GIS Analysis of Salem's Potential Urban Tree Canopy

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Source: City of Salem Public Works Department

Prepared for:
The City of Salem, Oregon
Public Works Department

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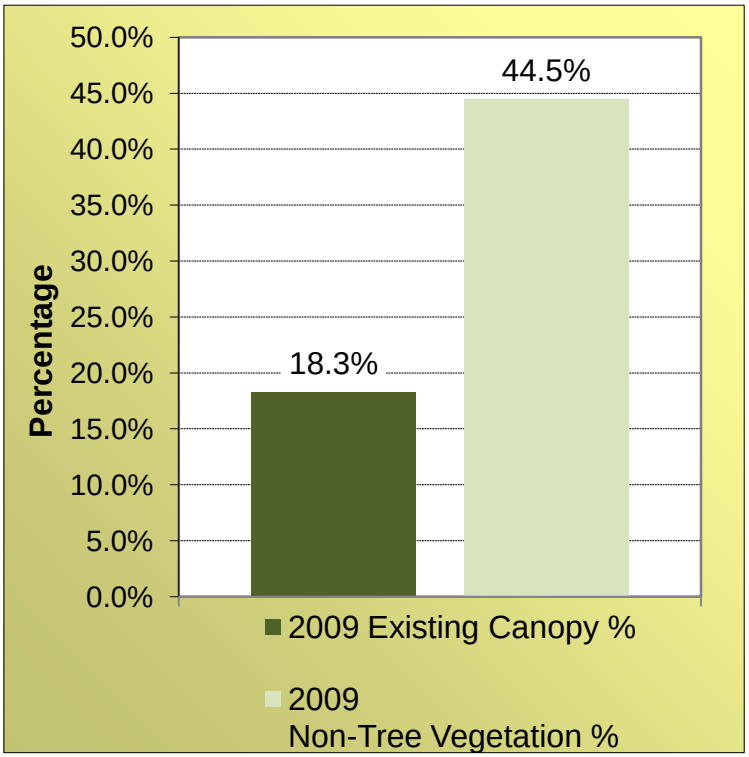
Introduction

In 2010 AMEC Environment and Infrastructure (AMEC) performed an Urban Tree Canopy (UTC) assessment for the City of Salem utilizing remote sensing and GIS technology. This phase 1 assessment shows a citywide canopy cover of 18.3% (Figure 1) based on 2009 imagery. This indicates a slight increase in canopy cover from the 2001 imagery where a canopy cover of 18.2 % was determined. The Phase 1 UTC report provided existing canopy cover for eight (8) zoning categories and Salem's sub-basins (sub-watersheds) in addition to the citywide canopy cover.

In 2011, the City of Salem undertook Phase 2 of its urban tree canopy assessment, the assessment of "Potential" tree canopy. The objective in analyzing Potential urban tree canopy was to create an easy-to-use and meaningful GIS database that could support future canopy goal setting at 10-year intervals for monitoring over time.

Figure 1. Citywide existing tree canopy and non-tree vegetation in Salem in 2009



This analysis additionally provides 2009 canopy metrics for the geographic boundaries of neighborhoods, street rights-of-way, city-owned properties, parks and schools. For these geographic boundaries, AMEC also mapped and calculated the area and percent of non-tree canopy vegetation. This is referred to as "possible plantable area" or areas where it is possible to plant trees and establish tree canopy (see Figures 1 and 2). This particular level of analysis does not take into account site specifics or the desirability of tree planting locations.

To estimate Potential UTC, additional analysis was conducted to project the amount of canopy area that can be produced from the possible plantable area (see Figure 3). As an example, a narrow planting strip along a street has a small amount of possible plantable area but has high potential tree canopy area given the canopy will grow beyond the planting strip over the street, sidewalk, a driveway, a parking lot or yard. As part of the Potential UTC analysis, AMEC developed a GIS-based grid across the city and created numerous attributes for prioritizing potential planting areas. Example factors where tree planting is a priority include areas of low canopy cover,

high possible plantable area, and proximity to impervious area, major transportation routes, and riparian corridors. Additional information on the methods is provided in this report. The dataset is designed to provide Salem with a flexible, dynamic way of locating and ranking plantable areas at the neighborhood scale to assist in goal setting and public outreach.

In addition, a UTC Calculator spreadsheet tool was developed as a simple way for non-GIS users to see the effects of tree planting on canopy cover by zoning types and citywide. By adjusting the number of trees planted and average canopy size, the increase in percent canopy is updated, or a desired canopy cover percent goal can be entered to calculate the number of trees needed to reach that goal. The tool uses the existing tree canopy and possible plantable area metrics at the start.

AMEC also estimated tree benefits related to potential tree canopy goals using the U.S. Forest Service Program i-Tree Design. Using representative tree species in Salem, an average dollar value per tree was determined that includes combined benefits from stormwater, air quality mitigation, and carbon sequestration. A brief overview of i-Tree methods and results are provided in this report.

Deliverables from this analysis:

- GIS layers:
    - Land cover data (note that a tree canopy layer was delivered in Phase 1): a non-tree canopy vegetation layer comprised of grass, shrubs and other herbaceous vegetation and an impervious surface layer;
    - Metrics of existing UTC and possible plantable area as new fields and attributes in the boundaries listed above;
    - Potential UTC metrics citywide and by neighborhood projected for the years 2020, 2030, and 2040
    - Grid database including number of potential tree planting locations and other attributes for prioritizing potential tree canopy;
- An Excel-based Urban Tree Canopy Calculator; and
- This report documenting the methods and results of analysis, possible uses for canopy goal setting, and discussion and comparison of canopy goals for cities in the Pacific Northwest

Urban Tree Canopy (UTC) Assessment Terminology

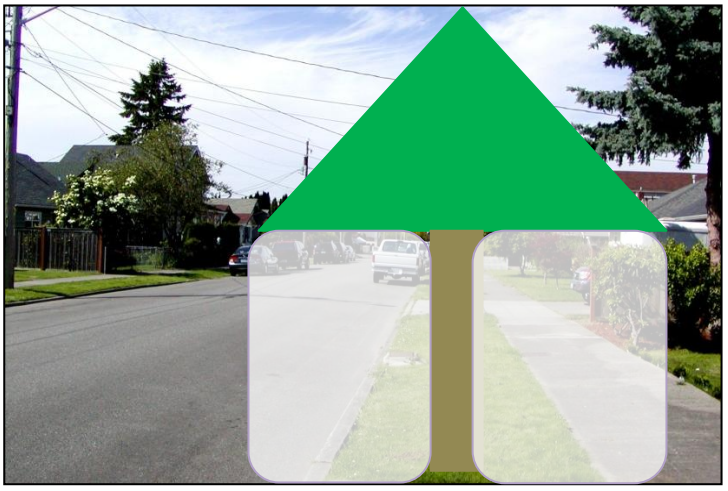
Canopy assessment involves analyzing existing tree cover and where there is potential to increase canopy. Two main terms are used in this assessment.

- **Possible Plantable Area**: non-road, non-building, and non-water land where it is feasible to plant trees. This term is in lieu of the commonly used "Possible UTC" which is a misnomer because it does not reflect canopy area but rather plantable space. In Salem's assessment, this includes the area of turf grass along streets and in yards as well as other non-tree canopy vegetation (open space). Maps, tables and charts that report the acres and percent of possible plantable area in this report show the cumulative amount of plantable area for different geographic boundaries.

Figure 2. Possible Plantable Area

- **Potential Urban Tree Canopy**: this is the result of adding existing canopy to newly planted trees grown out over time. Using grid cells 100x100 feet in size, the number of planting sites was determined based on possible plantable area and other factors. By "growing" these potential trees over time and adding to the existing UTC, estimates of Potential UTC were able to be generated, better representing total potential canopy cover. This was calculated for neighborhood boundaries at 10-year intervals for 2020, 2030, and 2040.

Figure 3. Potential Urban Tree Canopy

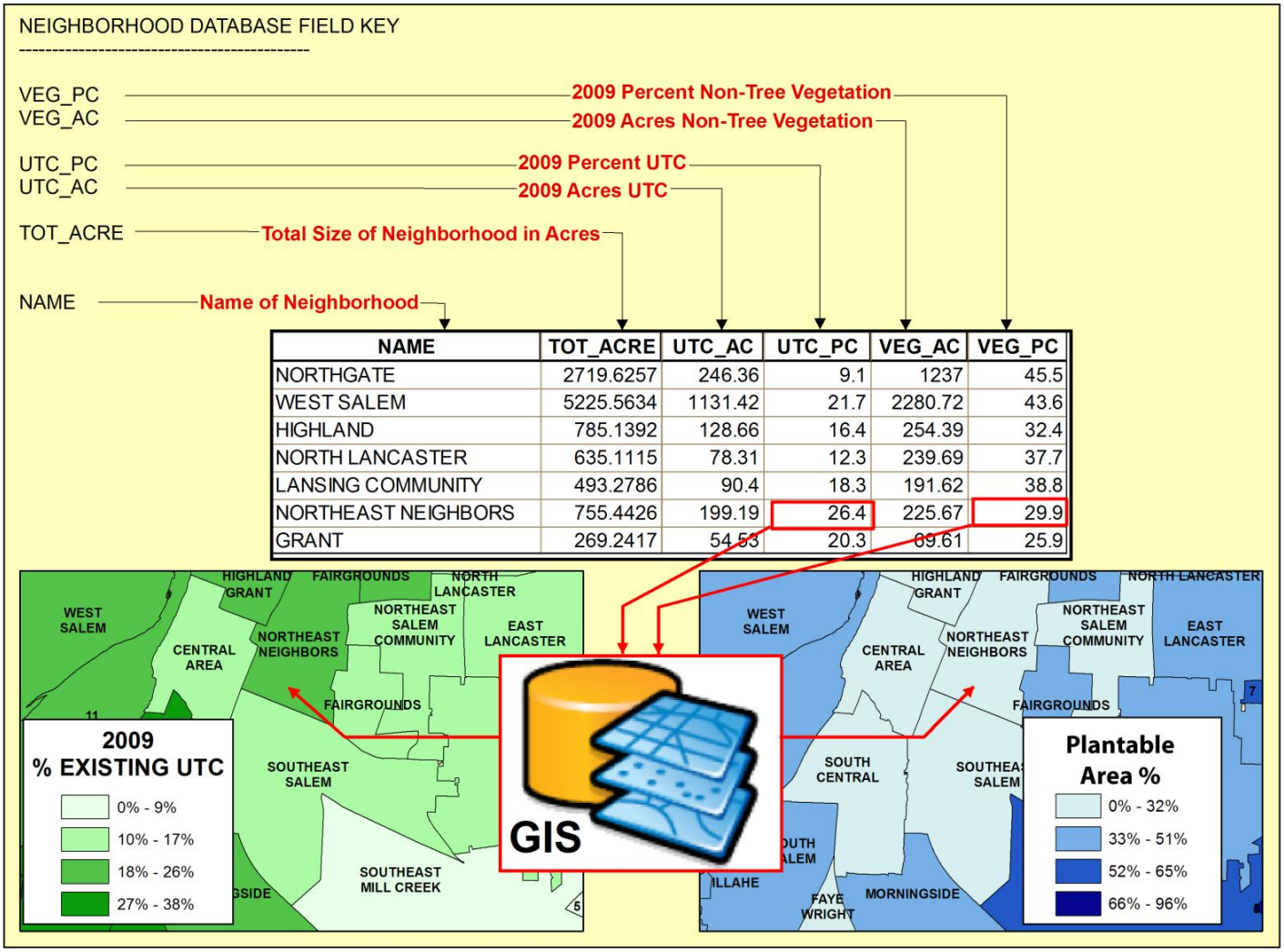


- **Preferable Urban Tree Canopy**: A third term, Preferable Urban Tree Canopy, is suggested for Salem's next level of analysis to determine what canopy cover is preferred in Salem, socially, financially and physically. This level of analysis is not included in this report.

