Urban Tree Canopy Assessment
Woodland, California

2018

WOODLAND
City of Trees
CALIFORNIA

DAVEY
Resource Group

Urban Tree Canopy Assessment Woodland, California

2018

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Table of Contents

Figures

Tables

Maps

Executive Summary

The amount and distribution of leaf surface area is the driving force behind the urban forest's ability to produce benefits for the community (Clark et al, 1997). As canopy cover increases, so do the benefits contributed by leaf area. These benefits, which include energy savings, air quality, water quality, stormwater interception, aesthetic and other socioeconomic benefits can be quantified for their value to the community. Understanding the location and extent of tree canopy is key to developing and implementing sound management strategies that promote the sustainability and growth of Woodland's urban forest resource and the benefits it provides.

In 2010, the City of Woodland contracted with Davey Resource Group (DRG) to conduct an urban tree canopy (UTC) assessment[1] using high-resolution aerial imagery and remote sensing software. The assessment resulted in a GIS map which detailed the location and extent of tree canopy (public and private) across the community. Since then, the urban forest has experienced changes in tree cover. In 2017, the City of Woodland contracted with DRG to develop an Urban Forest Master Plan (UFMP). An updated UTC assessment was developed as part of the plan development process. This report provides an update on tree canopy along with mapping other primary land cover, including impervious surface, grass and low-lying vegetation, bare soil, and water. This assessment also explores the condition of tree canopy and the benefits from this urban forest resource. As of 2018, the current land cover in Woodland is comprised of:

- 14.5% Tree Canopy
- 46.8% Impervious Surfaces
- 36.1% Pervious Surfaces (bare soils and low-lying vegetation)
- 2.6% Open Water

Land Cover

The City of Woodland encompasses approximately 15 square miles (9,624 acres). Excluding impervious surface (4,500 acres) and open water (260 acres), Woodland contains approximately five square miles (3,470 acres) which has the potential to support tree canopy. The following characterizes land cover in Woodland:

- 1,394 acres (14.5%) of tree canopy, including trees and woody shrubs.
- 4,500 acres (46.8%) of impervious surface, including roads and structures.
- 35.2 acres of tree canopy in parks, an average of 30.1% canopy cover.
- 73.2% of the urban forest canopy is in fair or better condition.
- 148,194 tons of carbon (CO_2) is stored in the woody and foliar biomass of Woodland's urban forest (public and private), valued at $5.2 million.
- A maximum canopy potential of 50.5% for the total urban forest (public and private).
- Since 2009, overall tree canopy has increased by 727 acres (109%) and the percentage of tree canopy cover has increased from 6.9% to 14.5%.
- Since 2009, tree canopy in parks has increased by 15 acres (74.4%) and the percentage of tree canopy cover in parks increased from 16.8% to 30.1%.

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[1] City of Woodland, California Urban Forest Resource Analysis and Community Canopy Study, February 2010

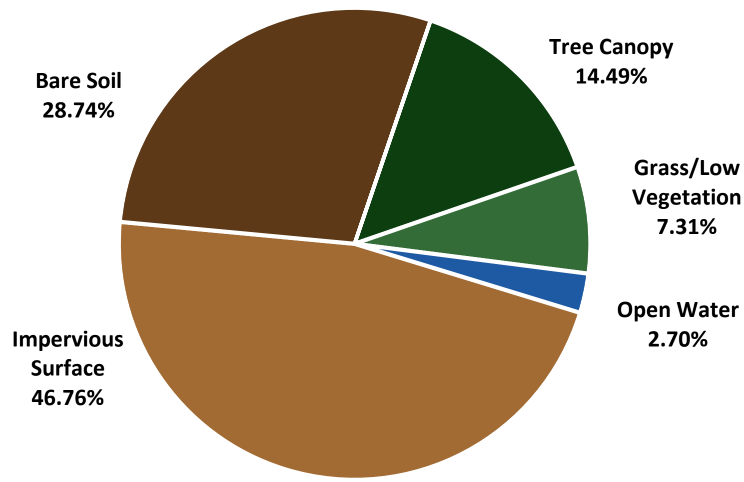


Figure 1: Woodland Land Cover Classes

Environmental Benefits

To determine the environmental benefits from the urban forest (public and private trees), Woodland's land cover was analyzed with i-Tree *Canopy* (v6.1). The analysis estimates that Woodland's trees annually provide $568,075 in benefits to air quality and stormwater runoff reduction (Figure 2, Table 2), including:

- Removing 40 tons of air pollutants, including carbon monoxide (CO), nitrogen dioxide (NO_2), ozone (O_3), sulfur dioxide (SO_2), and particulate matter (PM_{10}), valued at $181,749.
- Reducing stormwater runoff by 15.3 million gallons annually, valued at $122,038.
- Removing (sequestering) an additional 7,496 tons of CO_2, valued at $264,288.

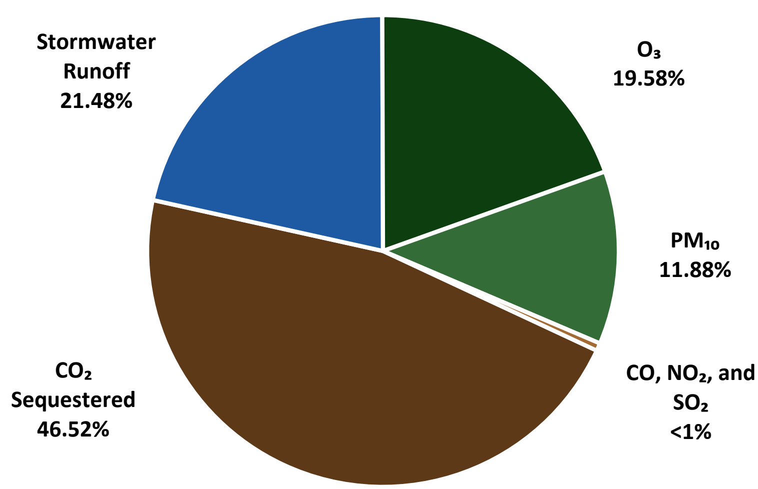


Figure 2: Annual Benefits Summary for Woodland

Table 1: Annual Environmental Benefits Summary

Item	Value ($)	% of Total Benefits
CO_2 Sequestered	264,288	46.52
Stormwater Runoff	122,038	21.48
O_3	111,232	19.58
PM_{10}	67,496	11.88
CO, NO_2, and SO_2	3,021	0.53
Total	**$568,075**	**100%**

Management Applications

Understanding the location and extent of tree canopy is key to developing and implementing sound management strategies that promote the sustainability of Woodland's urban forest resource. The data, combined with existing and emerging research, enables managers to balance urban growth with tree preservation and aids in identifying and assessing urban forestry opportunities. A spatial understanding of tree canopy can help urban forest managers and city leadership align urban forestry objectives with community vision. Identifying priority planting areas that yield the most return on investment is especially important.

Woodland has an existing tree canopy cover of 14.5% and a maximum potential for 50.5% canopy. To help identify the most beneficial sites for expanding canopy, potential sites were mapped and then prioritized based on soils, slope, and existing canopy. These maps are valuable tools for guiding tree planting projects. Recommendations for maintaining existing canopy and promoting growth include:

- Use priority planting site analyses to identify new tree planting locations to reduce erosion and soil degradation and decrease canopy fragmentation.
- Use the canopy health map to identify and explore locations where environmental factors like soil and/or water conditions may be impacting tree or species health.
- Promote species diversity for greater resilience and pest resistance.
- Plant large-stature shade trees where space and design allow.
- Remove and replace failing and over-mature trees.
- Incentivize tree planting on private property, particularly in high and very high priority planting areas.

California is famous for its oaks. Here, the City has constructed sidewalk around the trunk of a large oak tree.

Introduction

Woodland celebrated its first Arbor Day In 1903. Trees play a significant role in the community and the City is dedicated to developing tree canopy and protecting the health of this resource. By 1920, Woodland had been unofficially declared "the City of Trees" and the city flag was embellished with a valley oak. Numerous ordinances and programs have been created over the years to encourage the expansion of the community forest.

Individual trees play an essential role in the community of Woodland by providing many benefits, tangible and intangible, to residents, visitors, and neighboring communities. Research demonstrates that healthy urban trees can improve the local environment and lessen the impact resulting from urbanization and industry (Center for Urban Forest Research, 2017). Trees improve air quality, reduce energy consumption, help manage stormwater, reduce erosion, provide critical habitat for wildlife, and promote a connection with nature.

Woodland is located in the Central Valley of California and has a population of 59,068 according to 2016 estimates by the United States Census Bureau. The community experiences an average summer temperature of 95°F, an average winter temperature of 39°F and average annual precipitation of 21.4 inches.

Urban Tree Canopy and Geographic Information Systems

Urban Tree Canopy is the layer of leaves, branches, and stems that cover the ground when viewed from above. Since trees provide benefits to the community that extend beyond property lines, the assessment includes all tree canopy within the borders of the community and does not distinguish between publicly-owned and privately-owned trees. To place tree canopy in context and better understand its relationship within the community, the assessment included other primary landcover classifications, including impervious surfaces, pervious surfaces, bare soils, and water.

As more communities focus attention on environmental sustainability, community forest management has become increasingly dependent on geographic information systems (GIS). GIS is a powerful tool for urban tree canopy mapping and analysis. Understanding the extent and location of the existing canopy is key to identifying various types of community forest management opportunities, including:

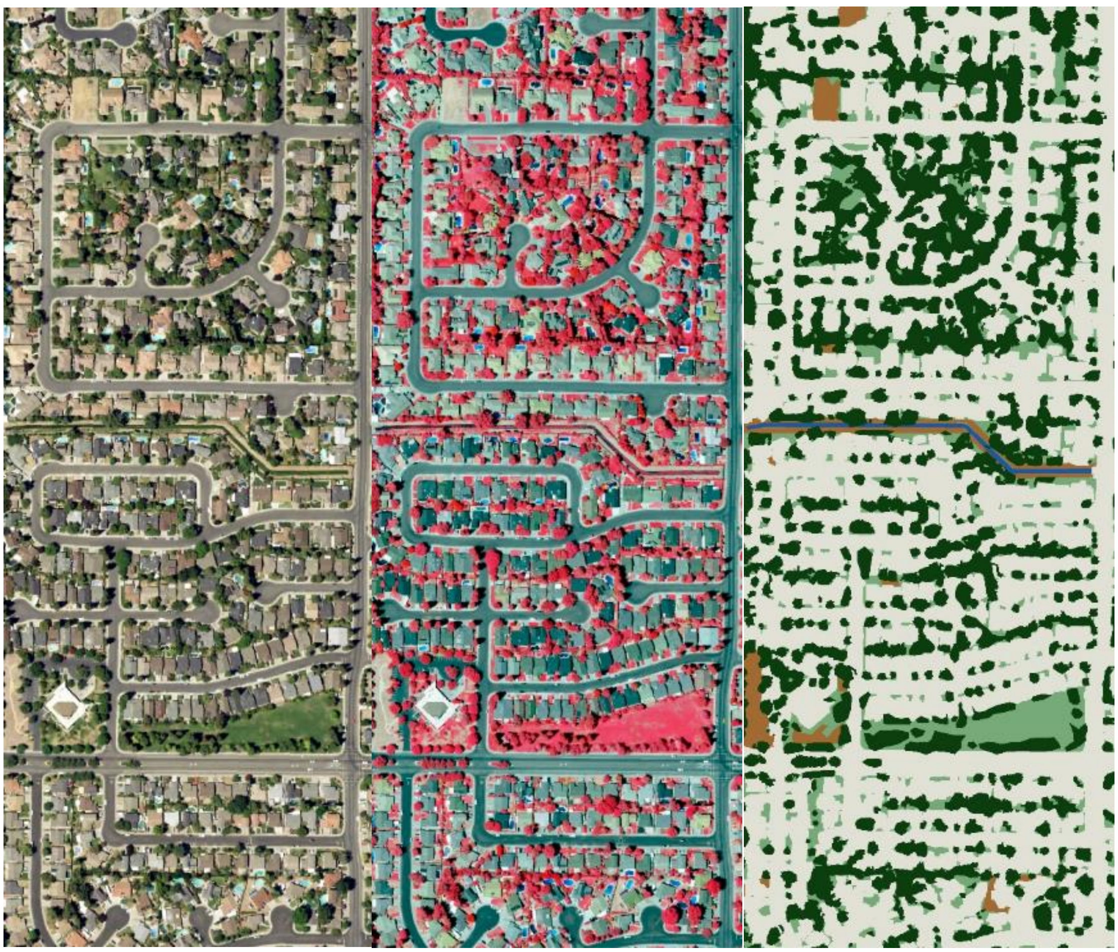
- Future planting plans
- Stormwater management
- Water resource and quality management
- Impact and management of invasive species
- Preservation of environmental benefits
- Outreach and education

High-resolution aerial imagery (2016) and infrared technology remotely mapped tree canopy and land cover (Figure 3). The results of the study provide a clear picture of the extent and distribution of tree canopy within Woodland. The data developed during the assessment becomes an important part of the City's GIS database and provides a foundation for developing community goals and urban forest policies. The primary purpose of the assessment was to update benchmark values and assess change since 2009. The results will enable managers to understand recent changes in the urban forest and measure the success of long-term management objectives over time. With this data, managers can determine:

- Woodland's progress towards local and regional canopy goals.
- Changes in tree canopy over time and in relation to growth and development.
- The location and extent of canopy at virtually any level, including land use, zoning, parks.
- The location of available planting space to develop strategies for increased canopy in underserved areas.

In addition to quantifying existing urban tree canopy, this assessment illustrates the potential for increasing tree canopy across Woodland. The data, combined with existing and emerging urban forestry research and applications, can provide additional guidance for determining a balance between growth and preservation and aid in identifying and assessing urban forestry opportunities.

Figure 3: Land Cover Mapping



High-resolution aerial imagery (left) is used to remotely identify existing land cover. Infrared technology delineates living vegetation including tree canopy (middle). Remote sensing software identifies and maps tree canopy and other land cover (right).

