City of Salem, Oregon
Urban Tree Canopy (UTC) Assessment
November 2010

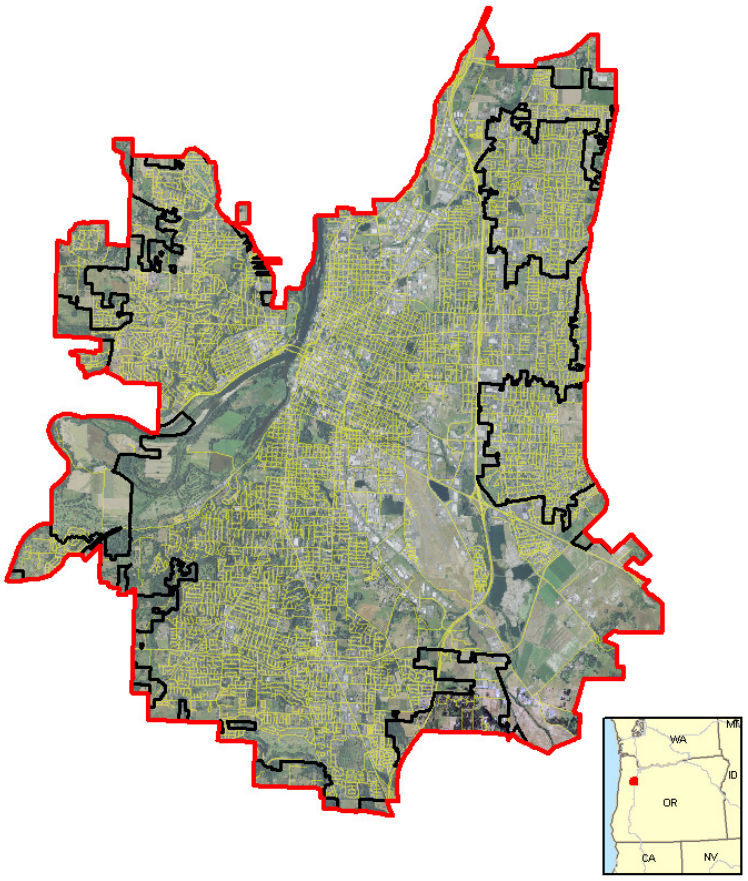
Source: City of Salem Public Works Department

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

Prepared by:
Ian Hanou
Senior Project Manager
AMEC Earth & Environmental

Introduction

Figure 1. Salem, Oregon city boundary (black outline) and Urban Growth Boundary (red outline) showing streets (yellow lines) and 2009 NAIP Imagery



Trees are valuable natural and cultural resources to the City of Salem (City) that provide multiple benefits, including increased property worth, pollutant removal, stormwater runoff reduction, carbon sequestration, and energy savings. In 2001 an Urban Tree Canopy assessment was conducted for the City of Salem. Under Salem Revised Code (SRC) the City is to conduct a tree canopy study every census year to measure the effectiveness of their tree preservation code and other development-related ordinances in preserving and improving the amount of tree canopy area within the City (SRC 68.150(d)).

The objective of this project was to conduct a tree canopy assessment and comparison between the time periods of 2001 and 2009 within the City of Salem, Oregon and its Urban Growth Boundary (UGB), excluding the City of Keiser, an area of approximately 61 square miles. See Figure 1 at right. The urban tree canopy (UTC) results provide a benchmark from which to measure the success of planning and urban forestry programs and to educate the public about the many benefits of trees. Deliverables included GIS-based tree canopy polygon data for 2001 and 2009; UTC metrics project-wide, for sub-basins and for zoning categories; a tree grove data layer; interactive GeoPDF maps; and this summary report, which describes GIS data and imagery requirements, tree canopy classification methods, UTC modeling, UTC results, and finally conclusions and recommendations.

Salem's Tree Canopy Cover at a Glance

2001 UTC: 18.2%
(7,078 acres)
2009 UTC: 18.3%
(7,120 acres)
Change in UTC: 0.1%
(42 acres)
Downtown UTC: 9.4%
Portion of UTC from Residential Land Use: 67.0%

Source: City of Salem Public Works Department

Acknowledgments – City of Salem Review team:

Francis Kessler, Operations Division Manager, Public Works Department

Nitin Joshi, Water and Environmental Resources Manager, Public Works Department

Patricia Farrell, Natural Resources Specialist, Public Works Department

Deborah Topp, Natural Resources Outreach Specialist, Public Works Department

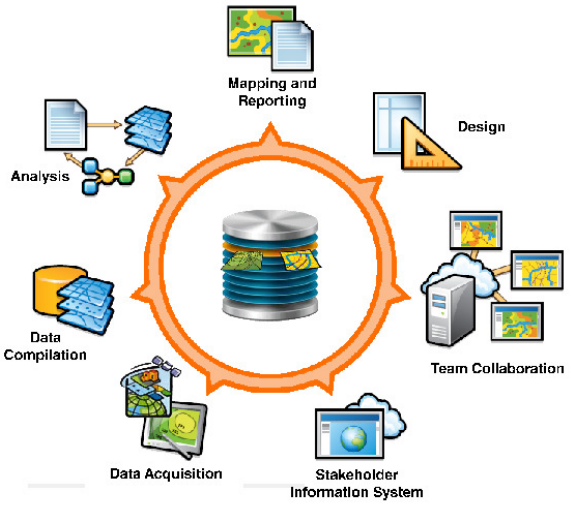
John Smith, GIS Supervisor, Public Works Department

Jan Staszewski, Urban Forester, Public Works Department

Aaron Panko (CD), Associate Planner, Community Development Department

Credit: Ron Cooper

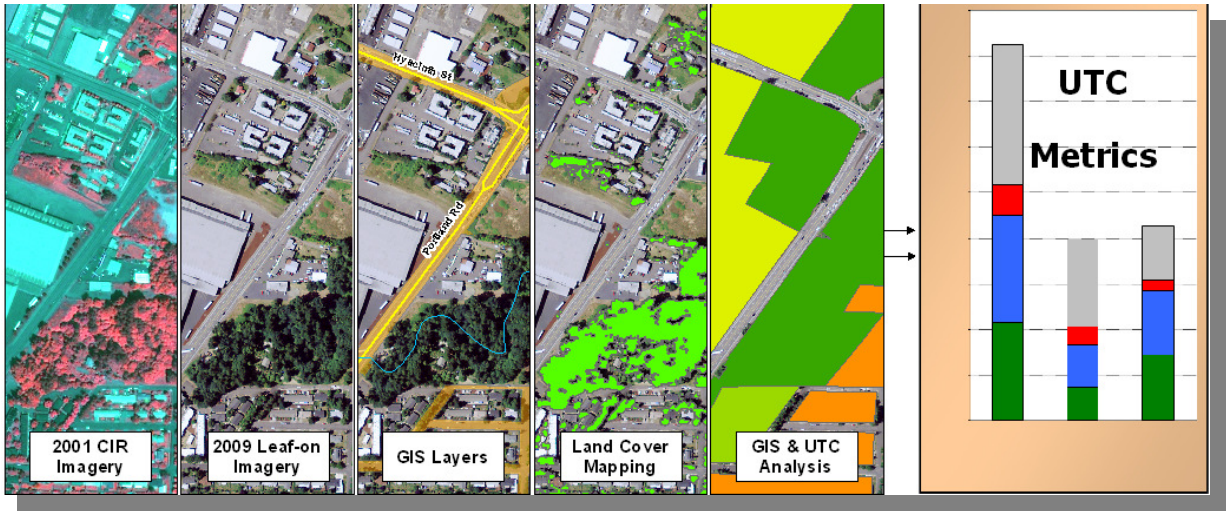
Figure 2. GIS Life Cycle



The UTC Process: Imagery and Data Requirements

Geographic Information Systems (GIS) and remote sensing technologies offer powerful analysis and decision support tools for managing urban natural resources. UTC projects have at least 5 main elements in common regarding data inputs and outputs: high-resolution imagery (Fig. 3, panels 1 and 2), supporting GIS layers from the community (panel 3), land cover data derived from the imagery (panel 4), geographic boundaries to summarize the acres and percent of tree canopy (panel 5), and reporting of the results through tables, charts, maps, and tools (panel 6).

