with age.

- Salem's trees store approximately 423 thousand tons of carbon, valued at $72.2 million and each year the tree canopy absorbs and sequesters approximately 3 thousand tons of carbon dioxide, valued at $1.5 million



CONCLUSIONS AND RECOMMENDATIONS

The City of Salem has demonstrated that it values its natural resources and wants to maintain a healthy and sustainable urban environment. This tree canopy assessment represents an important step in ensuring the long term health of its urban forest. A greater percent of canopy cover can be achieved with proper planning, investment, and care of existing trees. The City should continue to monitor the health of the urban forest and implement the following recommendations to ensure the urban forest is considered during future city planning and development to sustain and enhance the benefits that trees provide to the community.

Use priority planting data to identify suitable planting sites to address environmental, demographic, & socioeconomic benefits

1. Leverage the results of this assessment to promote the urban forest

To preserve, protect, and maintain Salem's tree canopy, the City should continue to have a tree canopy assessment performed on a regular interval. As the City changes, they will be able to use these data to ensure that their urban forest policies and management practices prioritize its maintenance, health, and growth. The City's urban forest provides Salem with a wealth of environmental, social, and even economic benefits which relate back to greater community interest in citywide initiatives and priorities. These results can be used to identify where existing tree canopy cover should be preserved, where there are opportunities to expand the City's canopy cover, and which areas would receive the greatest benefits from the investment of valuable time and resources into the urban forest in Salem.

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 and geographic assessment scale data should be disseminated to other City departments and sections (IT, GIS, Public Works, Trees Division) for urban forestry and other applications while they are current and most useful for decision-making and implementation planning. The information from this study can help refine canopy cover goals for the short- and long-term.

2. Use UTC, PPA, planting prioritization, and change analysis results to prioritize future plantings

The City of Salem and its various stakeholders can utilize the results of the UTC, PPA, planting prioritization, and change analyses to identify the best locations to focus future tree planting and canopy expansion efforts. While the City has canopy coverage spread throughout its entire area, breaking up the results by several different geographic boundaries demonstrated that this canopy is not evenly distributed. 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 Salem's urban forest.

3. Develop outreach programs towards private landowners

Out of all plantable space, 44% is found in residential areas as well as 68% of all PPA Vegetation. More specifically, 37% of all PPA and 52% of vegetated PPA is found in low or medium density residential areas. The City should focus

on community outreach and education programs to better inform citizens and private landholders of the environmental, social, and financial benefits that trees provide and consider other strategies to help preserve and grow the tree canopy. Tree giveaways, tree planting programs, and other incentives can be developed to further promote new tree plantings. In addition, the City should continue to conduct volunteer tree planting events to increase awareness levels in the community.

44% OF ALL PLANTABLE SPACE IN SALEM IS FOUND IN RESIDENTIAL AREAS

4. Incorporate the results of this assessment into the City's Community Forest Strategic Plan

Finalized and implemented in 2013, Salem's Community Forest Strategic Plan used the 2009 assessment of tree canopy as the baseline to inform future canopy goals. Plans and a goal were developed to achieve 23% canopy throughout the UGB. This 2018 analysis resulted in 24% average canopy cover in the UGB, thus meeting the City's initial goal. While some of the gains can be linked to the lack of LiDAR data in 2009 and differences in canopy exclusion areas, there is strong evidence that tree canopy in Salem has increased since 2009. Salem should develop new canopy goals based on the results of this latest canopy assessment. The geographic assessment scales in this study (e.g. zoning, census block groups, etc.) can provide valuable information on desirable and achievable goals that can be made to reach an overall goal throughout the urban growth boundary.

5. Use TreePlotter™ CANOPY software to evaluate possible management scenarios

The City can use TreePlotter™ CANOPY to explore a wide range of targeted, in-depth planting scenarios based on UTC and PPA metrics and planting prioritization criteria such as air quality, stormwater reduction, urban heat island, minority populations, underserved populations, and household income. CANOPY allows stakeholders to visualize existing land cover, create custom weighted priority planting maps, and quantify impacts that canopy growth or loss has on air quality and carbon sequestration in the City. These tools should be used to identify areas in most need of the benefits that trees provide.

REPORT 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 2018. 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. Eight hundred fifty (850) sample points, or approximately 14 points per square mile area in Salem (61 sq.miles), were randomly distributed across the study area and assigned a random numeric value.
2. Each sample point was then referenced using the OSIP 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 Salem’s landscape. The error matrix 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 blue boxes along the diagonals of the matrix represent agreement between the two-pixel maps. Off-diagonal values represent the

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.

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 (207 + 155 + 315 + 84 + 24 = 785 / 850 = 92%), and the matrix can be used to calculate per class accuracy percentages. For example, 207 points were manually identified in the reference map as Tree Canopy, and 225 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: (207/225 = .92), meaning that we can expect that ~92% of all 2018 tree canopy in the Salem, OR study area was classified as Tree Canopy in the 2018 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, 207 classification pixels intersecting reference pixels were classified as Tree Canopy, but 10 pixels were identified as Vegetation and one pixel as Impervious in the reference map. Therefore, the User's Accuracy for Tree Canopy is calculated as: (207/218 = 0.95), meaning that ~95% 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 Salem in 2018. The largest sources of classification confusion exist between tree canopy and vegetation.

Table A1. | Error matrix for land cover classifications in Salem, OR (2018).

Classification Data	Reference Data: Tree Canopy	Vegetation	Impervious	Soil / Dry Veg.	Water	Total Reference Pixels
Tree Canopy	207	10	1	0	0	218
Vegetation	11	155	8	6	0	180
Impervious	5	0	315	1	0	321
Soil / Dry Veg.	2	12	9	84	0	107
Water	0	0	0	0	24	24
Total	225	177	333	91	24	850

Overall Accuracy = 92%

Producer's Accuracy	
Tree Canopy	92%
Veg. / Open Space	88%
Impervious	95%
Bare Ground / Soil	92%
Water	100%

User's Accuracy	
Tree Canopy	95%
Veg. / Open Space	86%
Impervious	98%
Bare Ground / Soil	79%
Water	100%

ACCURACY ASSESSMENT RESULTS

Interpretation of the sample error matrix offers some important insights when evaluating Salem's urban tree canopy coverage and how land cover reported by the derived rasters and the human eye. The high accuracy of the 2018 data indicates that regardless of how and when it was achieved, Salem's current tree canopy can be safely assumed to match the figures stated in this report (approximately 24%).

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.

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

Total Acres: Total area, in acres, of the assessment boundary. (Salem City Limits combined with Salem Urban Growth 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 Growth Boundary: Lines drawn on planning and zoning maps to show where a city expects to experience growth for the next 20 years. Oregon land use laws limit development outside of urban growth boundaries. For purposes of this study, the Keizer portion of the Salem/Keizer UGB was excluded and the UGB boundary is for Salem only.

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 the urban forest. Tree canopy was generally taller than 10-15 feet tall.

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

DECEMBER | 2019

URBAN TREE CANOPY ASSESSMENT

SALEM, OREGON

CITY OF Salem AT YOUR SERVICE

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