Benefits of Urban Tree Canopy

Urban forests continuously mitigate the effects of urbanization and development and protect and enhance the quality of life within the community. The amount and distribution of leaf surface area is the driving force behind the ability of the urban forest to produce benefits for the community (Clark et al, 1997). Healthy trees are vigorous, often producing more leaf surface area each year. Trees and urban forests provide quantifiable benefits to the community in the following ways:

Air Quality

Urban trees improve air quality in five fundamental ways:

- Reducing particulate matter (dust)
- Absorbing gaseous pollutants
- Providing shade and transpiration
- Reducing power plant emissions
- Increasing oxygen levels

Urban trees protect and improve air quality by intercepting particulate matter (PM_{10}), including dust, ash, pollen, and smoke. The particulates are filtered and held in the tree canopy. Trees and forests also absorb harmful gaseous pollutants like ozone (O_3), nitrogen dioxide (NO_2), and sulfur dioxide (SO_2). Shade and transpiration reduce the formation of O_3, which is created during higher temperatures. In fact, scientists are now finding that some trees may absorb more volatile organic compounds (VOC's) than previously thought (Karl et al, 2010). VOC's are a class of carbon-based particles emitted from automobile exhaust, lawnmowers, and other human activities. By reducing energy needs, trees also reduce emissions from the generation of power. Also, through photosynthesis, trees and forests increase oxygen levels.

Annually, in Woodland, trees remove 80,208 pounds of air pollutants for a total value of $181,749, including: carbon monoxide (CO), nitrogen dioxide (NO_2), ozone (O_3), sulfur dioxide (SO_2), and particulate matter (PM_{10}).

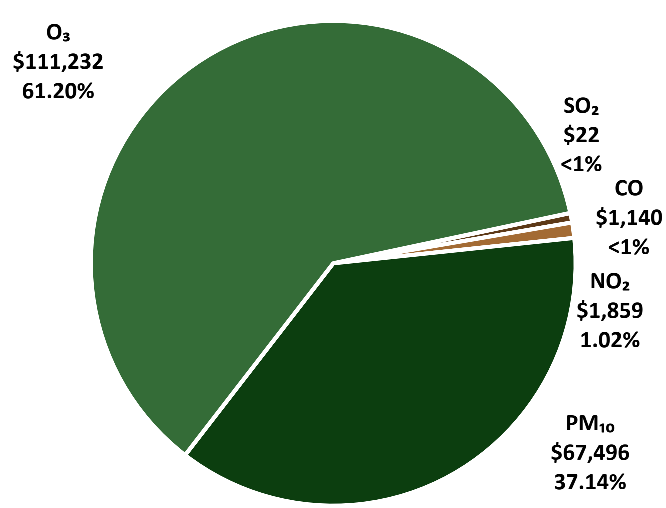


Figure 4: Air Pollutant Benefits Summary

Carbon Reduction

Trees and forests directly reduce CO_2 in the atmosphere through growth and sequestration of carbon as woody and foliar biomass. When trees die and decay, they release much of the stored carbon back to the atmosphere. In urban environments, most trees that die are removed and chipped or disposed of as firewood, releasing stored carbon. Thus, carbon storage is an indication of the amount of carbon that can be gained and lost over the course of a trees lifecycle through growth and decomposition. Indirectly, trees and forests reduce CO_2 by lowering the demand for energy and reducing the CO_2 emissions from the consumption of natural gas and the generation of electric power.

Purchasing emission allowances (offsets) has led to the acceptance of carbon credits as a commodity that can be exchanged for financial gain. Thus, some communities are exploring the concept of planting trees to develop a carbon offset (or credit). UESPD and USDA Forest Service recently led the development of Urban Forest Greenhouse Gas Reporting Protocol (McPherson et al, 2008/2010). The protocol establishes methods for calculating reductions and provides guidance for accounting and reporting. These methods guide urban forest managers in developing tree planting and stewardship projects that could be registered for greenhouse gas reduction credits.

The urban forest in Woodland currently stores 148,194 tons of carbon (CO_2) in woody biomass, valued at over $5.2 million. Furthermore, annually, Woodland trees sequester 7,496 tons of carbon valued at $264,288.

Stormwater Reduction

Trees and forests improve and protect the quality of surface waters, such as creeks, rivers, and lakes, by reducing the impacts of stormwater runoff through:

- Interception
- Increasing soil capacity and rate of infiltration
- Reducing soil erosion

Trees intercept precipitation in their canopy, which acts as a mini-reservoir (Xiao et al, 1998). During storm events, this interception reduces and slows runoff. In addition to catching stormwater, canopy interception lessens the erosive impact of raindrops on bare soil. Root growth and root decomposition increase the capacity and rate of soil infiltration by rainfall and snowmelt (McPherson et al, 2002). Each of these processes greatly reduces the flow and volume of stormwater runoff, avoiding erosion and preventing sediments and other pollutants from entering local creeks and waterways.

Surface runoff is a cause for concern in many urban areas as it contributes to the pollution and flooding of streams, wetlands, rivers, lakes, and oceans. Figure 4 illustrates the benefits of trees to reducing stormwater runoff. When rain falls on impervious surfaces it cannot permeate into the soil. Instead, it collects into flows and runoff. The runoff picks up sediment, trash, oil, bacteria, and other contaminants from paved surfaces and carries this non-point source pollution to bodies of water. Along with pollutants, stormwater runoff can produce flows with large volumes of water in a short period of time, causing flooding and erosion.

During precipitation events, some portion of the precipitation is intercepted by vegetation (trees, shrubs, grass, other vegetation). Some of the water is temporarily held by leaves and bark and later evaporates or gradually infiltrates the soil, which slows the movement of water off site. The portion of the precipitation that reaches the ground and does not infiltrate into the soil or falls on impervious surfaces, becomes surface runoff (Hirabayashi, 2012). In urban areas, the substantial extent of impervious surface increases the amount of surface runoff and the cost of infrastructure a community must invest to manage stormwater for the safety of residents and property.

Annually, the urban forest in Woodland reduces stormwater runoff by 15.3 million gallons valued at $122,038. This accounts for 21.5% of the annual environmental benefits provided by Woodland's urban forest. A full explanation of stormwater value calculations are found in Appendix B.

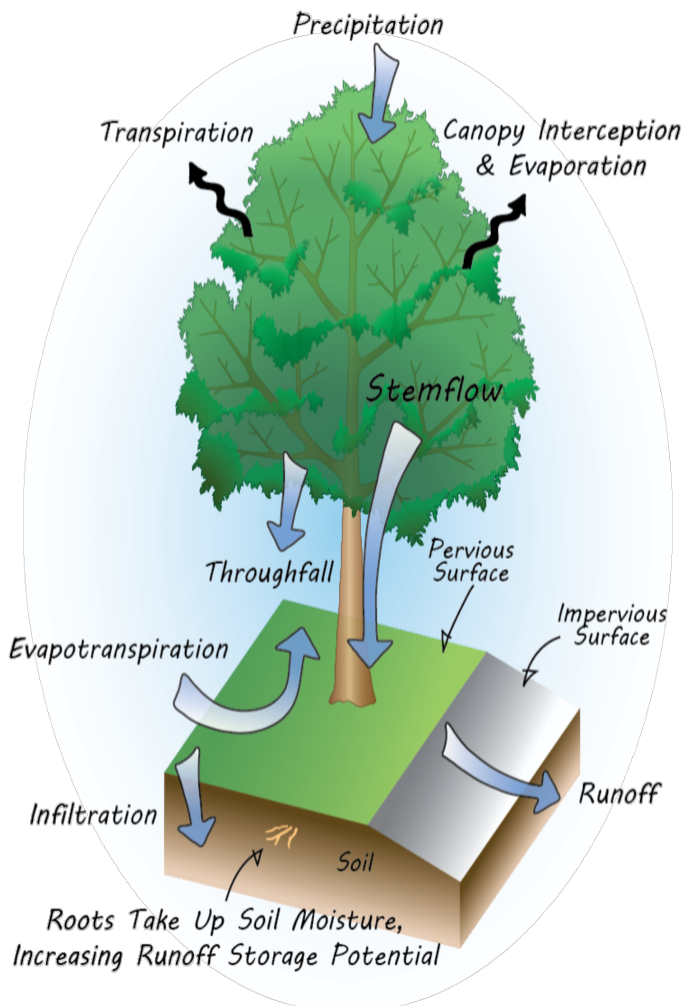


Figure 5: Stormwater Runoff Diagram

Energy Savings

Urban trees and forests modify climate and conserve energy in three principal ways:

- Shading dwellings and hardscape
- Transpiration
- Wind reduction

Shade from trees reduces the amount of radiant energy absorbed and stored by hardscapes and other impervious surfaces, thereby reducing the heat island effect, a term that describes the increase in urban temperatures in relation to surrounding locations. Transpiration releases water vapor from tree canopies, which cools the surrounding area. Through shade and transpiration, trees and other vegetation within an urban setting modify the environment and reduce heat island effects. Temperature differences of more than 9°F (5°C) have been observed between city centers without adequate canopy cover and more vegetated suburban areas (Akbari et al, 1997).

Trees reduce wind speeds relative to their canopy size and height by up to 50%. Trees also influence the movement of warm air and pollutants along streets and out of urban canyons. By reducing air movement into buildings and against conductive surfaces (e.g., glass and metal siding), trees reduce conductive heat loss from buildings, translating into potential annual heating savings of 25% (Heisler, 1986). Reducing energy needs has the bonus of reducing carbon dioxide (CO_2) emissions from fossil fuel power plants.

Aesthetics and Socioeconomics

While perhaps the most difficult to quantify, the aesthetic and socioeconomic benefits from trees may be among their greatest contributions, including:

- Beautification, comfort, and aesthetics
- Shade and privacy
- Wildlife habitat and ecosystem health
- Opportunities for recreation
- Creation of a sense of place and history
- Human health

Many of these benefits are captured as a percentage of property values, through higher sales prices where individual trees and forests are located.

Calculating Tree Benefits

While all these tree benefits are provided by the urban forest, it can be useful to understand the contribution of just one tree. Individuals can calculate the benefits of individual trees to their property by using the National Tree Benefit Calculator or with i-Tree *Design*. (design.itreetools.org).

Calculate My Tree Benefits

Land Cover

Overall Canopy

Woodland encompasses an area of approximately 15 square miles (9,624 acres), of which approximately two (2) square miles (1,394 acres) are tree canopy (Figure 5). In addition to tree canopy, Woodland's land cover includes 46.8% impervious surface, 28.7% bare soil, 7.3% grass and low-lying vegetation, and 2.7% open water.

Considering the existing tree canopy and possible tree canopy over impervious areas, the canopy potential of Woodland is 50.5%%, although the actual potential may be higher where tree canopy can shade impervious surfaces such as roads, parking lots, and buildings.

The potential future tree canopy can be estimated by comparing the area of existing canopy to the area of low-lying vegetation and impervious surface. This analysis excludes sports fields, cemeteries, and other sites not suitable for trees. Based on this methodology, the analysis found an additional three (3) square miles (2,075 acres) where trees could be planted to augment existing canopy. If Woodland were to plant trees to cover all this area, then the overall tree canopy could be increased to 50.5%.

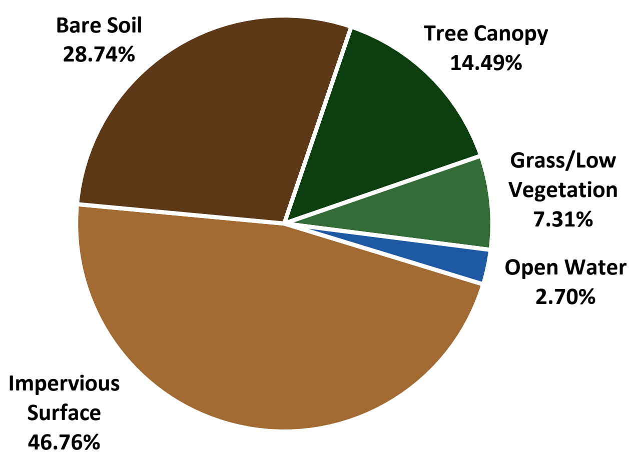
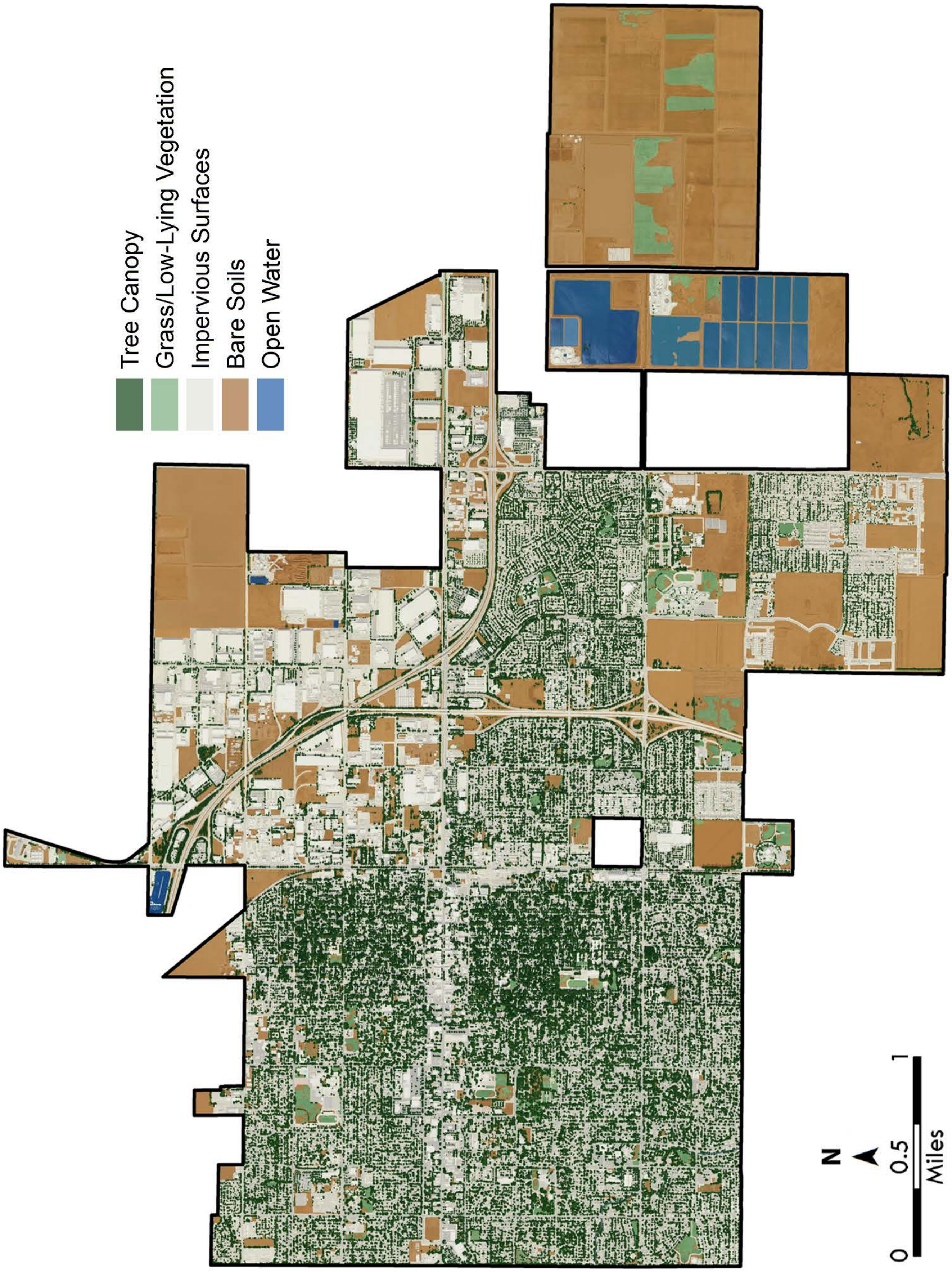