Figure 3. Visualization of the Common Elements of UTC Assessments



The City provided AMEC with the following GIS layers to support the analysis: City boundary, UGB, parcel and zoning categories, sub-basins (watersheds), road centerlines, creeks, and public rights of way. The City also provided two imagery datasets for the classification of tree canopy from two time periods: May 2001 4-band multispectral IKONOS satellite imagery and summer 2009 aerials from the National Agricultural Imagery Program (NAIP), both with 1-meter spatial resolution. It should be noted that a previous study used 4-meter resolution 2001 imagery. While the difference in UTC citywide was only 0.1% between the 1-meter and 4-meter 2001 imagery, visual inspection showed that the 1-meter derived results were more precise at a finer scale.

Figure 4. GIS Data Provided by

Land Cover Classification Methodology

AMEC analyzed the 2001 IKONOS imagery and 2009 NAIP imagery using a technique known as geographic object-based image analysis (GEOBIA) and developed a tree canopy land cover dataset for both time periods that would support the needs of this project and other applications (Figure 5 below). The GEOBIA approach provided a highly accurate, automated and cost-effective method for feature extraction and can be incorporated with other GIS datasets from the City. For the purposes of this project, the City and AMEC chose not to include shrub vegetation or young, sparse plantations or tree farms in the two tree canopy datasets since the two classes do not provide tree canopy. The classification was refined with a manual quality assurance / quality control (QA/QC) process that removed incorrect features mapped during automation in order to finalize the two land cover datasets at high accuracy (Figure 6 below). The 2001 and 2009 tree canopy land cover results were provided in raster and vector based GIS formats. Additionally, per the City's request, a tree "groves" sub-feature type of trees was created for both 2001 and 2009. Groves were defined as connected areas of tree canopy greater than 0.5 acres in size.

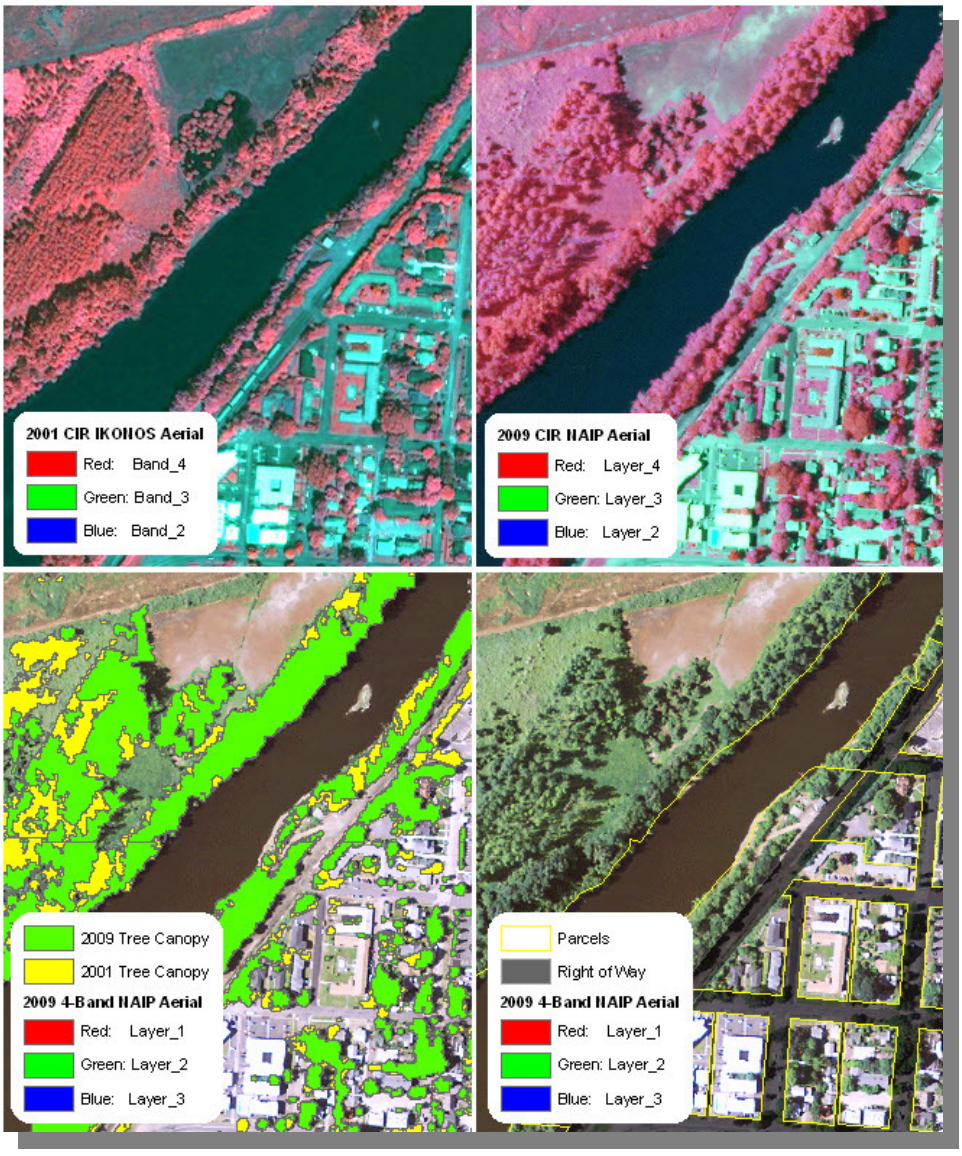
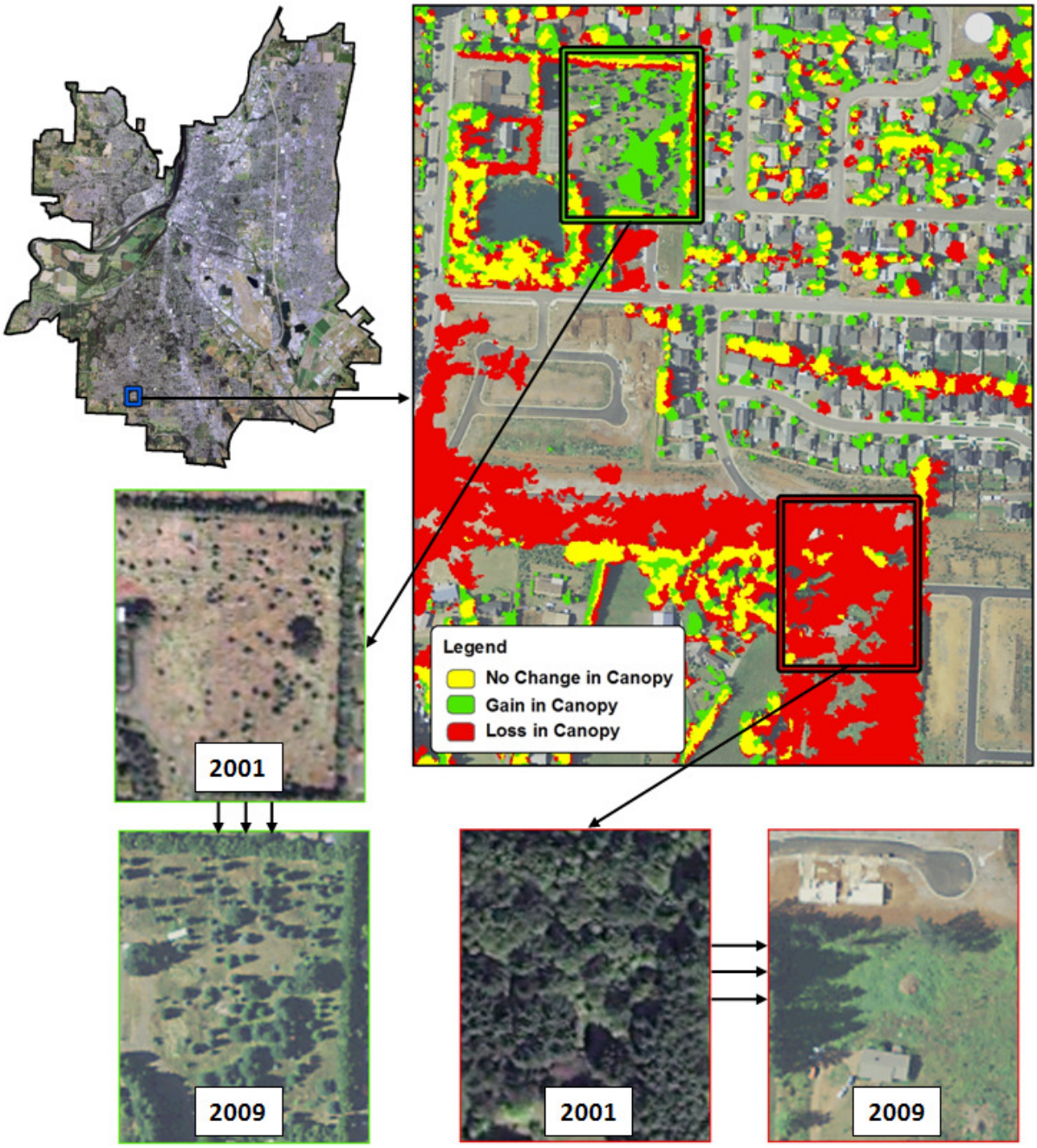


Figure 5. Examples of tree canopy mapping using May 2001 IKONOS imagery and summer 2009 NAIP imagery. Clockwise from top to left: 1.) 2001 IKONOS color infrared (CIR), 2.) 2009 CIR NAIP leaf-on aerial, 3.) Parcel boundaries and right of ways, 4.) 2001 and 2009 tree canopy.

