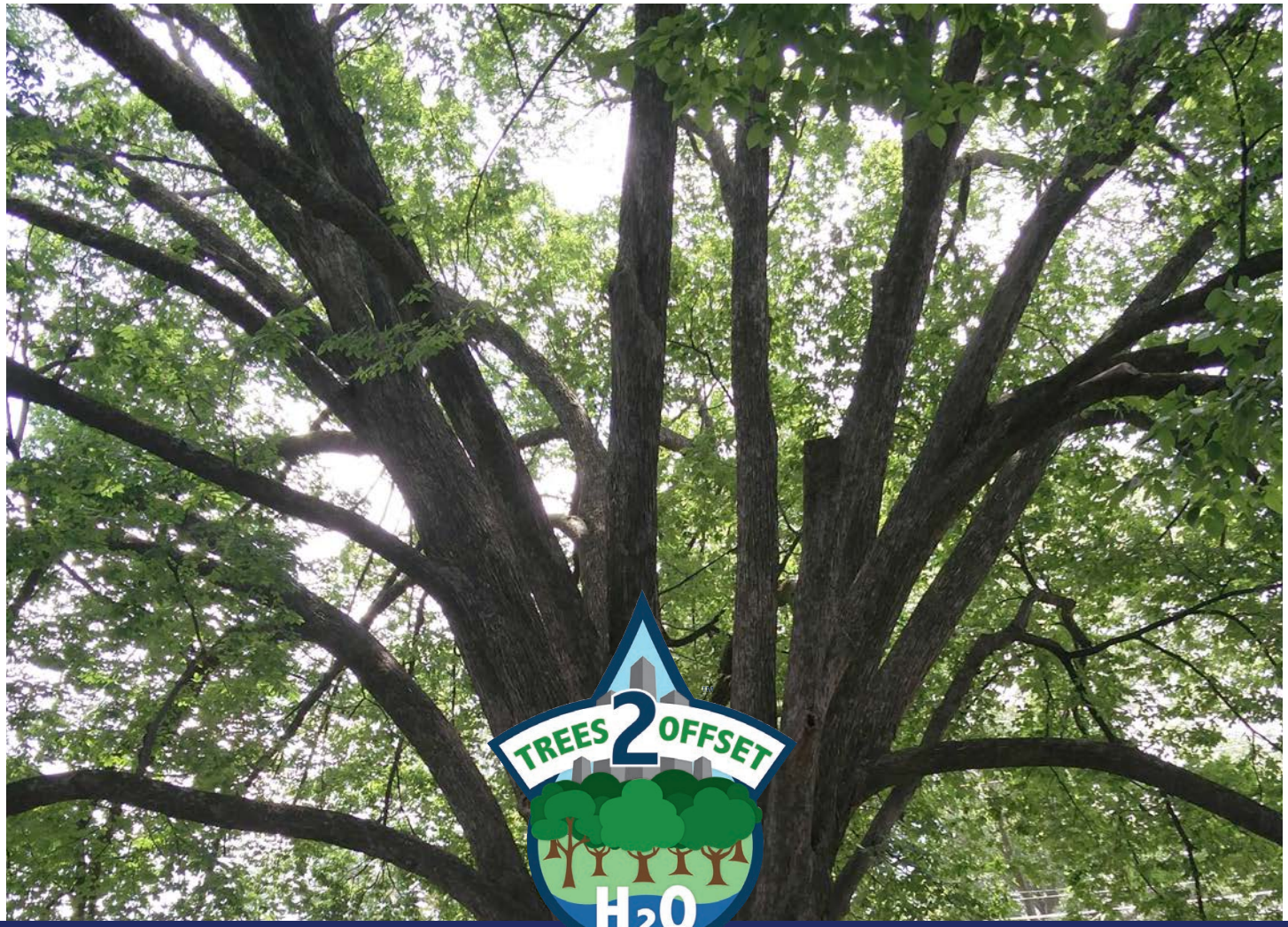

TREES TO OFFSET STORMWATER

Case Study 06: City of Norcross, Georgia

Green Infrastructure Center

GEORGIA FORESTRY COMMISSION

FOREST SERVICE U.S. DEPARTMENT OF AGRICULTURE

NORCROSS a place to imagine

October 2018

The Green Infrastructure Center Inc. is the technical services consultant for this project and the case study author. Images and illustrations in the report are by the Green Infrastructure Center Inc. (GIC).

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Case Study 06: Norcross, Georgia

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PROJECT OVERVIEW

This project Trees to Offset Stormwater is a study of Norcross's tree canopy and its role in taking up, storing and releasing water. This study was undertaken to assist Norcross in evaluating how to better integrate trees into their stormwater management programs. More specifically, the study covers the role that trees play in stormwater management and shows how the city can benefit from tree conservation and replanting. It also evaluates ways for the city to improve forest management as the city re-develops.

PROJECT FUNDERS AND PARTNERS

The project was developed by the nonprofit Green Infrastructure Center Inc. (GIC) in partnership with the states of Georgia, Alabama, Florida, South Carolina, North Carolina and Virginia. The GIC created the data and analysis for the project and published this report. This study is one of 12 pilot projects evaluating a new approach to estimate the role of trees in stormwater uptake. The USDA Forest Service provided the funding for Georgia to determine how trees can be utilized to meet municipal goals for stormwater management. The Georgia Forestry Commission (GFC) administered the pilot studies in Georgia and selected Norcross to be one of the two test cases. The City of Alpharetta is the other Georgia municipality selected for study.

The project was spurred by the on-going decline in forest cover throughout the southern United States. Causes for this decline arise from multiple sources including land conversion for development, storm damages, lack of tree replacement as older trees die, and for coastal cities, inundation from Sea Level Rise. Many localities have not evaluated their current tree canopy, which makes it difficult to track trends, assess losses or set goals to retain or restore canopy. As a result of this project, Norcross now has baseline data against which to monitor canopy protection progress, measures for the stormwater and water quality benefits provided by its urban forest, and locations for prioritizing canopy replanting.

Trees downtown add to the city's charm.

OUTCOMES

This report includes those findings and recommendations that are based on tree canopy cover mapping and analysis, the modeling of stormwater uptake by trees, a review of relevant city codes and ordinances, and citizen input and recommendations for the future of Norcross. More specifically, the following deliverables were included in the pilot study:

- Analysis of the current extent of the urban forest through high resolution tree canopy mapping,
- Possible Planting Area analysis to determine where additional trees could be planted,
- A method to calculate stormwater uptake by the city's tree canopy,
- A review of existing codes, ordinances, guidance documents, programs and staff capabilities related to trees and stormwater management, and recommendations for improvement,
- Two community meetings to provide outreach and education,
- Presentation about the pilot studies as a case study at regional and national conferences, and
- A case book and presentation detailing the study methods, lessons learned and best practices.

The project began in May 2017 and Norcross staff members have participated in project review, analysis and evaluation. The following city divisions were involved in the project planning and review as the Technical Review Committee (TRC): Community Development and Planning; Public Works, Utilities, and Parks and include Geographic Information Staff and Sustainability Coordinators.

COMMUNITY ENGAGEMENT

Two community meetings were held. The first meeting held in March 2018 provided an overview of the project and opportunities to correct the maps. The second meeting held in October 2018 provided recommendations (listed below) for the city and elicited feedback. All individual comments were provided to the city.

The community forums invited public comments on the mapping that had been done so far for the project, and solicited public comment on the health and needs of the urban forest. Residents identified specific tree planting opportunities based on the possible planting area analysis. For example, they requested tree planting on along the county-controlled right of way along State Route 141, planting trees along medians on Buford Highway, and many other street tree planting options identified on workshop maps. They also suggested parks where more trees could be planted for shade and beauty.

At the final meeting, results of the codes analysis were presented as well as findings from the stormwater calculator. Community members were shown seven specific code/ordinance or practice changes recommended to the City of Norcross. Meeting attendees were asked to choose the top three changes they felt would most benefit the urban forest. The policy or code changes are listed below in priority order (most to least popular).

Objectives in Priority Order:

- Tighten the development footprint.
- Use volunteers to plant trees and teach the community about trees.
- Use the stormwater calculator tool and increase urban canopy.
- Use the urban forestry funding calculator to develop an urban tree canopy goal.
- Conduct an urban forest assessment to compare data every four years.
- Monitor the urban forest and collect forestry data.

The city was congratulated for already having moved into implementations for several recommendations including plans to hire a certified arborist to provide tree care and guidance as well as for creating a tree bank and; a fund from development fees used to replant trees where they are most needed.

Community members also suggested contiguous plantings of pollinator gardens for areas where trees would not fit. GIC staff noted that planting such gardens across backyards is one way to create pathways for birds and pollinators through an urban landscape.

Residents and stakeholders also suggested conducting a city-wide green infrastructure study to identify and plan for landscape connectivity. This could be accomplished with additional funding (but it is beyond the scope of the current project, which is limited to trees and stormwater evaluation).

Residents review areas for possible tree plantings.

SC Foresty Commission staff Susan Granberry (left) listens to urban foresty conservation ideas.

Norcross City Engineer Erica Madsen listens to community ideas for forest conservation.

Norcross can use this report and its associated products to:

- *Set goals and develop a management plan for retaining or expanding its tree canopy by watershed.*
- *Improve management practices so trees will be well-planted and well-managed.*
- *Educate developers about the importance of tree retention and replacement.*
- *Motivate private landowners (residential, commercial, and institutional) to plant and protect their trees.*
- *Support grant applications for tree conservation projects.*

SUMMARY OF FINDINGS

Satellite imagery was used to classify the types of land cover in Norcross (for more on methods see page 15). This shows the city those areas where vegetative cover helps to uptake water and those areas where impervious land cover is more likely to result in stormwater runoff. High-resolution tree canopy mapping provides a baseline that is used to assess current tree cover and to evaluate future progress in tree preservation and planting. An ArcGIS geodatabase with all GIS shape files from the study was provided to Norcross.

The goal of this study was to identify ways in which water entering the city's municipal separate storm sewer system (MS4) could be reduced by using trees to intercept and soak up runoff. Tree canopy serves as 'green infrastructure' that can provide more capacity for the city's grey infrastructure (i.e. stormwater drainage systems) by absorbing or evaporating excess water before it runs off. The model created shows how the city can reduce potential pollution of its surface waters, which can impact Total Maximum Daily Load (TMDL) outcomes and watershed and island plans.

The detailed land cover analysis created for the project was used to model how much water is taken up by the city's trees in various scenarios. This new approach allows for more detailed assessment of stormwater uptake based on the landscape conditions of the city's forests. It distinguishes whether the trees are growing in a more natural setting (e.g. a cluster of trees in an urban forest), a lawn setting, or over pavement, such as streets or sidewalks. The amount of open space and the condition of surface soils affect the infiltration of water.

As city trees are evaluated, it's important to remember that trees within a cluster provide more value than individual trees alone because they also tend to have a more natural ground cover, more leaf litter (as they are not managed or mowed under) and less compacted soils. Thus, there is more stormwater retention for trees found in a natural setting than a tree over a lawn or over pavement. Trees also shelter one another from wind damages and are less likely to fall. As cities develop and lose forest, trees planted in isolation do not provide equivalent value as the same number of trees found clustered together. Therefore, when counting total trees in a city, managers should also consider the setting in which those trees are found and they should protect intact clusters of trees as often as possible.

One mature tree can absorb thousands of gallons of water per year.

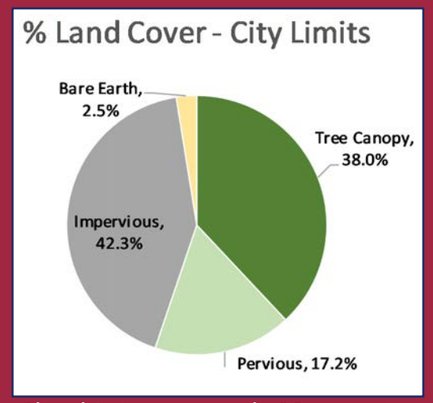
During an average high volume rainfall event in Norcross (a 10-year storm), over 24 hours the town's trees take up an average of 7.6 million gallons of water.