Figure 6: Woodland Land Cover Classification Summary

Table 2: Woodland Land Cover Classification Summary

Land Cover Class	Acres	% of Land Cover
Impervious Surface	4,500	46.76
Bare Soil	2,766	28.74
Tree Canopy	1,394	14.49
Grass/Low Vegetation	704	7.31
Open Water	260	2.70
Total	**9,624**	**100%**



Map 1: Woodland by Land Cover Class

Tree Canopy Health

Canopy health can be determined using near-infrared imagery and Normalized Difference Vegetation Index (NDVI) transformation. NDVI values are averaged over time to establish normal growing conditions in a region. Further analysis can then characterize the health of vegetation relative to the established normal condition. This allows identification of where plants are in very good condition, and where they are in decline. The results of this analysis provided detail canopy health information when viewed and analyzed in GIS software.

The UTC Tree Canopy Health analysis provides a detailed GIS layer.

In Woodland, 73.2% of the canopy is comprised of trees in fair or better condition. Healthy trees are vigorous, often producing more leaf surface area each year. 14.8% of Woodland's canopy is made up of trees in poor condition or dead or dying. The remaining 11.9% from this analysis are considered shadows or unclassified. This important baseline data can contribute to understanding forest health over time. The data can also be used as a comparison should emerging pests or disease become an issue.

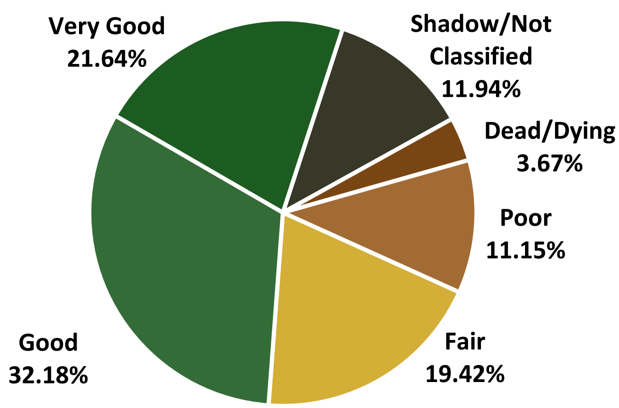
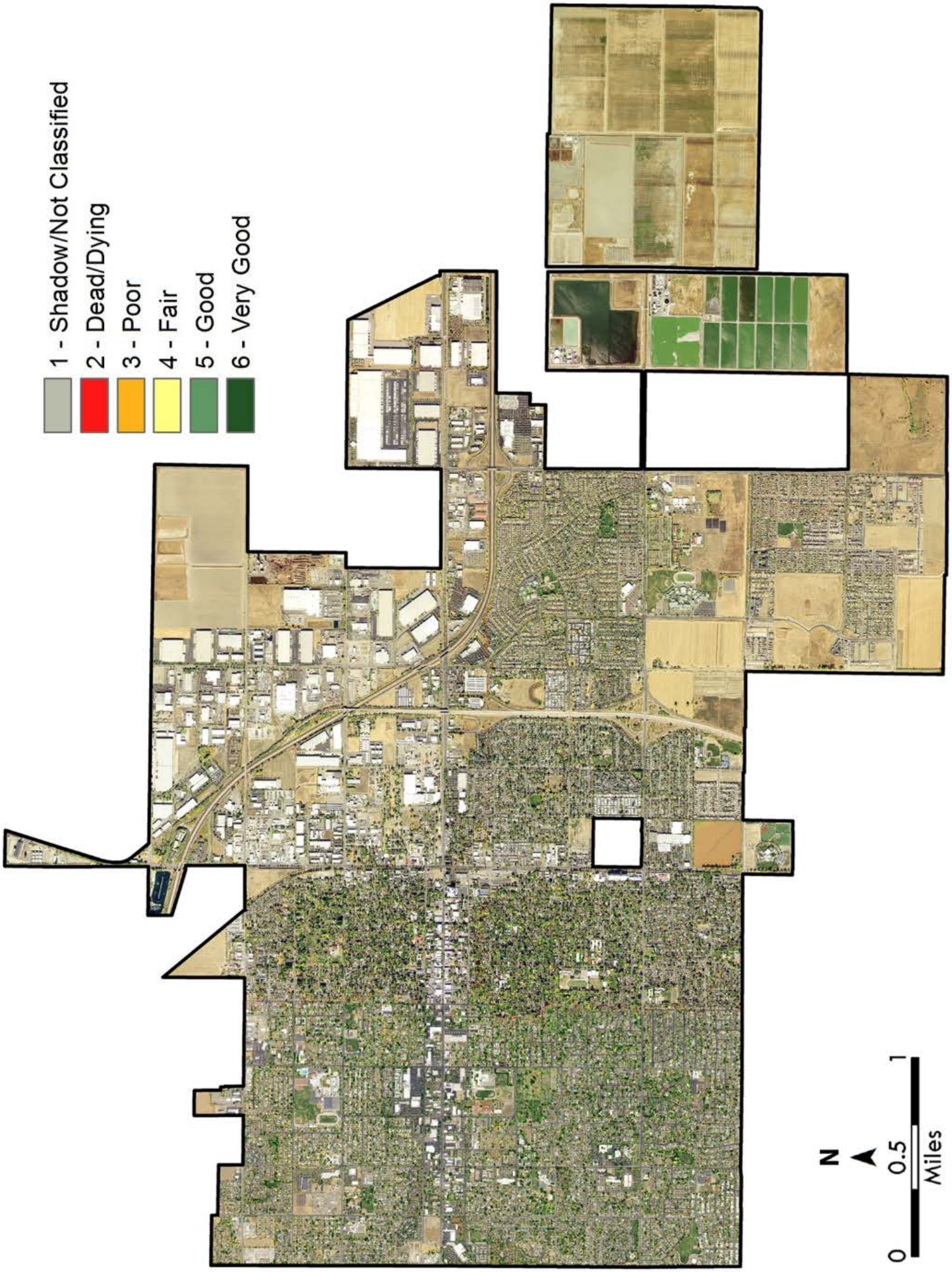


Figure 7: Summary of Canopy Health

Table 3: Summary of Canopy Health

Heath Rating	Acres	%
Shadow/Not Classified	167	11.94
Dead/Dying	51	3.67
Poor	155	11.15
Fair	271	19.42
Good	449	32.18
Very Good	302	21.64
Total	**1,394**	**100%**



Map 2: Tree Canopy Health

Tree Canopy by Council District

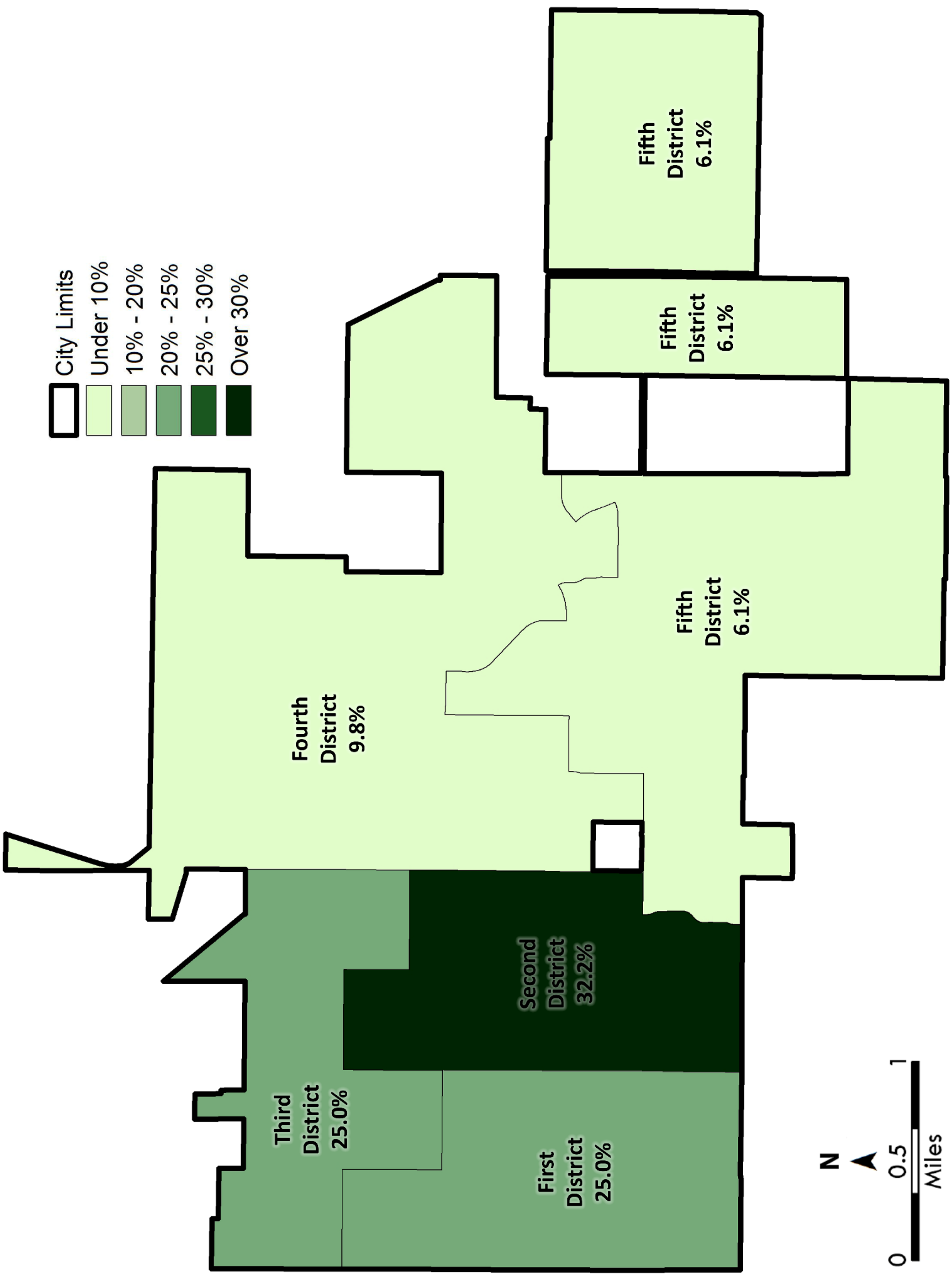
Council District boundaries are often used to better understand the distribution of tree canopy, as they tend to reflect geographies that are recognized by community members and elected officials. Exploring canopy distribution and socioeconomic indicators at this level can help facilitate outreach and education activities as well as develop a deeper understanding of tree canopy at a meaningful scale.

Woodland is divided into five (5) Council Districts (Map 3). The Second District has the greatest canopy cover (32.2%), followed by the First District (24.9%) and the Third District (24.9%). The Fifth district is the largest (3,414 acres) and has the lowest average canopy cover at 6.1%.

