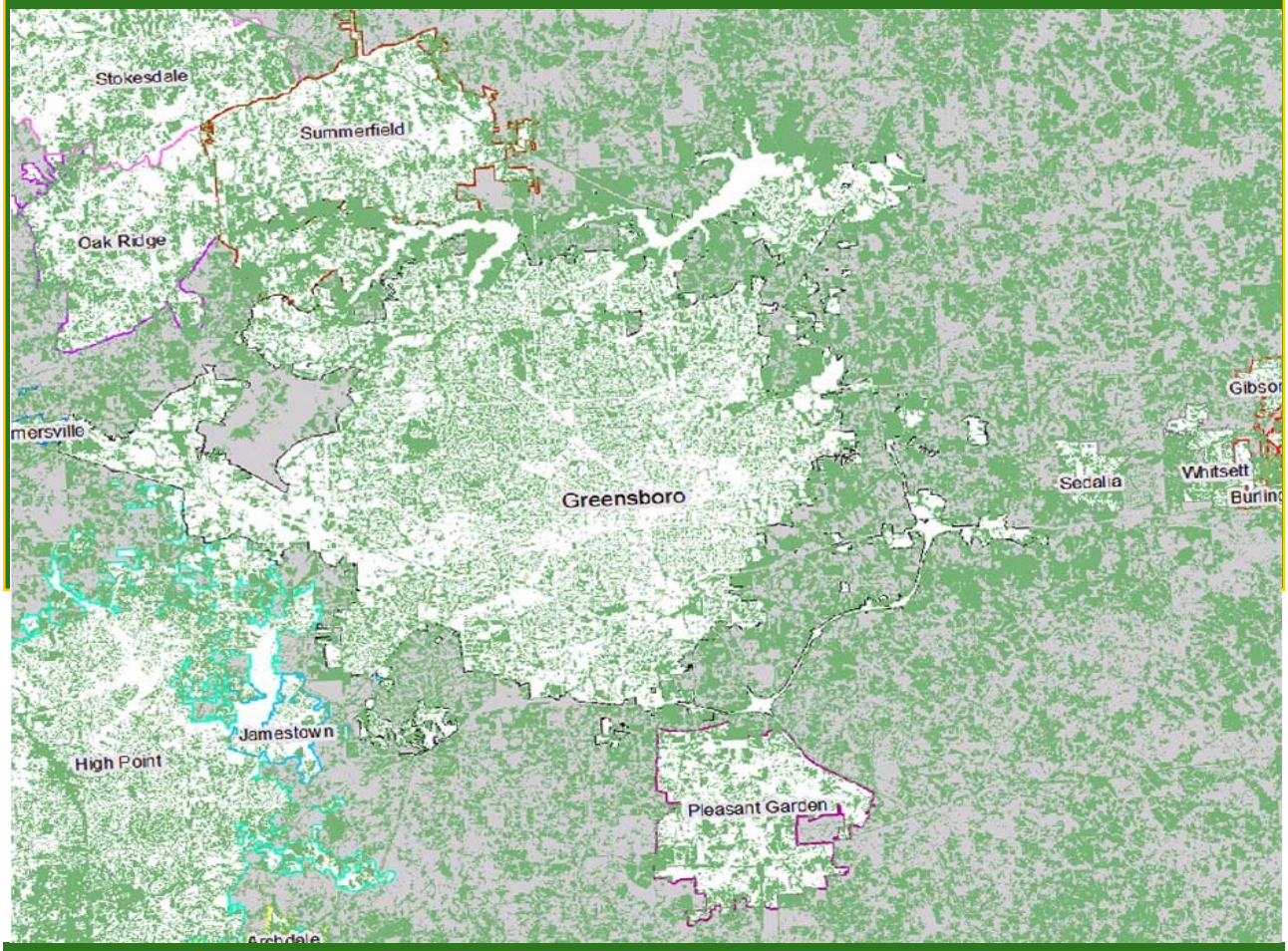
Guilford County
Tree Canopy Study
2009



City of Greensboro
Planning Department
&
Guilford County
Parks and Recreation

Acknowledgements

Funding Sources

Funding for this project was provided in part through an Urban and Community Forestry Grant from the North Carolina Division of Forest Resources, Department of Environment and Natural Resources, in cooperation with the USDA Forest Service, Southern Region.

Matching grant funds were provided by the City of Greensboro and Guilford County.

Canopy Analysis GIS Data and Report

The canopy analysis, development of GIS layers and the statistical report were provided by North Carolina State University, College of Natural Resources, Department of Forestry and Environmental Resources.

Aerial Photographs

The aerial photography used in this study was provided by the City of Greensboro and Guilford County with assistance from Spatial Data Consultants, Inc.

NCSU was provided full resolution, true color orthorectified and unrectified images over the entire study area. With the City of Greensboro facilitating, Spatial Data Consultants, Inc. provided GeoTiffs of the orthorectified, images and Tiffs for the unrectified, images for both the county and the city. City of Greensboro images were acquired at 6 inch resolution under leaf-off conditions in early 2007; the remainder of Guilford County was acquired at one foot resolution under leaf-off and partial leaf-out conditions, also in early 2007. Greensboro and Guilford County provided GIS data layers that were used to define municipal boundaries and watershed boundaries.

NCSU also obtained additional vector data such as streets and building footprints, as available, from the city and county and from existing sources. Vector data (e.g. county boundaries, city limits (mask files for tiles) were organized in a Personal Geodatabase and a grid was developed to compile and identify appropriate image files by tile.

Report

The following report was prepared by; Michael S. Cusimano, Urban Forester, City of Greensboro, Planning Department and Roger Bardsley, Parks Planner, Guilford County. City and County staff assisting in the preparation of this report; Alex Ashton, Guilford County Open Space Planner and Jessica Hill, City of Greensboro Planning Intern.

Project Overview

With growing concerns for cleaner air and water, the importance of trees has become more apparent in recent years. Recognizing this, the City of Greensboro and Guilford County applied for a grant through the Urban and Community Forestry Grant program administered by the North Carolina Division of Forest Resources to conduct a tree canopy study of Guilford County and its municipal jurisdictions. The results of the study, based on 2007 aerial photography, are presented by political and watershed drainage boundaries. Both the county and the city have conducted tree canopy studies in the past that revealed a significant loss of tree canopy during their respective study periods. While this information was useful and led to policy decisions adopted to conserve trees and open space; the studies were limited and had no provisions for updates or follow up studies. The new study has been developed to provide a baseline inventory of the existing tree canopy. This system will allow the users to develop a management strategy for maintenance of a sustainable tree canopy.

The data developed in the new study can be incorporated into a Geographic Information System and combined with other data to develop policy decisions relating to air and water quality, open space planning, and infrastructure development. The information derived from the study can be used to insure that the social, economic and environmental benefits of trees are maximized to provide a better quality of life for the citizens of this region.

Benefits of Trees

Trees are one element of our environment that provides a multitude of benefits. Everyone recognizes their beauty and esthetic qualities, but trees also provide environmental, social and economic benefits as well. By managing our trees we are in effect controlling the level of benefits we receive from them. Trees reduce cooling costs, purify the air we breathe, filter contaminants from our water and provide habitat for wildlife. Trees also provide great opportunities for outdoor activities such as hiking, mountain biking and nature study, all of which enhance our lives and wellbeing. Trees also increase real estate values and make commercial shopping centers and business parks more attractive.

Cooling Effect: The net cooling effect of trees varies from one application to the next. Everyone agrees, however, that trees play a significant roll in reducing energy costs. According to the US Department of Agriculture "the net cooling effect of a young, healthy tree is equivalent to ten room-size air conditioners operating 20 hours a day." In urban areas where large areas of concrete and asphalt exist, the sun's radiant heat causes temperatures to rise as much as 10 degrees as compared to surrounding areas. This effect, known as the urban heat island, can be reduced by planting more trees in these built up areas. The trees not only provide shade to help reduce temperatures but also release water through their leaves to provide an evaporative cooling effect.