Figure 6. The following illustration provides an example of the tree canopy results and the change in coverage over the time period of 2001 to 2009.



Urban Tree Canopy (UTC) Modeling

Using the tree canopy data, geoprocessing models were created to calculate the area and percent of 2001 and 2009 UTC for the geographic boundaries seen below in Figure 7. The urban growth boundary excluding Keizer totals 38,926 acres while the sub-basins cover 38,288 acres and the land use areas cover 33,308 acres. Sub-basins cover 638 acres less than the project boundary because the Willamette River is not included in the basin

boundaries, while the land use areas cover 5,618 acres less than the project boundary because both the river area and public rights-of-way were not included. Eight land use classes were chosen by the City including three residential types: low density (residential/agriculture and Exclusive Farm Use), medium density (single family/duplex) and high density (multifamily). Note that the term 'impact' is used interchangeably with 'density.'

These geographies were chosen specifically to provide different scales and meaning for planning and monitoring purposes. UTC metrics were provided in GIS format, Excel, and GeoPDF for each geographic boundary.

Figure 7. UTC Target Geographies

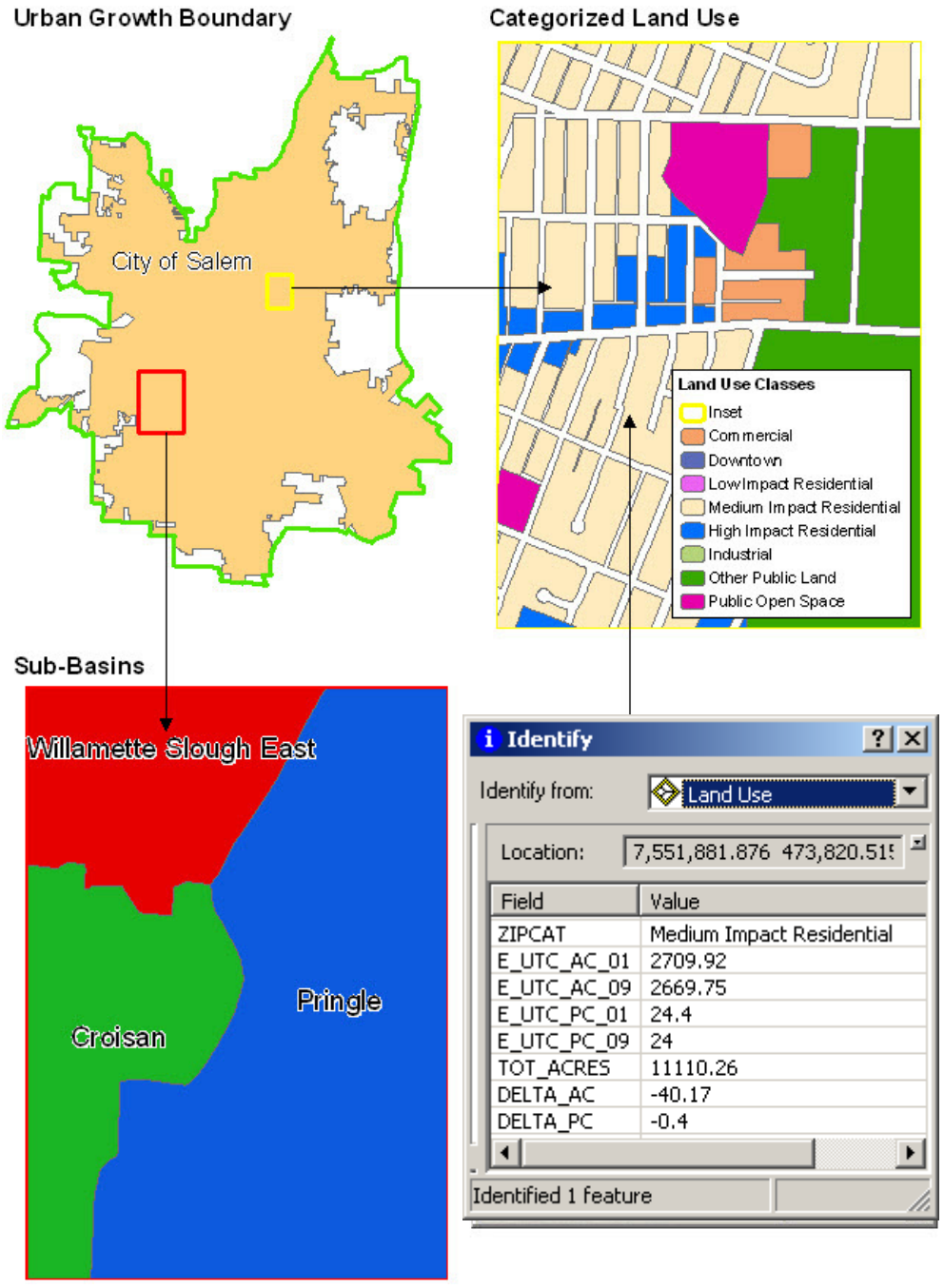


Figure 8. The illustration below depicts the GIS modeling workflow of the UTC Assessment process from imagery to land cover classification to GIS modeling and finally delivery of the UTC metrics for each geographic boundary.

