WAKE COUNTY
NORTH CAROLINA

APEX LAND COVER ANALYSIS & TREE CANOPY ASSESSMENT

Community Report | Town of Apex


SEABOARD
1138
VA DIV.
12 VDC
BATTERY BOX
SEABOARD AIR LINE RAILROAD

This report belongs to a series of reports produced by the Wake County Land Cover Analysis and Tree Canopy Assessment (Wake LCA/TCA), a countywide initiative led by Wake County Government in consultation with Davey Resource Group, Inc.

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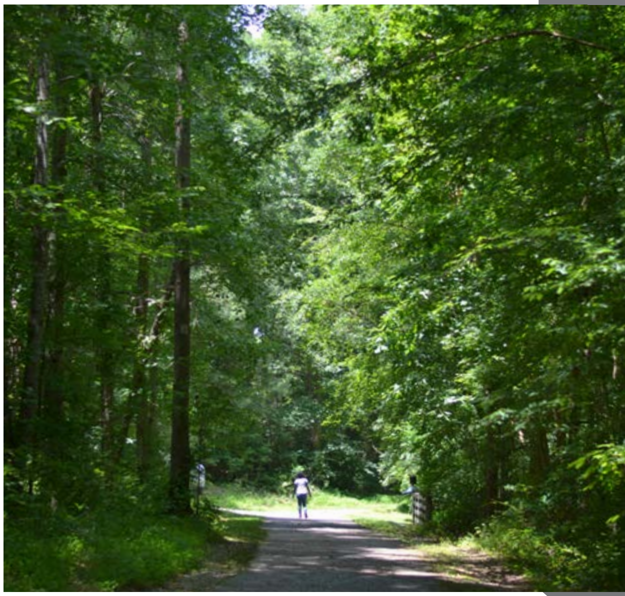

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Executive Summary

Foreword

The Wake LCA/TCA utilized geospatial analysis to identify and measure countywide land cover, including tree canopy, as it existed in 2020. The project also evaluated tree canopy type and health and measured the change in tree canopy cover over the ten-year period from 2010–2020.

This is not a policy document; it is a summary report offering a visual, high-level overview of the project, the accompanying analyses and the results. The report intention is to leave readers with an impression of the intrinsic value of tree canopy an understanding of how land cover data can be leveraged as a resource for policymakers, researchers, civic organizations, residents and stakeholders of the greater Wake community.

Background

County Growth and Development

Wake County has experienced high population and job growth over the last decade, with significant ongoing and anticipated development occurring in the next five years. As economic opportunity and population growth fuel land development, the county is consequently experiencing a conversion of open spaces, natural areas and agricultural lands into built environments at a similarly rapid rate.

County Response

This growth has underscored the necessity of intentionally prioritizing tree canopy management and understanding the associated impacts on the environment to ensure sustainability and livability in Wake County communities. Recognizing this necessity, the Wake County Department of Planning, Development and Inspections (PDI) received state-administered federal funding, made available by the American Rescue Plan Act., to commission the Wake LCA/TCA.

PDI contracted Davey Resource Group, Inc. (DRG), a national environmental consulting firm, to lead the project and perform the analysis, which encompasses the entirety of Wake County's 857 square miles of land area and includes the planning jurisdiction of each of the county's 12 core municipalities: Apex, Cary, Fuquay-Varina, Garner, Holly Springs, Knightdale, Morrisville, Raleigh, Rolesville, Wake Forest, Wendell and Zebulon.

Purpose

Provide data to guide and support planning and implementation efforts on both a county and municipal level.

County Goals

- Support a higher quality of life for vulnerable residents and communities.
- Preserve and enhance the County residents' quality of life through coordinated land use and transportation planning.
- Preserve and protect a clean and abundant water supply.
- Preserve open space and expand access to parks, preserves, recreation resources and greenways.
- Promote sustainability and address issues associated with climate change.

Municipal Collaboration

Wake County worked closely with municipal partners to determine the project scope. Additionally, the Wake LCA/TCA provides comprehensive deliverables for the county's 12 core municipalities, including the data and this report.

Project Objectives

Analyze

Analyze the existing land cover conditions.

Evaluate

Evaluate tree canopy type, health and change over a ten-year span (2010-2020).

Measure

Measure the environmental and socioeconomic impact of tree canopy cover.

Identify

Identify potential opportunities for canopy restoration, with a focus on equity for vulnerable communities.