Table 4: Council District Summary by Acreage

Council District	Acres	Canopy Acres	Canopy %	Impervious Acres	Grass/Low Vegetation Acres	Bare Soil Acres	Water Acres	Preferred Plantable Acres	Potential UTC
First District	1,125	281	24.95	655	138	51	1	189	41.72
Second District	1,111	358	32.21	619	119	15	0	134	44.25
Third District	1,021	255	24.97	576	87	103	0	189	43.52
Fourth District	2,956	291	9.84	1,755	110	788	10	898	40.21
Fifth District	3,414	209	6.13	892	250	1,807	248	2,057	66.39

Aerial Image of Woodland



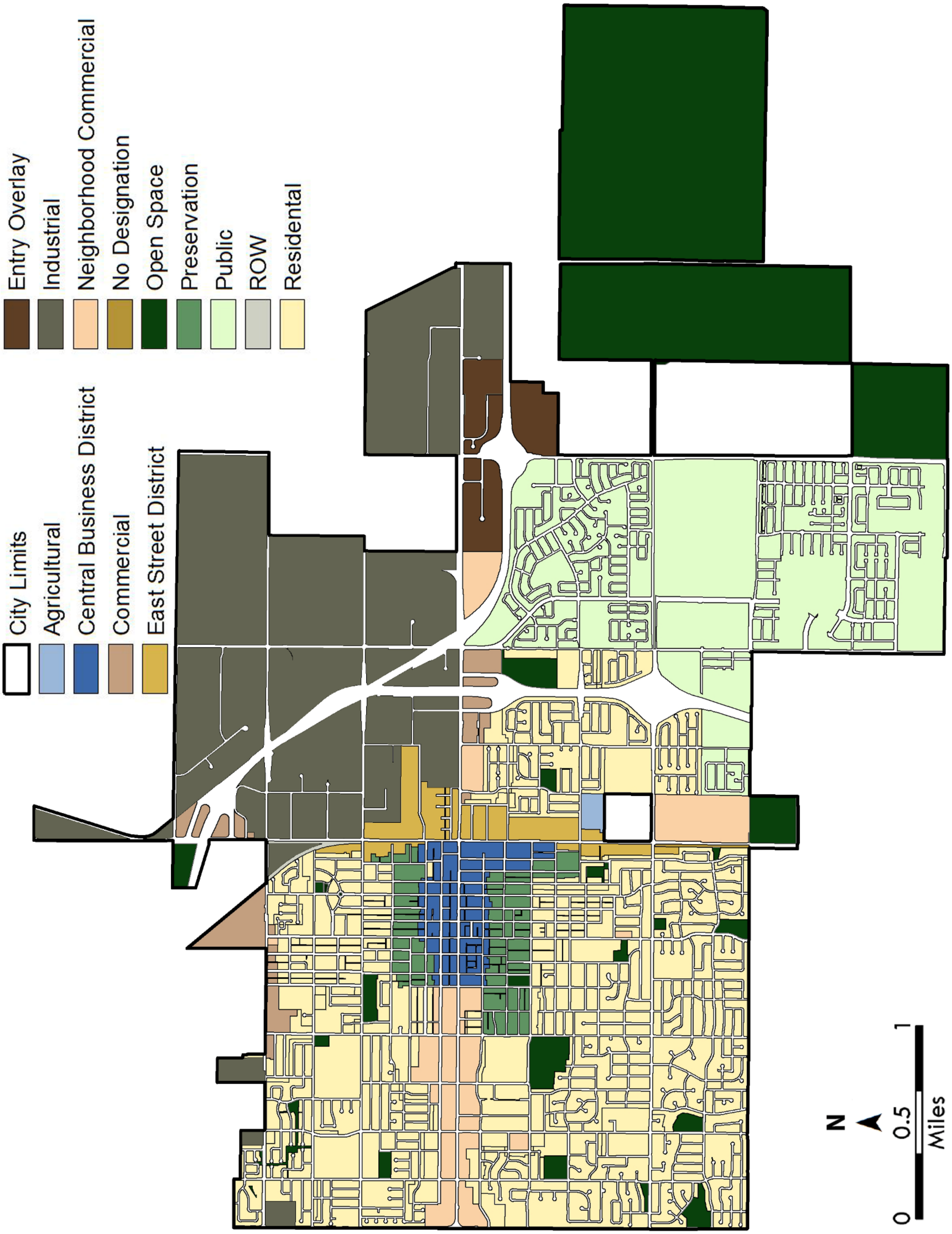
Map 3: Tree Canopy by Council District

Tree Canopy by Zoning

Zoned areas encompass 8,032 acres of the overall area in Woodland (9,624 acres). Open space (1,735 acres) encompasses the greatest area, followed by single family residential (1,714 acres), and industrial (1,696 acres). Single family residential areas have the greatest amount of tree canopy (531acres), but the highest canopy cover (39.8%) is found in areas with no designation followed by general commercial (37.3%). The Spring Lake Specific Plan refers to a parcel in south Woodland near the freeway that will be developed into private homes. This area is represented as public space on the map, but in the coming years will transition to residential.

Table 5: Tree Canopy by Zoning

Zoning Description	Acres	Canopy Acres	Canopy %	Impervious Acres	Grass/Low Vegetation Acres	Bare Soil Acres	Water Acres	Preferred Plantable Acres	Potential UTC
Open Space	1,734.61	51.31	27.20	66.33	175.72	1,180.61	256.16	1,356.33	81.15
Single Family Residential	1,714.46	531.36	2.96	876.44	243.02	61.99	1.17	305.00	48.78
Industrial	1,695.79	72.04	24.17	970.39	27.54	622.05	2.33	649.59	42.55
Spring Lake Specific Plan	932.11	44.64	4.79	282.75	82.13	522.59	0.00	604.72	69.67
Southeast Area Specific Plan	373.96	99.44	26.59	243.64	26.27	4.61	0.00	30.88	34.85
General Commercial	287.10	41.15	37.30	183.65	5.95	56.35	0.00	62.30	36.03
Multi Family	277.96	67.18	30.99	175.35	26.00	9.43	0.00	35.43	36.91
Duplex Residential	222.87	83.14	6.93	103.22	28.79	7.72	0.00	36.51	53.68
Neighborhood Preservation	164.69	65.50	25.66	76.00	20.84	2.34	0.00	23.19	53.85
East Street District	162.61	30.61	4.25	99.09	12.66	20.24	0.00	32.90	39.06
Central Business District	138.97	29.47	7.28	96.17	10.02	3.31	0.00	13.33	30.80
Entry Overlay-Industrial/Planned Development	91.69	6.68	19.98	48.54	1.43	35.05	0.00	36.48	47.06
Service Commercial	87.33	6.05	18.82	34.90	1.92	43.82	0.00	45.74	59.31
Entry Overlay	73.18	6.50	14.33	55.40	1.57	9.67	0.00	11.24	24.24
Highway Commercial	41.64	8.32	8.88	25.61	0.39	7.32	0.00	7.71	38.50
Agriculture	14.32	0.68	4.76	4.15	2.61	6.87	0.00	9.48	71.00
Right of Way	9.22	0.97	17.11	4.52	0.75	2.97	0.00	3.73	50.97
No Designation	4.48	1.22	39.77	2.08	0.34	0.83	0.00	1.18	53.46
Neighborhood Commercial	3.11	0.80	21.21	2.15	0.16	0.00	0.00	0.16	30.83
Single Family Residential/Planned Development	2.25	0.38	10.52	1.05	0.05	0.77	0.00	0.82	53.39



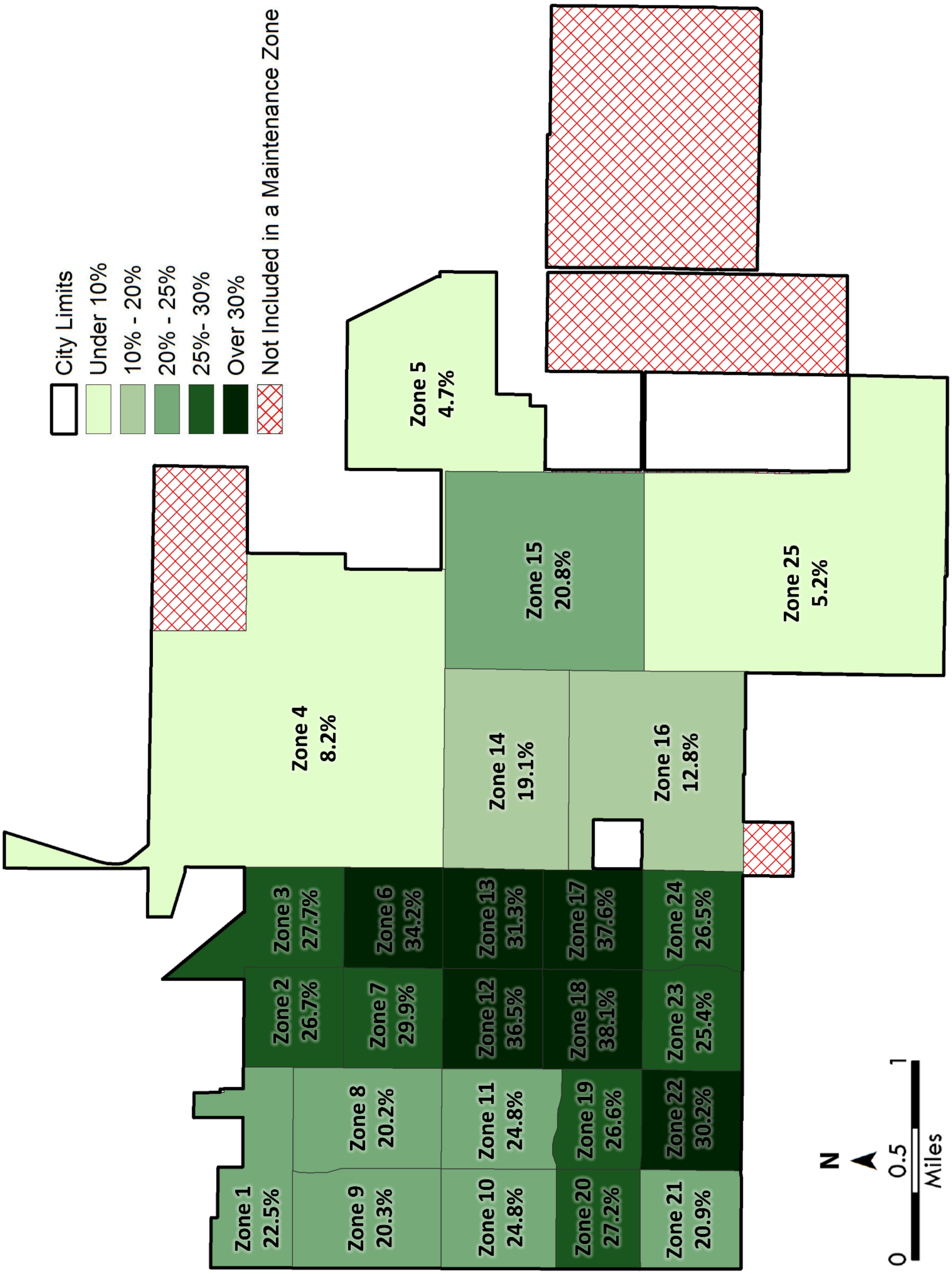
Map 4: Woodland Zoning

Tree Canopy by Tree Maintenance Zone

The City of Woodland has divided the community into 25 Maintenance Zones. Of these, Zone 4 and Zone 25 have highest overall acreage, but both zones are among the lowest for canopy cover at 8.2% and 5.2%. Zone 18 has the highest canopy cover at 38.1%. Zone 5 has the lowest canopy cover at 4.7% and a maximum potential for 30.9% tree canopy. Zone 25, which currently has 5.2% canopy cover has a potential canopy cover of 65.8% and 680.85 acres of preferred plantable area.

Table 6: Tree Canopy by Maintenance Zone

Maintenance Zones	Acres	Canopy Acres	Canopy %	Impervious Acres	Grass/Low Vegetation Acres	Bare Soil Acres	Water Acres	Preferred Plantable Acres	Potential UTC
1	229.06	51.50	22.48	140.27	15.88	20.86	0.00	36.73	38.52
2	160.18	42.73	26.68	93.84	12.20	11.41	0.00	23.61	41.42
3	206.19	57.15	27.72	82.37	14.64	51.79	0.00	66.43	59.94
4	1,414	116.41	8.23	903.22	25.56	355.87	10.50	381.43	35.21
5	507.59	24.06	4.74	347.14	19.19	114.02	0.00	133.21	30.98
6	160.76	54.91	34.16	87.72	15.79	2.34	0.00	18.13	45.43
7	159.81	47.79	29.91	89.85	18.48	3.69	0.00	22.17	43.78
8	243.92	49.23	20.18	160.67	26.66	7.37	0.00	34.02	34.13
9	235.69	47.83	20.29	140.88	21.21	25.78	0.00	46.99	40.23
10	184.20	45.67	24.79	114.06	21.76	2.72	0.00	24.47	38.08
11	187.94	46.58	24.78	100.29	24.85	16.22	0.00	41.07	46.64
12	162.25	59.26	36.52	86.35	14.06	2.59	0.00	16.65	46.78
13	161.51	50.54	31.29	96.09	12.77	2.11	0.00	14.88	40.50
14	402.52	77.00	19.13	240.17	34.13	51.21	0.00	85.34	40.33
15	634.85	132.17	20.82	425.36	28.51	48.81	0.00	77.32	33.00
16	526.18	67.54	12.84	252.10	57.44	149.04	0.00	206.48	52.08
17	160.71	60.41	37.59	81.32	18.10	0.88	0.00	18.98	49.40
18	159.71	60.91	38.14	72.56	24.44	1.80	0.00	26.24	54.57
19	135.66	36.07	26.59	81.37	17.40	0.83	0.00	18.22	40.02
20	134.56	36.53	27.15	79.23	14.66	3.44	0.69	18.10	40.60
21	160.46	33.58	20.93	95.69	23.13	7.83	0.21	30.97	40.23
22	160.81	48.49	30.16	88.26	19.44	4.12	0.39	23.56	44.81
23	164.99	41.95	25.43	104.65	16.84	1.56	0.00	18.39	36.57
24	156.51	41.50	26.52	95.16	17.81	1.98	0.00	19.80	39.16
25	1,123.86	58.74	5.23	381.37	59.33	621.51	0.00	680.85	65.81



