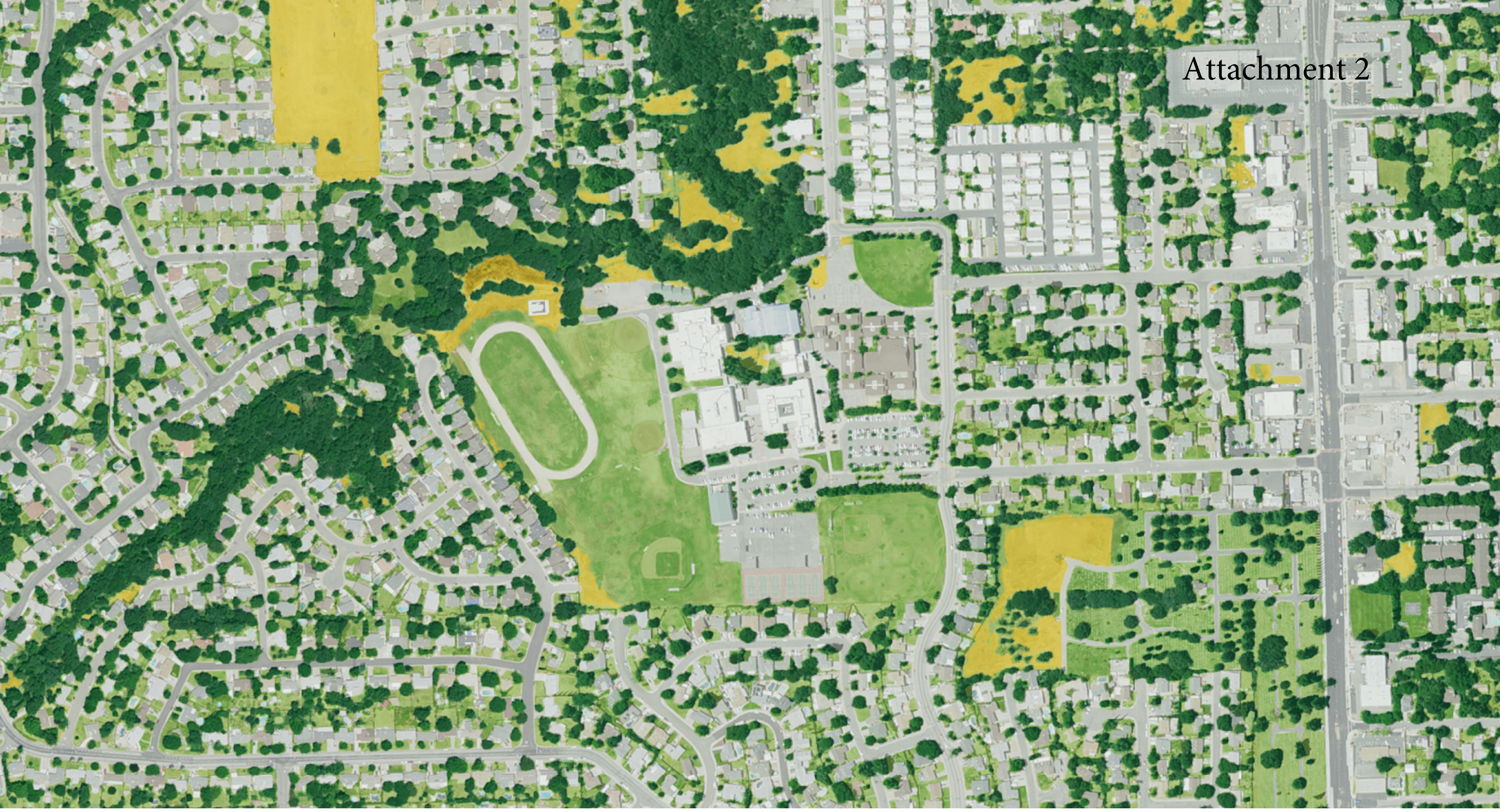
Attachment 2



City of Citrus Heights

Urban Tree Canopy Assessment

A component of the Citrus Heights Urban Greening Strategy (CHUGS)

2015

City of Citrus Heights

Urban Tree Canopy Assessment

2015

Prepared for:

City of Citrus Heights
6237 Fountain Square Drive
Citrus Heights, California 95621
Phone: 916-725-2448

Prepared by:

Davey Resource Group
A Division of the Davey Tree Expert Company
6005 Capistrano Ave., Suite A
Atascadero, California 93422
Phone: 805-461-7500
Toll Free: 800-966-2021
Fax: 805-461-8501
www.davey.com/drg

Table of Contents

Figures

Tables

Maps

Introduction

In 2013, the Strategic Growth Council awarded funding for the development of the Citrus Heights Urban Greening Strategy (CHUGS). The strategy aims to develop a more sustainable urban forest by improving conditions for trees and optimizing the environmental, economic, and social benefits that urban trees provide to the community. CHUGS supports the General Plan (Goal 55) to reduce community-wide greenhouse gas (GHG) emissions to 10-15% below 2005 levels by 2020. The strategy includes the development of an Urban Forest Master Plan to guide the management of public trees and the growth and preservation of tree canopy over the next 25 years. Citrus Heights' Greenhouse Gas Reduction Plan (2011) aims to reduce GHG emissions by 110 MT CO_2e[1] per year in building energy savings and 630 MT CO_2e per year through carbon sequestration and storage. By 2020, the City intends to plant an additional 1,500 trees in support of this Plan.

In 2015, the City commissioned Davey Resource Group (DRG) and Foothill Associates to develop an Urban Forest Master Plan (UFMP), a Water Efficient Landscape Ordinance, and guidelines for native and/or drought tolerant landscapes. These documents provide the foundation and long-range vision for CHUGS.

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 socio-economic 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 smart growth and sustainability of Citrus Heights' urban forest resource and the invaluable benefits it provides. To acquire this information, DRG conducted an Urban Tree Canopy (UTC) Assessment using high-resolution, infrared aerial imagery and remote sensing software[2]. The assessment resulted in a GIS map layer detailing the location and extent of existing tree canopy (public and private) along with other primary landcover classifications, including impervious and pervious surfaces, bare soils, and water. The assessment identifies and summarizes the current overall landcover classification as:

- 25% Tree Canopy
- 51.6% Impervious Surfaces

DRG assessed the location and extent of existing tree canopy and other land cover in Citrus Heights. The UTC Assessment establishes a benchmark for the UFMP.

Urban Tree Canopy and Geographic Information Systems (GIS)

Urban Tree Canopy is the layer of leaves, branches, and stems of trees that cover the ground when viewed from above. The UTC assessment does not distinguish between publicly-owned and privately-owned trees. Since trees provide benefits to the community that extend beyond property lines, the assessment includes all tree canopy within the borders of the community. 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) for urban tree canopy mapping and analysis. Understanding the extent and location of existing canopy is key to identifying various types of community forest management opportunities, including:

[1] CO2e. **Carbon dioxide equivalent** is a measure used to compare the emissions from various greenhouse gases based upon their global warming potential. For example, the global warming potential for methane over 100 years is 21.

[2] Methodology for the UTC Assessment is discussed in Appendix A

- Future planting plans
- Stormwater management
- Water resource and quality management
- Impact and management of invasive species
- Preservation of benefit stream and sustainability
- Outreach and education

High-resolution aerial imagery and infrared technology was used to remotely map tree canopy and land cover (Figure 1). The results of the study provide a clear picture of the extent and distribution of tree canopy within Citrus Heights. 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 establish a benchmark value to measure the success of long-term management objectives over time.

With this data, managers can determine:

- Citrus Heights' 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 neighborhood, land use, zoning, parking lots and parcels.
- The location of available planting space and develop strategies to increase canopy in underserved areas.

In addition to quantifying existing UTC, the assessment illustrates the potential for increasing tree canopy across Citrus Heights. 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 1. High-resolution aerial imagery (Right) 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 (Bottom).

Summary

Land Cover Summary

The City of Citrus Heights encompasses a total area of 14.4 square miles (Map 1). Excluding impervious surfaces (4,702 acres), open water (4 acres), and other unsuitable sites (300 acres), Citrus Heights includes 6.4 square miles (4,100 acres) with the potential to support tree canopy. Using remote image sensing and GIS analysis, DRG determined that the following information characterizes land cover within the City of Citrus Heights:

- 3.6 miles^2 (2,278 acres) of overall tree canopy, including trees and woody shrubs, an overall average tree canopy cover of 25%.
- Considering suitable planting sites on areas of existing pervious surface and bare soil (1,823 acres) and the existing canopy (2,278 acres), the canopy potential for Citrus Heights is 45%.
- 7.4 miles^2 (4,702 acres) of overall impervious surfaces, including roads, parking lots, and structures, an average of 51%.
- 2.7 miles^2 (1,706 acres) of overall pervious surfaces, including grass and low-lying vegetation, an average of 19%.
- 417 acres of bare soils, an average of 5%.
- 3.9 acres of open water, an overall average of 0.04%.
- 157 acres of tree canopy in SRPD parks and open space areas, an average canopy cover of 49.7%.
- 19 acres of tree canopy is on school campuses, an average canopy cover of 11.3%.
- 566 acres of tree canopy along creeks and in floodplains, an average canopy cover of 62.9%.