That's 12 Olympic swimming pools of water!

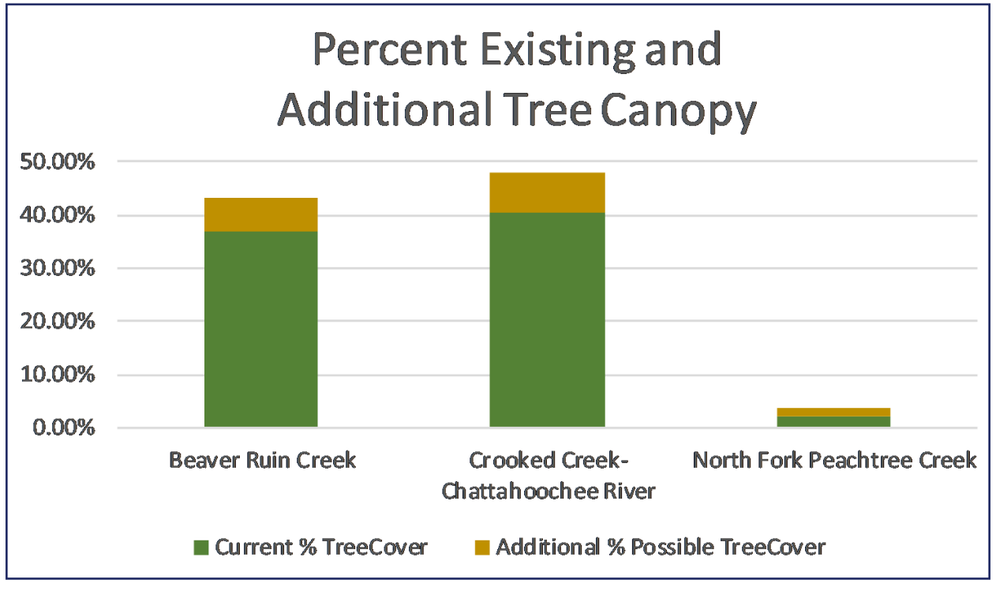
Norcross: Fast Facts & Key Stats

- Piedmont community in North Central Georgia.
- County: ..... Gwinnett
- 2017 U.S. Census Population Estimate: ..... 16,845 people
- City Area
  - Total area: ..... 4.6 sq. mi.
  - Land: ..... 6 sq. mi.
  - Water: ..... .02 sq. mi.
  - Streams: ..... 5.48 miles
  - Tree Canopy: ..... 1,459 acres (38%)

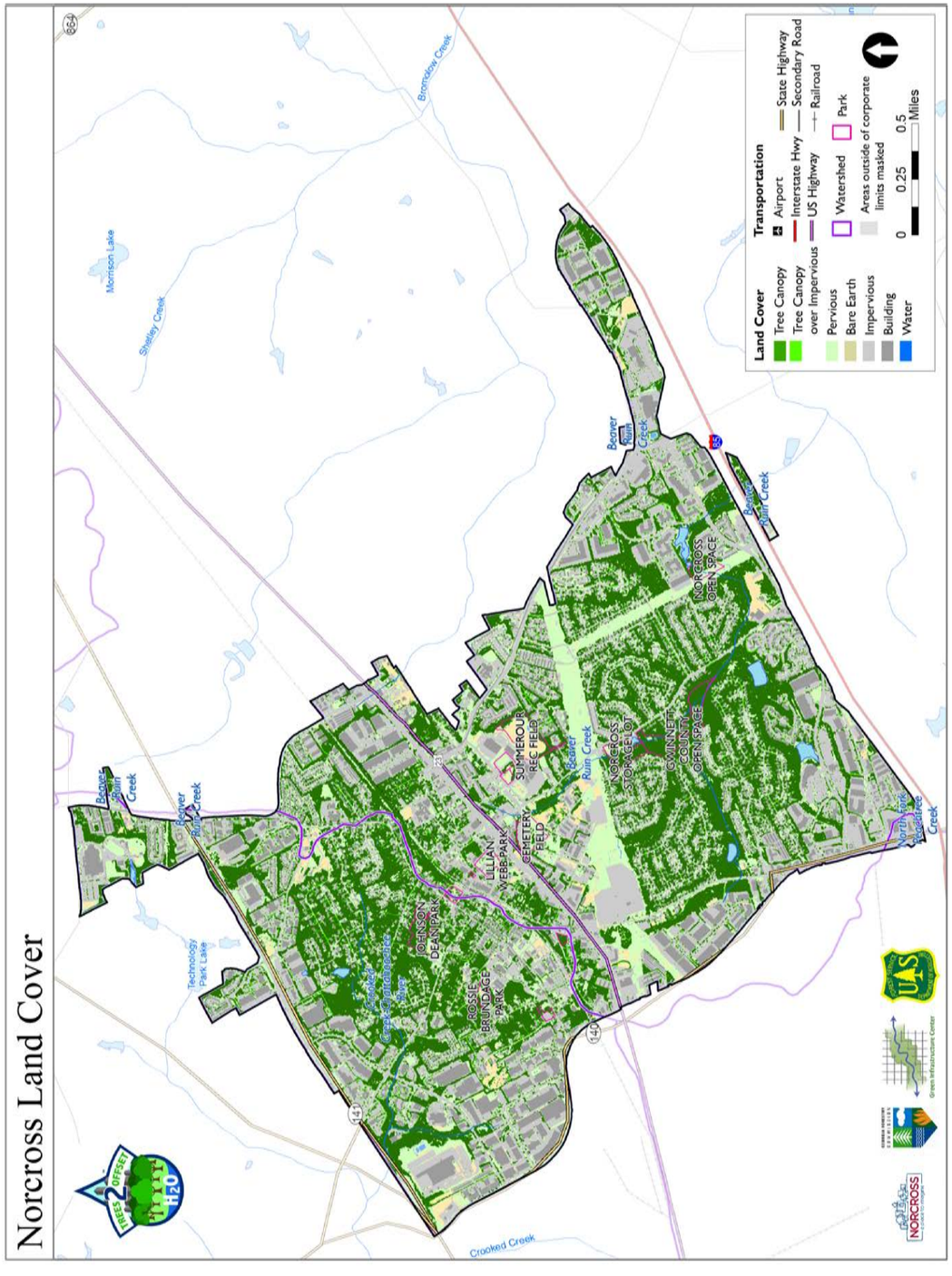
    Half of the tree canopy coverage is hardwood tree species and the other half is softwood tree species.



Citywide tree canopy is 38 percent.



Percent Tree Cover and Possible Planting Area by Watershed



This map shows the tree canopy of the city which covers 38 percent of the area.

WHY PROTECT OUR URBAN FORESTS?

Today, municipalities are losing their trees at an alarming rate, estimated at four million trees annually nationwide (Nowak 2010). This is due, in large part, to population growth. This growth has brought pressures for land conversion to accommodate both commercial and residential development. Cities are also losing older, established trees from the cumulative impacts of land development, storms, diseases, old age and other factors (Nowak and Greenfield 2012). At 38 percent canopy, Norcross has a relatively good coverage by the urban forest.

However, many cities such as Norcross have lost their natural forest cover as the city has grown. While the canopy is relatively good today, the city may see losses unless planting and urban forest care are better funded. As older trees die (or before they die), younger trees need to be planted to restore the canopy. For recommendations on how the city can better protect and manage its urban forests, see the Codes and Ordinances section of this report.

The purpose of this report is not to seek a limit on the city's development, but to help the city better utilize its tree canopy to manage its stormwater. Additional benefits of improved canopy include:

- cleaner air,
- aesthetic values,
- reduced heating and cooling costs,
- decreased urban heat island effects,
- buffering structures from wind damage.
- increased bird habitat;
- fostering walkability and multimodal transportation; and,
- increased revenue from tourism and retail sales.

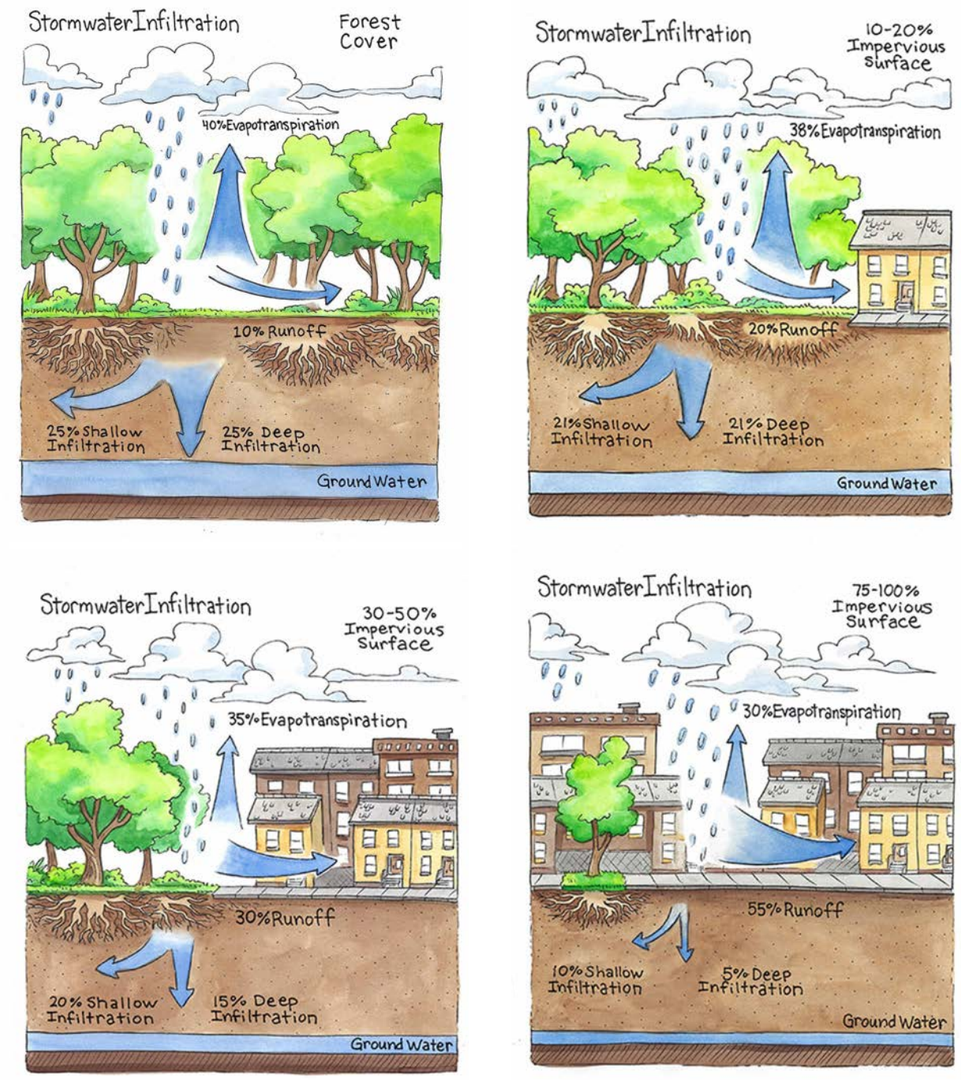
Assessment and inventory of trees is key to ensuring a healthy forest.

Neighborhood trees

According to the U.S. Environmental Protection Agency (EPA), excessive stormwater runoff accounts for more than half of the pollution in the nation's surface waters and causes increased flooding and property damages, as well as public safety hazards from standing water. The EPA recommends a number of ways to use trees to manage stormwater in the book Stormwater to Street Trees.

