URBAN TREE CANOPY
ASSESSMENT

TITUSVILLE, FLORIDA

JANUARY | 2023

PlanIT Geo
developers of TreePlotter

Titusville
FLORIDA

earth define

AN ASSESSMENT OF
URBAN TREE CANOPY IN
TITUSVILLE, FLORIDA

" **To be without trees would, in the most literal way, to be without our roots.**

-Richard Mabey "

PREPARED BY

PlanIT Geo, Inc., Arvada, Colorado

PREPARED FOR

City of Titusville

COMPLETED

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7,685
ACRES OF CANOPY

42%
TREE CANOPY COVER IN 2021

EXECUTIVE

SUMMARY

PURPOSE OF THIS ANALYSIS

Located along the Indian River Lagoon on Florida's eastern coast, the City of Titusville is approximately 34 square miles, or 21,754 acres, in size. The urban forest in Titusville is a valuable asset providing residents and visitors with many environmental, social, and economic benefits. This assessment mapped urban tree canopy (UTC), possible planting area (PPA), and analyzed how they are distributed throughout Titusville and its study area zones, census block groups, and stormwater basins. **For the purpose of this report, tree canopy refers to percentage of tree canopy coverage for the city's total land including water bodies. Whereas urban tree canopy cover is the percentage of tree canopy coverage excluding water bodies.**

PROJECT METHODOLOGY

The results, based on 2021 imagery from the USDA's National Agriculture Imagery Program (NAIP), provide a current look at land cover in Titusville and will allow the City to revise and develop existing and new strategies to protect and expand the urban forest. This study used modern machine learning techniques to create land cover data that are more reproducible and will allow for a more even comparison the next time tree canopy and land cover are assessed.

CITY OF TITUSVILLE'S URBAN FOREST

In 2021, Titusville had 42% urban tree canopy cover and 27% possible planting area, not including surface water bodies which do not support trees without significant modification. The City's total land, including water bodies cover contained 35% tree canopy, 6% shrubs, 20% other vegetation; 3% soil/dry vegetation; 20% impervious surfaces, and 16% water. Titusville's 7,685 acres of tree canopy provide a multitude of economic, environmental, and social benefits, valued at just over $5.2 million annually, as well as $47 million in carbon storage.

Of the 23 study area zones in Titusville, Zone 23 had the highest canopy cover at 74% (see Figure 11 on page 10). This zone (located southwest of the Space Coast Regional Airport) contained 1,022 acres of canopy making up 13% of the City's total canopy cover. Zone 2 contained the greatest potential for canopy expansion, offering 564 acres (30% PPA by area and 12% of the City's total plantable space). Across Titusville's 47 stormwater basins, unnamed SJ (St. John) basin made up 55% of City's land area and contributed the greatest amounts of UTC (59%) towards the citywide canopy total. This basin also had the highest percent tree canopy cover (45%) within its boundary. PPA percent was highest within the Harrison-Washington Basin with 84% of its land area available for tree planting.
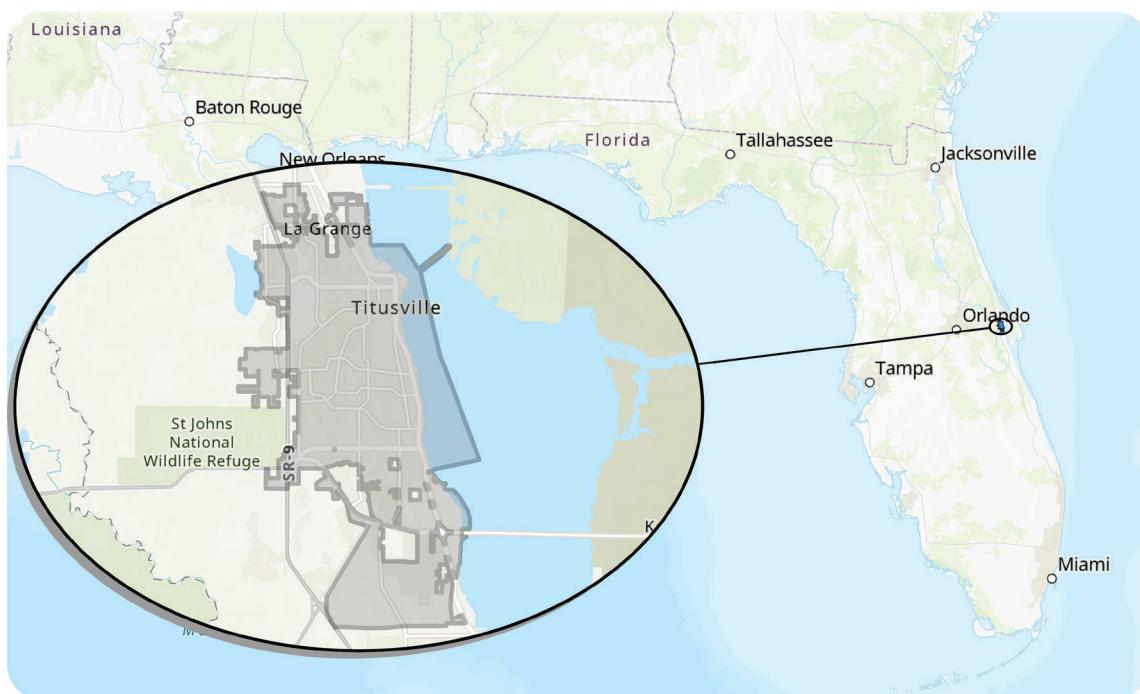
Figure 1. The City of Titusville occupies approximately 34 square miles on the eastern coast of Florida.

RECOMMENDATIONS

The results of this analysis can be used to develop a continued strategy to protect and expand Titusville's urban forest. This study revealed that the City of Titusville contains 7,685 acres of tree canopy. With 4,855 acres of possible planting area, Titusville has the opportunity to continue to increase urban tree canopy coverage on both public and private property. There are over 1,400 acres of plantable space along Titusville's coastal basins and an additional 3,455 acres of PPA throughout the rest of the city. With partnerships, education, and outreach programs to private landowners, the City of Titusville can aim to plant wind-resistant species to stabilize the shoreline, address tree inequity, and set actionable goals. It is important for the City to use this assessment to inform future investments in the urban forest so that all those who live, work, and play in Titusville can benefit from the urban forest. The City should proactively work to protect the existing urban forest and replenish the canopy with additional trees and native shrubs. Through management actions, strategic plantings, and protections for existing canopy informed by the UTC and PPA metrics included in this report, the City of Titusville has an opportunity to expand its current urban tree canopy to its fullest potential.

42%
URBAN TREE CANOPY

27%
POSSIBLE PLANTING AREA

20%
IMPERVIOUS SURFACE

Figure 2. Based on an analysis of 2021 high-resolution imagery, the City of Titusville contains 42% tree canopy, 27% areas that could support canopy in the future, and 20% total impervious areas.
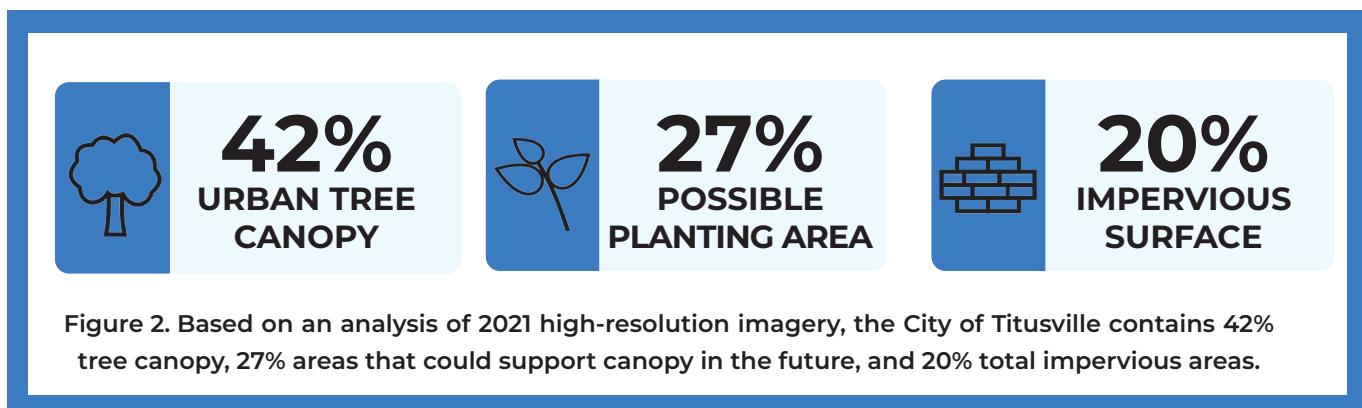
PROJECT
METHODOLOGY

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

DATA SOURCES

This assessment utilized high-resolution (60-centimeter) multispectral imagery from the U.S. Department of Agriculture's National Agriculture Imagery Program (NAIP) collected in 2021 to derive the land cover data set. The NAIP imagery was used to classify all types of land cover.

MAPPING LAND COVER

The land cover data set is the most fundamental component of an urban tree canopy assessment. Tree canopy and land cover data from the EarthDefine US Tree Map (https://www.earthdefine.com/treemap/) provided a six class land cover data set. The US Tree Map is produced using a modern machine learning technique to extract tree canopy cover and other land cover types from the latest available 2021 NAIP imagery. These six classes are shown in Figure 3 and described in the Glossary found in the Appendix.