Methods for Possible Plantable Area and Potential UTC Analysis

The initial step to better understand Salem's Potential UTC involved extracting all non-tree canopy vegetation (grass, meadow, and open space) from the 1-meter resolution 2009 imagery used in the initial UTC assessment. Non-tree canopy vegetation was mapped by masking out (excluding) trees/forests using a technique known as geographic object-based image analysis (GEOBIA). This GIS land cover layer became the Possible Plantable Area. The area and percent of plantable area was calculated citywide, for zoning types, neighborhoods, sub-watersheds, parks, schools and other public properties. An example at the neighborhood scale showing how this data was provided is seen in Figure 4 below. All other geographic boundaries assessed include a similar field naming and database structure and can be queried and displayed to produce similar maps. Results for each geographic boundary are provided in the Results section of this report beginning on page 11.

Figure 4. Field Key of the Existing UTC and Possible Plantable Area Database for Neighborhoods



The next step was to analyze Potential UTC. The objective was to create an easy-to-use and meaningful GIS database that could support future canopy goal setting at 10-year intervals and be monitored over time. A grid cell layer was developed across the city at 100-foot spacing as a way to break up possible plantable areas and estimate the potential area of canopy that could be created. After calculating the possible plantable area within each grid cell, the number of trees that could be planted in each grid was determined. City staff performed field checks to guide the development of rules for planting 0, 1, 2, or 3 trees in each grid cell based on the amount of plantable area, building area, water, impervious surface, and zoning type.

With the grid layer in place to calculate Potential UTC, a series of GIS steps were then conducted to allow the City to prioritize tree planting opportunities. Factors that influence planting were discussed and created as attributes in the grid database based on available GIS data. Other factors can be added to the model at a later date as new data becomes available.

The following attributes and processes were added and applied to each grid cell:

- Number of potential tree planting sites
    - This ranged from 0 to 3 trees and was supported by field checks performed by the City staff across different zoning categories and densities of development. Note that a value of 0.5 (half of a tree) was allowed as a way to conservatively allocate the number of trees in some areas.
- Factors (attributes for querying, map-making, and ranking opportunities):
    - Percent of existing tree canopy, non-tree canopy vegetation (grass and open space), impervious surfaces, water and buildings
    - Predominant zoning category (12 types) including schools, parks, city-owned properties and street ROW) and secondary mixed zoning category (e.g. ROW_Low_Density_Residential)
    - Proximity to large impervious areas, within 50-feet streams, riparian shade zones (0-3 value), and in or near transportation thoroughfares
    - Sub-basin and neighborhood associated with each grid cell
- Prioritizing areas for planting and weighting factors
    - Schools, parks, street rights-of-way, and city-owned properties were valued higher than other zoning types
    - Factors were weighted on a 0 to 10 scale (See example in Figure 7 on page 10 for each factor and weight it received.)
    - A weighted suitability score between 0 and 100 was then generated for each grid cell (the higher the score, the higher the suitability)
- Projecting increases in Potential UTC spatially and temporally
    - Using the grids with the highest suitability score first, Salem's Potential UTC was calculated by neighborhood at intervals of 10, 20 and 30 years (2020, 2030, and 2040)

- Over this 30-year period, roughly 4,000 grids were allocated per year in the model equating to approximately 6,000 tree plantings per year (includes public and private property). This variable can be changed in the model to see the effects of more or less tree planting.
- Additionally, the annual growth rate of average trees can be adjusted to automatically recalculate Potential UTC at a given year. The age of each tree is included in the formulas which summarize the new area of tree canopy per neighborhood.

For grids with 100% water or building, or in golf courses, the airport, agricultural fields and recreational ball fields, the number of trees was set to zero (0) or these cells were deleted from the grid layer. As seen in Figure 5, there is possible plantable area in ball fields but then quality control steps and suitability analysis removes or reduces this.

Some limitations of this process include:

- Overestimation of potential planting sites due to existing small trees not mapped in the land cover data and therefore 'double counted'
- Overestimation of the number of potential planting sites due to conflicts involving safety, social desire, or utilities
- Underestimation where land cover data did not indicate additional trees were possible, for example, narrow planting strips along streets.

Pages 8-10 provide elements and examples of the grid-based methodolody and the maps on pages 18-19 (Figures 18 and 19) show the results of Potential UTC by neighborhood for the projected years of 2020, 2030, and 2040.

Figure 5 (a-d). a. Color-infrared image and streets where red indicates vegetation, b. Land cover data [trees and other vegetation (green) and impervious surfaces (black)] with 100-foot grid, c. grids symbolized by number of plantable trees, and d. example of grids ranked by described factors.

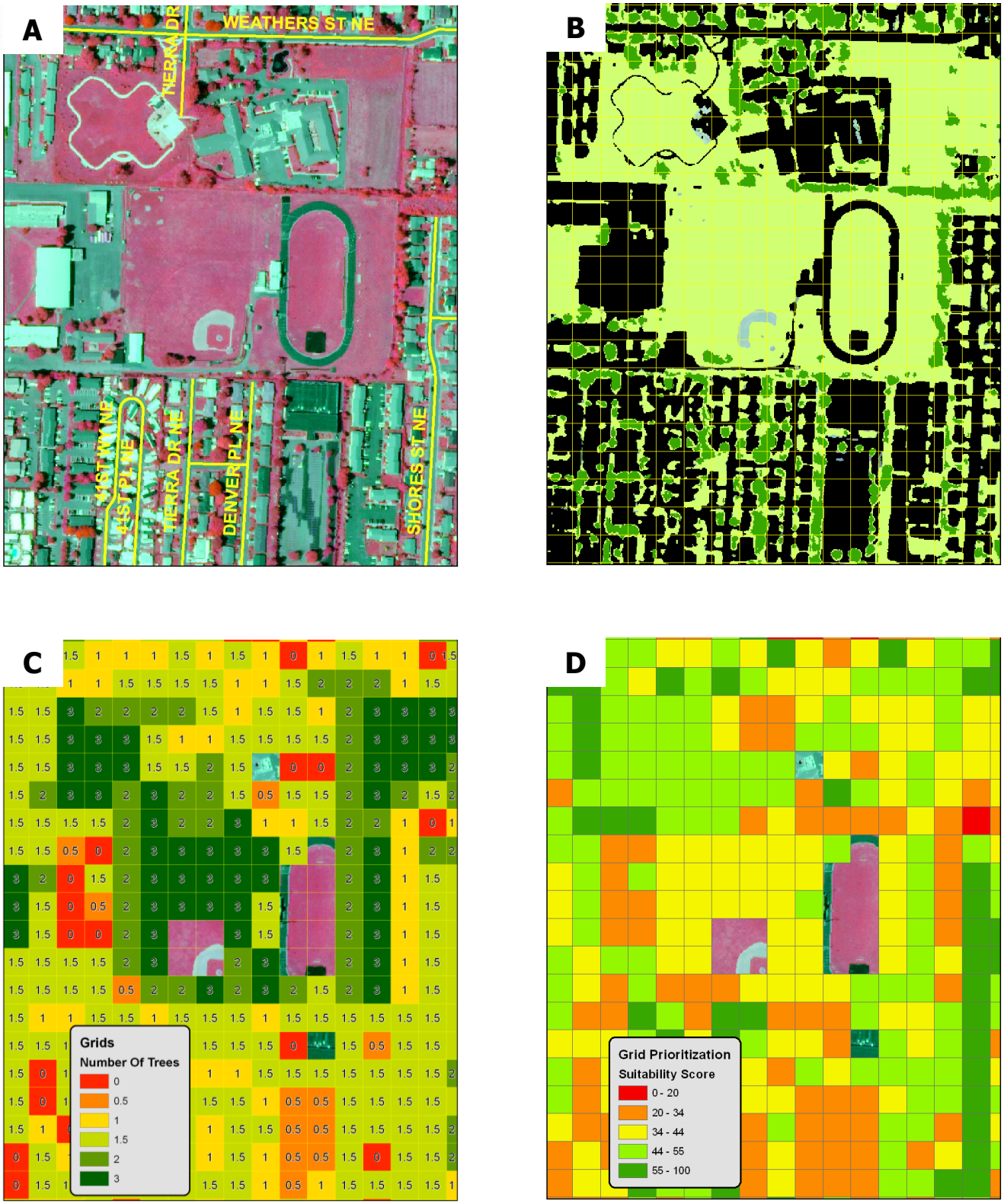


Figure 6 (a and b). a. Larger overview of infra-red image and streets showing the b. grid layer color-coded by Suitability Score using the factors and example weights described. Dark green cells equal the highest scores and red cells are areas with the lowest planting potential.

