Tree Canopy Change Assessment

Charlotte, North Carolina

November 17, 2019

THE NEED FOR GREEN

Communities are facing a host of environmental challenges, from stormwater runoff to the urban heat island effect. At the same time, communities are seeking to become more livable and sustainable to attract companies and residents while ensuring equitable access to environmental amenities.

Trees provide a wealth of ecosystem services. Their canopies provide habitat for wildlife, the transpiration process reduces summer temperatures, and research shows that they can even improve social cohesion and reduce crime. A healthy and robust tree canopy is crucial to the sustainability and livability of our communities.

TREE CANOPY CHANGE ASSESSMENT

The USDA Forest Service Tree Canopy Assessment protocols were developed to help communities develop a better understanding of their green infrastructure through tree canopy mapping and data analytics. Understanding how tree canopy changes over time is crucial to managing this important resource and for developing policies and initiatives that ensure a robust tree canopy for years to come. Mapping tree canopy change is challenging. Rarely does a community have two perfect data sources from which to map change. The Tree Canopy Assessment Protocols, minimize the issues associated with the source data to ensure that the changes identified in tree canopy can be attributed to actual gains and losses as opposed to differences in the source data.

This study mapped tree canopy change over the 2012-2018 time period for the City of Charlotte.

FINDINGS

Overall, the City has a robust amount of tree canopy but it is under threat, with a marked decline from 2012 to 2018.

Tree canopy change is not evenly distributed nor similar. It varies from backyard individual tree removal to the clearing of large patches for new construction.

Most of the existing tree canopy lies within residential areas and most of the loss has occurred on residential land.

Current land use, new development, and natural factors all play a role in influencing tree canopy change.

Gains were largely limited to individual trees and small patches whereas losses ranged from individual trees to large tracts of forested land. Trees are being removed before they reach maturity.

Tree canopy is declining in the rights-of-way. New roads construction, losses on adjacent land, and removal of some street trees have contributed to this.

All city council districts experienced a loss in tree canopy but it was most acute in districts 1, 3, and 6.

The tree canopy is trending in the wrong direction if the City wishes to achieve its goal of 50%.

Tree canopy is declining overall but the story is more nuanced. There were 2,195 acres of tree canopy gain and 9,864 acres of tree canopy loss.

RECOMMENDATIONS

Preserving existing tree canopy is most effect means for securing future tree canopy as loss is an event but gain is a process.

Planting new trees in areas where tree canopy is low or in locations where there has been tree canopy has been removed will help the City to recover its recent losses.

Having trees with a broad age distribution and a variety of species will ensure that a robust and healthy tree canopy is maintained over time.

The City's residents are crucial if tree canopy is to be maintained over time. Having a populace that is knowledgeable about the value and services trees provide will help Charlotte stay green for years to come.

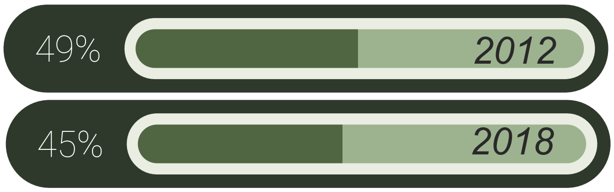
The tree canopy change assessment data should be integrated into planning decisions at all levels of government.

Tree canopy should be reassessed at 5-10 year intervals to monitor change.

Tree canopy assessments require high-quality, high-resolution data. Local governments should continue to invest in LiDAR and imagery to support these assessments and other mapping needs.

This assessment provides a comprehensive census of tree canopy but information on tree species, size, and health can only be obtained through field data collection.

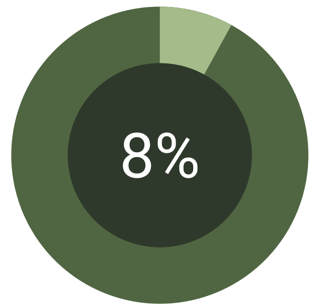
Tree Canopy Change Metrics



Tree canopy declined from 49% in 2012* to 45% in 2018

Net acres of tree canopy were lost from 2012 to 2018

Gain: 2,195 acres **Loss: 9,864 acres**



Charlotte lost 8% of its tree canopy

Three different, but complementary, tree canopy change metrics were calculated for this study:

Area Change - the change in the area of tree canopy between the two time periods. The city lost 7669 acres of tree canopy.

Absolute % Change - the percentage point change between the two time periods. Tree canopy declined from 49% to 45% resulting in a 4 percentage point loss.

Relative % Change - the relative loss of tree canopy using 2012 as the base year. Relative to the 2012 amount of tree canopy, the city lost 8% of its tree canopy.

Comparisons to Past Studies

A vital component of the Tree Canopy Assessment Protocols is ensuring that changes in tree canopy are attributed to actual gains and losses in tree canopy as opposed to differences in the source data. The first Tree Canopy Assessment was completed in 2014 by the University of Vermont, using data from 2012. These data are not as detailed or as accurate as the 2018 data. Furthermore, recent improvements in the tree canopy mapping methods provided the opportunity to revisit the 2012 mapping. This re-analysis found that the 2012 mapping slightly underestimated tree canopy, particularly in dense forested areas, due to the lower quality of the LiDAR.

THE TREE CANOPY ASSESSMENT PROCESS

Remotely sensed data forms the basis of tree canopy mapping. This project employed the USDA Forest Service's Urban Tree Canopy Assessment and Change protocols, making use of hundreds of thousands of dollars of data provided by community partners.

Remotely sensed data forms the foundation of the tree canopy assessment. High-resolution aerial imagery and LiDAR were used to map tree canopy change.