Pollutant Removal: Trees are extremely efficient at removing pollutants from our air. Elements such as nitrogen dioxide, sulfur dioxide, ozone, carbon monoxide and particulate matter are absorbed by trees. In addition, while they are purifying our air trees are producing oxygen essential to our survival. One report from the US Department of Agriculture states that one acre of forest is capable of absorbing six tons of carbon dioxide and releasing four tons of oxygen per year. Based on research conducted by the US Forest Service and the Public Service Commission of Georgia calculated the cost to society to remove pollutants from the air in the Atlanta Metro Area. Their finding revealed that to replace the pollution absorption rate of the existing tree canopy would cost approximately $47 million dollars annually.

Carbon Sequestration: Recently there has been a tremendous amount of publicity concerning the effects of burning fossil fuel on weather patterns and global temperatures. The argument is that burning coal and oil that was sequestered in the ground millions of years ago increases the amount of CO2 circulating in the atmosphere. CO2 is a "greenhouse gas" that traps heat from the sun, thus increasing temperatures. Trees absorb CO2 as they manufacture cellulose (wood) and sequester it in their trunks and branches. The effect is temporary, since trees may die or be burned for fuel. If the trees are cut for lumber, or allowed to grow for a long period, however, the sequestration may last for 100 years or more. This is a simple and low-cost means of reducing the amount of CO2 in the atmosphere at a time when reductions may be critical.

Trees take up carbon at a high rate when relatively young. An actively-growing forest stand sequesters carbon at a rate five times higher than a fully mature stand. If forest land is managed for carbon uptake and storage it should be harvested regularly and the wood products made into durable goods (OSB, plywood, furniture and lumber).

Stormwater Reduction: Trees play a major role in the reduction of storm water runoff. The leaves of trees intercept rain water and reduce its velocity, thereby reducing its effect on soil erosion. Some of this intercepted water remains on the leaves and evaporates back into the atmosphere, reducing the amount of storm water that must be managed. A trees root system and soil acts like a sponge which absorbs, stores, and filters storm water before returning it to the ecosystem. American Forests, an organization dedicated to assisting and guiding communities to develop healthier forests, estimates that each acre of forested land "manages" over 5,000 cu. ft. of stormwater that would otherwise have to be conveyed in pipes and ditches and stored in ponds. They value this benefit at $2/cu. ft. In a report done by American Forests for the Washington D.C. metro area it was estimated that the region's 46% tree canopy reduced the need for stormwater retaining devices by 949 million cubic feet. That equated to a cost saving in construction of those devices of $4.7 billion dollars per 20 year construction cycle.

Wildlife Habitat: With the growing pressure to develop land, wildlife habitat is being lost or compromised at an alarming rate. According to a report released by the North Carolina Wildlife Commission over 100,000 acres of forests and fields are being

developed each year—an area the size of Winston-Salem and High Point combined. In fact, North Carolina is the only state in the nation with three of the nation's top 20 "sprawl centers": the Triangle, the Triad, and the Charlotte metro region. By saving trees during development and by preserving open space and parks we can provide habitat for a wide variety of wildlife for thousands of citizens to enjoy.

Recreation: There are many social benefits to trees that often times go unnoticed or are taken for granted. Thousands of people live a relatively sedentary lifestyle. Saving trees in greenways, parks and open spaces provides areas for outdoor activities such as walking, nature viewing and other recreational pursuits. The exercise obtained during these activities helps improve overall health and wellbeing. Trees also provide shade protecting people from the sun and its cancer causing effects. By purifying the air we breathe trees can help relieve the symptoms of pulmonary diseases. In laboratory research, "visual exposure to settings with trees has produced significant recovery from stress within five minutes, as indicated by changes in blood pressure and muscle tension."—Dr. Roger S. Ulrich Texas A&M University.

Real Estate Values: We have seen that trees provide many benefits that may have been overlooked in the past. Today, however, with more attention placed on trees and the environment, their benefits are being realized. This is also true when discussing the economic value of trees. Traditionally, trees have been valued for their ability to produce wood products such as lumber, furniture, paper, etc. Recently, however, trees have been recognized as adding value to real estate. The US Forest Service reports healthy, mature trees add an average of 10 percent to a property's value. Trees are also recognized as having a positive effect on economic growth. The National Arbor Day Foundation states that trees can be a stimulus to economic development, attracting new business and tourism. Commercial retail areas are more attractive to shoppers, apartments rent more quickly, tenants stay longer, and space in a wooded setting is more valuable to sell or rent.

In summary there is little doubt that trees are an invaluable asset to our communities. They may be the single best dollar value to reduce pollution and improve our environment. They provide many social and economic benefits that create a better quality of life for our citizens. To insure that this resource is protected we must begin to manage our trees just as we would any other valuable asset.

Guilford County Preview

Guilford County comprises an area of 649.42 square miles or 415,630 acres. The estimated current population is 470,000. The 2000 census states that 83.8% of the population lived in urban areas. Table 1 provides statistics that are considered to be good indicators of growth. They demonstrate that over the past decade Guilford County has experienced considerable growth.

Table 1
Guilford County Growth Statistics

Population Growth, 1998-2008	60,663
Population Growth rate, 1998-2008	14.90%
Job Growth rate, 1998-2008	1.60%
Job Growth rate, 2003-2008	5.20%
Net Jobs added, 1998-2008	4,440
Net Jobs added, 2003-2008	13,711
New Housing Starts, 1998-2008	39,385
Labor Force Growth, 1998-2008	26,692
Labor Force Growth rate, 1998-2008	12.30%
Property Value Growth rate, 1998-2008	58.20%

(Piedmont Triad Council of Governments)

This growth combined with some large projects such as the construction of a portion of the outer loop of Interstate 40/85 and the expansion of the Federal Express Hub at the Piedmont Triad International Airport have placed an enormous burden on our tree canopy and our environment.

In April of 2004 Guilford County, along with eight other piedmont counties were almost officially designated as an ozone non-attainment by the EPA. Other surrounding areas were. These nine counties formed a regional air quality Early Action Compact (EAC) to address the situation. The counties made improvements which reduced ozone emissions and the region was officially designated “in attainment” for the 8-hour standard by the EPA. In **March 2010** the EPA is expected to raise the ozone standards and **Guilford and the surrounding counties will once again be designated "non-attainment"**. The consequences of non-attainment can be very serious. Although rarely evoked, the EPA can withhold federal transportation dollars. This means that there is the potential for approximately $65 million of highway funds to be witheld annually. More often the EPA designates non-attainees as “new source review” for new or expanding industry. This means that industrial expansions or new industries have to be reviewed to insure they do not increase ozone emissions in the region. Guilford County is already under “new source review” because it violates federal fine particles (PM2.5) standards.

In 2009 the North Carolina General Assembly will be considering the proposed Jordan Lake Rules which, if adopted, will represent some of the most stringent water quality regulations in North Carolina. Jordan Reservoir is a multi-use impoundment with an area of 13,940 acres, formed by damming the Haw River in the Cape Fear River Basin. The reservoir is operated for flood control, downstream low-flow augmentation for water quality, fish and wildlife conservation, recreation, and water supply. It currently provides drinking water to the growing cities of Cary, Apex, Morrisville, and Chatham County.

In 2002, the Division of Water Quality determined that the Upper New Hope Creek Arm no longer met its designated uses due to excess nutrient inputs, based on chlorophyll levels that exceed established standards. The Division made the same determination for the rest of the lake in 2006, also finding pH levels that exceed standards as an eutrophication indicator in the Haw River Arm. As a result, the entire reservoir is now on North Carolina's list of impaired waters under Section 303(d) of the Federal Clean Water Act.