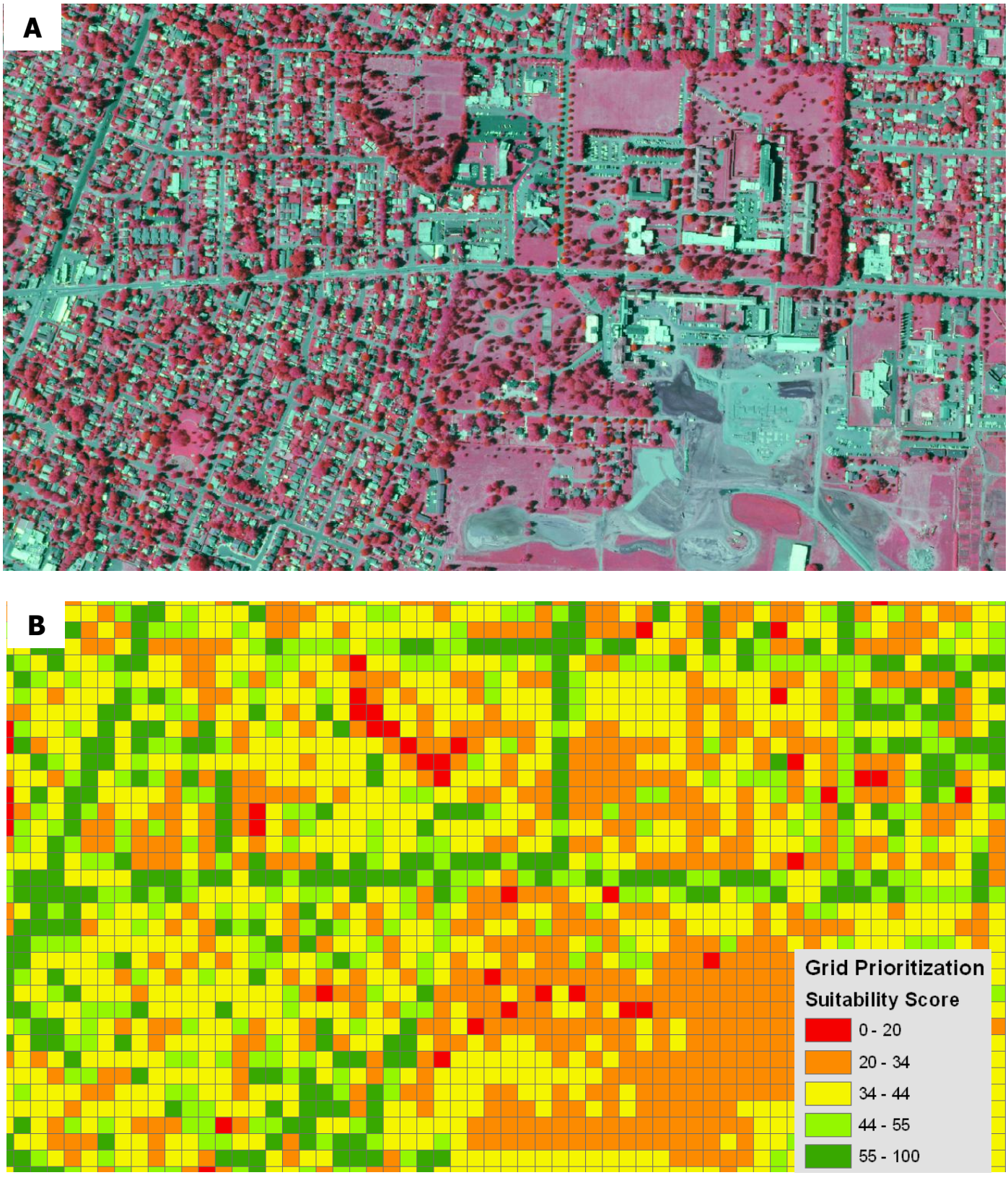
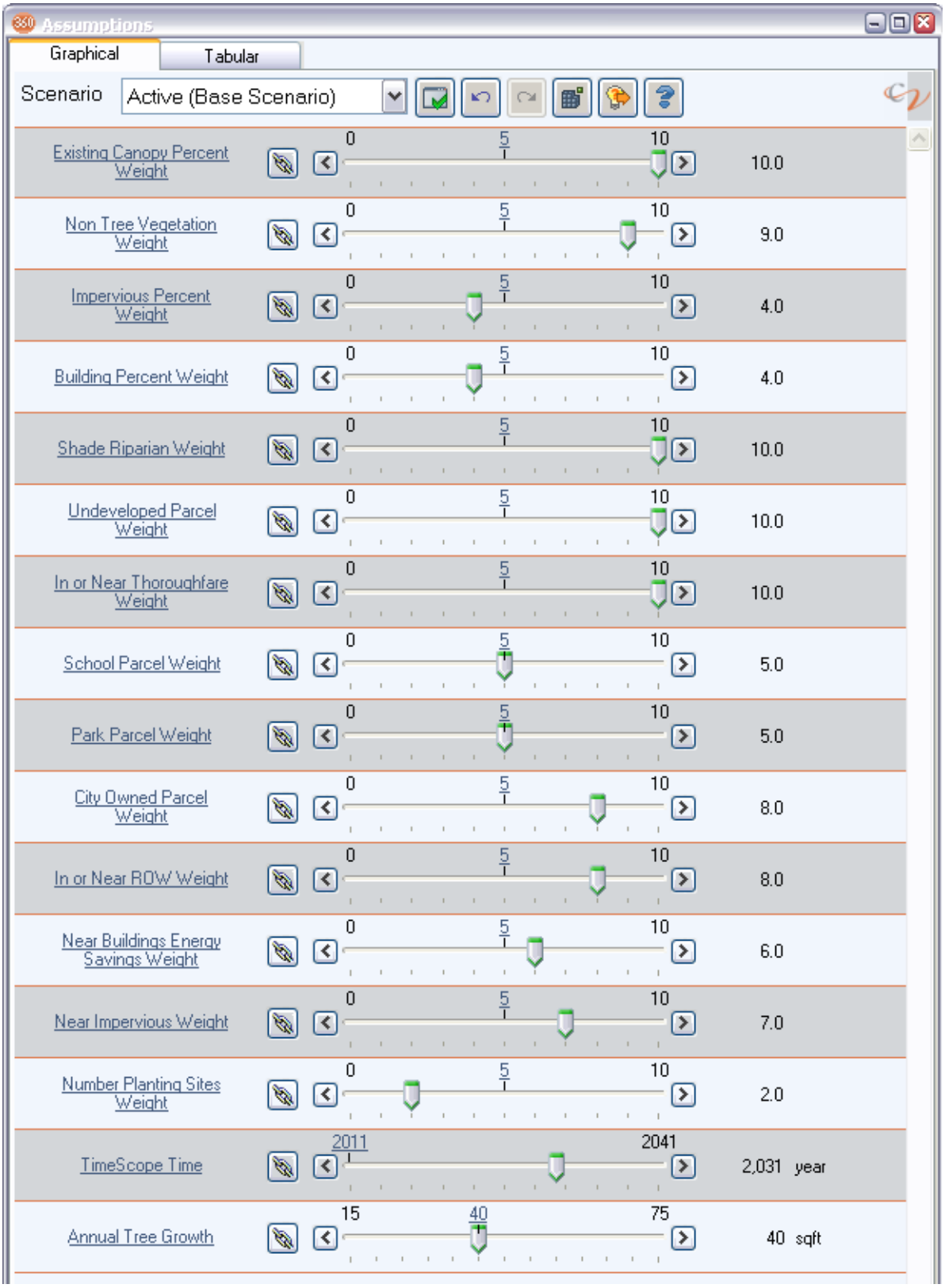


Figure 7. Factors used in a Grid-Based Suitability Analysis including an example of weighting from 0 to 10. Salem can apply different weights to see the effect on Potential Urban Tree Canopy scenarios by neighborhood. Custom maps and selections can be made to locate tree planting opportunities for specific purposes.



Results

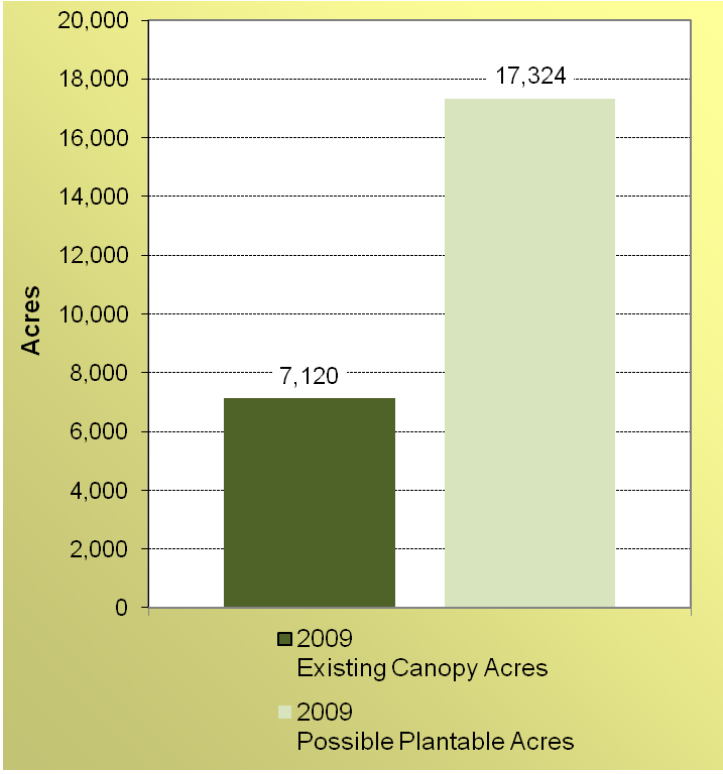
Results for Existing urban tree canopy (UTC), Possible plantable area, and Potential UTC are shown in the following tables, charts, and maps. They illustrate the results beginning at the citywide scale followed by 8 broad zoning categories, then parks, schools, city-owned properties, street rights-of-way, sub-basins, and neighborhoods. Note that total acreage of the study area is different from other boundaries due to slight differences in the periphery of certain GIS layers and because the Willamette River is not included in zoning types, sub-basins or neighborhoods.

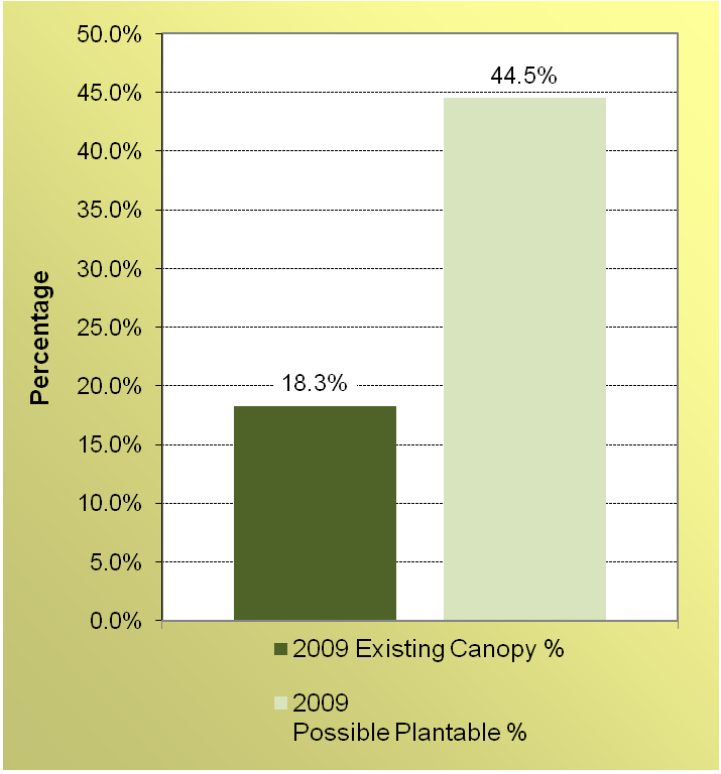
Results Citywide

Table 1. Existing UTC and Possible Plantable Area in Salem

Salem Urban Growth Boundary (excludes Keizer)	Total Acres	2009 Existing Canopy Acres	2009 Existing Canopy %	2009 Possible Plantable Acres	2009 Possible Plantable %
	38,926	7,120	18.3%	17,324	44.5%

