URBAN TREE CANOPY

# ASSESSMENT

BROOKHAVEN,

GEORGIA

MAY | 2020

Brookhaven GEORGIA

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AN ASSESSMENT OF
URBAN TREE CANOPY

# BROOKHAVEN, GEORGIA

> **Someone is sitting in the shade today because someone planted a tree a long time ago.**
> **-Warren Buffet**


**PREPARED BY**
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**PREPARED FOR**
City of Brookhaven, GA

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**3,411 CANOPY ACRES**

**44% CANOPY COVER**

**4% LOSS OF CANOPY SINCE 2009**

# EXECUTIVE SUMMARY

## PURPOSE OF THIS ANALYSIS

The City of Brookhaven is located within DeKalb County, Georgia in the Atlanta metropolitan area (Figure 1). It is approximately 11 square miles or 7,805 acres of which 7,739 are land acres. Across the City, trees along streets, in parks, yards, and natural areas constitute a valuable urban and community forest. This resource is a critical element of the region's green infrastructure, contributing to environmental quality, public health, water supply, local economies, and aesthetics. The primary goal of this assessment was to provide a baseline and benchmark of the City's tree canopy, interpret the results across the City's zoning types, and evaluate how canopy has changed over the last decade using data from previous assessments as well as newly created data.

## URBAN TREE CANOPY IN BROOKHAVEN

Land cover results of this study indicated that in 2019, the city of Brookhaven contained 44% urban tree canopy (or 3,411 of the City's 7,805 total acres); 21% non-canopy vegetation (1,632 acres); 33% impervious (2,570 acres); 2% soil/dry vegetation (125 acres); and 1% water (67 acres). In order to align with previous studies all results are based on the total area of the City as opposed to the more commonly used land area (total area minus water area). Urban tree canopy cover was 47% (3,700 acres) in 2009, 51% (4,006 acres) in 2010, 49% (3,791 acres) in 2013, 53% (4,114 acres) in 2015, and 50% (3,939 acres) in 2017. Tree canopy data from previous studies in 2010, 2013, and 2015 were combined with newly created data for annexations that occurred after these studies in order to make an even comparison between citywide datasets using the current (2019) boundary.

## ASSESSMENT BOUNDARIES

This study assessed UTC throughout the City as well as within zoning types in order to provide actionable information to a diverse range of audiences. By identifying the resources and opportunities that exist at these scales, the City can be more proactive in their approach to protect and expand their urban tree canopy. Metrics were generated at the following geographic scales: the citywide boundary (1); and zoning types (4).

## RECOMMENDATIONS

The results of this analysis can be used to develop a continuing strategy to protect and expand the urban forest in Brookhaven. The UTC metrics can be used as a guide to determine where the City has been successful in protecting and expanding its urban forest resource, while also targeting areas to concentrate future efforts based on needs, benefits, and available planting space. Brookhaven can use these results to ensure that their urban forest policies and management practices continue to prioritize the maintenance, health, and growth of the urban forest.