Map 5: Tree Canopy by Maintenance Zone

Canopy Cover by Parks

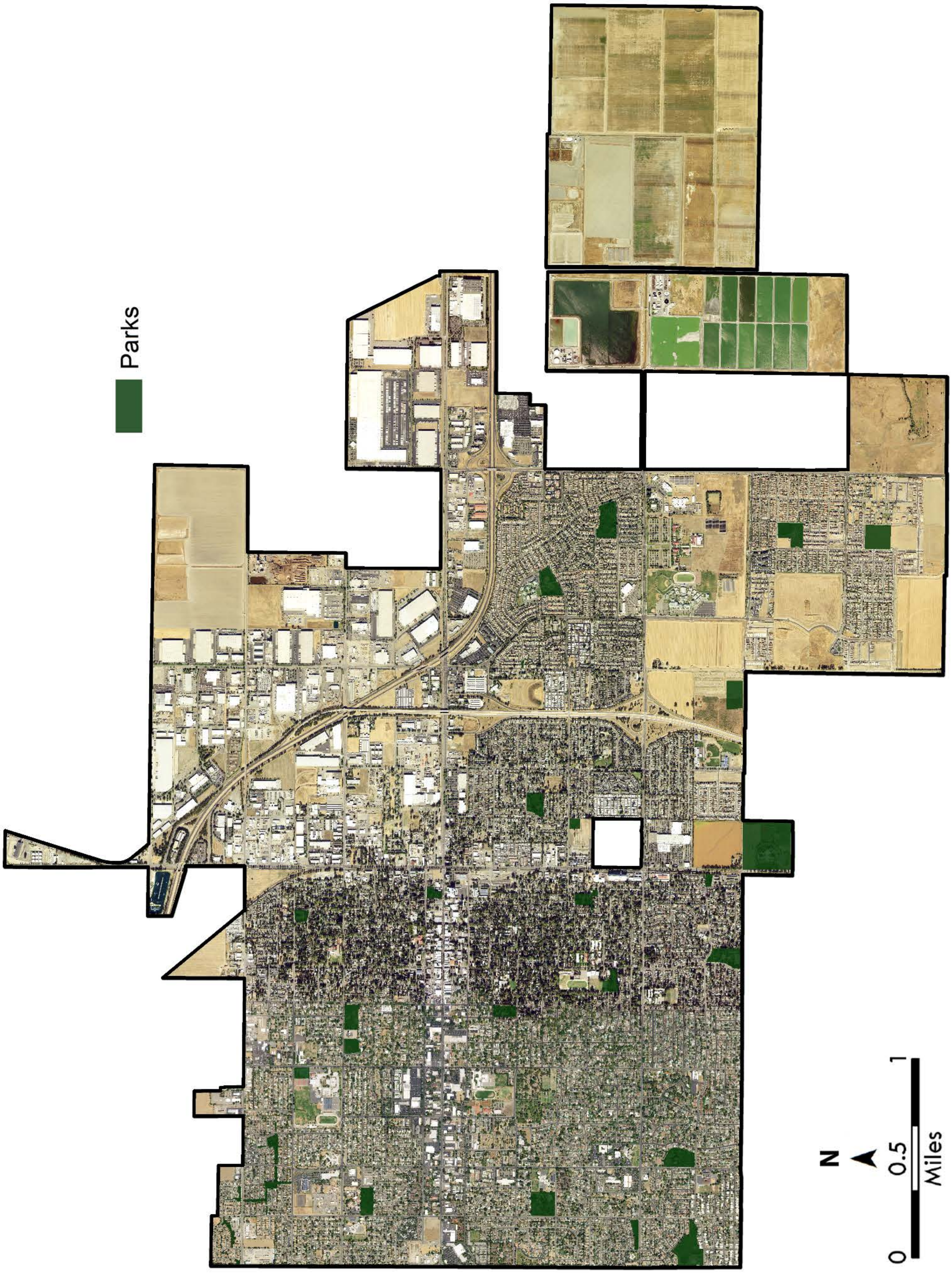
The City of Woodland has 33 areas designated as parks. The form and use of these areas varies from ball fields to detention ponds to open green spaces. The availability of space to plant trees is limited by these types of parks. For example, ball fields are unsuitable sites for trees. These areas are not included in the later planting priority analysis. However, they are included in this parks land cover analysis.

Of Woodland's 33 parks, the top ten largest by acreage are summarized in Table 7. Woodland's largest park is Woodland Community & Senior Center, which encompasses 43 acres with two (2) acres of canopy cover, or 4.02%, with a maximum UTC of 58.4%, which suggests that there is a large of area suitable for planting trees. John Ferns Park has the greatest percent canopy at 41.5%, but still has a maximum UTC of 83.4%. Other parks have lower maximum UTC percentages, possibly due to impervious surfaces or the presence of fields, which are not suitable sites for planting and were not considered in the preferred plantable acreage.

Table 7: Canopy Cover in Woodland's Top Ten Largest Parks

Park	Acres	Canopy Acres	Canopy %	Impervious Acres	Grass/Low Vegetation Acres	Bare Soil Acres	Water Acres	Preferred Plantable Acres	Maximum UTC
Woodland Community & Senior Center	43.39	1.74	4.02	12.63	11.07	12.51	0.00	23.58	58.37
Dave Douglass Park	12.84	0.73	5.68	2.13	8.09	1.89	0.00	9.98	83.38
Rick Gonzales, Sr. Park	10.14	0.01	0.06	0.13	0.00	10.00	0.00	10.00	98.70
Pioneer Park	10.05	2.65	26.38	1.84	5.56	0.00	0.00	5.56	81.68
John Ferns Park	9.29	3.85	41.48	1.54	3.66	0.23	0.00	3.90	83.43
Crawford Park	8.27	2.01	24.30	2.62	3.40	0.24	0.00	3.64	68.33
Woodside Park	8.21	3.25	39.62	1.24	3.00	0.60	0.12	3.60	83.44
Jack Slaven Park	7.95	0.32	4.05	1.34	5.01	1.28	0.00	6.28	83.14
Spring Lake Park	7.55	0.00	0.00	0.00	1.83	5.72	0.00	7.55	100.00
Dick Klenhard Park	7.24	1.47	20.27	1.58	3.49	0.70	0.00	4.19	78.20
All other parks	54.68	19.20	35.11	9.39	23.70	6.18	0.00	26.10	82.83
All parks total	**179.6**	**35.24**	**19.62%**	**34.44**	**68.81**	**35.56**	**0.12**	**104.37**	**77.73%**

Woodland has 1,394 acres of canopy or 14.5% of the overall land cover



Map 6: Woodland Parks

Land Cover by Landscape and Lighting Districts

Woodland has 7 Landscape and Lighting Districts (LL Districts), which are fee districts within Woodland that support tree care. Of these districts, the Spring Lake Assessment District has the greatest acreage with 393 acres, a canopy cover of approximately 5.9%, and a maximum UTC of 56.3%. The Spring Lake Maintenance Community Facilities District has the greatest maximum UTC at 83.4%, with 133 total acres and 109 preferred plantable acres. The Gateway Landscaping and Lighting District is the smallest with less than one (1) acre and the smallest UTC, because most of the acreage is made up of impervious surface 93.3%.

Table 8: Canopy Cover by Landscape and Lighting Districts

Name	Acres	Canopy Acres	Canopy %	Impervious %	Grass/Low Lying Veg. %	Bare Soil %	Preferred Plantable %	Preferred Plantable Acres	Maximum UTC
Spring Lake Assessment District	392.73	23.23	5.92	43.73	5.52	44.83	50.35	197.74	56.27
Gibson Ranch/SEA Landscaping and Lighting District	344.18	92.68	26.93	64.70	7.40	0.97	8.37	28.82	35.30
Spring Lake Maintenance Community Facilities District	132.70	1.76	1.33	16.61	4.55	77.51	82.06	108.89	83.39
Streng Pond Landscaping Maintenance District	34.15	10.04	29.39	47.94	16.64	4.69	21.34	7.29	50.73
North Park Landscaping and Lighting District	23.04	6.30	27.34	56.23	10.45	5.98	16.43	3.79	43.77
Westwood Landscaping and Lighting District	4.85	1.05	21.66	67.93	9.11	1.29	10.40	0.50	32.07
Gateway Landscaping and Lighting District	0.88	0.01	1.33	93.25	5.32	0.00	5.32	0.05	6.65

Canopy Cover Comparison with Neighboring Communities

Woodland has approximately 14.5% canopy cover. Of neighboring communities (Figure 6), Citrus Heights has the highest canopy cover at 25.0%.

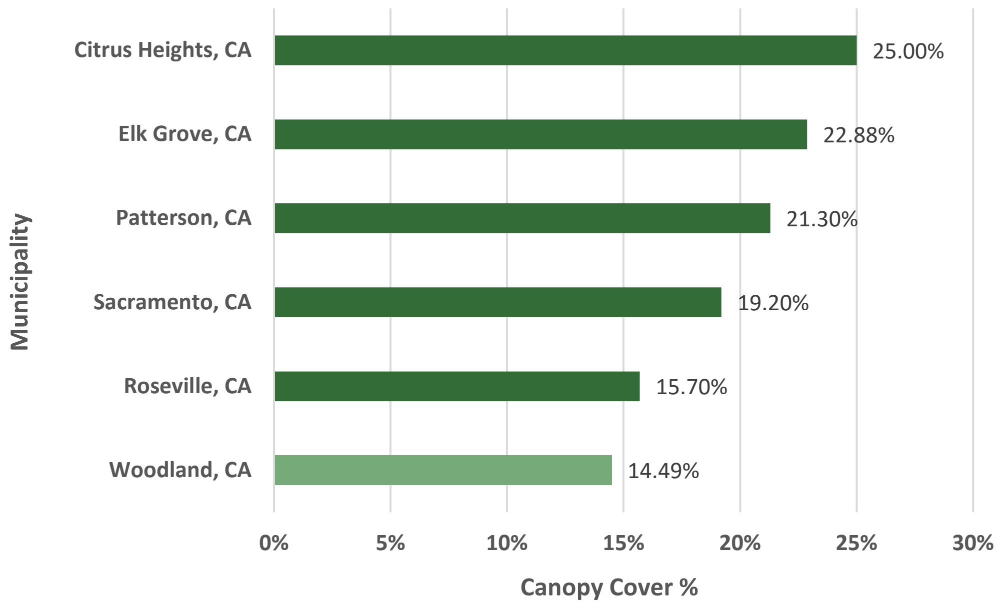
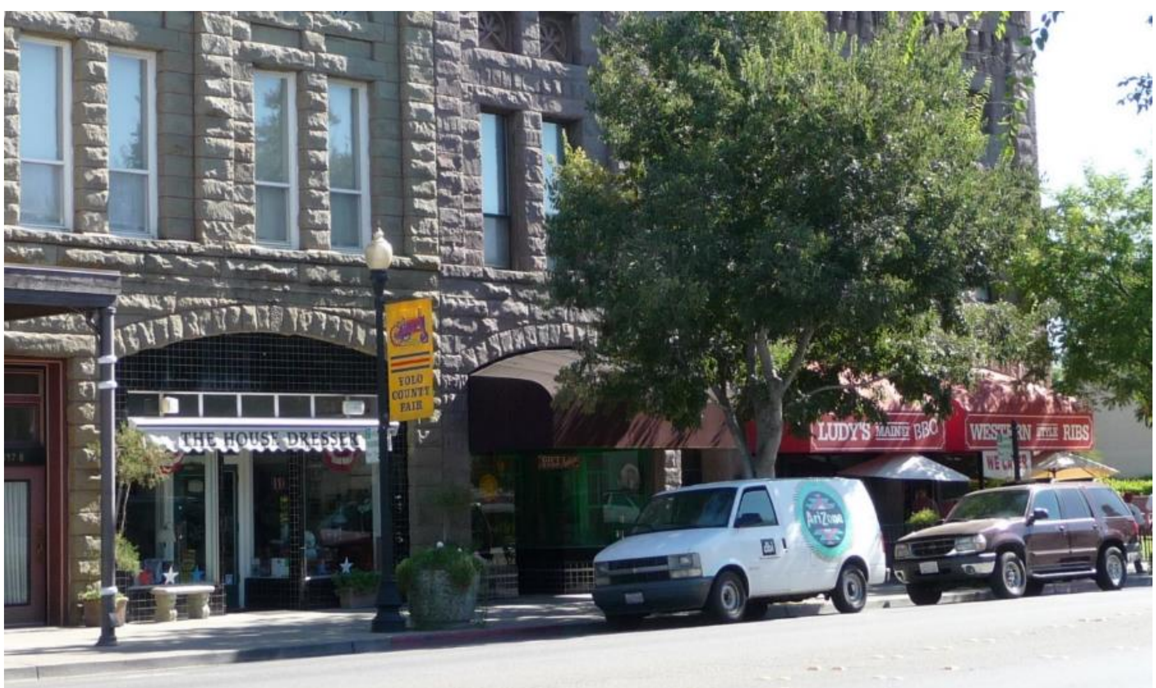


Figure 8: Neighboring Municipalities Canopy Coverage Comparison



Street Trees in Downtown Woodland

Historic Change

Canopy data derived from 2009 NAIP imagery was used to determine change over the seven-year period. The 2009 canopy data was summarized for all features in each feature class data layer. Geospatial processing was conducted to get the acreages and percentages. These values were compared to the 2016 NAIP imagery to determine change acres, change percent, and absolute change. The accuracy of change acres and percentages were based on the accuracy of the 2009 tree canopy dataset.

Table 9: Historic Canopy Cover

	Canopy Acres	Canopy %
Canopy 2009	667	6.93
Current Canopy	1,394	14.49

Woodland encompasses 9,624 acres with a tree canopy that currently covers 1,394 acres or 14.5% of the overall land cover. In 2009, the tree canopy was only 667 acres, which at the time was 6.9% of the land cover. The change in canopy acreage from 2009 to today is 727 acres or a 108.9% increase in canopy cover.

