Tree Canopy Assessment
Charlotte, North Carolina

Scope of Work

Charlotte is a rapidly growing city, recently ranked 13th out of 20 on Forbes magazine's list of "America's fastest-growing cities" for 2016, based on measurements of the fastest-growing populations and economies. With this high rate of growth comes a high level of development, which is often associated with a loss of trees and tree canopy. This study aimed to update the existing 2012 baseline canopy data to represent conditions closer to current day in order to measure the changes that have occurred and evaluate whether tree program strategies and protection policies are needed.

Summary of Findings

This study compares the 2012 tree canopy coverage to the 2016 tree canopy coverage. Appropriate aerial images were available from federal and state sources to complete the analysis based on data from these two years. The imagery to do another study is anticipated to be available in 2020-21.

The study finds that Charlotte's tree canopy in 2016 remains at a similar level of coverage as it did in 2012. The change observed is a possible loss of .2% to .3%, or 399 to 520 acres. Both of these observations are well within the margin of error of .9%. Given this margin, the canopy may have actually gained .6% or may have lost up to 1.2%.

Figure 1 - NAIP aerial imagery from May 2016.

Data Sources

Two different data sources were used as the primary inputs to the remote sensing process of mapping Charlotte's tree canopy. Four-band, multispectral, 1-meter, aerial imagery from the National Agriculture Imagery Program (NAIP) was acquired from the U.S. Department of Agriculture. This imagery was the latest available imagery at the time that met all project needs for the Charlotte area. Images were collected in May 2016. The four bands represent different wavelengths of the electromagnetic spectrum including the red, green, blue, and the near-infrared. The first three bands represent natural color or what is naturally visible to the human eye. The near-infrared band is not visible to the human eye, but specialized sensors on the camera can detect levels of radiation in this wavelength. The near-infrared band is crucial when mapping urban tree canopy as healthy vegetation reflects large amounts of near-infrared light compared to other land cover types such as water and impervious surfaces.

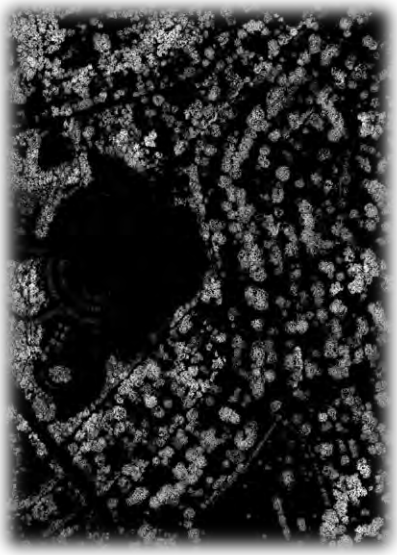


Figure 2 - Normalized digital surface model from winter 2016/17 LiDAR.

The second source used was a LiDAR dataset provided by the City and collected by the NC Emergency Management in the winter of 2016-2017. LiDAR provides extremely detailed information on the height of objects on

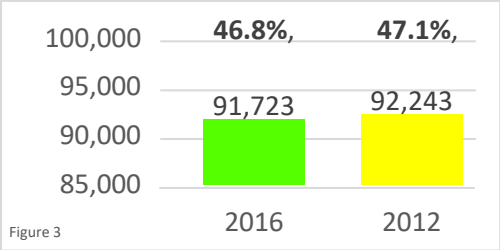
the Earth's surface using reflectance of light from a laser. Two different subsets of the raw point cloud were extracted to prepare the data for the needs of this project: the first returns and last returns. The first returns represent the top of objects when looking from overhead and often represent building rooftops, tree canopy, or ground if the landscape is bare. The last returns typically represent bare ground unless an object is present that the laser cannot penetrate such as a building. A normalized digital surface model (nDSM) was created by subtracting the last returns from the first returns representing the relative height of objects including trees.

Methodology

An object-based image analysis (OBIA) software program called Feature Analyst was used to classify land cover features through an iterative approach, where the spectral signatures across the four aerial image bands (blue, green, red, and near-infrared), LiDAR height, as well as textures and pattern relationships were considered. This process resulted in one land cover class representing tree canopy cover. After the initial automated classification, manual classification was performed to improve and check for quality control by GIS technicians at roughly 1':1,500" scale in ArcGIS. A similar study for all of Mecklenburg County was completed by the University of Vermont Spatial Analysis Lab in 2013 using 2012 data. This dataset was used as a reference to establish consistency in the final tree canopy data. A comparison between the results of the 2016 and 2012 datasets is shown in the Results section of this report.