The tree canopy change mapping identified areas of gain, loss, and no change down to the individual canopy level.

The tree canopy change data were summarized by various geographical units, ranging city to land use units.

These summaries, in the form of tree canopy metrics, formed exhaustive geospatial database that enabled change to be analyzed at various geographical units.

The tree canopy change metrics data analytics provided basic summary statistics in addition to inferences on the relationship between tree canopy and other variables.

The report (this document) summarized the project methods, results, and findings.

No Change

Tree canopy that has remained constant over the 2012-2018 time period.

Loss

Areas in which tree canopy was present in 2012 but is no longer present in 2018.

Gain

Areas in which tree canopy was not present in 2012 but was present in 2018.

MAPPING TREE CANOPY CHANGE FROM ABOVE

Tree canopy change mapping relies on remotely sensed data in the form of aerial imagery and light detection and ranging (LiDAR). These datasets, which have been acquired by various governmental agencies in the region, are the foundational information for tree canopy change mapping. This study made use of LiDAR data acquired in 2012 and 2016, and leaf-on imagery acquired in 2012 and 2018. LiDAR is positionally more accurate and thus served as the primary data source for determining change. The imagery was used to update the change mapping to the most current conditions possible (2018). Over relatively short time periods, such as this study, it is easier to detect loss and gain. Loss tends to be due to a large event, such as tree removal, whereas gains are incremental. The differences in the source data meant that small amounts of natural growth over the 2012-2018 time period fell below the detection threshold. Future mapping, over longer time periods, will enable this growth to be detected.

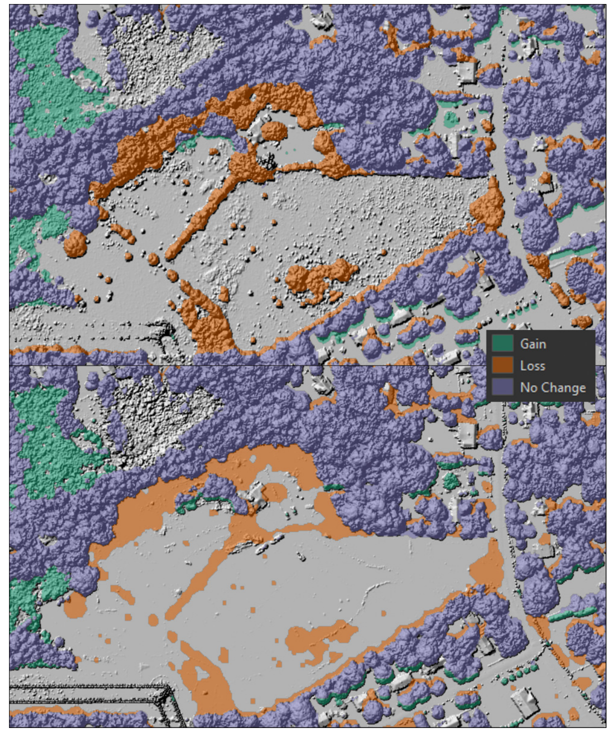


Figure 1. Tree canopy change mapping for the area in the vicinity of Dewey Creek Lane. The tree canopy change mapping is overlaid on a LiDAR hillshade dataset for 2012 (top) and (2016) bottom. Rough areas generally correspond to areas with tree canopy and smooth areas are those without tree canopy. Shrubby areas grew over the time period to the point at which they met the mapping specifications for tree canopy and are classified as gain. New construction in the area resulted in the removal of tree canopy, and those features are classified as loss.

1+ Billion

Billions of data points were processed to generate the tree canopy change map

It is common practice to remove tree canopy during construction. New construction in the City resulted in the loss of tree canopy not just over the 2012-2018 timeframe, but in the years between 2016 and 2018. Tree canopy loss is an event, but gain is a process. It will be many years before the new trees planted in the areas contribute measurably to the City's tree canopy.

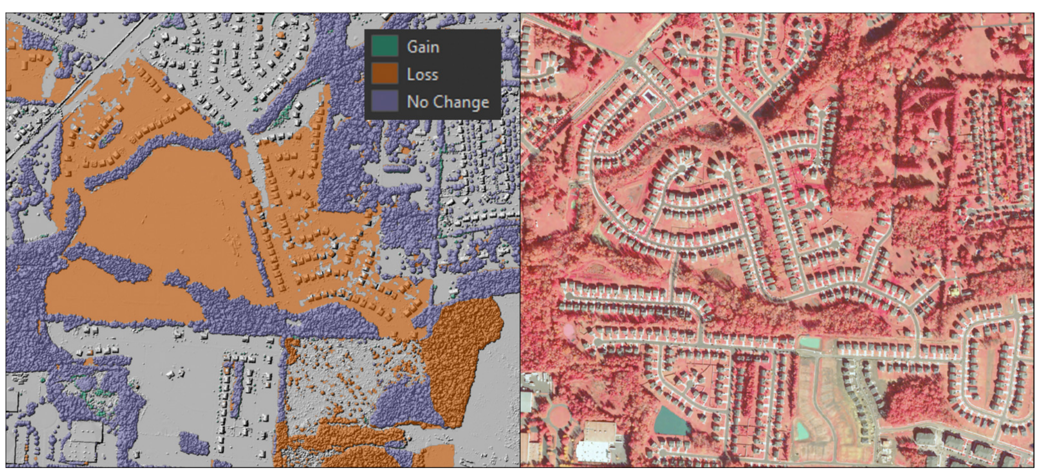


Figure 2. Tree canopy change in the 2016 LiDAR (left) as compared to the 2018 imagery (right). This new subdivision, located between Shopton Road and Steele Creek Road, was being developed over the 2016-2018 time period. On the right portion of the development, there are areas that were tree canopy in 2016 that were then cleared by 2018.