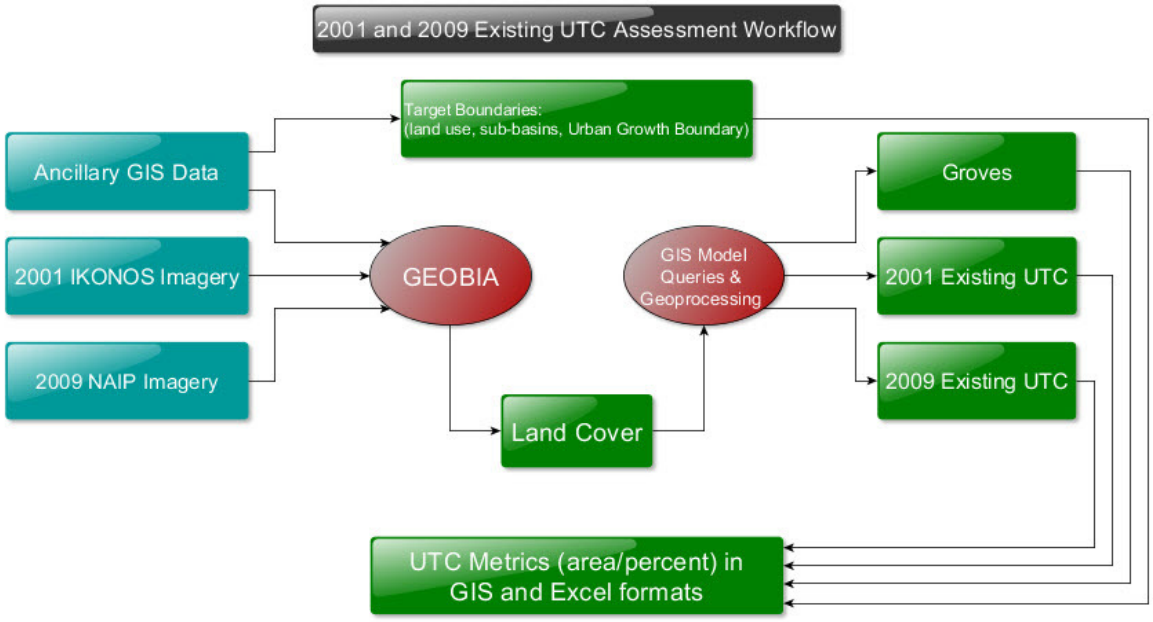
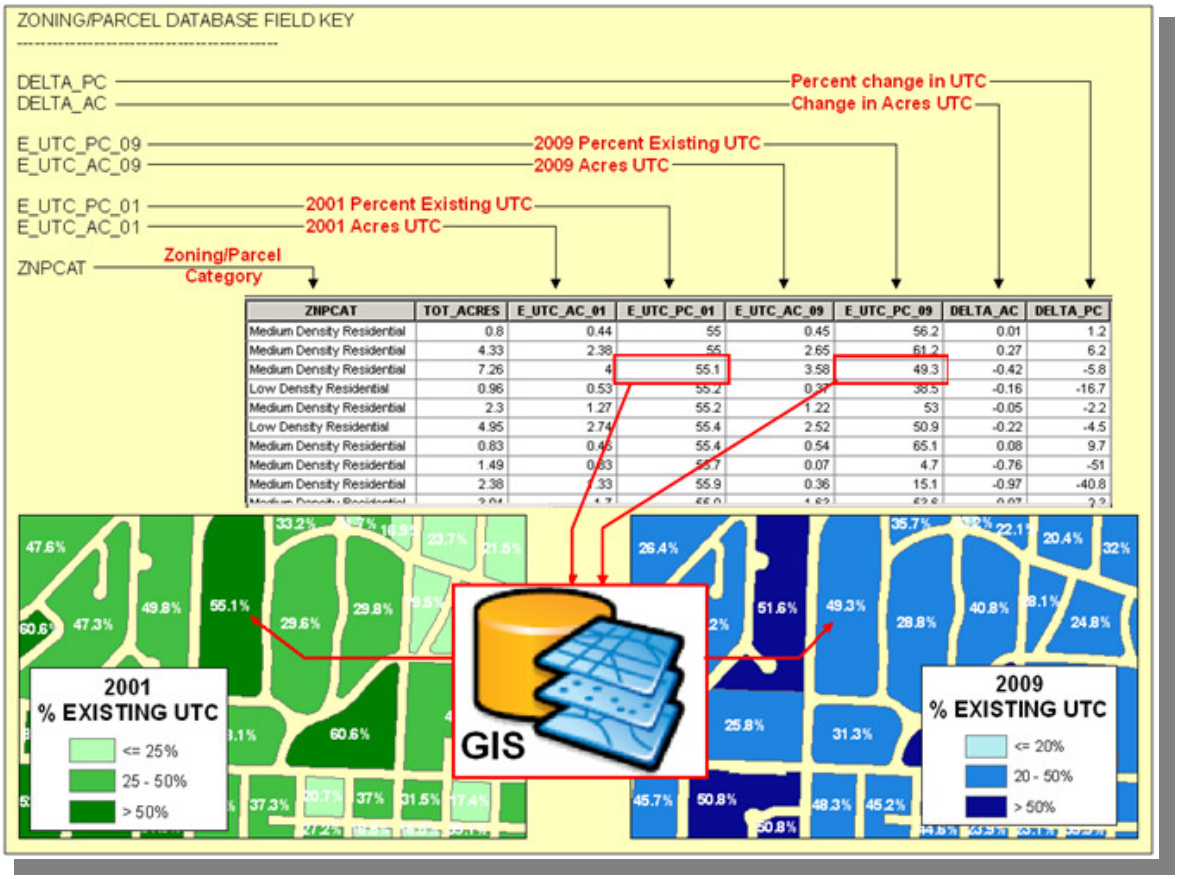


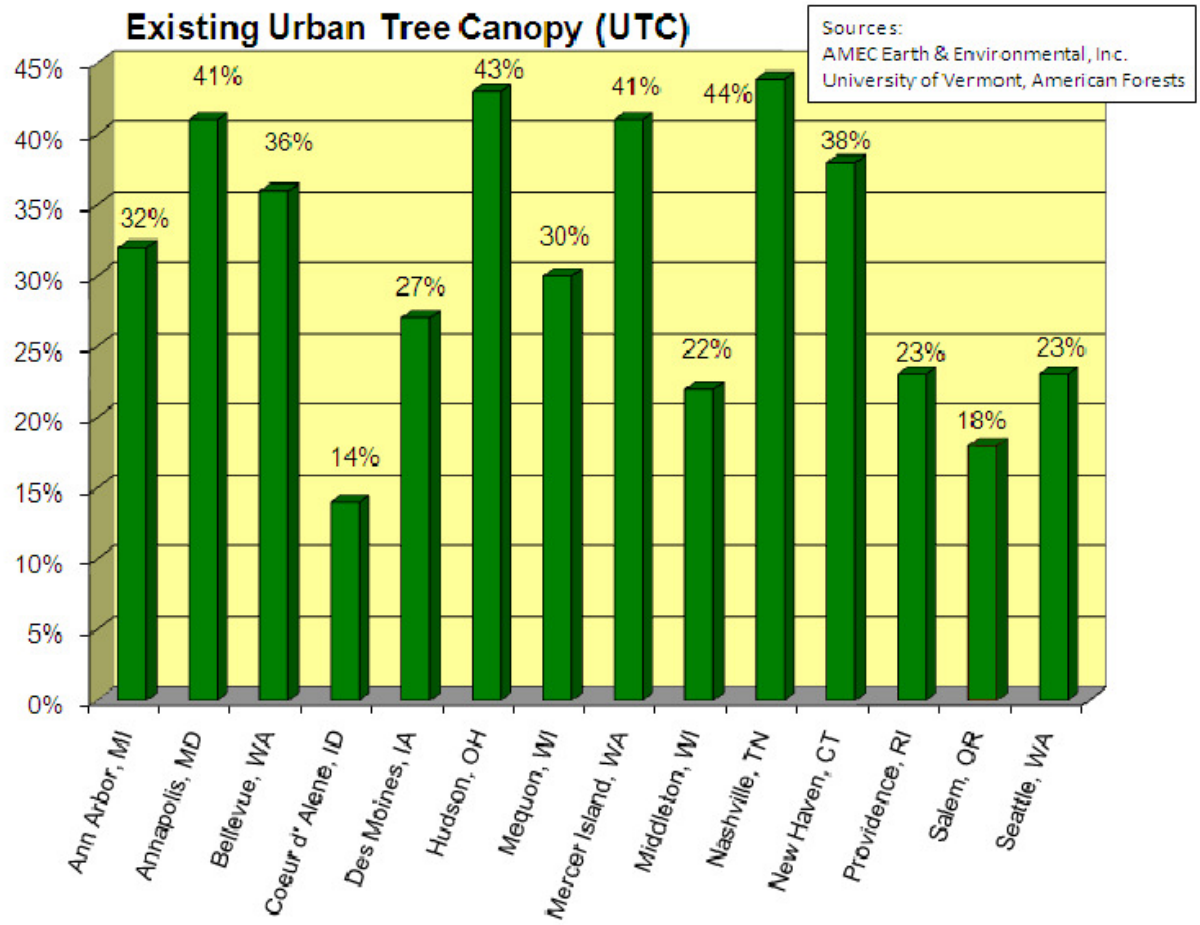
Figure 9. Illustration of the detailed land use UTC database delivered to Salem. This example shows the GIS attribute table, a field key for each column heading and how the UTC metrics in the attribute table are tied to the spatial polygons that are used for thematic maps of the UTC results.



Urban Tree Canopy Assessment Results

The area and percent of UTC were calculated for the different geographic boundaries listed above for 2001 and 2009 conditions. The 2001 UTC citywide in Salem was found to be 18.2% and 2009 UTC was found to be 18.3% for a modest increase of 0.1% or 42 acres (Table 1 and Figure 11). While the change citywide was nominal, the finer-scale geographies provided a better illustration of where UTC has increased or decreased throughout Salem. Figure 10 below provides a comparison of tree canopy cover percent in Salem to that of other U.S. communities that are similar in size and general climate conditions. Note that only studies using high-resolution imagery resolution (1-meter or better) were used and few studies were available in the Pacific Northwest for comparison.