URBAN TREE CANOPY

OTHER VEGETATION

SHRUB OR SCRUB

SOIL AND DRY VEGETATION

IMPERVIOUS SURFACES
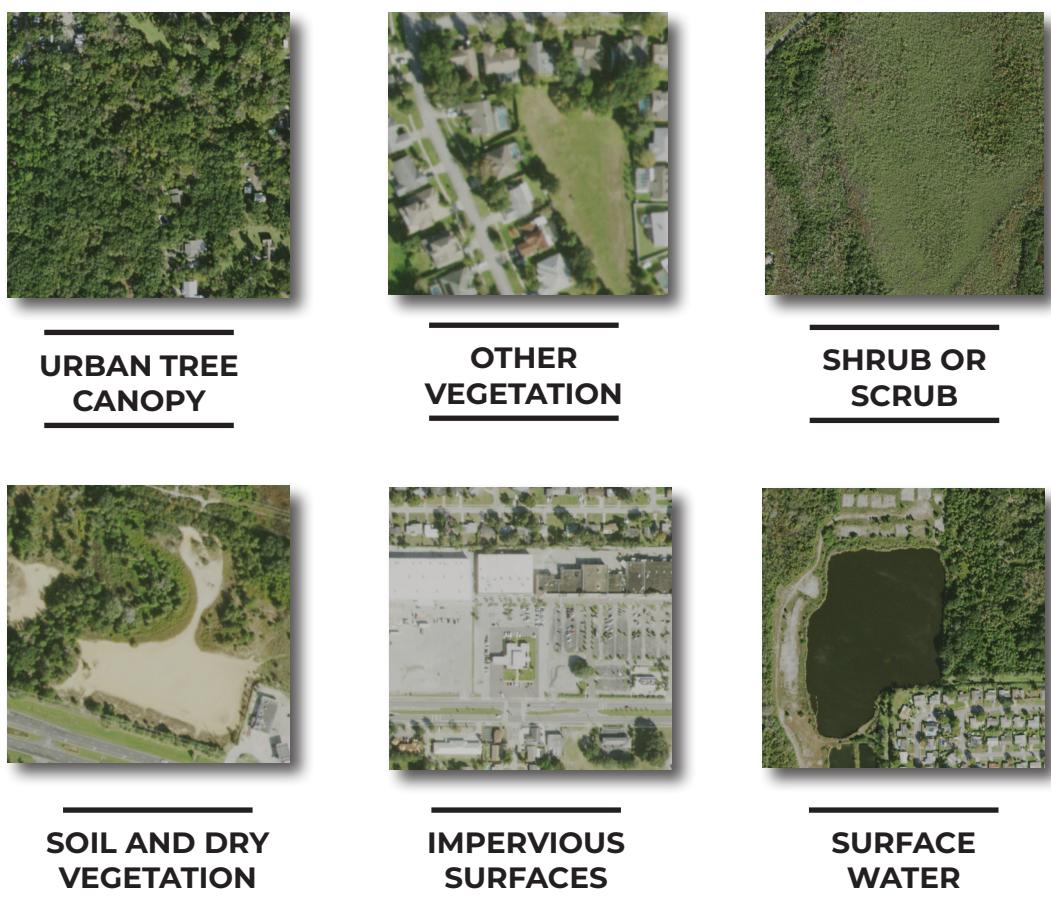
SURFACE WATER

Figure 3. Six (6) distinct land cover classes were identified in the 2021 tree canopy assessment: urban tree canopy, shrubs, other vegetation, bare soil and dry vegetation, impervious surfaces, and water.

IDENTIFYING POSSIBLE PLANTING AREAS AND UNSUITABLE AREAS FOR PLANTING

In addition to quantifying the City of Titusville's existing tree canopy cover, another metric of interest in this assessment was the area where tree canopy could be expanded. To assess this, all land area in the City of Titusville that was not existing tree canopy coverage was classified as either possible planting area (PPA) or unsuitable for planting.

Possible planting areas were derived from the vegetation and shrubs layer. Unsuitable areas, or areas where it was not feasible to plant trees due to biophysical or land use restraints (e.g. golf course playing areas, recreation fields, utility corridors, airports, etc.) were manually delineated and overlaid with the existing land cover data set (Figure 4). The final results were reported as PPA Vegetation, Unsuitable Impervious, Unsuitable Vegetation, Unsuitable Soil, and Water.
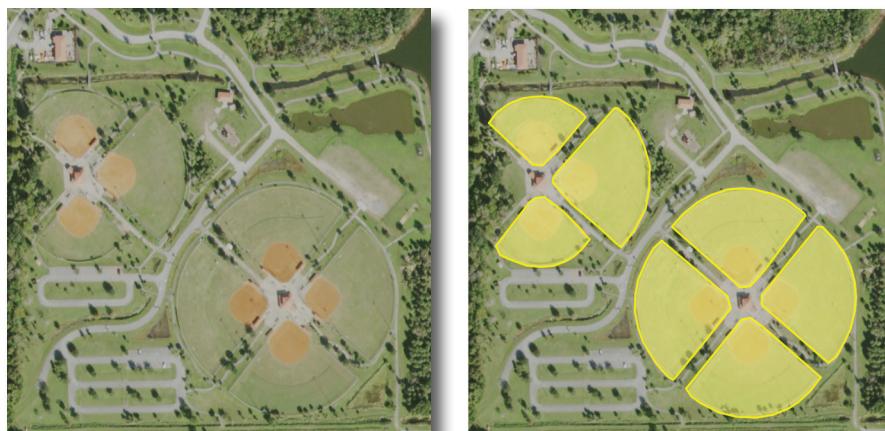

Figure 4.
Vegetated areas where it would be biophysically feasible for tree plantings but undesirable based on their current usage (left) were delineated in the data as "Unsuitable" (right). These areas included recreational sports fields, golf courses, and other open space.

DEFINING ASSESSMENT LEVELS

In order to best inform Titusville's various stakeholders, urban tree canopy and other associated metrics were tabulated across a variety of geographic boundaries. These boundaries include the city boundary, study area zones, census block groups, and stormwater basins.
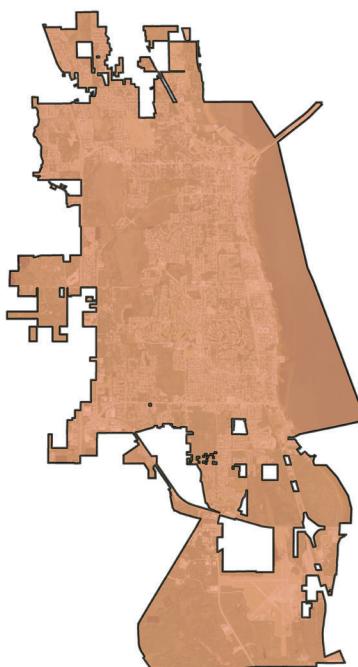
City of Titusville
The **City boundary** is the one (1) main area of interest over which all metrics were summarized.
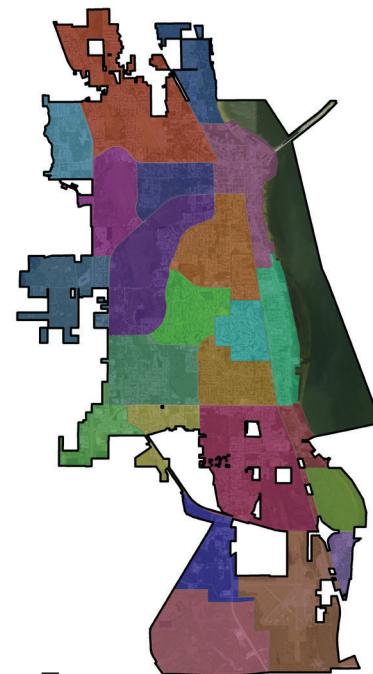
Study Area Zones
Twenty-three (23) **study area zones** were assessed to further dissect urban tree canopy within different communities.
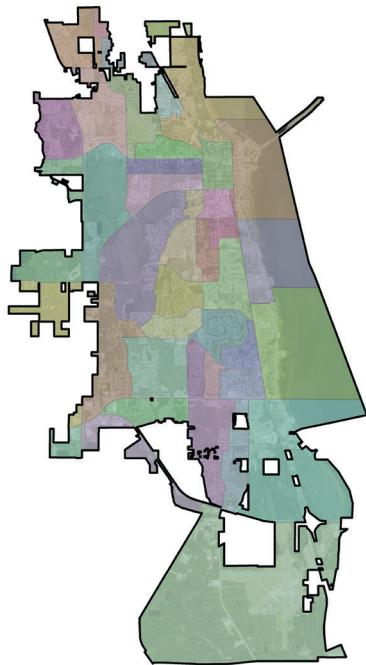
Census block groups

Forty-one (41) **census block groups** were assessed to show the relationship between tree canopy and socio-demographics and highlight potential environmental justice issues.
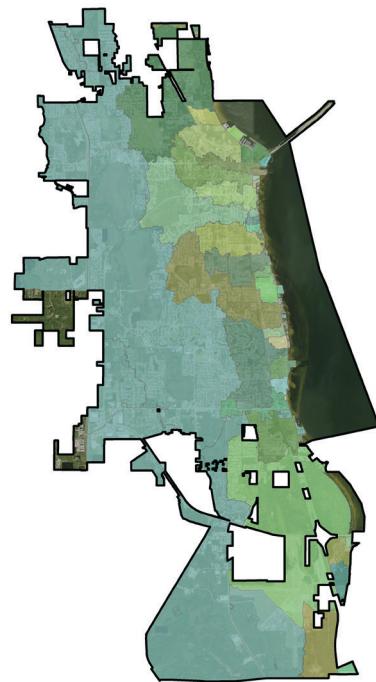
Stormwater basins

Since trees play an important role in stormwater management, forty-seven (47) **stormwater basins** were assessed.