Guilford and surrounding counties whose waters flow to the Haw River Arm, which comprises 80% of the entire Jordan watershed, will have to adopt regulations designed to reduce the amounts of nitrogen and phosphorus entering the water resource. These will include strategies which result in reductions by point source discharges and in nutrient runoff from agriculture, existing development, and new development. In addition, riparian buffer protection rules would largely stem loading increases that would otherwise result from loss of those landscape features, while requirements to establish buffers during a change in land use would achieve some loading reduction. Lastly, a fertilizer management rule would result in training of fertilizer applicators in the watershed, potentially reducing nutrient inputs through education.

Everyone realizes that economic growth and development are necessary for our community to thrive. However, that growth comes at a cost. The purpose of this study is to provide information that local governments can use to ensure that our growth is tempered with our need to protect our environment.

Methodology

NCSU used an object-oriented classifier to identify trees within individual, natural color air photos (tiles). Placed within a Geographic Information System, the resultant tree cover polygons were used to identify larger contiguous forested areas and to determine acres of trees for a series of administrative and natural boundaries.

Data Preparation

NCSU obtained copies of the City of Greensboro and the Guilford County mosaics created from true color aerial photography acquired in winter 2007.

It was determined that the color balances for the two mosaics (city and county) were different, and leaf stage was slightly different over the entire study area. This meant that processing of the data required separate training sets for City data and County data and for selected subsets of the coverage, especially in the county.

The City of Greensboro provided samples of the full resolution aerial photography. These images provided the level of detail and appropriate file sizes that were needed to reliably identify tree cover. With the City of Greensboro facilitating, Spatial Data Consultants, Inc. provided GeoTiffs of the orthorectified, images and Tiffs for the unrectified, images for both the county and the city, at full resolution, on an external hard-drive. A list of images provided by Spatial Data was used to develop a reference grid for the images.

Object-Oriented Classification of the Images

Because of differences in color balance and phenology, images from the City and County were analyzed separately. NCSU developed a series of models with the object-oriented classifier, Feature Analyst (http://www.vls-inc.com/), to identify forested and non-forested areas. In the county, multiple models were required to account for changes in conditions and leaf stage. The results of the models were collapsed into two possible outcomes for each cell within each tile: tree cover or non-forest. For each tile, feature analyst classifications and iterative products were examined for accuracy. The output was a vector layer (polygons) of forested areas.

Post-Processing Analyses

The tree cover polygons were very detailed and served as a base for subsequent analyses. NCSU overlaid a one-acre grid on the tree cover data and for each one-acre grid cell determined the percent of tree cover. NCSU then categorized the output into 5 canopy closure categories (1 - 20%; 21 - 40%; 41 - 60%; 61 - 80% and 81 - 100%) and one “no canopy” category (0%).

The tree cover polygons were used to identify contiguous forested areas equal to or greater than 4 acres. For each of these forested stands, intermediate products from the feature analyst models were used to identify the forest type (conifer or hardwood) within each area. Lidar-derived tree height data for North Carolina (unpublished data in draft form) was used to determine an average tree height (scaled) in each stand. Scaled values were compared to the original photographs and were grouped into 3 categories: juvenile; intermediate; mature. The forest stand polygons were each attributed with percent of stand in each forest type and a height category.

Data Compilation

Based on the detailed tree cover polygons, the number of acres of tree cover within each municipality in Guilford County was calculated using municipal boundaries provided by the City of Greensboro and Guilford County GIS departments. Portions of the municipalities that fell outside of Guilford County were not included in the acreage.

Guilford County GIS provided watershed boundaries within Guilford County. These boundaries and detailed tree cover polygons were used to determine the number of acres of tree cover in each watershed.

In addition to tabulating results by watershed and jurisdictional boundaries, NCSU calculated the relationship between tree cover and air and water quality expressed in volume of pollutants stored or removed. Potential carbon storage (tons) and carbon sequestration (tons per year) provided by tree cover in Greensboro and in Guilford County was also calculated. These values were based on accepted multipliers for the relation between tree cover and carbon storage and sequestration developed by the USDA Forest Service and used in CityGreen (http://www.americanforests.org/productsandpubs/citygreen/).
The contribution of trees to water quality improvement was determined by calculating the possible change in pollutant loading due to the presence of forested areas. For this purpose only two land use / land cover classes were considered - Forest and Non-Forest. Export coefficients for nitrogen and phosphorous developed for the Jordan Lake TMDL study conducted by Tetra Tech (2003) were used to determine the possible contribution to pollutant loading by each land cover or land use. For this study, average coefficients were computed for forest and non-forest by combining two or more land uses. The export coefficients for nitrogen and phosphorous from forested areas were calculated as an average of the export coefficients of forest and wetland land covers. Similarly, export coefficients for several land uses (e.g. commercial, residential, pasture, industrial) were averaged to compute the coefficient used for non-forested areas. To determine the reduction in pollutant loads, the differences were determined between loadings assuming no forest was present vs. loadings with actual forest present.

Study Findings

Tree Canopy

The Guilford County study area is comprised of approximately 415,630 acres. In the table below, the total area is shown as 422,929.50 acres. This discrepancy is caused by the need to overlap the county line with photos in order to capture all of the canopy data within the county. Of that total approximately 210,183.50 acres were covered by tree canopy or 49.7% of the total study area. The following tables give a breakdown of acres of trees and percentage of trees by political jurisdiction (table 2) and by watershed boundary (table 3);

Table 2
Guilford County Forest Cover by Jurisdiction

City	Total Area (acres)	Tree Cover (acres)	% Tree Cover
Archdale	566.70	212.89	37.57%
Burlington	509.00	111.41	21.89%
Gibsonville	1,554.50	573.73	36.91%
Greensboro	84,065.00	31,796.49	37.82%
High Point	33,548.70	13,844.67	41.27%
Jamestown	1,814.10	1,027.96	56.67%
Kernersville	382.30	213.22	55.77%
Oak Ridge	9,992.20	5,733.97	57.38%
Pleasant Garden	9,693.50	5,583.82	57.60%
Sedalia	1,290.30	786.91	60.99%
Stokesdale	12,494.80	7,214.83	57.74%
Summerfield	17,027.70	9,828.37	57.72%
Whitsett	1,670.40	692.97	41.49%
Municipal Total	174,609.20	77,621.24	44.45%
Unincorporated Area	248,320.30	132,562.26	53.38%
Entire Guilford County	422,929.50	210,183.50	49.70%