Environmental Benefits

Citrus Heights' landcover data was used with i-Tree Canopy (v6.1) (Appendix A) to estimate the environmental benefits from the entire urban forest (public and private). Trees in Citrus Heights are providing air quality and stormwater benefits worth more than \$2.6 million annually (Figure 2) by:

- Removing 78 tons of air pollutants, including carbon monoxide (CO), nitrogen dioxide (NO_2), ozone (O_3), sulfur dioxide (SO_2), and particulate matter (PM_{10})
- Reducing stormwater runoff by more than 243 million gallons, valued at nearly \$2 million
- Citrus Heights' urban forest is currently storing 287,630 tons of carbon (CO_2) in its biomass, valued at more than \$5.5 million
- Annually, this resource removes (sequesters) an additional 14,550 tons of CO_2, valued at \$281,733

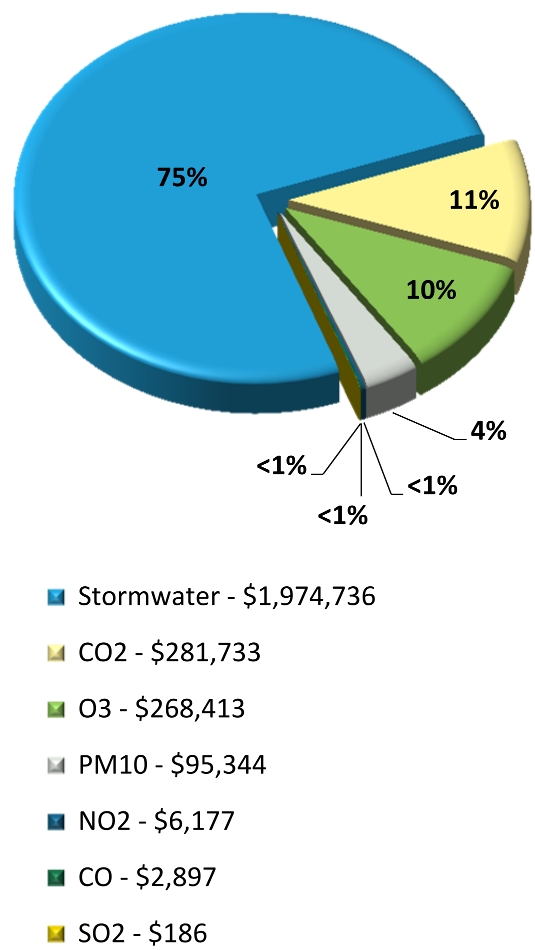
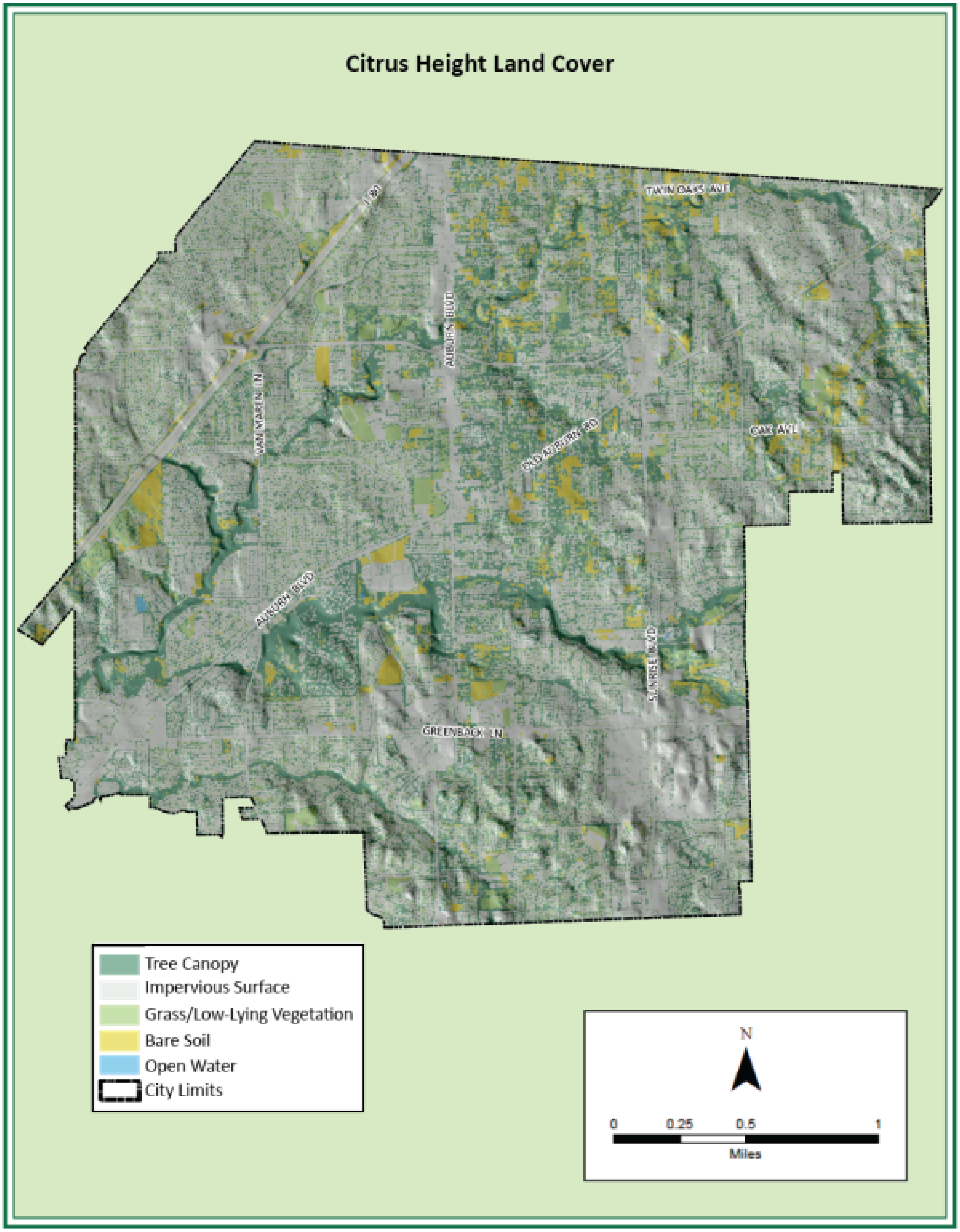


Figure 2. Annual Environmental Benefits from Tree Canopy



Map 1. City Boundary of Citrus Heights Showing Land Cover in Relief

Land Cover in Citrus Heights

Overall Land Cover Classification

Citrus Heights encompasses a total area of 14.4 square miles (9,216 acres) (Map 2). Land cover classification within the boundary includes the following (Figure 3):

- 25% – Canopy, 2,278 acres
- 51% – Impervious surfaces, 4,702 acres
- 19% – Grass/Low-lying vegetation, 1,706 acres
- 5% – Bare soil, 417 acres
- 0.04% – Open water, 4 acres

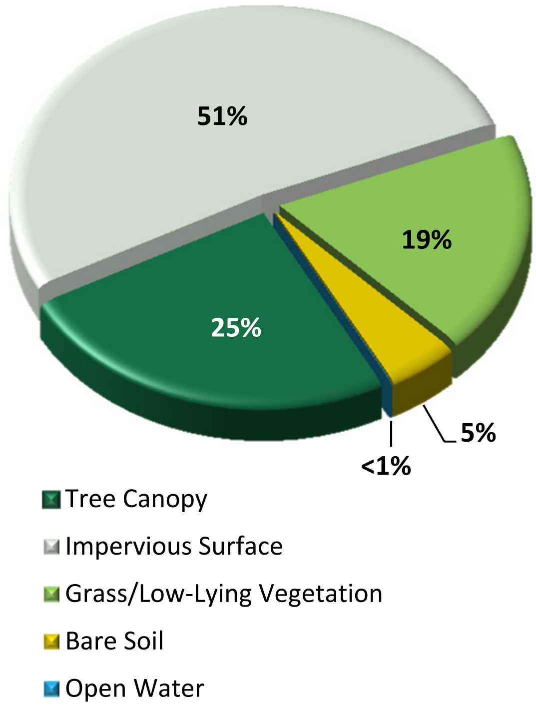
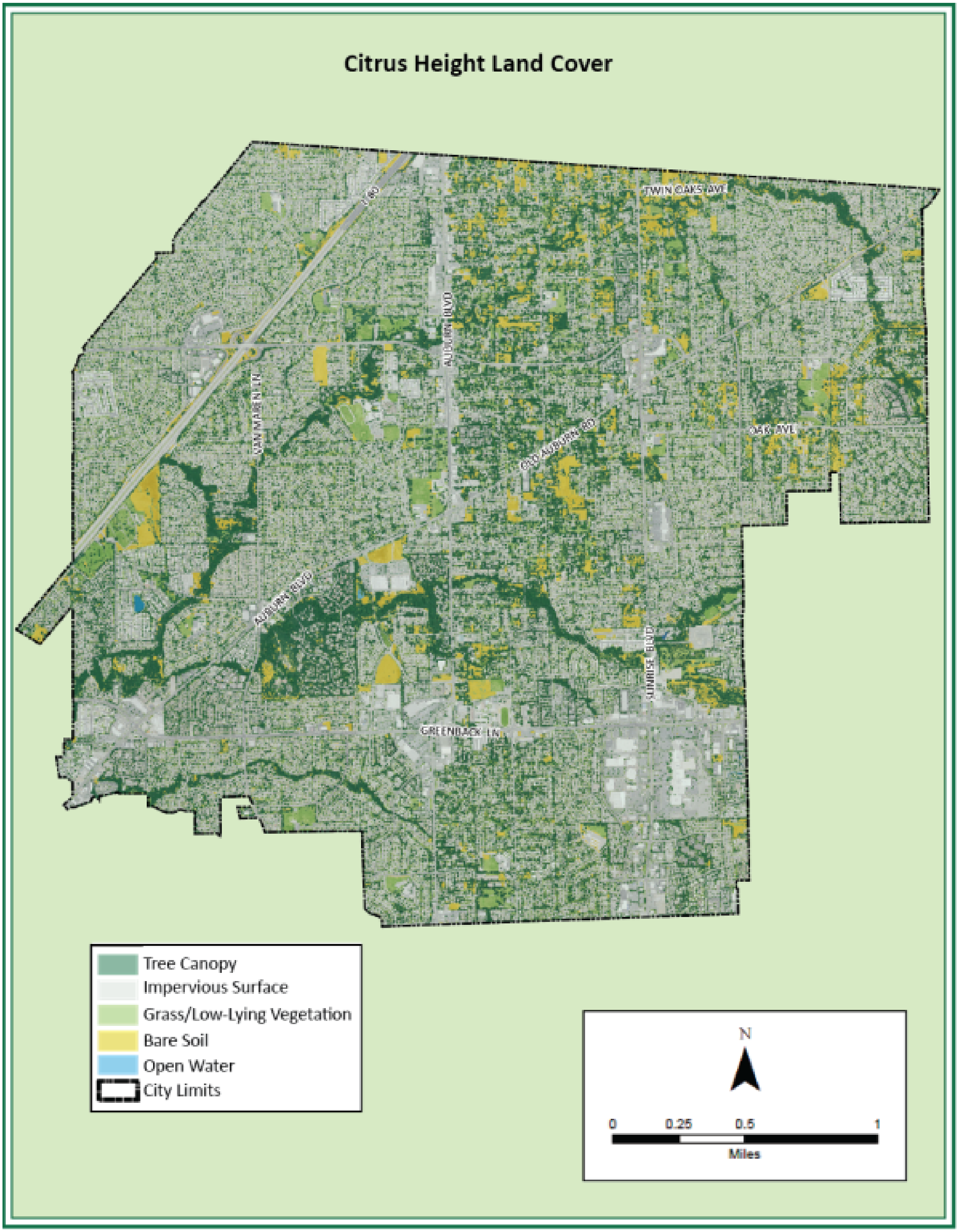


Figure 3. Overall Land Cover Classification



Map 2. Citrus Heights Land Cover

Tree Canopy by Land Use

Land use is a reflection of development patterns and the community's plan for growth in specific areas (Map 3). Canopy cover can vary significantly between different land uses. Parks and suburban residential areas typically have less impervious surface and are able to support a greater percent of tree canopy. Because they generally have a high proportion of impervious surface, commercial areas often have a lower percentage of tree canopy.