In considering runoff, the amount of imperviousness is one consideration; the other is the degree and type of forested land cover, since vegetation helps absorb stormwater and reduces the harmful effects of runoff. As their urban forest canopies have declined across the south, municipalities have seen increased stormwater runoff. Unfortunately, many cities do not have a baseline analysis of their urban forests or strategies to replace lost trees.

When forested land is converted to impervious surfaces, stormwater runoff increases. This increase in stormwater causes temperature spikes in receiving waters, increased potential for pollution of surface and ground waters and greater potential for flooding. When underground aquifers are not replenished, land subsides.



Runoff increases as land is developed. Information source: U.S. EPA

Another cause of canopy decline is the many recent powerful storms that have affected the Southeastern United States. This study was funded to address canopy decline by helping municipalities monitor, manage and replant their urban forests and to encourage cities to enact better policies and practices to reduce stormwater runoff and improve water quality.

It is not just development and storms that contribute to tree loss. Millions of trees are also lost as they reach the end of their life cycle through natural causes. For every 100 street trees planted, only 50 will survive 13-20 years (Roman et al 2014).

Even in older developed areas with a well-established tree canopy, redevelopment projects may remove trees. Choosing the wrong tree for a site or climate, planting it incorrectly, or caring for it poorly can all lead to tree canopy loss. It is also important to realize that an older, well-treed neighborhood of today may not have good coverage in the future unless young trees – the next generation – are planted.

Urbanizing counties and cities are beginning to recognize the importance of their urban trees because trees provide tremendous dividends. For example, urban canopy can reduce

Excess impervious areas cause hot temperatures and runoff. Some older paved areas predate regulations requiring stormwater management.

stormwater runoff anywhere from two to seven percent (Fazio 2010). According to Penn State Extension, during a one-inch rainfall event, one acre of forest will release 750 gallons of runoff, while a parking lot will release 27,000 gallons! This could mean an impact of millions of gallons during a major precipitation event. While stormwater ponds and other management features are designed to attenuate these events, they cannot fully replicate the pre-development hydrologic regime. In addition, as an older city, parts of Norcross may lack stormwater management practices that are now required for new developments.

Trees filter stormwater and reduce overall flows. So planting and managing trees is a natural way to mitigate stormwater. Estimates from Dayton, Ohio study found a seven percent reduction in stormwater runoff due to existing tree canopy coverage and a potential increase to 12 percent runoff reduction as a result of a modest increase in tree canopy coverage (Dwyer et al 1992). Conserving forested landscapes, urban forests, and individual trees allows localities to spend less money treating water through the municipal storm systems and also reduces flooding.

Each tree plays an important role in stormwater management. For example, based on the GIC's review of multiple studies of canopy rainfall interception, a typical street tree's crown can intercept between 760 gallons to 3000 gallons per tree per year, depending on the species and age. If a community were to plant an additional 5,000 such trees, the total reduced runoff per year could amount to millions of gallons of reduced runoff. This means less flooded neighborhoods and reduced stress on storm drainage pipes and decreased runoff into the city's creeks.

Another compelling fiscal reason for planning to conserve trees and forests as a part of a green infrastructure strategy is minimizing the impacts and costs of natural disasters. Not only do trees reduce the likelihood of extensive flooding, they also serve as a buffer against storm damages from wind.

In urban areas, Geographic Information Systems (GIS) software is used to map the extent of the current canopy as well as to estimate how many new trees might be fitted into an urban landscape. A Possible Planting Area (PPA) map estimates areas that may be feasible to plant trees. A PPA map helps communities set realistic goals for what they could plant (this is discussed further on in the Methods Appendix).

This house has a newly planted tree, which increases the home's value.

Trees in yard.

ADDITIONAL URBAN FOREST BENEFITS

Quality of Life Benefits

During Georgia's hot summers, more shade is always appreciated. Tree cover shades streets, sidewalks, parking lots, and homes, making southern urban locations cooler, and more pleasant for walking or biking. Trees absorb volatile organic compounds and particulate matter from the air, improving air quality, and thereby reducing asthma rates. Shaded pavement has a longer lifespan thereby reducing maintenance costs associated with repairing or replacing roadways and sidewalks (McPherson and Muchnick 2005).

Communities with greener landscapes benefit children by reducing both asthma and ADHD symptoms.

This artist appreciates the shade as she paints.

These trees shade the water and buffer runoff.

Children who suffer from Attention Deficit Hyperactivity Disorder (ADHD) benefit from living near forests and other natural areas. One study showed that children who moved closer to green areas have the highest level of improved cognitive function after the move, regardless of level of affluence (Wells 2000). Thus, communities with greener landscapes benefit children and reduce ADHD symptoms. Trees also cause people to walk more and walk farther. This is because when trees are not present, distances are perceived to be longer and destinations farther away, making people less inclined to walk than if streets and walkways are well treed (Tilt, Unfried and Roca 2007).

Well treed areas encourage people to walk.

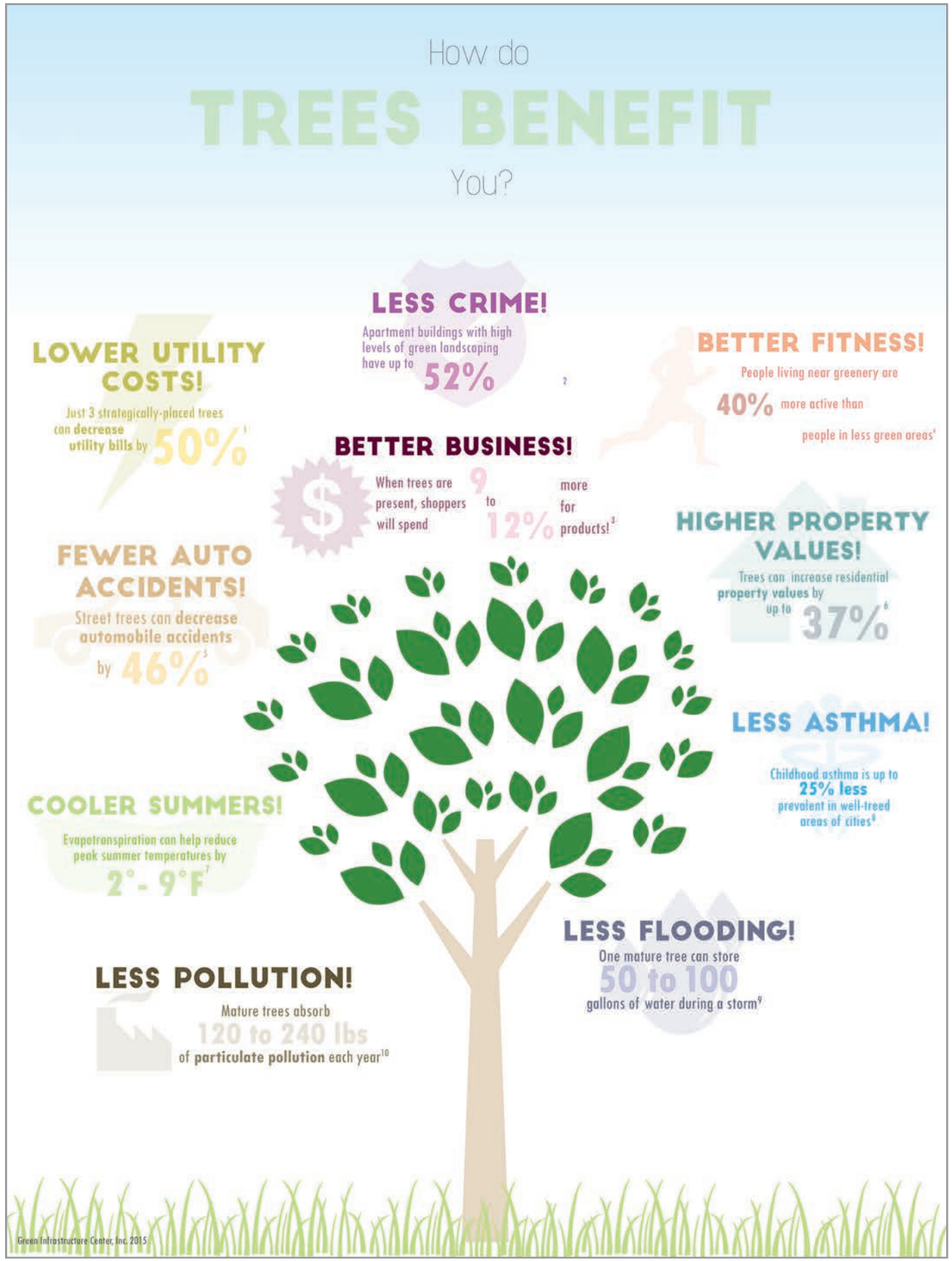
Economic Benefits

Developments that include green space or natural areas in their plans sell homes faster and for higher profits than those that take the more traditional approach of building over an entire area without providing for community green space (Benedict and McMahon 2006). This desire for green space is supported by a National Association of Realtors study which found that 57 percent of voters surveyed were more likely to purchase a home near green space and 50 percent were willing to pay 10 percent more for a home located near a park or other protected area. A similar study found that homes adjacent to a greenbelt were valued 32 percent higher than those 3,200 feet away (Correll et al. 1978).

Meeting Regulatory Requirements

Trees also help meet the requirements of the Clean Water Act. The Clean Water Act requires Georgia to have standards for water quality. When waters are impaired they may require establishment of a Total Maximum Daily Load (TMDL) standard and a clean-up plan (i.e., Best Management Action Plan) to meet water quality standards. Since a forested landscape produces higher water quality by cleaning stormwater runoff (Booth et al 2002), increasing forest cover results in less pollutants reaching the city's surface and ground waters.

Trees would beautify this commercial area.



NATURAL ECOLOGY IN URBAN CONDITIONS – CHANGING LANDSCAPES

Natural history, even of an urbanized location, informs planting and other land-management decisions. Norcross is located in the Piedmont Region of Georgia, characterized by gently rolling, well-rounded hills and long, low ridges with a few hundred feet of elevation difference between the hills and valleys. It generally has high-grade metamorphic rocks and scattered igneous intrusions. Its vegetation consists of early succession and scrub-shrub habitat with low, woody vegetation and herbaceous plants with periodic disturbances that result in dense understory vegetation. While the urban landscape of Norcross is highly altered, the urban forest still supports birds, bees and other pollinators while providing shade and cooling for the city. The city's Thrasher Park even supports a tree tour http://www.norcrossga.net/DocumentCenter/View/1770/ and city hall boasts a state champion Elm tree! The city is working with the Atlanta Regional Commission on a multi-use trail system connecting Norcross to Lilburn, for more see https://www.gateway85.com/portfolio/norcross-to-lilburn-trail/

This American elm located in the Betty Mauldin Park is a state champion with a crown spread of 105 feet and a height of 79 feet.

HISTORIC LAND COVER

Today, Norcross's downtown is charming with its restaurants, sidewalks and shops. Although it's a small city, Norcross maintains nine city parks, with abundant opportunities to enjoy the outdoors and support native species. City parks, such as Thrasher Park, named after the city's founder, are popular places to experience nature in the city and add to the city's livability. Norcross was a natural location to site a town, sitting as it does astride the Northeastern Continental Divide. This ridgeline formed an ideal place to site a railroad. In 1998, John J. Thrasher bought 250 acres around a railroad terminal and he named the new town for his friend, Atlanta's then Mayor Jonathan Norcross. Today, the downtown showcases a classic 19th century railroad town and it is now a National Historic District.