Figure 5. Four (4) distinct geographic boundaries were explored in this analysis: Titusville City boundary, study area zones, census block groups, and stormwater basins.

STATE OF THE CANOPY AND ──────

KEY FINDINGS

The results and key findings of this study, including the land cover map and canopy analysis results, are presented below. These results can be used to design a strategic approach to identifying existing canopy and future planting areas. Land cover percentages are based on the City Boundary as of 2022. The City boundary includes six land cover classes including tree canopy, shrub/scrub, soil and dry vegetation, other vegetation, impervious surfaces, and water, see Table 1 and Figure 6 for the breakdown of percentages. While citywide urban tree canopy includes urban tree canopy, PPA vegetation, unsuitable impervious, unsuitable soil, see Table 2 for the breakdown of percentages.

In 2021, the City land cover consisted of 35% tree canopy, 20% other vegetation, 20% impervious surface, 16% water, 6% shrub, and 3% soil & dry vegetation.

Table 1. Land cover classes in acres and percent in City of Titusville.

City of Titusville, FL	Acres	% of Total
City of Titusville	21,754	100%
Tree Canopy	7,685	35%
Shrubs	1,313	6%
Other Vegetation	4,385	20%
Impervious Surfaces	4,258	20%
Soil & Dry Vegetation	661	3%
Water	3,453	16%
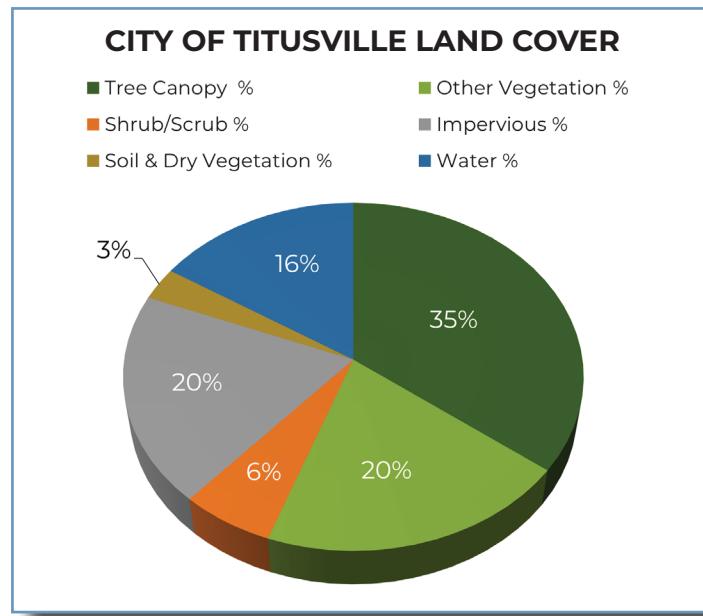
**Figure 6.** Land cover classification results (percentages based on total area of Titusville including water bodies).

Land Cover Classification

- Non-Canopy Vegetation
- Soil and Dry Vegetation
- Impervious
- Water
- Tree Canopy
- Shrub
- Tree Canopy Over Impervious
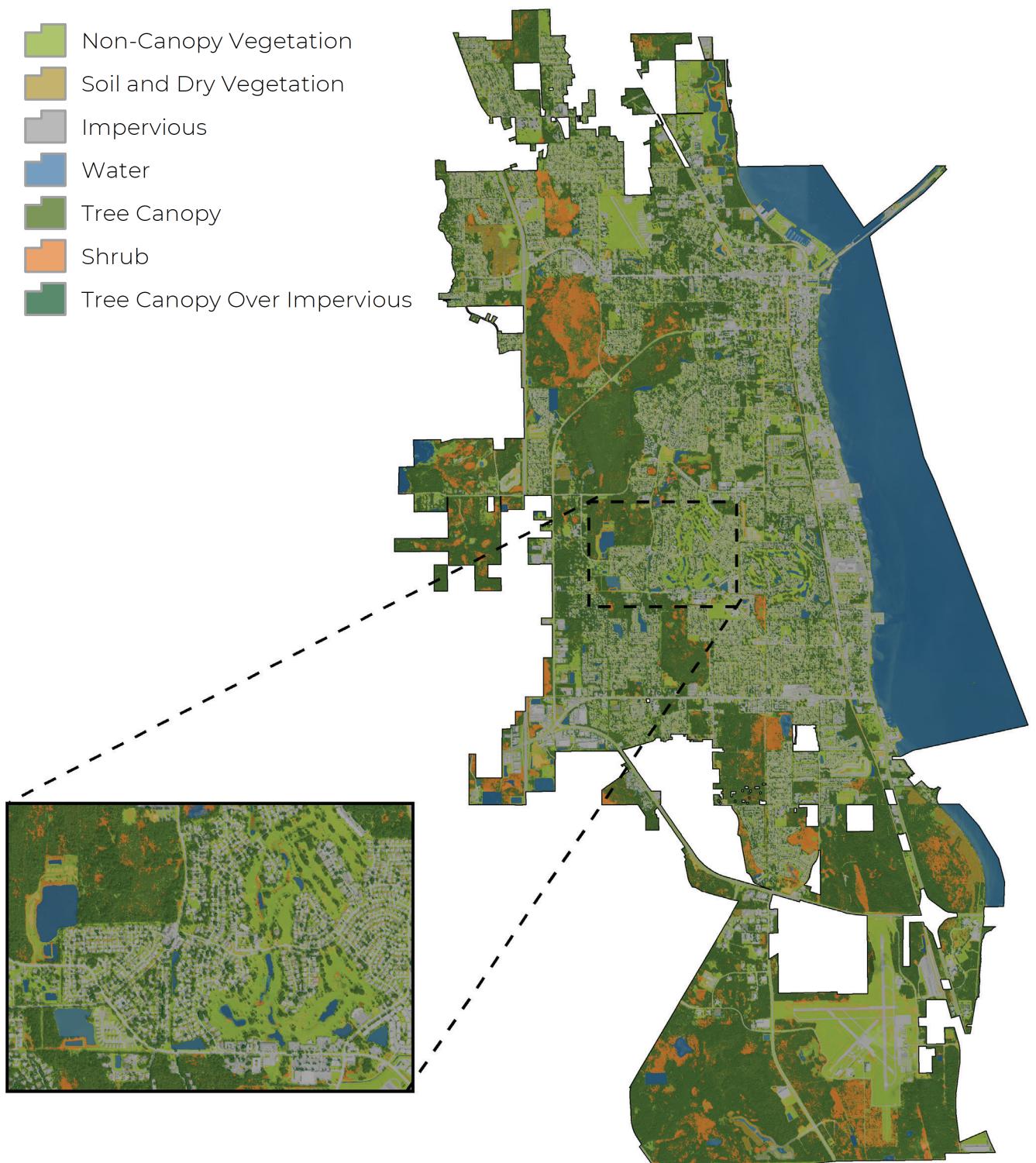
Figure 7. Distribution of land cover throughout Titusville.

CITYWIDE URBAN TREE CANOPY

This urban tree canopy assessment utilized the land cover data as a foundation to determine tree canopy cover and possible planting areas (PPA) throughout the City of Titusville. Results of this study indicate that within the city boundary, 7,685 acres are covered with urban tree canopy, making up 42% of the city's 18,301 land acres; 4,855 acres are covered with other vegetation where it would be possible to plant trees, making up 27% of the city; and the other 5,761 acres were considered unsuitable for tree planting, making up 31% of the city. The unsuitable areas include recreational sports fields, golf course playing areas, airports, utility corridors, areas of bare soil and dry vegetation, and impervious surfaces. Impervious surfaces made up 74% (or 4,258 acres) of total unsuitable areas. Total unsuitable percentages were broken down by land cover type in Figure 10. Note that these results are based on land area, which excludes water bodies, and should be used to describe the City's current tree canopy cover.