Figure 10. Tree Canopy Comparison



This section of the report provides just a snapshot of the main tree canopy assessment findings. In the following pages, Tables 1-4 and Figures 11-15 provide examples of the results for the overall project area and for the more detailed geographic boundaries (sub-basins and land use) in tables, charts and maps. Additionally, the full results can be accessed through the attribute table of each GIS layer, by using the interactive GeoPDF, or through the UTC Spreadsheet. A Summary of Findings is also presented further below along with Opportunities and Recommendations.

Overall Tree Canopy Results

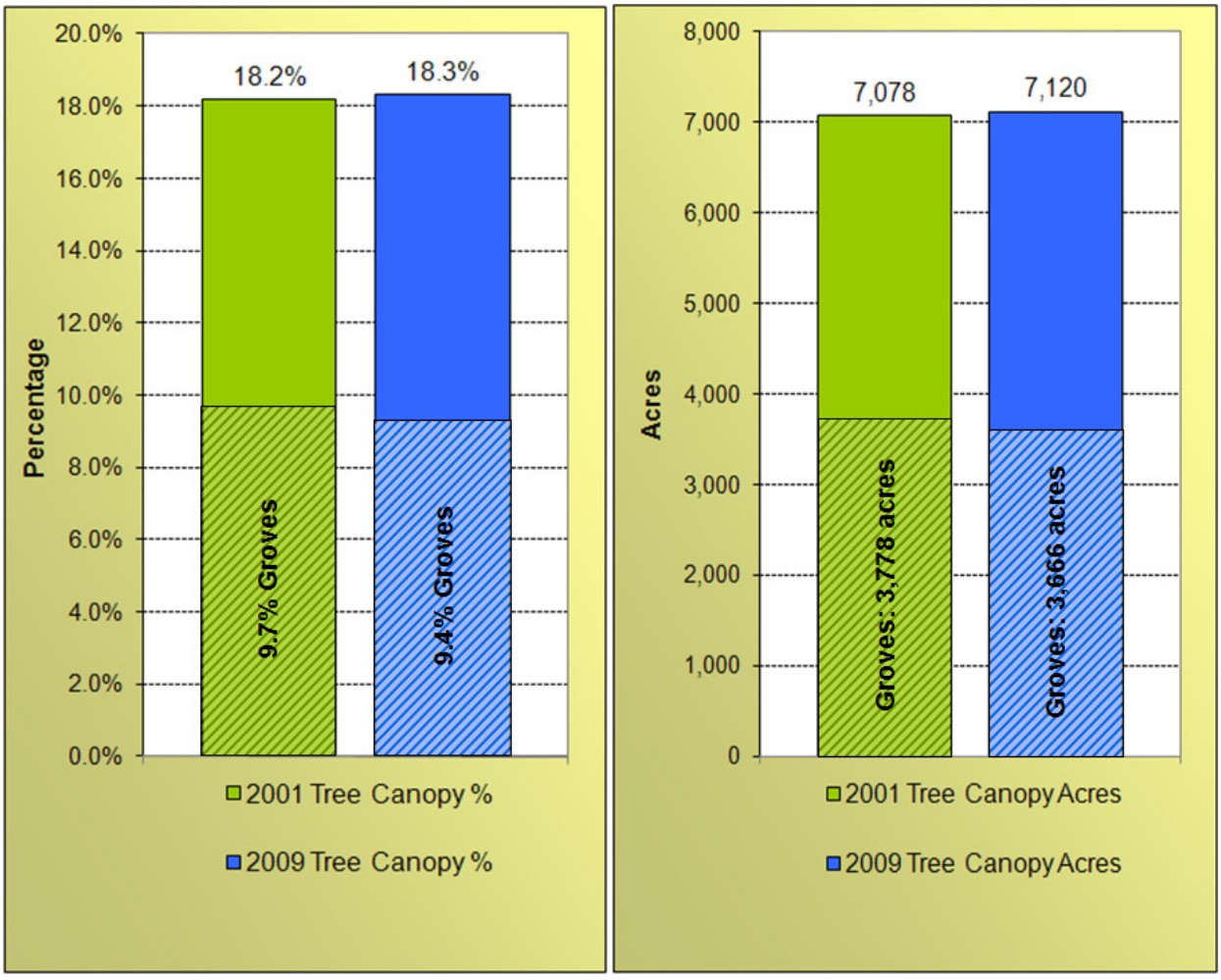
Table 1. UTC Metrics for City of Salem (the project boundary was defined as including the City of Salem and the Urban Growth Boundary but excluding the City of Keizer).

Area	Total Acres	2001 Tree Canopy Acres	2001 Tree Canopy %	2009 Tree Canopy Acres	2009 Tree Canopy %	Change in Acres	Percent Change in UTC
Project Boundary	38,926	7,078	18.2%	7,120	18.3%	42	0.1%

Table 2. UTC Grove Metrics

2001 Grove Acres	2001 Grove Percentage of Salem	2001 Percent of UTC from Groves	2009 Grove Acres	2009 Grove Percentage of Salem	2009 Percent of UTC from Groves	Change in Grove Acres
3,778	9.7%	53.4%	3,666	9.4%	51.5%	112