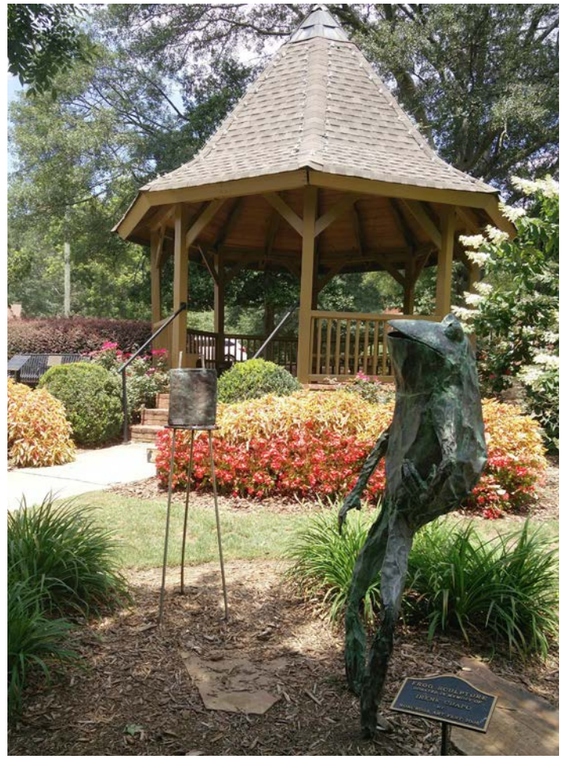
Norcross supports a vibrant and charming downtown.

GROWTH AND DEVELOPMENT CHALLENGES

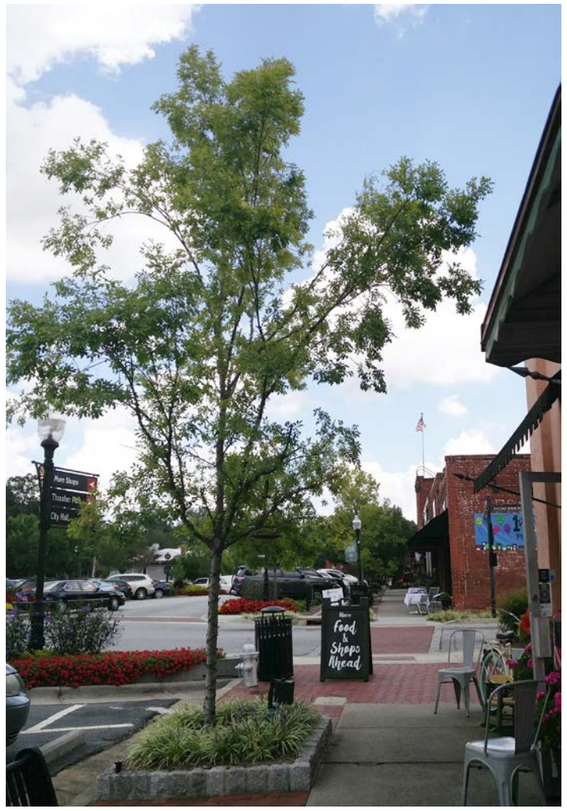
Demands for space to meet the needs for housing, commercial, business, and transportation uses put strains on both the city's grey and green infrastructure. Its close proximity to the burgeoning Atlanta Metro Region and its small town charm, mean that land for development and re-development is in high demand. The population has increased 11% since the 2010 census (U.S. Census Bureau).

As an older city, chartered in 1870, there are areas that pre-date the 1987 Clean Water Act Amendments which requires the treatment of stormwater runoff. Adding stormwater treatment for older areas is achieved by either retrofitting stormwater best management practices into the landscape, or adding them as properties are re-developed. Adding more trees is a best management practice that provides other benefits beyond stormwater uptake, such as shade, air cleansing and aesthetic values. Recommendations for improvements to better utilize trees to manage stormwater and to reduce imperviousness are found in the Codes, Policies and Practices section of this report.

Residents can make a difference in runoff as these local tree board members demonstrate!



Whimsical nature sculptures such as this frog by Beau Smith, compliment the urban forest setting of Thrasher Park.



Newly planted tree downtown.

Reducing imperviousness and increasing vegetation are one way to ease the frequency of flooding because this limits the amount of water that needs to be drained by the storm drainage system. Vegetation reduces water entering the system by intercepting, capturing and transpiring that water.

The requirements set forth by the Clean Water Act of 1972 for the Environmental Protection Agency's National Pollution Discharge Elimination System (NPDES) permitting program, and subsequent amendments in 1987 regulating nonpoint source pollution, form the foundation for the city's stormwater management program.

High rates of stormwater runoff cause siltation problems for streams and loss of channel capacity.

ANALYSIS PERFORMED

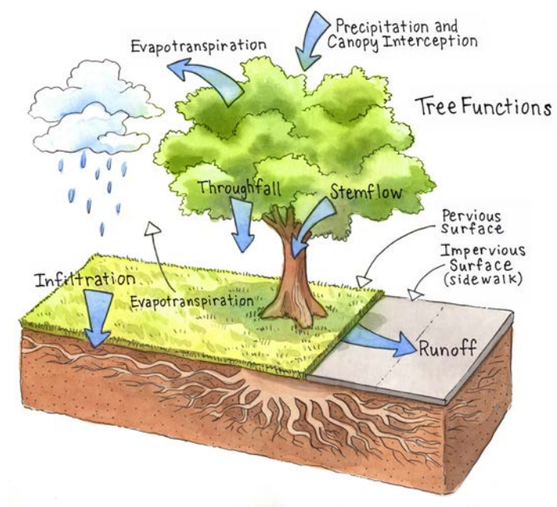
This project evaluated options for how to best model stormwater runoff and uptake by the city's tree canopy. Its original intended use was for planning at the watershed scale for tree conservation. An example is provided on page 16. However, new tools created for the project allow the stormwater benefits of tree conservation or additions as to be calculated at the site scale as well.

As noted, trees intercept, take up and slow the rate of stormwater runoff. Canopy interception varies from 100 percent at the beginning of a rainfall event to about three percent at the maximum rain intensity. Trees take up more water early on during storm events and less water as storm events proceed and the ground becomes saturated (Xiao et al. 2000). Many forestry scientists, as well as civil engineers, have recognized that trees have important stormwater benefits (Kuehler 2017, 2016). See diagram of tree water flow below.

METHOD TO DETERMINE WATER INTERCEPTION, UPTAKE AND INFILTRATION

Currently, most cities use TR-55 curve numbers developed by the Natural Resources Conservation Service (NRCS) to model expected runoff amounts. The city can use the modified TR55 curve numbers (CN) from this study that include a factor for canopy interception. This project is also a tool for setting goals at the watershed scale for planting trees and for evaluating consequences of tree loss as it pertains to stormwater runoff.

This study used modified TR-55 curve numbers to calculate stormwater uptake for different land covers, since they are widely recognized and understood by stormwater engineers. Curve numbers produced by this study can be utilized in the city's modeling and design reviews. The project's spreadsheet calculator tool makes it very easy for the city to change the curve numbers if they so choose. A canopy interception factor is added to account for the role trees play in interception of rainfall based on location and planting condition (e.g. trees over pavement versus trees over a lawn or in a forest).



Trees and the Water Cycle

Unit of Analysis	Percent Tree Canopy
Beaver Ruin Creek	37.0%
Crooked Creek – Chattahoochee River	40.3%
North Fork Peachtree	2.0%
Citywide	38.0%

Tree canopy reduces the proportion of precipitation that becomes stream and surface flow, also known as water yield. In a study, Hynicka and Divers (2016) modified the water yield equation of the NRCS model by adding a canopy interception term (Ci) to account for the role that canopy plays in capturing stormwater, resulting in:

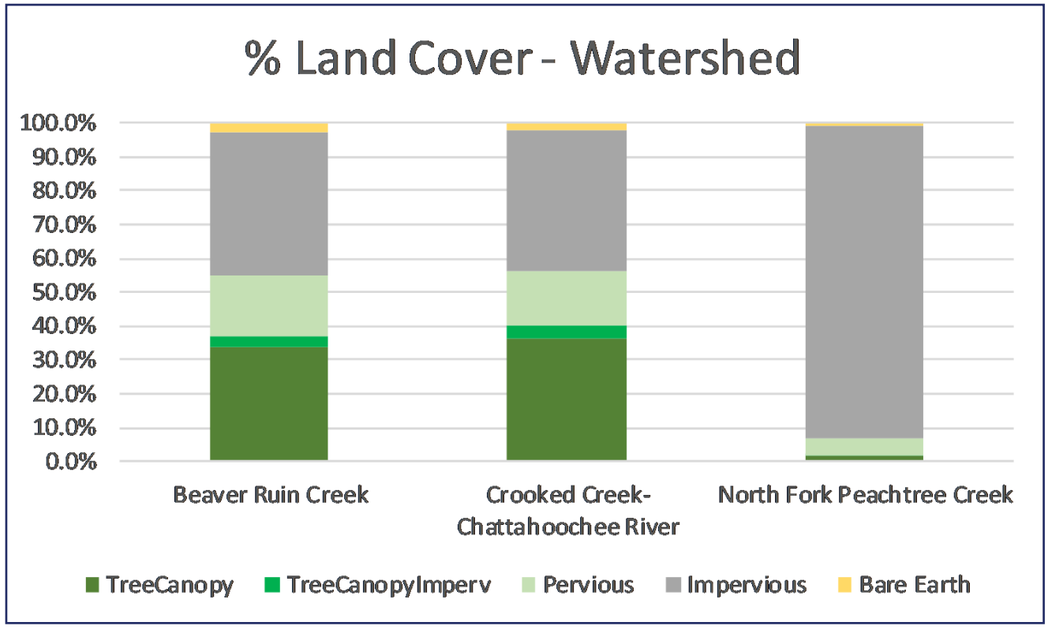
$$R = \frac{(P - C_i - I_a)^2}{(P - C_i - I_a) + S}$$

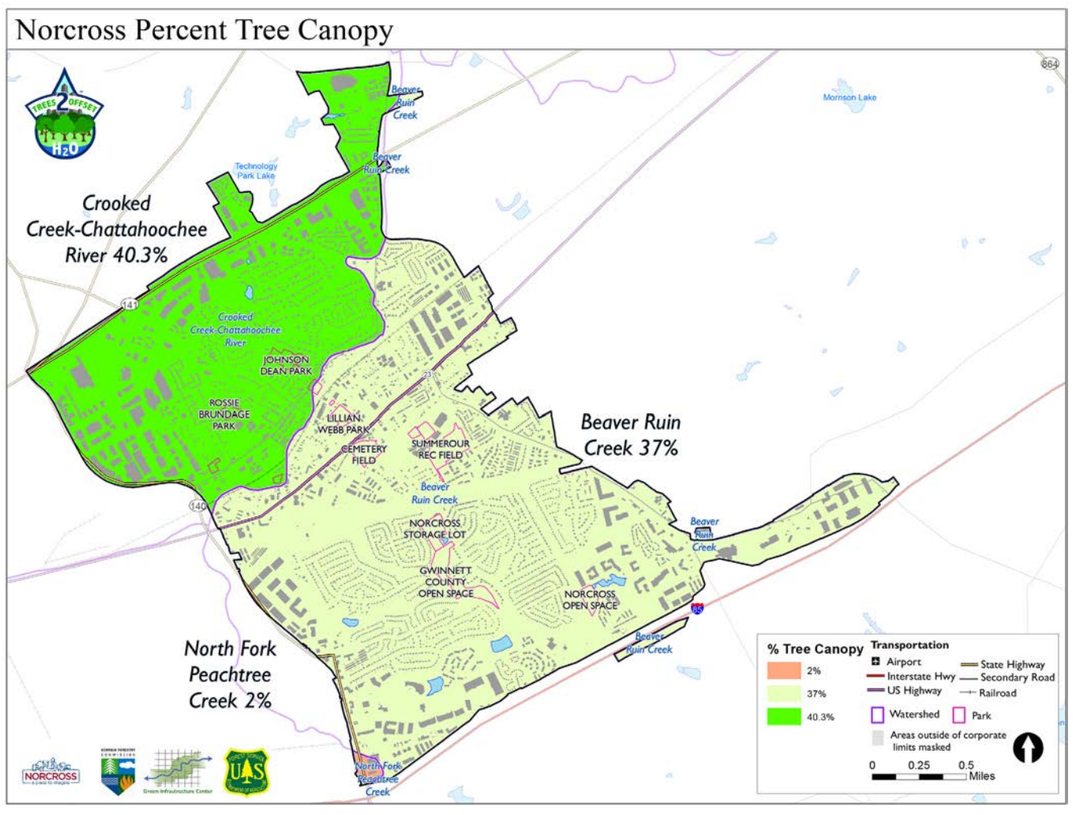
Where R is runoff, P is precipitation, Ia is the initial abstraction for captured water, which is the fraction of the storm depth after which runoff begins, and S is the potential maximum retention after runoff begins for the subject land cover (S = 1000/CN – 10).