Urban Tree Canopy Potential

- Urban Tree Canopy
- PPA Vegetation
- Unsuitable Vegetation
- Unsuitable Impervious
- Unsuitable Soil
- Water
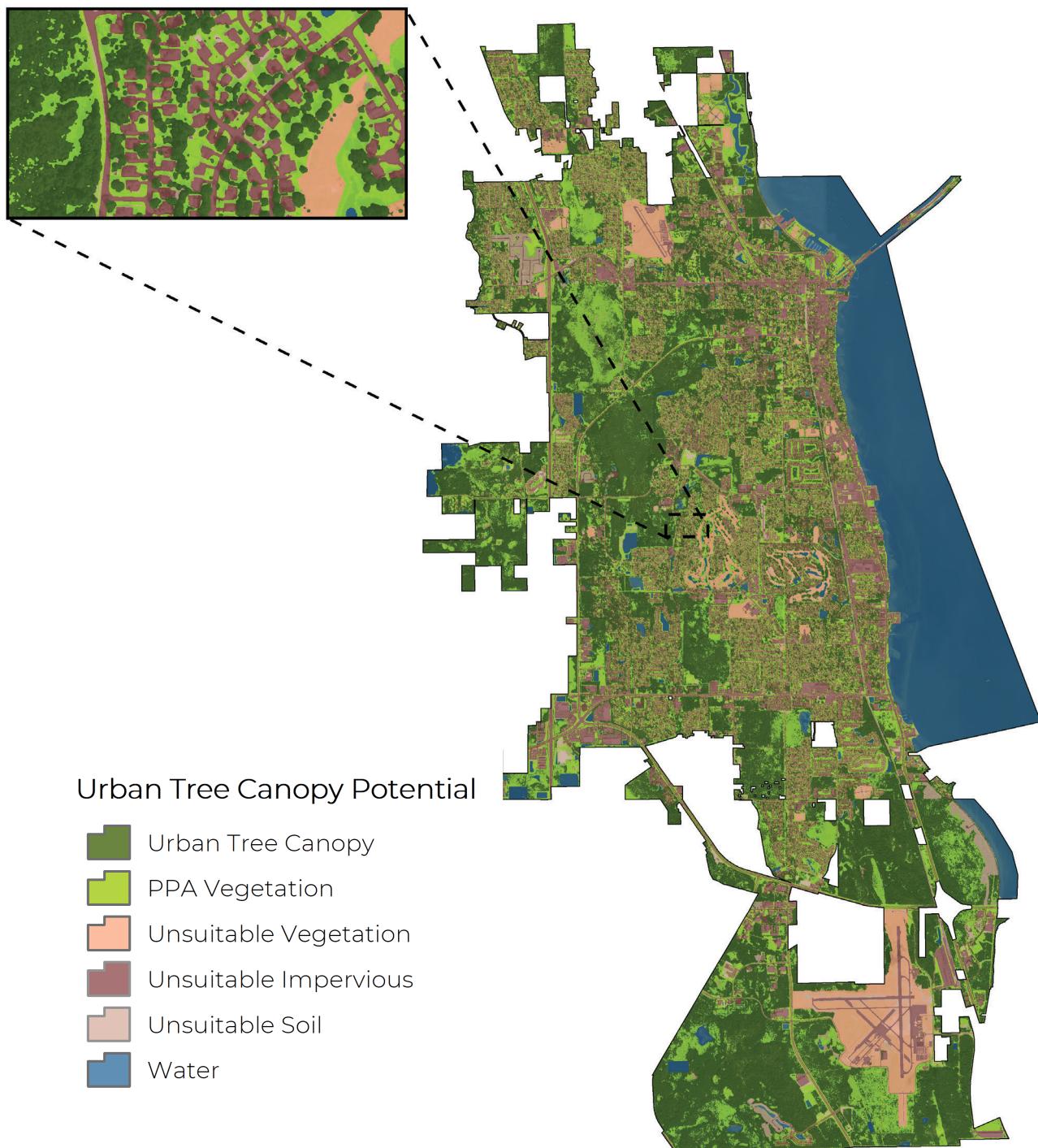
Figure 8. Distribution of existing and potential urban tree canopy throughout Titusville.
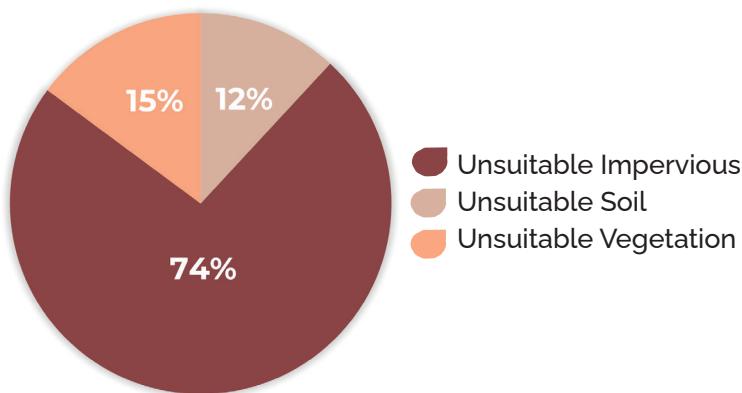
Figure 9. Total unsuitable area broken down by unsuitable soil, unsuitable impervious, and unsuitable vegetation percentages.

The city's 7,685 acres of urban tree canopy were further divided into subcategories based on whether the canopy was overhanging pervious or impervious surfaces. Tree canopy overhanging an impervious surface can provide many benefits through ecosystem services such as localized cooling provided by shading and increased stormwater absorption. Results indicated that the City of Titusville's UTC was predominantly overhanging pervious surfaces at 97%, while 3% was overhanging impervious surfaces.

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

City of Titusville	Acres	%
Total Area	21,754	100%
Land Area	18,301	84%
Urban Tree Canopy	7,685	42%
Total Possible Planting Area	4,855	27%
Total Unsuitable Area	5,761	31%

Table 3. Detailed urban tree canopy classifications.

City of Titusville	Acres	%
Overhanging Pervious Surfaces	7,432	97%
Overhanging Impervious Surfaces	253	3%
Total	7,685	100%

**Titusville's Urban Tree Canopy Potential**
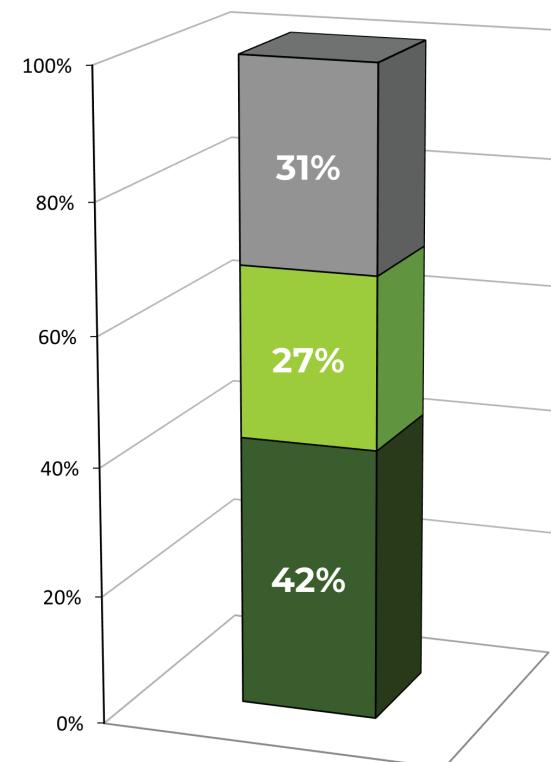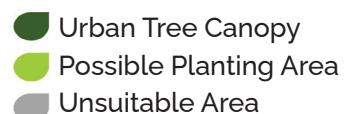
Figure 10. Urban tree canopy, possible planting area, and area unsuitable for UTC in City of Titusville. Percentages based on total land area, not including water bodies.

URBAN TREE CANOPY BY STUDY AREA ZONES

Urban tree canopy metrics were assessed for Titusville's 23 study area zones. In 2021, Zone 23 had the highest percentage of urban tree canopy with 74%, or 1,022 acres. This zone accounted for 13% of the citywide canopy distribution. Zones 8 and 17 contributed the second highest amounts of citywide UTC distributions at 11%. Canopy cover within these zones was 64% and 50% respectively. Results indicated that more than half of Titusville's study area zones contained greater than 40% canopy cover. Furthermore, 20 of the 23 study area zones contained 20-40% PPA. Zone 4 had the highest percentage of PPA within its boundary with 41% PPA. Zone 21 had the lowest percentage of PPA at 17% and the highest citywide distribution of impervious surface. This zone includes the regional airport and other industrial zoned uses. Along the Indian River Lagoon, Zone 1 includes the Chain of Lakes Park with 41% of UTC coverage and has 31% PPA. Zone 12 contained the highest citywide distribution of impervious surfaces and had the lowest percent canopy cover at 17%.

Figure 11. Tree canopy percent by Titusville's study area zones.

Table 4. Urban tree canopy and possible planting percent by study area zones.

Study Area Zones	UTC %	PPA %
1	41%	31%
2	32%	30%
3	30%	31%
4	42%	41%
5	45%	28%
6	24%	24%
7	31%	31%
8	64%	19%
9	57%	30%
10	24%	29%
11	32%	20%
12	17%	23%
13	21%	31%
14	47%	26%
15	18%	40%
16	40%	28%
17	50%	26%
18	27%	34%
19	54%	27%
20	46%	30%
21	35%	17%
22	55%	23%
23	74%	20%

URBAN TREE CANOPY BY CENSUS BLOCK GROUPS

UTC and PPA were also assessed at the census block group level. Census block groups contain clusters of census block boundaries. This is the second smallest geographic unit of measure at which the U.S. Census publishes statistical data within a state and represents between 600 and 3,000 people. Census block groups are particularly valuable for assessing the equitable distribution of tree canopy throughout the city, as the block groups are linked to all demographic and socio-economic data. Results indicated that canopy cover varied substainally throughout Titusville's census block groups, as seen in Figure 12. Eight of Titusville's 41 census block groups contained less than 20% canopy cover, over half (27) contained between 20-50%, and the other six contained greater than 50%. Sixteen census block groups exceeded 40% tree canopy. Plantable space was not distriubuted as evenly across census block groups, with 85% of all block groups containing 20-40% PPA. Only 3 census block groups exceeded 40% PPA.
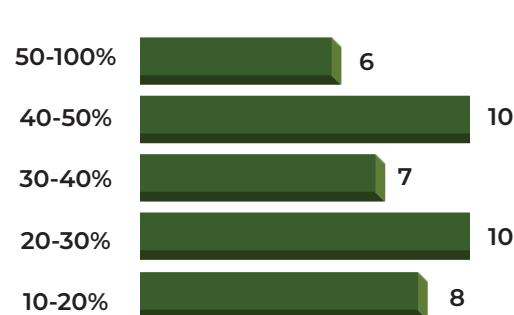

Figure 12. Number of census block groups with percent canopy cover ranges.
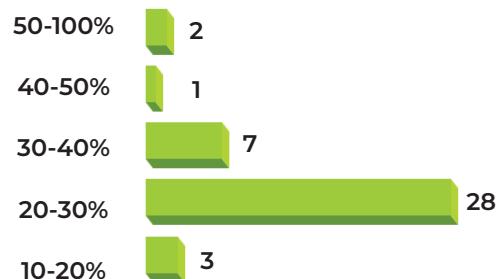

Figure 13. Number of census block groups with percent possible planting area ranges.