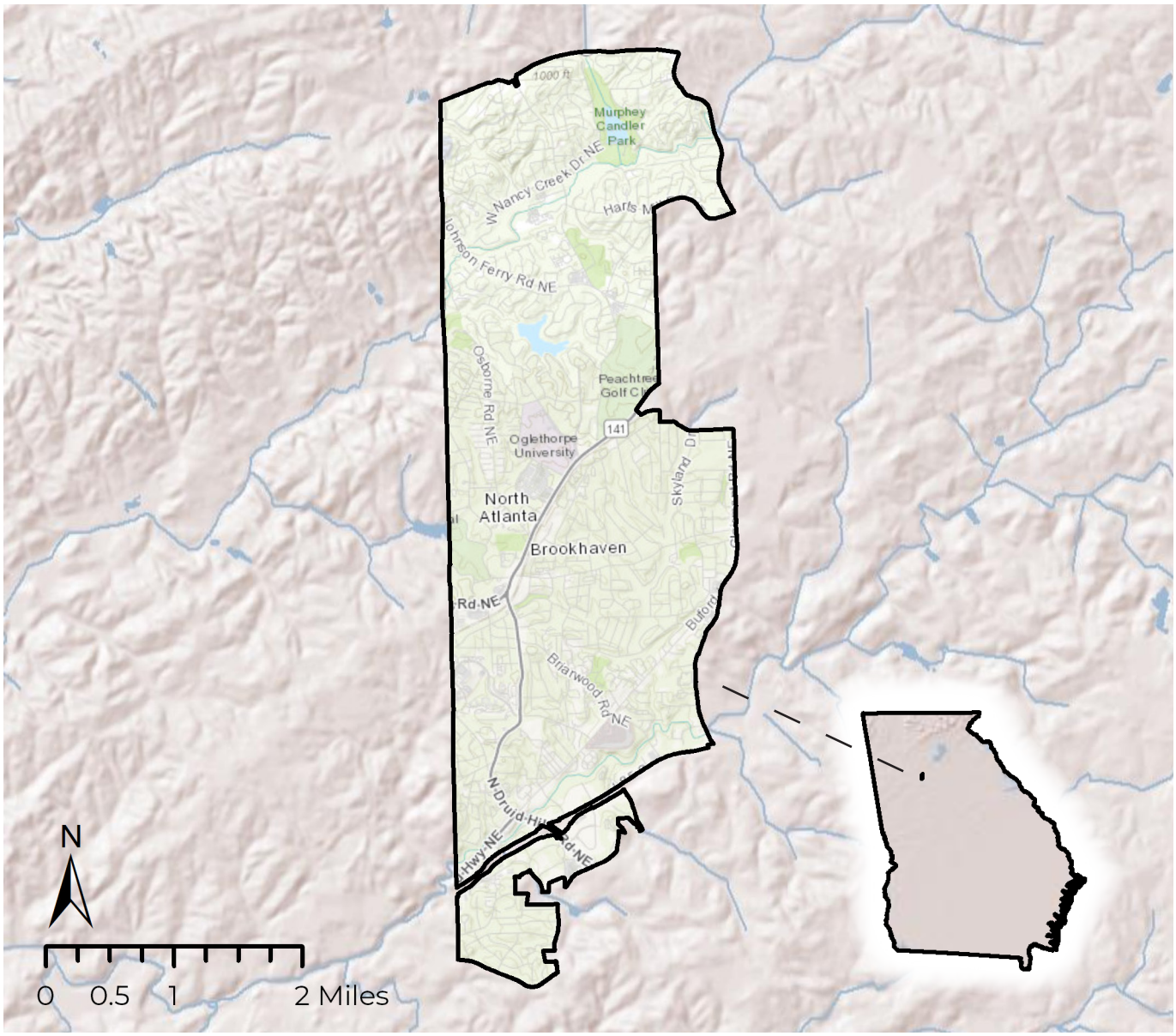



*Figure 1. | Brookhaven occupies approximately 11 square miles in DeKalb County, Georgia.*

**44%**
**URBAN TREE CANOPY**

**21%**
**NON-CANOPY VEGETATION**

**33%**
**IMPERVIOUS SURFACE**

***Figure 2. | Based on an analysis of 2019 high-resolution imagery, Brookhaven contains 44% tree canopy, 21% non-canopy vegetated areas that may or may not be able to support canopy in the future, and 33% total impervious areas.***

# PROJECT METHODOLOGY

Land cover and urban tree canopy were mapped using the sources and methods described below. These datasets provide the foundation for the metrics reported at the selected geographic assessment scales.

## DATA SOURCES

This assessment utilized high-resolution (1-meter) multispectral imagery from the U.S. Department of Agriculture's National Agriculture Imagery Program (NAIP) collected in September 2019 to derive the land cover dataset. Additional GIS layers provided by the City of Brookhaven were also incorporated into the analysis.

## MAPPING LAND COVER

An initial land cover dataset was to be created prior to mapping tree canopy. The land cover data set is the most fundamental component of an urban tree canopy assessment. An object-based image analysis (OBIA) software program called Feature Analyst was used to classify features through an iterative approach. In this process, objects' spectral signatures across four bands (blue, green, red, and near-infrared), textures, and pattern relationships were considered. This remote sensing process used the NAIP imagery to derive five initial land cover classes. These classes are shown in Figure 3 and described in the Glossary on page 16. After manual classification improvement and quality control were performed on the remote sensing products, additional data layers from the city including buildings and roads were utilized to capture finer feature detail and further categorize the land cover dataset.