Figures 8 and 9. Existing UTC and Possible Plantable Area in Acres and Percent





Results for Zoning Categories

Table 2. Existing UTC and Possible Plantable Area by Zoning Type

Zoning Type	Total Acres	2009 UTC Acres	2009 % UTC	2009 Possible Plantable Acres	2009 Possible Plantable %
Commercial	2,322	228	9.8%	686	29.6%
Downtown	139	13	9.4%	19	13.6%
Industrial	4,189	308	7.4%	1,970	47.0%
Low Density Residential	6,698	1,649	24.6%	4,009	59.9%
Medium Density Residential	10,591	2,609	24.6%	4,469	42.2%
High Density Residential	2,362	413	17.5%	824	34.9%
Other Public Land	3,664	374	10.2%	2,343	64.0%
PROW	5,934	777	13.0%	1,519	25.6%
Public Open Space	2,472	674	27.3%	1,413	57.2%
Totals	**38,370**	**7,045**	**18.4%**	**17,252**	**45.0%**

Figure 10. Existing UTC and Possible Plantable Area by Zoning Type in Percent

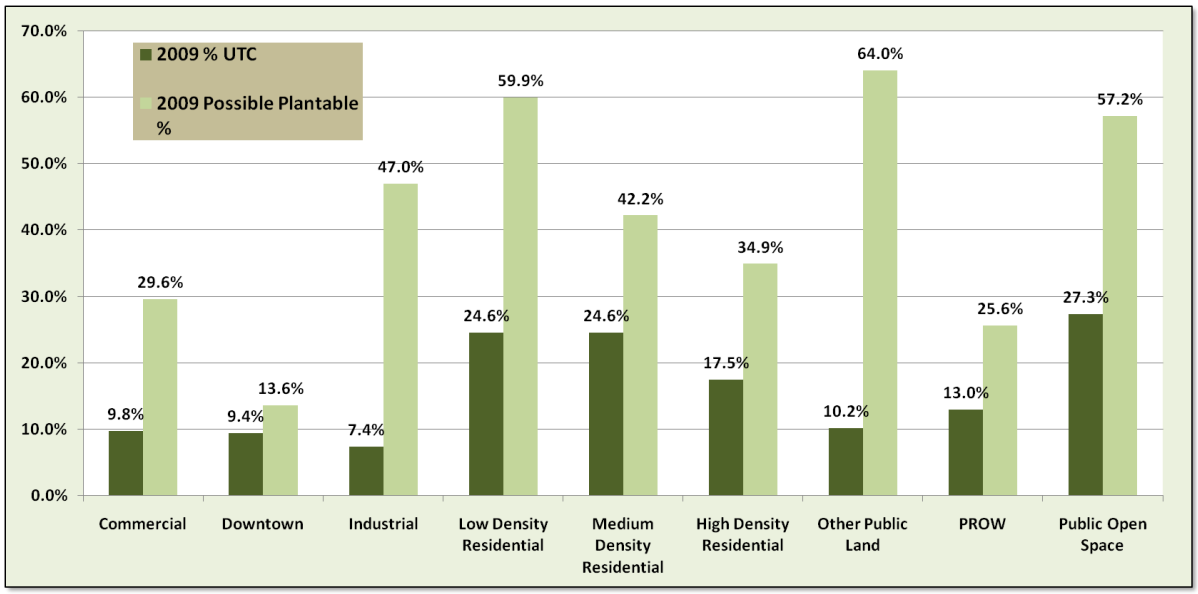
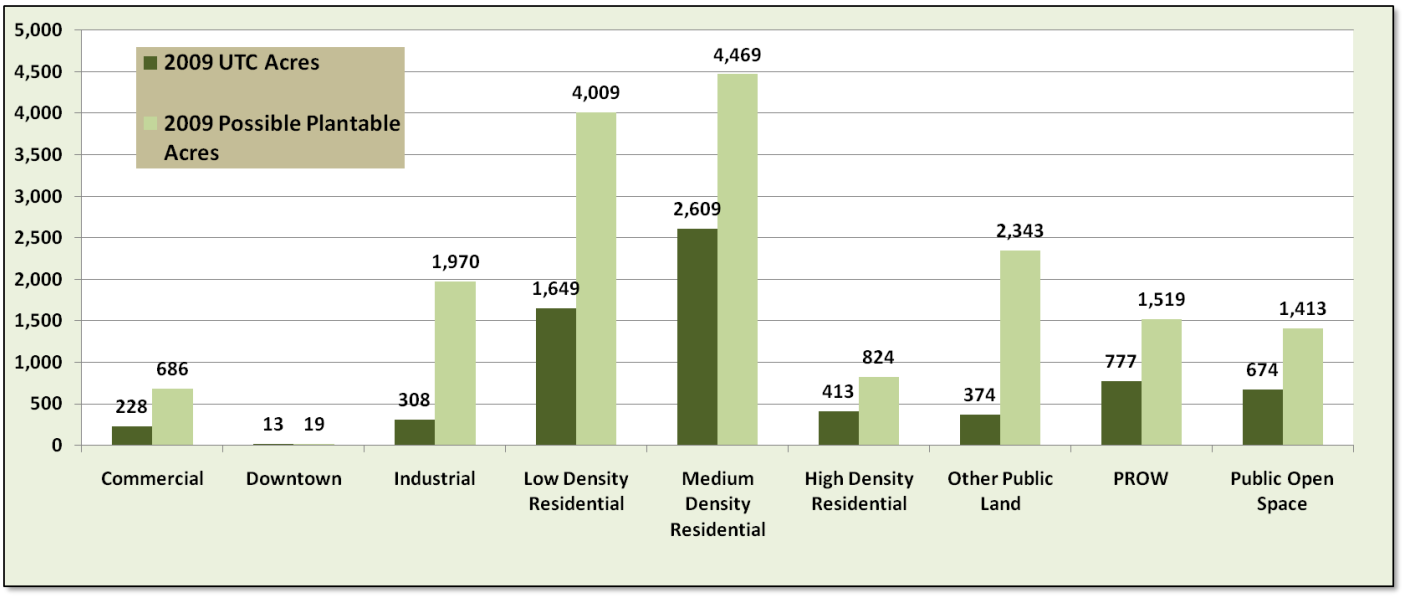


Figure 11. Existing UTC and Possible Plantable Area by Zoning Type in Acres

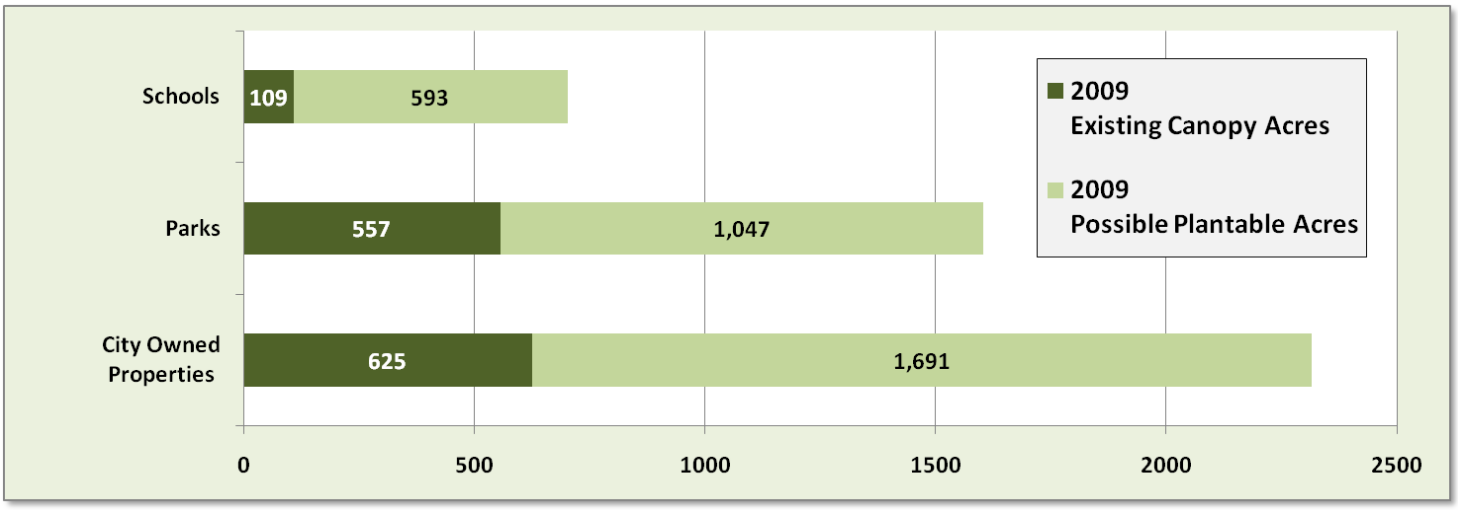


Salem's Existing UTC and Possible Plantable Area by Other Property Types

Table 3. Existing UTC and Possible Plantable Area for Other Property Types

Other Property Types	Total Acres	2009 Existing Canopy Acres	2009 Existing Canopy %	2009 Possible Plantable Acres	2009 Possible Plantable %
City Owned Properties	2,783	625	22.5%	1,691	60.8%
Parks	1,847	557	30.2%	1,047	56.7%
Schools	982	109	11.1%	593	60.4%
Total	5,612	1291	23.0%	3,331	59.4%