Urban Tree Canopy %

0% - 15%
16% - 25%
26% - 35%
36% - 45%
46% - 100%
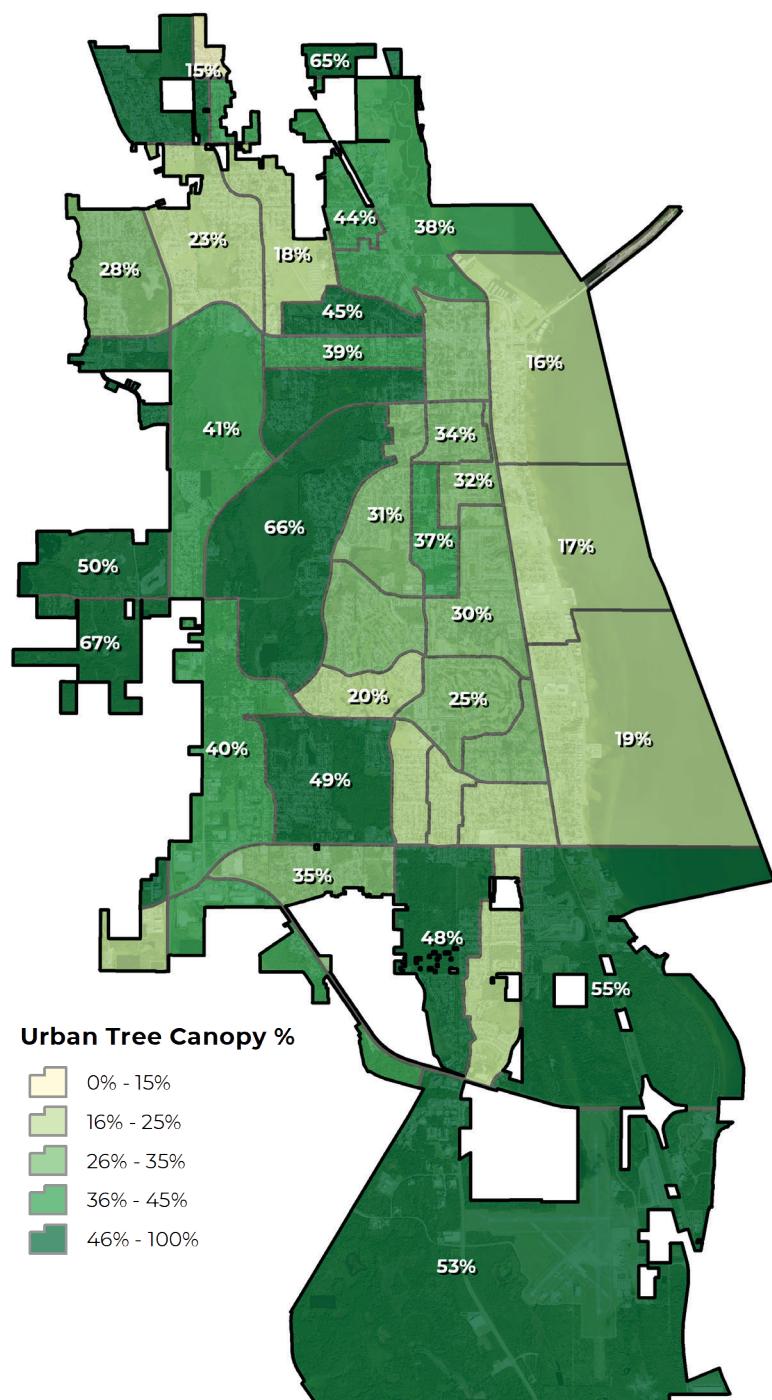
Figure 14. Urban tree canopy by City of Titusville's census block groups.

URBAN TREE CANOPY BY STORMWATER BASINS

Due to their benefits for regulating stormwater runoff, reducing flooding, and maintaining a healthy water cycle, urban tree canopy metrics were also assessed by stormwater basins. Trees planted within these areas can help to intercept and absorb stormwater runoff that may otherwise carry unhealthy pollutants into surface water bodies. UTC and PPA were assessed across Titusville's 47 stormwater basins. The unnamed SJ (St. John's) basin, along the western side of the City, made up 55% of City's land area and contributed the greatest amounts of UTC (59%) and PPA (58%) towards the citywide totals. This basin also contained the greatest proportion of PPA with 58%. Addison Canal Basin followed with the second greatest citywide contributions of UTC and PPA, with 12% and 8%, respectively. Parrish and Ponce De Leon Basin had the highest tree canopy cover per land area with 75% UTC. Possible planting area was highest within the Harrison-Washington Basin with 84% (2 acres) of its land area available for tree planting.
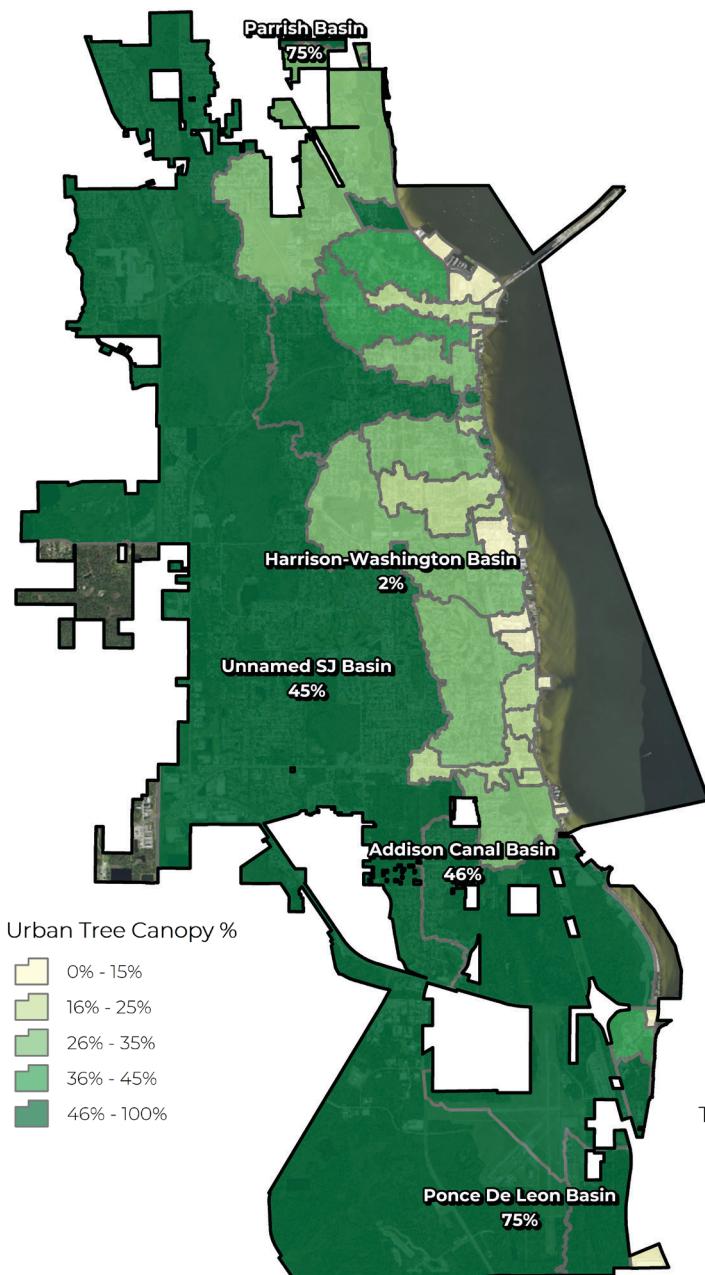

Figure 15. Urban tree canopy by stormwater basins.
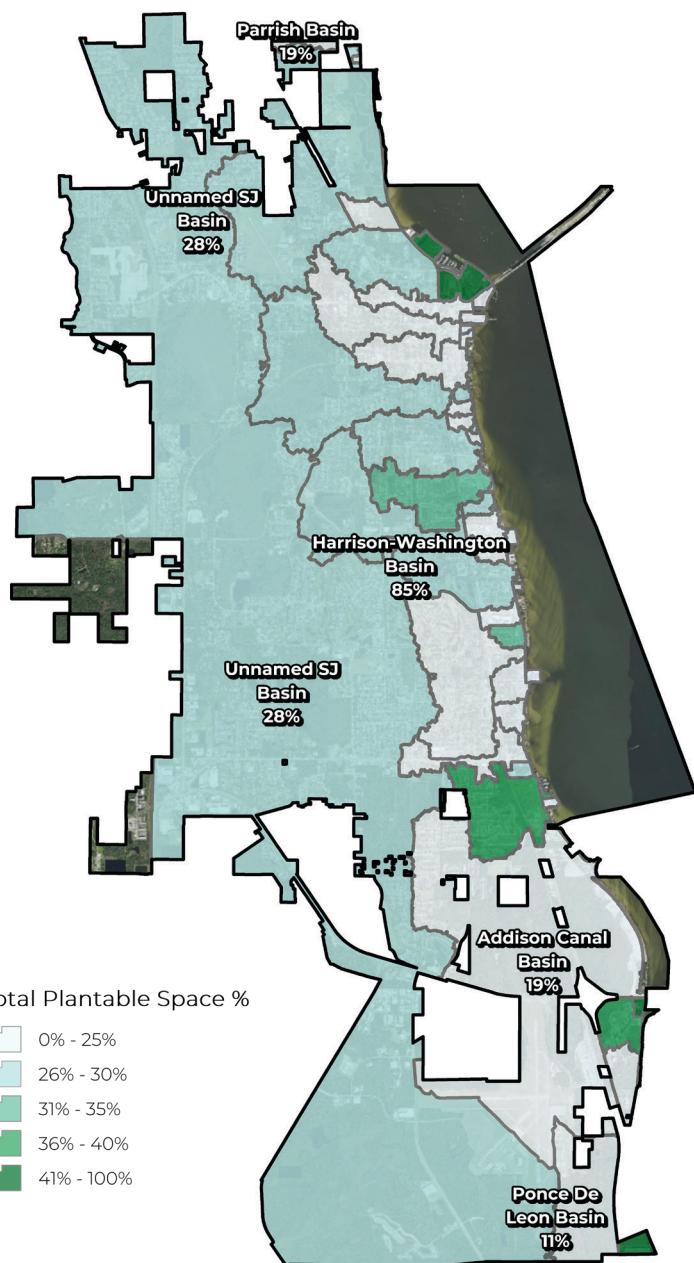
Figure 16. Plantable space by stormwater basins.