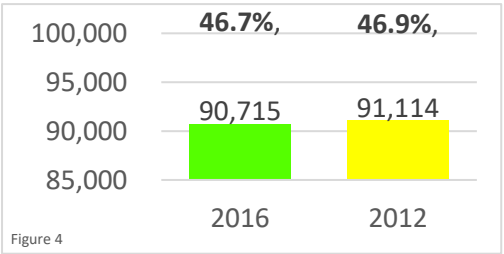
Results

This assessment covered 195,913 land acres (not including water bodies) using the city boundary from 2018. This boundary included many areas that were annexed since the previous study was performed. To account for that, change was determined both within the 2013 city boundary, that was used in the previous analysis, and within the current 2018 boundary. Tree canopy data were available in newly annexed areas since the entire county was mapped using 2012 data. Results within each boundary are discussed below.



Within the current 2018 city boundary using 2016 data, there was approximately 46.8% tree canopy coverage (91,723 acres). This represents a possible decrease in canopy cover city-wide of .3% (520 acres) since 2012. The margin of error in the analysis is .9%.

Figure 3 - Tree canopy percent and acres within the 2018 city boundary.



Within the 2013 city boundary (194,452 land acres) using 2016 data, there was approximately 46.7% tree canopy coverage (90,715 acres). This represents a possible decrease in canopy cover city-wide of .2% (399 acres) since 2012. The margin of error in the analysis is .9%.

Figure 4 - Tree canopy percent and acres within the 2013 city boundary.

Several examples of canopy growth and loss were observed throughout the city. Canopy loss was typically from areas that were clear-cut or had individual trees removed for new development. Canopy gains came from new tree plantings, logged areas that were reforested, or natural growth of existing trees. (Figure 5)

Figure 5 - Canopy loss (red) at the Lawrence Orr Elementary school built in 2014 (left), new trees planted in the right-of-way 2009 that were not captured in 2012 (center), reforestation of clear-cut area (2016) that was not mature enough in 2012 (yellow) (right).

Accuracy

An accuracy assessment was completed using 2,000 sample points that were randomly distributed across the City. Each sample point was then referenced using the May 2016 aerial imagery and assigned a value of 1 if it landed on a tree or a value of 0 if it did not land on a tree. An automated script was then used to assign values from the classification raster to each point. The classification supervisor provides unbiased feedback to quality control technicians regarding the types of corrections required. Misclassified and corresponding canopy cover were inspected for necessary corrections. Accuracy was re-evaluated until an acceptable classification accuracy of 94% is achieved.

Classification accuracy serves two main purposes: First, 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.

With a 95% confidence interval, there was a .9% margin of error equating to 46.8% canopy cover +/- .9% or a range of 47.7% to 45.9%. Compared to 2012 canopy coverage (47.1%), there was a possible change of a gain of .6% to a loss of -1.2%. Based on this margin of error and the inherent differences in data sources and methods between two studies, the City of Charlotte's tree canopy in 2016 remains at a similar level of coverage as it did when it was previously assessed in 2012.

Recommendations

The scope of this project was limited to mapping tree canopy in 2016 and comparing the coverage to the tree canopy in 2012. While there is great utility and value in this information, a full urban tree canopy assessment is recommended in order to provide City staff with more specific action items and ways to address issues throughout the City. A full assessment should include mapping of all land cover, not just tree canopy. Having a land cover map would allow the City to understand the level of gray versus green infrastructure, locate and prioritize possible planting areas for new trees, and assess levels of canopy coverage, planting space, and imperviousness within meaningful geographic boundaries such as land use or zoning classes, watersheds, tax parcels, or neighborhoods.

To continue to preserve, protect, and maintain Charlotte's tree canopy, the City should continue to assess their tree canopy on a regular interval. Appropriate aerial coverage data should be available from federal and state sources in 2020-21. As the City changes, they will be able to use information from these studies to ensure that their urban forest policies and management practices prioritize its maintenance, health, and growth. It may be beneficial to map any areas that are annexed between 2018 and whenever the next study is performed using the 2016 source data to ensure that the entire city's forest is measured. Additional data downloads and processing may be necessary depending on the extent of annexation.

The results of this assessment can and should be used to encourage investment in 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 and social issues. The canopy cover data should be disseminated to diverse partners for urban forestry and other applications while the data is current and most useful for decision-making and implementation planning.