URBAN TREE CANOPY
ASSESSMENT

CHARLOTTE, NORTH CAROLINA

NOVEMBER | 2023

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AN ASSESSMENT OF URBAN TREE CANOPY IN

CHARLOTTE, NORTH CAROLINA

> **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

Trees Charlotte

The City of Charlotte

COMPLETED

November 2023

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94,161
ACRES OF CANOPY

47.3%
OF CHARLOTTE'S LAND AREA WAS COVERED WITH CANOPY IN 2022

EXECUTIVE
SUMMARY

PURPOSE OF THIS ANALYSIS

This collaborative Tree Canopy Assessment by the City of Charlotte and TreesCharlotte, a local non-profit, aims to update past analyses performed, and to better understand the distribution of tree cover throughout the City. In addition, land cover outside of the City's current boundaries were also included and assessed to provide context for future planning efforts. This analysis takes an in-depth look at current and past tree canopy, areas where planting may be possible in the future, and analyzes the distribution of both among several different geographic scales. Continuing with past assessments performed, a central component of this project identifies change in canopy metrics over time. By utilizing modern machine learning techniques and data analysis methods, this study seeks to reveal data and insights that will help all stakeholders contribute to a greener environment.

This analysis can be used for informed, data-driven decision making that will shape the road ahead. Current canopy goals, policies, ordinances and management practices can be amended based on the results provided herein. By highlighting areas where current efforts are working well, but also areas where improvement is needed, this assessment serves a strategic compass for future planning efforts.

PROJECT METHODOLOGY

The results, based on 2022 imagery from the USDA's National Agriculture Imagery Program (NAIP), provide a near-current look at land cover in the City of Charlotte (and surrounding areas), and will allow the City to revise and develop existing and new strategies to protect and expand the urban forest. This study utilized modern machine learning techniques to create land cover data that are reproducible and will allow for a more uniform comparison in future tree canopy and land cover assessments.

CHARLOTTE'S URBAN FOREST

In 2022, Charlotte land area (not including water bodies) contained 47.3% urban tree canopy cover, 18.5% possible planting area, and the other 34.2% of the City was classified as unsuitable for planting without significant land modification. The City's extraterritorial jurisdiction (ETJ) zoned areas added 24,889 acres of canopy (63% within its boundaries), bringing the City and ETJ's combined canopy cover up to 49.9%. By comparison, land area in the County as a whole, not including water bodies, was categorized by 51.8% urban tree canopy cover, 19.7% possible planting area, and the other 28.5% of the County's area was classified as unsuitable for planting.

Results also indicated that the City of Charlotte's canopy may not be declining as quickly as previous assessments have indicated. In 2022, 47.3% of the City's land areas was covered with tree canopy; this new assessment of 2018 data indicated that overall, canopy coverage was down from 47.8% (-0.5%). This represents an overall loss of canopy at just under 1,000 acres (or 10X the size of Freedom Park). Residential development seems to be the cause for most losses, while new tree plantings and regenerative growth contributed to gains.
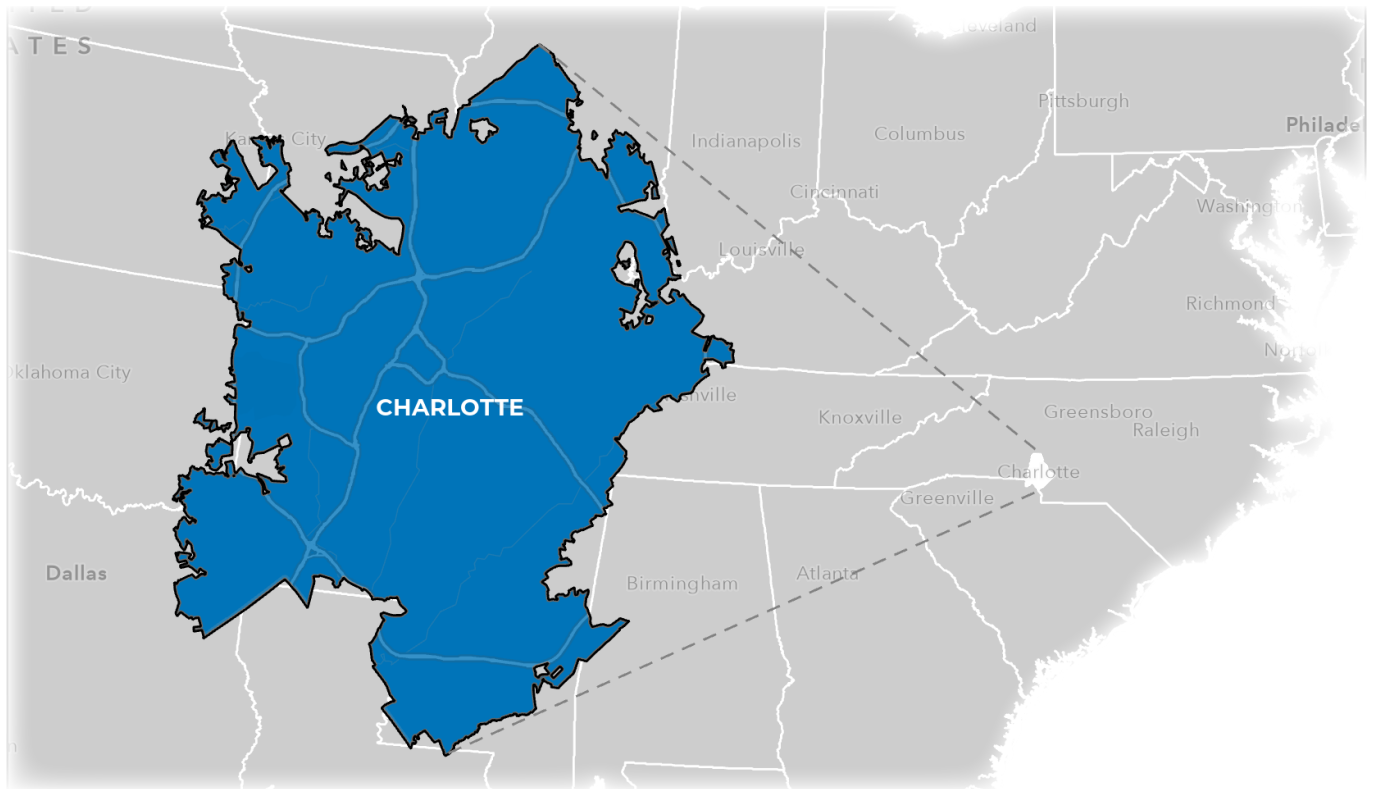
Figure 1. The City of Charlotte occupies approximately 311 square miles within Mecklenburg County, North Carolina.

RECOMMENDATIONS

The results of this analysis can be used to develop a continued strategy to protect and expand the City of Charlotte's urban forest. This study revealed that the City contains 94,161 acres of tree canopy. With 36,795 acres of possible planting area (PPA), there exists an opportunity to continue to increase urban tree canopy (UTC) coverage on both public and private property within the City boundaries. Moreover, there are an additional 24,889 acres of UTC and 7,549 acres of PPA located in Charlotte's Extraterritorial Jurisdiction (ETJ). The ETJ zoned areas bring the combined City and ETJ canopy cover up to 49.9%. Through partnerships, education, and outreach programs to private landowners, the City of Charlotte and stakeholders can aim to plant native species to stabilize riparian corridors, address tree inequity, and mitigate the urban heat island effect. It is important for this assessment to be utilized to inform future investments in the urban forest; the City should consider updating local urban tree canopy goals and planning documents with new, data-driven content presented within. Proactive work should be undertaken to protect the existing urban forest and replenish the canopy with additional trees and native shrubs and remove invasive species when and where possible. Through sustainable management actions, strategic plantings, and protections for existing canopy informed by the UTC and PPA metrics included in this report, current urban tree canopy can be expanded to its fullest potential.

Figure 2. Based on an analysis of 2022 high-resolution imagery, the City of Charlotte contains 47% tree canopy, 18% areas that could support canopy in the future, and 29% 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. In order to incorporate contextual surrounding data for the City of Charlotte, the most recent geographic boundaries of the surrounding Mecklenburg County, as of 2023, were used as the area of interest (AOI) for this analysis.

DATA SOURCES

This assessment utilized high-resolution (60-centimeter) multi-spectral imagery from the U.S. Department of Agriculture's National Agriculture Imagery Program (NAIP) collected in 2022 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 five 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 2022 NAIP imagery. These five classes are shown in Figure 3 and described in the Glossary found in the Appendix.

While no methodology for obtaining a land cover data set is inherently wrong, there are limitations and considerations that must be factored into each analysis on a project-by-project basis. For example, when performing a change analysis, it is often very difficult to accurately compare the results derived from previous assessments that used divergent methods for generating a land cover (or tree canopy cover) data set. Parameters used such as the height of a tree versus a shrub, how quality control measures were performed, and what type of data was used for input all have a significant effect on the derived data, and thus the urban tree canopy metrics calculated based on that data. This assessment utilized the same methodology for calculating canopy cover for the two time periods analyzed, in order to minimize this effect.

The methods used in this assessment reduce the chance of variability from year to year and assessment to assessment. NAIP imagery was used as the basis for our analysis due to its reliability and is readily available on a repeating basis every two to three years. Other methods may rely heavily on LiDAR data, but this is more difficult and expensive to obtain, and the chances of obtaining the underlying data for the vintage year needed is relatively low. While LiDAR is generally considered a great option for producing high-quality land cover data, producers may have to settle for using data that is 2-4 years offset from the year that is being analyzed. In addition, other methods may rely heavily on a human, manual quality control process that makes it difficult to reproduce than a similar output from year to year. PlanIT Geo has partnered with EarthDefine to eliminate these associated problems.

URBAN TREE CANOPY **SOIL AND DRY VEGETATION** **OTHER VEGETATION** **IMPERVIOUS SURFACES** **SURFACE WATER**
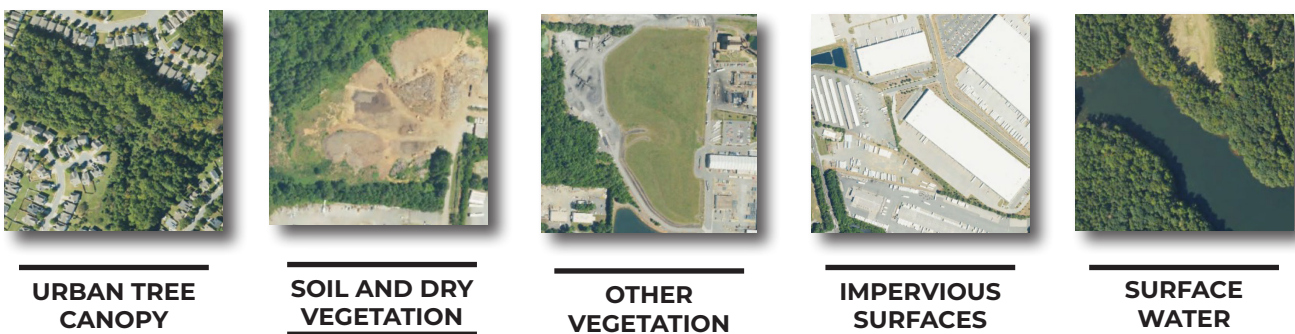
Figure 3. Five (5) distinct land cover classes were identified in the 2023 tree canopy assessment: urban tree canopy, bare soil and dry vegetation, other vegetation, impervious surfaces, and water.

IDENTIFYING POSSIBLE PLANTING AREAS AND UNSUITABLE AREAS FOR PLANTING

In addition to quantifying Charlotte'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 entire area of interest (AOI) 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 classes. 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, Charlotte Douglas International Airport, 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.
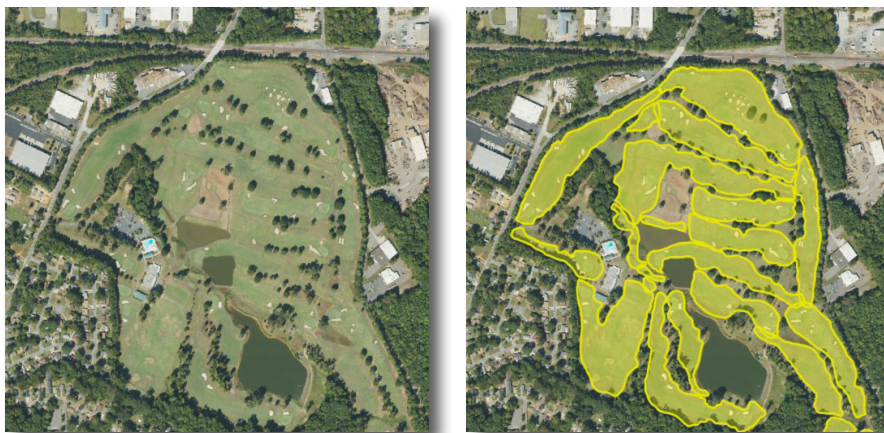

Figure 4.
Vegetated areas where it would be biophysically feasible for tree plantings but undesirable based on their current usage (left) were delineated in the data as "Unsuitable" (right). These areas included recreational sports fields, air ports, and other open space.

Urban Heat Map Prioritization

Urban heat island data from the Trust for Public Land was used to identify local hot spots where tree plantings can be focused to help cool hotter areas in the City. This heat map data set was created using the thermal band of a Landsat 8 satellite image collected in the summer of 2022, patched with data from summer 2020 where necessary. The mean surface temperature within the City was calculated. Areas that are 1.25 F° or greater than the citywide average were then categorized from low to high severity based on a Jenks Natural Breaks classification scheme. Planting priority areas were created within a refined version of the possible planting area (PPA) classification which removed utilities, sports fields, and sports playing areas. Each site was then assigned a value based on the heat severity of where the point was located. The average surface temperature severity was classified by census block groups and was then calculated and correlated with available plantable space to identify areas that could benefit from the cooling shade that additional trees can provide.

Figure 5. The Trust for Public Land surface temperature raster used in the urban heat island (UHI) analysis.
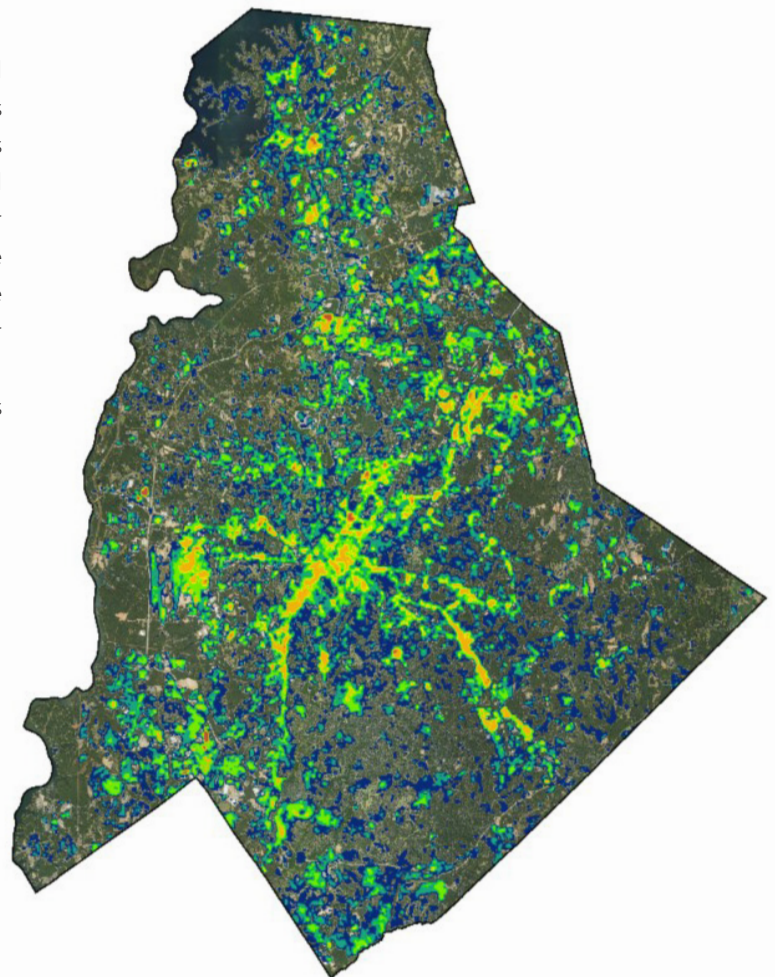
DEFINING ASSESSMENT LEVELS