ASSESSMENT OF
ECOSYSTEM BENEFITS

Using the best available science from i-Tree tools, values were calculated for some of the benefits and functions provided by the urban tree canopy in City of Titusville. The urban forest holds millions of dollars of savings in avoided infrastructure costs, pollution reduction, and stored carbon. The following values were calculated using the USDA Forest Service's i-Tree Landscape tool with the City of Titusville's total acres of urban tree canopy as the input data. Detailed methodology can be found in the Appendix.

AIR QUALITY

Trees produce oxygen, indirectly reduce pollution by lowering air temperature, and improve public health by reducing air pollutants which cause death and illness. The existing tree canopy in the City of Titusville removes approximately 691,000 pounds of air pollution annually, valued at over $1.8 million.

STORMWATER AND WATER QUALITY

Trees and forests mitigate stormwater runoff which minimizes flood risk, stabilizes soil, reduces sedimentation in streams and riparian land, and absorbs pollutants, thus improving water quality and habitats. The tree canopy in Titusville absorbs 130 million gallons of water per year. Extrapolated citywide, this means that the City of Titusville's existing canopy provides over $1,160,000 annually in stormwater benefits.

CARBON STORAGE AND SEQUESTRATION

Trees accumulate carbon in their biomass; with most species in a forest, the rate and amount increase with age. The City of Titusville's trees store approximately 490 million pounds of carbon, valued at over $41 million, and each year the tree canopy absorbs and sequesters approximately 25 million pounds of carbon dioxide, valued at over $2.1 million.

Ecosystem Benefit Values of City of Titusville's Urban Forest

$5,212,026 Annual Benefits
(Air quality, stormwater, and carbon sequestration)

$47,143,035 Total Benefits
(Total annual benefits plus stored carbon)

Air Quality:
$1,867,491
(691,400 lbs of pollution removed annually)

Stormwater reduction:
$1,164,334
(130 million gallons of runoff prevented annually)

Carbon Sequestration:
$2,180,199
(12,783 tons of carbon sequestered annually)

Carbon Storage:
$41,931,008
(245,856 tons of carbon stored in the urban forest)

Figure 17. Eco-benefits of Titusville's urban forest.

TREE PLANTING
PRIORITIZATION
PRIORITIZATION CRITERIA DESCRIPTIONS

Urban tree canopy provides a multitude of direct and indirect benefits. To provide the most complete understanding of where those benefits are lacking, tree planting priorities were identified based on environmental, socio-demographic, and public health data sets.

Tree planting prioritization ranking is needs-based and designed to rank census block groups on each area's need for a particular benefit that trees can provide. Rankings are sorted from highest priority (dark blue) to lowest priority (light yellow) and were calculated for each individual criteria as well as overall to show where multiple needs overlap. Viewing combined ranks show where tree canopy benefits can have the greatest impact by addressing multiple needs.

HUMAN HEALTH

• **Human Health:** Trees clean the air that we breathe and, in turn, improve public health. Planting trees can be a cost-effective way of improving a city's overall public health. This indicator utilizes the CDC PLACES health database and represents a composite index of asthma, mental health, physical health, and coronary heart disease rates.

SOCIO-DEMOGRAPHIC

• **Underserved Populations**: Income inequality often occurs with environmental inequality where lower-income residents live in highly impervious areas with limited numbers of trees, parks, and other greenspaces. This criterion shows the percentage of residents living below the poverty level, as reported by the U.S. Census American Community Survey 5-year estimates.
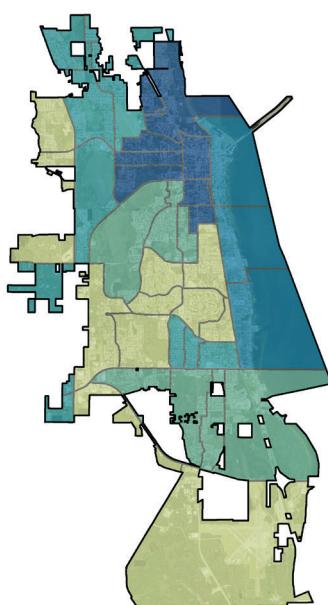
Human Health

Underserved Populations

Highest Priority   Lowest Priority
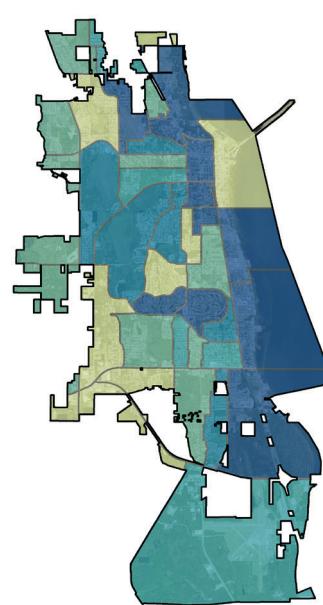
LAND USE

- **Right-of-Way:** Trees planted along roads provide valuable benefits to improve air quality, reduce stormwater, and calm traffic. This criterion highlights census block groups with a greater amount of plantable space within the right-of-way and considers these areas high priority for tree planting.

ENVIRONMENTAL

- **Stormwater Reduction:** This indicator uses available planting area within 100 feet of all surface water bodies and impervious surfaces to identify areas with plantable space that will reduce stormwater runoff. Areas close to water bodies and impervious surfaces were considered high priority planting areas.

- **Wildlife Habitat Connectivity:** Large block groups of connected canopy cover can improve habitat for local wildlife. This indicator identifies available planting areas within 10 feet of large canopy block groups (equal to or greater than 5 acres). Areas where opportunities to expand connectivity are high were considered higher priority for planting

- **Urban Heat Island:** The average relative heat severity value within each feature. Urban heat severity data from the Trust for Public Land derived using the thermal band of a Landsat 8 satellite image were used. Areas with hotter surface temperatures were considered high priority for tree planting.

Highest Planting Priority

Lowest Planting Priority

Right-of-Way

Stormwater Reduction

Wildlife Habitat Connectivity

Urban Heat Island
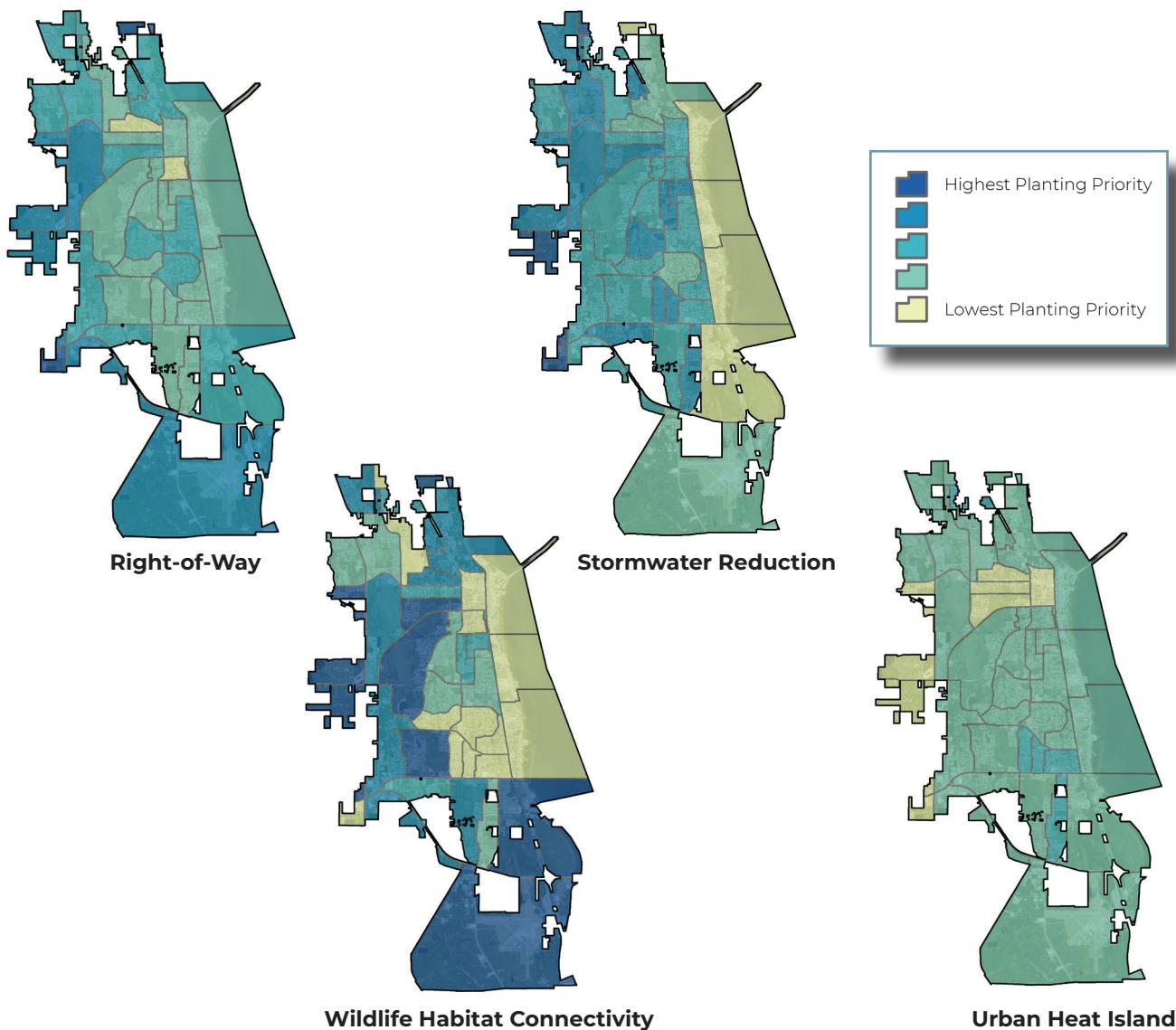
- **Overall:** The overall suitability for tree planting score is based on an equally weighted formula that includes all planting prioritization categories. The weights of priority criteria can be adjusted and customized with the TreePlotter™ CANOPY application.