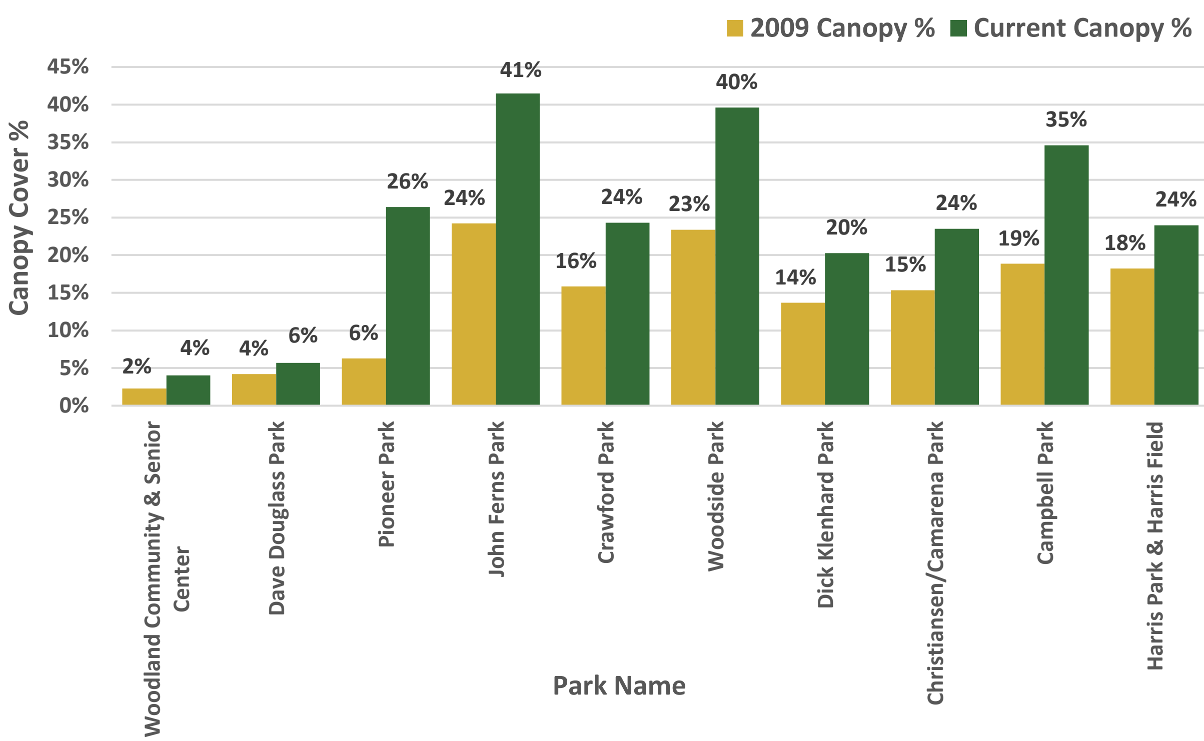


Figure 9: Woodland's Top 10 Largest Parks - Historic Tree Canopy Change from 2009

Comparing present day findings to those of the 2009 canopy assessment conducted by DRG, we can compare tree canopy in parks and tree maintenance zones to better understand the changes in the urban canopy.

Figure 9 shows the top 10 largest parks (that existed in 2009 and currently) and compares historical and current canopy cover. Currently, parks encompass nearly 180 acres with over 35 acres of canopy cover. In 2009, Woodland parks encompassed approximately 162 acres of total area and 20 acres of canopy cover. Since 2009, Woodland has added 4 parks and the average park canopy acreage increased from 0.7 acres to 1.2 acres. Although, parks represent a fraction of Woodland, comparing current tree canopy acreage with 2009 data provides a visual for the changes in Woodland's urban tree canopy. Further, this historical park analysis highlights continued areas of opportunity for expanding the canopy through parks in Woodland.

Another useful historical comparison is between Tree Maintenance Zones. Unlike Woodland parks, the Tree Maintenance Zones have not changed in total acreage since the 2009 assessment, but canopy cover has increased from nearly 665 acres to approximately 1,389 acres, since 2009. Figure 10 shows that all Tree Maintenance Zones experienced positive changes in canopy cover. On average, each Tree Maintenance Zone saw an increase of 28.9 acres of tree canopy. Tree Maintenance Zones 4, 15, and 25 experienced the most gains in canopy acreage, with Zone 4 increasing by nearly 64 acres (1.2%), Zone 15 increasing by nearly 108 acres (4.4%), and Zone 25 increasing by over 50 acres (5.8%).

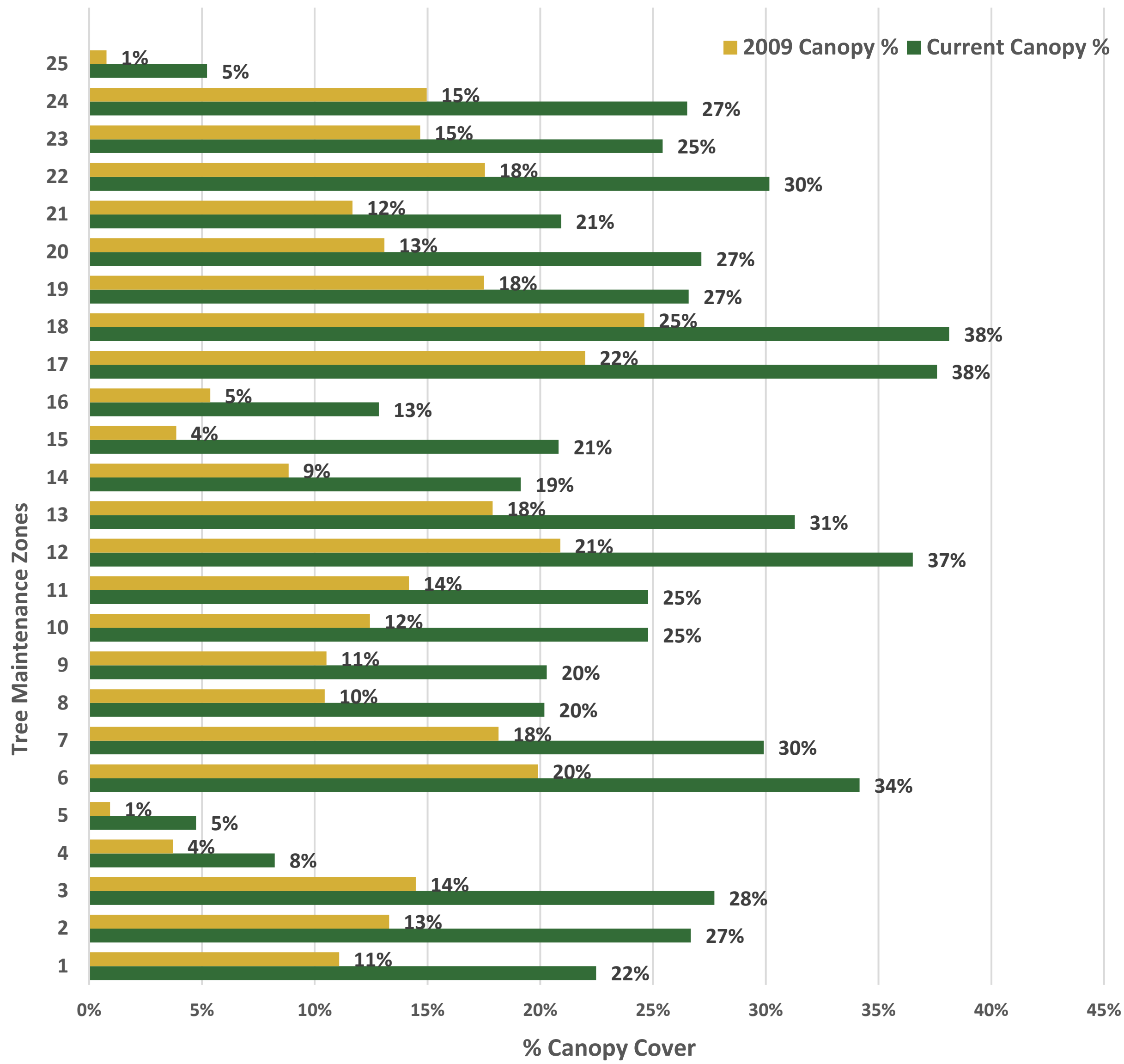


Figure 10: Tree Maintenance Zone Acreage - Historic Tree Canopy Change from 2009

Preferred Planting Sites

Woodland has 3,469.49 acres of preferred plantable acres. To identify and prioritize planting potential, DRG assessed environmental features to identify and prioritize the risk potential for soil loss and degradation from storm and flood events. Weighted consideration was provided for proximity to hardscape and canopy, soil permeability, location within a floodplain, slope, population density, road density, and a soil erosion factor (K-factor) (Table 10). Each feature was assessed using a separate grid map. A value between zero (0) and four (4) (with zero (0) having the lowest risk potential) was assigned to each feature/grid assessed. Overlaying these grid maps and averaging the values provided the risk potential at any given point. A priority ranging from very low to very high was assigned to areas on the map based on the calculated average.

Table 10: Stormwater Factors Used to Prioritize Tree Planting Sites

Dataset	Source	Weight
Proximity to Hardscape	Urban Tree Canopy Assessment	0.30
Soil Permeability	Natural Resource Conservation Service	0.20
Soil Erosion (K-factor)	Natural Resource Conservation Service	0.20
Canopy Fragmentation	Urban Tree Canopy Assessment	0.30

While available planting sites may ultimately be planted over the next several decades, the trees that are planted in the next several years, should be planned for areas of greatest need, and where they will provide the most benefits and return on investment.

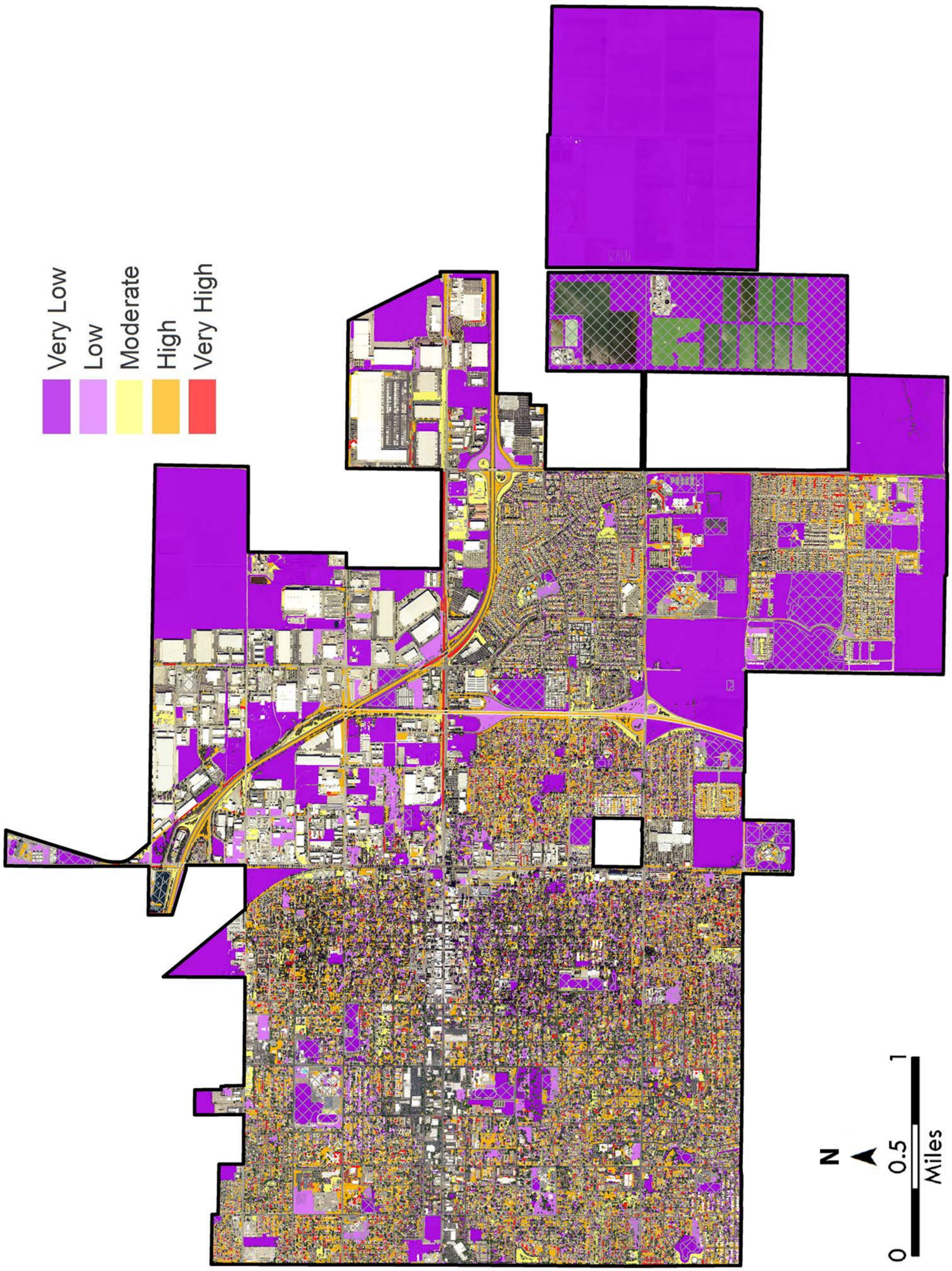
The analysis identified the following acres of planting:

- Very Low–2,765 acres
- Low–183 acres
- Moderate–206 acres
- High–252 acres
- Very High–58 acres

Table 11: Priority Planting by Land Use

Land Use	Priority Planting Total Acres	Very Low Priority Acres	Low Priority Acres	Moderate Priority Acres	High Priority Acres	Very High Priority Acres
Public Lands	956.66	806.83	71.21	42.94	30.05	4.64
Private Lands	611.97	276.15	58.27	98.85	142.26	36.44
Commercial Properties	747.42	604.71	41.39	49.98	44.63	6.71
Other	888.68	887.11	0.03	0.60	0.91	0.00
Total	**3,204.73**	**2,574.81**	**170.89**	**192.36**	**217.85**	**47.79**

Note that the priority planting total in Table 11 is less than the citywide total of 3,469 plantable acres. The discrepancy can be attributed to planting sites located in the rights-of-way, mainly around interstate/highway interchanges.



Map 7: Planting Priority

Conclusion

Since 2009, overall tree canopy has increased city-wide by 727 acres (109%). This increase in canopy (the amount of canopy that covers the ground, when viewed from aerial photography) can come from the planting of new trees and the continued growth of existing trees. Since 2009 four (4) parks were added; Avignon Park, Jack Slaven Park, Spring Lake Park, and Rick Gonzales Senior Park. The average park canopy acreage increased from 0.7 acres to 1.2 acres. Tree Maintenance Zones in Woodland also increased tree canopy with nearly 724 acres added since 2009. Because the urban forest is a dynamic, growing, and ever-changing resource it will continue to require sound and proactive management to fully realize its maximum potential.

The UTC Assessment establishes a new baseline for monitoring overall tree canopy cover throughout the community and augments the City's GIS database with a landcover layer that identifies the location and extent of existing canopy. This data layer can be used in conjunction with other infrastructure layers to prioritize planting sites and increase canopy cover strategically by neighborhood, park, or land use. This assessment provides a foundation for developing urban forest management strategies and measuring the success of those strategies over time.