Apex

Incorporated in 1873 and situated between Cary and Holly Springs in southwest Wake County, Apex's corporate limits encompass a total land area of 16,217 acres — equivalent to roughly 25 square miles. The town planning jurisdiction includes an additional 7,981 acres.

Growth and Development

From 2010-2020, the town population climbed from 37,476 to 58,780 residents — an increase of 57%, which is roughly six times greater than the growth rate of North Carolina (9.5%) and almost eight times greater than the national growth rate over the same period (7.4%).

The study area of this report is the Apex planning jurisdiction, which spans a total area of approximately 24,199 acres. Within these bounds are a variety of community green spaces, five individual watersheds and a diversity of land uses, including agriculture, industrial, commercial and residential areas.

The planning jurisdiction is comprised of two distinct jurisdictional types: corporate limits and extra-territorial jurisdiction.

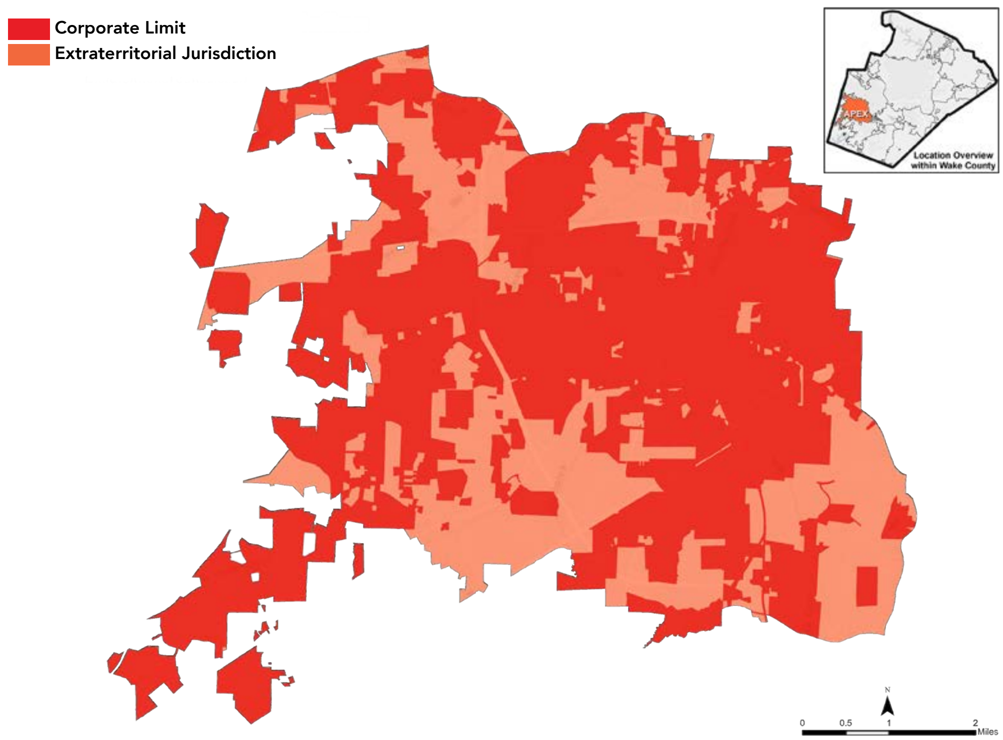
Corporate Limits

The corporate limits (i.e., town limits) are the incorporated land area belonging to a municipality. At the time of analysis, the Town of Apex corporate limits consisted of 16,127 acres.

Extra-territorial Jurisdiction

Extra-territorial jurisdiction (ETJ) describes land that is physically located outside of the corporate limits, but where Apex holds regulatory authority over land development and building construction. At the time of analysis, the Apex ETJ contained 7,981 acres.

MAP E.1 APEX PLANNING JURISDICTION (2022)



Land Cover

DRG employed geospatial analysis and remote-sensing methods to identify the land cover composition throughout the planning jurisdiction of Apex. The analysis utilized 2020 imagery made available by the United States Department of Agriculture's National Agriculture Imaging Program (NAIP). Imagery analysis is cost-effective and attains a high degree of accuracy.

Land cover data are a valuable resource for supporting a variety of multidisciplinary efforts, including environmental management, resource conservation, urban planning, sustainable development, emergency preparedness and climate change mitigation.

The analysis classified the entire land area within the planning jurisdiction into five distinct types of land cover (Figure E.1).

Tree Canopy — **12,196 acres**

Land area that is covered by tree trunks, branches and leaves, as seen from above.