Figure 11. Overall Summary of UTC Assessment



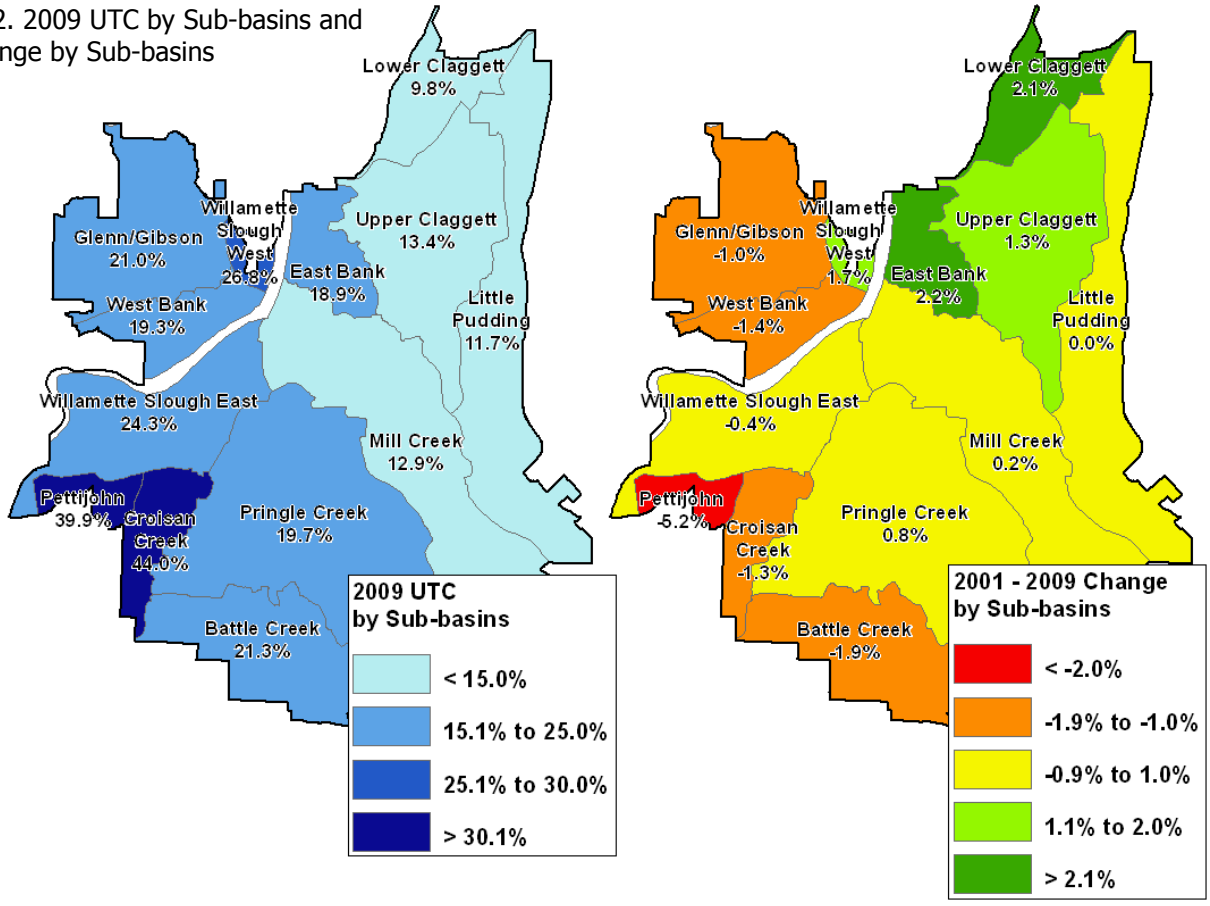
Tree Canopy Results by Sub-basins

2009 UTC Ranges from 9.8% to 44.0%

Table 3. UTC Metrics in Salem by Sub-basins

Sub-basins	Sub-basin Code	Total Acres	2001 UTC Acres	2001 UTC %	2009 UTC Acres	2009 UTC %	Change in UTC Acres	Change in UTC %
Lower Claggett	01-LCB	1,484	114	7.7%	145	9.8%	**31**	2.1%
East Bank	02-EBB	1,261	211	16.7%	238	18.9%	**27**	2.2%
Upper Claggett	03-UCB	4,328	524	12.1%	578	13.4%	**54**	1.3%
Little Pudding	04-LPB	4,602	540	11.7%	538	11.7%	**-2**	0.0%
Willamette Slough East	05-WSE	3,285	812	24.7%	798	24.3%	**-13**	-0.4%
Mill Creek	06-MCB	6,096	773	12.7%	787	12.9%	**14**	0.2%
Croisan Creek	07-CCB	1,167	528	45.3%	513	44.0%	**-15**	-1.3%
Pringle Creek	08-PCB	7,342	1,387	18.9%	1,448	19.7%	**60**	0.8%
Battle Creek	09-BCB	3,017	701	23.2%	641	21.3%	**-60**	-1.9%
Willamette Slough West	10-WSW	254	64	25.1%	68	26.8%	**4**	1.7%
Glenn/Gibson	11-GGB	3,569	784	22.0%	749	21.0%	**-35**	-1.0%
West Bank	12-WBB	1,320	273	20.7%	255	19.3%	**-18**	-1.4%
Pettijohn	13-PJB	562	254	45.1%	224	39.9%	**-30**	-5.2%
Totals		38,288	6,966		6,984		18	

Figure 12. 2009 UTC by Sub-basins and UTC Change by Sub-basins



Tree Canopy Results by Land Use

Table 4. Tree Canopy Metrics by Land Use Type

Land Use Category	Total Acres	% of Total Acres (Fig. 12a)	2001 UTC Acres	2001 % UTC	2001 % of Total UTC	2009 UTC Acres	2009 % UTC	2009 % of Total UTC (Fig. 12b)	Change in UTC Acres	Percent Change in UTC
Commercial	2,392	7.2%	195	8.1%	2.8%	231	9.7%	3.2%	36	1.6%
Downtown	142	0.4%	10	6.8%	0.1%	13	9.4%	0.2%	4	2.6%
Industrial	4,211	12.6%	276	6.6%	3.9%	311	7.4%	4.4%	35	0.8%
Low Density Residential	6,887	20.7%	1,746	25.4%	24.7%	1,682	24.4%	23.6%	-64	-1.0%
Medium Density Residential	11,110	33.4%	2,710	24.4%	38.3%	2,670	24.0%	37.5%	-40	-0.4%
High Density Residential	2,421	7.3%	383	15.8%	5.4%	418	17.3%	5.9%	35	1.5%
Other Public Land	3,666	11.0%	386	10.5%	5.4%	375	10.2%	5.3%	-11	-0.3%
Public Open Space	2,478	7.4%	666	26.9%	9.4%	675	27.2%	9.5%	10	0.3%
Totals	33,308	100%	6,370		90.0%	6,375		89.5%	5	5.1%

Figure 13a. Distribution of Land Area by Land Use Type

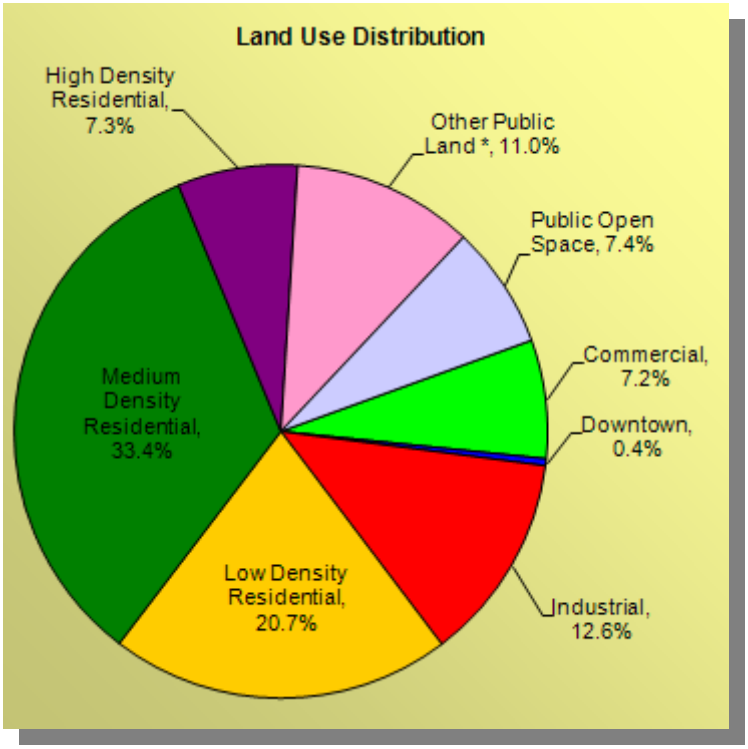
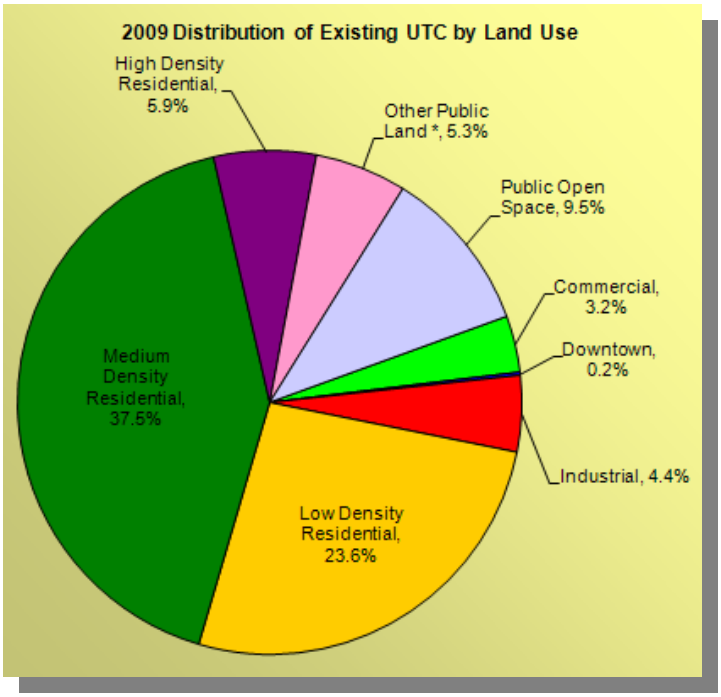


Figure 13b. Distribution of 2009 UTC by Land Use Type



Figures 14 a, b, and c. Thematic maps illustrating tree canopy change from 2001 to 2009 by land use type.

Figure 14a.