Figure 12. Existing UTC and Possible Plantable Area for Other Property Types

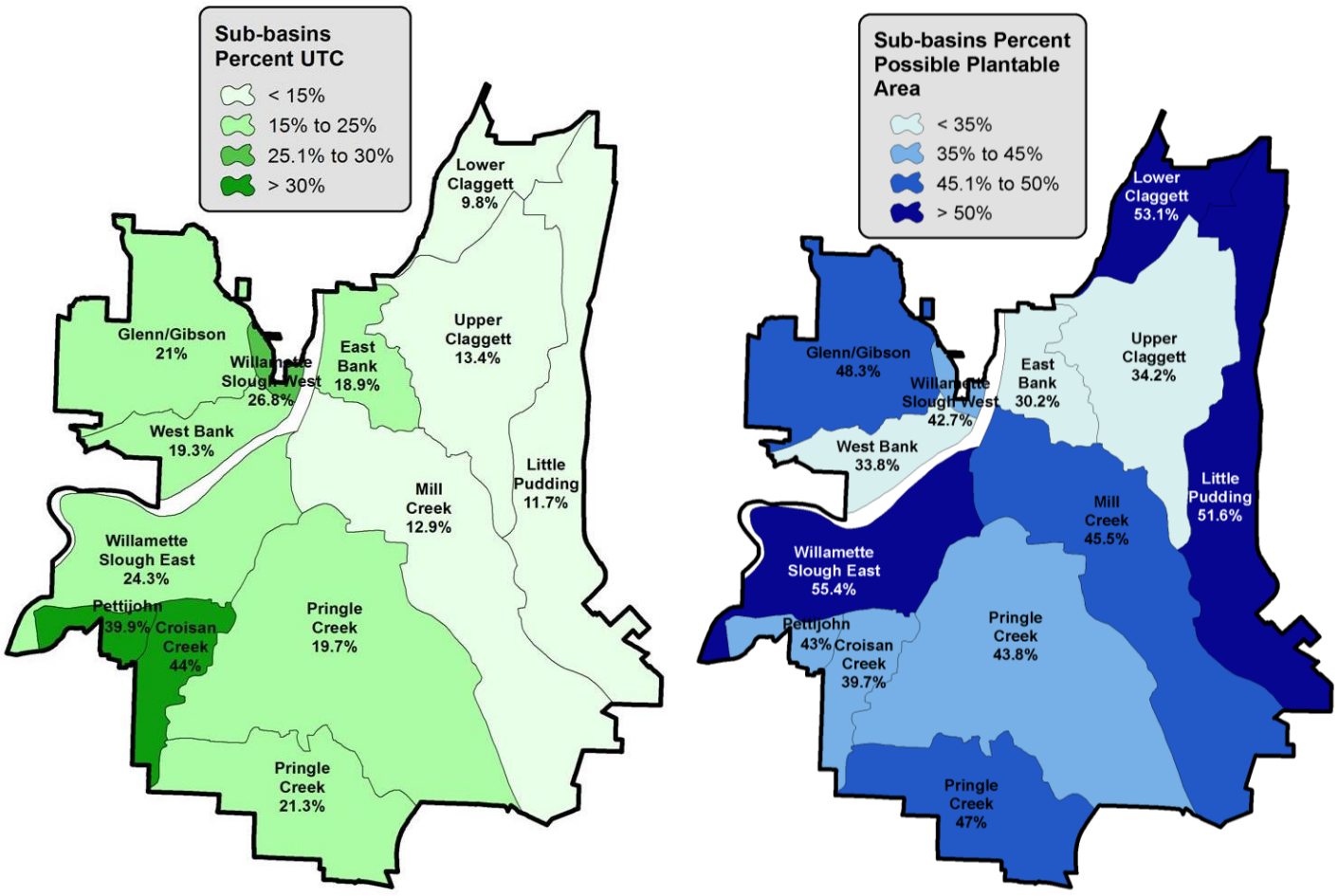


Results for Sub-Basins

Table 4. Existing UTC and Possible Plantable Area by Sub-basin (Note: does not include acreage from Willamette River)

Sub-basins	Sub-basin Code	Total Acres	2009 UTC Acres	2009 UTC %	2009 Possible Plantable Acres	2009 Possible Plantable %
Lower Claggett	01-LCB	1,484	145	9.8%	788	53.1%
East Bank	02-EBB	1,261	238	18.9%	380	30.2%
Upper Claggett	03-UCB	4,328	578	13.4%	1,481	34.2%
Little Pudding	04-LPB	4,602	538	11.7%	2,373	51.6%
Willamette Slough East	05-WSE	3,285	798	24.3%	1,820	55.4%
Mill Creek	06-MCB	6,096	787	12.9%	2,776	45.5%
Croisan Creek	07-CCB	1,167	513	44.0%	463	39.7%
Pringle Creek	08-PCB	7,342	1448	19.7%	3,217	43.8%
Battle Creek	09-BCB	3,017	641	21.3%	1,418	47.0%
Willamette Slough West	10-WSW	254	68	26.8%	109	42.7%
Glenn/Gibson	11-GGB	3,569	749	21.0%	1,724	48.3%
West Bank	12-WBB	1,320	255	19.3%	447	33.8%
Pettijohn	13-PJB	562	224	39.9%	241	43.0%
Totals		**38,288**	**6984**		**6,984**	

Figures 13 and 14. Existing UTC and Possible Plantable Area by Sub-basin



Results for Neighborhoods

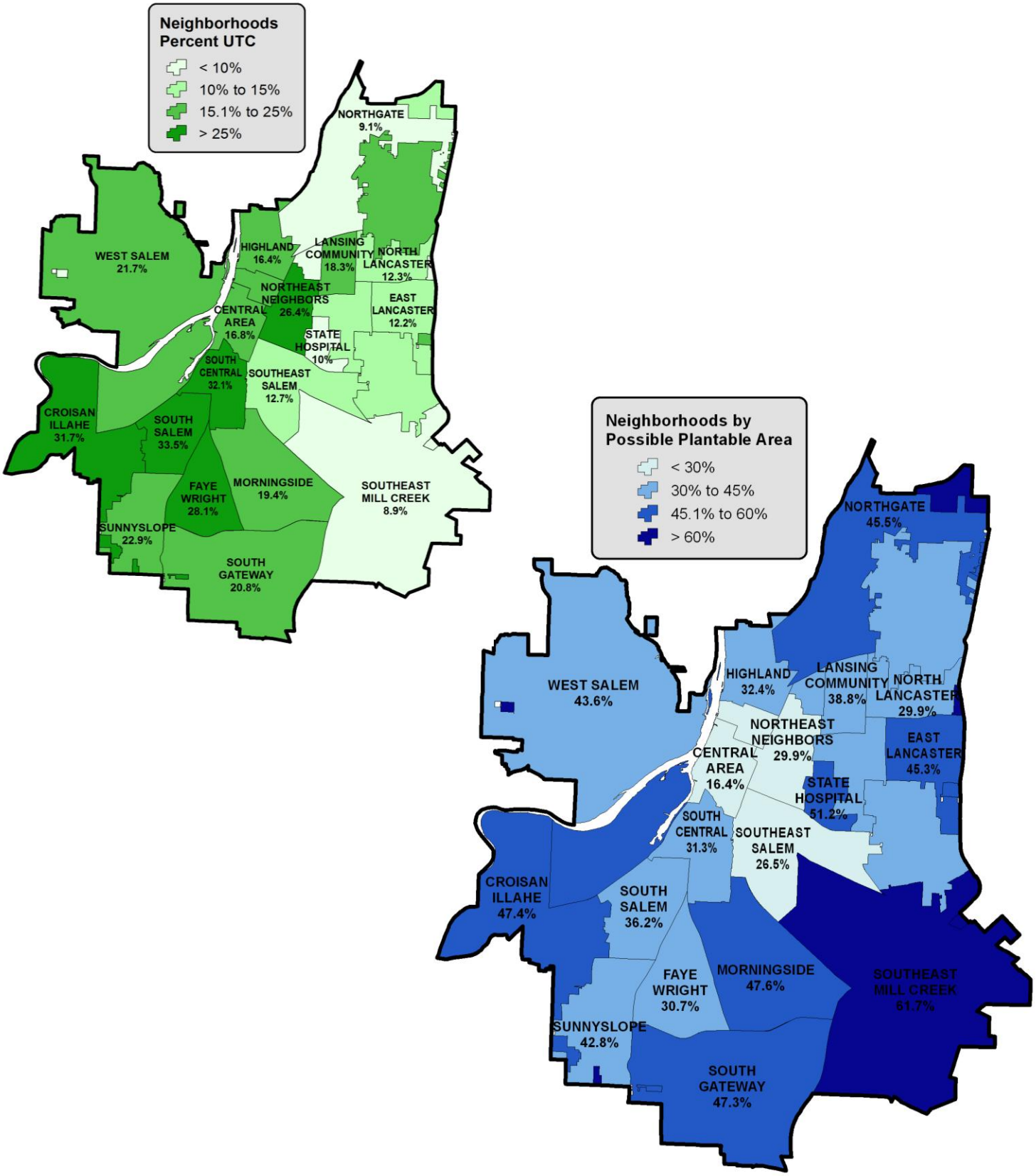
Salem has 21 named neighborhoods that provide a community-based scale for urban tree canopy enhancement and public outreach, education and involvement. When compared to Salem's urban growth boundary (excluding Keizer), 12 holes exist in the neighborhoods layer that were filled in sequentially from 1-12. For each neighborhood boundary, the Existing UTC, Possible Plantable Area and Potential UTC metrics were calculated. Existing UTC and Possible Plantable Area was also calculated within the public rights-of-way (PROW) by neighborhood.

Table 5. Existing UTC and Possible Plantable Area by Neighborhood and by Public Right-of-Way (PROW) per Neighborhood

Neighborhoods	Total Acres	2009 UTC Acres	2009 UTC %	2009 Possible Plantable Acres	2009 Possible Plantable %	Total PROW Neighborhoods Acres	PROW Neighborhoods %	PROW UTC Acres	PROW UTC %	PROW Possible Plantable Acres	PROW Possible Plantable %
CENTRAL AREA	626	105	16.8%	103	16.4%	193	30.8%	36.1	18.8%	26.9	13.9%
CROISAN ILLAHE	2,504	793	31.7%	1188	47.4%	141	5.6%	32.1	22.7%	39.4	27.9%
EAST LANCASTER	940	114	12.1%	426	45.3%	138	14.7%	14.0	10.1%	26.1	18.9%
FAIRGROUNDS	173	14	8.1%	69	39.7%	10	5.8%	0.9	9.2%	0.9	8.5%
FAYE WRIGHT	1,146	322	28.1%	351	30.7%	217	18.9%	36.4	16.8%	44.3	20.4%
GRANT	269	55	20.4%	70	25.9%	99	36.9%	25.0	25.1%	24.5	24.6%
HIGHLAND	785	129	16.4%	254	32.4%	208	26.5%	34.6	16.6%	54.5	26.2%
LANSING COMMUNITY	493	90	18.2%	192	38.8%	113	23.0%	11.1	9.8%	29.8	26.3%
MORNINGSIDE	2,100	407	19.4%	999	47.6%	325	15.5%	45.1	13.9%	89.0	27.4%
NORTH LANCASTER	635	78	12.3%	240	37.7%	116	18.2%	9.9	8.5%	25.2	21.7%
NORTHEAST NEIGHBORS	755	199	26.3%	226	29.9%	189	25.0%	50.6	26.8%	46.1	24.4%
NORTHEAST SALEM COMMUNITY	689	80	11.6%	219	31.8%	165	23.9%	13.5	8.2%	38.8	23.6%
NORTHGATE	2,720	246	9.0%	1237	45.5%	559	20.5%	32.0	5.7%	200.3	35.8%
SOUTH CENTRAL	850	273	32.1%	266	31.3%	204	24.0%	53.9	26.4%	50.7	24.9%
SOUTH GATEWAY	3,316	691	20.8%	1570	47.3%	586	17.7%	74.8	12.8%	150.8	25.7%
SOUTH SALEM	1,015	340	33.5%	367	36.2%	187	18.4%	38.2	20.4%	47.7	25.4%
SOUTHEAST MILL CREEK	5,800	517	8.9%	3578	61.7%	552	9.5%	38.5	7.0%	224.3	40.7%
SOUTHEAST SALEM	1,564	199	12.7%	414	26.5%	332	21.2%	48.7	14.7%	79.0	23.8%
STATE HOSPITAL	358	36	10.0%	183	51.2%	16	4.4%	3.6	22.6%	3.7	23.2%
SUNNYSLOPE	1,244	284	22.8%	532	42.8%	224	18.0%	31.1	13.9%	48.2	21.5%
WEST SALEM	5,226	1131	21.6%	2281	43.6%	748	14.3%	76.9	10.3%	146.1	19.5%
1*	18	7	37.9%	11	56.8%	0	0.1%	0.0	0.0%	0.0	0.0%
2*	20	1	4.9%	18	90.7%	0	0.0%	0.0	0.0%	0.0	0.0%
3*	20	6	29.5%	13	65.0%	0	0.0%	0.0	0.0%	0.0	0.0%
4*	26	6	23.5%	15	59.7%	0	0.2%	0.0	36.6%	0.0	36.6%
5*	27	1	3.7%	26	95.8%	4	14.4%	0.1	2.6%	3.8	97.2%
6*	35	0	0.0%	33	94.1%	2	5.0%	0.0	0.6%	0.4	21.2%
7*	39	9	23.1%	22	55.8%	1	1.4%	0.1	16.6%	0.1	12.9%
8*	78	24	30.9%	47	60.0%	3	4.0%	0.5	16.3%	0.8	24.4%
9*	279	40	14.3%	176	63.1%	18	6.5%	2.0	11.0%	6.4	35.5%
10*	1,361	192	14.1%	502	36.9%	248	18.2%	21.5	8.7%	43.7	17.6%
11*	1,893	415	21.9%	951	50.2%	24	1.3%	9.9	40.7%	5.7	23.2%
12*	1,909	308	16.1%	730	38.2%	313	16.4%	35.9	11.4%	61.8	19.7%
Totals	38,914	7,112	18.3%	17,307	44.5%	5,934	15.2%	777	2.0%	1,519	3.9%