With an average overall canopy of 14.5% and a maximum UTC potential 50.5%, Woodland has ample opportunity to expand the urban forest. Community engagement and support are vital to a successful urban forestry program. Based on this assessment, urban forest managers have the following opportunities:

- Considering that 46.8% of Woodland is covered by impervious surface and that the current canopy cover is 14.5% with 7.3% cover by grass and low-lying vegetation and 28.7% by bare soil, the potential UTC is 50.5%. Given the maximum potential UTC of 50.5%, the community must decide what is a reasonable UTC goal for their needs.
- Prioritized maps provide a basis for a strategically focused planting plan to increase trees and canopy that will support stormwater management, preserve soil, and complement the existing urban infrastructure for the greatest impact and return on investment. These prioritized maps exclude open spaces that will never get planted, such as athletic fields.
- Among the top 10 largest parks in Woodland, all have a potential UTC above 58%, with nearly 78 acres of preferred planting sites, which could be a fantastic opportunity for adding large-stature shade trees.
- Incentivize tree planting on private property, particularly in high and very high priority planting areas. An area that could benefit from this incentive is Maintenance Zone 25 with a potential UTC of 65.8%, with 681 acres of preferred plantable acres.

Tree canopy, since 2009, has increased city-wide by 727 acres.

Appendix A: References

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Appendix B: Methodology

Calculating Benefits

Air Quality

The i-Tree *Canopy* v6.1 Model was used to quantify the value of ecosystem services for air quality. i-Tree *Canopy* was designed to give users the ability to estimate tree canopy and other land cover types within any selected geography. The model uses the estimated canopy percentage and reports air pollutant removal rates and monetary values for carbon monoxide (CO), nitrogen dioxide (NO_2), ozone (O_3), sulfur dioxide (SO_2), and particulate matter (PM) (Hirabayashi 2014).

Within the i-Tree *Canopy* application, the U.S. EPA's BenMAP Model estimates the incidence of adverse health effects and monetary values resulting from changes in air pollutants (Hirabayashi 2014; US EPA 2012). Different pollutant removal values were used for urban and rural areas. In i-Tree *Canopy*, the air pollutant amount annually removed by trees and the associated monetary value can be calculated with tree cover in areas of interest using BenMAP multipliers for each county in the United States.

To calculate ecosystem services for the study area, canopy percentage metrics from UTC land cover data performed during the assessment were transferred to i-Tree *Canopy*. Those canopy percentages were matched by placing random points within the i-Tree *Canopy* application. Benefit values were reported for each of the five listed air pollutants.

Carbon Storage and Sequestration

The i-Tree *Canopy* v6.1 Model was used to quantify the value of ecosystem services for carbon storage and sequestration. i-Tree *Canopy* was designed to give users the ability to estimate tree canopy and other land cover types within any selected geography. The model uses the estimated canopy percentage and reports carbon storage and sequestration rates and monetary values. Methods on deriving storage and sequestration can be found in (Nowak et al, 2013).

To calculate ecosystem services for the study area, canopy percentage metrics from UTC land cover data performed during the assessment were transferred to i-Tree *Canopy*. Those canopy percentages were matched by placing random points within the i-Tree *Canopy* application. Benefit values were reported for carbon storage and sequestration.

Stormwater

The i-Tree *Hydro* v5.0 Model was used to quantify the value of ecosystem services for stormwater runoff. i-Tree *Hydro* was designed for users interested in analysis of vegetation and impervious cover effects on urban hydrology. This most recent version (v5.0) allows users to report hydrologic data on the city level rather than just a watershed scale giving users more flexibility. For more information about the model, please consult the i-Tree *Hydro* v5.0 manual (http://www.itreetools.org).

To calculate ecosystem services for the study area, land cover percentages derived for the project area and all municipalities that were included in the project area were used as inputs into the model. Precipitation data from 2005-2012 was modeled within the i-Tree *Hydro* to best represent the average conditions over an eight-year time period. Model simulations were run under a Base Case as well as an Alternate Case. The Alternative Case set tree canopy equal to 0% and assumed that impervious and vegetation cover would increase based on the removal of tree canopy. Impervious surface was increased 0.7% based on a percentage of the amount of impervious surface under tree canopy and the rest was added to the vegetation cover class. This process was completed to assess the runoff reduction volume associated with tree canopy since i-Tree *Hydro* does not directly report the volume of runoff reduced by tree canopy. The volume (in cubic meters) was converted to gallons to retrieve the overall volume of runoff avoided by having the current tree canopy.

Through model simulation, it was determined that tree canopy decreases the runoff volume in the project area by nearly 15.3 million gallons per year using precipitation data from 2005-2012. This equates to approximately 10,940 gallons per acre of tree canopy (15.3 million gals/1,394.38 acres).

To place a monetary value on storm water reduction, the cost to treat a gallon of storm/waste water was taken from (McPherson et al, 1999). This value was $0.008 per gallon. Tree canopy was estimated to contribute roughly $122,038 to avoided runoff annually to the project area.

Priority Planting Analysis

The planting location polygons were created by taking all grass/open space and bare ground areas and combining them into one dataset. Non-feasible planting areas such as agricultural fields, recreational fields, major utility corridors, airports, etc. were removed from consideration. The remaining planting space was consolidated into a single feature and, then, exploded back out to multipart features creating separate, distinct polygons for each location. Using zonal statistics, the priority grid raster was used to calculate an average value for each planting location polygon. The averages were binned into five (5) classes with the higher numbers indicating higher priority for planting. These classes ranged from very low to very high.

Land Cover Extraction and Accuracy Assessment

Davey Resource Group utilized an object-based image analysis (OBIA) semi-automated feature extraction method to process and analyze current high-resolution color infrared (CIR) aerial imagery and remotely-sensed data to identify tree canopy cover and land cover classifications. The use of imagery analysis is cost-effective and provides a highly accurate approach to assessing your community's existing tree canopy coverage. This supports responsible tree management, facilitates community forestry goal-setting, and improves urban resource planning for healthier and more sustainable urban environments.

Advanced image analysis methods were used to classify, or separate, the land cover layers from the overall imagery. The semi-automated extraction process was completed using Feature Analyst, an extension of ArcGIS®. Feature Analyst uses an object-oriented approach to cluster together objects with similar spectral (i.e., color) and spatial/contextual (e.g., texture, size, shape, pattern, and spatial association) characteristics. The land cover results of the extraction process was post-processed and clipped to each project boundary prior to the manual editing process in order to create smaller, manageable, and more efficient file sizes. Secondary source data, high-resolution aerial imagery provided by each UTC city, and custom ArcGIS® tools were used to aid in the final manual editing, quality checking, and quality assurance processes (QA/QC). The manual QA/QC process was implemented to identify, define, and correct any misclassifications or omission errors in the final land cover layer.

Classification Workflow

1) Prepare imagery for feature extraction (resampling, rectification, etc.), if needed.
2) Gather training set data for all desired land cover classes (canopy, impervious, grass, bare soil, shadows). Water samples are not always needed since hydrologic data are available for most areas. Training data for impervious features were not collected because the City maintained a completed impervious layer.
3) Extract canopy layer only; this decreases the amount of shadow removal from large tree canopy shadows. Fill small holes and smooth to remove rigid edges.
4) Edit and finalize canopy layer at 1:2000 scale. A point file is created to digitize-in small individual trees that will be missed during the extraction. These points are buffered to represent the tree canopy. This process is done to speed up editing time and improve accuracy by including smaller individual trees.
5) Extract remaining land cover classes using the canopy layer as a mask; this keeps canopy shadows that occur within groups of canopy while decreasing the amount of shadow along edges.
6) Edit the impervious layer to reflect actual impervious features, such as roads, buildings, parking lots, etc. to update features.
7) Using canopy and actual impervious surfaces as a mask; input the bare soils training data and extract them from the imagery. Quickly edit the layer to remove or add any features. Davey Resource Group tries to delete dry vegetation areas that are associated with lawns, grass/meadows, and agricultural fields.
8) Assemble any hydrological datasets, if provided. Add or remove any water features to create the hydrology class. Perform a feature extraction if no water feature datasets exist.
9) Use geoprocessing tools to clean, repair, and clip all edited land cover layers to remove any self-intersections or topology errors that sometimes occur during editing.
10) Input canopy, impervious, bare soil, and hydrology layers into Davey Resource Group's Five-Class Land Cover Model to complete the classification. This model generates the pervious (grass/low-lying vegetation) class by taking all other areas not previously classified and combining them.
11) Thoroughly inspect final land cover dataset for any classification errors and correct as needed.
12) Perform accuracy assessment. Repeat Step 11, if needed.

Automated Feature Extraction Files

The automated feature extraction (AFE) files allow other users to run the extraction process by replicating the methodology. Since Feature Analyst does not contain all geoprocessing operations that Davey Resource Group utilizes, the AFE only accounts for part of the extraction process. Using Feature Analyst, Davey Resource Group created the training set data, ran the extraction, and then smoothed the features to alleviate the blocky appearance. To complete the actual extraction process, Davey Resource Group uses additional geoprocessing tools within ArcGIS®. From the AFE file results, the following steps are taken to prepare the extracted data for manual editing.

1) Davey Resource Group fills all holes in the canopy that are less than 30 square meters. This eliminates small gaps that were created during the extraction process while still allowing for natural canopy gaps.

2) Davey Resource Group deletes all features that are less than 9 square meters for canopy (50 square meters for impervious surfaces). This process reduces the number of small features that could result in incorrect classifications and also helps computer performance.
3) The Repair Geometry, Dissolve, and Multipart to Singlepart (in that order) geoprocessing tools are run to complete the extraction process.
4) The Multipart to Singlepart shapefile is given to GIS personnel for manual editing to add, remove, or reshape features.

Table 12: Classification Matrix

Reference Data	Classification Data							
Classes	**Tree Canopy**	**Impervious**	**Grass / Veg.**	**Bare Soils**	**Water**	**Row Total**	**Producer's Accuracy**	**Errors of Omission**
Tree Canopy	137	1	2	0	0	140	97.86%	2.14%
Impervious	2	431	3	1	0	437	98.63%	1.37%
Grass/Vegetation	3	1	70	0	0	74	94.59%	5.41%
Bare Soils	1	8	4	308	0	321	95.95%	4.05%
Water	0	0	0	0	28	28	100.00%	0.00%
Column Total	143	441	79	309	28	1000		
User's Accuracy	95.80%	97.73%	88.61 %	99.68%	100%		**Overall Accuracy**	97.40%
Errors of Commission	4.20%	2.27%	11.39 %	0.32%	0.00%		**Kappa Coefficient**	0.96

Accuracy Assessment Protocol

Determining the accuracy of spatial data is of high importance to Davey Resource Group and our clients. To achieve to best possible result, Davey Resource Group manually edits and conducts thorough QA/QC checks on all urban tree canopy and land cover layers. A QA/QC process will be completed using ArcGIS® to identify, clean, and correct any misclassification or topology errors in the final land cover dataset. The initial land cover layer extractions will be edited at a 1:2000 quality control scale in the urban areas and at a 1:2500 scale for rural areas utilizing the most current high-resolution aerial imagery to aid in the quality control process.

To test for accuracy, random plot locations are generated throughout the city area of interest and verified to ensure that the data meet the client standards. Each point will be compared with the most current NAIP high-resolution imagery (reference image) to determine the accuracy of the final land cover layer. Points will be classified as either correct or incorrect and recorded in a classification matrix. Accuracy will be assessed using four metrics: overall accuracy, kappa, quantity disagreement, and allocation disagreement. These metrics are calculated using a custom Excel® spreadsheet.

Land Cover Accuracy

The following describes Davey Resource Group's accuracy assessment techniques and outlines procedural steps used to conduct the assessment.

1. ***Random Point Generation***—Using ArcGIS, 1,000 random assessment points are generated.

2. ***Point Determination***—Each point is carefully assessed by the GIS analyst for likeness with the aerial photography. To record findings, two new fields, CODE and TRUTH, are added to the accuracy assessment point shapefile. CODE is a numeric value (1–5) assigned to each land cover class (Table 1) and TRUTH is the actual land cover class as identified according to the reference image. If CODE and TRUTH are the same, then the point is counted as a correct classification. Likewise, if the CODE and TRUTH are not the same, then the point is classified as incorrect. In most cases, distinguishing if a point is correct or incorrect is straightforward. Points will rarely be misclassified by an egregious classification or editing error. Often incorrect points occur where one feature stops and the other begins.

3. ***Classification Matrix***—During the accuracy assessment, if a point is considered incorrect, it is given the correct classification in the TRUTH column. Points are first assessed on the NAIP imagery for their correctness using a "blind" assessment—meaning that the analyst does not know the actual classification (the GIS analyst is strictly going off the NAIP imagery to determine cover class). Any incorrect classifications found during the "blind" assessment are scrutinized further using sub-meter imagery provided by the client to determine if the point was incorrectly classified due to the fuzziness of the NAIP imagery or an actual misclassification. After all random points are assessed and recorded; a classification (or confusion) matrix is created. The classification matrix for this project is presented in Table 12. The table allows for assessment of user's/producer's accuracy, overall accuracy, omission/commission errors, kappa statistics, allocation/quantity disagreement, and confidence intervals.
4. Following are descriptions of each statistic as well as the results from some of the accuracy assessment tests.

Overall Accuracy – Percentage of correctly classified pixels; for example, the sum of the diagonals divided by the total points ((137+441+79+309+28)/1,000 = 97.40%).

User's Accuracy – Probability that a pixel classified on the map actually represents that category on the ground (correct land cover classifications divided by the column total [137/143 = 95.80%]).

Producer's Accuracy – Probability of a reference pixel being correctly classified (correct land cover classifications divided by the row total [137/140 = 97.86%]).

Kappa Coefficient – A statistical metric used to assess the accuracy of classification data. It has been generally accepted as a better determinant of accuracy partly because it accounts for random chance agreement. A value of 0.80 or greater is regarded as "very good" agreement between the land cover classification and reference image.