Vegetation — **5,590 acres**

Shrubs, grasses and other low-lying vegetation that allow rainfall to infiltrate soil.

Impervious Surface — **4,840 acres**

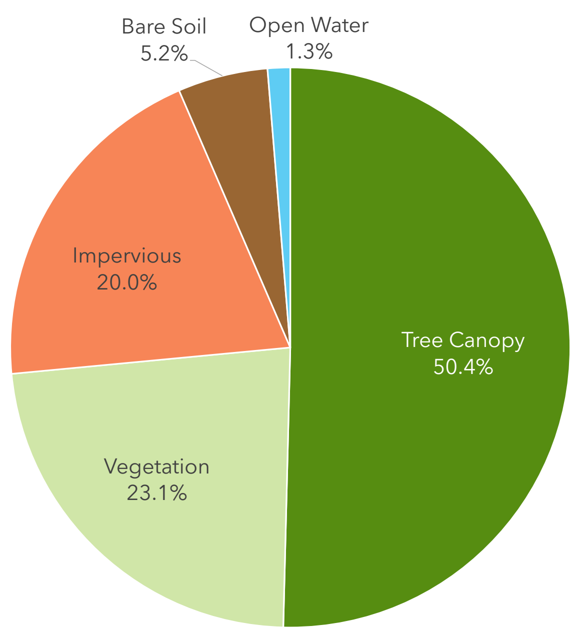
Buildings, roads, sidewalks and other paved or built areas that do not allow rainfall to infiltrate the soil.

Bare Soil — **1,258 acres**

Exposed soil that lacks vegetation, such as vacant lots, construction sites, agricultural fields and baseball infields.

Open Water — **315 acres**

Lakes, ponds, streams, wetlands and other water features.

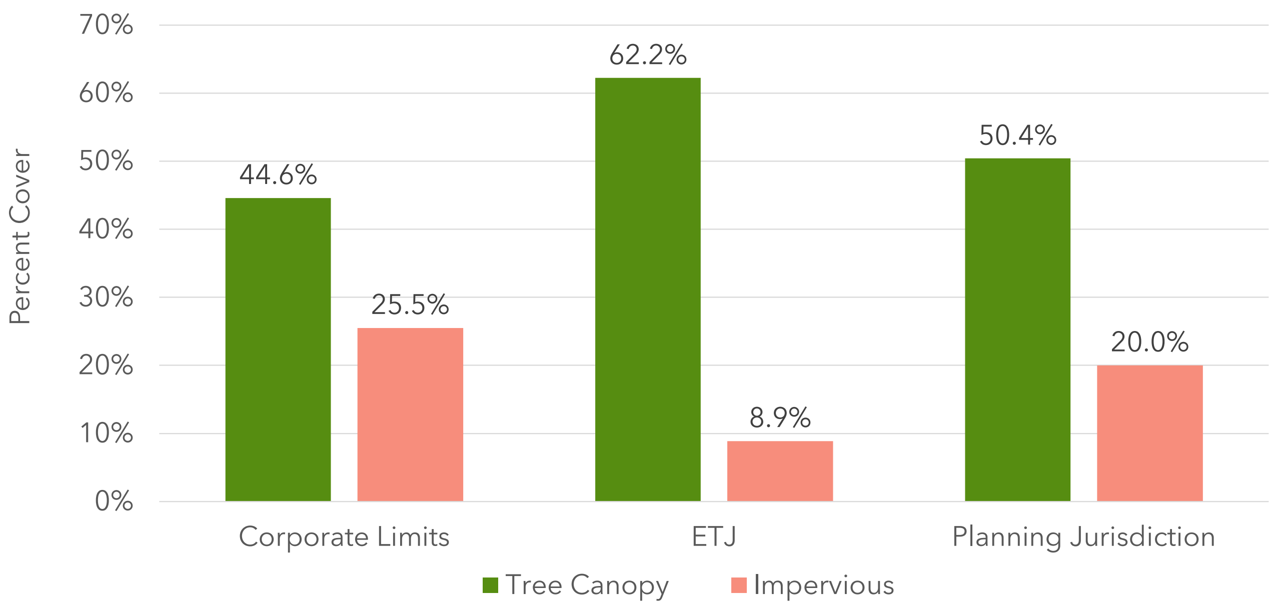


E.1 PLANNING JURISDICTION LAND COVER (2020)

Jurisdictional Analysis

To further support planning and implementation efforts, the study looked within the planning jurisdiction and individually examined the corporate limits and ETJ (Figure E.2).