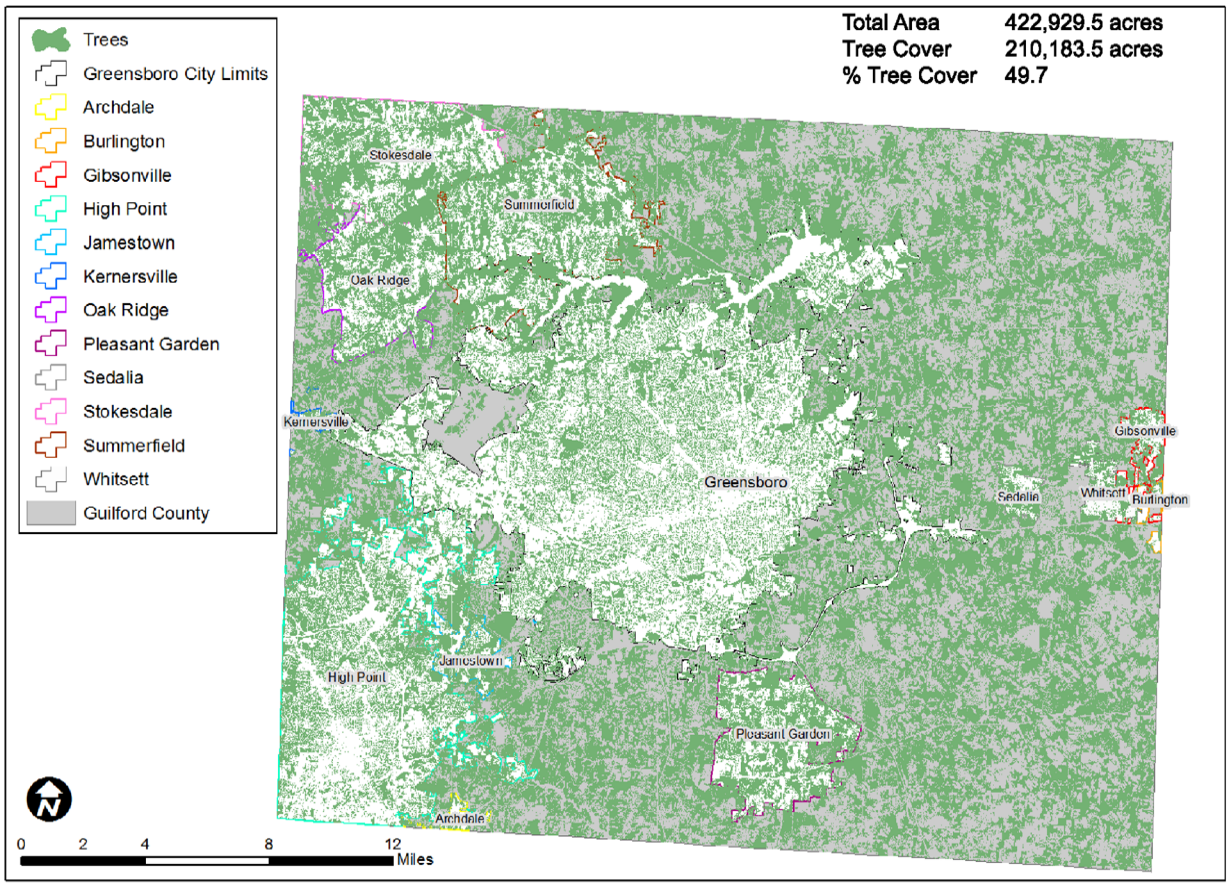


Figure 1: Forest Cover in Guilford County

Table 3
Guilford County Forest Cover by Watershed Basin

Watershed	Total Area (acres)	Tree Cover (acres)	% Tree Cover
Reedy Fork	65,464.70	33,221.80	50.75%
Troublesome	2,899.00	1,503.50	51.86%
Alamance	79,196.00	42,366.20	53.50%
Deep	78,689.90	38,069.80	48.38%
Polecat	14,793.40	8,051.70	54.43%
Sandy	548.4	225.7	41.16%
Stinking Quarter	20,179.30	10,055.20	49.83%
Abbots	5,339.20	2,251.10	42.16%
Belews	7,577.90	5,020.00	66.25%
Buffalo	103,870.40	45,981.80	44.27%
Haw	44,371.30	23,436.60	52.82%
Total	422,929.50	210,183.50	49.70%

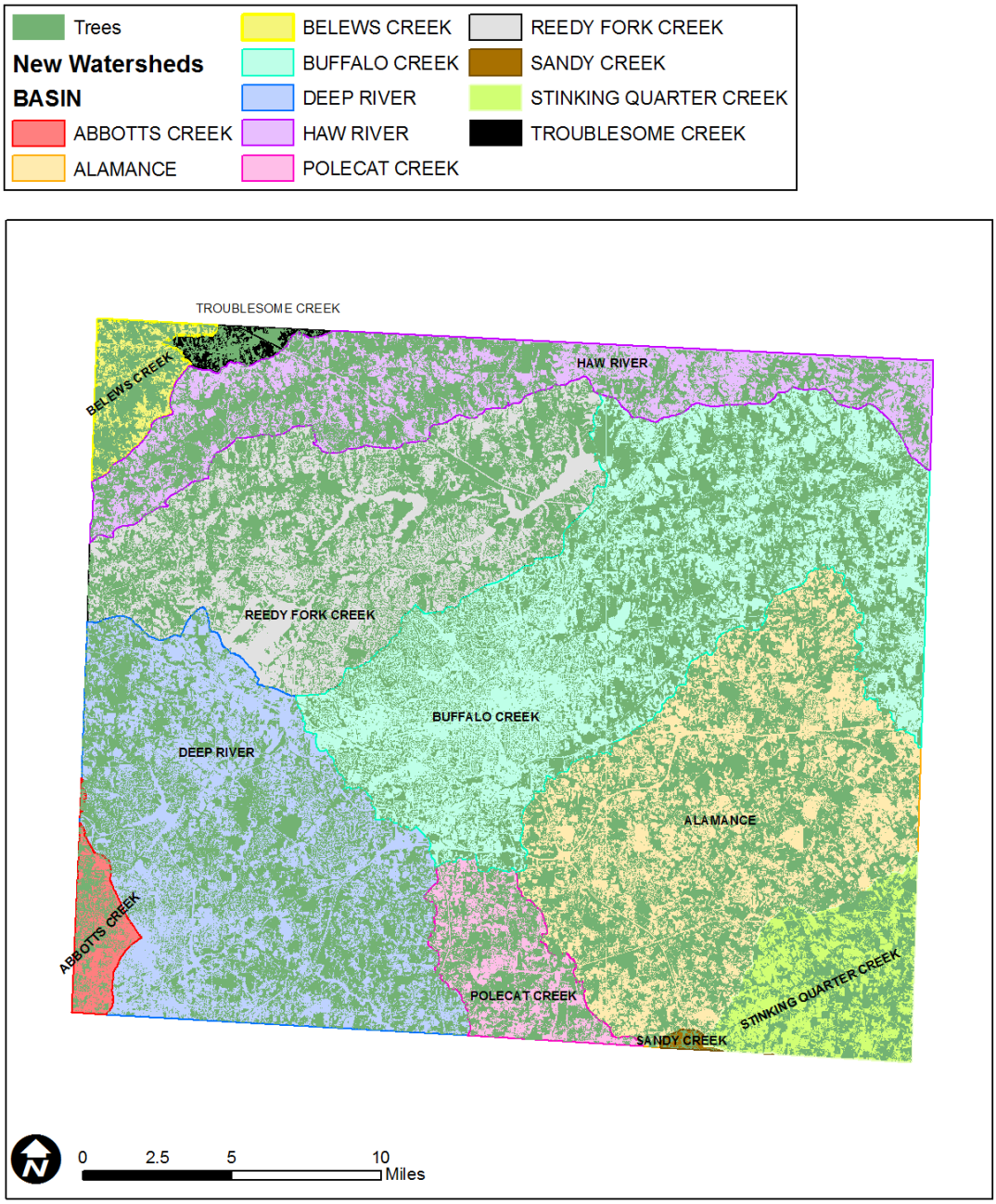


Figure 2: *Guilford County Forest Cover by Watershed*

Tree Canopy Closure

The study also captured data relating to the percent of crown closure. The number of one-acre cells falling in each canopy closure category was determined for the City of Greensboro and for Guilford County. Since these totals are based on summing all one-acre cells that have one or more trees, the total acreage differs from the detailed tree cover acres.

Table 4
Canopy Closure in the City of Greensboro and Guilford County

	City of Greensboro		Guilford County	
Canopy Closure Category	Acres	Percent	Acres	Percent
81 – 100%	10,305	12.26	105,034	24.90
61 – 80%	6,255	7.44	55,436	13.14
41 - 60%	11,786	14.01	63,398	15.03
21 – 40%	12,499	14.87	42,350	10.04
1 - 20%	15,799	18.80	46,133	10.93
No tree cover	27,420	32.62	109,523	25.96
Total	84,064 (one-acre grid cells)		421,874 (one-acre grid cells)	

Note: Canopy closure in the city and county based on one-acre grid cells. County figures include all municipalities within the county.