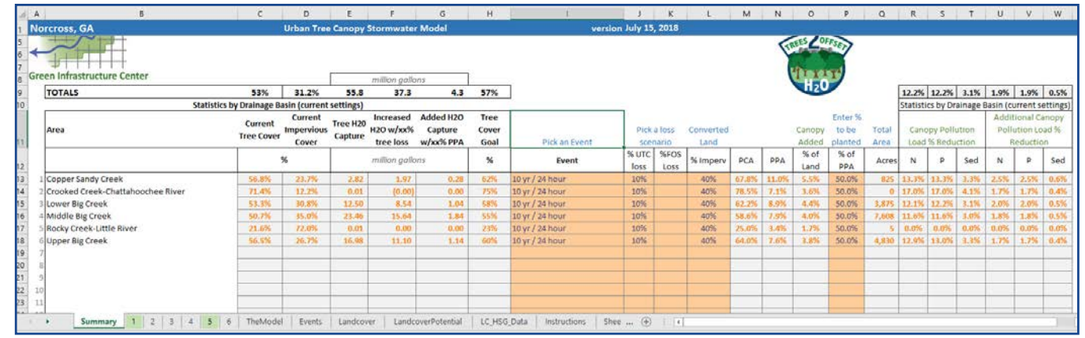
Factors that influence stormwater capture include:

- The hydrologic soil group (defined by surface infiltration rates and transmission rates of water through the soil profile, when thoroughly wetted)
- Land cover types
- Hydrologic condition – density of vegetative cover, surface texture, seasonal variations
- Treatment – design or management practices that affect runoff

What is new about the calculator tool is that the curve numbers relate to the real land cover conditions in which the trees are







The calculator tool developed for this project allows the city to see the water uptake by existing canopy and model impacts from changes, whether positive (adding trees) or negative (removing trees).

found. In order to use the equation and model scenarios for future tree canopy and water uptake, the GIC first developed a highly detailed land cover analysis and an estimation of potential future planting areas, as described following. These new land cover analyses can be used for many other projects, such as looking at urban cooling, walkability (see map of street tree coverage on following pages), trail planning and for updating the comprehensive plan.

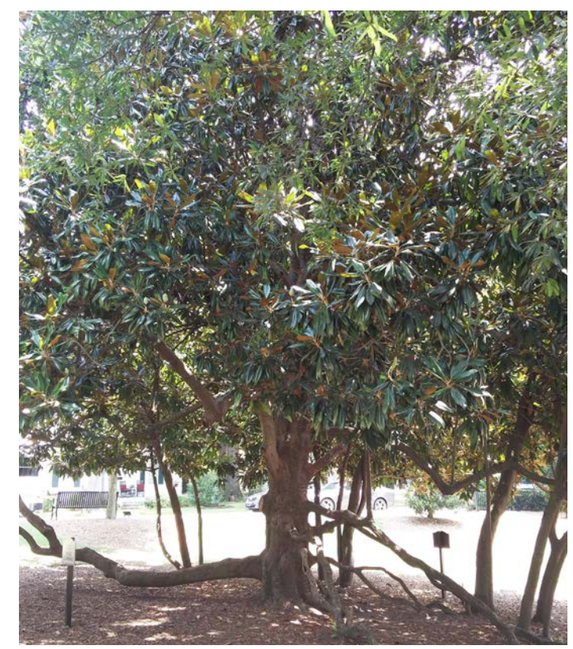
An example of how this modeling tool can be used for watershed-scale forest planning is indicated following. The actual model spreadsheet was provided to Norcross. It links to the land cover statistics for each type of planting area. It also allows the city to hypothetically add or reduce tree canopy to see what are the effects for stormwater capture or runoff. The key finding from this work is that removal of mature trees generates the greatest impacts for stormwater runoff. As more land is re-developed in Norcross, the city should maximize tree conservation for maintenance of surface water quality and groundwater recharge. This will also benefit the city's quality of life by fostering clean air, walkability, and attractive residential and commercial districts. Several studies have shown that higher tree canopy percentage is associated with lower overall hospitalization numbers and also with lower hospital visits from asthma.

The stormwater runoff model provides estimates of precipitation capture by tree canopy and the resulting reductions in runoff yield. It takes into account the interaction of land cover and soil hydrologic conditions. It can also be used to run 'what-if' scenarios, specifically losses of tree canopy from development and increases in tree canopy from tree planting programs.

The trees and stormwater model can be used to estimate the impact of the current canopy, possible losses to that canopy, and potential for increasing that canopy. As shown below, for a 10-year,* 24-hour storm a loss of 10% of the urban tree canopy would increase runoff by 3 million gallons, while increasing canopy coverage from the current 38% to 41% would decrease runoff by almost 1 million gallons. (See graphic at top of page.)

* A 10-year storm refers to the average recurrence interval, or a 10 percent chance of that level of rainfall occurring.

This new approach allows for more detailed assessments of stormwater uptake based on the landscape conditions of the city's forests. It distinguishes whether the trees are within a tree cluster, a lawn setting, a forested wetland or over pavement, such as streets or sidewalks. Tree setting is considered because the conditions in which the tree is living affect the amount of water the tree can intercept. The amount of open space and the condition of surface soils affect the infiltration of water. In order to determine these conditions, a detailed land cover assessment was performed as described following. The analysis can be used to create plans for where adding trees or better protecting them can reduce stormwater runoff impacts and improve water quality.



This magnolia in a local park has plenty of room to grow and can capture a lot of water through its canopy and roots.

LAND COVER, POSSIBLE PLANTING AREA, POSSIBLE CANOPY AREA ANALYSIS

The land cover data were created using 2015 leaf-on imagery from the National Agriculture Imagery Program (NAIP) distributed by the USDA Farm Service Agency. Ancillary data for roads (from Norcross government), and hydrology (from National Wetlands Inventory and National Hydrography Dataset) were used to determine:

1) Tree cover over impervious surfaces, which otherwise could not be seen due to these features being covered by tree canopy; and

2) Wetlands not distinguishable using spectral/feature-based image classification tools.

In cities studied for this project, forested open space was identified as areas of compact, continuous tree canopy greater than one acre, not intersected by buildings or paved surfaces.

The final classification of land cover consists of six classes listed below. The Potential Planting Area (PPA) is created by selecting the land cover features that have space available for planting trees. (i.e., areas were the growth of a tree will not affect or be affected by existing infrastructure.) Of the seven land cover classes, only pervious (grass and scrub vegetation) is considered for PPA.

- Tree Canopy
- Tree Canopy over Impervious
- Pervious
- Impervious
- Bare earth
- Water

Next, these eligible planting areas are limited based on their proximity to features that might either interfere with a tree's

Urban trees often are constrained by sidewalks and buildings.

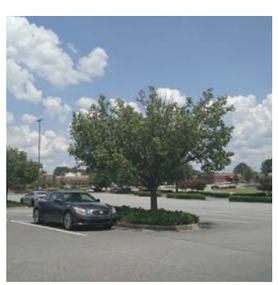
This shows what is currently treed (green) and areas where trees could be added (orange).

natural growth (such as buildings) or places a tree might affect the feature itself such as power lines, sidewalks or roads. Playing fields and other known land uses that would not be appropriate for tree cover are also avoided. However, there may be some existing land uses (e.g., soccer fields or golf courses) that are unlikely to be used for tree planting areas but that may not have been excluded from the PPA. In addition, the analysis did not take into account proposed future developments (e.g., planned developments) that would not likely be fully planted with trees. Therefore, the resulting PPAs represent the maximum potential places trees can be planted and grow to full size. A good rule is to assume about half the available space could be planted with trees.

Tree over street

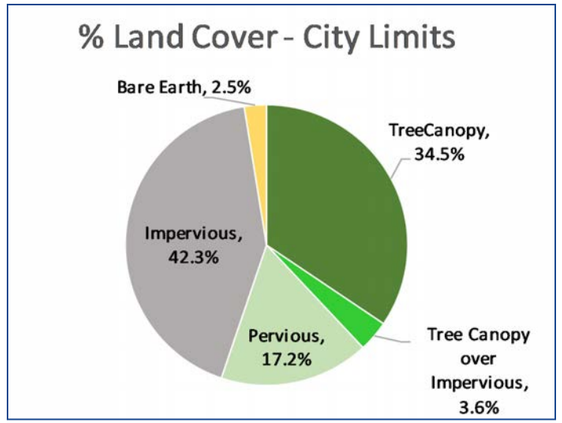
Trees over forest

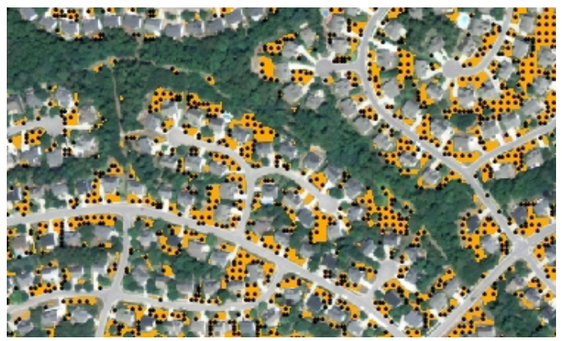
Tree over lawn



Tree over parking lot

Potential Planting Area (PPA) shown in orange depicts areas where it may be possible to plant trees. All sites would need to be confirmed in the field and may be on private or public lands.