*Figure 3. | Five (5) distinct land cover classes were identified in the 2019 tree canopy assessment: urban tree canopy, other non-canopy vegetation, bare soil and dry vegetation, impervious (paved) surfaces, and water.*

## DEFINING ASSESSMENT LEVELS

In order to best inform the City Council and Brookhaven's various stakeholders, urban tree canopy and other associated metrics were tabulated across the city boundary and zoning types. The City of Brookhaven citywide boundary is the one (1) main area of interest over which all metrics are summarized. Four (4) unique zoning types were assessed to provide detail on tree canopy within the current human uses of land across the city. These areas are aggregates of the City's zoning categories

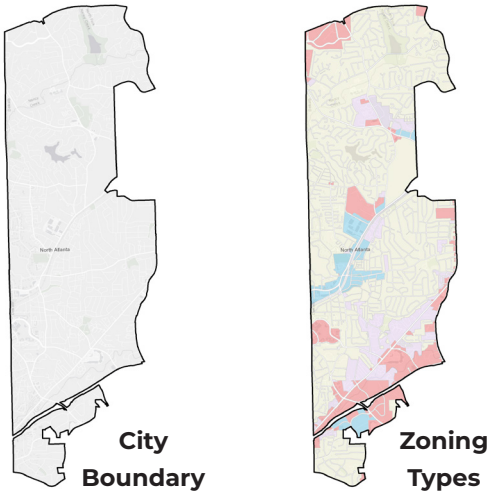



*Figure 4. | Two geographic boundaries were explored in this analysis: the city boundary and zoning types.*

## GROUND-TRUTHING

Most tasks in this study were performed remotely with the exception being a field-based sampling and measurement of trees in Brookhaven. These field measurements were carried out by a local non-profit organization, Trees Atlanta. Prior to the field measurements, PlanIT Geo worked with the City to select four sample sites, one in each city council district, each less than one acre in size and located within city parks. Using data and maps provided by PlanIT Geo, Trees Atlanta staff visited the selected sample sites. To measure the canopy perimeter or dripline of all trees located within each sample site, a Trimble R1 GNSS unit was used in conjunction with an Android tablet and ESRI's Collector for ArcGIS application. Trees Atlanta staff drew polylines by tracking their location and walking the dripline of each tree within each site. The polylines were then converted to shapefile format and converted to polygons to represent each tree's canopy. The area of the field-based tree canopy polygons was calculated and compared to the 2019 tree canopy area. These field-based tree canopy polygons were also overlaid on top of 2019 tree canopy data to look for inconsistencies in shape, size, and location of each tree measured.

***Table 1. | Ground-truthing sample site areas, field canopy measurement results, tree canopy area, and comparison.***

| Site/Park Name | Sample Site Total Area | Urban Tree Canopy | | |
|---|---|---|---|---|
| | *Acres* | *Remote Sensing (acres)* | *Surveyed (acres)* | *Difference (%)* |
| **1 - Lynwood Park** | 0.74 | 0.42 | 0.44 | 96% |
| **2 - Parkside Park** | 0.69 | 0.45 | 0.49 | 92% |
| **3 - Clacks Corner Park** | 0.39 | 0.17 | 0.17 | 99% |
| **4 - Peachtree Creek Greenway** | 0.97 | 0.06 | 0.08 | 76% |

## RESULTS

In all four sample sites, the 2019 assessment data estimated tree canopy area to be slightly less than the area calculated by field measurements. In each sample site, there was less than a tenth of an acre difference in canopy area. The differences that were observed can occur due to new tree plantings and removals since the 2019 imagery was collected, natural growth, and imagery shift. An example of new planting was found in the Peachtree Creek Greenway sample site. Much of the tree canopy area there was labeled by field staff as "New Planting". This area is likely to have had many new plantings due to its recent development into a multi-use pathway and greenspace. To account for this inconsistency, newly planted areas were removed before any comparisons were made. The sample site located in Clack's Corner Park was the only site where a tree was removed after the 2019 NAIP imagery was collected. Adjusting the 2019 data to reflect the removal did not have a significant effect on the ground-truthing results. Overall, ground-truthing measurements showed strong similarities with the remotely sensed data 2019 tree canopy classification and warranted no further remote sensing classification or manually editing of the tree canopy data. These results also highlight the dynamic nature of tree canopy and aerial imagery and stress the importance of comparing multiple years of tree canopy data to identify larger trends at the citywide scale.

# 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, or metrics, help inform a strategic approach to identifying existing canopy and future planting areas. Land cover percentages are based on the total area of interest.

## CITYWIDE LAND COVER

In 2019, tree canopy constituted 44% of Brookhaven's land cover; non-canopy vegetation was 21%; soil/dry vegetation was 2%; impervious was 33%; and water was 1%. These generalized land cover results are presented below in Table 2.

The impervious land cover class was then subdivided into more specific classifications. Approximately 10% of Brookhaven was buildings, 6% was roads, and 17% was "other impervious". The detailed land cover results, including impervious classifications, are presented in Figure 5.