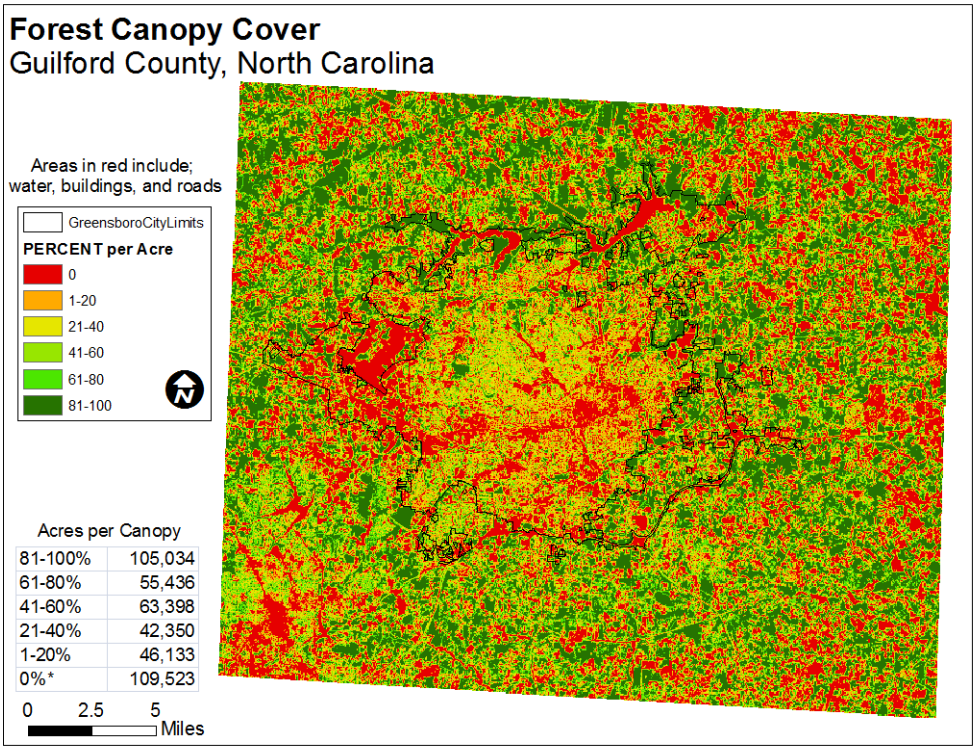


Figure 3: Forest Canopy Cover, Guilford County, North Carolina

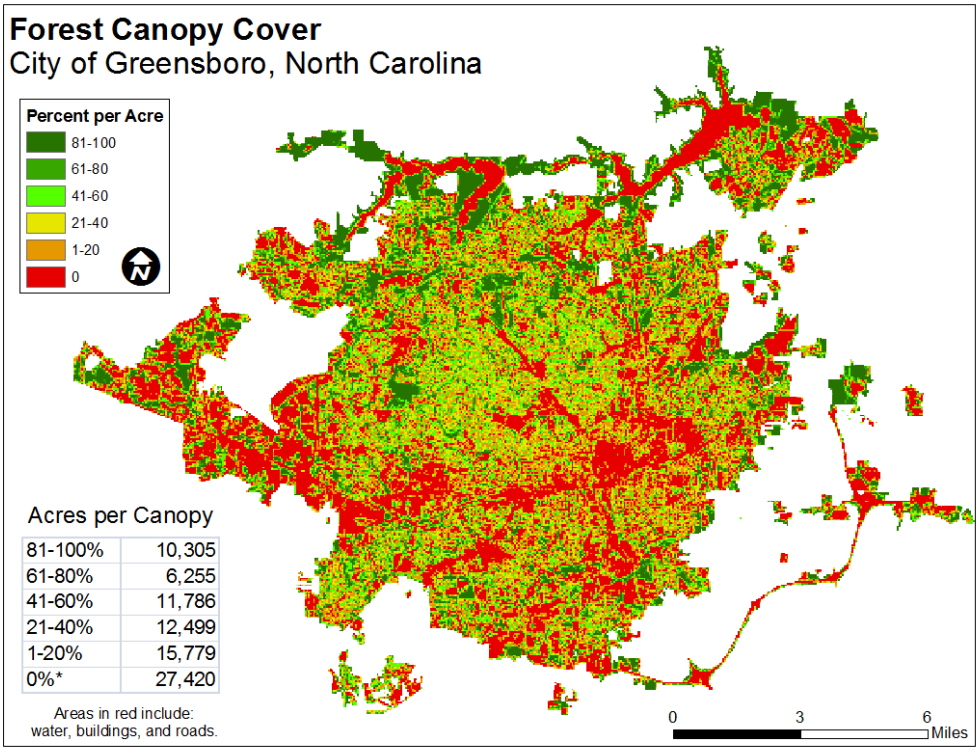


Figure 4: Forest Canopy Cover, City of Greensboro, North Carolina

Forest Stands

The study also captured tree stand data. Parameters were set up to analyze contiguous stands of trees that are four acres in size or greater. The data collected identified these stands by predominant species category; deciduous, conifer or mixed. This information is useful when formulating management decisions regarding large, contiguous stands of trees versus individual trees. The charts and tables table below provides a breakdown of this information for the entire county by political jurisdiction and by watershed basin.