In order to best inform the City and it's stakeholders, urban tree canopy and other associated metrics were tabulated across a variety of geographic boundaries. These boundaries include: Mecklenburg County (used as an overall AOI to incorporate contextual and future planning areas), Charlotte's city boundary and ETJ, land ownership, city council districts, jurisdictions, place types, watersheds, neighborhood profile areas, and census block groups.
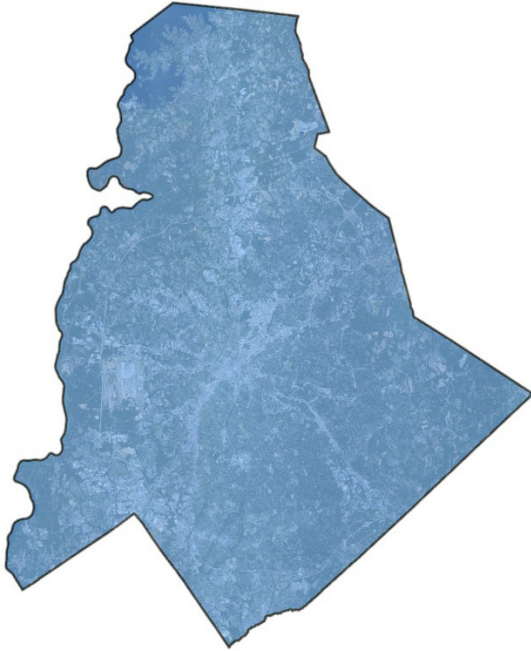
Mecklenburg County
The **County boundary** was used to define the overall area of interest in which all analyses was performed.
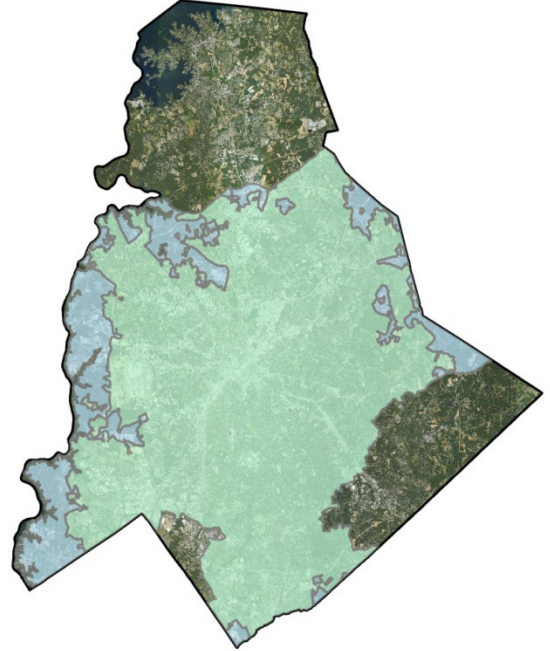
Charlotte City Limits and ETJ
Charlotte's city limits (green) and its **Extraterritorial Jurisdiction boundary** (blue) were analyzed for tree canopy metrics.
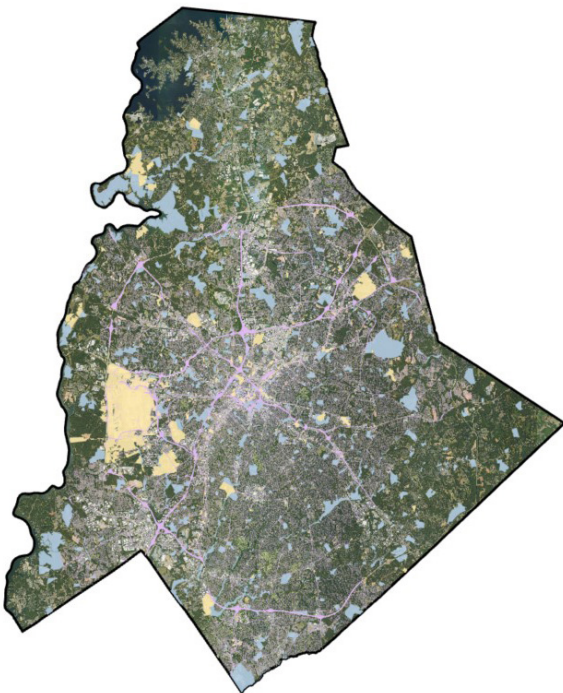
Land Ownership
Three (3) **land ownership** types were analyzed to determine how tree canopy differs on land owned by different public entities. City-owned parcels are orange, rights-of-way are shown in purple, and other-public lands are shown in blue,.
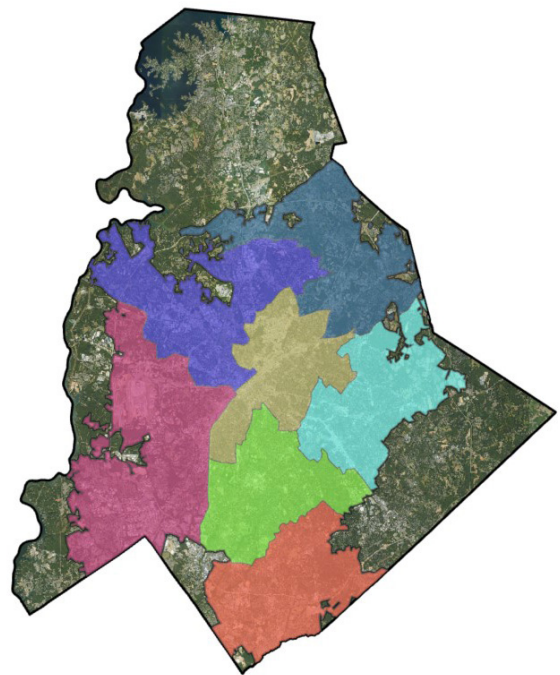
City council Districts
The City of Charlotte's seven (7) **City Council Districts** were assessed to inform the council members and citizens residing in each individual voting district.
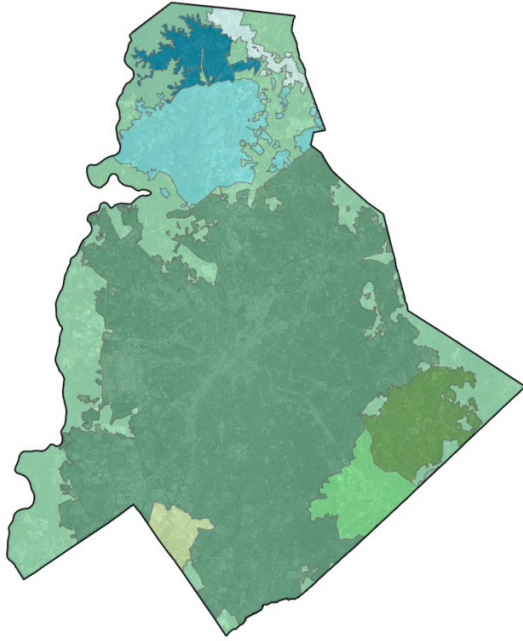
JURISDICTIONS

Nine (9) **Jurisdictions** surrounding the City were analyzed for comparison and benchmarking across the county.
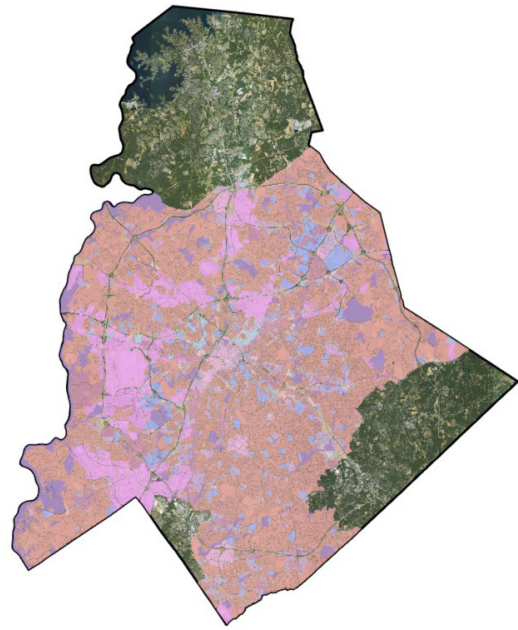
PLACE TYPES

Ten (10) **Place Types** were assessed to identify urban tree canopy patterns at a scale that allows for informed land development planning.
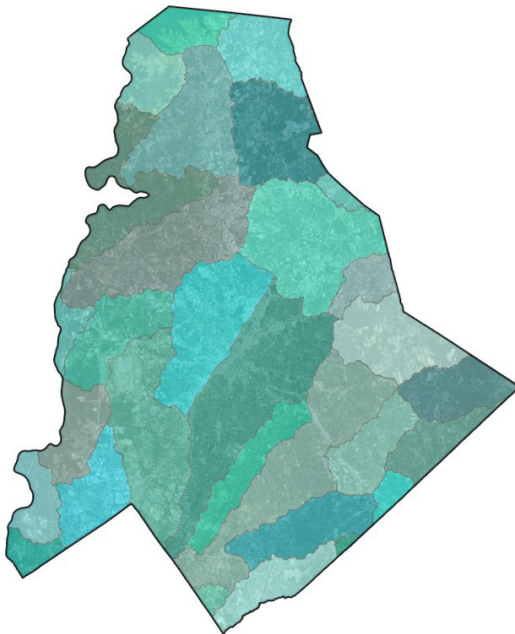
WATERSHEDS

Because trees play an important role in storm-water management, thirty (30) USGS HUC-12 **watersheds** were assessed.
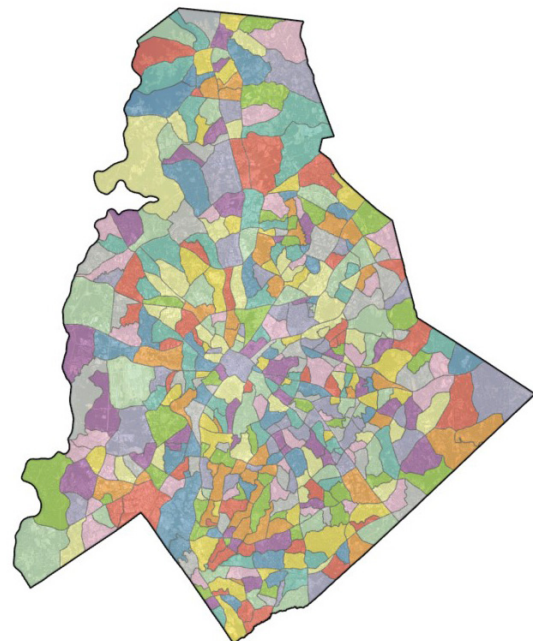
NEIGHBORHOOD PROFILE AREAS

OVer four hundred (459) **Neighborhood Profile Areas** were assessed to provide additional insight about Charlotte's neighborhoods.
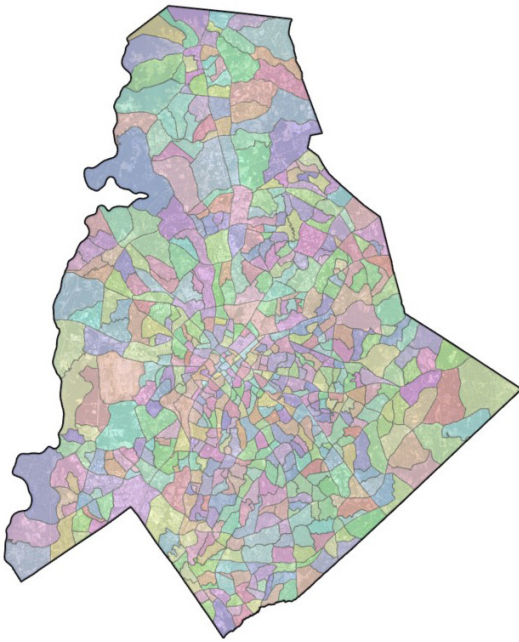
Census Block Groups

Six hundred and twenty four (624) **census block groups** were assessed to show the relationship between tree canopy and sociodemographic and highlight potential environmental justice issues.

Figure 6. Nine (9) distinct geographic boundaries were explored in this analysis: Mecklenburg County, Charlotte's city boundary and ETJ, land ownership, city council districts, jurisdictions, place types, watersheds, neighborhood profile areas, and census block groups.

While the purpose of this assessment is to inform activities, policies, and programs within the City of Charlotte, several Assessment Levels were selected that include urban tree canopy data across portions of the surrounding area in Mecklenburg County. This contextual data is included to help to inform planners and policy makers of canopy trends in future areas of growth, and to also provide benchmarking data from surrounding communities.

STATE OF THE CANOPY AND
KEY FINDINGS

The results and key findings of this study, including the city-wide 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 2023. Land cover data includes five land cover classes including tree canopy (further distinguished by canopy over impervious surfaces and over pervious surfaces), soil and dry vegetation, other vegetation, impervious surfaces, and water (see Table 1 and Figure 6 for the breakdown of percentages). City-wide urban tree canopy potential includes urban tree canopy, possible planting area (PPA) vegetation, unsuitable impervious, unsuitable soil (see Figure 9 for the breakdown of percentages).

In 2022, the City of Charlotte land cover consisted of 47% tree canopy, 29% impervious surface, 21% other vegetation, 3% soil & dry vegetation, and 1% water (note that these are "raw" percentages calculated with water bodies included).
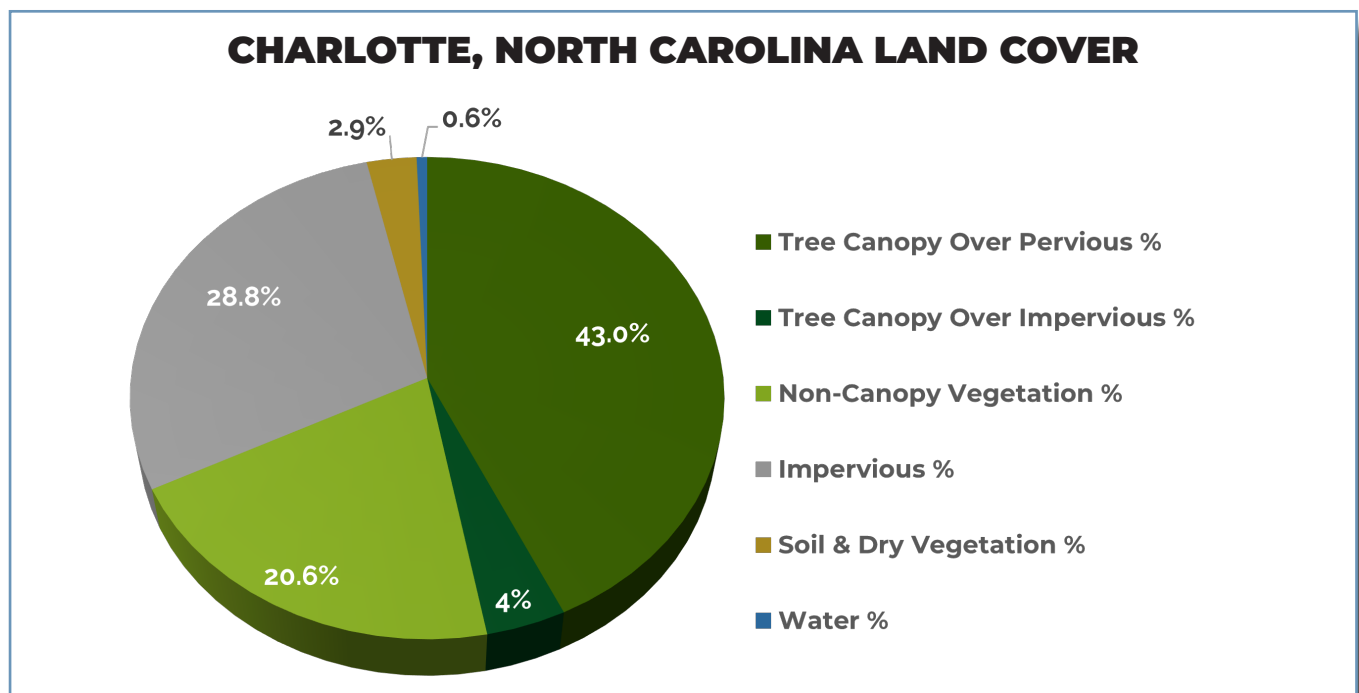
Figure 7. Land cover classification results (percentages based on total area of the City of Charlotte including water bodies).

Land Cover Classification

- Non-Canopy Vegetation
- Soil and Dry Vegetation
- Impervious
- Water
- Tree Canopy
- Tree Canopy Over Impervious
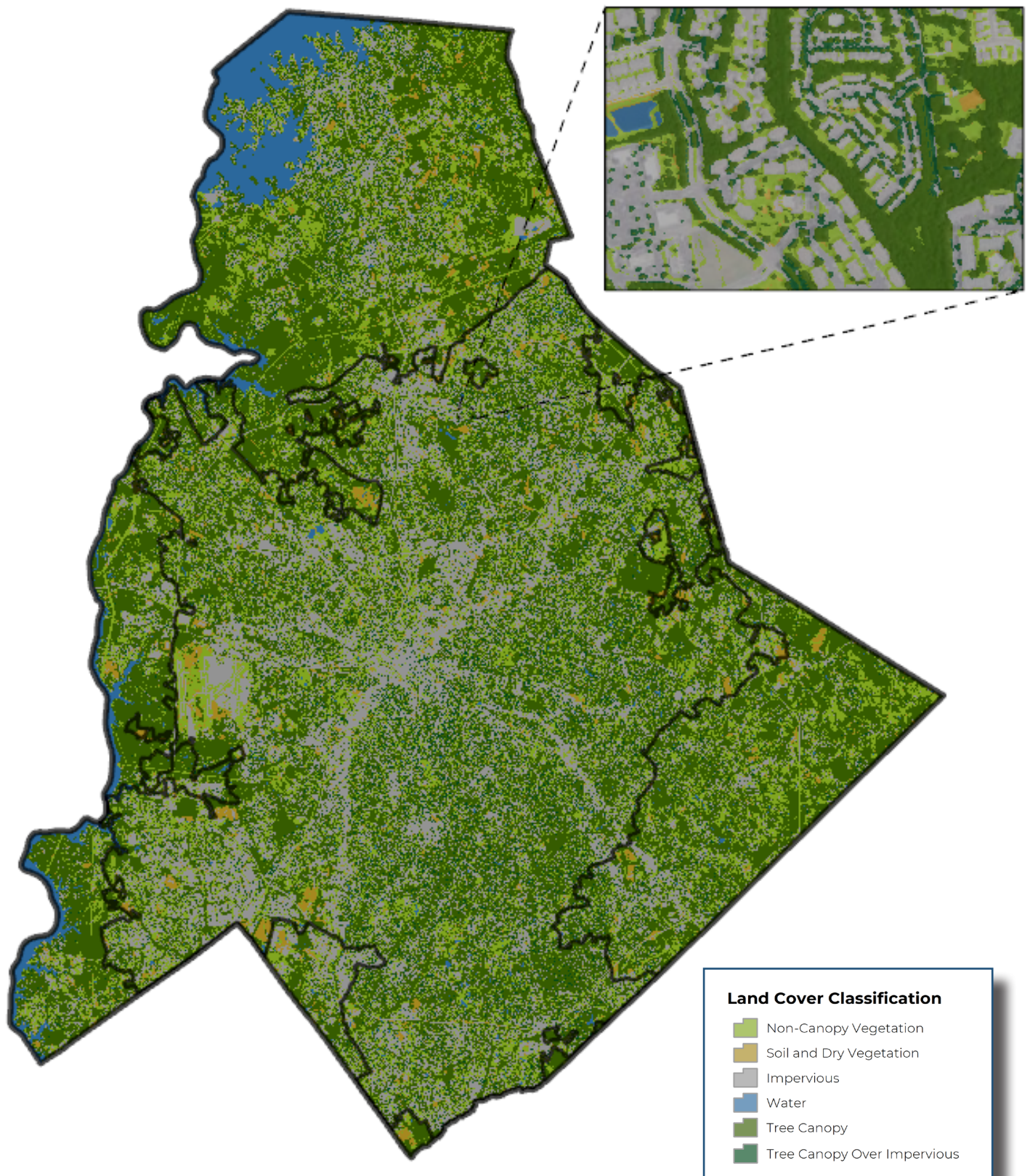
Figure 8. Distribution of land cover throughout the City of Charlotte and surrounding areas of Mecklenburg County.