***Table 2. | Generalized land cover classification results.***

| City Boundary | City Boundary | Tree Canopy | Non-Canopy Vegetation | Impervious Surfaces | Soil & Dry Vegetation | Water |
|---|---|---|---|---|---|---|
| **Acres** | 7,805 | 3,411 | 1,632 | 2,570 | 125 | 67 |
| **% of Total** | 100% | 44% | 21% | 33% | 2% | <1% |

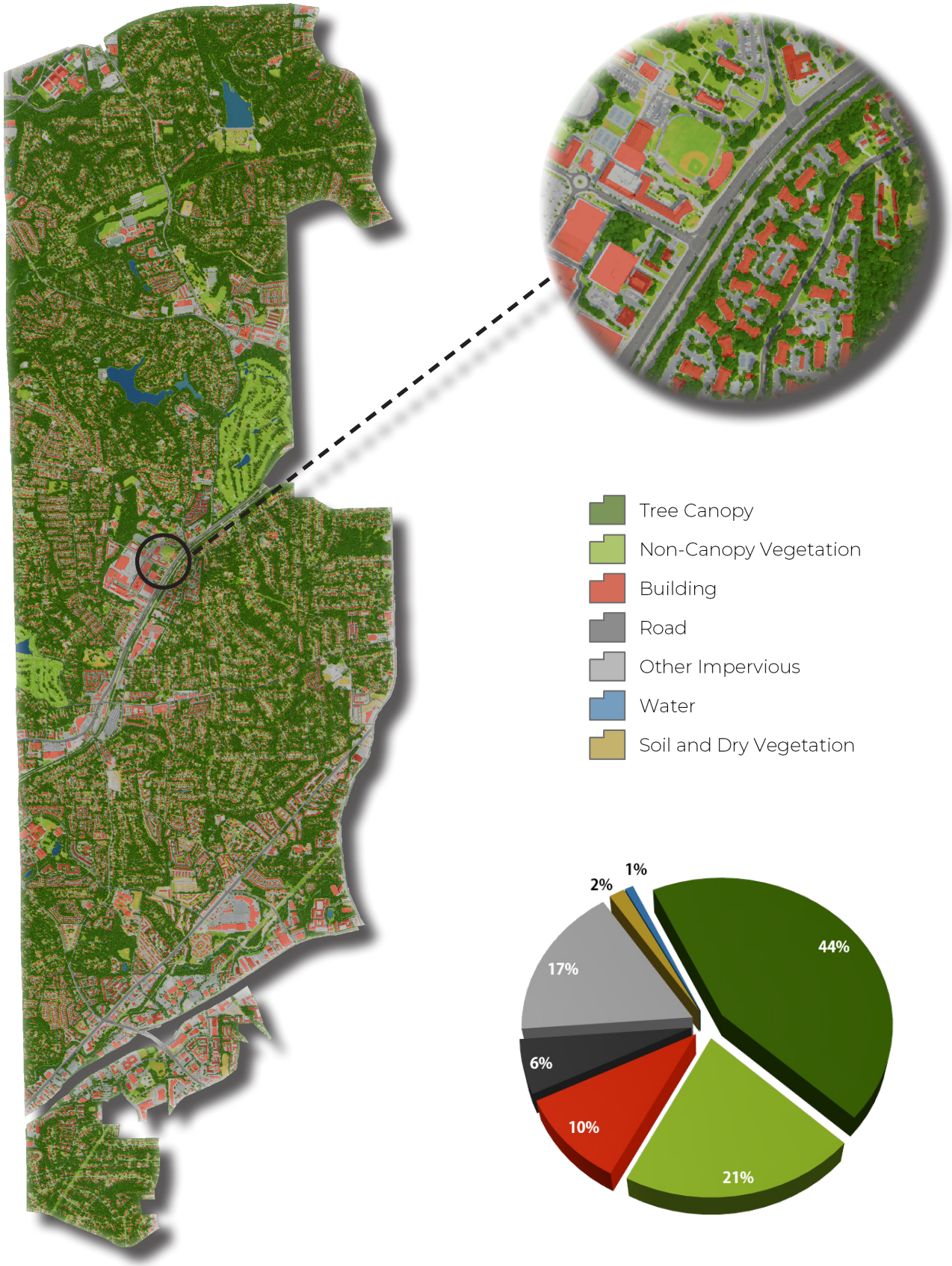



*Figure 5. | Land cover classes for Brookhaven, Georgia based on 2019 NAIP imagery and data provided by the City. (Percentages based on total acres of the City.)*

## URBAN TREE CANOPY BY ZONING

Urban tree canopy was assessed for four zoning types in Brookhaven. UTC varied greatly throughout the different zoning types with the lowest UTC found in Mixed-Use (24%) and the highest found in Single Family Residential Areas (52%). Mixed-Use areas consisted of mixed residential and commercial areas from the original zoning layer provided by the City. Residential areas as a whole made up 81% of the City, and 87% of all canopy cover is found in these areas.