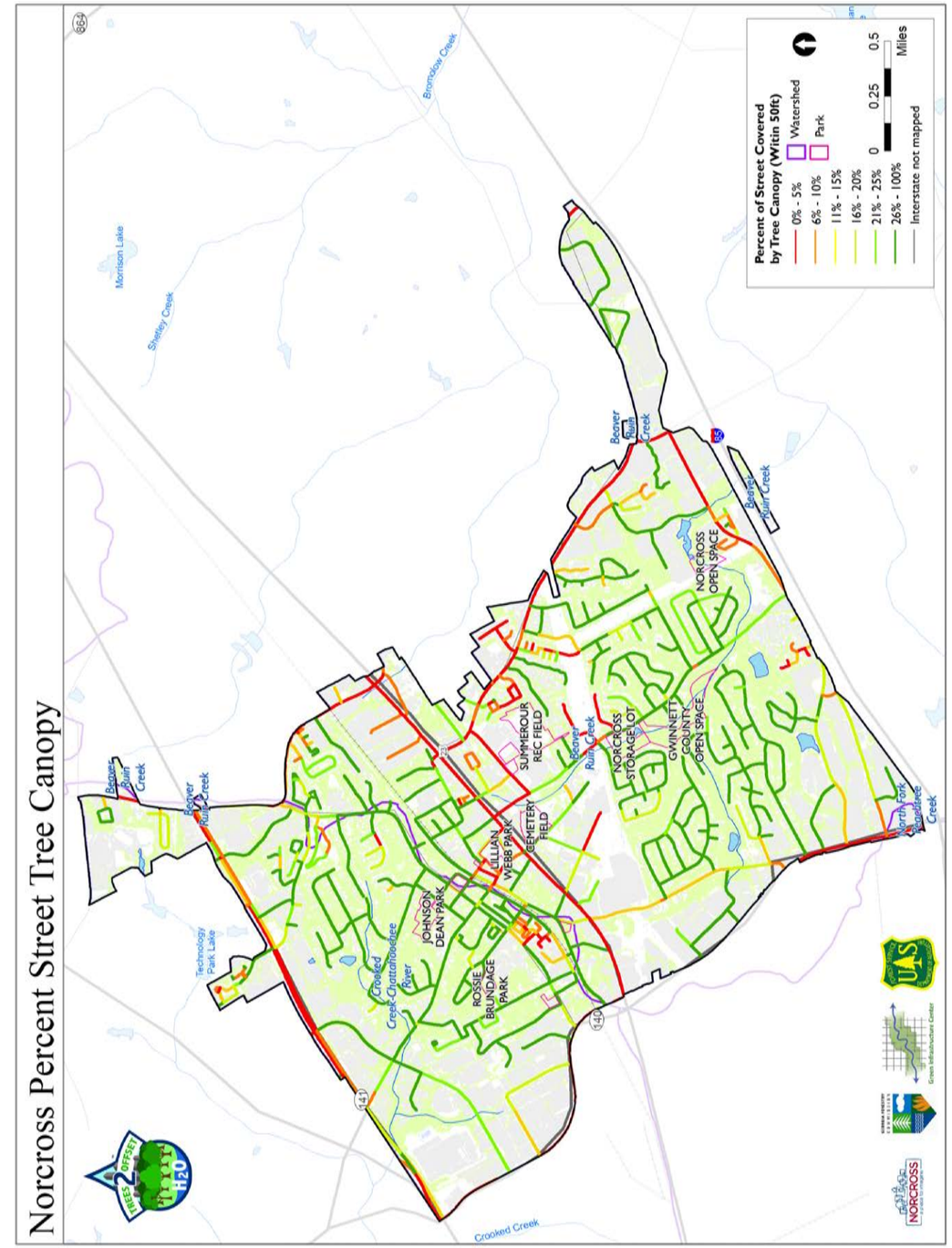
Potential Planting Spots (PPS)

Potential Canopy Area (PCA)

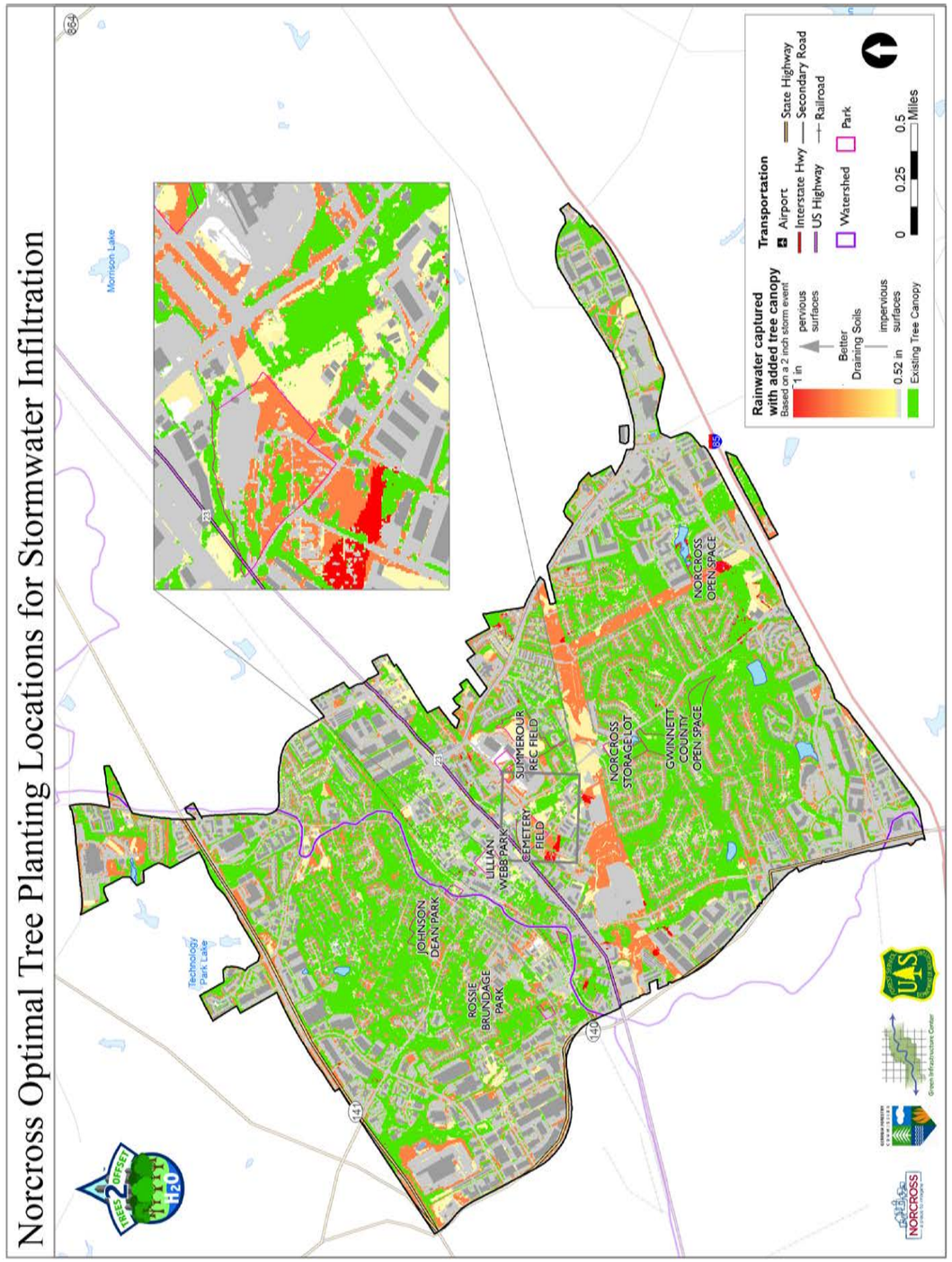
The Potential Planting Spots (PPS) are created from the PPA. The PPA is run through a GIS model that selects those spots where a tree can be planted depending on the size of trees desired. For this analysis, expected sizes of both 20 ft. and 40 ft. diameter of individual mature tree canopy were used with priority given to 40 ft. diameter trees (larger trees have more benefits). It is expected that 30 percent overlap will occur as these trees reach maturity. The result demonstrates a scenario where, if planted today, once the trees are mature, their full canopy will cover the potential planting area and overlap adjacent features, such as roads and sidewalks.

The Potential Canopy Area (PCA) is created from the PPS. Once the possible planting spots are selected, a buffer around each point that represents a tree's mature canopy is created. Similarly, the tree buffer radius is 20 ft. or 40 ft. diameter canopy for each tree. These individual tree canopies are then dissolved together to form the potential overall canopy area.

Percent Street Trees (see map on following page) is calculated using the Land Cover Tree Canopy and road centerlines, which are buffered to 50 ft. from each road segment's centerline. The percent value represented is the percentage of tree cover within that 50 ft. buffer.



The street trees map shows which streets have the most canopy (dark green) and which have the least (red). Streets lacking good coverage can be targeted for planting to facilitate uses, such as safe routes to school or beautifying a shopping district. See Methods Appendix for more details on mapping methodology.



This map shows which plantable areas are the most permeable and will provide the greatest stormwater infiltration benefits.

CODES, ORDINANCES AND PRACTICES REVIEW

This review is designed to determine which practices make the city more impervious (e.g. too much parking required) and which make it more pervious (e.g. conserving trees or requiring open spaces). Documents reviewed during the codes, ordinances and practices analysis for the project include relevant sections of the city's current code that influence runoff or infiltration. Data were gathered through analysis of city codes and policies, as well as interviews with city staff, whose input was incorporated directly on the spreadsheet summary prepared by the GIC. The spreadsheet provided to the city lists all the codes reviewed, interviews held and relevant findings. A more detailed memo submitted to the city by GIC, also provides additional ideas for improvement.

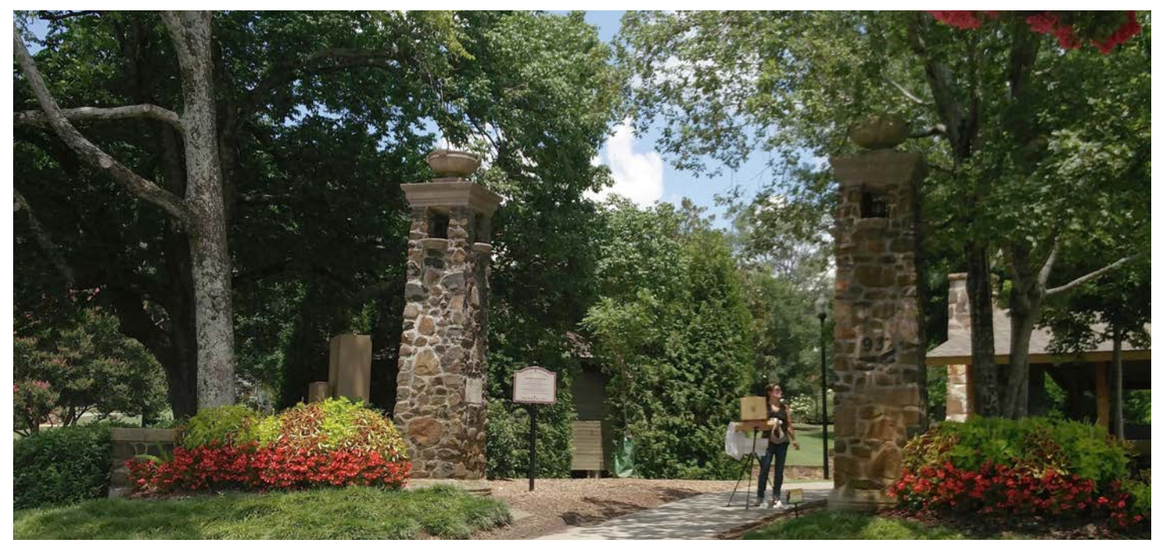
EVALUATION AND RECOMMENDATIONS

Points were assigned to indicate what percentage of urban forestry and planning best practices have been adopted to date by the city. The spreadsheet tool created for city codes can also serve as a tracking tool and to determine other practices or policies the city may want to adopt in the future to strengthen the urban forestry program or to reduce impervious land cover. A final report comparing all studied localities will be issued by GIC in 2019.

Norcross invests staff time and funds to manage its urban forest. The city's half-mile walk through the city's Historic District highlights some of the tree species found throughout Georgia. The city just celebrated its fifteenth year of being recognized as a 'Tree City USA' by the Arbor Day Foundation, which means that it spends adequate funds per capita on tree care, it has a tree ordinance, and it practices tree management. The City's Tree Preservation Board meets bi-monthly and is established to assist the Community Development Department in interpreting and enforcing the provisions of the Tree Preservation Ordinance.

The recommendations provided in this report are a way to increase the protections for, and size of, the forest in Norcross. As

noted earlier, although the city's canopy is about 38 percent, it is not distributed equally citywide and will require new plantings to maintain this level of coverage. Norcross is one of 12 localities in a six-state area of the Southeastern U.S. to be studied and the sixth to be completed. As other places are studied, they will be compared to the city, and vice versa.



Top recommendations to improve forest care in Norcross listed in priority order include the following:

1. **Use the GIC's stormwater uptake calculator to determine the benefits of maintaining or increasing tree canopy goals by watershed.** The calculator provided to Norcross allows the city to determine the stormwater benefits or detriments (changes in runoff) from adding or losing trees and to calculate the pollution loading reductions for nitrogen, phosphorus, and sediment.

2. **Use the urban forestry funding calculator to develop an urban tree canopy coverage goal and determine the cost of achieving that goal.** Request funding from city council to achieve the desired goal. Planting and maintaining more trees costs money but is well worth the outcome as trees pay the city back in improved property values, sales tax revenues and energy savings.