Considering land use, Open Space has the highest average canopy cover at 46.8%, followed by Very Low Density Residential (33.1%), and High Density Residential (33%). Commercial land use parcels have the lowest average canopy cover at 2.6% (Figure 4 and Table 3).

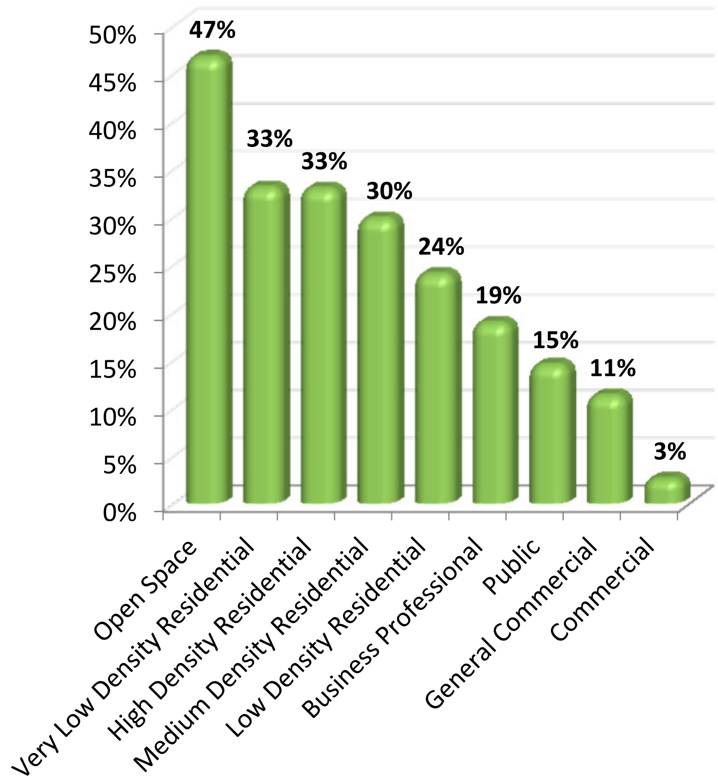
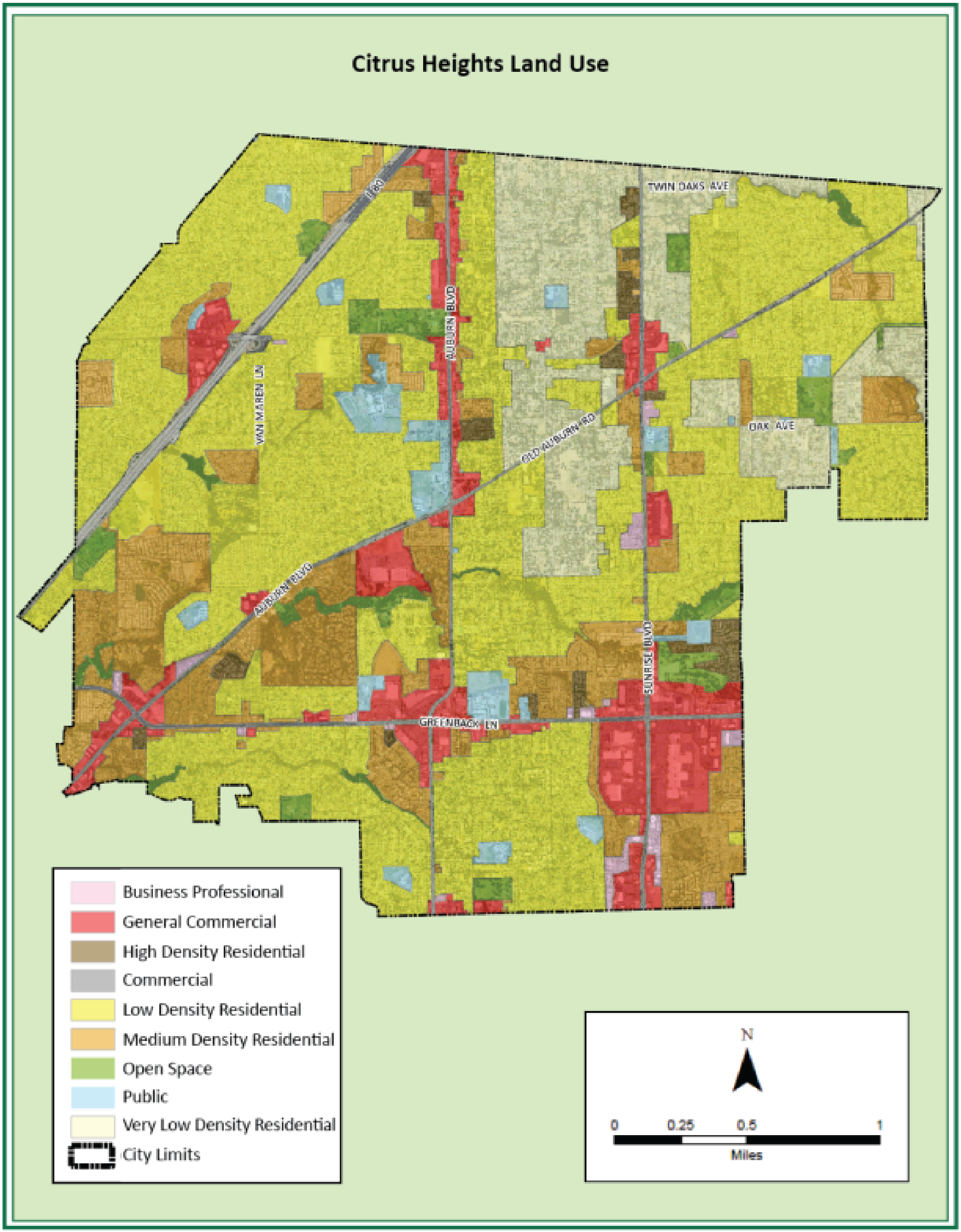


Figure 4. Canopy Cover by Land Use

Table 1. Tree Canopy and Impervious Surface by Land Use

Land Use	Total Acres	Canopy Acres	% Canopy	Impervious Acres	% Impervious
Business Professional	77	**14.59**	18.95	52	**67.08**
General Commercial	819	**92.85**	11.34	635	**77.54**
High Density Residential	128	**42.13**	33.00	69	**54.18**
Commercial	<1	**<1**	2.62	<1	**79.66**
Low Density Residential	4,579	**1,102.14**	24.07	2,395	**52.29**
Medium Density Residential	1,458	**435.93**	29.89	778	**53.35**
Open Space	309	**144.56**	46.75	38	**12.26**
Public	267	**38.87**	14.55	116	**43.28**
Very Low Density Residential	1,119	**370.53**	33.13	350	**31.30**
Total Zoning	**7,732**	**2,092**		**3,676**	



Map 3. Land Use

Tree Canopy by Neighborhood

Neighborhood boundaries are often used to understand tree canopy as they tend to reflect geographies that are well understood by community members and social institutions. Exploring canopy distribution and socio-economic 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.

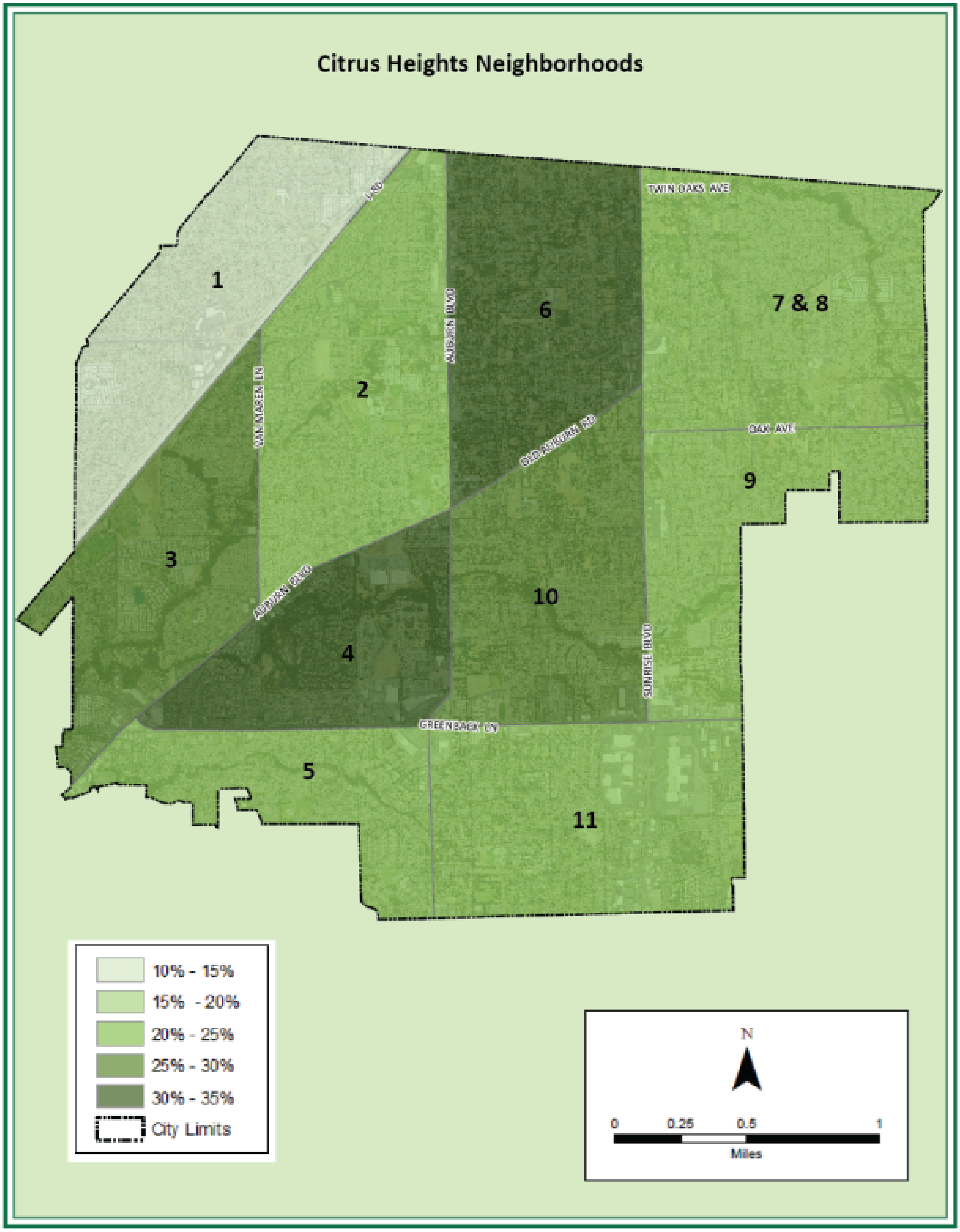
Citrus Heights is divided into 11 neighborhoods (Map 4) and 10 neighborhood associations. Each association represents an area, with areas 7 and 8 combined. And, each of these organizations has established bylaws and a board to guide neighborhood projects and improvements.