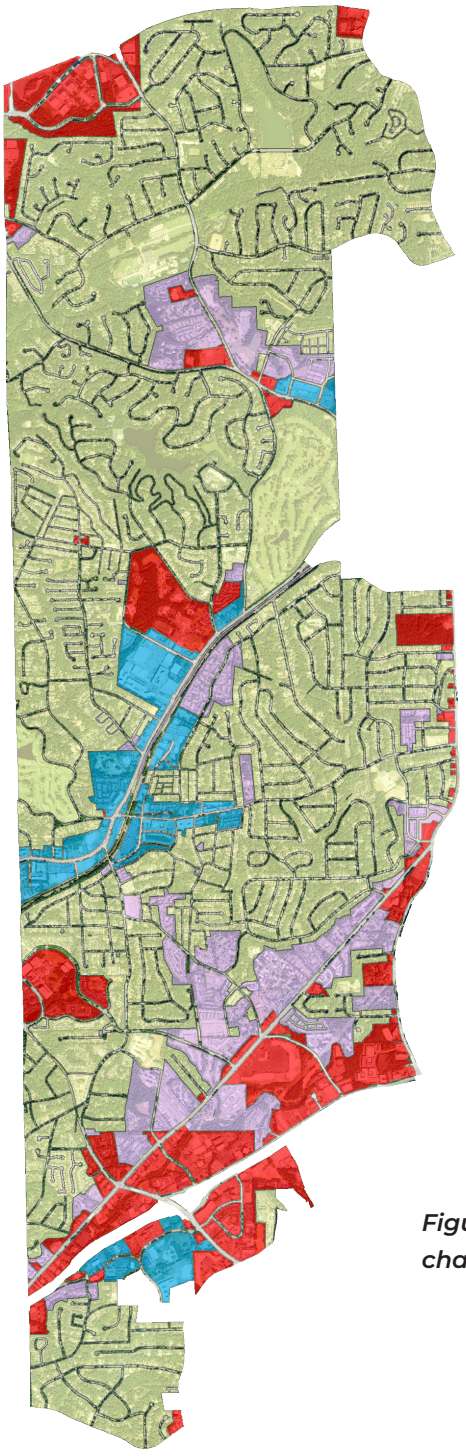


*Table 3. | Urban tree canopy assessment results by zoning type. UTC results include acres, percent of area covered by UTC (%), and distribution of the City's total UTC within each zoning type.*

| Zoning | Total Area | | Urban Tree Canopy | | |
|---|---|---|---|---|---|
| | *Acres* | *Dist.* | *Acres* | *%* | *Dist.* |
| **Commercial/ Industrial Areas** | 937 | 14% | 314 | 33% | 10% |
| **Mixed-Use** | 355 | 5% | 84 | 24% | 3% |
| **Multifamily Residential Areas** | 730 | 11% | 262 | 36% | 8% |
| **Single Family Residential Areas** | 4,706 | 70% | 2,446 | 52% | 79% |
| **Totals** | **6,728** | **100%** | **3,106** | **46%** | **100%** |

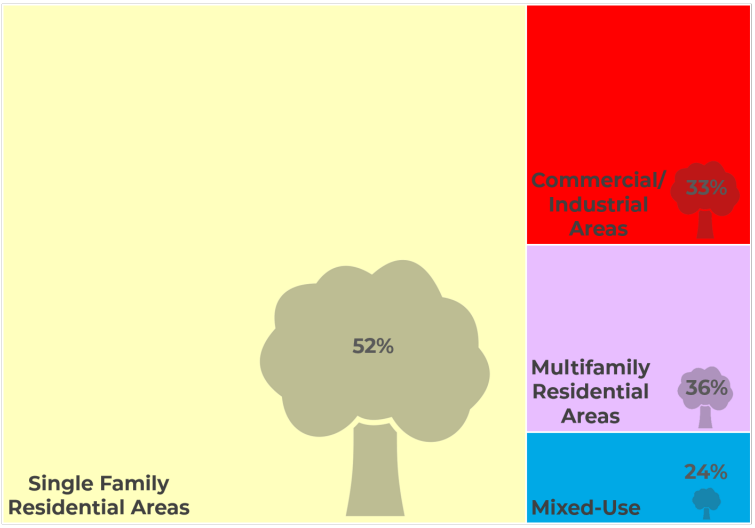



*Figure 6. | A map of zoning types in Brookhaven (left). The treemap chart (above) shows the proportional distribution of land in each zoning type as well as the UTC% within each zone.*