Overall Prioritization
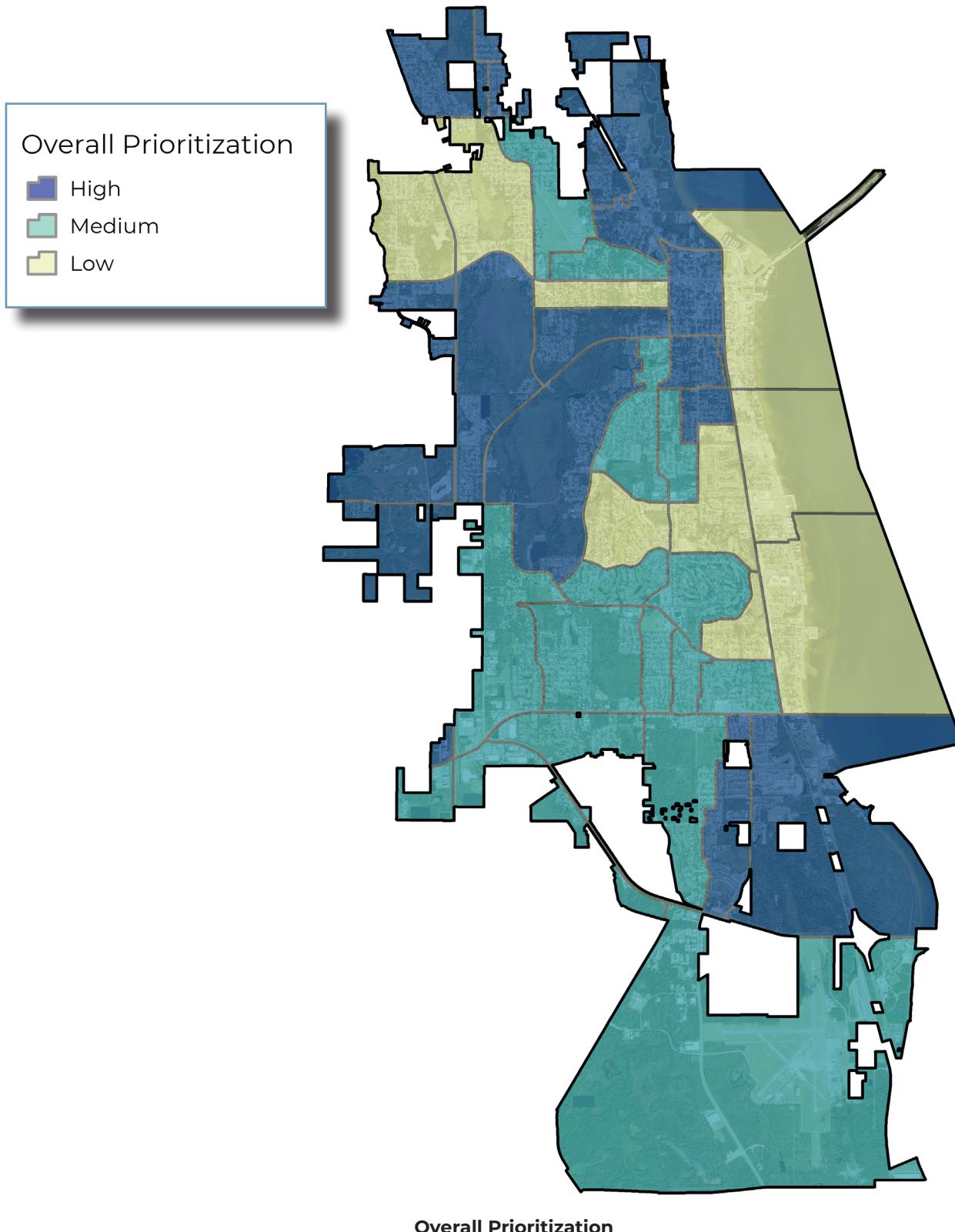
CONCLUSIONS AND
RECOMMENDATIONS

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

Study Area Zone 2

Contains high priority planting block groups

12% of all plantable space citywide

28% of all impervious citywide
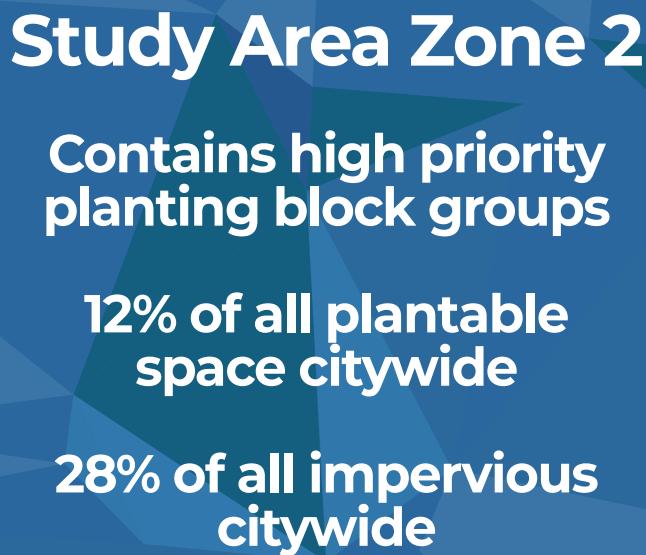
To preserve, protect, and maintain Titusville's tree canopy, the City should continue to have a tree canopy assessment performed at regular intervals through a TreePlotter™ CANOPY subscription or continuing regular projects. As the City grows, they will be able to use these data to ensure that their urban forest policies and management practices prioritize its maintenance, health, and growth. The City's urban forest provides Titusville with a wealth of environmental, social, and even economic benefits which relate back to greater community pride and interest in citywide initiatives and priorities. These results can be used to identify where existing tree canopy cover should be preserved, where there are opportunities to continue to expand the City's canopy cover, and which areas would receive the greatest benefits from the investment of valuable time and resources into Titusville's urban forest.

1. Leverage the results of this assessment to promote the urban forest and set canopy goals

The results of this assessment should be used to encourage investment in urban forest monitoring, maintenance, and management; to prepare supportive information for local budget requests/grant applications; and to develop targeted presentations for city leaders, planners, engineers, resource managers, and the public on the functional benefits of trees in addressing environmental issues. The land cover, tree canopy, and plantable space data should be disseminated to diverse partners for urban forestry and other applications while the data are current and most useful for decision-making and implementation planning. The information from this study can help establish new canopy cover goals for the short- and long-term to continue to expand City of Titusville's urban forest to its known potential.

2. Use the urban tree canopy data to identify areas to prioritize canopy expansion

The City and its various stakeholders can utilize the results of the UTC and PPA analyses to identify the best locations on City-owned and private property to focus future tree planting and canopy expansion efforts. Trees can play a large role in improving public health by improving air quality, reducing temperatures, and addressing climate change. The City can acquire parcels for public use as part of redeveloped neighborhoods to be used as carbon sinks to address community access to nature, climate, human health, and equity. Plantable space in the right-of-way is often found close to high concentrations of impervious surfaces. Focus on planting the right tree in the right place and selecting the appropriate tree species for the surrounding soil to maximize ecosystem services. Planting trees near impervious surfaces can offset the urban heat island effect, stormwater runoff, and energy consumption. The priority planting analysis should be used to identify planting opportunities adjacent to high concentrations of impervious surfaces in these areas to provide shading for walkways and roadways. The City can develop a proactive street tree maintenance program to take on the responsibility of planting and managing street trees, ensuring healthy trees are distributed

equitably across the city. It is recommended that planting efforts take into account the City's Resiliency Plan for future climate trends. The City should evaluate city codes to increase tree preservation, create space for existing trees during the development process, and set aside space for new larger stature trees to be planted both on private property and within the public right-of-way to maximize the benefits of trees. The City of Titusville can utilize these results to protect the vanishing scrub habitat that supports the Florida Scrub-Jay, Gopher tortoise, and other threatened or endangered native species. Sand Point Park contains 28 acres of plantable space available for sabal palms, live oaks, and other native shore stabilizing species.