Urban Tree Canopy Potential

- Urban Tree Canopy
- PPA Vegetation
- Unsuitable Vegetation
- Unsuitable Impervious
- Unsuitable Soil
- Water
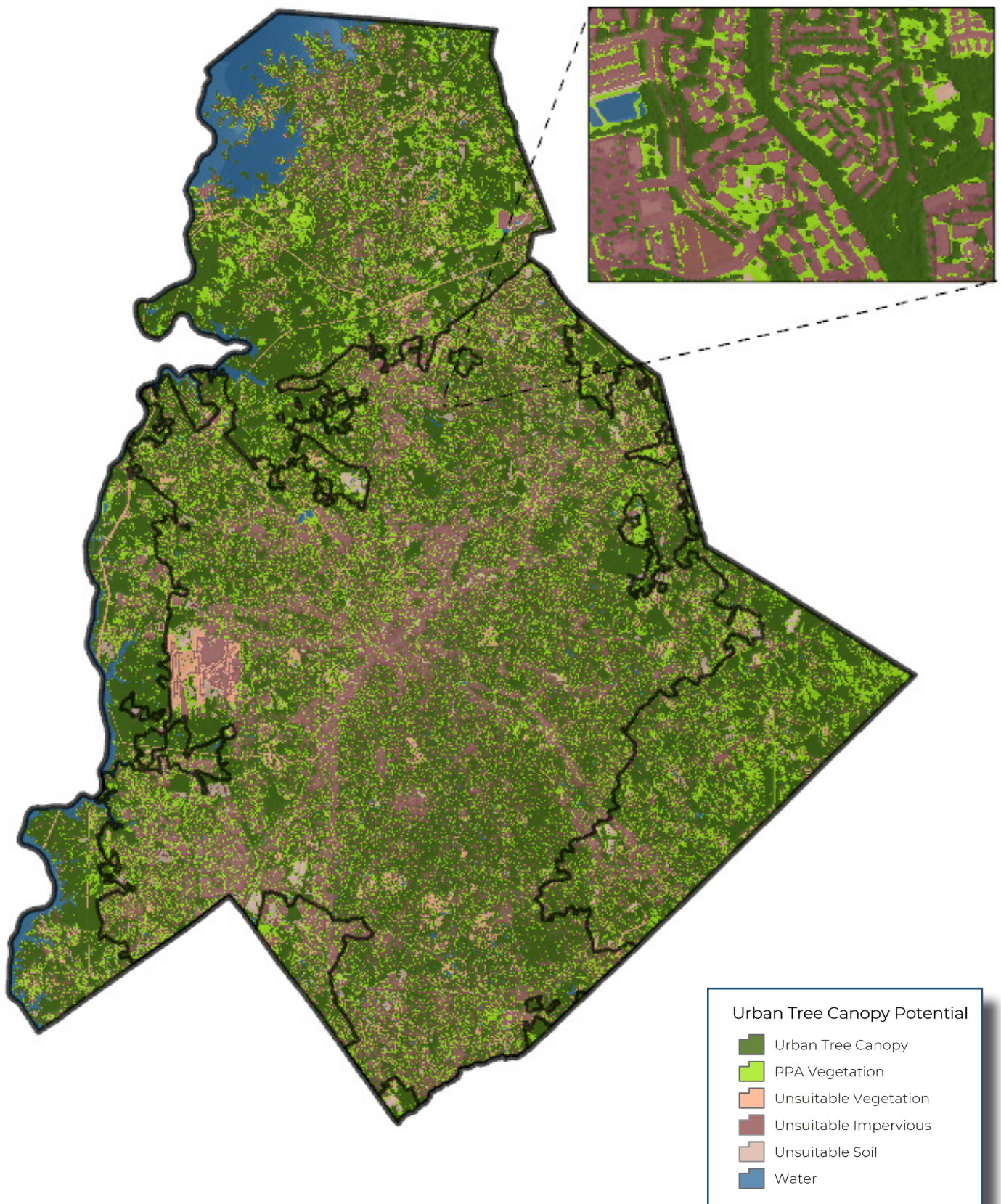
Figure 9. Distribution of existing and potential urban tree canopy throughout the City of Charlotte and the surrounding areas of Mecklenburg County.

CITY-WIDE URBAN TREE CANOPY

The findings reveal that within the official boundaries of the City of Charlotte, 94,161 acres were covered with urban tree canopy. This constitutes 47% of the city's total land expanse of 199,022 acres. Furthermore, there are 36,795 acres covered with other vegetation where it would be possible to plant trees, making up 18.5% of the city. Consequently, Charlotte's urban tree canopy potential, combining the existing canopy with the potentially viable planting areas, is 66%. The remaining 68,066 acres, 34% of the city, were deemed unsuitable for tree planting. A detailed breakdown of the unsuitable percentages by land cover can be found in Figure 10.

URBAN TREE CANOPY POTENTIAL

34% 47% 18%

🟢 Urban tree Canopy
🟢 Possible Planting Area
⚪ Unsuitable Area

UNSUITABLE FOR PLANTING

9% 7% 85%

🟤 Unsuitable Impervious
🟫 Unsuitable Soil
🟠 Unsuitable Vegetation
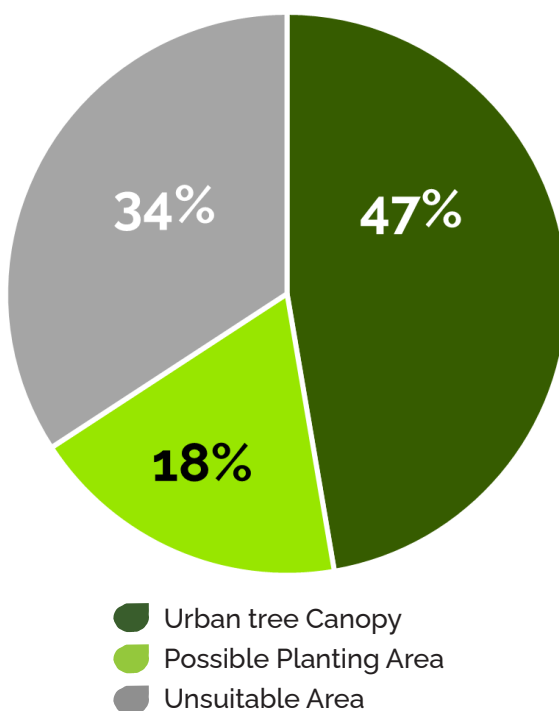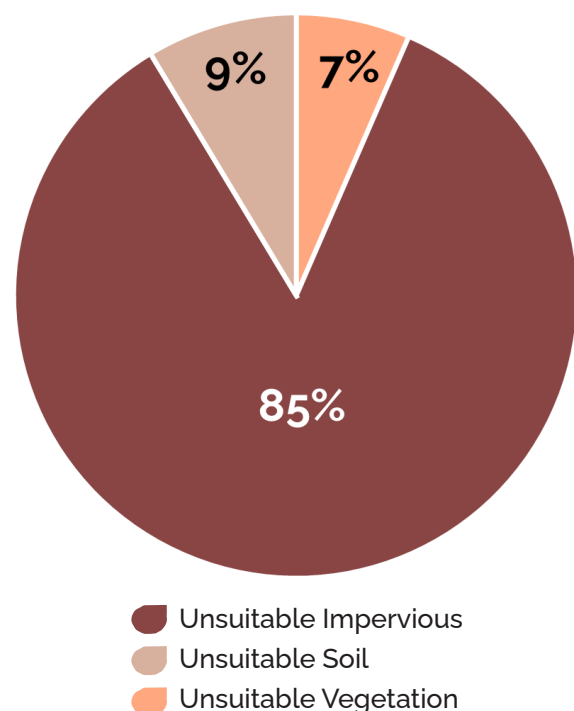
Figure 10. Urban tree canopy, possible planting area, and area unsuitable for UTC (right) for the City of Charlotte. Charlotte's total unsuitable area broken down by unsuitable soil, unsuitable impervious, and unsuitable vegetation percentages (left).

CITY-WIDE URBAN TREE CANOPY CHANGE

In this assessment, Charlotte's urban tree canopy moderately declined. The City experienced a loss of 969 acres of canopy, attributable to multiple factors (for a detailed analysis, see Agents of Canopy Change on page 24). This loss equates to a reduction of 0.5% of the city's entire tree cover in just four years. For perspective, this loss is comparable to ten times the land area of Freedom Park.

However, it is reasonable to infer that tree canopy could have gone through times of fluctuation throughout the study period. Previous analyses performed by PlanIt Geo noted that in 2012, canopy cover was at 47.1, and by 2016 it had slightly receded to 46.8%. Given the proactive efforts of TreesCharlotte, combined with interdepartmental partnerships and collaboration with private land owners, the canopy cover seems to have stabilized around 47%. It is imperative for the city to continue these alliances to ensure the preservation of its canopy cover and the realization of its canopy goals.

CHARLOTTE'S CANOPY OVER IMPERVIOUS SURFACE

The City's 94,161 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 storm-water absorption. Results indicated that 91% of the City of Charlotte's Urban Tree Canopy (UTC) was overhanging pervious surfaces, while just 9% was overhanging impervious surfaces. Planting trees along rights of ways in public areas, and strengthening ordinances for planting around parking lots in new developments can help to offset the negative effects of impervious surfaces.

Table 1. Land cover classes in acres and percent in Mecklenburg County, (percentages based on total area of the Mecklenburg County including water bodies).

County-wide Land Cover	Acres	% of Total
Overall County	349,206	100%
Tree Canopy	173,531	52%
Impervious Surfaces	78,481	22%
Non-Canopy Vegetation	73,274	21%
Water	13,944	4%
Soil and Dry Vegetation	9,977	3%

COUNTY-WIDE URBAN TREE CANOPY

To gather context and to help understand Charlotte's tree canopy in comparison with surrounding areas, this urban tree canopy assessment utilized county-wide land cover data as a foundation for all analyses within. The entire area of Mecklenburg County (335,262 land acres, not including water bodies) was comprised of 52% UTC, about 5% higher than the City alone. There are 66,148 acres available for tree planting opportunities over the entire area, again coming in slightly more than that of the City. These more favorable results for the county as a whole are expected due to a lower relative amount of urbanized area in the County as a whole, but represent prime opportunities to preserve and protect canopy as Charlotte expands. Conversely, about 22% of the County was covered with impervious surfaces such as roads and parking lots (-7% compared to the City). There is also another other 6% composed of recreational sports fields, areas of bare soil and dry vegetation. Altogether, the County area as a whole has about 5% less unsuitable planting areas than just the City boundary (29% and 34% respectively).

COUNTY-WIDE URBAN TREE CANOPY CHANGE

Over the last four years (2018-2022), the County saw a modest growth in tree canopy. In 2018 the County contained 171,718 acres of canopy. Since then, canopy cover in the overall area increased by 273 acres. To provide prospective, this expansion is equivalent to gaining 204 football fields of canopy. However, given the vast expanse of Mecklenburg County's land area, this translates to a less than 1% increase.

URBAN TREE CANOPY BY CHARLOTTE'S EXTRATERRITORIAL JURISDICTION

Charlotte's official city boundary was combined with the City's Extraterritorial Jurisdiction (ETJ), sometimes referred to as the "Sphere of Influence", to create a more comprehensive study area that accounts for areas of future growth. This ETJ area adds approximately 39,791 land acres to the City's area and serves multiple purposes for the municipality such as: authority to enforce zoning and development ordinances as well as aid in ability for the regional government to manage the Catawba River resources. This extension of the city is heavily forested, composed of various parks and nature preserves. This assessment found that Charlotte's ETJ had 63% of it's land area cover with tree canopy in 2022; about 11% higher than the county-wide UTC and 16% higher than that of the City. The 24,889 canopy acres in the ETJ area constitute 21% of the combined area's total distribution of canopy. Without the ETJ the City has a canopy cover of 47% however, after adding the canopy within the ETJ the combined canopy cover is up to 50%.
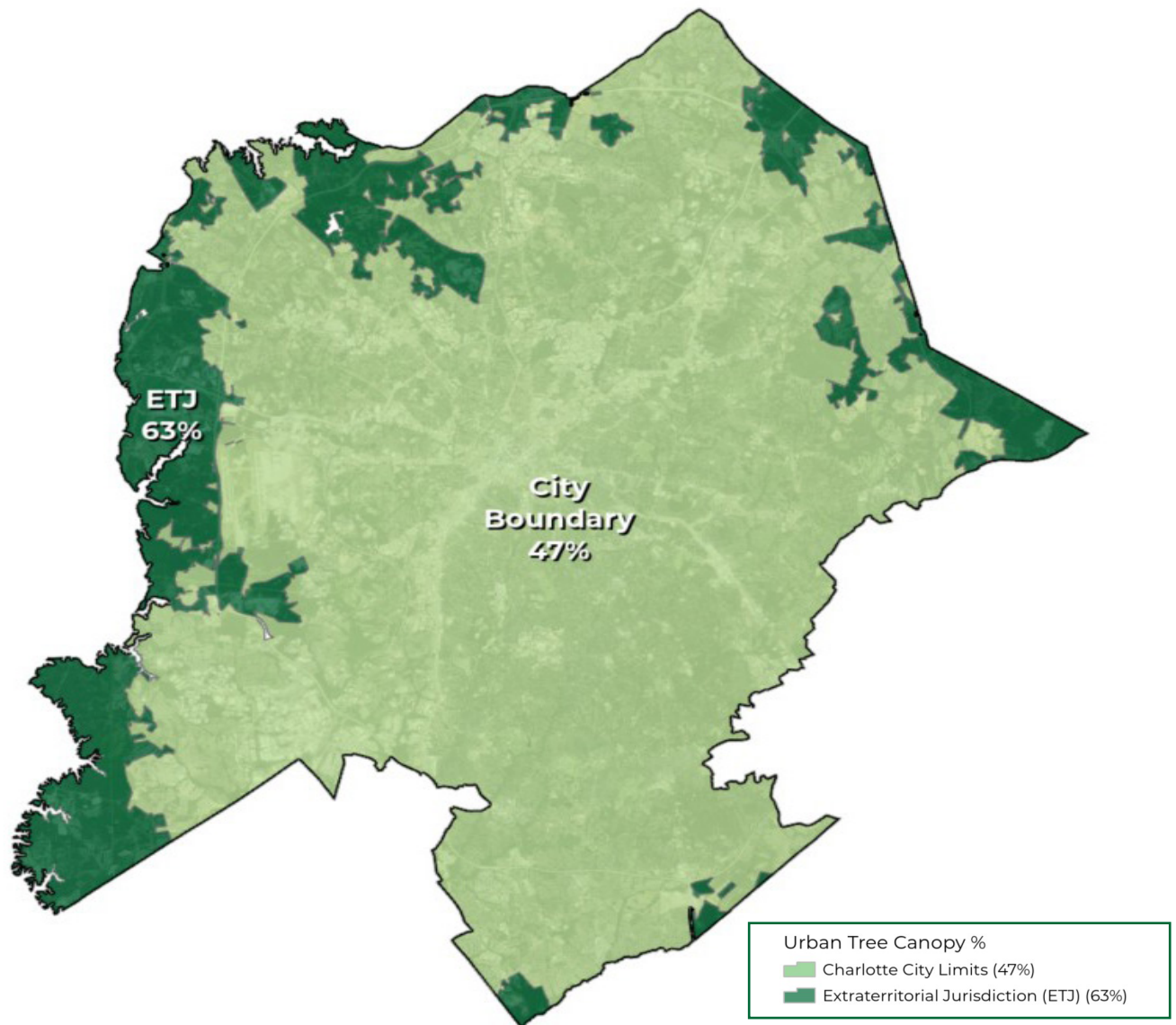
Figure 11. Urban tree canopy throughout Charlotte and the City's Extraterritorial Jurisdiction.

URBAN TREE CANOPY CHANGE BY CHARLOTTE'S EXTRATERRITORIAL JURISDICTION

The ETJ occupies 17% of the combined study area (while the City of Charlotte contains the other 83%). Notably, over the past four years the ETJ areas have seen an average 1% growth in canopy. These 323 acres increased the urban tree canopy of the ETJ from 62% to 63% during the study period. The land area in the ETJ is most likely being considered for advancing development beyond the current city limits. It is paramount that the ETJ zoned areas are prioritized for canopy preservation in tandem with the city's expansion.