Change Distribution

To visualize and analyze the distribution of tree canopy change within the city, hexagons of 1000 acres in size were generated. For each of the hexagons, the three tree canopy change metrics were calculated This strategic view provides insight into broader patterns of tree canopy change in the City (Figure 3). The most significant concentrations of loss are in two areas. The first is towards the middle of the City in a southeast pattern that generally follows Providence Road. The second is on the western edge of the city, to the north and south of Westinghouse Boulevard. A multitude of factors drives tree loss in the first area. New construction has resulted in the removal of tree canopy, everything from large forested areas to individual trees scattered throughout a property. In the second area on the western side of the city new construction is the apparent cause of the loss, with larger forest patches being removed for new construction. Change was also examined based on the size of the gain or loss (Figure 4). The vast majority of gains and losses have been within small patches but the losses have an understandably greater distribution with relative large forested areas being removed.

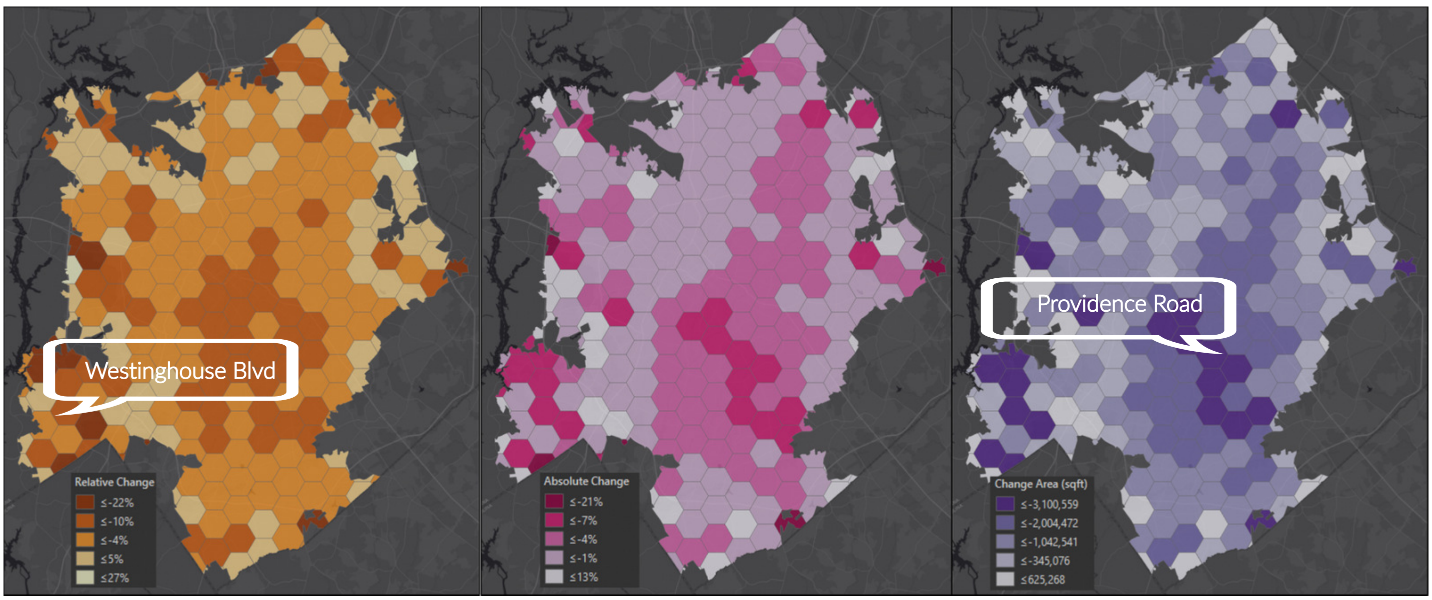


Figure 3: Tree canopy change metrics for 1000 acre hexagons.