## URBAN TREE CANOPY CHANGE

In addition to assessing Brookhaven's current urban tree canopy, this study also quantified changes in urban tree canopy using data from previous assessments (2010, 2013, 2015) and data created during this study (2009, 2010, 2013, 2015, 2017). Data from 2010, 2013, and 2015 were created by InterDev - Atlanta in a January 2017 study using the same National Agriculture Imagery Program (NAIP) aerial imagery source as this assessment. Since the 2017 study, the City has annexed several areas in DeKalb County that are south of Interstate Highway 85 including Executive Park, Briarcliff Commons, and LaVista Park. These areas increased the City's size by over 500 acres. In order to make the most even comparison between the canopy coverage in each year, tree canopy data were created in these annexations in all years to fully cover the current (2019) city boundary. Tree canopy cover acreages and percentages in 2010, 2013, and 2015 will, therefore, differ from those listed in the 2017 report.

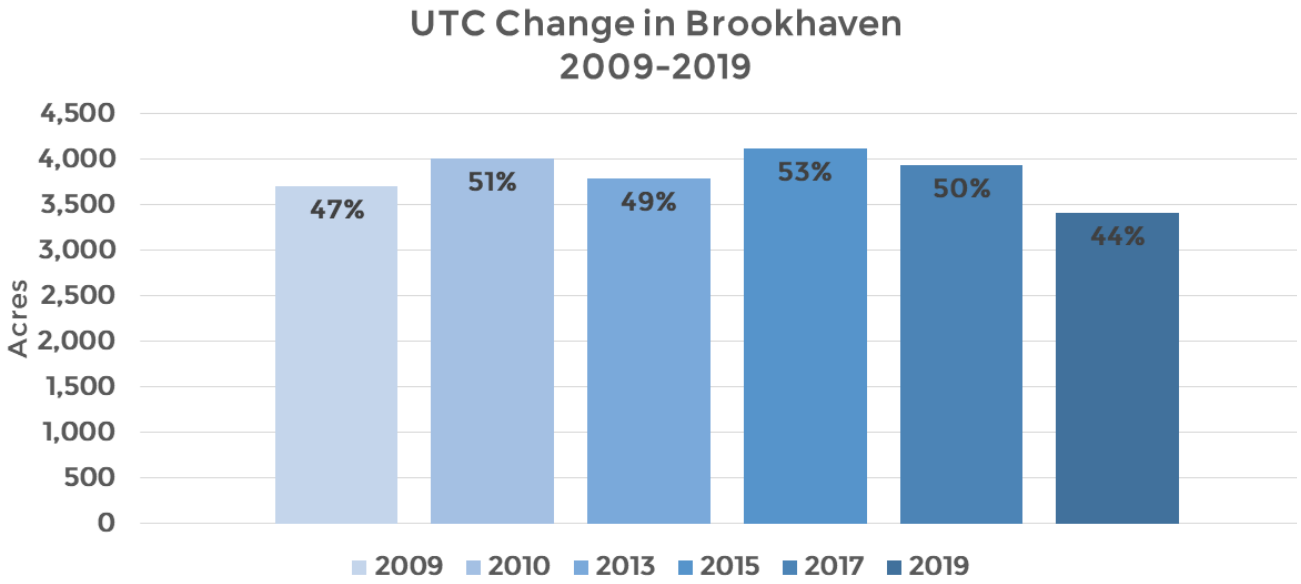



*Figure 7. | Urban tree canopy coverage over the last decade. While canopy cover has increased and decreased over the years, a net loss was experienced between 2009 and 2019.*

Current urban tree canopy coverage in Brookhaven is 44% with 3,411 acres. In 2009, urban tree canopy covered 47% of the 2019 city boundary with 3,700 acres. Throughout the years of canopy measurement, both tree canopy gains due to natural growth, regeneration, and tree planting and canopy losses due to new developments were noted. A net total of 289 acres of canopy were lost equating to a change of -4% throughout the City. Tree canopy gains often occur at a much slower rate and are much less noticeable than losses especially in metropolitan areas experiencing developmental growth.