URBAN TREE CANOPY BY LAND OWNERSHIP

Urban tree canopy metrics were also assessed for three public property ownership types to inform strategies for tree care and assess performance within each. The three ownership types analyzed in this report were: City-Owned property, City Right-of-Way (ROW) property, and Other-Public Owned property. The other-public layer was created by aggregated data from the following sources: Charlotte Mecklenburg School Owned Parcels, Central Piedmont Community College (CPCC) Owned Parcels, County Owned Parcels, and Town Owned Parcels. It's important to note that every parcel of land in the assessment area was not assessed within this assessment scale. Out of the entire study area (Mecklenburg County's 335,267 land acres) there were 68,310 acres that fit into these three ownership types and considered in this portion of the analysis.

In 2022, the City ROW areas were comprised of 28% urban tree canopy (UTC), while City-Owned properties had 46% UTC (in-line with Charlotte's overall canopy numbers). Other-Public property, made up of various other public entities in mostly non-urban areas throughout the county, contained 71% of the distribution of publicly managed tree canopy.

Each of the three types of public properties had about the same ratio of possible areas to plant (PPA), ranging from 14-16% of each overall area.

Urban Tree Canopy %
- City-Owned (46%)
- Other Public Owned (71%)
- Right-of-Way (28%)
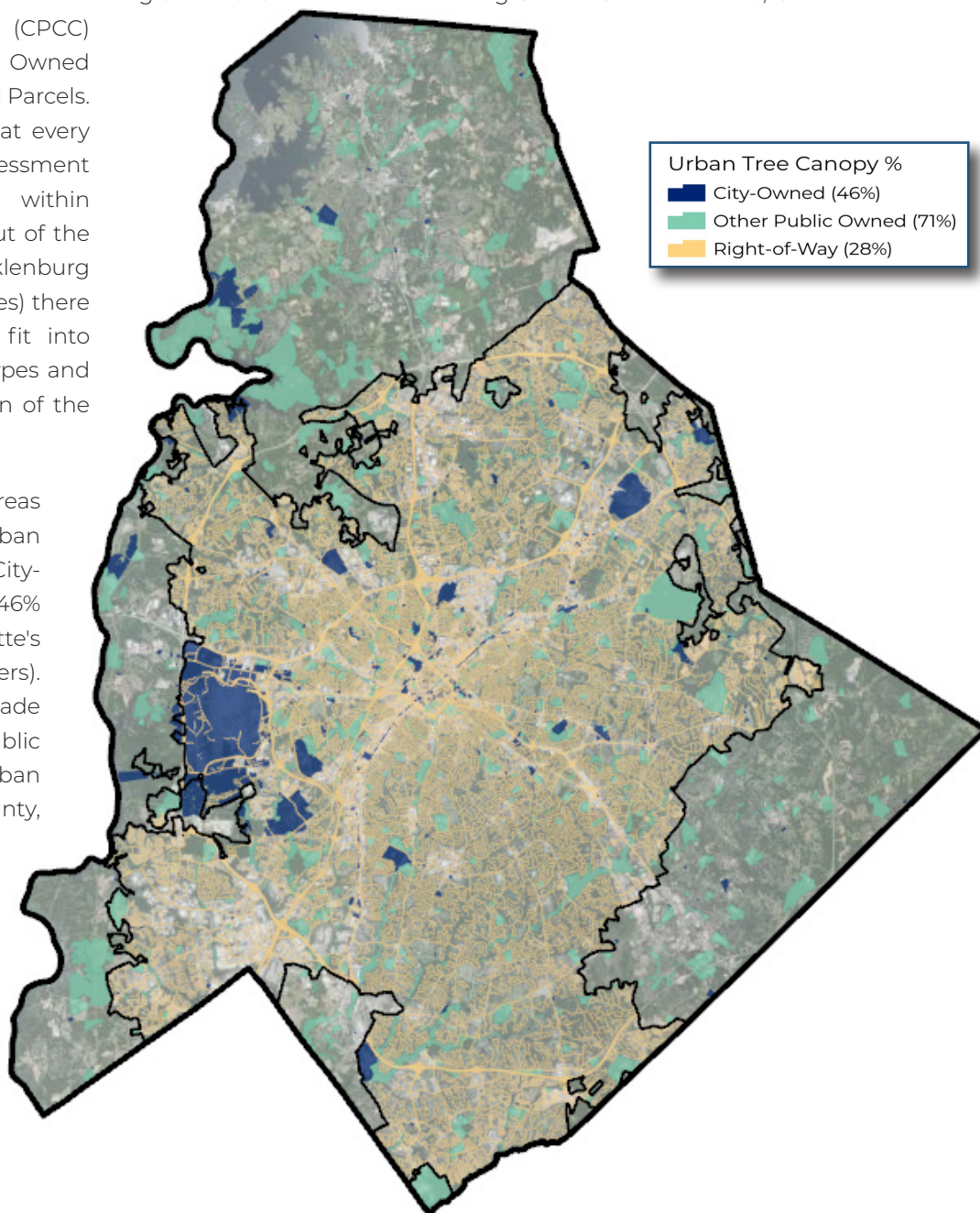
Figure 12. Distribution of UTC among City-Owned parcels, ROW, and Other-Public Owned property.

URBAN TREE CANOPY CHANGE BY LAND OWNERSHIP

All three public ownership types saw positive increases in canopy cover during the four year study period. The largest increase happened on lands designated Other-Public at +2%, or 585 acres. The City Right-of-Way (ROW) and City-Owned property also had some increase in tree cover, although it was small; less than 1%. Land owned by the City added 32 acres of trees. Positive trends in these public areas (where trees can be especially difficult to cultivate) are great news for the City of Charlotte and it's partners. This indicates that current management practices, including planting, pruning, and maintenance strategies, are contributing to the overall stabilization of canopy area across the entire city area.

URBAN TREE CANOPY BY CITY COUNCIL DISTRICTS

Urban tree canopy metrics were also assessed for Charlotte's seven City Council Districts. District 3 occupied the largest land area of all the Districts at 22%. Even though the canopy cover in this district was one of the lowest at 41%, it was still contained 17,566 acres of canopy (or 16% of the citywide total) – the largest contribution to the city's overall canopy out of all the districts. District 2 contained 15% of the City's canopy cover, boasting 14,328 acres of canopy within its boundaries. District 5 and 6 had canopy covering over half of their respective land areas (55% each), making them the top districts in terms of canopy percentages. Those districts contained 13,955 and 13,342 acres of canopy respectively. Geographically speaking, the eastern and southeastern-most districts contributed the largest percentages of canopy to the overall average, while the central (urban) and western districts had the lowest.

Both District 2 and District 4 had the highest proportion of land area suitable for planting, each at 21%. Considering that District 3 occupied the most land, it was also the largest contributor of plantable space – a significant 7,979 acres, which translates to 18% of its total land area and a substantial 22% of the city's overall available planting space.

Through the lens of this geographic scale, it's easy to see the impact of urbanization on relative tree canopy areas. Districts 1 and 3 had the lowest urban tree canopy (UTC); 6% lower than the city-wide average and 11% lower than the county-wide average. As urban sprawl continues from these areas, it's important for local authorities to manage urban growth in a sustainable manner that limits tree canopy removals and impervious surface installation, but also increases the amount of possible planting to create suitable habitat for future canopy expansion.

Urban Tree Canopy %
- 0% - 15%
- 16% - 25%
- 26% - 35%
- 36% - 45%
- 46% - 100%
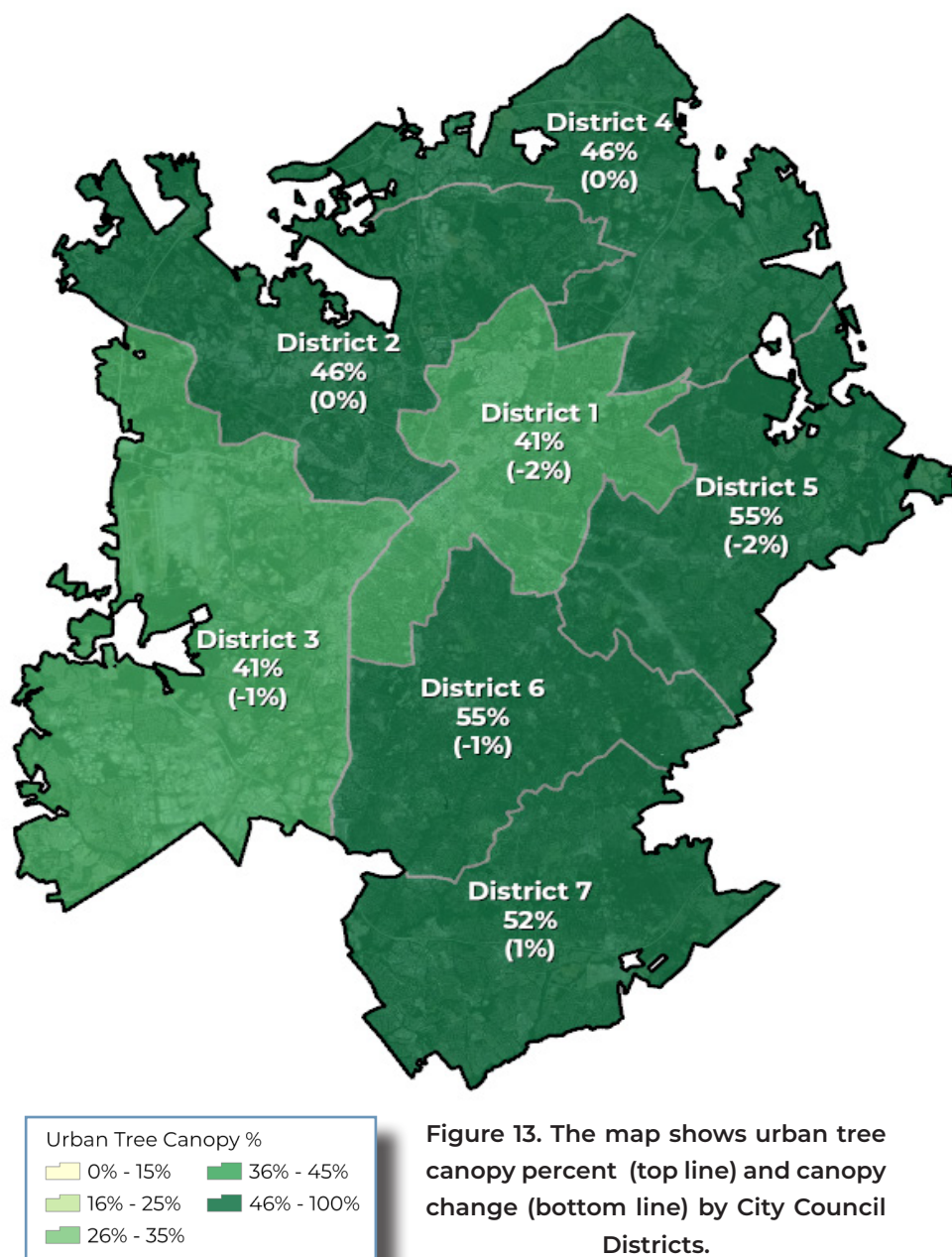
Figure 13. The map shows urban tree canopy percent (top line) and canopy change (bottom line) by City Council Districts.

URBAN TREE CANOPY CHANGE BY CHARLOTTE'S CITY COUNCIL DISTRICTS

Four of Charlotte's seven City Council Districts experienced tree canopy losses between 2018 and 2022. The largest tree canopy loss occurred in District 5, losing 562 canopy acres. District 1 also suffered significant canopy loss, losing 2% of its canopy (or 369 acres) in just four years. District 2, 4, and 7 all experienced canopy gains during the study period. The greatest tree canopy gain occurred in District 7, where 358 acres were added for an 1% increase. District 2 and 4 gained 64 and 41 acres of tree canopy respectively. This translates to about a 0.15% gain of canopy each.

URBAN TREE CANOPY BY CHARLOTTE'S PLACE TYPES

The City of Charlotte has created a classification of ten unique place types to describe the vision for future development practices of Charlotte. These categories describe the characteristics, buildings, primary land uses of each area, and were created from the Charlotte's Future 2040 Policy Map- **refer to the Appendix on Page 38 for a comprehensive descriptions of the ten unique place types.** The first type, Neighborhood 1, occupied a majority of the land area at 57%. This type is predominantly comprised of low-rise single-family homes, although duplexes and commercial buildings may also be found within. Neighborhood 1 has the most urban tree canopy by area, making up 63% of the total canopy within all place types.

66%

of all PPA

is within
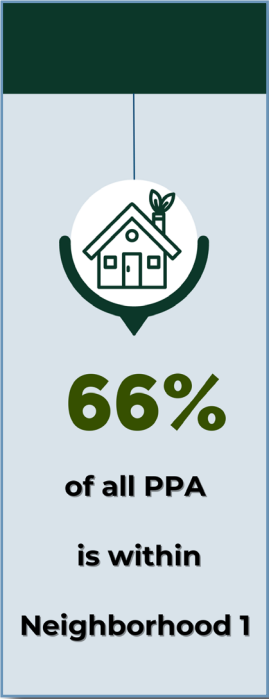
Neighborhood 1

The Parks and Preserves type, where land is designated for open spaces, parks, and land set aside to protect natural spaces, had the highest percentage of urban tree canopy (UTC) with 78% or 11,891 acres within its boundaries. Neighborhood 2 (comprised mostly of multi-family homes, schools, neighborhood parks, and religious institutions) had the third highest canopy cover at 47%. Manufacturing & Logistics contained 14% of all Place Type land area, and represented 9% of the total canopy cover within. The Regional Activity Center had the lowest number of trees, with only 22% of its land containing trees.

Looking at plantable space, Neighborhood 1 contained the highest percentage of PPA at 22%. This represents about two-thirds (66%) of the total plantable space within all Place Types. Both Campus and Neighborhood 2 each had 18% of their total land area available for planting. Although, Manufacturing & Logistics only had a small percentage of its area available for planting (14%), this equates to a large proportion of the total plantable space available (10% of distribution of city-wide plantable space or 4,002 acres).

Interestingly, Parks and Preserves had the lowest availability of plantable space at just 12% (5% of the city-wide total). Though, its important to note that 10% of Parks and Reserve's land area set aside for specific uses, and is considered unsuitable for planting.

Table 3. Urban tree canopy, citywide canopy distribution, and possible planting percent by place type.

Place Type	Distribution of Land Area %	UTC %	Distribution of Total Canopy %	PPA %	Distribution of Total PPA %
Parks & Preserves	7%	78%	11%	12%	5%
Neighborhood 1	57%	59%	63%	22%	66%
Neighborhood 2	7%	47%	6%	18%	7%
Campus	5%	44%	4%	18%	4%
Community Activity Center	5%	40%	4%	13%	4%
Manufacturing & Logistics	14%	37%	9%	14%	10%
Commercial	2%	35%	1%	16%	1%
Innovation Mixed-Use	1%	29%	0%	15%	1%
Neighborhood Center	1%	29%	1%	14%	1%
Regional Activity Center	2%	22%	1%	13%	1%

URBAN TREE CANOPY CHANGE BY CHARLOTTE'S PLACE TYPES

Nine of City's ten designated Place Types lost canopy during the study period. The only Place Type that gained canopy was Parks & Preserves. These areas gained 244 acres of canopy (increasing their canopy cover by 2%). Community Activity Center areas lost 3% of its canopy in four years, dropping its canopy cover from 43% to 40%. The largest loss of trees occurred in Neighborhood 1, where there was a decline of more than 700 acres of canopy (about -1%). This decline represents 57% of all canopy loss among place types. However, this type, still represents the largest area of canopy overall.