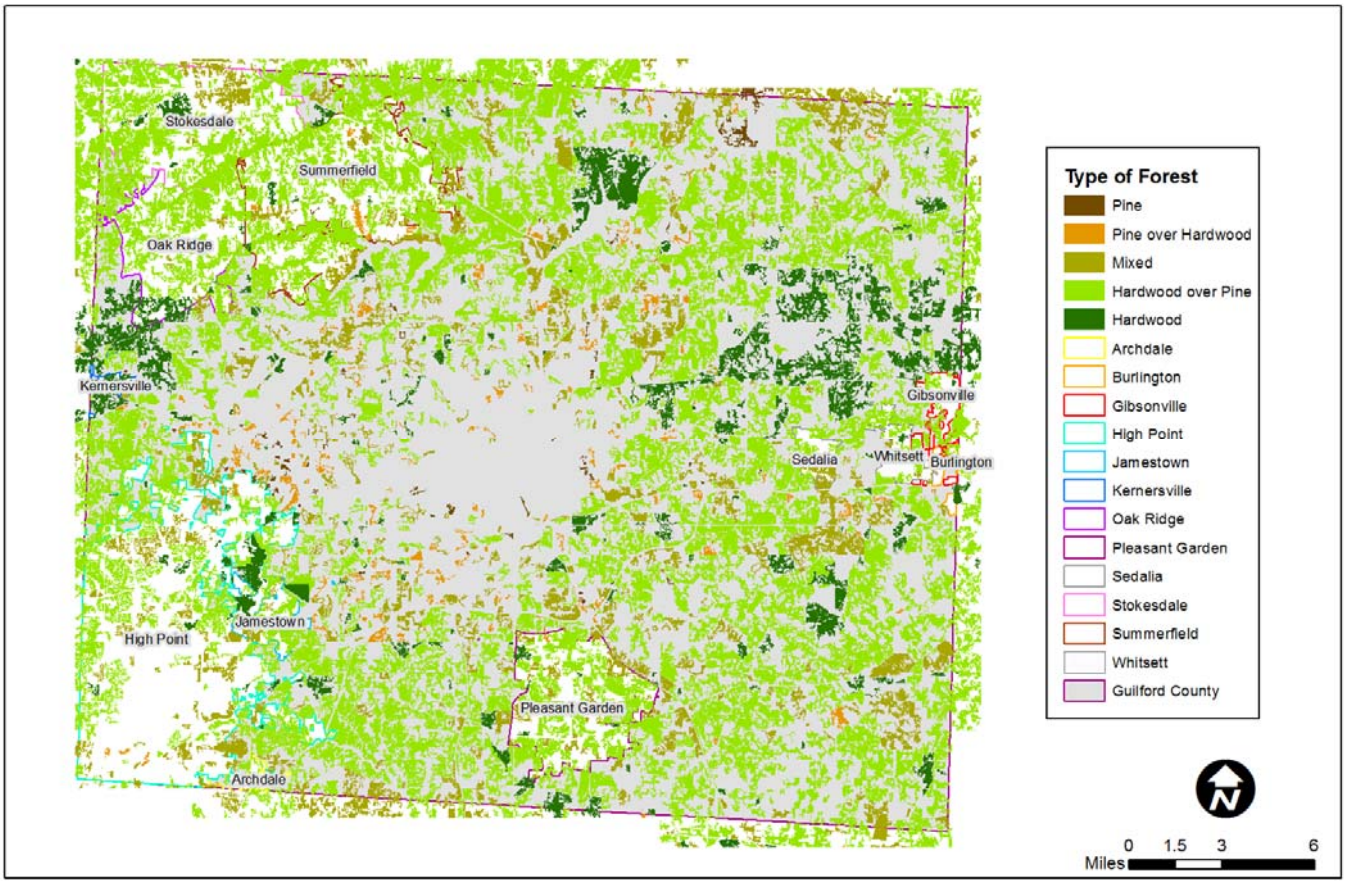
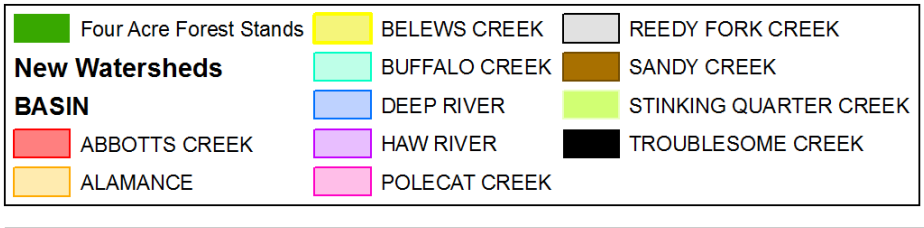


Figure 5: Guilford County Forests, by Stands (greater than or equal to 4 Acres)

Table 5
Guilford County Forest Stands Greater than or Equal to Four Acres by Jurisdiction

City	Total Area (acres)	Forested Stands >=4 acres (acres)	% Forested stands
Archdale	566.70	114.50	20.20%
Burlington	509.00	79.30	15.58%
Gibsonville	1,554.50	384.00	24.70%
Greensboro	84,065.00	1,8973.00	22.57%
High Point	33,548.70	9,390.40	27.99%
Jamestown	1,814.10	754.20	41.57%
Kernersville	382.30	186.60	48.81%
Oak Ridge	9,992.20	4,940.00	49.44%
Pleasant Garden	9,693.50	4,798.30	49.50%
Sedalia	1,290.30	680.30	52.72%
Stokesdale	12,494.80	6,384.40	51.10%
Summerfield	17,027.70	8,568.00	50.32%
Whitsett	1,670.40	528.40	31.63%
Unincorporated Area	248,320.30	115,398.00	46.47%
Entire Guilford County	422,929.50	171,179.00	40.47%

The forest stand data was also generated by watershed basins. Figure 6 and table 6 displayed below depicts Forest Stands by watershed basin;



Watershed	Forest Acre	Percent Covered	Watershed	Forest Acre	Percent Covered	Watershed	Forest Acre	Percent Covered
Abbotts	1650.7	30.9	Deep	29959.7	38.1	Sandy	149.2	27.2
Alamance	36710.7	46.4	Haw	21163.9	47.7	Stinking Quarter	8688.3	43.1
Belews	4655.9	61.4	Polecat	6796.5	45.9	Troublesome	1283.4	44.3
Buffalo	33094.7	31.9	Reedy Fork	27499	42			

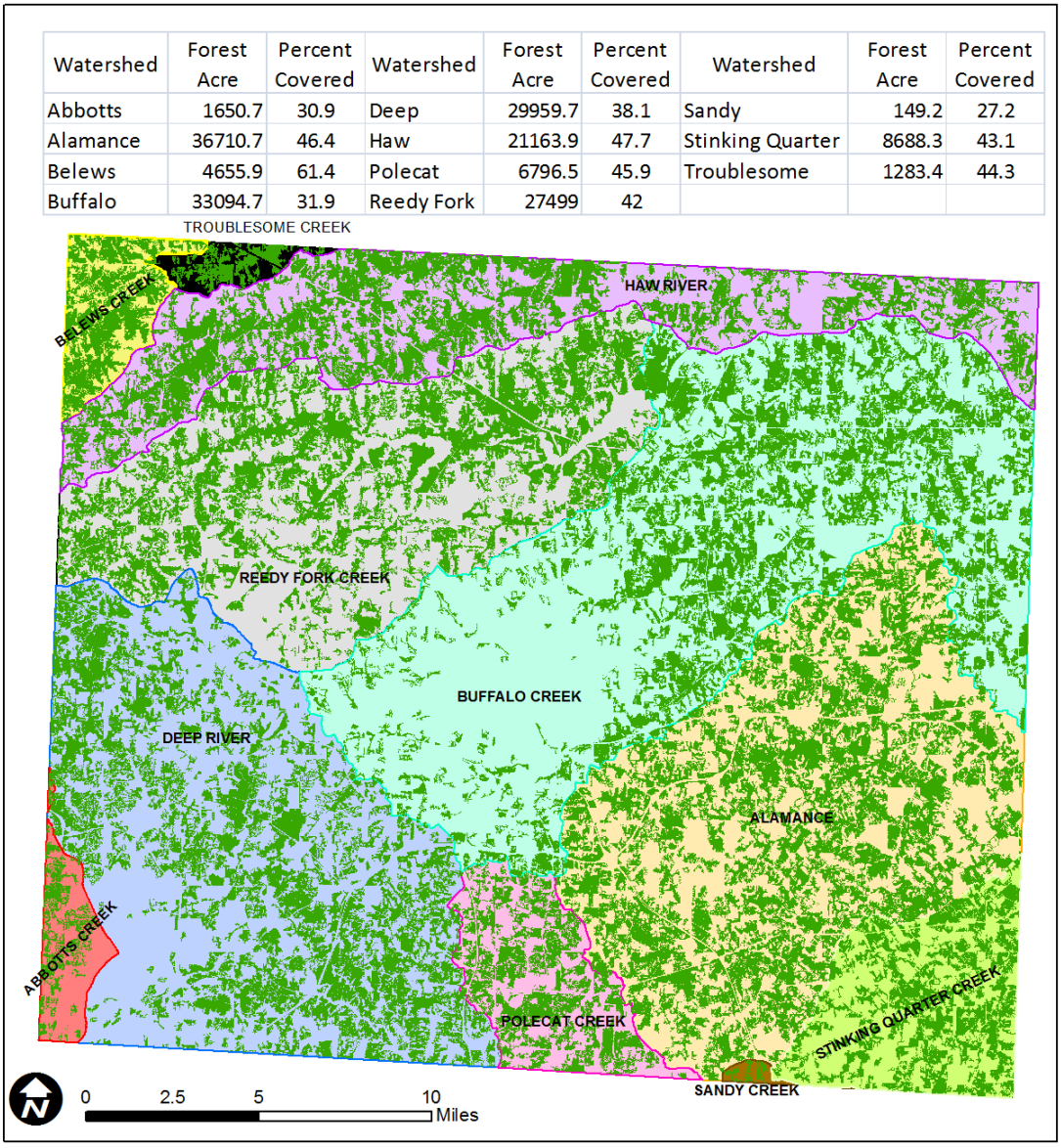


Figure 6: Guilford County Forest Stands (greater than or equal to 4 acres) by Watershed.