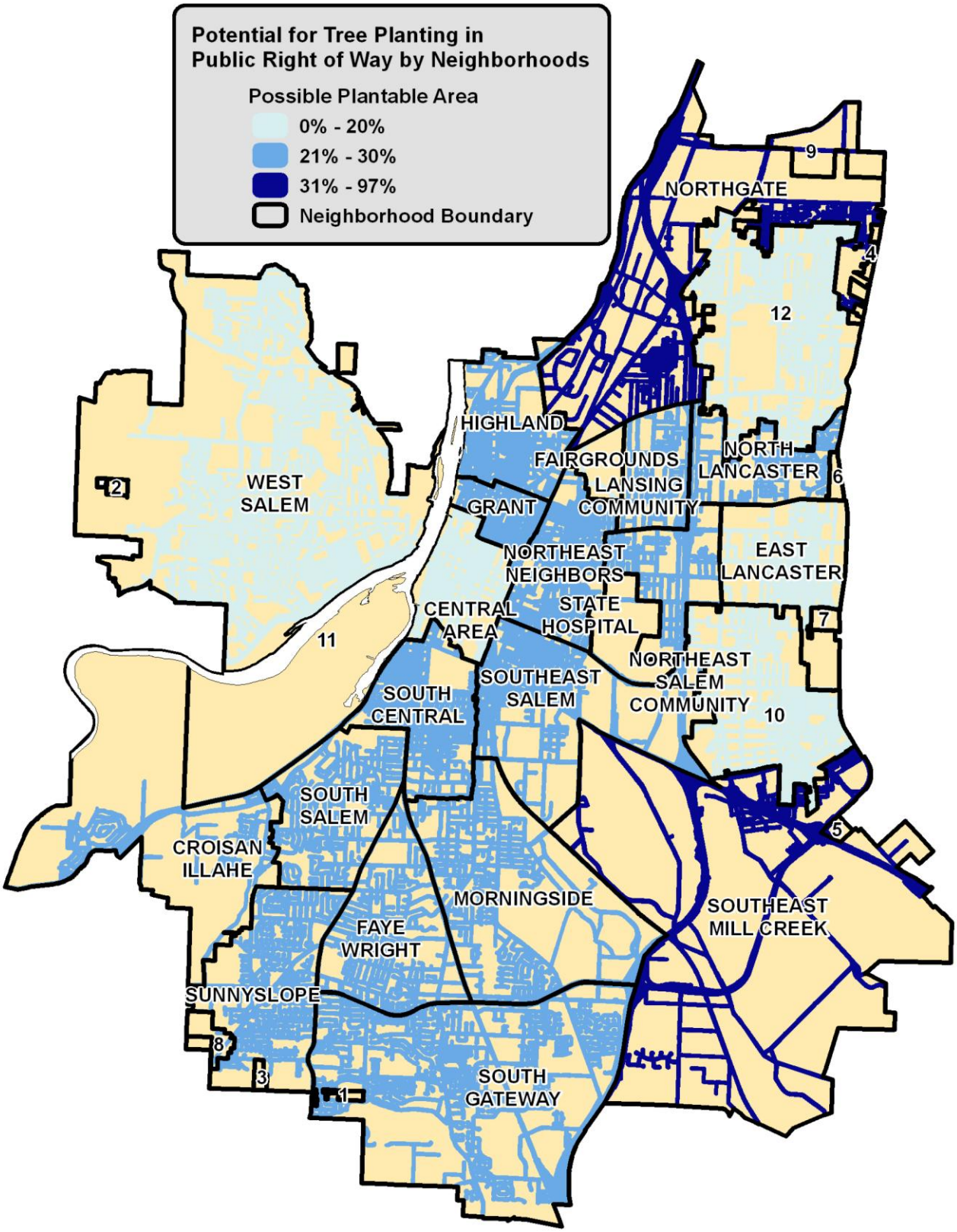
Results for Neighborhoods

Figures 15 and 16. Existing UTC and Possible Plantable Area by Neighborhood



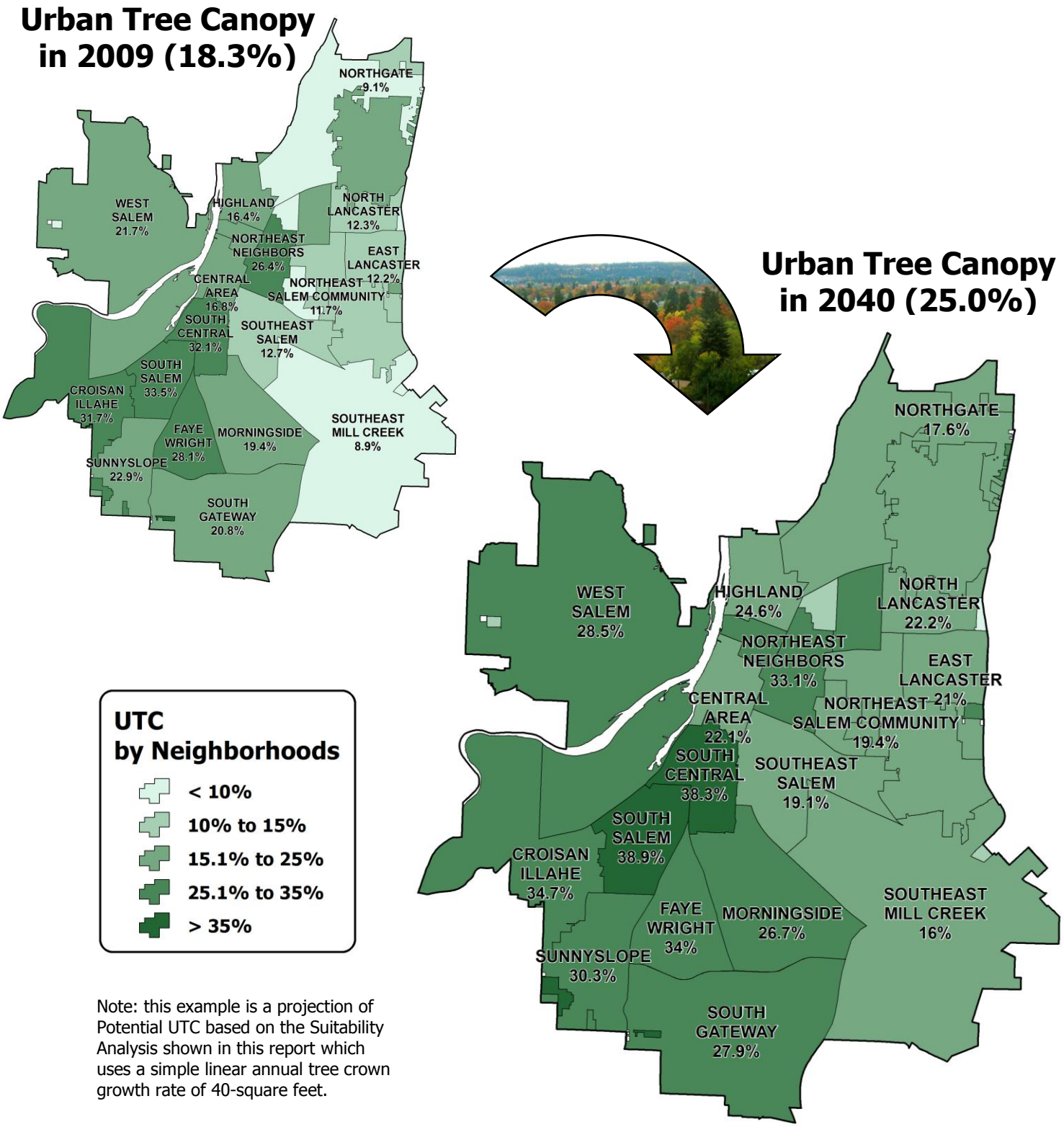
Results for Streets Rights-of-Way

Figure 17. Possible Plantable Area by Neighborhood in Streets Rights-of-Way



Results for Neighborhoods

Figure 18. Potential UTC Over Time by Neighborhood Based on the Grid Analysis



Note: this example is a projection of Potential UTC based on the Suitability Analysis shown in this report which uses a simple linear annual tree crown growth rate of 40-square feet.