> # 85%
> ## OF THE HARRISON-WASHINGTON BASIN'S LAND AREA WAS CONSIDERED POSSIBLE PLANTABLE SPACE

3. Develop outreach programs towards private landowners

In City of Titusville, 11% of all citywide PPA is found within Study Area Zones 5, 15, and 18. The City should focus on community outreach and education programs to better inform citizens and private landholders of the environmental, health, social, and financial benefits that trees provide and consider other strategies to help preserve existing trees and grow the tree canopy in the 4,855 acres of plantable space in Titusville. The City should explore options to develop grant programs for tree maintenance or removal of hazard or invasive trees within the city to remove barriers for overburdened communities which lack tree canopy. Native tree giveaways, tree planting programs, and tree maintenance events can help to promote proper pruning techniques for maintaining healthy, wind-resistant trees. To promote new plantings, expand the partnership with local contractors to plant more trees on redeveloped or newly developed property focusing on low-canopy and underserved neighborhoods. The City should also continue to develop partnerships with Community Based Organizations and individual champions throughout neighborhoods to build stewardship at the community level. In addition, the city should continue to conduct volunteer tree planting and tree maintenance events to increase awareness levels in the community.

4. Use TreePlotter to identify areas in need of tree canopy, prioritize planting efforts, and continue to monitor the urban forest

Performing a canopy assessment every five years is recommended. An up-to-date subscription to TreePlotter Canopy will guarantee updated assessments occur once than every 2-3 years. To maximize impact, see greater return on investment, and provide the greatest number of benefits to the community, we recommend that the City focus planting and management efforts in areas with high weighted priority rankings. Planting priority maps and data, displayed in TreePlotter™ CANOPY, show land cover metrics and the areas of highest priority collectively and individually for all planting prioritization criteria. The City should also use the GIS data provided to create unique weighted scenarios to focus efforts in targeted areas that meet specific criteria. For instance, the City could find areas that have low UTC, high PPA, or would offer the greatest benefits to improving air quality and reducing summertime temperature. Focusing urban forest management resources on expanding and maintaining tree canopy in areas like these will have positive impacts on multiple factors that the City has deemed important. Efforts should focus on outreach to the residents of these neighborhoods, as well as local business and landowners, in order to promote new tree plantings and continued maintenance of existing trees. NAIP imagery was collected in 2021 in Florida and is collected by the USDA every two-three years. The City's CANOPY application can be updated with new UTC and PPA metrics when they become available in mid- to late-2023 if the city chooses to subscribe.

REPORT ━━━━━━━━

APPENDIX

ACCURACY ASSESSMENT

Classification accuracy serves two main purposes. Firstly, accuracy assessments provide information to technicians producing the classification about where processes need to be improved and where they are effective. Secondly, measures of accuracy provide information about how to use the classification and how well land cover classes are expected to estimate actual land cover on the ground. Even with high resolution imagery, very small differences in classification methodology and image quality can have a large impact on overall map area estimations.

The classification accuracy error matrix illustrated in Table A1 contain confidence intervals that report the high and low values that could be expected for any comparison between the classification data and what actual, on the ground land cover was in 2021. This accuracy assessment was completed using high resolution aerial imagery, with computer and manual verification. No field verification was completed.

THE INTERNAL ACCURACY ASSESSMENT WAS COMPLETED IN THESE STEPS:

1. One hundred and eighty sample points, or approximately 5 points per square mile area in City of Titusville (34 sq. miles), were randomly distributed across the study area and assigned a random numeric value.

2. Each sample point was then referenced using the NAIP aerial photo and assigned one of five generalized land cover classes ("Ref_ID") mentioned above by a technician.

3. In the event that the reference value could not be discerned from the imagery, the point was dropped from the accuracy analysis. In this case, no points were dropped.

4. An automated script was then used to assign values from the classification raster to each point ("Eval_ID"). The classification supervisor provides unbiased feedback to quality control technicians regarding the types of corrections required. Misclassified points (where reference ID does not equal evaluation ID) and corresponding land cover are inspected for necessary corrections to the land cover.[1]

5. Accuracy is re-evaluated (repeat steps 3 & 4) until an acceptable classification accuracy is achieved.

SAMPLE ERROR MATRIX INTERPRETATION

Statistical relationships between the reference pixels (representing the true conditions on the ground) and the intersecting classified pixels are used to understand how closely the entire classified map represents City of Titusville's landscape. The error matrix shown in Table A1 represent the intersection of reference pixels manually identified by a human observer (columns) and classification category of pixels in the classified image (rows). The blue boxes along the diagonals of the matrix represent agreement between the two-pixel maps. Off-diagonal values represent the number of pixels manually referenced to the column class that were classified as another category in the classification image. Overall accuracy is computed by dividing the total number of correct pixels by the total number of pixels reported in the matrix (34 + 6 + 35 + 27 + 69= 174 /180 = 98%), and the matrix can be used to calculate per class accuracy percentage's. For example, 34 points were manually identified in the reference map as Tree Canopy, and 36 of those pixels were classified as Tree Canopy in the classification map. This relationship is called the "Producer's Accuracy" and is calculated by dividing the agreement pixel total (diagonal) by the reference pixel total (column total). Therefore, the Producer's Accuracy for Tree Canopy is calculated as: (34/36 = .987), meaning that we can expect that ~99% of all 2021 tree canopy in City of Titusville, FL study area was classified as Tree Canopy in the 2021 classification map.

Conversely, the "User's Accuracy" is calculated by dividing the total number of agreement pixels by the total number of classified pixels in the row category. For example, 34 classification pixels intersecting reference pixels were classified as Tree Canopy, but 2 pixels were identified as water in the reference map. Therefore, the User's Accuracy for Tree Canopy is calculated as: (34/36 = 0.97), meaning that ~97% of the pixels classified as Tree Canopy in the classification were actual tree canopy. It is important to recognize the Producer's and User's accuracy percent values are based on a sample of the true ground cover, represented by the reference pixels at each sample point. Interpretation of the sample error matrix results indicates this land cover, and more importantly, tree canopy, were accurately mapped in City of Titusville in 2021. The largest sources of classification confusion exist between tree canopy and water.

1 Note that by correcting locations associated with accuracy points, bias is introduced to the error matrix results. This means that matrix results based on a new set of randomly collected accuracy points may result in significantly different accuracy values.

Table A1. | Error matrix for land cover classifications in City of Titusville, FL (2021).

ACCURACY ASSESSMENT RESULTS

Interpretation of the sample error matrix offers some important insights when evaluating City of Titusville's urban tree canopy coverage and how well aligned the derived land cover data are with interpretations by the human eye. The high accuracy of the 2021 data indicates that regardless of how and when it was achieved, City of Titusville's current tree canopy can be safely assumed to match the figures stated in this report (approximately 35%).

ECOSYSTEM BENEFITS CALCULATIONS

Environmental benefits were calculated through the USDA Forest Service's i-Tree Landscape tool. The i-Tree tool reported monetary, pollution removal, and benefit value coefficients per tree canopy acre, tailored to the Titusville area. The per-acre coefficients were then applied to the high-resolution tree canopy acreage derived from PlanIT Geo's tree canopy assessment (7,685 acres). Additional i-Tree methodology and documentation can be found here: https://www.itreetools. org/support/resources-overview/i-tree-methods-and-files.

Air Quality		Stormwater and Water Quality		Carbon Sequestration		Carbon Storage	
243	**$ per acre**	0.017	**gallon per year per acre**	5456.214	**$ per acre**	283.695	**$/year/acre**
89.967	**lbs per acre**	151.51	**$/year/acre**	31.991	**tons/acre**	1.663	**tons/year/acre**
0.044	**tons/acre**						

GLOSSARY/KEY TERMS

Land Acres: Total land area, in acres, of the assessment boundary (excludes water).

Non-Canopy Vegetation: Areas of grass and open space where tree canopy does not exist.

Possible Planting Area - Vegetation: Areas of grass and open space where tree canopy does not exist, and it is biophysically possible to plant trees.

Shrub: Areas of shrub or other leafy and woody vegetation (smaller than 6ft tall) that are not classified as tree canopy

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

Total Acres: Total area, in acres, of the assessment boundary (includes water).

Unsuitable Impervious: Areas of impervious surfaces that are not suitable for tree planting. These include buildings and roads and all other types of impervious surfaces.

Unsuitable Planting Area: Areas where it is not feasible to plant trees. Airports, ball fields, golf courses, etc. were manually defined as unsuitable planting areas.

Unsuitable Soil: Areas of soil/dry vegetation considered unsuitable for tree planting. Irrigation and other modifiers may be required to keep a tree alive in these areas.

Unsuitable Vegetation: Areas of non-canopy vegetation that are not suitable for tree planting due to their land use.

Urban Tree Canopy (UTC): The "layer of leaves, branches and stems that cover the ground" (Raciti et al., 2006) when viewed from above; the metric used to quantify the extent, function, and value of the urban forest. Tree canopy was generally taller than 10-15 feet tall.

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

URBAN TREE CANOPY

ASSESSMENT
CITY OF TITUSVILLE, FLORIDA

PlanIT Geo™
developers of TreePlotter

Titusville
FLORIDA

earth Define