*Figure 8. | Examples of urban tree canopy loss in red (left and center) and gain in yellow (right).*

Despite using similar imagery sources, the two studies had significant differences. The technical remote sensing method in the previous study was an Iso Cluster Unsupervised Classification which is a traditional pixel-based image classification technique. This study used object-based image analysis which identifies objects based on contextual clues rather than just looking at the spectral signatures of individual pixels. It produces a cleaner, less pixelated, and more accurate dataset.

The Quality Assurance and Quality Control procedures also appear to be less thorough in the previous study. In the 2010 data, some open space areas were partially classified or, in the case of one baseball field, entirely classified as tree canopy. Many other examples of inaccuracies and overestimations exist throughout the data. Several examples are shown below in Figure 9.

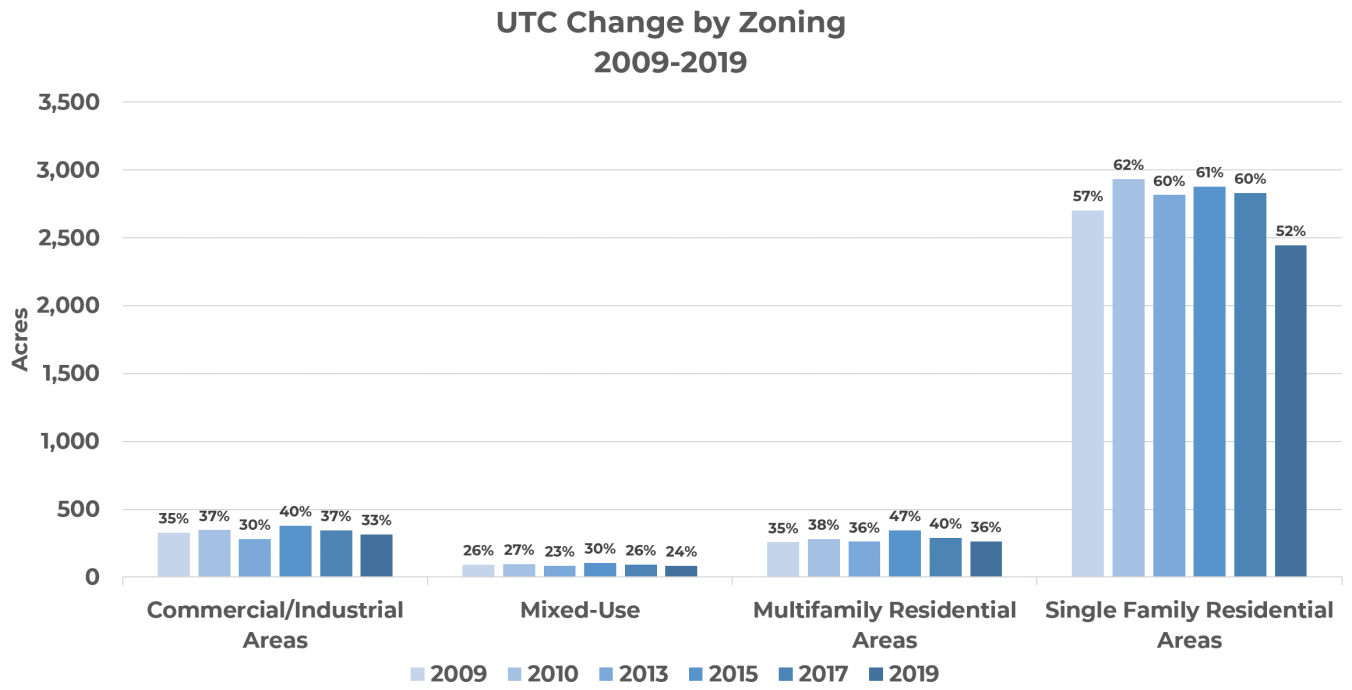
***Figure 9. | Examples of problems with data from the previous 2017 study. An entire baseball field was classified as tree canopy (left, 2010), a track had tree canopy in the middle of it in open and shadowed areas (middle, 2010), and there were highly overestimated areas such as open space, power line corridors, golf courses, and residential lawns (right, 2015).***

Data created in this study for 2017 were also problematic. In this case, the source imagery (NAIP 2017) appeared to create an overestimation of tree canopy cover. The overestimation was due to a large area of the City where the imagery was collected at an angle. This can cause trees and other tall objects to appear to cover a larger area than they actually do. This phenomenon can be seen in the images below where the trees in the left image (2017) appear to lean to the west (left) and cover a larger area than they do in the right image (2019). Notice how the tree canopy covers much more of north-south running Granger Dr. in 2017 than it does in 2019. When this overestimation is extended across the entire City, it can have a great impact on the overall canopy coverage observed in 2017. Even with this overestimation, many new developments did take place between 2017-2019 and it is likely there was an actual loss in canopy coverage.