The largest neighborhood association, CHASE (1,239 acres), includes 308 acres of canopy for an average canopy cover of 25% and 616 acres of impervious surfaces (50%) (Table 2).

Arcade Creek Neighborhood Empowerment Association (711 acres) has the highest canopy cover of 40% followed by Sunrise Ranch Neighborhood Association (32%), and Sylvan Old Auburn Road Neighborhood (30%).

Table 2. Tree Canopy and Impervious Surface by Neighborhood Association

Neighborhood Association	Area	Total Acres	Canopy Acres	% Canopy	Impervious Acres	% Impervious
Northwest	1	881	118	**13.38**	547	**62.05**
Rusch Park	2	1,084	229	**21.14**	580	**53.53**
CHANT	3	867	240	**27.70**	436	**50.34**
Arcade Creek	4	711	241	**33.85**	350	**49.21**
Park Oaks	5	612	150	**24.52**	331	**54.15**
Sunrise Ranch	6	973	313	**32.14**	389	**39.92**
CHASE	7 & 8	1,239	308	**24.88**	616	**49.69**
Sunrise Oaks	9	766	181	**23.68**	414	**54.03**
Sylvan Old Auburn Road	10	936	277	**29.61**	433	**46.31**
Birdcage Heights	2	1,037	220	**21.20**	616	**59.40**
All Neighborhoods		**9,106**	**2,277**	**25.01**	**4,712**	**51.75**



Map 4. Canopy Cover by Neighborhood Association

Tree Canopy in Parks and Open Space

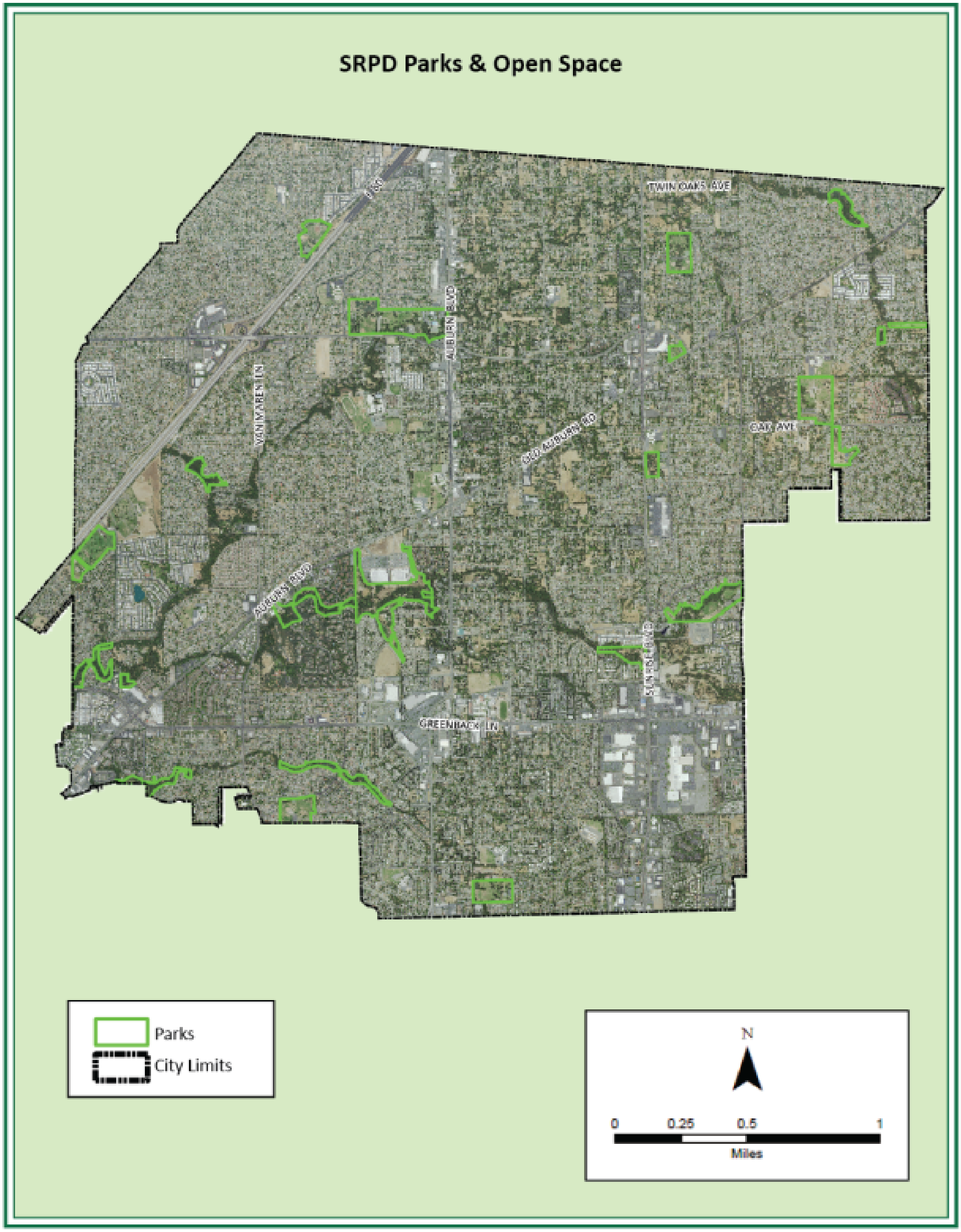
The Sunrise Recreation and Park District (SRPD) manages and maintains 20 parks and open space areas in Citrus Heights. Park and open space areas encompass 315 acres and include 157 acres of tree canopy for an overall canopy cover of 49.7% (Map 5 and Table 3).

Citrus Heights' largest park, Rusch Community Park (49 acres), has 20 acres of tree canopy and an average canopy cover of 40.4%. Edgecliff Court Park (9 acres) has the highest canopy cover at 94.2%, followed by Crosswoods Community Park (16 acres) at 90.1% canopy cover, and Indian River Drive Park (10 acres) at 89.5% canopy cover.

Open space areas (50 acres) include 32 acres of tree canopy and an overall canopy cover of 56.9%.

Table 3. Tree Canopy in SRPD Parks and Open Space Areas

Park	Total Acres	Canopy Acres	% Canopy
Brooktree Park	14.90	2.68	**17.95**
C-Bar-C Park	25.51	5.53	**21.67**
Cherry Creek Manor Park	10.86	9.27	**85.30**
Crosswoods Community Park	15.74	13.70	**90.13**
Edgecliff Court Park	8.66	8.16	**94.18**
Foothill Golf Center	15.14	3.16	**20.85**
Greenback Woods Park	4.06	1.19	**29.26**
Indian River Drive Park	10.21	9.08	**89.51**
Madera Park	15.55	5.81	**37.38**
Mcdonald Park	2.89	0.55	**19.06**
Northwoods Park	8.27	2.45	**29.69**
Open Space Areas	50.27	32.15	**56.94**
Rusch Community Park	48.95	19.75	**40.35**
San Juan Park	14.64	4.81	**32.87**
Shadow Creek Park	8.73	7.20	**83.06**
Sunrise Oaks Park	5.24	3.76	**71.71**
Tempo Park	24.74	13.17	**53.24**
Twin Creek Park	6.96	6.16	**88.40**
Van Maren Park	8.12	3.15	**38.83**
Westwood Park	11.66	2.58	**22.12**
Woodside Oaks Park	4.27	2.54	**61.54**
Total Parks	**315.36**	**156.85**	**49.73**



Map 5. Sunrise Recreation Park District (SRPD) Parks and Open Space

Tree Canopy and Schools

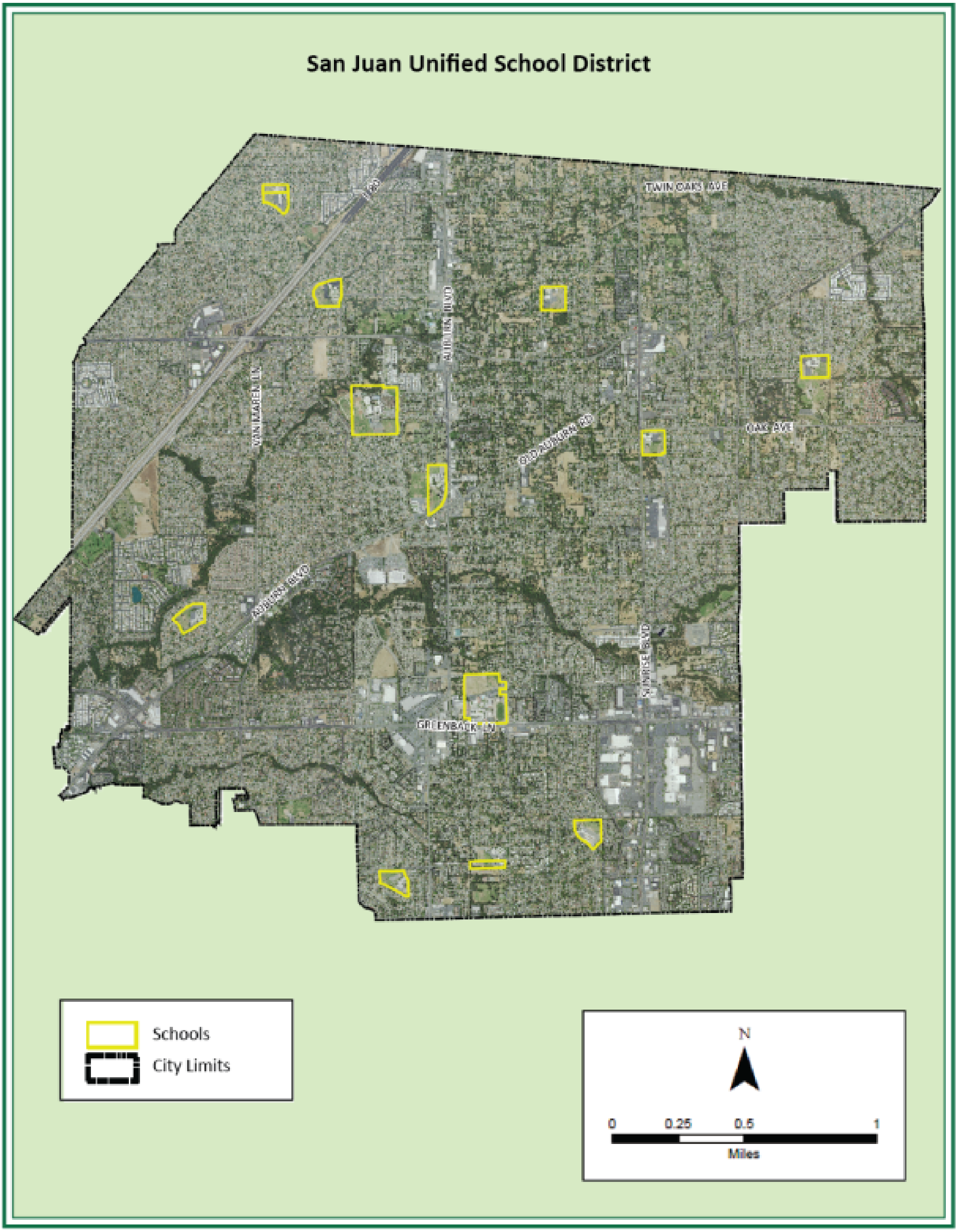
Green infrastructure (e.g., trees, shrubs, and other landscaping) has a positive effect on human health and wellbeing. Studies find that increased canopy cover can reduce the symptoms in children with ADD (Taylor, Kuo, & Sullivan, 2001) and ADHD (Taylor & Kuo, 2009). Views that include a higher concentration of trees and shrubs from cafeteria and classroom windows are positively associated with standardized test scores, graduation rates, percentages of students planning to attend a four-year college, and fewer occurrences of criminal behavior (Matsouka, R.H., 2010). In addition, children who spend extended periods of time in woodlands to become familiar with the natural environment, improve in confidence, motivation and concentration, language and communication, and physical skills (O'Brien, 2009).