Regional Activity Center already had the lowest canopy cover, just 23% in 2018. Although these areas were already canopy-deficient, they've continued to lose canopy. Regional Activity Centers lost 36 acres over four years, translating to a loss of about 9 acres a year. The City should keep working towards its unique canopy cover goals for each Place Type to help counter the loss of trees and tailor strategies for effectiveness by individual characteristics.
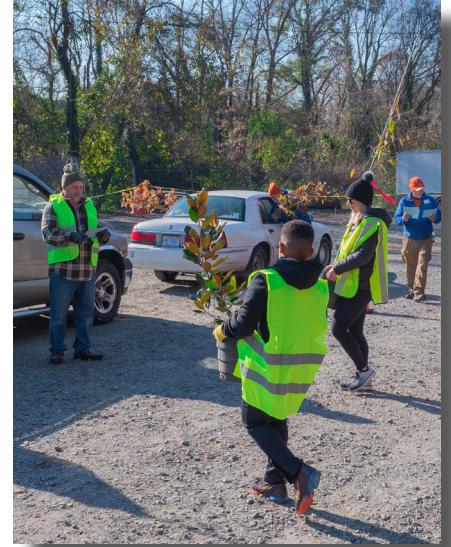
EXISTING URBAN TREE CANOPY (%) BY PLACE TYPES

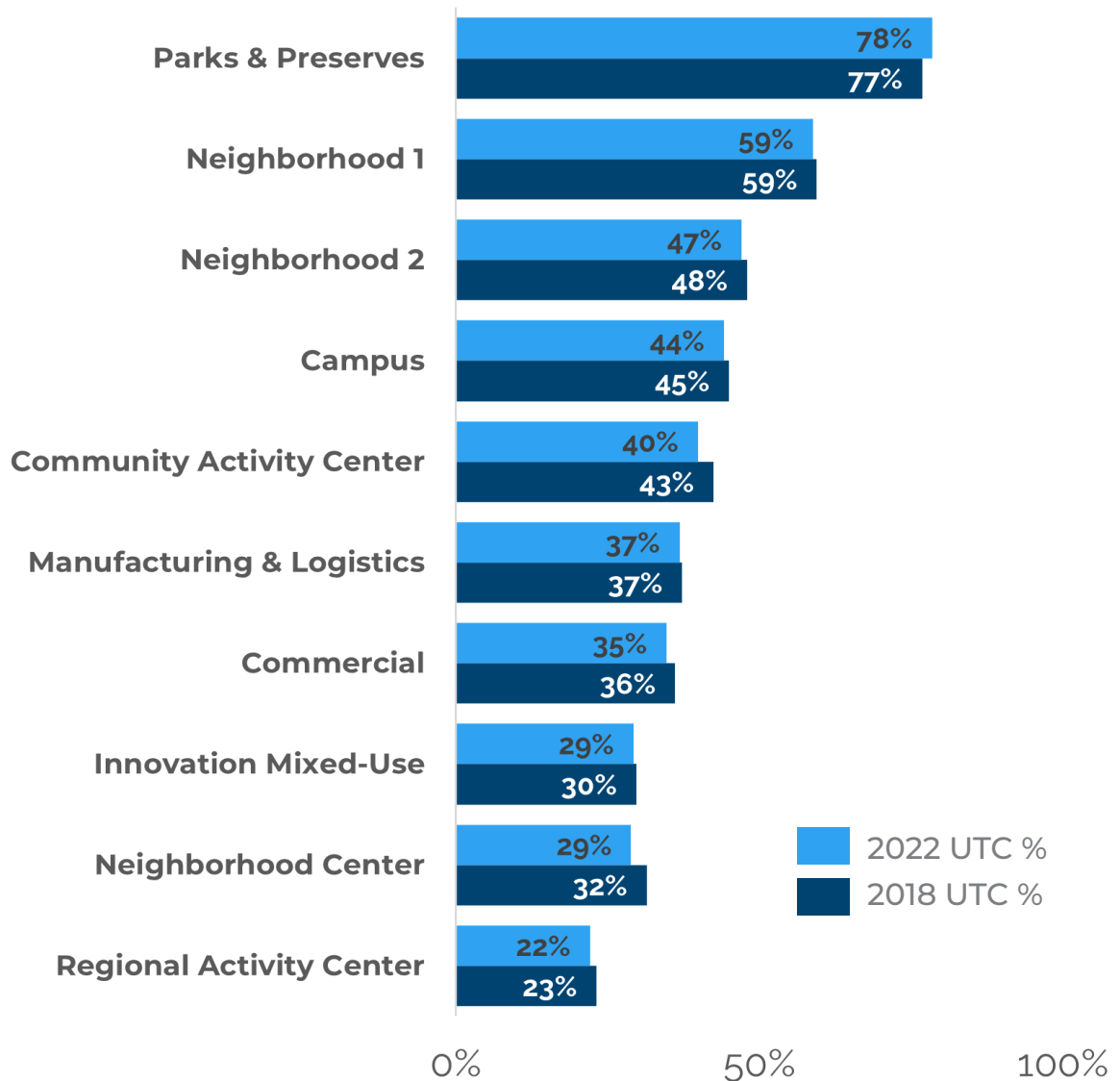| Place Type	2022 UTC %	2018 UTC %
Parks & Preserves	78%	77%
Neighborhood 1	59%	59%
Neighborhood 2	47%	48%
Campus	44%	45%
Community Activity Center	40%	43%
Manufacturing & Logistics	37%	37%
Commercial	35%	36%
Innovation Mixed-Use	29%	30%
Neighborhood Center	29%	32%
Regional Activity Center	22%	23%

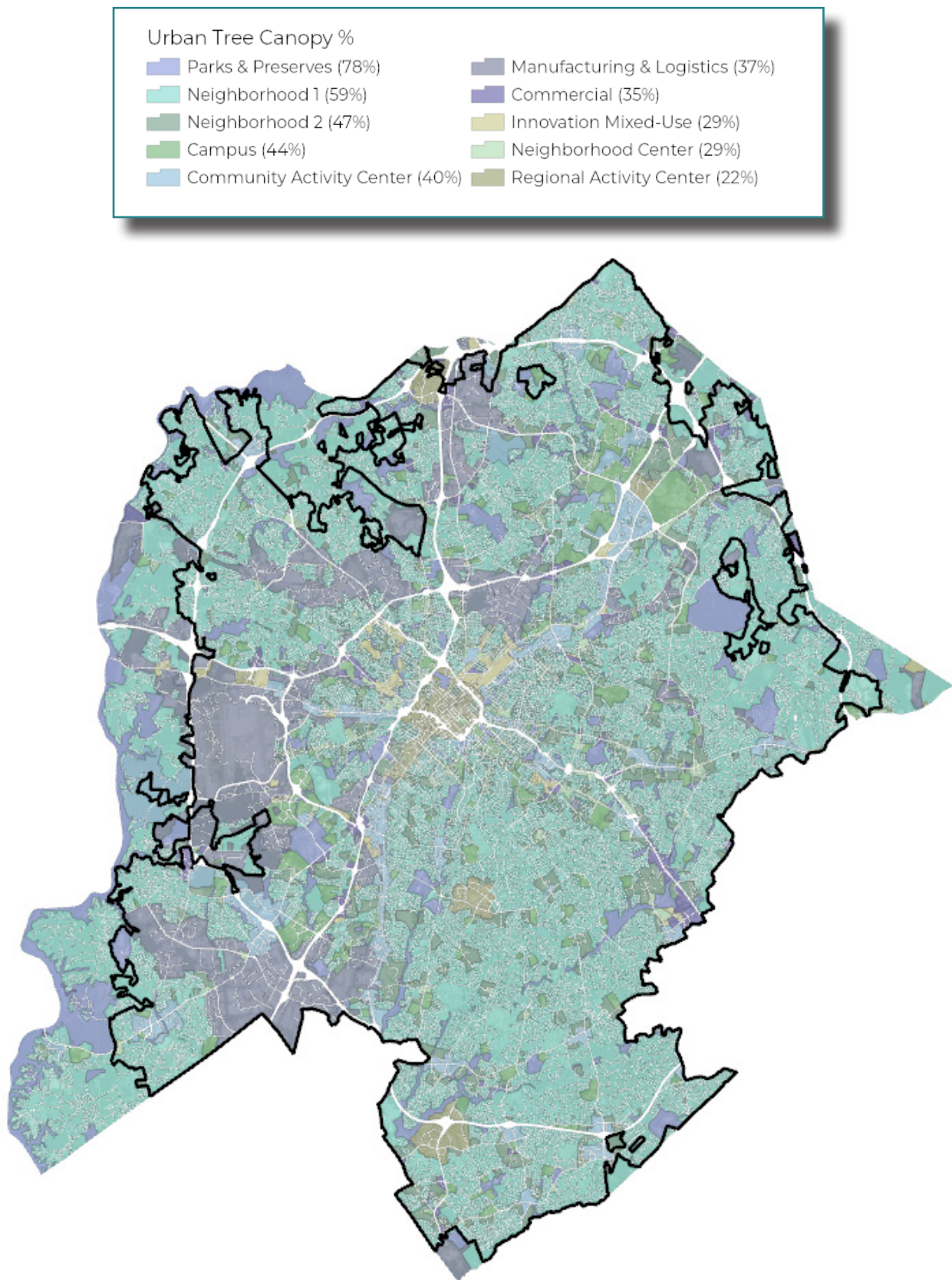**Figure 14. Urban tree canopy percent by Place Types.**

Figure 15. Urban tree canopy percent by Place Types.

URBAN TREE CANOPY BY SURROUNDING JURISDICTIONS

For comparison and context to the trends in canopy coverage in the greater area, UTC and PPA were assessed for nine jurisdictions including and surrounding the Charlotte City limits, but within Mecklenburg County. Out of the nine areas assessed, the two largest areas were represented by Charlotte itself, and unincorporated County areas as well. Charlotte occupied 59% of the total land area, and Mecklenburg occupied 20%. By comparison, the third largest feature was Huntersville, covering just 8% of all area assessed.

Due to Charlotte's large land area, this jurisdiction made up 54% of the County's tree canopy. Mecklenburg had the highest percentage of UTC within its borders, with 64% canopy cover, making up a quarter (25%) of the County's total tree canopy. Mint Hill had the second highest tree canopy coverage with 58% or 9,095 canopy acres. Huntersville also contained notable tree canopy coverage with 13,912 acres of its land covered with canopy. Pineville had a canopy cover well below average at 37%.

Mint Hill contained the greatest PPA per land area, with 25%, or 3,885 acres, of PPA. Huntersville had the second highest percentage of land available for planting at 24%.

THE CITY OF CHARLOTTE'S
Canopy cover was 4% less than the average of all jurisdictions (52%)

Huntersville's 6,413 acres of plantable space contributed 10% to the county-wide total. Charlotte contributed the greatest amount of PPA of all jurisdictions at almost 37,000 acres, or 56% of the county-wide total. Davidson, Matthews, and Stallings had the lowest available plantable space, with less than 20% of their land available for planting.

URBAN TREE CANOPY CHANGE BY SURROUNDING JURISDICTIONS

Jurisdictions that lost canopy from 2018-2022:

Pineville, Mint Hill, and Charlotte

During the four-year study period, six of the nine jurisdictions gained canopy. Excluding unincorporated areas of the County and the City proper, the largest increase in canopy was seen by Cornelius at +3%. Cornelius added of 244 acres of canopy, raising its canopy cover from 42% in 2018 to 45% in 2022. Huntersville also gained a significant amount of canopy (171 acres or +1%).

Pineville, Mint Hill, and Charlotte all saw a decrease in canopy during the 4 year study period. Charlotte saw a 0.5% decrease in tree coverage, while Mint Hill and Pineville each lost 1% of their canopy cover, resulting in losses of 977, 202, and 41 acres, respectively.

Table 3. Urban tree canopy, citywide canopy distribution, and possible planting percent by Jurisdictions.

Jurisdictions	UTC %	Distribution of Citywide Canopy %	PPA %	Distribution of Citywide PPA %	UTC % Change
Mecklenburg	64%	25%	21%	21%	1%
Mint Hill	58%	5%	25%	6%	-1%
Matthews	55%	3%	18%	3%	1%
Stallings	54%	0%	18%	0%	1%
Huntersville	52%	8%	24%	10%	1%
Davidson	52%	1%	19%	1%	2%
Charlotte	47%	54%	18%	56%	-0.5%
Cornelius	45%	2%	21%	3%	3%
Pineville	37%	1%	21%	1%	-1%

URBAN TREE CANOPY BY WATERSHEDS

Charlotte's watersheds help maintain and promote a healthy natural environment by providing long-term protection of streams, wetlands, and riparian corridors. UTC and PPA were assessed across 30 watersheds in the City and surrounding areas of the County. Little Sugar Creek was the largest watershed, representing 10% of the total land area and contained 8% of the total tree canopy cover (equating to 44% canopy cover within its boundaries or 14,351 canopy acres). McAlpine Creek was the second largest watershed and contained a larger than average canopy coverage at 55%. This watershed represents 9% of all canopy cover, the largest of all watersheds. Mill Creek-Lake Wylie had the highest percentage of canopy within its boundary at 71%. Mountain Island Lake also had significant forested areas with 69% canopy cover. Steele Creek was the only watershed to have less than 40% canopy cover.

Back Creek and Clear Creek had the largest percentage of PPA with 28% each. Little Sugar Creek, Long Creek, and Mallard Creek all contained over 5,000 acres of plantable space and each contained 8% of the total distribution of plantable space.

URBAN TREE CANOPY CHANGE BY WATERSHEDS

In this assessment, 16 watersheds gained canopy and the other 14 watersheds lost canopy. Torrence Branch-Lake Wylie lost 5% of its canopy in four years. Reedy Creek and Mill Creek-Lake Wylie also suffered significant canopy losses, losing 3% each. Little Sugar Creek experienced the largest loss in canopy, with a reduction of 570 canopy acres.

Headwaters Rocky River increased its canopy by 4% with the addition of 405 canopy acres. Catawba River-Lake Norman also increased its canopy by 4% (with 100 additional acres of canopy). Long Creek, Six Mile Creek, Mountain Island Lake, and McDowell Creek all gained over 200 acres of canopy.

Utilizing the 66,000+ acres of plantable space within the watershed boundaries can help mitigate storm-water runoff that may otherwise carry unhealthy pollutants (such as nitrogen, phosphorous, and suspended sediment) into surface water bodies. Additionally, it is important that these areas continue to grow canopy area to increase resistance to erosion, promote floodplain connectivity, and promote nutrient exchange in Charlotte's watersheds. Special attention should be paid to the City's urbanized areas, where canopy is lower, impervious surface is higher, and potential for impact to water quality is most significant.

Urban Tree Canopy %
- 0% - 15%
- 16% - 25%
- 26% - 35%
- 36% - 45%
- 46% - 100%
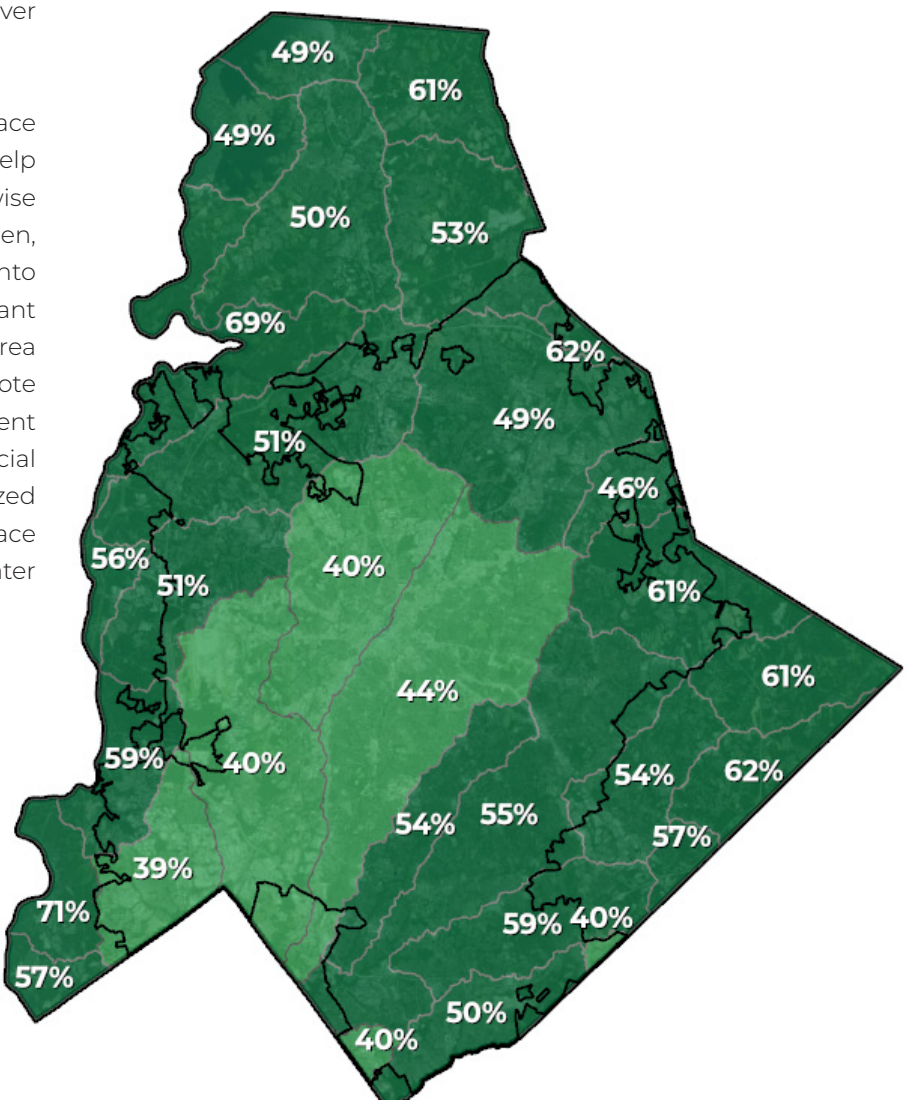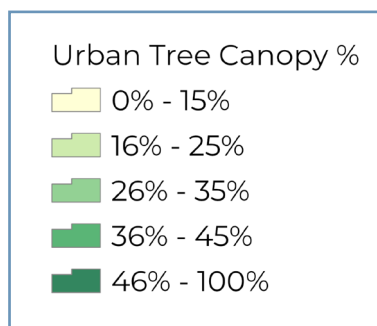
Figure 16. Urban tree canopy percent by watersheds.

URBAN TREE CANOPY BY NEIGHBORHOOD PROFILE AREAS

UTC and PPA were also assessed for Charlotte's Neighborhood Profile Areas (NPA). These NPAs provide additional insight about smaller communities inside Charlotte's (and surrounding) neighborhoods. There are a total of 459 NPAs, spanning the entirety of the County that were assessed for this study. The majority of the areas (79%) contained between 40-100% canopy cover. Roughly half of the NPAs (269) exceeded the citywide average canopy cover of 47%.

There was only one NPA that had less than 10% canopy cover, NPA 338. That tree-deficient NPA is located just north of South Side Park and highlighted in Figure 18. Fortunately, this NPA contains almost 30 acres of plantable space and is a prime candidate for targeting planting efforts.