***Figure 9. | A comparison of NAIP imagery in 2017 (left) and 2019 (right). The relatively large off-nadir angle in 2017 causes trees to lean in one direction and appear to cover a larger area than they actually do. This can cause overestimation in the canopy cover data.***

## URBAN TREE CANOPY CHANGE BY ZONING

UTC change between 2009 and 2019 was assessed for the four different zoning types in Brookhaven. Even though zoning has probably changed over the years, the City's 2019 zoning configuration was used in all six years to provide the most even comparison. Three zoning types experienced net losses, while one experienced a net gain. Commercial/Industrial Areas had a 2% loss (-14 acres), Mixed-Use had a 2% loss (-7 acres), and Single Family Residential Areas had a 5% loss (-254 acres). Multifamily Residential Areas had a gain of 1% (5 acres). As Brookhaven has grown, many forested areas have been cleared for new commercial and residential developments. Additionally, many trees on residential properties were removed to expand lawns. The City should continue to encourage or mandate that new trees be planted to mitigate losses on new developments and certain trees are retained in development plans. Newly planted trees do not provide the same canopy cover or ecosystem service benefits that a mature and established tree provides, but, over time and with proper species selection and care, these trees should grow to achieve similar benefits.




# 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 2019. 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. Two hundred (200) sample points, or approximately 15 points per square mile area in Brookhaven (11 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]

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 Brookhaven’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

*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.*

classification image. Overall accuracy is computed by dividing the total number of correct pixels by the total number of pixels reported in the matrix (74 + 43 + 58 + 6 + 5 = 186 / 200 = 93%), and the matrix can be used to calculate per class accuracy percentage's. For example, 77 points were manually identified in the reference map as Tree Canopy, and 74 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: (74/77 = .96), meaning that we can expect that ~96% of all 2019 tree canopy in the Brookhaven, GA study area was classified as Tree Canopy in the 2019 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, 74 classification pixels intersecting reference pixels were classified as Tree Canopy, but 3 pixels were identified as Vegetation in the reference map. Therefore, the User's Accuracy for Tree Canopy is calculated as: (74/77 = 0.94), meaning that ~96% 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 Brookhaven in 2019. The largest sources of classification confusion exist between tree canopy and vegetation.

***Table A1. | Error matrix for land cover classifications in Brookhaven, GA (2019).***

| Classification Data \ Reference Data | Tree Canopy | Vegetation | Impervious | Soil / Dry Veg. | Water | Total Reference Pixels |
|---|---|---|---|---|---|---|
| Tree Canopy | 74 | 3 | 0 | 0 | 0 | 77 |
| Vegetation | 3 | 43 | 1 | 0 | 0 | 47 |
| Impervious | 0 | 4 | 58 | 0 | 0 | 62 |
| Soil / Dry Veg. | 0 | 1 | 1 | 6 | 0 | 8 |
| Water | 0 | 1 | 0 | 0 | 5 | 6 |
| Total | 77 | 52 | 60 | 6 | 5 | 200 |

**Overall Accuracy = 93%**

| Producer's Accuracy | |
|---|---|
| Tree Canopy | 96% |
| Veg. / Open Space | 83% |
| Impervious | 97% |
| Bare Ground / Soil | 100% |
| Water | 100% |

| User's Accuracy | |
|---|---|
| Tree Canopy | 96% |
| Veg. / Open Space | 91% |
| Impervious | 94% |
| Bare Ground / Soil | 75% |
| Water | 83% |

## ACCURACY ASSESSMENT RESULTS

Interpretation of the sample error matrix offers some important insights when evaluating Brookhaven'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 2019 data indicates that regardless of how and when it was achieved, Brookhaven's current tree canopy can be safely assumed to match the figures stated in this report (approximately 44%).

## GLOSSARY/KEY TERMS

**Dripline**: Area located under the outer circumference of a tree

**Ground-Truthing**: The process of checking the accuracy of remotely sensed data by taking measurements of physical locations and objects on the ground represented in the data.

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

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

**Total Acres**: Total area, in acres, of the assessment boundary.

**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.

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