3. **Establish a tree bank to help fund planting and maintenance of the urban forest.** Fines and fees collected from development activities are used by many municipalities to fund urban forest planting and maintenance. When trees are removed from private developments, the city should be allowed to replace those trees on public land.

4. **Hire a certified arborist to provide forest care oversight and tree management.** There are creative ways in which this can be accomplished. Municipal arborists educate community members about trees, care for city-owned trees, educate developers in caring for privately owned trees, and work in collaboration with planners, engineers, and GIS staff to plan for the future urban tree canopy. Arborists are essential to any urban forestry program, regardless of municipality size.

5. **Conduct a land cover assessment every four years to determine and allow for comparison of tree canopy coverage change over time.** Keeping tree canopy coverages at levels that promote public health, walkability, and groundwater recharge for watershed health is vital for livability and meeting state water quality standards. Regular updates to land cover maps allow for this analysis and tree planning to occur.

6. **Develop a Norcross Tree Stewards group.** The city has a tree protection board. The city should provide them with resources and guidance so they can continue to help build and maintain the urban forest. Trees are central to the city's identity. Residents at both community meetings of the Trees and Stormwater Project said they either moved to Norcross or stayed in Norcross because of the abundant tree canopy coverage. Residents also said that they wanted to help the city increase and maintain their tree canopy. Tree steward groups can carry out tree planting projects, provide tree care trainings, and increase the public's awareness of the value and care of trees.

7. **Work with developers to shrink the development footprint to minimize impervious surface.** Holding a pre-development conference allows all parties to explore ideas for tree conservation before extensive funds are spent on land planning. Impervious surfaces can be reduced though multiple tactics such as flexible parking standards, permeable walkways and expanded landscaping requirements.

8. **Expand tree inventory requirements to include hardwoods 18" DBH and over, softwoods 24" and over, and all understory species 8" and over.** Tree protection begins with tree inventory. A tree inventory contains information about the type, age, and caliper of existing trees on a site. The city can expand tree inventories and protect more urban tree canopy.

9. **Require the inventory and protection of loblolly pines.** The city should allow for discretion in loblolly pine protection requirements as they can be easily damaged by weather, ice, and wind. Current inventory requirements exclude the loblolly pine (Pinus taeda). A recent i-Tree study, completed in July of 2018, estimates Norcross' tree canopy makeup (hardwood v. softwood). Half of the tree canopy coverage is hardwood tree species and the other half is of softwood tree species. As the loblolly pine is very common in Norcross, excluding its protection could endanger up to half of Norcross' urban tree canopy.

10. **Modify the existing stream buffer ordinance to protect 100' on either side of perennial streams and, when present, expand the buffer to include adjacent wetlands, steep slopes, and floodplains.** A 100' forested stream buffer can take up more than 90 percent of the nitrogen and phosphorus entering the buffer as runoff. Norcross currently has a stream buffer ordinance which protects 50' on either side of perennial, intermittent, and ephemeral streams. For areas where it is possible, expand buffer requirements to 100' on perennial streams to maximize pollutant uptake and stream protection. Expand the buffer to include and protect adjacent wetlands, steep slopes, and floodplains.

11. **Determine urban forestry data needs and which software will best collect the needed urban forestry data.** The city should implement a data collection process as part of its urban forestry program. Monitoring urban forest composition and health is necessary for maintaining a thriving urban forest that serves both people and wildlife. Current urban forest survey technology make data collection far less arduous than it was in the past. Use of these software systems allows urban forest managers to make more strategic and cost-effective decisions for managing the urban forest.

12. **Require and enforce 600, 1,000 and 1,500 cubic feet soil volume planting requirements for small, medium, and large trees respectively.** At a minimum, canopy trees require 1,000 cubic feet of soil volume to thrive as recommended by the Environmental Protection Agency (Stormwater to Street Trees, 2013). The city urban forester should be consulted to recommend soil volumes based on species.

13. **Develop an Urban Forest Management Plan (UMFP).** A management plan includes the current condition of the urban forest maintenance costs, urban tree canopy coverage goals and steps to achieve them. A UFMP meshes local government and community interests to proactively manage the urban canopy and provide long term benefits.

14. **Hold inter-departmental meetings about proposed projects to discuss and minimize site conflicts that could result in excess tree loss.** Requirements such as curb/gutter, sidewalks, driveways, parking pads etc. often result in tree removals. Many of these requirements are managed by city departments such as Transportation, Planning, and Public Works. Since these requirements are managed by more than one department, inter-departmental communication is a critical component of achieving a site design which minimizes tree canopy coverage loss and maximizes livability and connection.

15. **Account for stormwater interception of tree canopy over impervious surfaces in the Low Impact Parcel stormwater credit.** Norcross has a stormwater utility fee and has several impressive forward thinking methods for landowners to reduce the fee. These include 'Low-Impact Parcels, Public Participation, Direct Discharges, and Rain Barrels.' The percentage of stormwater utility fee reduction reflects the amount of stormwater mitigated on-site. However, trees over impervious surfaces are not credited in the fee mitigation system. Include areas covered by trees over impervious surfaces in the fee mitigation system.

16. **Re-use urban waste wood. Norcross should launch a city-wide campaign to encourage the re-use of waste wood and let citizens know how they can get involved.** The city can use the Southeast Urban Wood Exchange guidance to establish an urban waste wood program. Establishing such a program is an excellent way to engage community members in re-using valuable wood products. It allows those who have extra wood (e.g. a downed tree) and those who need it (e.g. carpenters) to efficiently share the resource. For more information, see http://www.urbanwoodexchange.org/

BEST PRACTICES FOR CONSERVING TREES DURING DEVELOPMENT

Tree planting or preservation opportunities can be realized throughout the development process. A first step is to engage in constructive collaboration with developers. The City of Norcross can hold planning concept reviews at the pre-development stage. These meetings and funding for the city's urban forestry program could expand the options for conservation of the city's trees.

It is also be necessary to actively promote the implementation of development designs that minimize the loss of urban forest canopy and habitat. While the city encourages site layouts that conserve trees, developers may not always agree to implement staff suggestions. The GIC has found that economic arguments (real estate values for treed lots, access to open spaces, and rate of sales) are usually the most compelling way to motivate developers to take the extra effort and care to design sites and manage construction activities to promote tree conservation.

This will facilitate site designs which save more trees and thereby require less constructed stormwater mitigation. Many developers are willing to cooperate in such ventures, as houses often sell for a higher premium in a well-treed development.

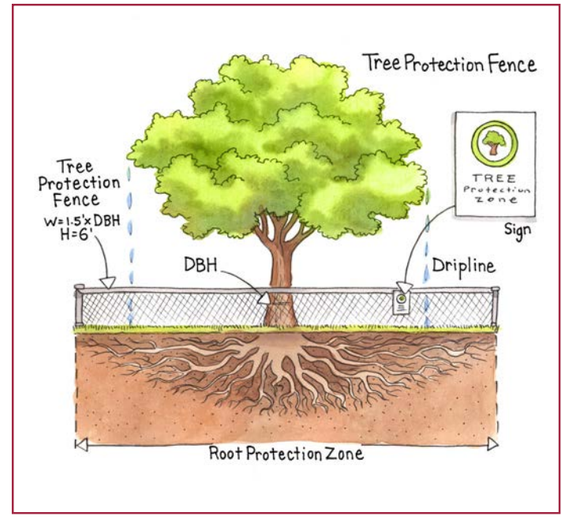
Tree Protection Fencing and Signage

Small roots at the radial extents of the tree root area, uptake water and absorb nutrients. Protection of these roots is critical for the optimal health of a tree. While protection at the dripline is an accepted practice, it does not adequately protect the roots.

Trees slated for protection may still suffer development impacts such as root compaction and trunk damage. The most common form of tree protection during construction is tree protection fencing. It is a physical barrier that keeps people and machines out of tree's critical root zones during

This tree is suffering from drought and heat scalding as shown by die-off of its upper leaves and trunk damage. Lack of care or poor planting conditions are likely to blame. Trees need at least two years of care to ensure roots take hold and the tree is well established.

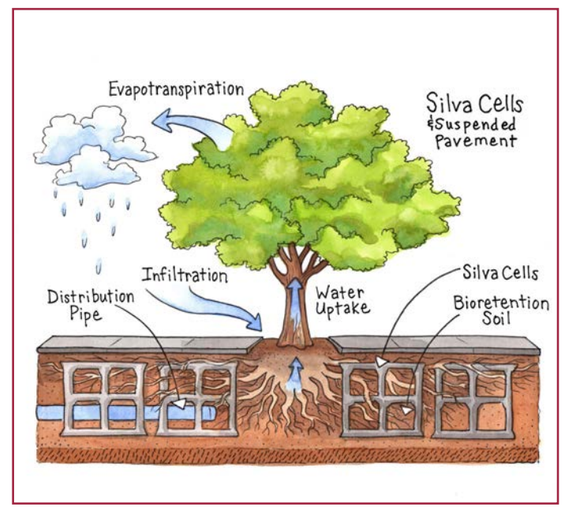
Although planted in a parking lot in less open space, this tree has an enlarged planting area and is thriving.



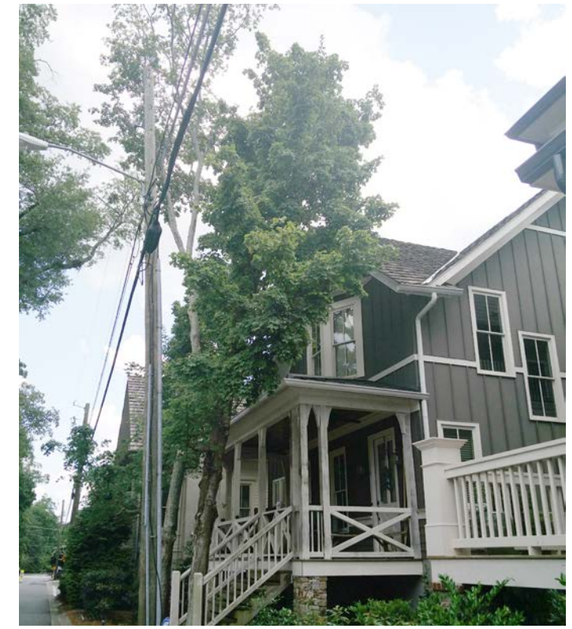
Tree Protection Fence and Signage

land disturbance. Code language requires tree protection fence placement at the critical root zone (CRZ). However, in city code, the CRZ is not defined. The city should define the CRZ as the area comprising the distance from the trunk which is 1.5' times the diameter at breast height (DBH) of the tree.

Tree protection signage communicates how work crews should understand and follow tree protection requirements. It also informs crews and citizens about the consequences of violating city code. Construction crew members may not understand that building materials may not be placed in tree protection zones and that moving the protective fencing around the tree is never permitted.