Errors of Commission – A pixel reports the presence of a feature (such as trees) that, in reality, is absent (no trees are actually present). This is termed as a false positive. In the matrix below, we can determine that 4.20% of the area classified as canopy is most likely not canopy.

Errors of Omission – A pixel reports the absence of a feature (such as trees) when, in reality, they are actually there. In the matrix below, we can conclude that 2.14% of all canopy classified is actually classified as another land cover class.

Allocation Disagreement – The amount of difference between the reference image and the classified land cover map that is due to less than optimal match in the spatial allocation (or position) of the classes.

Quantity Disagreement – The amount of difference between the reference image and the classified land cover map that is due to less than perfect match in the proportions (or area) of the classes.

Confidence Intervals – A confidence interval is a type of interval estimate of a population parameter and is used to indicate the reliability of an estimate. Confidence intervals consist of a range of values (interval) that act as good estimates of the unknown population parameter based on the observed probability of successes and failures. Since all assessments have innate error, defining a lower and upper bound estimate is essential.

Table 13: Confidence Interval

95% Confidence Intervals

Land Cover Assessment

Class	**Acreage**	**Percentage**	**Lower Bound**	**Upper Bound**	**Statistical Metrics Summary:**	
Tree Canopy	1,394	14.50%	14.10%	14.80%		
Impervious	4,500	46.80%	46.30%	47.30%	**Overall Accuracy =**	97.40%
Grass / Veg.	703.5	7.30%	7.00%	7.60%	**Kappa Coefficient =**	0.9618
Bare Soils	2,766	28.70%	28.30%	29.20%	**Allocation Disagreement =**	1%
Water	259.7	2.70%	2.50%	2.90%	**Quantity Disagreement =**	1%
Total	9,623	100.00%				

Accuracy Assessment

Class	**User's Accuracy**	**Lower Bound**	**Upper Bound**	**Producer's Accuracy**	**Lower Bound**	**Upper Bound**
Tree Canopy	95.80%	94.10%	97.50%	97.90%	96.60%	99.10%
Impervious	97.70%	97.00%	98.40%	98.60%	98.10%	99.20%
Grass/Vegetation	88.60%	85.00%	92.20%	94.60%	92.00%	97.20%
Bare Soils	99.70%	99.40%	100.00%	96.00%	94.80%	97.10%
Water	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

Appendix C: Tables and Figures

Table 14: Canopy Cover in Woodland Parks

Park	Acres	Canopy Acres	Canopy %	Impervious Acres	Grass/Low Vegetation Acres	Bare Soil Acres	Water Acres	Preferred Plantable Acres	Potential UTC
Avignon Park	0.25	0.15	61.95	0.08	0.01	0.00	0.00	0.01	67.84
Beamer Circle Park	0.15	0.04	30.80	0.03	0.07	0.00	0.00	0.07	76.30
Beamer Park	2.26	0.86	37.90	0.70	0.58	0.13	0.00	0.70	69.07
Buchignani Field	1.71	0.09	5.25	0.17	0.93	0.52	0.00	1.45	90.06
Campbell Park	5.57	1.93	34.62	0.83	2.81	0.00	0.00	2.81	85.14
Charles Brooks Community Swim Center	2.75	0.16	5.96	1.59	0.87	0.13	0.00	1.00	42.11
Christiansen/Camarena Park	5.59	1.32	23.51	0.72	2.95	0.61	0.00	3.56	87.10
City Park	3.93	1.92	48.96	0.81	1.19	0.00	0.00	1.19	79.26
Clark Field	3.52	0.01	0.26	0.51	2.40	0.60	0.00	3.00	85.45
Crawford Park	8.27	2.01	24.30	2.62	3.40	0.24	0.00	3.64	68.33
Dave Douglass Park	12.84	0.73	5.68	2.13	8.09	1.89	0.00	9.98	83.38
Dick Klenhard Park	7.24	1.47	20.27	1.58	3.49	0.70	0.00	4.19	78.20
Everman Park	3.93	2.06	52.30	0.46	1.42	0.00	0.00	1.42	88.33
Freeman Park	2.25	0.90	39.81	0.77	0.54	0.04	0.00	0.58	65.75
Gary Traynham Park	1.38	0.93	67.59	0.21	0.24	0.00	0.00	0.24	84.83
Grace Hiddleson Pool	0.79	0.11	14.34	0.61	0.06	0.00	0.00	0.06	21.92
Harris Park & Harris Field	5.54	1.33	23.98	0.66	3.25	0.30	0.00	3.56	88.17
Jack Slaven Park	7.95	0.32	4.05	1.34	5.01	1.28	0.00	6.28	83.14
Jeff Roddy Park	0.48	0.12	25.10	0.22	0.14	0.00	0.00	0.14	54.15
John Ferns Park	9.29	3.85	41.48	1.54	3.66	0.23	0.00	3.90	83.43
Joseph Schneider Park	3.22	2.14	66.65	0.33	0.75	0.00	0.00	0.75	89.85
Pioneer Park	10.05	2.65	26.38	1.84	5.56	0.00	0.00	5.56	81.68
Rick Gonzales, Sr. Park	10.14	0.01	0.06	0.13	0.00	10.00	0.00	10.00	98.70
Southland Park	3.23	1.39	42.91	0.16	1.69	0.00	0.00	1.69	95.17
Spring Lake Park	7.55	0.00	0.00	0.00	1.83	5.72	0.00	7.55	100.00
Streng Pond Park	2.50	0.85	34.20	0.03	1.61	0.00	0.00	1.61	98.80
Tredway Park	1.22	0.26	21.15	0.04	0.91	0.01	0.00	0.92	96.61
Unnamed city-maintained park	0.26	0.15	57.77	0.01	0.09	0.02	0.00	0.10	97.57
Wayne Cline Park	3.79	2.32	61.09	0.37	1.06	0.05	0.00	1.11	90.22
Woodland Community & Senior Center	43.39	1.74	4.02	12.63	11.07	12.51	0.00	23.58	58.37
Woodland West Park	0.37	0.16	42.20	0.08	0.14	0.00	0.00	0.14	79.79
Woodside Park	8.21	3.25	39.62	1.24	3.00	0.60	0.12	3.60	83.44

Table 15: Historic Canopy Cover for Woodland Parks

Park	Current Total Acres	2009 Total Acres	Current Canopy Acres	2009 Canopy Acres	Current Canopy %	2009 Canopy %
Beamer Circle Park	0.15	0.15	0.04	0.03	30.80	0.20
Beamer Park	2.26	2.26	0.86	0.53	37.90	0.23
Buchignani Field	1.71	14.14	0.09	0.11	5.25	0.01
Campbell Park	5.57	5.57	1.93	1.05	34.62	0.19
Charles Brooks Community Swim Center	2.75	2.75	0.16	0.08	5.96	0.03
Christiansen/Camarena Park	5.59	5.60	1.32	0.86	23.51	0.15
City Park	3.93	3.93	1.92	0.98	48.96	0.25
Clark Field	3.52	3.52	0.01	0.02	0.26	0.01
Crawford Park	8.27	8.27	2.01	1.31	24.30	0.16
Dave Douglass Park	12.84	12.84	0.73	0.54	5.68	0.04
Dick Klenhard Park	7.24	7.24	1.47	0.99	20.27	0.14
Everman Park	3.93	3.43	2.06	0.88	52.30	0.26
Freeman Park	2.25	2.25	0.90	0.74	39.81	0.33
Gary Traynham Park	1.38	1.38	0.93	0.56	67.59	0.41
Grace Hiddleson Pool	0.79	0.79	0.11	0.08	14.34	0.10
Harris Park & Harris Field	5.54	5.54	1.33	1.01	23.98	0.18
Jeff Roddy Park	0.48	0.48	0.12	0.00	25.10	0.00
John Ferns Park	9.29	9.29	3.85	2.25	41.48	0.24
Joseph Schneider Park	3.22	2.93	2.14	1.03	66.65	0.35
Pioneer Park	10.05	10.05	2.65	0.63	26.38	0.06
Rick Gonzales, Sr. Park	10.14	4.54	0.01	0.33	0.06	0.07
Southland Park	3.23	3.23	1.39	0.93	42.91	0.29
Streng Pond Park	2.50	2.50	0.85	0.57	34.20	0.23
Tredway Park	1.22	1.22	0.26	0.26	21.15	0.21
Wayne Cline Park	3.79	2.40	2.32	0.94	61.09	0.39
Woodland Community & Senior Center	43.39	37.27	1.74	0.86	4.02	0.02
Woodland West Park	0.37	0.37	0.16	0.04	42.20	0.11
Woodside Park	8.21	8.21	3.25	1.92	39.62	0.23

Table 16: Historic Canopy Cover for Woodland Tree Maintenance Zones

Maintenance Zone	Acres	Current Canopy Acres	2009 Canopy Acres	Current % Canopy	2009 % Canopy
1	229.06	51.50	25.39	22.48	11.08
2	160.18	42.73	21.30	26.68	13.30
3	206.19	57.15	29.86	27.72	14.48
4	1,414	116.41	52.53	8.23	3.72
5	507.59	24.06	4.70	4.74	0.93
6	160.76	54.91	32.00	34.16	19.91
7	159.81	47.79	29.00	29.91	18.15
8	243.92	49.23	25.47	20.18	10.44
9	235.69	47.83	24.79	20.29	10.52
10	184.20	45.67	22.92	24.79	12.44
11	187.94	46.58	26.64	24.78	14.17
12	162.25	59.26	33.87	36.52	20.88
13	161.51	50.54	28.88	31.29	17.88
14	402.52	77.00	35.57	19.13	8.84
15	634.85	132.17	24.52	20.82	3.86
16	526.18	67.54	28.23	12.84	5.37
17	160.71	60.41	35.33	37.59	21.98
18	159.71	60.91	39.30	38.14	24.61
19	135.66	36.07	23.75	26.59	17.51
20	134.56	36.53	17.62	27.15	13.09
21	160.46	33.58	18.73	20.93	11.67
22	160.81	48.49	28.21	30.16	17.54
23	164.99	41.95	24.20	25.43	14.67
24	156.51	41.50	23.42	26.52	14.96
25	1,124	58.74	8.69	5.23	0.77

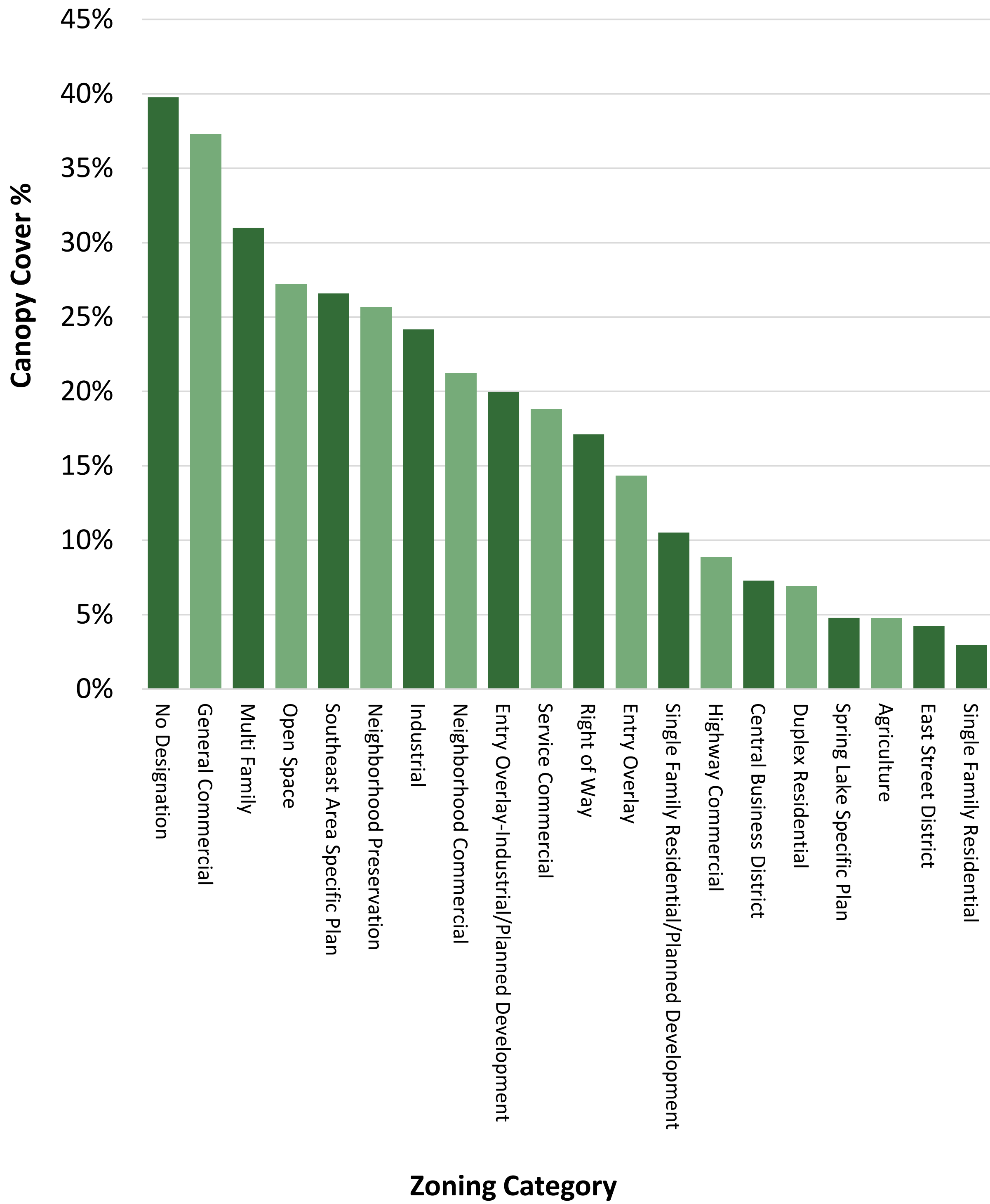

Figure 11: Canopy Coverage by Zoning Category