Urban Tree Canopy %
- 0% - 15%
- 16% - 25%
- 26% - 35%
- 36% - 45%
- 46% - 100%
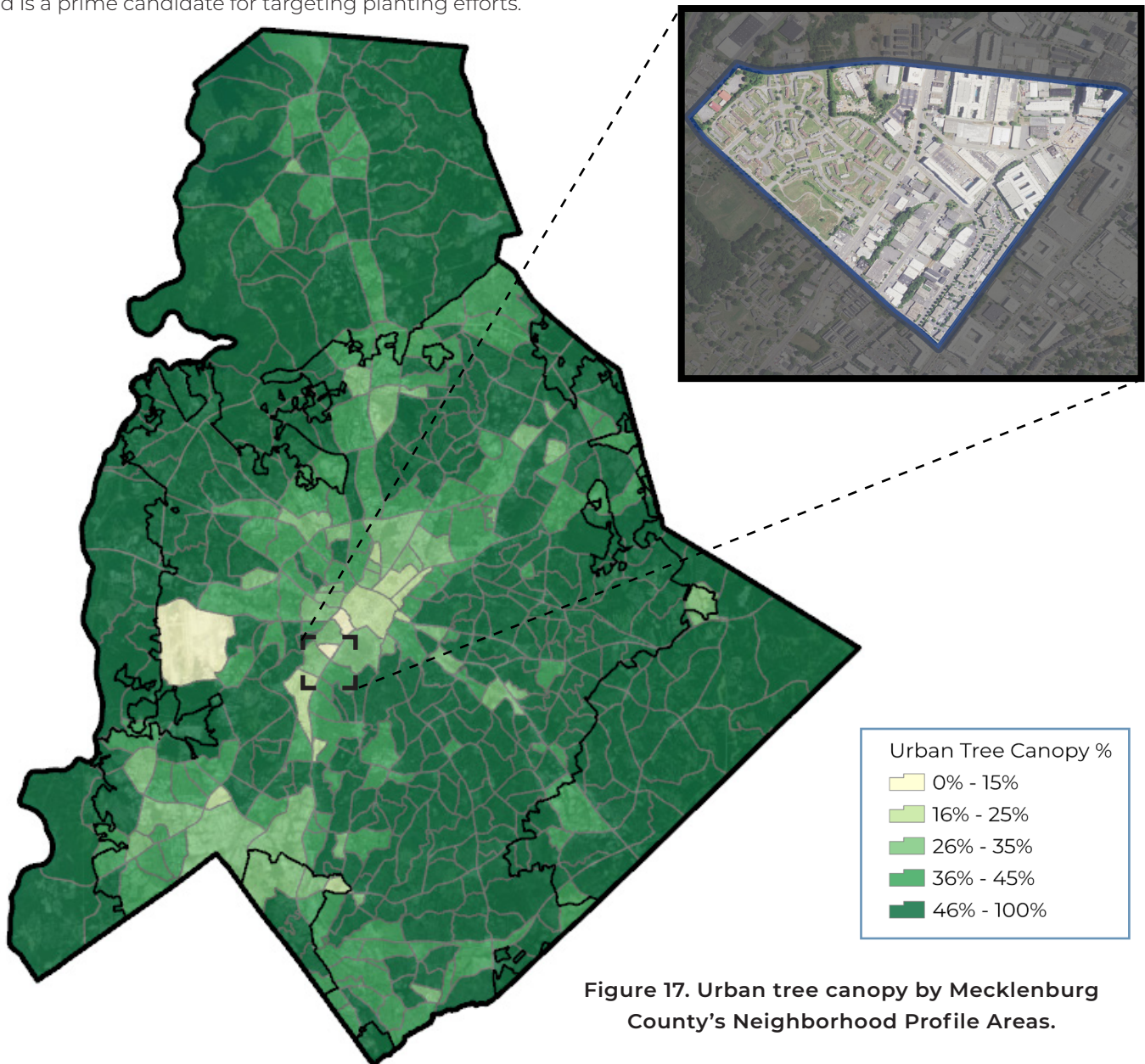
Figure 17. Urban tree canopy by Mecklenburg County's Neighborhood Profile Areas.

URBAN TREE CANOPY CHANGE BY NEIGHBORHOOD PROFILE AREAS

During the four-year study period, Charlotte's NPAs had diverse areas of both canopy growth and decline. Two NPAs, NPA 246 and 450, gained over 200 acres of canopy. Notably, NPA 469, situated between Habersham Park and Rocky River Bluff experienced the most substantial increase in canopy. This area increased its canopy by 10%, which translates to an addition of 271 acres of canopy in 4 years. In a broader perspective, the most significant canopy increases occurred in the northern sectors of the County. Conversely, two NPAs, namely NPA 256 and 174, experienced a decline of over 200 acres in their canopy. The largest percentage loss of canopy occurred just south Sherman Branch Nature Preserve and Bradfield Farms, with NPA 228 witnessing a 23% reduction in canopy.

Urban Tree Canopy Change %

-99.9% - -25.0%	-4.9% - -2.0%	5.1% - 10.0%
-24.9% - -10.0%	-1.9% - 2.0%	10.1% - 25.0%
-9.9% - -5.0%	2.1% - 5.0%	25.1% - 100.0%
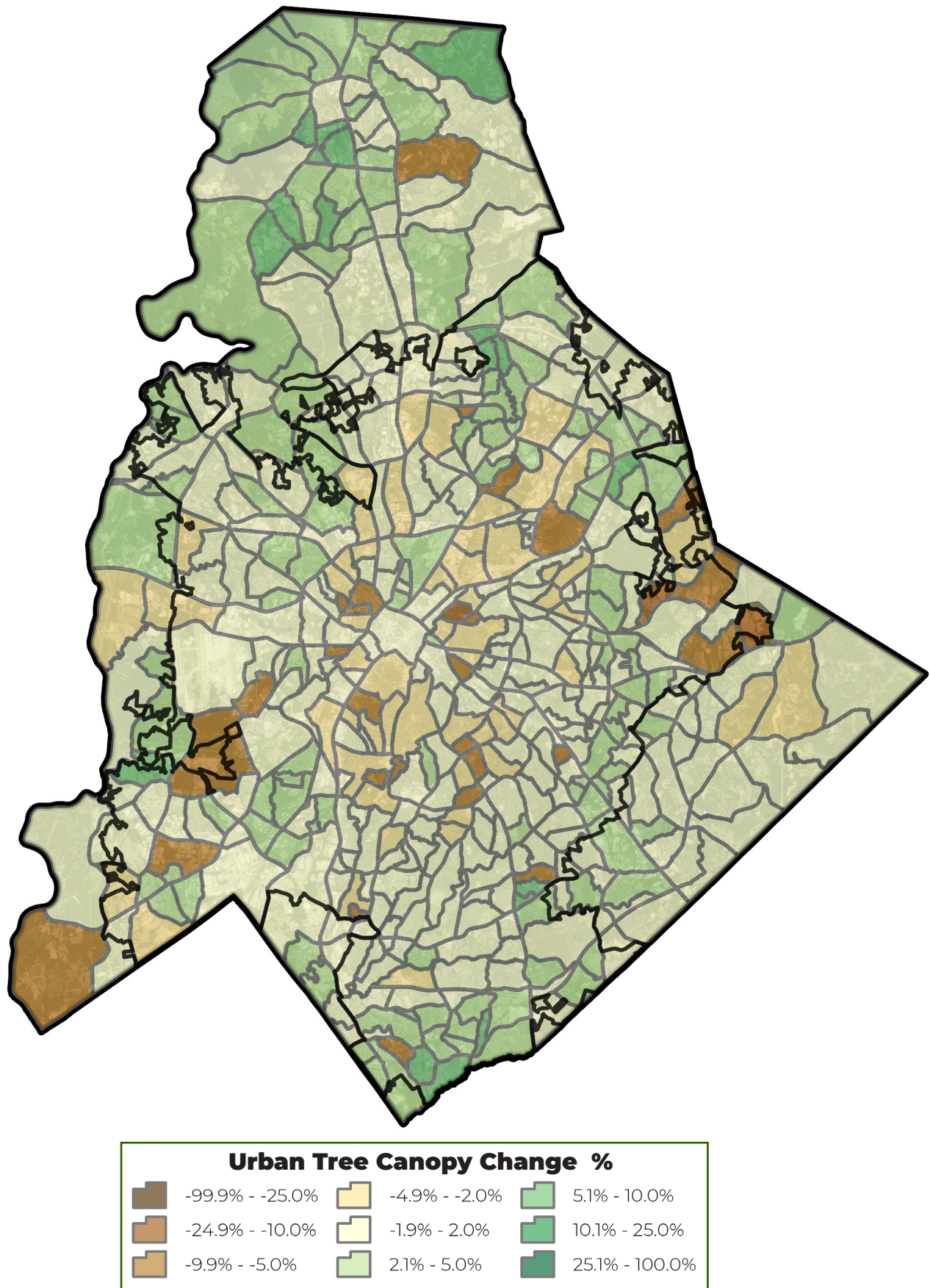
Figure 18. Urban tree canopy change by Mecklenburg County's Neighborhood Profile Areas.

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 readily available demographic and socio-economic data.

Results indicated that canopy cover varied substantially throughout Mecklenburg County's census block groups, as seen in Figure 19. Out of the total 624 census block groups analyzed county-wide, 44% of all block groups contained between 40-100% canopy cover. More than half (321 or 52%) of the groups exceeded the city-wide canopy cover (47% UTC).

Plantable space values were more consistent across census block groups, with 72% of all block groups containing 10-20% PPA. No census block groups exceeded 30% PPA.

Total Plantable Space %
- 0% - 15%
- 16% - 25%
- 26% - 35%
- 36% - 45%
- 46% - 100%
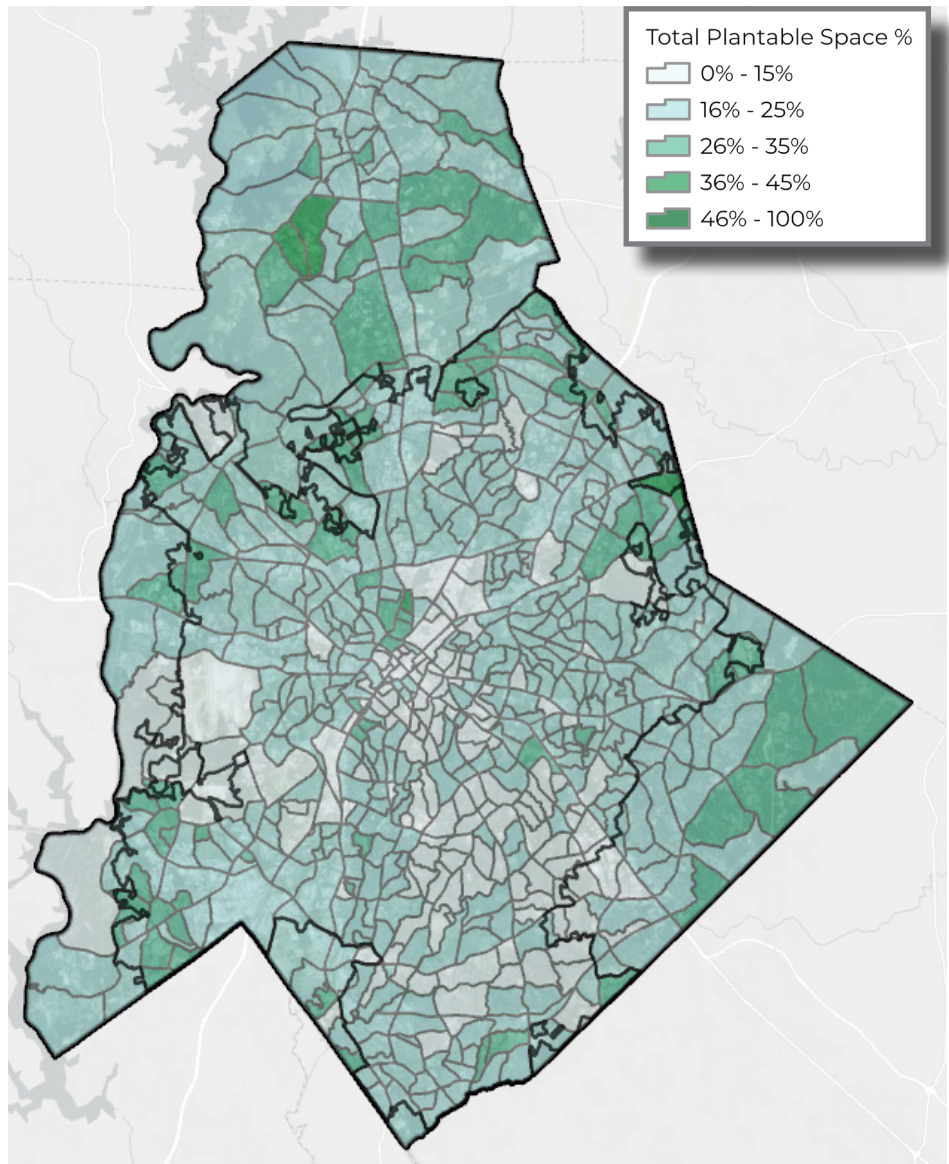
Figure 19. Plantable Space by census block groups.
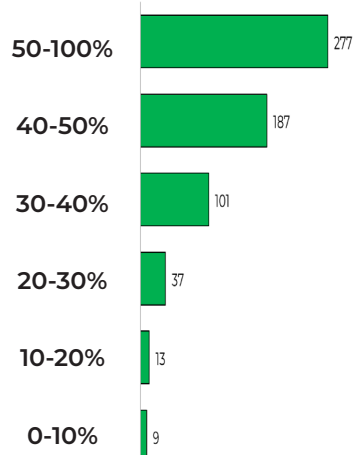
Figure 20. Number of census block groups with percent canopy cover ranges.

Range	Count
50-100%	277
40-50%	187
30-40%	101
20-30%	37
10-20%	13
0-10%	9
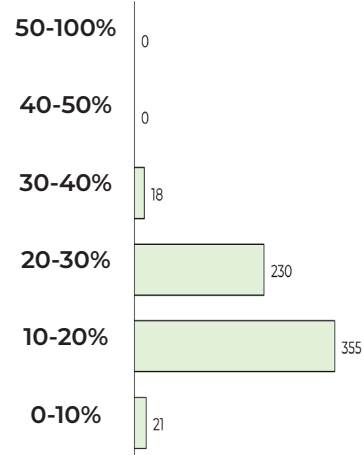
Figure 21. Number of census block groups with percent possible planting area ranges.

Range	Count
50-100%	0
40-50%	0
30-40%	18
20-30%	230
10-20%	355
0-10%	21

URBAN TREE CANOPY CHANGE BY CENSUS BLOCK GROUPS

Out of the county's 624 census block groups, 317 gained canopy, 246 lost canopy, and the other 61 remained relatively stable. Generally, the largest increases in canopy acres occurred near the northern boundary of Mecklenburg County.

The largest percentage loss within one block group occurred at the southeast boundary of the City, just southeast of Bradfield Farms. This block group lost -23% of it's canopy, translating to 191 acres, to make room for a residential development. However, there was one block group that lost more canopy acres, this time near the western border of Charlotte's city limits in between Griers Fork and Eagle Lake. 222 acres of canopy were cleared for retail and commercial developments. On the brighter side, the largest percentage increase in tree cover was down at the southern end of the City near Six Mile Creek.

Urban Tree Canopy Change %

- -99.9% - -25.0%
- -24.9% - -10.0%
- -9.9% - -5.0%
- -4.9% - -2.0%
- -1.9% - 2.0%
- 2.1% - 5.0%
- 5.1% - 10.0%
- 10.1% - 25.0%
- 25.1% - 100.0%

LARGEST UTC % DECREASE

LARGEST UTC % INCREASE

Figure 20. Urban tree canopy change by census block groups.
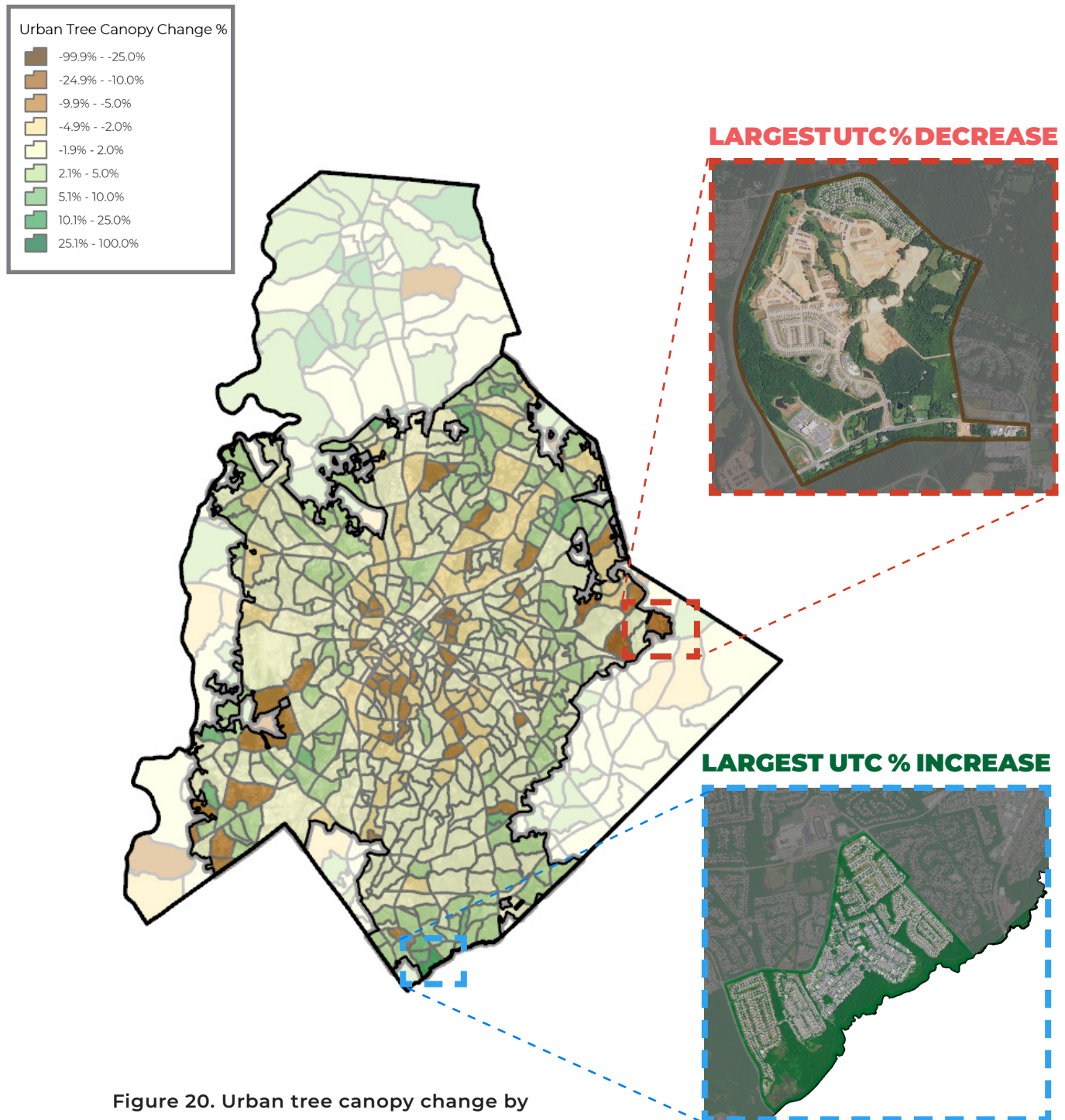
AN ANALYSIS OF POTENTIAL
AGENTS OF CHANGE

In addition to the analysis described previously, an attempt was made to survey the City of Charlotte to help determine potential causes of canopy change (losses and gains). A qualitative survey was undertaken, and four of the apparent largest causes of change were cataloged and described in detail below.