E.2 TREE CANOPY AND IMPERVIOUS SURFACE BY JURISDICTION TYPE (2020)



Canopy Assessment

A canopy assessment takes a detailed look at the tree canopy data obtained from the land cover analysis. DRG employed a variety of remote-sensing methods to extrapolate additional information such as canopy type, canopy health and canopy change over time.

Canopy Type

Canopy type analyses support sustainable forest management and natural resource planning. The data can also help inform decisions about zoning, infrastructure development and urban expansion.

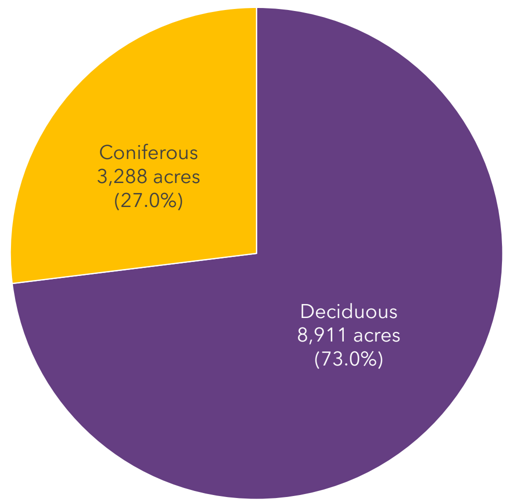
The assessment classified tree canopy into two distinct forest types (Figure E.3):

Coniferous — 3,288 acres

The canopy is characterized by the predominance of cone-bearing trees which typically retain their leaves or needles year-round. Wax-leaf evergreens, such as hollies and magnolias, are included in this category.

Deciduous — 8,911 acres

The canopy is characterized predominately by trees which lose their leaves during winter. In North Carolina, common deciduous species include oak, hickory, maple, beech and elm.



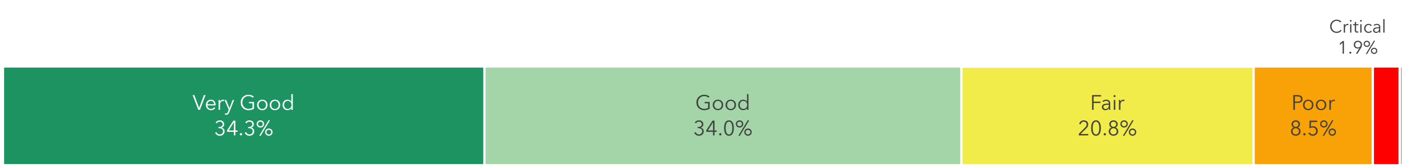
E.3 PLANNING JURISDICTION CANOPY TYPE (2020)

Canopy Health

A canopy health assessment provides valuable insights into overall forest well-being and vitality. The data aids in the detection and management of diseases, nutrient deficiencies and environmental stressors. The analysis also supports proactive tree maintenance in public areas (greenways, parking lots, etc.) or along major road corridors utilized by first responders, a key aspect of an emergency preparedness plan.

Tree canopy throughout the planning jurisdiction is assessed to be predominantly in Very Good and Good condition (Figure E.4).

FIGURE E.4 PLANNING JURISDICTION CANOPY HEALTH (2020)



Canopy Change

To measure temporal change in the amount of tree canopy, DRG compared 2020 tree canopy to canopy as it existed in 2010 by performing an additional land cover analysis utilizing 2010 NAIP imagery.