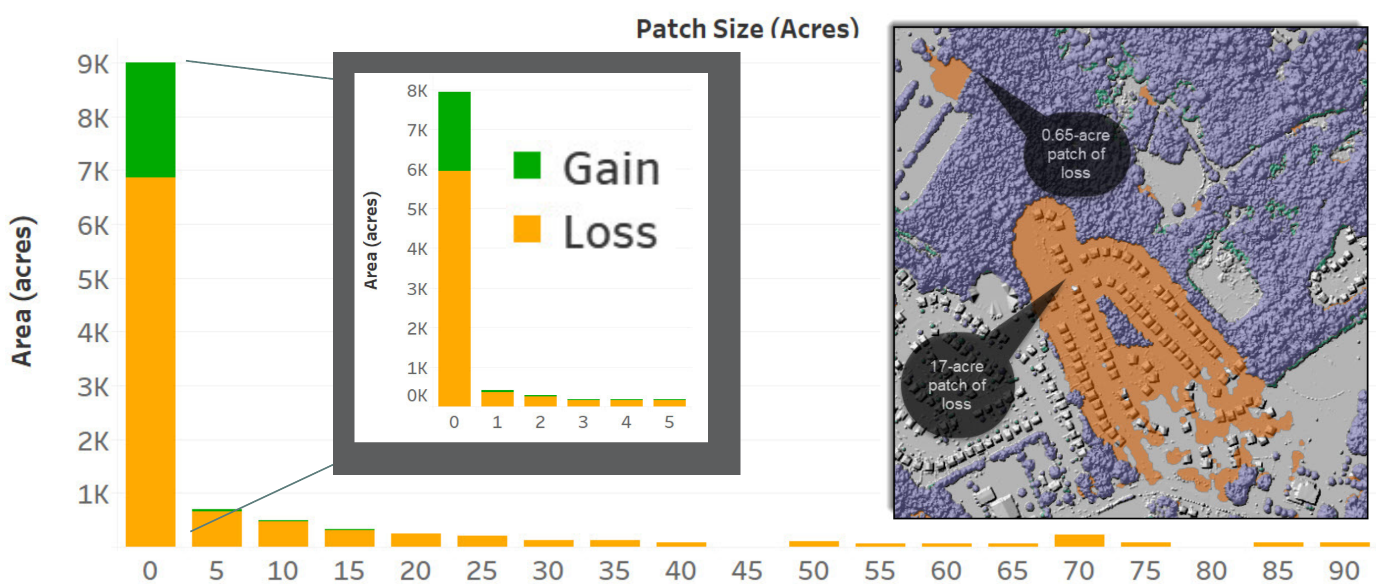


Figure 4: Tree canopy gains and losses by patch size. The majority of gains and losses occur in patches that are less than 5 acres. There are few gains in patches greater than 5 acres but there are losses out to patches exceeding 90 acres in size.

Land Use

Land use is how we, as humans, make use of the land. Understanding the relationship between land use and tree canopy change provides insight into the drivers of change, along with the many actors who influence tree canopy change. The Mecklenburg County land use dataset was aggregated into eight general classes. Tree canopy change metrics were summarized for each class. Relative tree canopy loss was highest in the unknown/vacant land uses, followed by the rights-of-way (ROW). The story for absolute change is similar but with the ROW moving into the second-highest loss bracket. The loss on unknown/vacant land use types is not cause for great concern given that this land use contains less than 800 acres of tree canopy. The vast majority of the City's tree canopy (68%) is on residential land. There were over 4,700 acres of tree canopy lost on residential land from 2012-2018. Some of this loss was due to new construction, but there are thousands of examples of individual trees being removed on residential sites with no apparent signs of construction. Storms, disease, tree age, or changes in attitudes to tree canopy could all play a role.

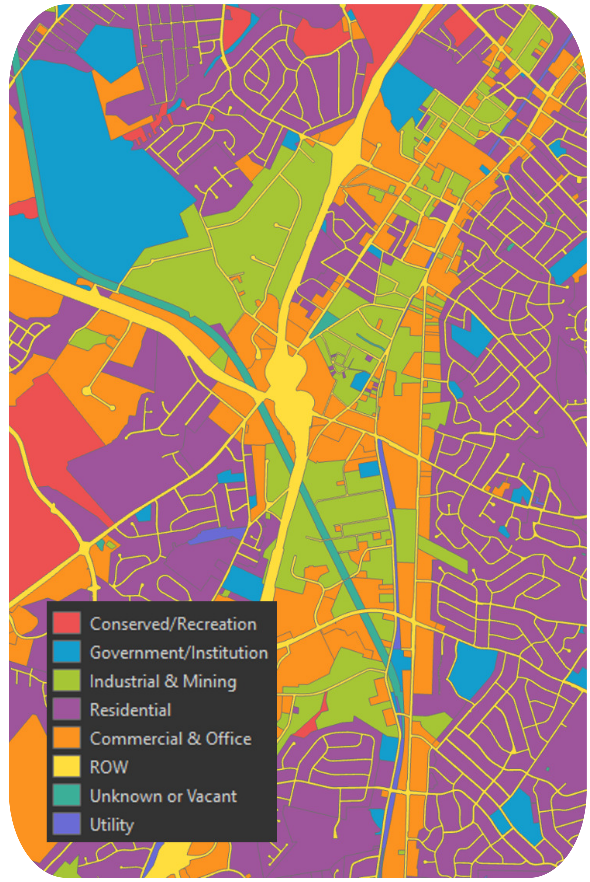


Figure 5: Land use.