EXAMPLES OF CANOPY GAINS

Overall, the majority of canopy gains can be described by the following three categories: 1) new tree plantings and associated growth (figure 21 below), 2) natural regeneration of areas previously classified as vegetation (figure 24), and 3) growth/expansion of canopy previously existing at the time of the historical study. Causes one and two are documented with examples below. Cause three is the most discrete type and the most difficult to notice.

2018   **2022**

Figure 21. Tree canopy gains from 2018 to 2022 due to apparent tree planting efforts in between Steele Creek Rd and Sledge Rd.

2018   **2022**

Figure 22. Tree canopy gains attributed to growth and expansion of existing canopy near the intersection of E Independence Blvd and Briar Creek Rd.

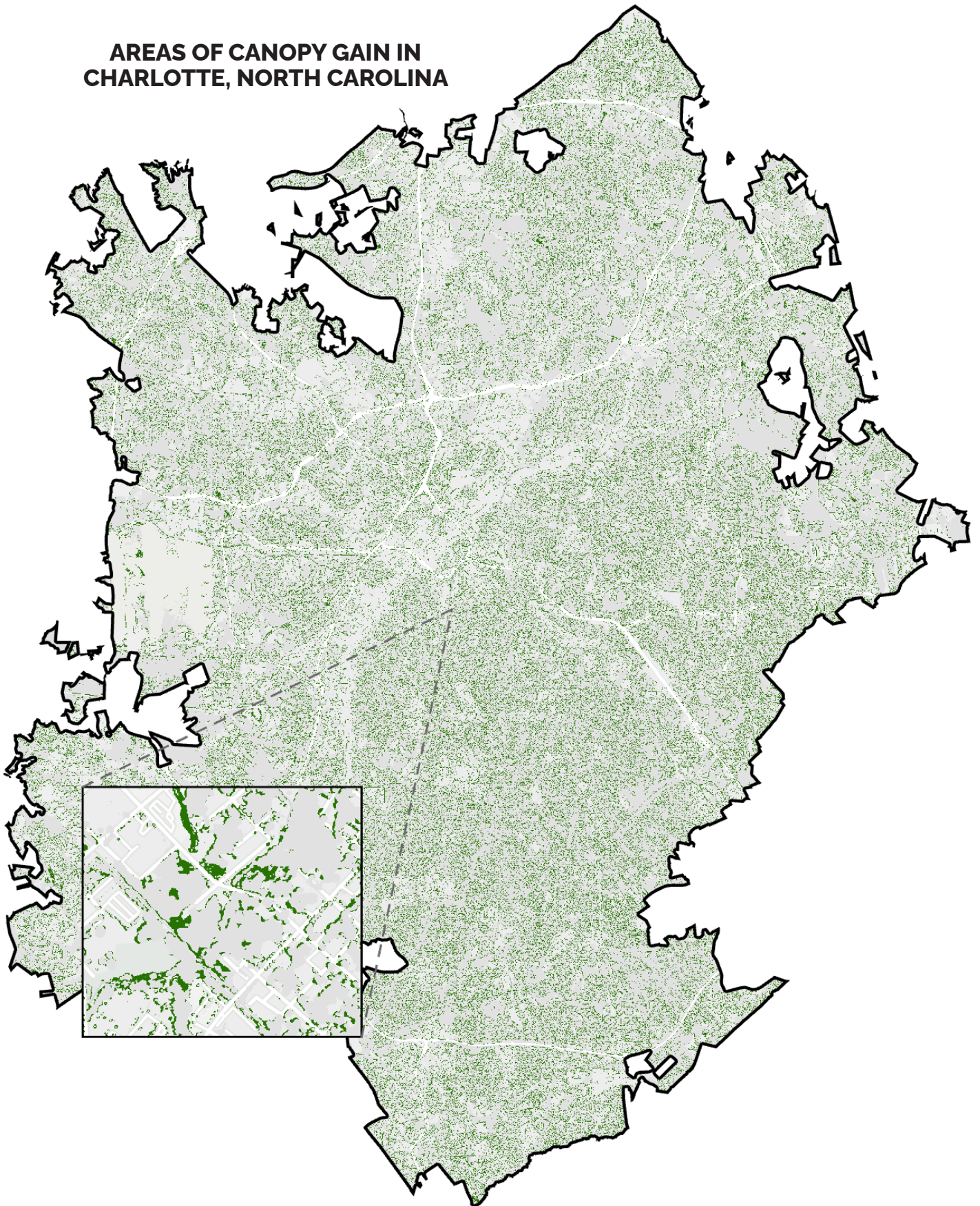**AREAS OF CANOPY GAIN IN
CHARLOTTE, NORTH CAROLINA**

Figure 23. In comparison to losses, tree canopy gains from 2018 to 2022 are much more difficult to detect. Because trees grow relatively slowly, positive increases often go unnoticed. The inset map provides a view of West Midtown.

EXAMPLES OF CANOPY LOSSES

Generally, large losses of canopy can be attributed to clearing for developments, residential and commercial development, as well as pruning or clear cutting for storm-water or utility rights-of-way access. Other potential agents of losses may be attributed to tree mortality due to climate change, hydrological shifts, or pressure from various pests and diseases. Figures 24 and 25 show the loss of canopy from 2018 NAIP imagery to 2022.

2018   **2022**

Figure 24. Tree canopy losses from 2018 to 2022 due to right-of-way clearing off of Margaret Wallace Rd along McAlpine Creek.

2018   **2022**

Figure 25. Tree canopy losses from 2018 to 2022 due to residential development activity between the intersection of Grier Rd and E W.T. Harris Blvd.

CONCLUSIONS

While canopy losses can be quite shocking and very apparent to the public eye, it's important to understand that most of the loss in canopy described in this report was in fact offset by the large number of gains described above. It's often difficult to notice the impact of growth of a tree or group of trees throughout the years, because these types of change happen so slowly. Gains are described by slow, incremental, and consistent changes from year to year, while losses are often defined by quick, sudden removal of large areas of woods and mature trees. It should also be noted that while most losses were offset, not all were. During the time period studied, the City experienced a net loss of canopy equal to just under 1,000 acres; that's about 10 times the footprint of Freedom Park!

AREAS OF CANOPY LOSS IN CHARLOTTE, NORTH CAROLINA
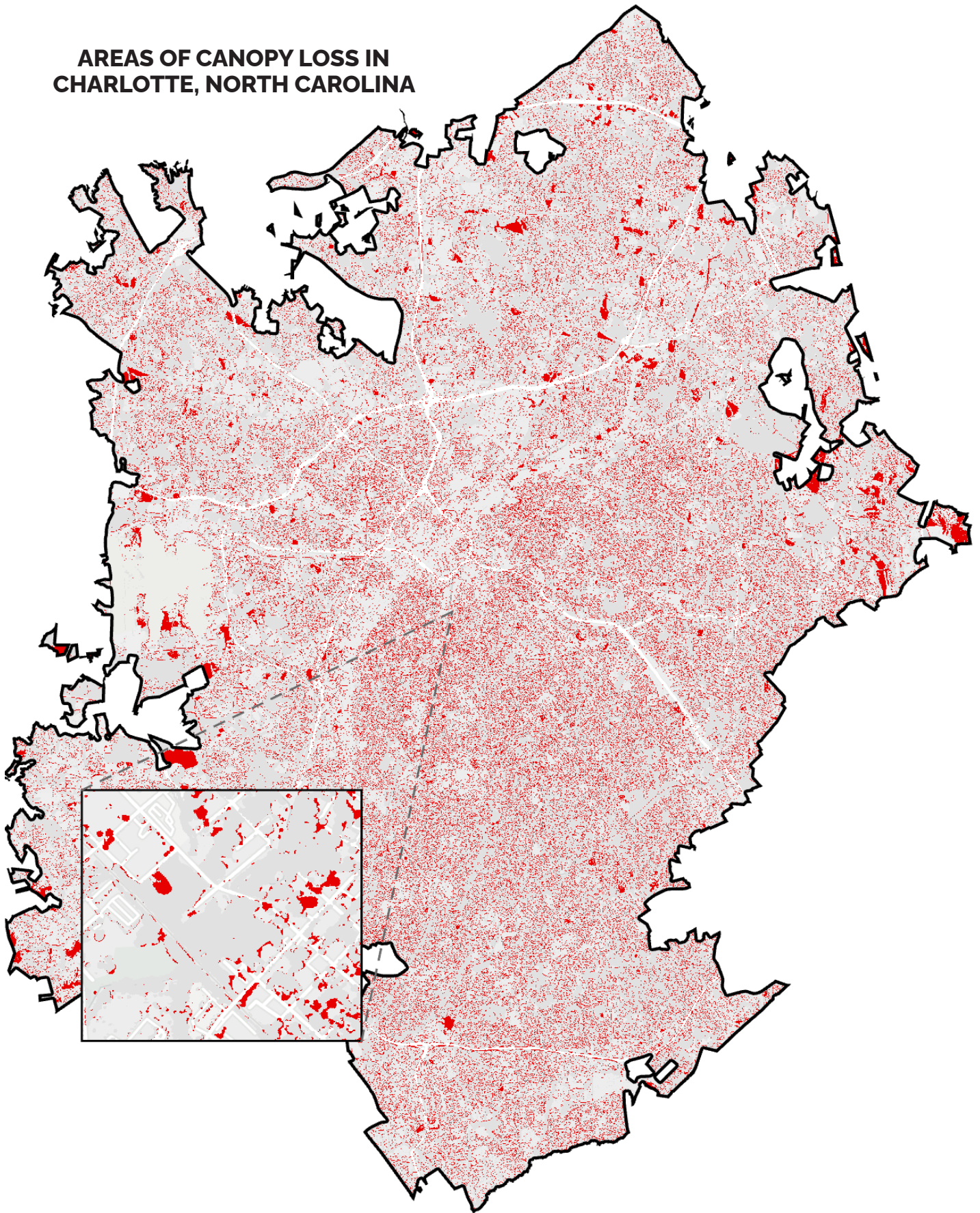
Figure 26. Tree canopy loss from 2018 to 2022 distributed throughout the City of Charlotte. In comparison to gains, losses were generally larger and more noticeable. In addition, the largest losses seem to be clustered around the perimeter of the city, perhaps in areas of fast population growth.

A NOTE ON TREE CANOPY AND INVASIVE SPECIES

In the summer of 2022, a comprehensive inventory analysis was performed by certified arborists from PlanIT Geo. The assessment cataloged over 185,895 total trees, encompassing a diverse array of over 100 distinct species. A noteworthy observation was the identification of 6,866 Callery pear trees constituting a significant portion of Charlotte's urban landscape. In Figure 29, one can discern 126 individual pear trees can be seen lining the avenues of Spring Street and Oaklawn Ave.

Within Charlotte's TreePlotter Inventory Application, non-native trees can be judiciously selected and reviewed for prospective maintenance strategies and replacement opportunities to work towards enhancing the quality, not just quantity, of the City's entire urban forest.

A robust tree canopy comprised of largely invasive species is not a healthy urban forest.

Figure 27. Callery pear data displayed in Charlotte's TreePlotter Inventory application

FORECAST ANALYSIS OF POSSIBLE
PLANTING SCENARIOS

A variety of possible planting scenarios were explored in order to assist the City and it's stakeholders in putting the urban tree canopy (UTC) and possible planting area (PPA) metrics derived in this study into action. These scenarios were designed to represent different approaches that urban forestry managers could take when deciding where to plant new trees and to help synthesize the UTC and PPA data with its goals, priorities, and available resources. Using PlanIT Geo's Canopy Calculator tool, target canopy cover goals were established for a given area of interest, and the amount of canopy required to achieve those targets (in both acres and number of trees planted) was calculated over a 27-year planning horizon. The calculator tool takes into account the estimated natural growth, regeneration, and loss of canopy due to mortality or development that would occur in that time frame. In this model, planting scenarios were explored for just the City of Charlotte's boundaries (199,022 land acres with 94,161 acres of canopy as of 2022).

With urbanization occurring rapidly across the City, public and private stakeholders would need to collectively plant 847,056 individual trees (or 31,372 per year) to maintain the existing current canopy cover (47%) If the City and other stakeholders continue with preexisting planting strategies (~6,500 trees per year), canopy is projected to decline to 40% amidst natural mortality and losses to development. Implementing the "attainable" urban canopy growth option, meant to represent a realistic level of canopy increase for Charlotte (40,462 trees per year), would increase the citywide canopy cover to 50% in 2050. On the other hand, if resources allow for "aggressive" urban planting schedule efforts (46,912 trees per year), the City could potentially grow it's city-wide canopy cover to 52%, a number similar to the current county-wide average.

CANOPY CALCULATOR ASSUMPTIONS

27	Planning Horizon (years)
1%	New Tree Mortality
1%	Annual Canopy Loss to Mortality
500	Annual Canopy Loss to Development (acres)
0.4%	Natural Regeneration
0.4%	Annual Canopy Growth

Tree size distribution (average crown radius at full maturity, percent of total tree population):

12.5 ft	Small Tree (15%)
15 ft	Medium Tree (35%)
30 ft	Large Tree (50%)

Table 1. *Planting scenario descriptions and results.*

Scenario	Goal	Citywide UTC % in 2023	Planting Required		Net Tree Canopy Change		Citywide UTC % in 2050	
			Total	Annual	Acres	%	Acres	%
Business as Usual Planting Trends	Calculate the city-wide canopy % in 2050 if ~6,500 trees continue to be planted per year for the next 27 years.	47%	177,328	6,568	-14,686	-7%	79,475	40%
Maintain Existing 47% UTC	Calculate the number of tree plantings required to maintain 47% canopy cover over the next 27 years.	47%	847,056	31,372	37	0%	94,199	47%
Attainable Growth	Calculate the number of tree plantings needed to grow the citywide canopy to 50% by 2050.	47%	1,092,465	40,462	5,433	3%	99,594	50%
Aggressive Growth	Calculate the number of tree plantings needed to grow the citywide canopy to 52% by 2050.	47%	1,266,626	46,912	9,261	5%	103,423	52%

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 the City of Charlotte, North Carolina. The following values were calculated using the USDA Forest Service's i-Tree Landscape tool with the City of Charlotte's total acres of urban tree canopy as the input data.

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 Charlotte removes approximately 6,990,000 pounds of air pollution annually, valued at over $16,600,000.

Trees and forests mitigate storm-water 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 the City absorbs 1,330 million gallons of water per year. Extrapolated city-wide, this means that Charlotte's existing canopy provides over $11.8 million annually in storm-water benefits.

Trees accumulate carbon in their biomass; with most species in a forest, the rate and amount increase with age. The trees of Charlotte store approximately 3.2 million tons of carbon, valued at over $560 million, and each year the tree canopy absorbs and sequesters 138,600 tons of carbon dioxide, valued at over $23.6 million.

TOTAL ANNUAL BENEFITS
Charlotte's trees annually provide **$52,131,770** in ecosystem benefits.

MENTAL HEALTH
People without views of nature from their desks claimed 23% more sick days than workers with views of nature.

WILDLIFE HABITAT
Planting and protecting trees provides habitat for Mecklenburg's +270 bird species.

CLEANER AIR
$16,605,517
Each year, Charlotte's roadside trees remove 3,493 tons of greenhouse gases.

ENERGY SAVINGS
Residents and businesses can save up to 50% on hot-day energy bills.

STORMWATER MANAGEMENT
$11,887,761
The City's tree intercepts 1,330 million gallons of runoff annually.