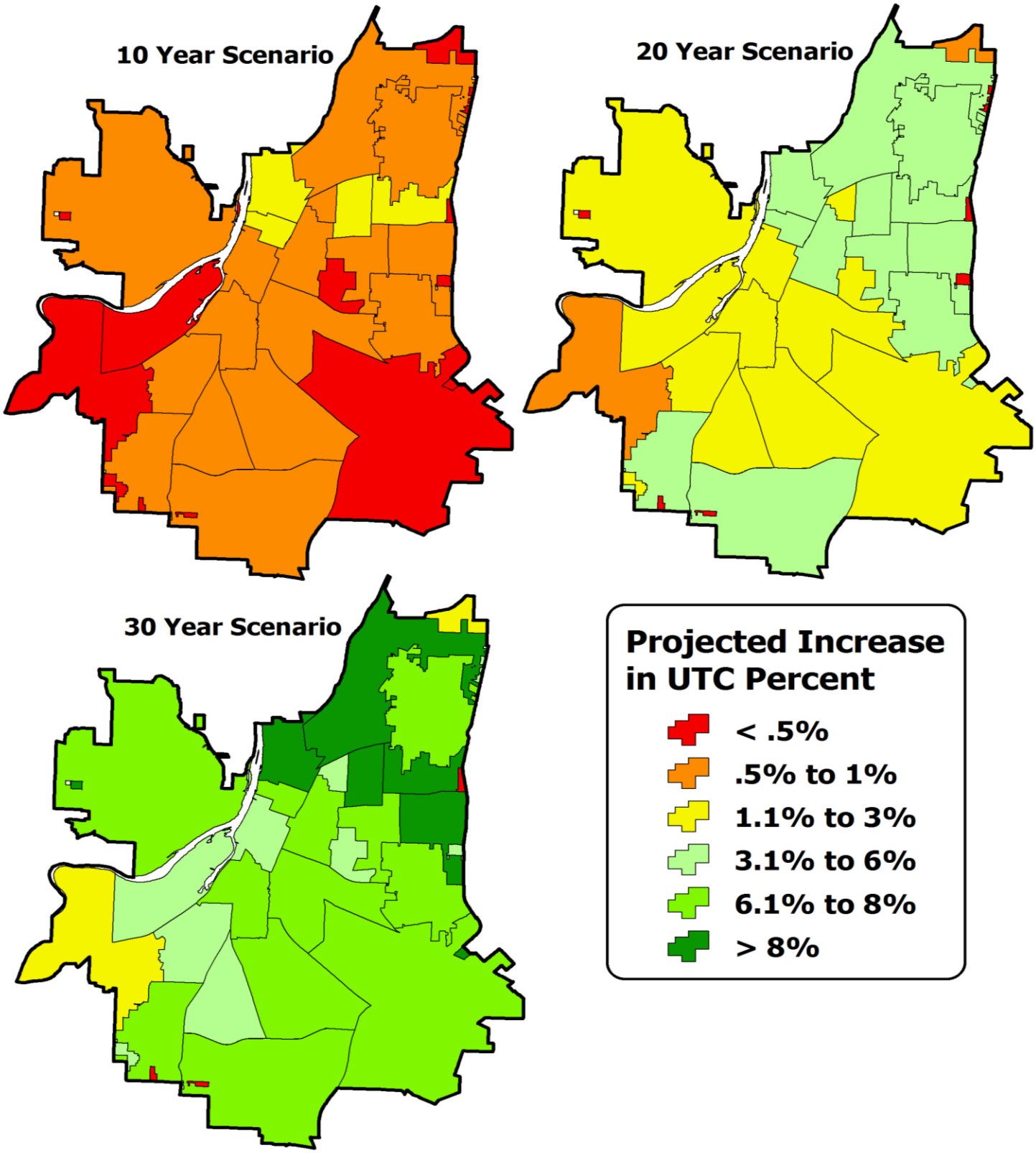
Results for Neighborhoods

Table 6. Complete Details of Potential UTC by Neighborhood in 2020, 2030 and 2040

Neighborhoods	Total Acres	2009 UTC Acres	2009 UTC %	2020 Canopy Acres	2020 Canopy %	2030 Canopy Acres	2030 Canopy %	2040 Canopy Acres	2040 Canopy %	10-yr Difference	20-yr Difference	30-yr Difference
CENTRAL AREA	626	105	16.8%	110	17.6%	122	19.5%	138	22.1%	0.8%	2.7%	5.3%
CROISAN ILLAHE	2,504	793	31.7%	797	31.8%	814	32.5%	868	34.7%	0.2%	0.8%	3.0%
EAST LANCASTER	940	114	12.1%	123	13.1%	149	15.8%	197	21.0%	1.0%	3.7%	8.8%
FAIRGROUNDS	173	14	8.1%	15	8.7%	17	9.8%	24	13.9%	0.6%	1.7%	5.8%
FAYE WRIGHT	1,146	322	28.1%	329	28.7%	354	30.9%	390	34.0%	0.6%	2.8%	5.9%
GRANT	269	55	20.4%	58	21.5%	65	24.1%	75	27.9%	1.1%	3.7%	7.4%
HIGHLAND	785	129	16.4%	137	17.4%	161	20.5%	193	24.6%	1.0%	4.1%	8.2%
LANSING COMMUNITY	493	90	18.2%	95	19.3%	110	22.3%	130	26.4%	1.0%	4.1%	8.1%
MORNINGSIDE	2,100	407	19.4%	421	20.1%	467	22.2%	561	26.7%	0.7%	2.9%	7.3%
NORTH LANCASTER	635	78	12.3%	86	13.5%	109	17.2%	141	22.2%	1.3%	4.9%	9.9%
NORTHEAST NEIGHBORS	755	199	26.3%	206	27.3%	223	29.5%	250	33.1%	0.9%	3.2%	6.8%
NORTHEAST SALEM COMMUNITY	689	80	11.6%	86	12.5%	106	15.4%	134	19.4%	0.9%	3.8%	7.8%
NORTHGATE	2,720	246	9.0%	268	9.9%	355	13.1%	480	17.6%	0.8%	4.0%	8.6%
SOUTH CENTRAL	850	273	32.1%	280	33.0%	298	35.1%	325	38.3%	0.8%	2.9%	6.1%
SOUTH GATEWAY	3,316	691	20.8%	713	21.5%	791	23.9%	925	27.9%	0.7%	3.0%	7.1%
SOUTH SALEM	1,015	340	33.5%	346	34.1%	365	36.0%	395	38.9%	0.6%	2.5%	5.4%
SOUTHEAST MILL CREEK	5,800	517	8.9%	540	9.3%	644	11.1%	927	16.0%	0.4%	2.2%	7.1%
SOUTHEAST SALEM	1,564	199	12.7%	211	13.5%	244	15.6%	299	19.1%	0.8%	2.9%	6.4%
STATE HOSPITAL	358	36	10.0%	36	10.0%	41	11.4%	54	15.1%	0.0%	1.4%	5.0%
SUNNYSLOPE	1,244	284	22.8%	293	23.6%	323	26.0%	377	30.3%	0.7%	3.1%	7.5%
WEST SALEM	5,226	1131	21.6%	1,169	22.4%	1,285	24.6%	1,491	28.5%	0.7%	2.9%	6.9%
1*	18	7	37.9%	7	37.9%	7	37.9%	7	37.9%	0.0%	0.0%	0.0%
2*	20	1	4.9%	1	4.9%	1	4.9%	3	14.8%	0.0%	0.0%	9.9%
3*	20	6	29.5%	6	29.5%	6	29.5%	6	29.5%	0.0%	0.0%	0.0%
4*	26	6	23.5%	6	23.5%	6	23.5%	7	27.4%	0.0%	0.0%	3.9%
5*	27	1	3.7%	1	3.7%	2	7.5%	4	14.9%	0.0%	3.7%	11.2%
6*	35	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0.0%	0.0%	0.0%
7*	39	9	23.1%	9	23.1%	9	23.1%	11	28.2%	0.0%	0.0%	5.1%
8*	78	24	30.9%	24	30.9%	25	32.2%	28	36.0%	0.0%	1.3%	5.1%
9*	279	40	14.3%	40	14.3%	42	15.1%	47	16.8%	0.0%	0.7%	2.5%
10*	1,361	192	14.1%	205	15.1%	242	17.8%	297	21.8%	1.0%	3.7%	7.7%
11*	1,893	415	21.9%	419	22.1%	451	23.8%	499	26.4%	0.2%	1.9%	4.4%
12*	1,909	308	16.1%	323	16.9%	370	19.4%	445	23.3%	0.8%	3.2%	7.2%
Totals	38,914	7,112	18.3%	7,360	18.9%	8,204	21.1%	9,728	25.0%			

Results for Neighborhoods

Figure 19. Increase in Potential UTC by Neighborhood Based on Grid-Based Analysis



Urban Tree Canopy Calculator

AMEC developed an Excel-based program called the UTC Calculator as a non-GIS tool that Salem can use in considering a canopy cover goal. The tool includes the existing canopy cover for zoning types and allows one to see the effects of tree planting on canopy within each zone as well as determine the number of planting sites needed to reach canopy goals. The average tree crown diameter can be adjusted by using a fixed tree crown diameter (in feet) or by entering the distribution of small, medium, and large sized tree species that will make-up the future urban forest. This calculates a weighted crown diameter. Additionally, a mortality rate can be entered.

An example of using the Calculator is provided below where goals by zoning type were entered that are similar to American Forests goals discussed later in this report. This example shows that 139,000 trees with an average tree crown diameter of 39 feet would result in 27.4% canopy cover citywide.

Figure 20. Example of Salem's UTC Calculator for Canopy Goal Setting by Zoning

User Inputs	Increase UTC % By	Update UTC % To	Update Number of Trees by:
Commercial		15.0%	
Downtown		15.0%	
High Density Residential		25.0%	
Industrial		15.0%	
Low Density Residential		40.0%	
Medium Density Residential		30.0%	
Other Public Land		30.0%	
PROW		20.0%	
Public Open Space		30.0%	
Average Crown Diameter (ft):	39		
Crown Areas (Acres):	0.027060		

Reset Cells

Warnings and Errors

Optional

Size of Tree	Crown Diameter (ft)	% Distribution by Size	Weighted Diameter (ft)
Small	20	10	2.00
Medium	30	25	7.50
Large	45	65	29.25
Weighted Average Crown Diameter (ft):			38.75

Tree Mortality Rate (annually)
5%

**Note: Reset Cells clears all user inputs and reverts "Average Crown Diameter to 30ft*

**Note: Only one of entry is acceptable per row, per column. For example, Commercial may not have entries in "Increase UTC % By" and "Increase UTC % To."*

Results

Salem Zoning	Total Acres	Existing UTC Acres	Existing UTC %	Total Possible Plantable Acres	Total Possible Plantable %	Raw % Change	Updated Relative %	Updated UTC Acres	UTC Acreage Change	Number of Trees Required	Updated Number of Trees Including Mortality
Commercial	2,392	231	10	697	29	5.3	15.0	358.8	127.9	4,727	4,963
Downtown	142	13	9	20	14	5.6	15.0	21.2	7.9	292	306
High Density Residential	2,421	418	17	836	35	7.7	25.0	605.2	187.4	6,925	7,272
Industrial	4,211	311	7	1,979	47	7.6	15.0	631.7	320.4	11,840	12,432
Low Density Residential	6,887	1,682	24	4,079	59	15.6	40.0	2,754.8	1,072.7	39,642	41,624
Medium Density Residential	11,110	2,670	24	4,581	41	6.0	30.0	3,333.1	663.4	24,516	25,742
Other Public Land	3,666	375	10	2,344	64	19.8	30.0	1,099.9	724.9	26,789	28,128
PROW	5,934	777	13	1,519	26	6.9	20.0	1,186.7	409.8	15,144	15,901
Public Open Space	2,478	675	27	1,415	57	2.8	30.0	743.5	68.4	2,528	2,654

Summary

Target Geography Totals	Geographic Area (Acres)	Existing UTC (Acres)	Existing %	Total Trees Added	Trees Added Including Mortality	Total Trees Added Acres	New UTC Acres	New %
Salem Zoning	39,241.5	7,152.3	18.2%	132,403	139,022	3,582.8	10,735.1	27.4%

Analyzing Potential Urban Tree Canopy Benefits

Urban and community forests provide numerous types of benefits sometimes referred to as "ecosystem services". Services such as improving air quality and reducing stormwater runoff, erosion control, and energy use are benefits trees provide that we tend to take for granted because they are not assigned a dollar value. Results of analyzing some of the economic and environmental benefits of Salem's urban forest are provided further below. Placing a value of the direct and indirect quantifies the many benefits of a "working" urban forest.