Table 6
Guilford County Forest Stands (greater than or equal to 4 acres) by Watershed

Watershed ID	Watershed	Total Area (acres)	Forested Stands ≥ 4 acres (Acres)	% Forested Stands
100	Reedy Fork	65,464.70	27,499.00	42.01%
200	Troublesome	2,899.00	1,283.40	44.27%
300	Alamance	79,196.00	36,710.70	46.35%
400	Deep	78,689.90	29,959.70	38.07%
500	Polecat	14,793.40	6,796.50	45.94%
600	Sandy	548.4	149.2	27.21%
800	Stinking Quarter	20,179.30	8,688.30	43.06%
900	Abbots	5,339.20	1,650.70	30.92%
1000	Belews	7,577.90	4,655.90	61.44%
1100	Buffalo	103,870.40	33,094.70	31.86%
1200	Haw	44,371.30	21,163.90	47.70%
Total		422,929.50	171,652.00	40.59%

* 171,652.00 ac based on the best available basin boundary data available.

Air and Water Quality

Trees are excellent at reducing air pollution. We found multipliers used to determine potential carbon storage (in tons) and carbon sequestration rates vary according to tree age. To estimate these parameters over large areas, an average value representing a relative mix of old and young trees is generally recommended. However, because the county tree cover is dominated by mature trees, we included an estimate based on both scenarios - mixed age and mature trees. In addition, multipliers derived from the American Forests' report on Mecklenburg County, NC were used to calculate the tons of pollutants removed annually and its corresponding dollar value, as well as to compute carbon storage and sequestration rates (*).

Table 7
Guilford County Tree Cover by Jurisdiction and Air Pollution and Carbon Storage Capacity

Jurisdiction	Tree Cover (Acres)	Carbon Storage Capacity Mixed age (tons)	Carbon Storage Capacity Mature (tons)	Carbon Sequestration Mixed age (tons per year) *	Carbon Sequestration Mature (tons/yr.) *	Annual Air Pollution Removed (lbs.) *	Annual Air Pollution Value ($) *
Archdale	212.89	9,154.27	9,410.59	71.32	16.05	20,223.60	50,559.00
Burlington	111.41	4,790.63	4,924.77	37.32	9.07	10,583.95	26,459.88
Gibsonville	573.73	24,670.39	25,361.16	192.20	44.013	54,504.35	136,260.88
Greensboro	31,796.49	1,367,249.07	1,405,532.04	10,651.82	2,449.92	3,020,666.55	7,551,666.38
High Point	13,844.67	595,320.81	611,989.80	4,637.96	1,066.73	1,315,243.65	3,288,109.13
Jamestown	1,027.96	44,202.28	45,439.94	344.37	79.20	97,656.20	244,140.50
Kernersville	213.22	9,168.46	9,425.18	71.43	16.07	20,256.28	50,640.70
Oak Ridge	5,733.97	246,560.71	253,464.41	1,920.88	441.80	544,727.15	1,361,817.88
Pleasant Garden	5,583.82	240,104.26	246,827.18	1,870.58	430.23	530,462.90	1,326,157.25
Sedalia	786.91	33,837.13	34,784.57	263.61	32.61	74,756.83	186,892.08
Stokesdale	7,214.83	310,237.69	318,924.35	2,416.97	555.90	685,408.85	1,713,522.13
Summerfield	9,828.37	422,619.91	434,453.27	3,292.50	757.28	933,695.15	2,334,237.88
Whitsett	692.97	29,797.71	30,632.05	232.14	52.93	65,832.06	164,580.14
Unincorporated Area	132,562.25	5,700,176.75	5,859,781.70	44,408.35	10,213.92	12,593,413.75	31,483,534.38
Entire Guilford County	210,183.50	9,037,890.50	9,290,951.43	70,411.47	16,194.64	19,967,432.50	49,918,581.25

Table 8
Potential Storage and Uptake of Carbon in Trees by Watershed

Watershed (Municipal)	Tree Cover (Acres)	Carbon Storage - Mixed Age (tons)	Carbon Storage - Mature (tons)	Carbon Sequestration - Mixed Age (tons per year)	Carbon Sequestration - Mature (tons per year)
Reedy Fork	33,221.83	1,428,538.69	1,468,537.77	11,129.31	2,559.74
Troublesome	1,503.50	64,650.5	66,460.71	503.67	115.84
Alamance	42,366.20	1,821,746.60	1,872,755.51	14,192.68	3,264.32
Deep	38,069.83	1,637,002.69	1,682,838.77	12,753.39	2,933.28
Polecat	8,051.74	346,224.82	355,919.11	2,697.33	620.39
Sandy	225.72	9,705.96	9,977.73	75.62	16.94
Stinking Quarter	10,055.19	432,373.17	444,479.62	3,368.49	774.75
Abbots	2,251.09	96,796.87	99,507.18	754.12	172.69
Belews	5,019.95	215,857.85	221,901.87	1,681.68	386.79
Buffalo	45,981.81	1,977,217.83	2,032,579.93	15,403.91	3,542.90
Haw	23,436.62	1,007,774.66	1,035,992.35	7,851.27	1,805.79
Total	210,183.50	9,037,890.5	9,290,951.43	70,411.47	16,194.64

Coefficients for pollutants that affect water quality are used to calculate loadings, or the "export" of pollutants from different cover types. To determine the relationship between tree cover and removal of nitrogen and phosphorus, we calculated loadings for these variables with and without the tree cover. The difference is reported as pollutant removal by trees.

Table 9
Guilford County Stormwater Pollutant Removal by Jurisdiction

City	Total Acres	Tree Cover (acres)	Nitrogen removal (lbs per year)	Phosphorus removal (lbs per year)	Stormwater Cu. Ft. Stored *	Stormwater $ Value Saved (20 yr.) *
Archdale	566.7	212.89	2,834.30	349.9	1,064,450	2,128,900.00
Burlington	509	111.41	1,483.30	183.1	557,050	1,114,100.00
Gibsonville	1,554.50	573.73	7,638.50	943	2,868,650	5,737,300.00
Greensboro	84,065.00	31,796.49	423,327.90	52,262.80	158,982,450	317,964,900.00
High Point	33,548.70	13,844.67	184,323.40	22,756.00	69,223,350	138,446,700.00
Jamestown	1,814.10	1,027.96	13,685.90	1,689.60	5,139,800	10,279,600.00
Kernersville	382.3	213.22	2,838.80	350.5	1,066,100	2,132,200.00
Oak Ridge	9,992.20	5,733.97	76,340.10	9,424.70	28,669,850	57,339,700.00
Pleasant Garden	9,693.50	5,583.82	74,341.10	9,177.90	27,919,100	55,838,200.00
Sedalia	1,290.30	786.91	10,476.70	1,293.40	3,934,550	7,869,100.00
Stokesdale	12,494.80	7,214.83	96,055.90	11,858.80	36,074,150	72,148,300.00
Summerfield	17,027.70	9,828.37	130,851.70	16,154.60	49,141,850	98,283,700.00
Whitsett	1,670.40	692.97	9,226.00	1,139.00	3,464,850	6,929,700.00
Unincorporated Area	248,320.30	132,562.26	1,764,889.70	217,888.20	662,811,300	1,325,622,600.00
Entire Guilford County	422,929.50	210,183.50	2,798,313.30	345,471.60	1,050,917,500	2,101,835,000.00

* American Forests estimates that each acre of forested land "manages" over 5,000 cu. ft. of Stormwater that would otherwise have to be conveyed in pipes and ditches and stored in ponds. They value this benefit at $2/cu. ft.