The San Juan Unified School District includes 12 schools within the City of Citrus Heights including nine elementary schools, one middle school, and two high schools (Table 4 and Map 6). Altogether, schools encompass 167 acres with 19 acres of tree canopy and an overall canopy cover of 11.3%.

Individual school properties range in size from 3.4 acres to more than 33 acres. Skycrest Elementary School (4.3 acres) has the highest canopy cover at 29.3%, followed by Mesa Verde High School (38 acres) at 14.9%. Woodside Elementary School (10 acres) has the least canopy cover at 3.4%.

Table 4. Tree canopy and impervious surface at Schools in Citrus Heights

School Name	Total Acres	Canopy Acres	% Canopy	Impervious Acres	% Impervious
Lichen Elementary School	9.82	0.40	**4.04**	4.60	**46.83**
Grand Oaks Elementary School	10.72	1.14	**10.68**	4.19	**39.04**
Mariposa Elementary School	9.73	1.42	**14.59**	4.07	**41.78**
Mesa Verde High School	37.61	5.61	**14.92**	15.99	**42.52**
Sylvan Middle School	13.36	1.69	**12.67**	5.07	**37.96**
Arlington Heights Elementary	9.96	1.43	**14.39**	4.73	**47.51**
San Juan High School	33.26	2.03	**6.12**	17.19	**51.67**
Kingswood Elementary School	10.14	1.43	**14.13**	4.67	**46.07**
Skycrest Elementary School	4.33	1.27	**29.27**	1.45	**33.38**
Cambridge Heights Elementary	8.75	0.82	**9.42**	4.03	**46.08**
Woodside Elementary School	10.31	0.35	**3.41**	5.12	**49.63**
Sunrise Elementary School	9.19	1.27	**13.79**	3.67	**39.91**
Total Schools	**167.18**	**18.87**	**11.29**	**74.77**	**44.72**



Map 6. Schools in Citrus Heights

Tree Canopy and Stormwater Management

The Role of Trees

According to Federal Clean Water Act regulations, municipalities must obtain a permit for managing their stormwater discharges into water bodies. Each city's program must identify the best management practices (BMPs) it will implement to reduce its pollutant discharge. Nationwide, non-point source pollution is one of the biggest contributors to poor water quality. Non-point source pollution occurs when stormwater deposits surface contaminants into surface or ground water. Preventing non-point source pollution and reducing stormwater runoff is becoming a serious environmental concern for many communities.

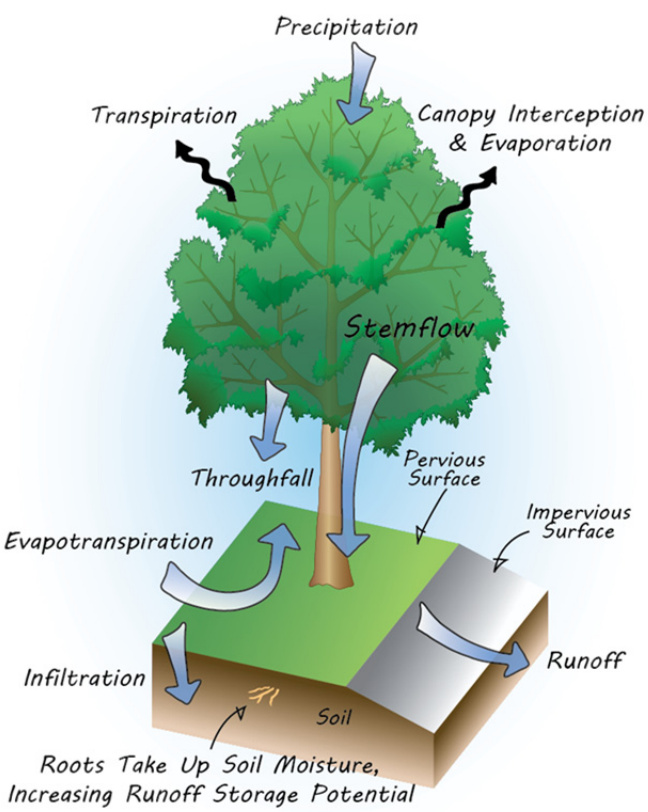
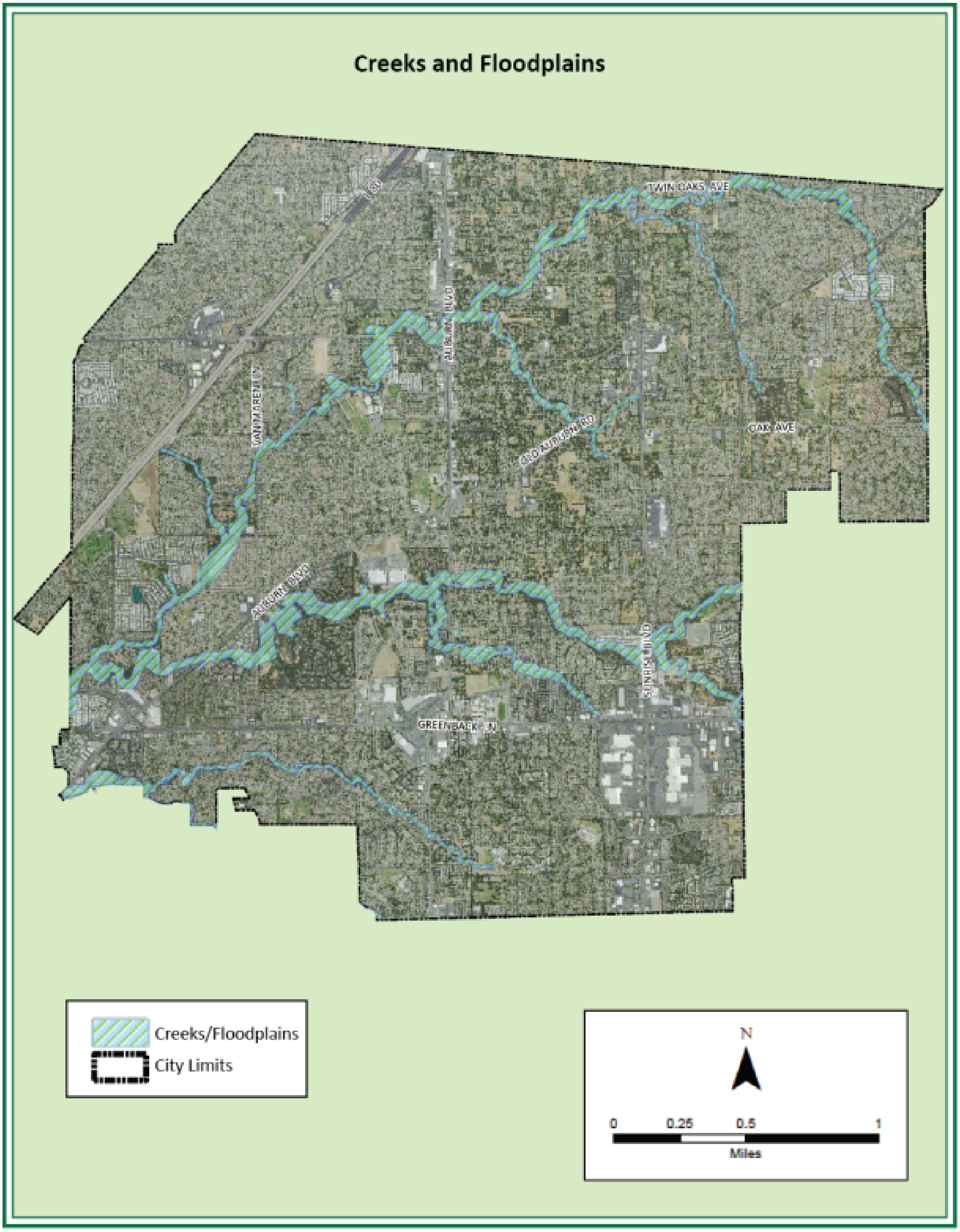


Figure 5. Intercepting precipitation, reducing runoff, and facilitating groundwater recharge, trees are a natural and cost effective part of a stormwater management program.

Trees and forests can be a natural, cost-efficient, and highly effective part of a stormwater management program (Figure 5). Many communities are turning to trees to help solve their stormwater issues in a less costly and more holistic manner. Engineered and natural stormwater systems that incorporate and take advantage of the natural benefits provided by trees and forests are providing to be more cost-effective and sustainable than traditional detention and treatment methods. While there are many methods and construction designs available for integrating urban trees into stormwater management infrastructure, including pervious pavement systems, suspended sidewalks, structural soils, bioswales, and stormwater tree pits, some of these designs can be costly to implement. Preserving natural or engineered forest stands and existing trees before, during, and after development can reduce runoff from urban and suburban properties and effectively solve many stormwater issues before they become costly and/or detrimental to the surrounding environment.

Citrus Heights is fortunate to enjoy a natural system of creeks and floodplains that contribute to stormwater management and preserve water quality. **Creeks and floodplains encompass 566 acres in Citrus Heights and include 356 acres of tree canopy for an overall average canopy cover of 62.9% (Map 7)**. Besides providing important cover and habitat for birds and other wildlife, creek and floodplains also provide flood water storage and conveyance. Trees and forest canopy play a role in the protection of watersheds, stream, and creek preservation by helping to reduce stormwater flows, increasing soil capacity and infiltration, aiding in bioremediation and preventing erosion.

Land cover percentages from Citrus Heights were used in conjunction with i-Tree Hydro (beta v5.0) to calculate and quantify the stormwater runoff reduction contributed by tree canopy. **Citrus Heights' tree canopy is decreasing runoff by 243.3 million gallons, valued at nearly $2 million** (Appendix B).