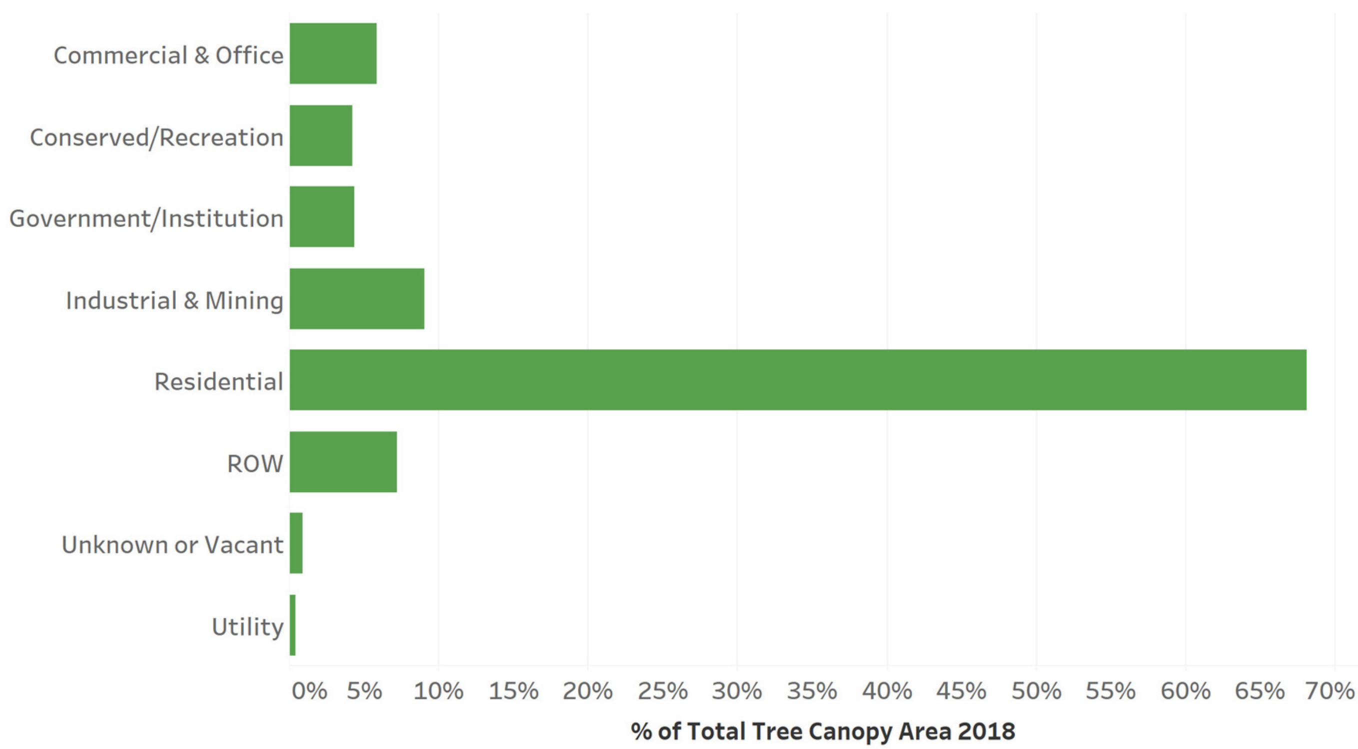


Figure 6: Percent of tree canopy in each land use class in 2018.

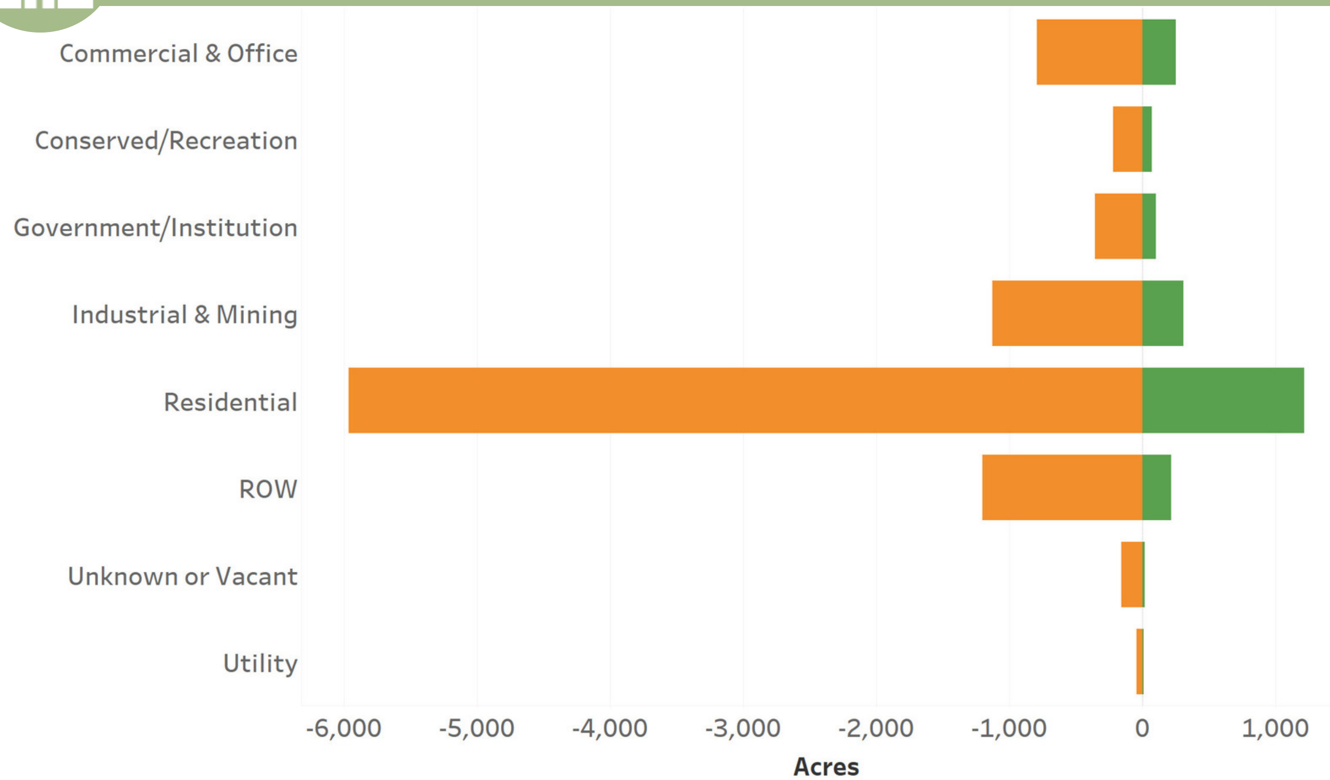


Figure 7: Tree canopy change, in acres, from 2012-2018 by land use class. Gains are shown in green and losses are shown in orange. Residential tree canopy had the greatest losses and the greatest gains. Losses in the ROW slightly surpassed those on Industrial & Mining lands, but the latter had more gain. The losses within the ROW were affected by the fact that the construction of new roads that resulted in tree canopy loss was included in the ROW calculations.