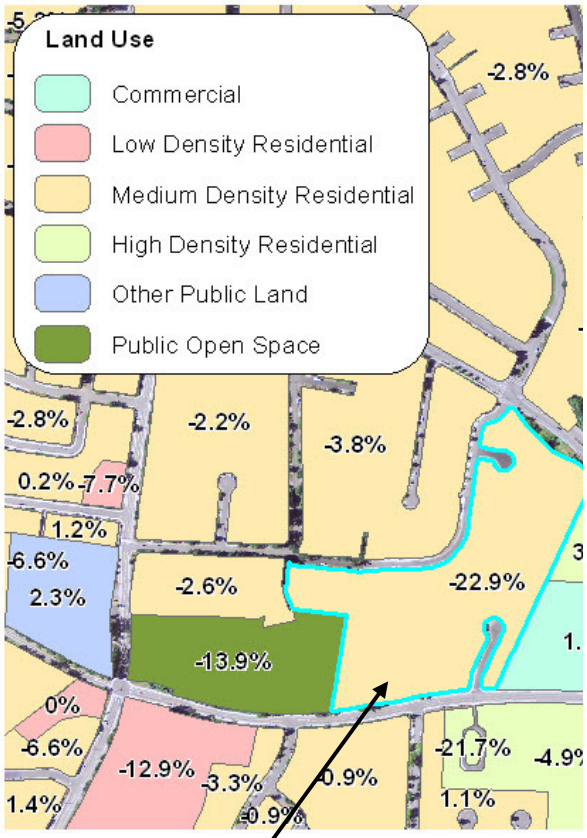
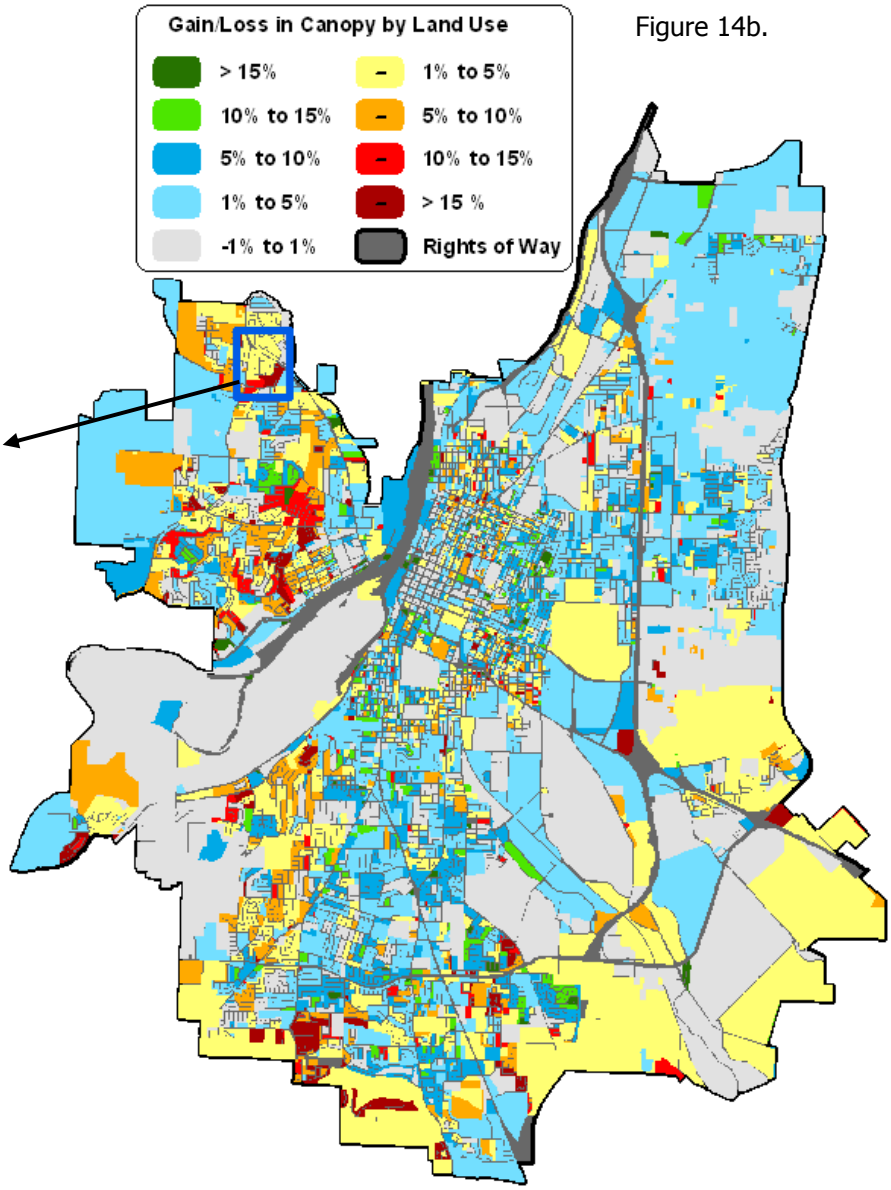


Figure 14b.



The highlighted Medium Density Residential area shown in the graphic above and attribute table below (Fig 14c) has decreased in tree canopy coverage by 22.9%.

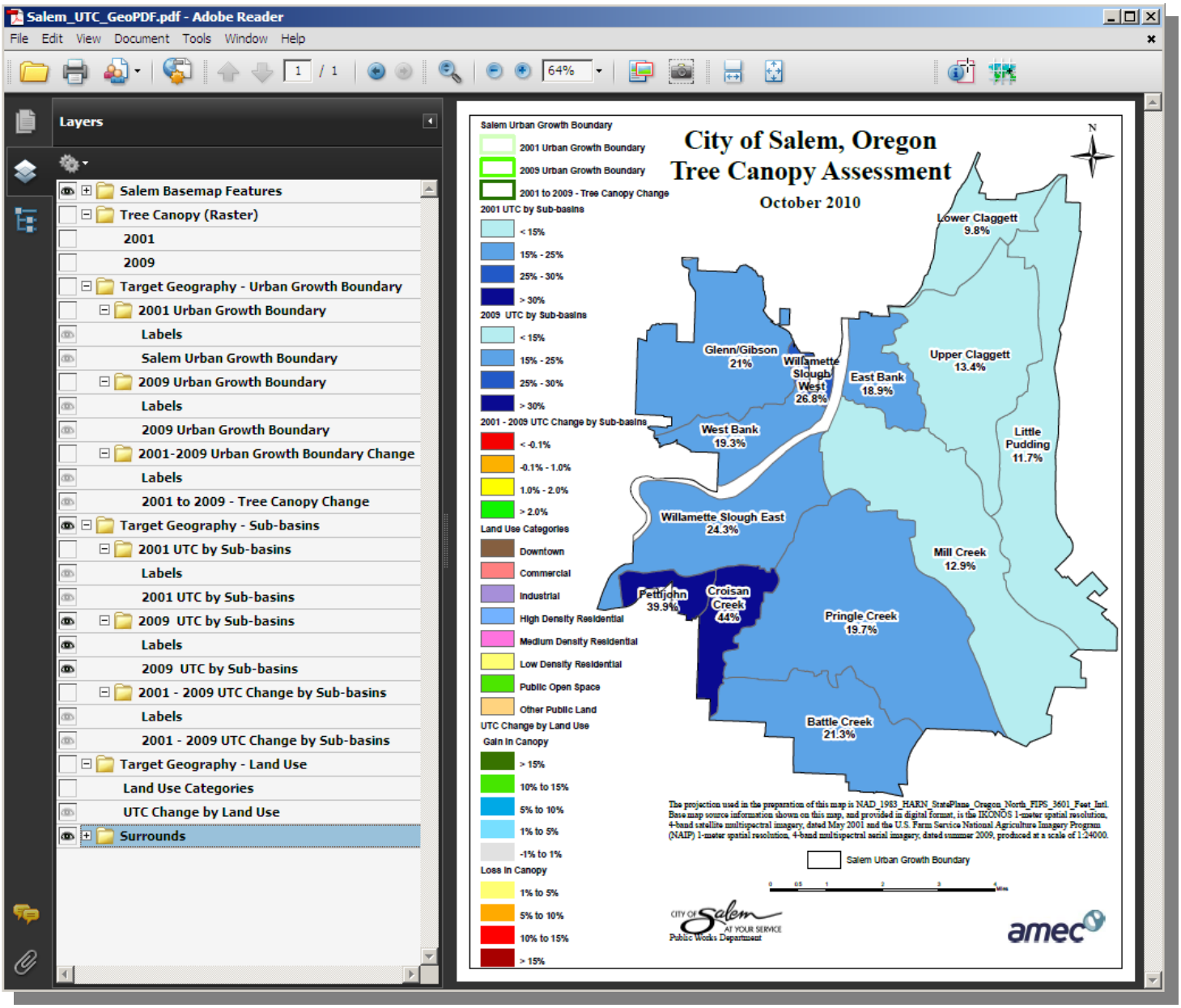
Figure 14c.