Map 7. Creeks and floodplains

Stormwater Risk Analysis

To identify areas were additional trees would provide the greatest benefits to stormwater management and reducing runoff and erosion, Citrus Heights' existing landcover data was analyzed along with impervious surface and environmental data (Table 5). Each of the datasets was classified based on the value of "risk" from 0-4, with 4 representing the greatest risk of contributing to stormwater runoff. Variables were weighted to produce a results grid. The grid was summarized using zonal statistics by each feature layer and each was assigned an average risk score. Areas and locations with the greatest risk score were classified as higher priority.

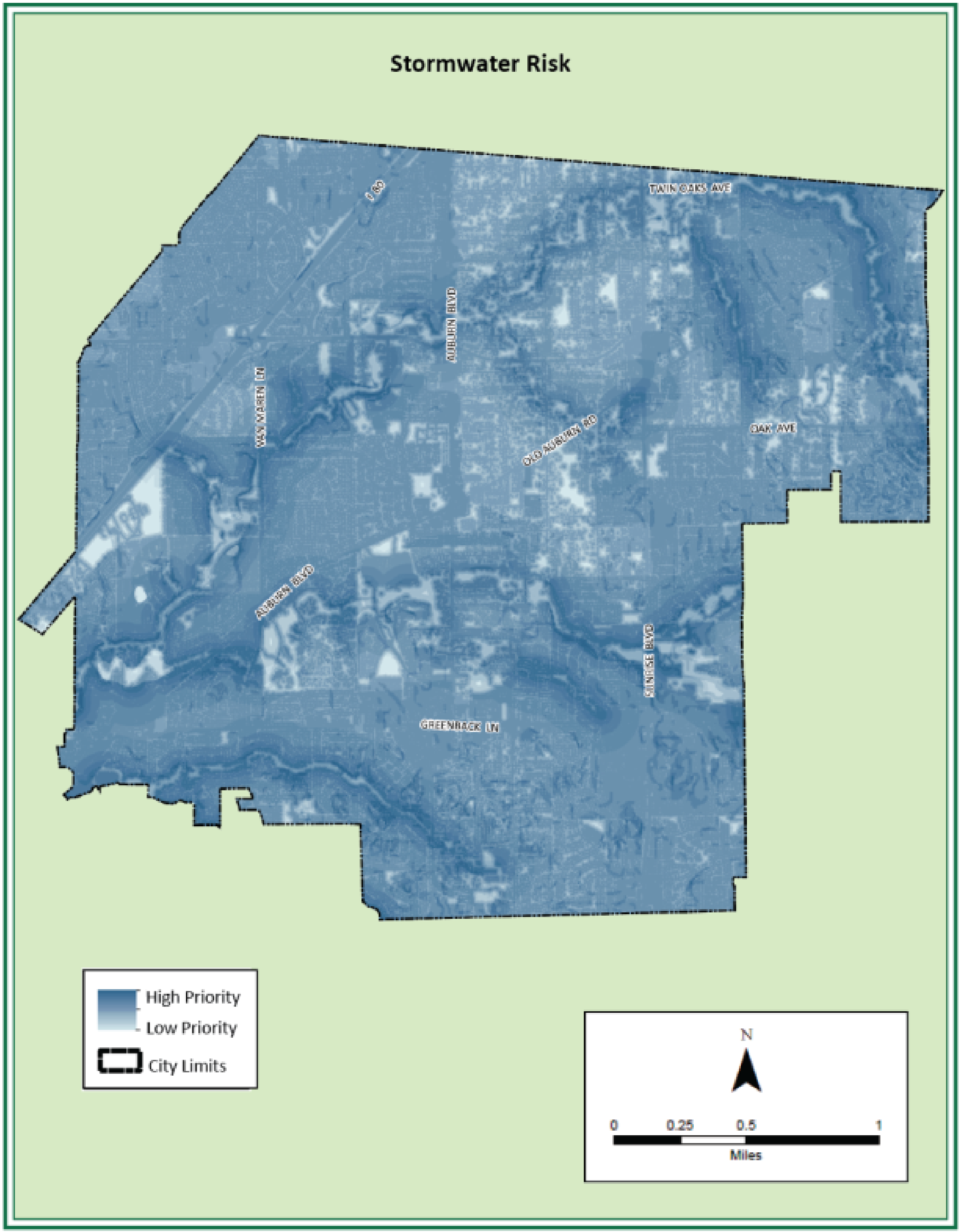
The Stormwater risk map (Map 8) illustrates areas based on runoff risk. Increasing the number of trees and canopy in areas with the highest risk (dark blue) will provide the greatest benefits to stormwater management by increasing capture rates, reducing runoff, and providing greater soil stability.

The analysis identified the following acres of planting sites based on stormwater runoff potential:

- Very High - 35 acres
- High – 232 acres
- Moderate - 724 acres
- Low - 802 acres
- Very Low – 0.14 acres

Table 5. Stormwater risk variables

Dataset	Weight	Source
Impervious Distance	0.35	Urban Tree Canopy Assessment
Slope	0.25	National Elevation Dataset
Floodplain	0.15	Metropolitan Sewer District
Soils	0.15	Natural Resource Conservation Service
K-Factor	0.10	Natural Resource Conservation Service



Map 8. Stormwater risk.

Priority Planting Sites

Some planting sites are more beneficial than others. The UTC analysis included consideration of social and environmental factors to prioritize planting sites with the greatest potential for return on investment.

Assessing Risk Potential

DRG assessed a number of environmental features to identify and prioritize the risk potential for soil loss and/or degradation from storm and/or flood events. 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). Each feature was assessed using a separate grid map (Table 6). A value between zero and four (with zero having the lowest runoff 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.

Prioritizing planting sites

All prospective planting sites were not treated equally as some sites are more suitable than others. In addition to risk potential, planting sites were ranked based on a number of factors including stormwater reduction, urban heat island mitigation, and environmental sensitivity (Figure 6 and Table 7).

Table 6. Priority Ranking Variables

Dataset	Source
Impervious Distance	Urban Tree Canopy Assessment
Slope	National Elevation Dataset
Floodplain	FEMA Flood Zones
Soils	Natural Resource Conservation Service
K-factor	Natural Resource Conservation Service
Population Density	United States Census Bureau
Road Density	City of Citrus Heights
Urban Heat Island	Urban Tree Canopy Assessment

While planting trees in all available sites may take a considerable amount of time and resources, a prioritized planting plan can help to focus efforts on areas with the greatest need and where additional trees will provide the most benefits and return on investment.

Stormwater

A Stormwater Runoff Risk Grid Map (Table 7 and Map 8) identifies runoff risk. Darker blues indicate places where runoff has the greatest risk of erosion, sediment deposits, higher volumes, etc. This grid indicates the darker blue areas should be focused on when planting trees if the primary goal is stormwater management.

Urban Heat Island

As cities continue to grow and develop, the removal of vegetation and tree canopy will be unavoidable. As long as this trend persists, urban heat islands remain a main issue in large cities. Replacing vegetation with impervious surface such as buildings, parking lots, and roads allows for more heat retention which increases evening temperatures. Urban heat islands lead to decreased air quality which contribute to health issues and increased energy consumption.

Urban heat islands within the City of Citrus were assessed using a ratio of impervious surface to canopy cover by establishing a grid of 50 X 50 meter squares. For each square, the amount of impervious surface and tree canopy was calculated. The amount of impervious area was then divided by the canopy cover yielding a ratio value for each grid cell. A larger ratio indicated areas of "hotter" surfaces or the presence of urban heat islands. These areas were synonymous with impervious surfaces such as buildings and parking lots. Small ratio values (less than 1) had a much greater presence of tree canopy.

An Urban Heat Island Grid Map (Table 7) identifies hotspots by using a ratio of impervious surfaces to tree canopy on a 50x50 meter grid. Reds denote "hotter" area. If the primary goal is to focus on urban heat isalnd mitigation, then trees should be planted in orange and red areas.

The analysis identified the following acres of planting sites based on urban heat island priorities:

- Very Low - 231 acres
- Low - 543 acres
- Moderate - 512 acres
- High – 371 acres
- Very High - 136 acres

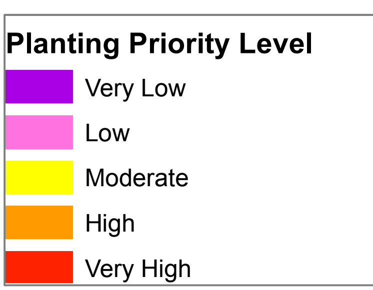
Environmental Sensitivity

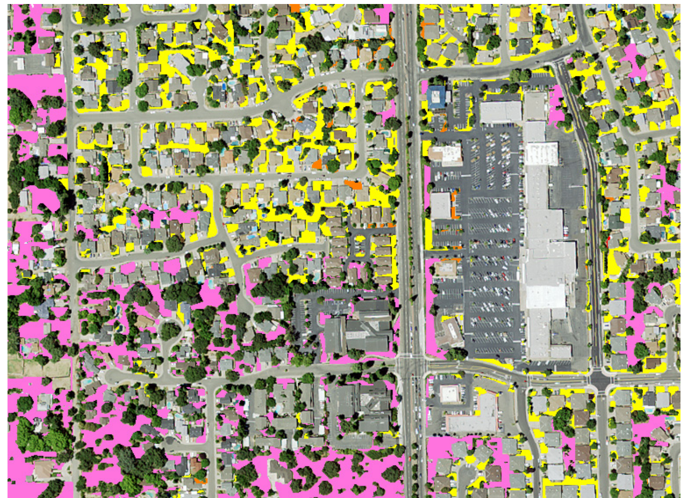
The environmental sensitivity analysis used all grids to prioritize sites tree planting will mitigate the most risks and provide the greatest overall benefits to the community. Red areas identify locations with the greatest environmental need for tree canopy as it takes all factors into account (Map 9).

The analysis identified the following acres of planting sites based on environmental priorities:

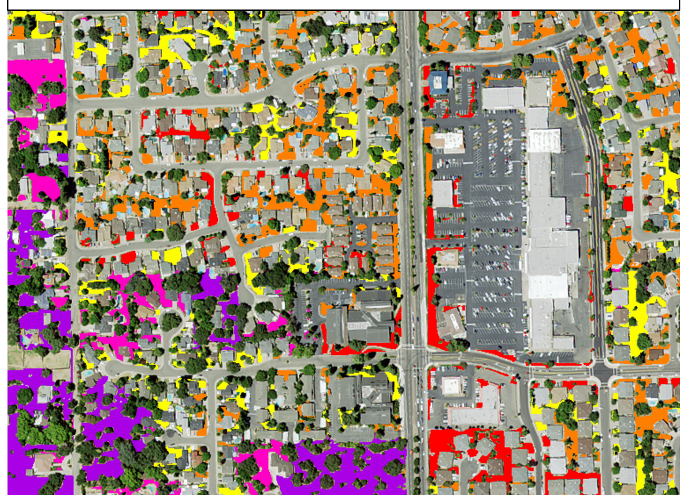
- Very High - 138 acres
- High - 417 acres
- Moderate - 419 acres
- Low - 433 acres
- Very Low - 386 acres

Figure 6. Examples of planting prioritization based on stormwater, urban heat island, and environmental sensitivity. Location is Copperwood Square Shopping Center (Sunrise Blvd. and Woodmore Oaks Dr.)