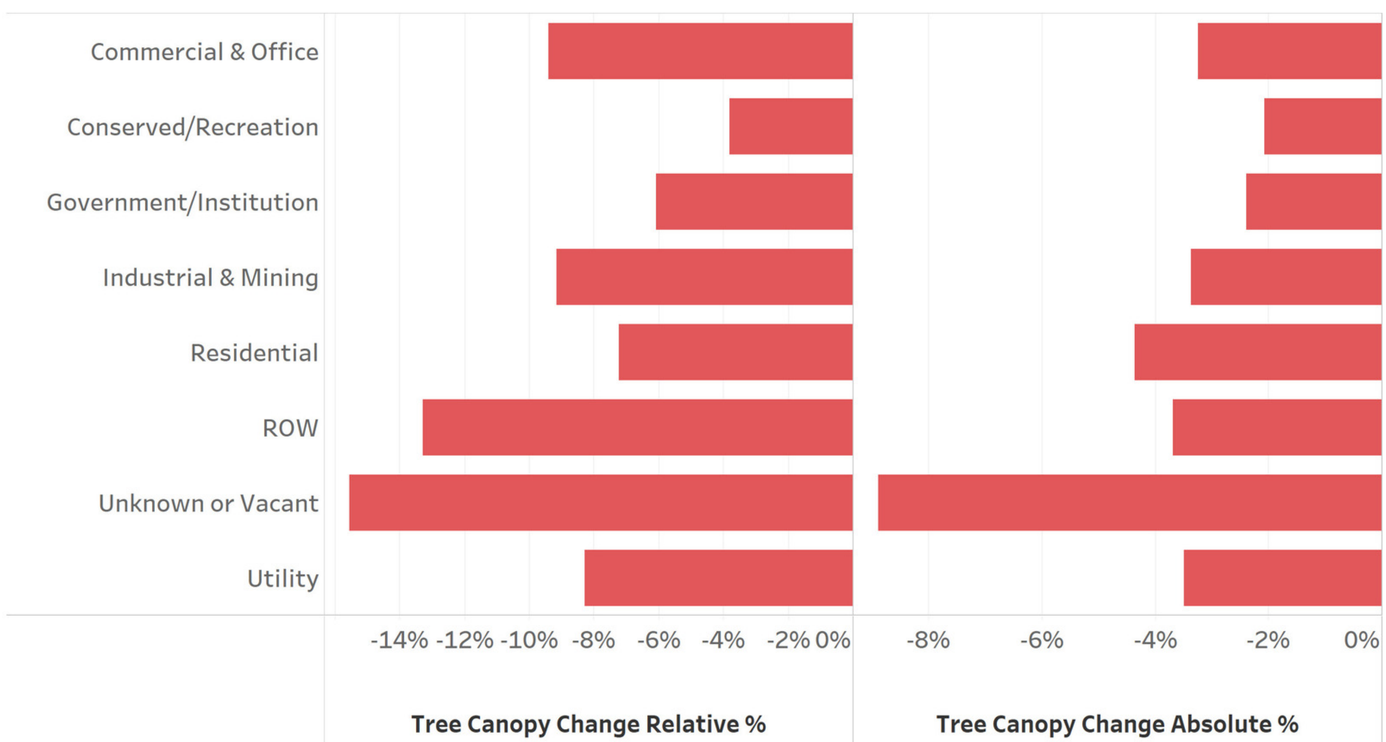


Figure 8: The relative and absolute change in tree canopy by land use from 2012 to 2018. Although the Unknown/Vacant class had the most relative and absolute loss, referring back to Figure 6 we can see that these losses did not have a substantial impact on the overall amount of tree canopy in the City as there is relatively little tree canopy that falls into this land use class.

City Council Districts

Each city council district lost tree canopy from 2012 to 2018. City council districts 1 and 6 lost the most tree canopy relative to what they had in 2012. The absolute percent change loss in each of these districts was also the highest. The new construction of subdivisions in district 3, which resulted in the removal of larger patches of forest, drove district 3 to the top district with the most acres of tree canopy loss. Within the districts, the loss can be found across all land use types with residential lands accounting for most of the removal. The one outlier is district 3 in which loss on industrial and mining land was nearly as significant as residential. District 3 also had the highest area of tree canopy loss within the right-of-way (ROW). Districts 6 and 7 saw the most considerable losses on conserved/recreation land.