Silva Cells and Suspended Pavement

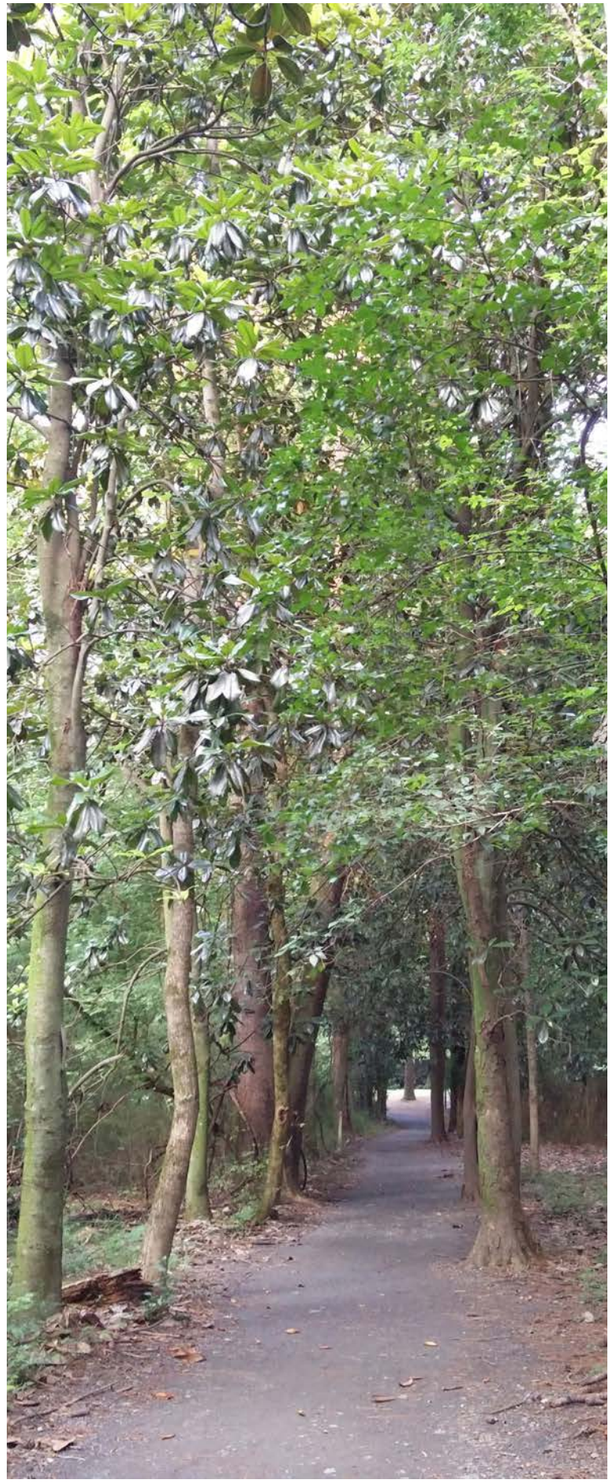


The city currently requires tree protection signage. However, it does not provide information on what can and cannot occur in tree protection zones. City staff should design a standard tree protection sign which summarizes the do's and don'ts of working near and around tree protection zones. Signage language should be written in both English and Spanish.

TREE PLANTING

In urban environments, many trees do not survive to their full potential life span. Factors such as lack of watering or insufficient soil volume and limited planting space put stresses on trees, stunt their growth and reduce their lifespans. For every 100 street trees planted, only 50 will survive 13-20 years (Roman et al 2014). This means that adequate tree well sizing standards are a critical factor in realizing the advantages of a healthy urban forest. At a minimum, canopy trees require 1000 cubic feet of soil volume to thrive. In areas where space is tighter or where heavy uses occur above roots, 'Silva cells' can be used to stabilize and direct tree roots towards areas with less conflicts (e.g. away from pipes).

In addition, large trees should not be planted where they may interfere with overhead lines. These and other practices, implemented to provide long term care, protection and best planting practices for the urban forest, will help ensure that investments in city trees will pay dividends for reducing stormwater runoff, as well as cleaner air and water, lower energy bills, higher property values and natural beauty long into the future.



CONCLUSION

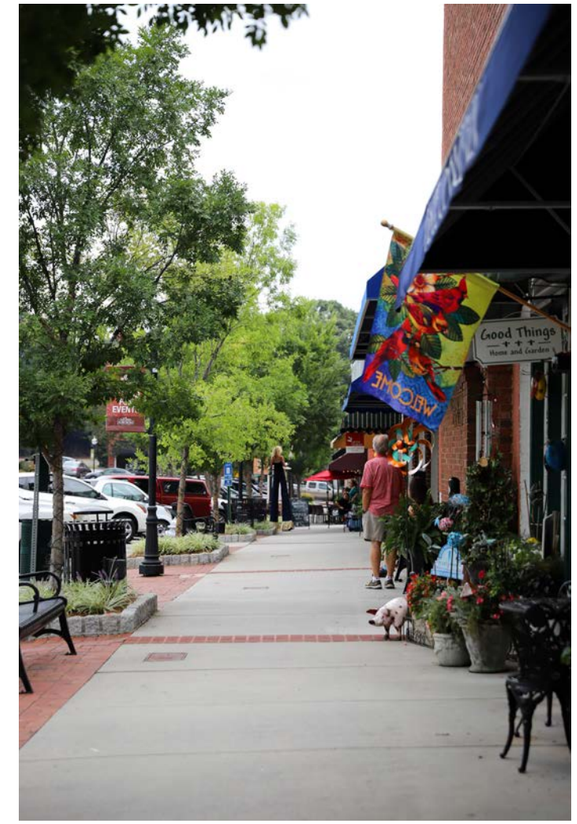
Adapting codes, ordinances and municipality practices to use trees and other native vegetation for greener stormwater management will allow Norcross to treat stormwater more effectively. Implementing these recommendations will significantly reduce the impact of stormwater sources (impervious cover) and benefit the local ecology by using native vegetation (trees and other vegetation) to uptake and clean stormwater. It will also lower costs of tree cleanup from storm damages since proper pruning or removal of trees deemed to be 'at risk' can be done before storms occur.

Remarkable results have already been achieved by this project's work with the City of Norcross Trees and Stormwater project. The city has adopted an amendment to the Tree Protection Ordinance which provides greater protections for trees regarding critical root zone protection, and tree protection fencing and signage requirements. The amendment also requires certain types of tree work only be completed by certified arborists.

In addition, the city is currently establishing a tree bank (Recommendation #3 in the Codes and Ordinances section). The city is also looking to hire a city arborist (Recommendation #4 in the Codes and Ordinances section). Norcross staff should be commended for the progress made so far.

Norcross has committed to maintaining its current canopy coverage at 38 percent. This will require the city to track tree removals and to actively plant trees to replace those that are lost to old age, storm damage or removals. New trees should be planted in areas of the city where canopy is lower and where soils have sufficient permeability to allow the water to soak in. And, since most of the city's land is in private ownership, just maintaining 38 percent canopy will require the full participation of residents and businesses to care for existing trees and to plant the next generation of Norcross' urban forest. Once new leaf-on aerial imagery data are available from the USDA, the city can verify achievement of the canopy coverage goal.

Norcross should use the canopy map and updates to track change over time and to set goals for increasing canopy by neighborhood. The city can use the canopy data, analysis and recommendations and stormwater calculator tool to continue to create a safer, cleaner, cost-effective and more attractive environment for all.



APPENDIXES

APPENDIX A: METHODS — TECHNICAL DOCUMENTATION

This section provides technical documentation for the methodology and results of the land cover classification used to produce both the Land Cover Map and Potential Planting Scenarios for Norcross.

Land cover classifications are an affordable method for using aerial or satellite images to obtain information about large geographic areas. Algorithms are trained to recognize various types of land cover based on color and shape. In this process, the pixels in the raw image are converted to one of several types of pre-selected land cover types. In this way, the raw data (i.e. the images) are turned into information about land cover types of interest, e.g. what is pavement, what is vegetation? This land cover information can be used to gain knowledge about certain issues; for example: What is the tree canopy percentage in a specific neighborhood?

Land cover classification

NAIP 2015 Leaf-on imagery (4 band, 1-meter resolution) was used for the Land cover classification. The full set of NAIP data was acquired through the Earth Resources Observation and Science (EROS) Center of the U.S. Geological Survey.

Pre-processing

The NAIP image tiles were first re-projected into the coordinate system used by the city.

NAD_1983_StatePlane_Georgia_West_FIPS_1002_Feet
WKID: 2240 Authority: EPSG

Projection: Transverse_Mercator
False_Easting: 2296583.333333333
False_Northing: 0.0
Central_Meridian: -84.16666666666667
Scale_Factor: 0.9999
Latitude_Of_Origin: 30.0
Linear Unit: Foot_US (0.3048006096012192)

Geographic Coordinate System: GCS_North_American_1983
Angular Unit: Degree (0.0174532925199433)
Prime Meridian: Greenwich (0.0)
Datum: D_North_American_1983
Spheroid: GRS_1980
Semimajor Axis: 6378137.0
Semiminor Axis: 6356752.314140356
Inverse Flattening: 298.257222101

Supervised classification

The imagery was classified using an object based supervised classification approach. The ArcGIS extension Feature Analyst was used to perform the primary classification with a 'bull's eye' object recognition configuration to identify features based on their surrounding features. Feature Analyst software is an automated feature extraction extension that enables a GIS analyst to rapidly and accurately collect vector feature data from high-resolution satellite and aerial imagery. Feature Analyst uses a model-based approach for extracting features based on their shape and spectral signature.

For better distinction between classes an NDVI image was created using Raster Calculator used instead of ArcGIS' Imagery Analyst menu for consistency. The NDVI image along with the source NAIP bands (primarily 4,1 and 2) were used to identify various features where they visually matched the imagery most accurately.

Post-processing

The raw classifications from Feature Analyst then went through a series of post-processing operations. Planimetric data were also used at this point to improve the classification. Roads, sidewalks, and trails were "burned in" to the raw classification (converted vector data to raster data, which then replaced the values in the raw classification). The "tree canopy" class was not affected by the burn-in process, however, because tree canopy can overhang streets. These data layers were also used to make logic-based assumptions to improve the accuracy of the classification. For example, if a pixel was classified as "tree canopy," but that pixel overlaps with the roads layer, then it was converted to Tree Cover over Impervious. The final step was a manual check of the classification. Several ArcGIS tools were built to automate this process. For example, the ability to draw a circle on the map and have all pixels classified as "tree canopy" to 'non-tree vegetation,' which is a process usually requiring several steps, is now only a single step.

Potential Planting Area Dataset

The Potential Planting Area dataset has three components. These three data layers are created using the land cover layer and relevant data in order to exclude unsuitable tree planting locations or where it would interfere with existing infrastructure.

1. Potential Planting Area (PPA)
2. Potential Planting Spots (PPS)
3. Potential Canopy Area (PCA)

The Potential Planting Area (PPA) is created by selecting the land cover features that have space available for planting trees, then eliminating areas that would interfere with existing infrastructure.

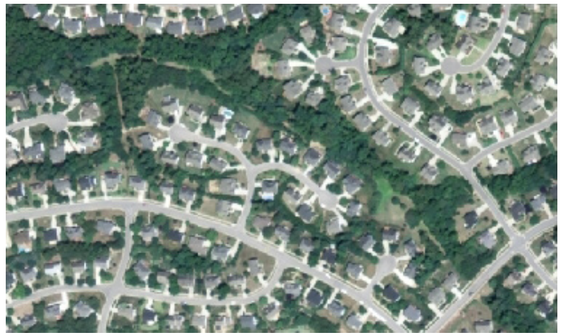
- **Initial Inclusion** (selected from GIC created land cover)
  - Pervious surfaces
  - Bare earth
- **Excluded Land Cover Features**
  - Existing tree land cover
  - Water
  - Wetlands
  - Imperious surfaces
  - Ball Fields (i.e.: Baseball, Soccer, Football) where visually identifiable from NAIP imagery. (Digitized by GIC)
- **Exclusion Features:** (buffer distance)
  - Roads Areas (10ft)
  - Rail roads (10ft)
  - Structures (10ft)
  - Power lines and other identifiable utilities (10ft)

Potential Planting Spots

The Potential Planting Spots (PPS) are created from the PPA. The potential planting areas (PPA) is run through a GIS model that selects spots a tree can be planted depending on the size trees that are desired. The tree planting scenario was based on a 20 ft. and 40 ft. mature tree canopy with a 30 percent overlap.

Potential Canopy Area

The Potential Canopy Area (PCA) is created from the PPS. Once the possible planting spots are given a buffer around each point, that represents a tree's mature canopy. For this analysis they are given a buffer radius of 10 or 20 ft. that results in 20 and 40 ft. tree canopy.



NAIP Image 2015

Potential Planting Area (PPA)

Potential Planting Spots (PPS)

Potential Canopy Area (PCA)

APPENDIX B: BIBLIOGRAPHY

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