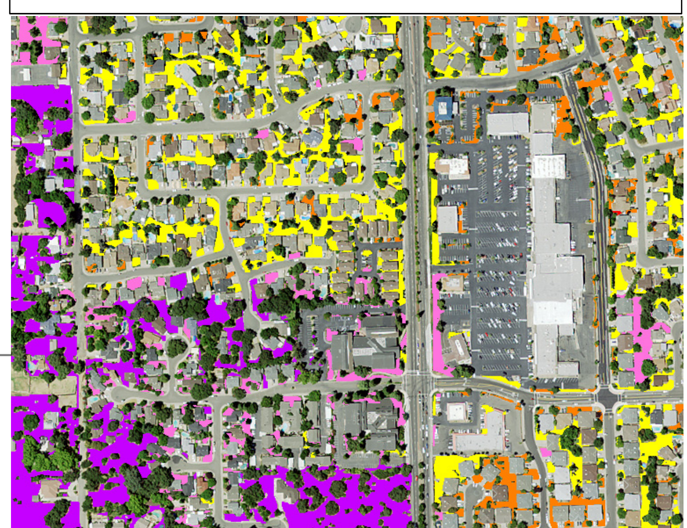




Planting priority to address stormwater runoff (above).

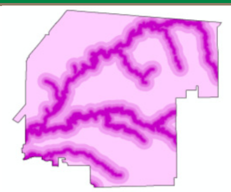
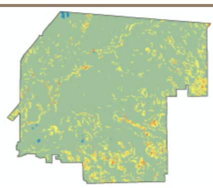
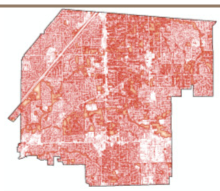
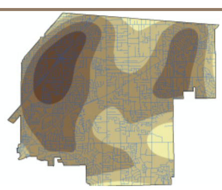
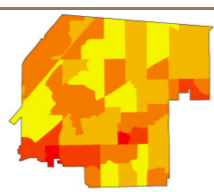
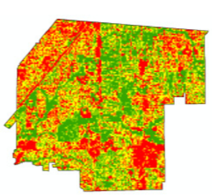


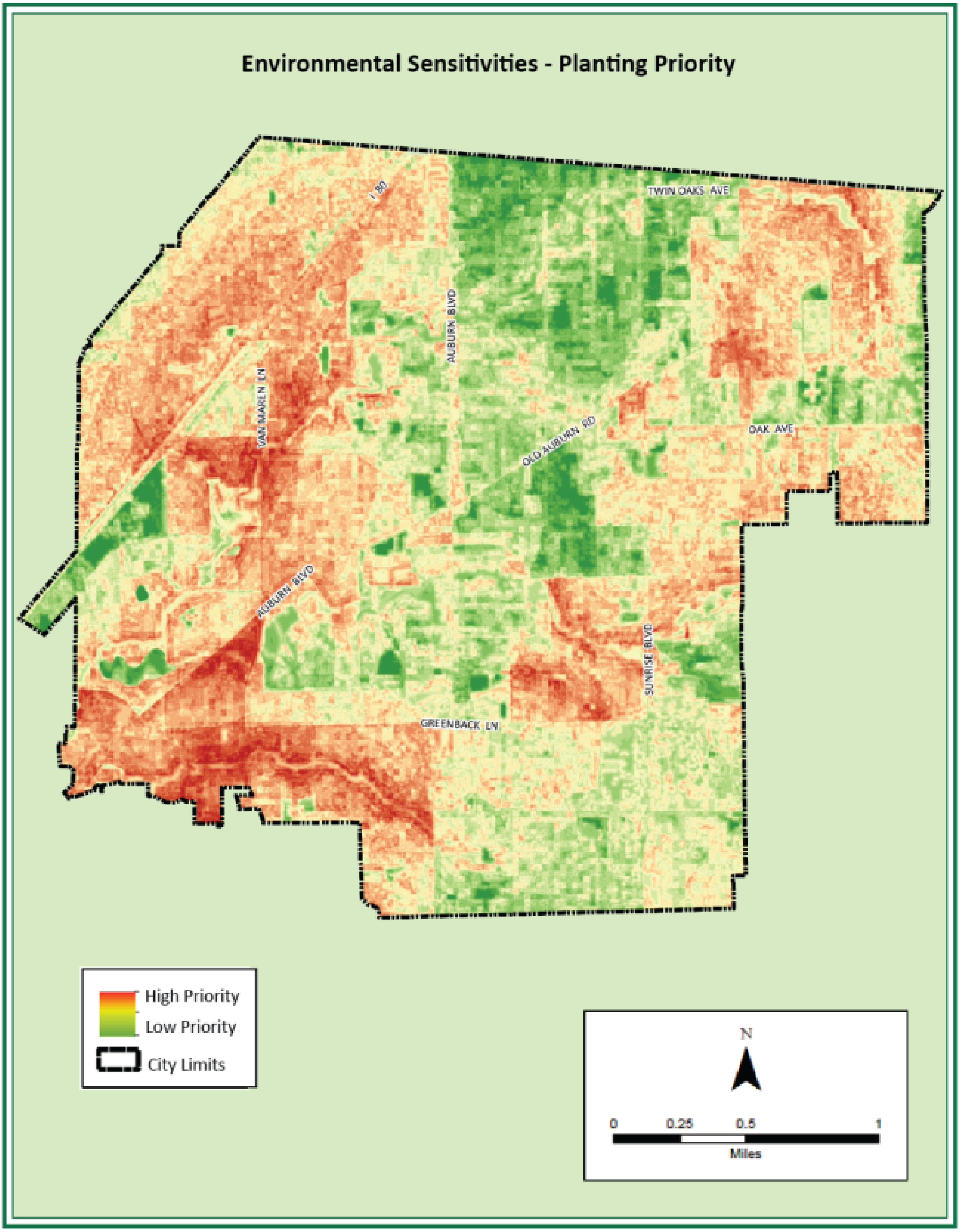
Planting priority to address urban Heat island (above).



Planting priority to address environmental sensitivity (above).

Table 7. Environmental and social factors considered in tree planting site prioritization

Factor	Justification
	Floodplain: A floodplain is an area of land adjacent to a stream or riverthat stretches from the banks of its channel to the base of the enclosing valley walls and experiences flooding during periods of high discharge. Floodplains can support particularly rich ecosystems, both in quantity and diversity. Protecting them is ecologically important.
	Hydrologic Soil Group: Soils are assigned groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms. The soils have four groups (A, B, C, and D). A soils have a high infiltration rate (low runoff potential) while D soils have slow infiltration rates (high runoff).
	Slope: Slope is a measure of change in elevation. It is a crucial parameter in several well-known predictive models used for environmental management. A higher degree of slope increases the velocity of stormwater runoff causing a greater risk of erosion due to sheeting, especially if slopes are bare.
	Hardscape Proximity: Impervious surfaces vastly increase the amount of runoff during storm events. By identifying these locations and their surroundings, measures can be taken to reduce the amount of runoff by planting trees close to hardscapes.
	Canopy Proximity: Canopy fragmentation has many ecological downsides by degrading the overall health of the trees and wildlife. It is essential to close as many gaps as possible and create more connectivity to increase biodiversity and canopy health.
	Road Density: The amount of road density signifies how much noise and air pollution are being released in the atmosphere. Controlling these factors helps maintain quieter neighborhoods as well as reduced levels of air pollution emissions such as carbon dioxide, ozone, and particulate matter.
	Population Density: Population density represents the number of people within a given area. Having greater amounts of people within an area attracts the need for more trees to aesthetically improve the urban landscape. By planting in areas with higher population density, there is more return on investment because more people receive this benefit.
	Urban Heat Island: An urban heat island is a metropolitan area that is significantly warmer than its surrounding rural areas due to human activities. The main cause of the urban heat island effect is from the modification of land surfaces, which use materials that effectively store short-wave radiation. Reducing the effects of urban heat island provides great health and social benefits to the community.



Map 9. Environmental Sensitivity – Priority planting sites

Conclusion

In comparison with other communities across the region, the existing tree canopy cover in Citrus Heights (25%) is quite high (Figure 7). Preservation of canopy will be key as ongoing development continues to occur. However, considering that many communities are working to increase canopy to at least 25%, Citrus Heights is in an enviable position. With proactive policies, the City can preserve existing canopy levels and continue to grow this beneficial resource. The Sacramento Tree Foundation has established a goal of 35% for the region through the Greenprint Initiative (sactree.com).

Considering that nearly 52% of the community is covered by impervious surfaces, including roads, parking lots, and structure, Citrus Heights has the potential to support 48% overall canopy cover. Of course, some areas and land uses are incompatible with trees, including athletic fields and golf courses (fairways). Other areas, including parks and schools have the potential to support greater canopy.

The Urban Tree Canopy Assessment establishes a GIS data layer that can be used in conjunction with other infrastructure layers to identify potential planting sites and increase canopy cover in under-treed neighborhoods. The assessment establishes a baseline for developing urban forest management strategies and measuring the success of those strategies over time.

Based on this assessment, DRG recommends the following:

- Citrus Heights' existing tree canopy is substantial and the preservation and protection of this resource is essential to maintaining a healthy and sustainable community. Proactive preservation and mitigation policies and ongoing tree replacement can ensure that canopy cover remains stable and continues to grow over time.
- Prioritized grid maps provide a basis for a strategically focused planting plan to increase trees and canopy that will support stormwater management, reduce urban heat island impacts, and complement the existing urban infrastructure for the greatest impact and return on investment.
- New tree planting should include strategies for increasing canopy cover on both public and private property with a focus on drought tolerance and water-efficient landscapes. Maintaining a diverse list of regionally compatible and drought resistant/low-water-use species will prove an invaluable resource for residents, developers, property managers, and landscape architects.
- This report provides an overview of the existing tree canopy and an important outreach tool for engaging public interest and support. However, the accompanying GIS layer that maps the location and extent of existing landcover can support a vast range of additional analysis when used in conjunction with other data layers. The data supports analysis from an overall community level down to the parcel level and can provide an important tool for investigating the relationship of tree canopy in correlation with other important issues, including transportation, walkability, human health, and social and economic concerns.