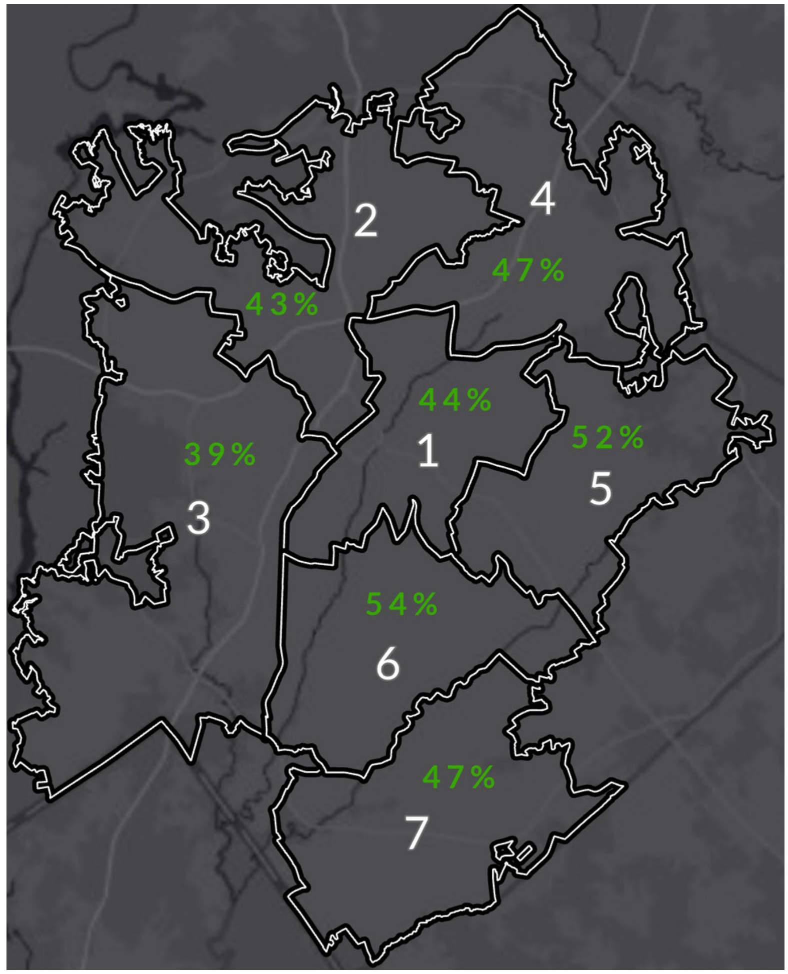


Figure 9: City council districts. Green numbers represent the percentage of land covered by tree canopy in 2018.

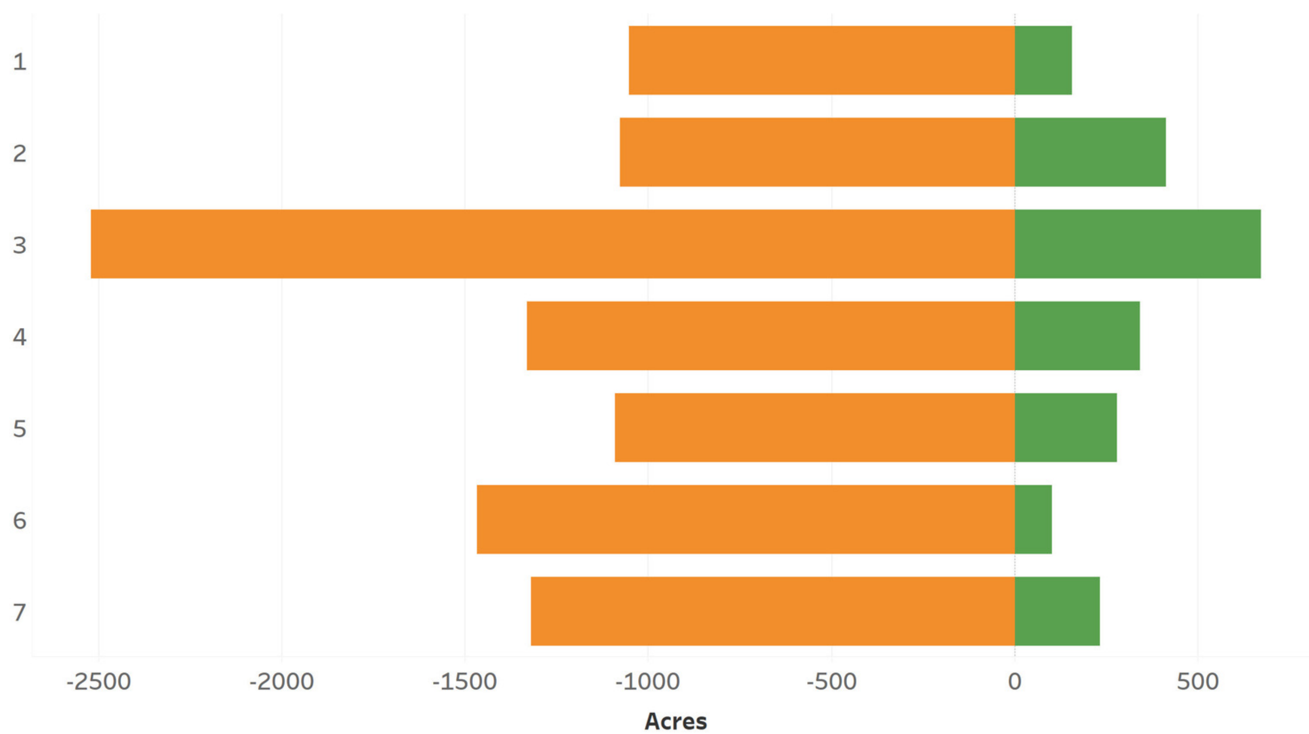


Figure 10: Tree canopy change, in acres, for each council district. Orange represents loss and green indicates gain.

A Mix of Loss and Gain

Although tree canopy has declined, on the whole, the story of tree canopy change in Charlotte is more nuanced. In the vicinity of the Stuart Creek Greenway and Freedom Drive, there are both gains and losses. Loss of larger patches is associated with new construction, whereas scattered removals of individual trees have no apparent driving factor. Some areas have undergone succession, with new tree canopy coming through natural growth. In subdivisions built before 2012, trees planted in those subdivisions are now contributing canopy.