Table 10
Guilford County Stormwater Pollutant Removal by Watershed. Potential for the removal of nitrogen and phosphorus by watershed.

Watershed Basin	Total Area (acres)	Tree Cover (acres)	Nitrogen Removal (lbs. per yr.)	Phosphorus Removal (lbs. per yr.)
Reedy Fork	65,464.74	33,221.83	442,304.40	54,605.62
Troublesome	2,899.00	1,503.50	20,017.08	2,471.25
Alamance	79,196.00	42,366.20	564,049.45	69,635.91
Deep	78,689.90	38,069.83	506,849.07	62,574.12
Polecat	14,793.40	8,051.74	107,198.18	13,234.38
Sandy	548.41	225.72	3,005.19	371.01
Stinking Quarter	20,179.33	10,055.19	133,871.39	16,527.37
Abbots	5,339.15	2,251.09	29,970.25	3,700.04
Belews	7,577.88	5,019.95	66,833.98	8,251.13
Buffalo	103,870.41	45,981.81	612,186.42	75,578.76
Haw	44,371.30	23,436.62	312,027.35	38,521.99
Total	422,929.52	210,183.48	2,798,312.76	345,471.58

Conclusions

American Forests is an organization dedicated to assisting and guiding communities to develop healthier forests. They are a world leader in reforestation efforts, a pioneer in the science and practice of urban forestry and a primary promoter of the value of trees and forests. Founded in 1875, American Forests has compiled decades of data related to trees and the environment. More recently they have moved to the forefront in the development of canopy analysis to assist communities who wish to manage their forest resources. Based on their research, American Forests has suggested that each community should establish tree canopy goals to ensure that this valuable resource is maintained at a minimum threshold. They recommend that for communities located east of the Mississippi River the following guidelines be used;

Table 11
American Forests Recommended Guidelines

Average tree cover counting all zones	40%
Suburban residential zones	50%
Urban residential zones	25%
Central business districts	15%

A comparison of the study results to table 11 indicates that our current tree canopy over the entire county is well within the parameters recommended by American Forests. The average canopy coverage over the entire county is 49.7%. All of our municipalities exceed the average recommended 25% coverage with an average of 44.5% tree canopy coverage. Further analysis will be required to compare the data for specific areas such as the central downtown or high density residential districts and specific suburban residential areas.

The analysis of forest stand data, greater than or equal to 4 acres, indicates that the areas of highest concentration are in the rural portions of the county. In rural parts of the county the loss of contiguous forest can be attributed to conversion of forestlands to farmland and development. In times of economic difficulty, such as 2008-2009, landowners will sell timber and land in order to pay bills. Sometimes, when just the timber is sold, these areas are replanted and other times they are left to regenerate naturally. In urban and suburban areas forest stands are most commonly lost to development. In these areas forest stands become fragmented with tree preservation and landscaping requirements accounting for future tree canopy coverage.

The analysis of the forest stand data indicates that the tree canopy is predominately mature and over-mature hardwoods. Aerial photos and study classifications were reviewed on a spot by spot basis with David Henderson, County Forester - NCDFR. David has worked in Guilford County for 20 years and has supervised the planting of

approximately 500 acres of trees each year. In almost all cases the trees have been loblolly pines which grow quickly and can be harvested in 25-30 years. Based on our review with Mr. Henderson we came to several conclusions:

- The computer classification system for each cell under-represented the amount of pine trees in Guilford County. This appeared to be caused by competition in planted pine stands by volunteer hardwoods. In the early growth stages (0-15 years) the hardwoods are visible and cause the stand to be classified as "mixed".
- Stands classified as "pine" are mature and have a closed canopy. Such stands are relatively rare because mature pines have a high economic value and are usually logged before reaching 50 years of age.
- The "seedling", "intermediate" and "mature" data classifications by height cannot be reliably used. The software could not identify seedlings less than 5 years in age. Likewise, intermediate age trees between 15 and 30 years old are often tall enough that the software classified them as "mature". We therefore believe that the average age of the canopy may be less than indicated by the study.

Amongst the many benefits of trees the analysis of the data clearly indicates that society's largest benefit from this resource is its ability to mitigate pollution. The data indicates that the current canopy has the capacity to retain over one billion cubic feet of stormwater which, if these trees were not in the landscape, would cost the public over two billion dollars to duplicate in construction costs for retention devices to contain the same volume of stormwater. In addition, every year the existing canopy can remove almost 20 million tons of pollutants from our air resulting in an annual savings of almost 50 million dollars in air pollution clean up costs. The existing forest canopy also has the capacity to store over 9 million tons of carbon and sequester up to over 70 thousand tons of carbon annually.

Recommendations

Create and Adopt a Forest Cover Management Plan

A citizen board should be appointed to work with city/county staff, tree professionals and stake holders to develop a master plan for trees that assures the retention of a sustainable tree canopy. The plan should not only consider saving existing trees but should also include a reforestation program to replace tree canopy lost to development and clearing for agriculture. The plan should be incorporated into the Comprehensive Land Use Plan and ordinance regulations. Tree programs should be developed to implement the plan. In addition, jurisdictions should provide a Registered Forester or a Certified Arborist to administrate the program and provide adequate staff to ensure enforcement of the adopted policies. The tree canopy study and the plan, including its supporting documents and policies, should be monitored and updated as needed to ensure the plan's success.

Specific Strategies to Maintain Sustainable Forest Canopy

The benefit of trees to society as a whole is apparent. Therefore, it follows that all of society must share the responsibility for maintaining a healthy, sustainable tree canopy. We recommend that jurisdictions, in addition to land use regulations, consider ways in which strategic areas of tree canopy can be saved either by purchasing them in fee simple, dedicate them as conservation easements or otherwise protect them by creating public parks and greenways for the enjoyment of all.

Regional Plan to Mitigate Air and Water Pollution

Water and air pollution are issues that not only affect individual communities but entire regions as well. We recommend that agencies such as the NC Division of Forest Resources and the Council of Governments look into ways by which local governments can partner with other stakeholders to create a larger, regional planning effort to develop a sustainable tree canopy. The strength of such a commitment would have a far reaching effect on the mitigation of air and water pollution as well as other benefits that would result from having more trees in the environment.

Update Study Data at Regular Intervals

The intent and purpose of this study was to produce a GIS database that could be used to analyze tree canopy coverage. The methodology and data used had to be repeatable so that the study could be updated at regular intervals. Having accomplished that goal we recommend that the study be updated each time new aerials are flown. This study has created a dateline by which all other updates can be compared. Having this ability will allow managers to monitor the effectiveness of tree programs and make projections for future trends and development.

Summary

Trees are valuable assets to every community. As such it is important that they be managed to provide the highest possible return to the community. In order to do that officials and staff must have knowledge of the tree canopy's current condition. A tree inventory would be the most comprehensive collection of data that could be obtained for this purpose. However, a tree inventory would be extremely expensive especially for larger jurisdictions. Since we are most interested in knowing some basic information about the tree canopy such as location of existing trees, broad species type, crown density, age classification and potential planting sites; a tree canopy study will suffice in lieu of an actual inventory.

The use of an object-orientated classifier to analyze high resolution aerial photography proved to be a cost effective method to create a GIS database for tree canopy coverage. The data resulting from this project clearly demonstrated the importance of trees and establishes their place as part of the community's infrastructure. Having this

database will allow managers to make informed decisions regarding the policies and strategies adopted to ensure the sustainability of this valuable asset. Incorporating these policies into a jurisdictions comprehensive land use plan provides a vehicle by which those policies can be implemented. By updating the database at regular intervals, the effectiveness of these decisions can be monitored and adjusted over time as needed.

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