Examples of ecosystem services provided by urban forests include:

- Providing habitat and protecting biodiversity
- Decreasing stormwater utility costs, erosion, and flooding
- Reducing urban heat island effect and cooling costs
- Increasing property values and tax revenues
- Increasing recreation opportunities, public health and well being
- Absorbing carbon dioxide through carbon sequestration and carbon storage
- Improving air quality, water quality and groundwater recharge

In this project, "first order" estimates of individual tree benefits in Salem were calculated using i- Tree Design, a free, online tool from the U.S. Forest Service. Additionally, air pollution removal from increased tree canopy was calculated using CITYgreen software. Other available software programs and resources are briefly described.

i-Tree Design (http://www.itreetools.org/design.php)

i-Tree Design (beta) allows one to calculate the approximate benefits individual trees provide. The carbon, air quality and stormwater calculations are based on methods and models derived from the i-Tree Streets application. As such, this tool relies on average species growth and geographic parameters for 16 national climate zones and, consequently, should be considered a starting point for understanding trees' value in the community rather than a scientific accounting of precise values. For more detailed information on urban and community forest assessments, please continue exploring the i-Tree website.

Species and dbh are important inputs to i-Tree Design. For this analysis, Salem forestry staff identified the most common tree species and estimated dbh (diameter at breast height) at 10-, 20- and 30-years of age. The results below represent the combined value of stormwater, air quality, and carbon benefits in 5-year increments for small, medium and large size tree species. Multiplying the number of potential planting sites in Salem times an annual benefit of $67.13 for the average medium sized tree at 25 years of age shows an impressive $14.2M in benefits annually.

Table 7. Benefits of common tree species in Salem estimated using i-Tree Design

	5-year value	10-year value	15-year value	20-year value	25-year value	30-year value	35-year value	40-year value
Large	$8.70	$17.40	$41.60	$65.80	$84.90	$104.00	$116.80	$129.60
Medium	$8.88	$17.75	$35.38	$53.00	**$67.13**	$81.25	$89.63	$98.00
Small	$9.83	$19.67	$30.50	$41.33	$49.00	$56.67	$58.17	$59.67

CITYgreen

CITYgreen is a GIS software developed by American Forests that calculates current and potential tree canopy benefits for carbon storage, carbon sequestration, air pollution removal, stormwater volume and water quality (percent change in contaminant loading). For this analysis, the online air quality calculator was used to project benefits of canopy cover in Salem based on Potential UTC estimates.

Tables 8 and 9. Example of Potential UTC (left) and air pollution removal benefits of increased canopy cover scenarios estimated using CITYgreen software

Total Acres	38,914
2009 Existing Canopy Acres	7,112
2009 Existing Canopy %	18.3%
2020 Canopy Acres	7,360
2020 Canopy %	18.9%
2030 Canopy Acres	8,204
2030 Canopy %	21.1%
2040 Canopy Acres	9,728
2040 Canopy %	25.0%

Note: this uses an average 40-square foot annual tree crown growth rate

Pollutant	Pounds Removed per Year	Dollar Value
At 7,112 Acres UTC		
Ozone	$190,062	$583,386
Particulate Matter	$195,133	$399,893
Nitrogen Dioxide	$94,883	$291,240
Sulfur Dioxide	$61,962	$46,458
Carbon Monoxide	$40,538	$17,284
Total	**$582,578**	**$1,338,262**
At 7,360 Acres UTC		
Ozone	$196,689	$603,729
Particulate Matter	$201,938	$413,837
Nitrogen Dioxide	$98,192	$301,396
Sulfur Dioxide	$64,123	$48,078
Carbon Monoxide	$41,952	$17,887
Total	**$602,893**	**$1,384,928**
At 8,204 Acres UTC		
Ozone	$219,244	$672,961
Particulate Matter	$225,095	$461,293
Nitrogen Dioxide	$109,452	$335,958
Sulfur Dioxide	$71,476	$53,592
Carbon Monoxide	$46,762	$19,938
Total	**$672,029**	**$1,543,743**
At 9,728 Acres UTC		
Ozone	$259,972	$797,973
Particulate Matter	$266,909	$546,985
Nitrogen Dioxide	$129,784	$398,367
Sulfur Dioxide	$84,753	$63,547
Carbon Monoxide	$55,449	$23,642
Total	**$796,867**	**$1,830,513**

Three (3) other resources are described below which Salem may want to utilize for further estimating the cost and benefit of trees and tree canopy.

i-Tree

i-Tree is a state-of-the-art, peer-reviewed software suite from the USDA Forest Service that provides urban and community forestry analysis and benefits assessment tools. The i-Tree tools help communities of all sizes to strengthen their urban forest management and advocacy efforts by quantifying the environmental services that trees provide and the structure of the urban forest.

i-Tree has been used by communities, non-profit organizations, consultants, volunteers, and students to report on the urban forest at all scales from individual trees, parcels, neighborhoods, cities, to entire states. By understanding the local, tangible ecosystem services that trees provide, i-Tree users can link urban forest management activities with environmental quality and community livability. Whether your interest is a single tree or an entire forest, i-Tree provides baseline data that you can use to demonstrate value and set priorities for more effective decision-making. The i-Tree suite v4.0 includes the following urban forest analysis tools and utility programs:

i-Tree Eco provides a broad picture of the entire urban forest. It is designed to use field data from complete inventories or randomly located plots throughout a community along with local hourly air pollution and meteorological data to quantify urban forest structure, environmental effects, and value to communities.

i-Tree Streets focuses on the benefits provided by a municipality's street trees. It makes use of a sample or complete inventory to quantify and put a dollar value on the street trees' annual environmental and aesthetic benefits. Streets also describes urban forest structure and management needs to help managers plan for the future.

i-Tree Hydro (beta) is a new application designed to simulate the effects of changes in tree and impervious cover characteristics within a watershed on stream flow and water quality.

i-Tree Vue allows you to make use of freely available national land cover data maps to assess your community's land cover, including tree canopy, and some of the ecosystem services provided by your current urban forest. The effects of planting scenarios on future benefits can also be modeled.

i-Tree Design (beta) is a simple online tool that provides a platform for assessments of individual trees at the parcel level. This tool links to Google Maps and allows you to see how tree selection, tree size, and placement around your home effects energy use and other benefits. This beta tool is the first stage in development of more sophisticated options that will be available in future versions.

i-Tree Canopy offers a quick and easy way to produce a statistically valid estimate of land cover types (e.g., tree cover) using aerial images available in Google Maps. The data can be used by urban forest managers to estimate tree canopy cover, set canopy goals, and track success; and to estimate inputs for use in i-Tree Hydro and elsewhere where land cover data are needed.

Community Tree Guides

The U.S. Forest Service Community Tree Guide for the Pacific Northwest provides cost and benefit values for public and private urban trees. Over a 40-year period, the guide breaks out benefit values for different types of trees by aesthetics and other benefits (including property value), stormwater and air pollution mitigation, energy savings (heating and cooling), and carbon sequestration. The guide includes cost for planting, maintenance (pruning, watering and infrastructure conflicts), and removal. Additionally, the guides offer guidelines on selecting and siting trees to maximize long-term tree benefits. As an example, one could use the guide to show the value of a bigleaf maple tree over its lifespan and compare it with a Douglas fir.

Western Washington Hydrology Model

Although not specific to Oregon, stormwater modeling on the benefits of trees can be conducted using the Western Washington Continuous Simulation Hydrology Model (WWHM). The regional parameters included in the model may provide more realistic estimates on the benefits of trees for reducing stormwater runoff than models such as CITYgreen.

The model was developed by the State of Washington Department of Ecology and includes local reference data and ability to model hydrologic benefits of forests versus other pervious and impervious surfaces. Both rainfall interception and infiltration can be modeled using slope, land use, land cover data and potential planting locations. The outputs can include changes in peak flow and runoff volume based on the number of potential tree planting sites and average parcel size in each zoning category.

Summary Discussion

This analysis provides the City of Salem with detailed information useful for possibly setting an urban tree canopy (UTC) goal. American Forests, a not-for-profit conservation organization has developed tree canopy guidelines by zoning categories as a starting point for cities to set canopy goals. Table 10 below shows canopy cover in Salem by zoning compared with goals set by American Forests and other cities in the Pacific Northwest using current best available information.

Table 10. Urban Canopy Goals – Regional Comparison of Existing Canopy and Targets

Urban Land Category	Salem 2009 UTC	American Forests Recommendation*	Portland**	Seattle**	Corvallis**	Vancouver, WA**
Commercial	9.7%	15%	15%			15%
Industrial	7.4%	15%		10%		14%
Downtown / CBD	9.4%	15%		12%		
Low Density Residential	24.4%	50%				52%
Medium Density Res. (SFR)	24.0%			31%		36%
High Density Residential (Urban Res.)	17.3%	25%	35-40%	20-25%		26%
Other Public Land / Institut.	10.2%			20%		38%
Public Open space	27.2%		30%			
Streets & Right-of-Way	13.0%		35%			14%
Natural Areas and Stream Corridors	N/A			80%		
Developed Parks and Open Space	11.1%	25%		25%		
Current Canopy	18.3%	40% (average counting all zones)	26.3%	18%	30%	19.7%
Target Canopy	TBD		33%	30%		28%

*http://www.americanforests.org/resources/urbanforests/treedeficit.php
** City of Gresham Draft UFMP 2010

The following recommendations are offered:

- Determine what canopy level is politically, socially, and financially possible and over what time frame
- Consider establishing a tree advisory board to help make decisions about urban tree canopy and gauge the public's interest in expanding the City's urban tree canopy and setting an official goal
- Utilize the information gained in this analysis in educational materials for the public as part of an outreach campaign
- Continue analysis of Preferable UTC by improving and enhancing the GIS grid database
- Use the prioritization grid cell database in a single neighborhood to develop an example community-based tree planting plan and demonstration project
- Use the database to create custom scenarios with different weights for factors influencing planting priority
- Calculate existing and potential canopy cover in natural areas and stream corridors
- Perform more detailed cost/benefits analysis using the U.S. Forest Service i-Tree programs like Eco or Streets, the Western Washington Hydrology Model (WWHM)
- Conduct street, park and natural area tree inventories to improve urban forest management, diversification, invasive species management, and use as an input to i-Tree valuation programs

18.3%
Percent of Salem covered by Tree Canopy in 2009

212,000
Approximate number of potential tree planting sites in Salem

-22%
Percentage below American Forests Recommended Tree Canopy of 40%

$1.3M
Value of air pollution removed annually by Salem's urban forest

$130
Estimated annual benefits from a large mature tree in Salem at 40-years of age

4,000
Estimated number of gallons of stormwater runoff intercepted annually by a mature large tree in Salem

S:\GROUP\PUBWKS\Water Resources\Trees and Vegetation\Urban Tree Canopy_Urban Forestry\AMEC Scope 2 Potential UTC Analysis\Final\Salem Phase-2 UTC Technical Report 09012011.docx