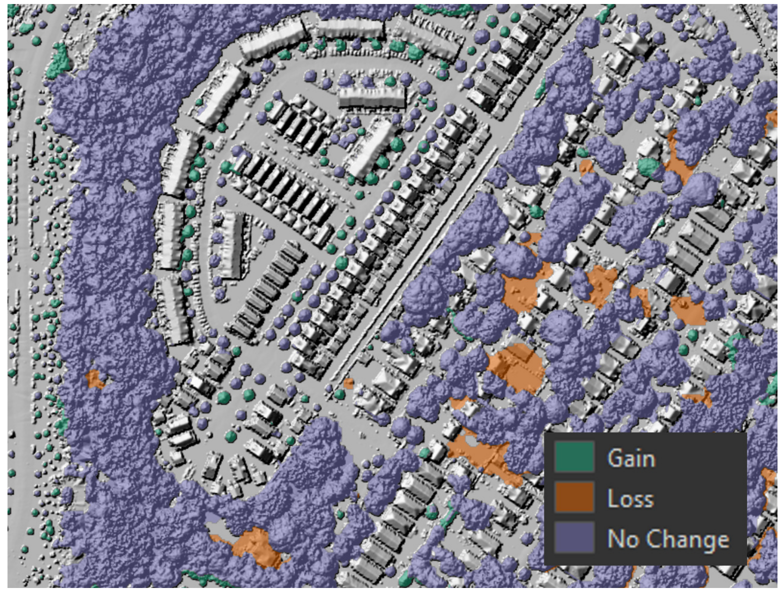


Figure 11: Tree canopy change overlaid on the 2016 LiDAR.

Figure 12: Tree canopy change overlaid on the 2016 LiDAR (left) and 2012 LiDAR (right).

Height

It is not possible to accurately infer age for a diverse urban forest from the overhead imagery and LiDAR used in this study but height can be used as a proxy. The tree canopy was segmented into polygons approximating individual trees. Each of these polygons was then attributed with the height from both the 2012 and 2016 LiDAR data. The height from the 2012 LiDAR was used to understand loss, whereas the height from the 2016 LiDAR was used to understand the gains. Most of the City's tree canopy falls in the 40 to 80-foot height range. This distribution has stayed consistent over the 2012-2016 timeframe. Losses were more concentrated in the middle height classes, indicating that the trees are removed before the age out. Gains mostly occurred in the shorter canopy. This pattern reflects the rapid growth that occurs in new canopy along with the challenge of detecting incremental growth in larger canopy.

Figure 13: Tree canopy height from the 2016 LiDAR.

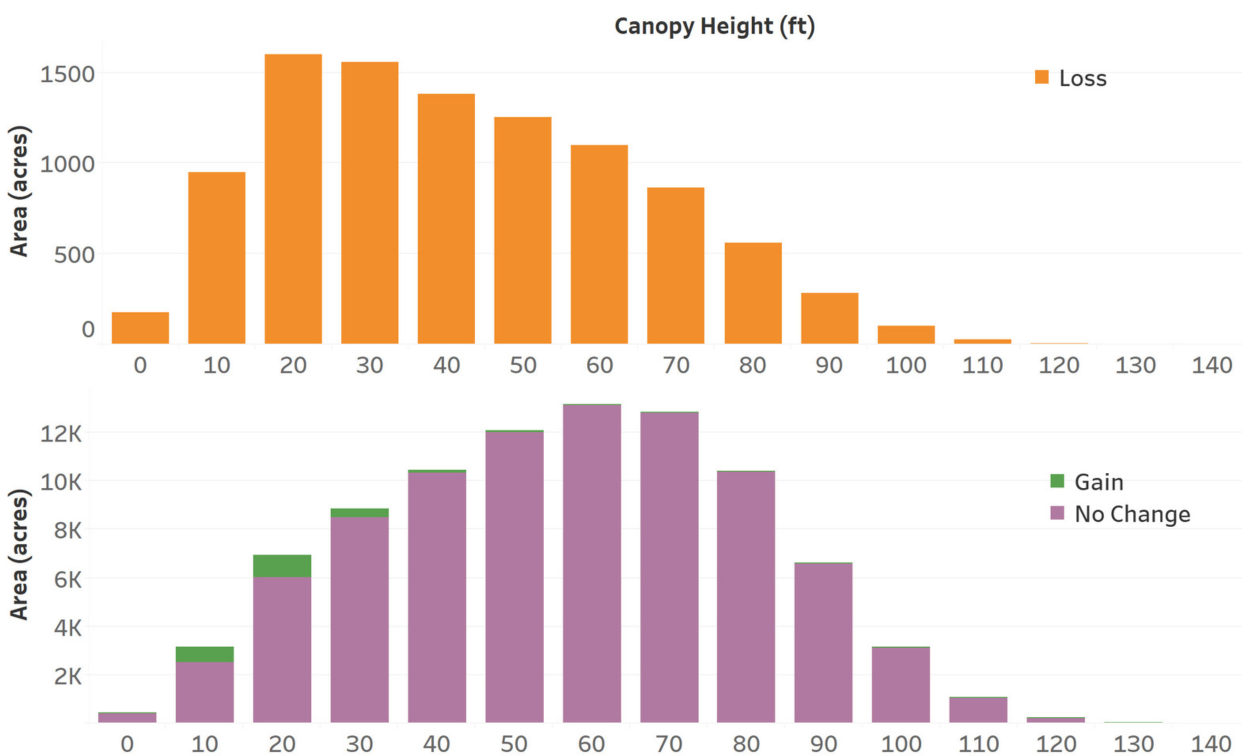


Figure 14: Tree canopy height distribution showing the height of losses based on the 2012 LiDAR (top) and the height of gains and no change based 2016 LiDAR (bottom).

This assessment was carried out by the University of Vermont Spatial Analysis Lab in collaboration with TreesCharlotte. The methods and tools used for this assessment were developed in collaboration with the USDA Forest Service. The source data used for the mapping came from the USDA, the State of North Carolina, and Mecklenburg County. The project was funded by TreeCharlotte. Additional support came from a Catalyst Award from the Gund Institute for Environment at the University of Vermont.

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