CARBON SERVICES
$23,638,491
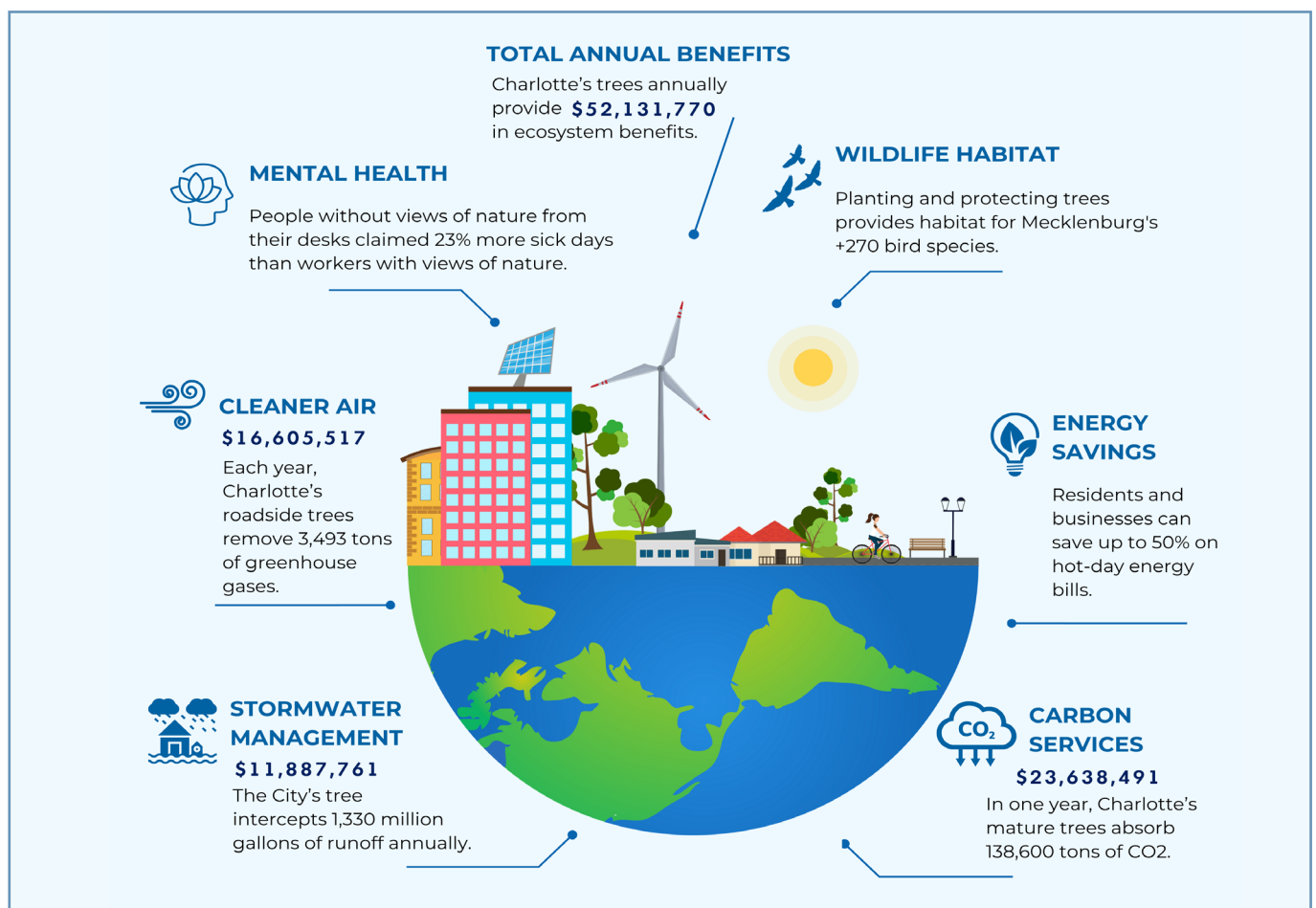In one year, Charlotte's mature trees absorb 138,600 tons of CO2.

Figure 28. Eco-benefits of Charlotte's urban forest derived from I-Tree. Additional data sourced from the Arbor Day Foundation and the EPA.

TREE PLANTING
PRIORITIZATION

URBAN HEAT ISLAND CRITERIA DESCRIPTION

Rapid development and urbanization often leads to the replacement of natural areas with dense concentrations of impervious surfaces. "Urban Heat Islands" (UHI) are defined as that area of high concentration of impervious surfaces which absorb and retain heat, leading to increases in energy costs, air pollution, and heat-related illness and mortality. The urban heat island effect results in increased temperatures of areas dominated by buildings, roads, and sidewalks and exacerbates issues already common to urban areas.

Trees can reduce the UHI effect by absorbing radiation from the sun and releasing moisture into the air. Broad leaves of tree canopy cover can lower surface temperatures by shading buildings, sidewalks, and other impervious surfaces, but also through evapotranspirative cooling (ET). The ET effect occurs as trees pull moisture out of the ground and evaporate gaseous water into the air, thereby converting heat energy into evaporation.

This priority criterion combined higher surface temperatures with availability of plantable space and considers these areas high priority for tree planting. Rankings are sorted from highest priority (dark blue) to lowest priority (light yellow).

The data derived from this analysis can be used to highlight areas in high need of planting to mitigate the UHI effect. At first glance, many of the heavily urbanized areas around Mecklenburg County and within the City of Charlotte can be easily isolated on the map to the right. While these areas should be targeted for planting programs within the City or organized and funded by non profit organizations, it is important to consider this in comparison to possible planting area data provided as part of this project. These data should be used in conjunction to set realistic planting goals for each local area.
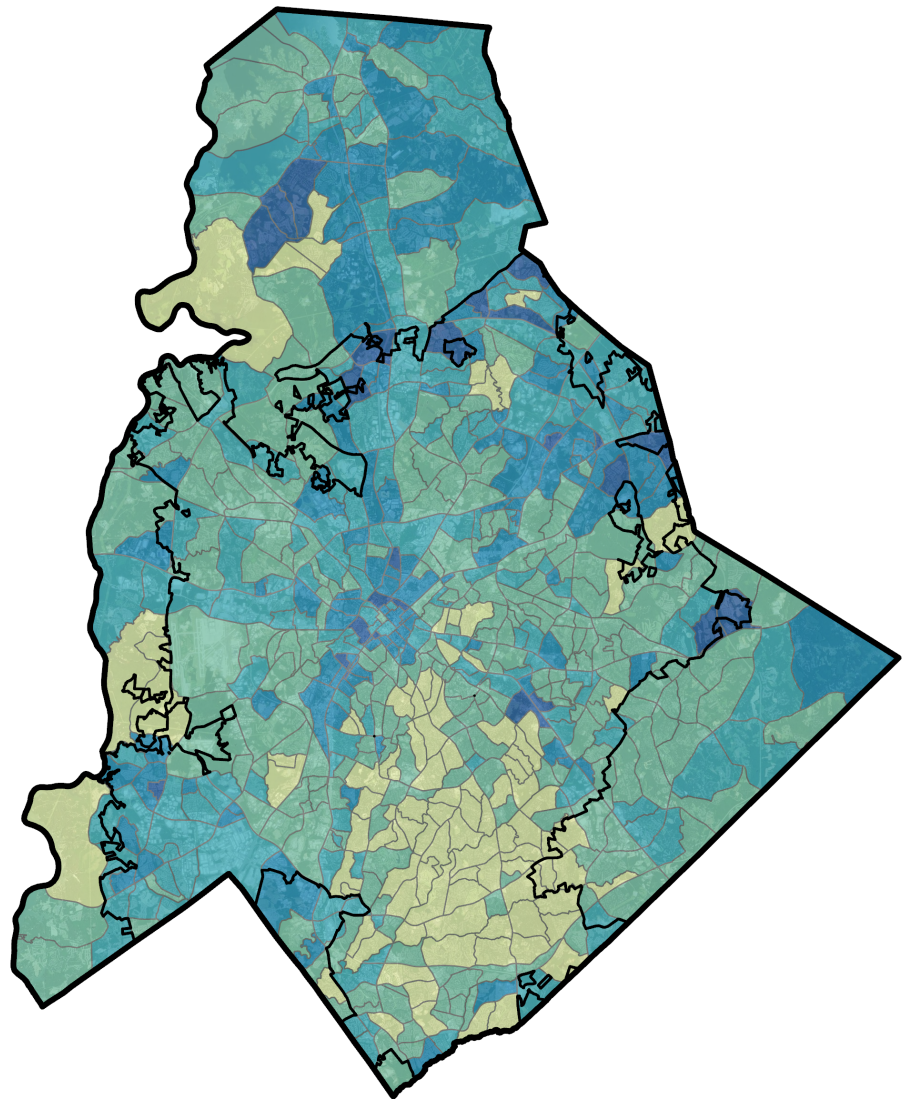
Figure 29. Urban heat island and plantable space prioritization by census block groups. Severity is measured on a scale of 0 to 1, with 0 being a relatively mild heat area (shown in light yellow), and 1 being a severe heat area (dark blue).

Highest Priority   Lowest Priority

CONCLUSIONS AND
RECOMMENDATIONS

SUMMARY OF KEY FINDINGS

Overall, both the City of Charlotte and the surrounding areas within Mecklenburg County have very large resource of Urban Tree Canopy and Plantable Spaces. Along with this resource comes the responsibility to protect and preserve the green infrastructure, especially in light of the current rapid pace of urbanization, development and overall growth. The key findings in the figure below represent a selection of actionable findings that this analysis uncovered. Page numbers with links are included for quick reference to the most important information.

• • • **PAGE 11** • • •
Tree canopy within City boundaries is declining, but not as fast as indicated by some previous estimates (this study saw a -0.5% decline).

• • • **PAGE 13** • • •
The City's ETJ areas have 16% higher UTC compared to the City, and represent a prime area of focus for tree preservation in the midst of rapid economic and population growth.

• • • **PAGE 14** • • •
City-owned properties (ROW excluded) experience an overall gain in canopy over the 4-year study period (+0.3%); ROW areas had low UTC at 28%, but also experienced similar growth.

• • • **PAGE 15** • • •
3 out of 7 City Council Districts saw a decline in canopy, while the others indicated small gains or were relatively stable in gains v. losses.

• • • **PAGE 17** • • •
Out of all Place Types, Parks & Preserves was the only type to experience a gain; Neighborhood Center experienced the fastest rate of loss at 3% over the 4 year study period.

• • • **PAGE 19** • • •
Charlotte's tree canopy (47%) was significantly lower than that of other Jurisdictions within Mecklenburg County (50%). Additionally, the City was among 3 others that experienced a loss.

• • • **PAGE 20** • • •
Half of the County's 28 watersheds experienced a significant decline in canopy.

• • • **PAGE 24** • • •
Substantial losses to development were observed especially around the perimeter of the City, but significant canopy growth and planting balanced out much of the loss.

RECOMMENDATIONS

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. While the County as a whole has exceeded 50% canopy coverage, it remains imperative to preserve and growth of the existing canopy as development continues. Additionally, the City of Charlotte should continue to strive for its short and long-term goals, such as those mentioned in Charlotte's Tree Canopy Action Plan, to achieve an average canopy cover of 50% by 2050. These goals can include setting an annual canopy planting goal or improving the quality of tree cover by planting a variety of large maturing trees when possible. Preserves and green spaces will need to drastically improve their canopy area to bring up the City's average and reverse the marginal downward trend of the City's urban forest cover.

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

Mecklenburg County and its various stakeholders can utilize the results of the UTC and PPA analyses to identify the best locations on public 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 could 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. The UHI priority planting analysis should be used to identify census block groups with the greatest need for canopy expansion. The census block groups with the highest surface temperature and largest concentration of plantable space were generally concentrated near Brookhill and Double Oaks neighborhoods. Targeting high ranking census block groups for tree plantings can help offset negative effects of urban heat islands, storm-water runoff, and excessive energy consumption.

Additionally, the right-of-way often contains high concentrations of impervious surfaces. Utilizing the 4,634 acres of plantable space in the right-of-way could provide significant shading for walkways and roadways. Jurisdictions within Mecklenburg County can develop and continue proactive street tree maintenance programs to take on the responsibility of planting and managing street trees, ensuring healthy trees are distributed equitably across the city. Each jurisdiction 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.

3. Update Charlotte's Tree Canopy Action Plan (TCAP)

Charlotte 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. Refining management strategies and revisiting strategic documentation can empower the county and it's stakeholders to not only evaluate its progress towards current objectives, but also formulate new ones as well. In the 2022 TCAP, the City of Charlotte provided the following recommendations for tree canopy on different Place Types:

Place Type	UTC Goal %	Current UTC %
Parks & Preserves	90%+	78%
Neighborhood 1	50% - 60%	59%
Neighborhood 2	35% - 45%	47%
Campus	40 - 50%.	44%
Community Activity Center	20% - 30%.	40%
Manufacturing & Logistics	25% - 35%.	37%
Commercial	25% - 35%.	35%
Innovation Mixed-Use	35% - 45%	29%
Neighborhood Center	25% - 35%	29%
Regional Activity Center	15 - 25%	22%

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 monitor the growth of non-native species. Additionally, TreePlotter can be used 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 2022 in North Carolina 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-2024 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 2022. 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 one sample points, or approximately 1.3 points per square mile area in Mecklenburg County (546 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 Mecklenburg County'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 (131 + 258 + 264 + 67 + 10 = 730/750 = 97.3%), and the matrix can be used to calculate per class accuracy percentage's. For example, 258 points were manually identified in the reference map as non-canopy vegetation, and 267 of those pixels were classified as non-canopy vegetation 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 non-canopy vegetation is calculated as: (258/267 = .966), meaning that we can expect that ~97% of all 2022 non-canopy vegetation in Mecklenburg County, NC study area was classified as non-canopy vegetation in the 2022 classification map. This also applies to tree canopy classifications.

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, classification pixels intersecting reference pixels were classified as Tree Canopy, and 10 pixels were identified as canopy in the reference map. Therefore, the User's Accuracy for Tree Canopy is calculated as: (131/134 =.977), meaning that ~98% 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 Mecklenburg County in 2022. The largest sources of classification confusion exist between tree canopy and impervious.

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 Mecklenburg County, NC (2022).

		Reference Data					
		Tree Canopy	Vegetation	Impervious	Soil / Dry Veg.	Water	Total Reference Pixels
Classification Data	Tree Canopy	131	3	0	0	0	134
	Vegetation	9	258	0	0	0	267
	Impervious	1	6	264	1	0	272
	Soil / Dry Veg.	0	0	0	67	0	67
	Water	0	0	0	0	10	10
	Total	141	267	264	68	10	750

Overall Accuracy = 97%

Producer's Accuracy	
Tree Canopy	93%
Veg. / Open Space	97%
Impervious	100%
Bare Ground / Soil	99%
Water	100%

User's Accuracy	
Tree Canopy	98%
Veg. / Open Space	97%
Impervious	97%
Bare Ground / Soil	100%
Water	100%

ACCURACY ASSESSMENT RESULTS

Interpretation of the sample error matrix offers some important insights when evaluating Mecklenburg County'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 2022 data indicates that regardless of how and when it was achieved, Mecklenburg County's current tree canopy can be safely assumed to match the figures stated in this report (approximately 52%).

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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.

PLACE TYPES AND THEIR GOALS

Campus: Relatively cohesive group of buildings and public spaces that are all serving one institution such as a university, hospital, or office park.

Goal: Provide places for large, multi-building institutions, such as educational, religious, civic, or health facilities, or for a concentration of office and research and development uses.

Commercial: Primarily car-oriented destinations for retail, services, hospitality, and dining, often along major streets or near interstates.

Goal: Provide places for the sale of goods and services in locations readily accessible by automobile.

Community Activity Center: Mid-sized mixed-use areas, typically along transit corridors or major roadways, that provide access to goods, services, dining, entertainment, and residential for nearby and regional residents.

Goal: Provide places that have a concentration of primarily commercial and residential activity in a well-connected, walkable place located within a 10-minute walk, bike, or transit trip of surrounding neighborhoods.

Innovation Mixed-Use: Places are vibrant areas of mixed-use and employment, typically in older urban areas, that capitalize on Charlotte's history and industry with uses such as light manufacturing, office, studios, research, retail, and dining.

Goal: Contribute to Charlotte's economic viability by providing mixed-use urban places that include light manufacturing, office, residential, and retail.

Manufacturing & Logistics: Places are employment areas that provide a range of job types, services, and wage levels in sectors such as production, manufacturing, research, distribution, and logistics.

Goal: Contribute to Charlotte's economic viability by accommodating places of employment for a range of uses related to manufacturing, logistics, production and distribution.

Neighborhood 1: Places are the lower density housing areas across Charlotte, where most of the city's residents live, primarily in single-family or small multi-family homes or ADUs.

Goal: Provide places for neighborhoods with a variety of housing types, where single-family housing is still the predominant use.

Neighborhood 2: places are higher density housing areas that provide a variety of housing types such as townhomes and apartments alongside neighborhood-serving shops and services.

Goal: Provide a range of moderate to higher intensity housing types, including apartment and condominium buildings, to meet the needs of a diverse population.

Neighborhood Center: Small, walkable mixed-use areas, typically embedded within neighborhoods, that provide convenient access to goods, services, dining, and residential for nearby residents.

Goal: Provide places that have a pedestrian-friendly focal point of neighborhood activity where nearby residents can access daily shopping needs and services within a 5-10 minute walk or a short drive.

Parks & Preserves: serve to protect public parks and open space while providing rest, recreation, and gathering places for Charlotteans.

Goal: Protect land that is intended to remain as parks or natural preserves in perpetuity. These places contribute to the quality of life of residents and visitors by providing places to gather and recreate, and further the environmental quality of our ecosystems including the tree canopy, waterways, and wildlife habitats.

Regional Activity Center: Large, high-density mixed-use areas, typically along transit corridors or major roadways, that provide access to goods, services, dining, offices, entertainment, and residential for regional residents and visitors.

Goal: Provide major employment locations and cultural destinations for residents from throughout the Charlotte region.

FULL DESCRIPTIONS CAN BE FOUND IN THE 2040 COMPREHENSIVE PLAN

URBAN TREE CANOPY

ASSESSMENT

CHARLOTTE, NORTH CAROLINA