Attributes of LandUse_Detailed_UTC

ZNPCAT	TOT_ACRES	E_UTC_AC_01	E_UTC_PC_01	E_UTC_AC_09	E_UTC_PC_09	DELTA_AC	DELTA_PC
Medium Density Residential	10.11	1.52	15	1.43	14.1	-0.09	-0.9
Medium Density Residential	8.81	0.86	9.8	0.96	10.9	0.1	1.1
Medium Density Residential	4.53	1.61	35.5	1.49	32.9	-0.12	-2.6
Medium Density Residential	0.86	0	0	0.01	1.2	0.01	1.2
Medium Density Residential	18.35	13.38	72.9	9.18	50	-4.2	-22.9
Medium Density Residential	4.31	0.15	3.5	0.16	3.7	0.01	0.2
Medium Density Residential	2.51	0.11	4.4	0.04	1.6	-0.07	-2.8
Medium Density Residential	27.28	5.63	20.6	3.83	14	-1.8	-6.6

Record: 1 Show: All Selected Records (1 out of 33 Selected) Options

Figure 15. Screenshot of the interactive GeoPDF document, or map-based PDF, that enables non-GIS users the ability to view the data layers for tree canopy and groves and the UTC results at different scales, specifically the City and Urban Growth Boundary, the sub-basin boundaries, and the zoning categories, by turning each layer on and off in the PDF. One can also use Adobe's "Analysis - Object Data" tool to identify GIS attributes such as area and percent of UTC for each record in each geographic target. Note that the imagery used in the land cover analysis is included as a background layer but is not visible here and that the PDF is shown displaying thematic UTC results for sub-basins.



Summary of Findings

- Between 2001 and 2009 the City of Salem gained 0.1% tree canopy (42 acres).
- With an urban tree canopy of 18.3% in 2009, the City of Salem has below average tree canopy cover compared with other similar cities in the United States.
- No land use type has increased or decreased in tree canopy by more than 2.6%. Downtown increased in tree canopy by 2.6% but this land use zone has the smallest overall acreage (142 acres or 0.2% of the total canopy).
- Tree groves represent nearly 51.5% of the 2009 tree canopy. Although the number of tree groves increased, the overall grove acreage declined by 112 acres between 2001 and 2009.
- The Lower Claggett and East Bank sub-basins experienced the largest increase in tree canopy (>2%) over the eight-year time period while the Pettijohn sub-basin had the greatest decrease (-5.2%).
- Croisan Creek sub-basin has the highest percent tree coverage in 2009 with 44% tree canopy, followed by Pettijohn sub-basin with 39.9% canopy.
- Glenn Gibson, West Bank, Croisan and Battle Creek sub-basins all experienced canopy loss in the 1-2% range, with a total canopy loss of 128 acres.
- Commercial and Industrial properties comprise 19.8% of the study area land use but only make up 3.2% and 4.4% of Salem's 2009 canopy cover respectively.
- Low, medium and high density residential zone makes up 61.4% of the landuse but contain 67% of the tree canopy.
- Salem's Downtown land use type has 9.4% tree canopy cover.

The modest increase in tree canopy from 2001 to 2009 (0.1% citywide) may indicate a "business as usual" or "status quo" condition for UTC in Salem and indicates that efforts or resources may likely be inadequate for increasing tree cover, if that is the goal of city forestry and natural resource efforts.

Opportunities and Recommendations

Below is a list of opportunities for increasing tree canopy in the City based on this assessment, followed by recommendations for further investigation of the City's tree cover and potential of setting a UTC goal. Metrics refer to 2009 results unless stated otherwise.

- Sorting the UTC spreadsheet and GIS attribute tables by %-UTC quickly identifies land use types and sub-basins with low existing UTC or changes in UTC. This provides a starting point for targeting increases in UTC at scales that are meaningful for planning and management purposes. In addition:
    - Low UTC and data on high impervious surface areas could help prioritize sub-basins for other watershed-related improvement projects.

- The "Land Use Detailed" GIS layer provides the finest scale of existing UTC and change in UTC. As an example, 1,175 out of 4,084 records (28.7%) in the land use database have less than 10% UTC and 290 records (7.1%) had a loss of greater than 10%, with the majority of losses in medium residential land use largely in the west and south parts of the study area. With the large amount of development Salem has experienced during the time period used for this study, the most significant gains in overall UTC will come from tree plantings in or near residential land use.

- All land use categories offer significant opportunity for increasing UTC. Tree canopy improvements could be targeted in tangent with green infrastructure initiatives to mitigate stormwater issues and to shade and beautify retail centers to increase local business revenues.
- There are significant opportunities to increase UTC in riparian corridors for habitat improvements or near impervious surfaces even without replacing significant portions of parking lots with trees. Benefits would include a decrease in the urban heat island effect, and improved infiltration, stormwater runoff mitigation, and water quality. UTC and planting locations could be assessed specifically in parking lots and riparian corridors.

The City of Salem should consider setting a UTC goal. From a high-level perspective, this may include but is not limited to the following actions:

- Perform a cost/benefit and scenario analysis to determine the environmental, economic, and social benefits of increased tree cover as well as the costs associated with such an initiative. This could be done using programs such as CITYgreen, the U.S. Forest Service i-Tree models (Streets, Eco, Vue, Species Selector and/or Hydro), the U.S. Forest Service Community Tree Guides and stormwater models such as the U.S. EPA's SWMM-LID. Information gained, that is the structure, function, and value of the forest, would benefit planning, management and outreach activities.
- Assess the potential for public/private partnerships, local non-profit capacity, incentive/education programs, and adequacy of tree preservation ordinances and development codes in relation to the UTC goal, both in Salem and in other cities.
- Conduct an urban forest "report card" assessment that would grade the City on tree cover, tree health, tree planting, tree awareness, and tree protection.
- In determination of the actual percent UTC goal, we would recommend the following:
  - Conduct a street tree inventory and assess UTC in streets at the block level.
  - Map the City's "Possible UTC", or the areas of grass, open space, and parking lots available for tree planting, as an additional metric at various scales
  - Generate and utilize a "UTC Calculator" spreadsheet tool that enables a user to see the impact of tree planting on a citywide UTC goal or UTC goals within specific land use types.
  - Identification of properties that realistically have less ability to increase tree cover (industrial, agricultural, etc) both biophysically and economically and can be removed from a more detailed analysis of what's possible in residential, open space, and commercial properties. This would include consideration of the age of land use or individual parcels as it relates to young vs. mature tree cover.

We recommend that the City further investigate where and why tree canopy was lost between 2001 and 2009, considering the following:

- As an example, 102 out of 4,084 records in the land use database lost more than 1 acre of tree cover, which was more than a 10% decline of tree canopy on 51 of these records. These 51 areas were mostly medium density residential land use.
- Assess or investigate why canopy isn't reaching its potential (e.g. disease/pests, wind or ice storms, lack of tree planting or maintenance, or socio-economic factors).

We recommend that the City further investigate where and why the most tree canopy was *gained* between 2001 and 2009 to identify successful tree planting and maintenance efforts:

- Doing a similar exercise as above but looking at the increase in UTC, 89 records in the detailed land use database show a UTC increase of 1-acre or more however this only resulted in more than a 10% increase in UTC in 18 of the 89 areas.
- Looking more closely at areas with new development (since 2001) and public open space may indicate that increases in UTC have only been associated with development in areas that previously did not have tree cover (agriculture or natural open space lands).
- A detailed analysis within the Public Rights-of-Way may also indicate where gains have been greatest.

This urban tree canopy assessment should be performed again in 5 to 8 years to monitor development and effectiveness of incentive or other programs, codes and ordinances. These results and data products should be used by the City of Salem and other stakeholders as a starting point for more detailed environmental studies, comprehensive planning, GIS analyses and targeted urban forestry implementation/outreach programs.

There are many benefits of tree canopy assessment projects, including low cost, rapid turnaround, integration with existing GIS resources and resulting datasets that meet multiple agency and department needs. A UTC project will not replace the more detailed information collected through a traditional street tree inventory as specific species are not identified and no attempt is made to qualify the existing canopy in terms of its sustainable and diverse species. Nonetheless, it is an effective method for establishing canopy cover goals, estimating overall ecosystem services, and assessing the urban forest with results that are easily communicated with project stakeholders and the community at large.

About AMEC Earth & Environmental, Inc.

AMEC Earth & Environmental (AMEC) is a leading full-service environmental engineering firm in North America, providing environmental and geotechnical engineering and scientific consulting services. AMEC is a focused supplier of high-value consultancy, engineering, and project management services to the world's environmental, energy, power and process industries. We are one of the world's leading environmental and engineering consulting organizations. Our full service capabilities cover a wide range of disciplines, including environmental engineering and science, geotechnical engineering, water resources, materials testing and engineering, surveying, information management (GIS, remote sensing, database/application development) and program/project management.

CITY OF Salem AT YOUR SERVICE

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