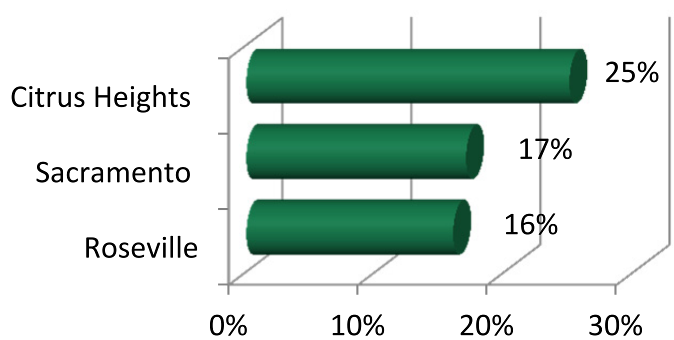


Figure 7. Canopy cover comparison

Appendices

A. References

American Forests. Sacramento Urban Forest Fact Sheet. [Accessed 10 March 2015] www.americanforests.org/our-programs/urbanforests/10-best-cities-for-urban-forests/10-best-cities-for-urban-forests-sacramento/sacramento-urban-forest-fact-sheet/

Citrus Heights. 2015. Urban Forest Resource Analysis. [Accessed 15 April 2015] http://www.citrusheights.net/DocumentCenter/View/3402

Clark JR, Matheny NP, Cross G, Wake V. 1997. A model of urban forest sustainability. Journal of Arboriculture 23(1):17-30.

Dwyer J, McPherson EG, Schroeder HW, Rowntree R. 1992. Assessing the Benefits and Costs of the Urban Forest. 1992. Journal of Arboriculture 18(5): 1-12.

Greenhouse Gas Reduction Plan. 2011. [Accessed 10 March 2015] www.citrusheights.net/203/Greenhouse-Gas-Reduction-Plan

Hirabayashi S. 2014. i-Tree Canopy Air Pollutant Removal and Monetary Value Model Descriptions. http://www.itreetools.org/canopy/resources/iTree_Canopy_Methodology.pdf [Accessed 10 April 2015]

i-Tree Canopy v6.1. i-Tree Software Suite. [Accessed 10 April 2015] http://www.itreetools.org/canopy

i-Tree Hydro v5.0 (beta). i-Tree Software Suite. [Accessed 10 April 2015] http://www.itreetools.org/hydro/index.php

Kaplan R, Kaplan S. 1989. The Experience of Nature: A Psychological Perspective. Cambridge: Cambridge University Press.

Matsuoka, R. H. (2010). Student performance and high school landscapes: Examining the links. Landscape and Urban Planning, 97(4), 273-282.

McPherson EG, Simpson JR, Peper PJ, Xiao Q. 1999. Benefit-Cost Analysis of Modesto's Municipal Urban Forest. Journal of Arboriculture. 25(5).

National Oceanic and Atmospheric Administration (NOAA). [Accessed 10 April 2015] http://www.crh.noaa.gov

O'Brien L. (2009). Learning outdoors: the Forest School approach. *Education 3–13*, *37*(1), 45-60.

Park BJ, Tsunetsugu Y, Kasetani T, Hirano H, Kagawa T, Sato M, Miyazaki Y. (2007). Physiological effects of Shinrin-yoku (taking in the atmosphere of the forest)-using salivary cortisol and cerebral activity as indicators. Journal of physiological anthropology, 26(2), 123-128.

Ulrich RS. 1986. Human Responses to Vegetation and Landscapes. Landscape and Urban Planning 13: 29-44.

U.S. Environmental Protection Agency (US EPA). 2012. Environmental Benefits Mapping and Analysis Program (BenMAP). http://www.epa.gov/air/benmap [Accessed 10 April 2015]

U.S. Forest Service. 2012. STRATUM Climate Zones. [Accessed 10 April 2015] http://www.fs.fed.us/psw/programs/uesd/uep/stratum.shtml

Taylor AF, Kuo FE. (2009). Children with attention deficits concentrate better after walk in the park. *Journal of Attention Disorders, 12*(5), 402-409.

Taylor AF, Kuo FE, Sullivan WC. (2001). Coping with ADD The surprising connection to green play settings. *Environment and Behavior, 33*(1), 54-77.

Troy A, Grove JM, O'Neil-Dunne J. (2012). The relationship between tree canopy and crime rates across an urban-rural gradient in the greater Baltimore region. Landscape and Urban Planning, 106(3), 262-270. doi: 10.1016/j.landurbplan.2012.03.010

B. Methodology and Accuracy Assessment

Davey Resource Group Classification Methodology

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 amount 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.

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.

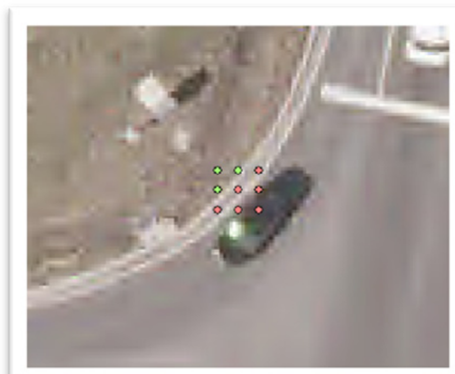
To test for accuracy, random plot locations are generated throughout the city area of interest and verified to ensure that the data meet the client standards. Each point will be compared with the most current NAIP high-resolution imagery (reference image) to determine the accuracy of the final land cover 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.

Table 8. Land cover classification code values

Land Cover Classification	Code Value
Tree Canopy	1
Impervious	2
Pervious (Grass/Vegetation)	3
Bare Soil	4
Open Water	5

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 8) 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 2. The table allows for assessment of user's/producer's accuracy, overall accuracy, omission/commission errors, kappa statistics, allocation/quantity disagreement, and confidence intervals (Figure 8 and Table 10).

Table 9. Classification matrix

	Classes	Tree Canopy	Impervious Surfaces	Grass & Low-Lying Vegetation	Bare Soils	Open Water	Row Total	Producer's Accuracy	Errors of Omission
Reference Data	Tree Canopy	244	13	15	0	0	272	89.71%	10.29%
	Impervious	6	473	11	2	0	492	96.14%	3.86%
	Grass/Vegetation	11	19	158	1	0	189	83.60%	16.40%
	Bare Soils	2	3	4	38	0	47	80.85%	19.15%
	Water	0	0	0	0	0	0	-	-
	Column Total	263	508	188	41	0	1,000		
	User's Accuracy	92.78%	93.11%	84.04%	92.68%	-		Overall Accuracy	91.30%
	Errors of Commission	7.22%	6.89%	15.76%	7.32%	-		Kappa Coefficient	0.8643

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 ((244+473+158+38+0)/1,000 = 91.30%).

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 [244/263 = 92.78%]).

Producer's Accuracy – Probability of a reference pixel being correctly classified (correct land cover classifications divided by the row total [244/272 = 89.71%]).

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 7.22% 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 10.29% of all canopy classified is actually present in the land cover data.

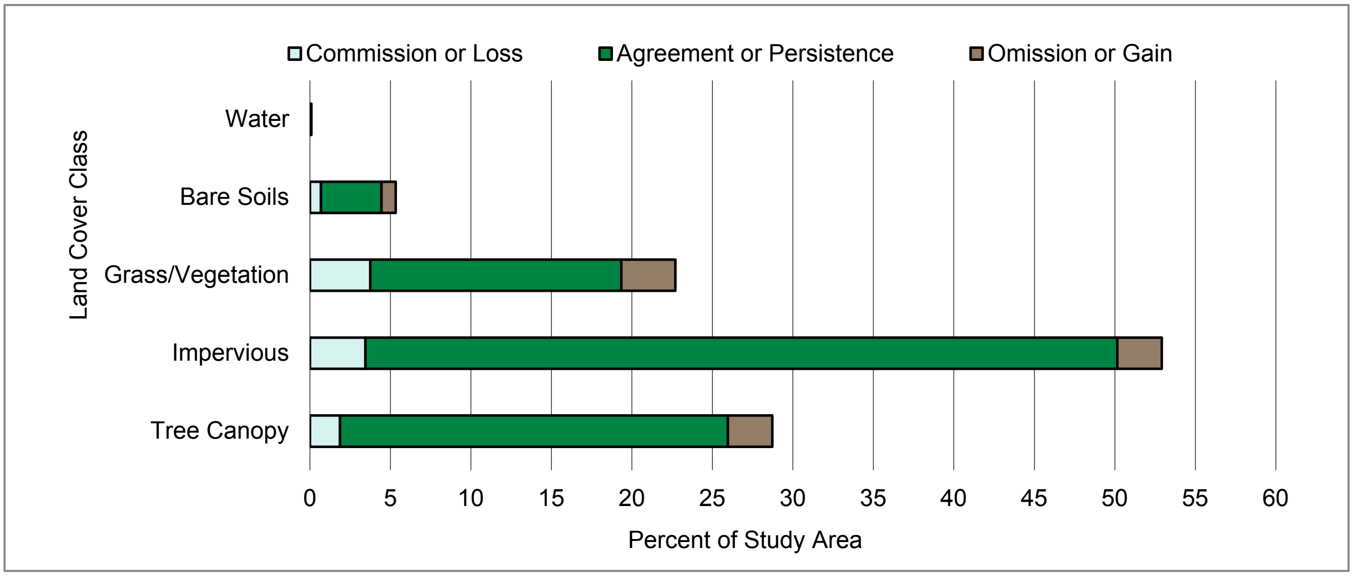


Figure 8. 95% confidence intervals, accuracy assessment, and statistical metrics summary

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 10. Omission/Commission errors

Confidence Intervals

Class	Acreage	Percentage	Lower Bound	Upper Bound
Tree Canopy	2,278	25.0%	24.6%	25.5%
Impervious Surfaces	4,702	51.6%	51.1%	52.2%
Grass & Low-Lying Vegetation	1,706	18.7%	18.3%	19.1%
Bare Soils	417	4.6%	4.4%	4.8%
Open Water	4	0.0%	0.0%	0.1%
Total	9,106	100.00%		

Statistical Metrics Summary

Overall Accuracy =	91.30%
Kappa Coefficient =	0.8643
Allocation Disagreement =	8%
Quantity Disagreement =	1%

Accuracy Assessment

Class	User's Accuracy	Lower Bound	Upper Bound	Producer's Accuracy	Lower Bound	Upper Bound
Tree Canopy	92.8%	91.2%	94.4%	89.7%	87.9%	91.5%
Impervious Surfaces	93.1%	92.0%	94.2%	96.1%	95.3%	97.0%
Grass & Low-Lying Vegetation	84.0%	81.4%	86.7%	83.6%	80.9%	86.3%
Bare Soils	92.7%	88.6%	96.7%	80.9%	75.1%	86.6%
Open Water	-	-	-	-	-	-