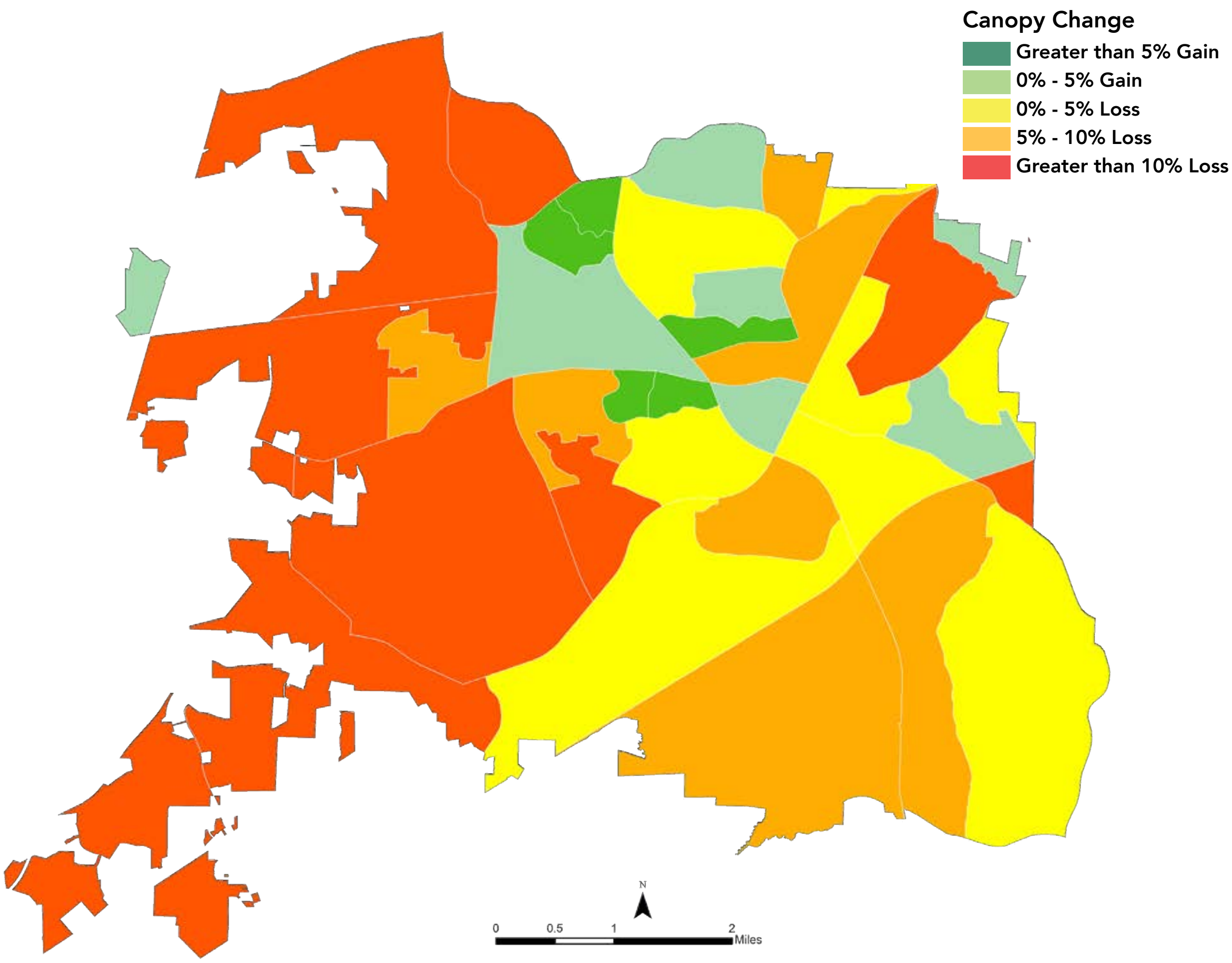
Canopy Loss

From 2010-2020, the Apex planning jurisdiction lost 2,180 acres of tree canopy. The loss represents a 15.2% decrease in the total amount of canopy and a 9.0% decline in canopy cover relative to overall land cover.

Specific to the corporate limits, the amount of tree canopy declined by 23.3%, resulting in a 13.6% decrease in canopy coverage relative to the other types of land cover.

Mapping canopy change by census block group illustrates the geographic distribution of canopy gains and losses throughout the planning jurisdiction over the ten-year span (Map E.1).

MAP E.2 CANOPY CHANGE (2010–2020) BY BLOCK GROUP



Benefits and Value of Apex's Tree Canopy

Trees help clean the air we breathe, filter the water we drink and mitigate the impacts of a changing climate. Through their natural biological and ecological functions, trees provide critical community infrastructure.

The ecosystem service capacity of tree canopy within the Apex planning jurisdiction was measured and valued using i-Tree, a software suite made available by the U.S. Forest Service.

THE TOTAL VALUE OF APEX'S TREE CANOPY IS $131 MILLION

Carbon Storage = $71,344,176

Trees are carbon sinks; they absorb carbon dioxide from the atmosphere and convert it into glucose, which is used as food for the tree. The leftover carbon is then stored within tree tissue, including the trunk, branches, leaves and roots.

Over their lifespan, Apex's trees are estimated to have collectively removed and **stored over 418,316 tons of carbon** from the atmosphere.

Total Annual Benefits = $59,744,666

The benefits analysis measured and valued three specific ecosystem service functions of tree canopy: **air pollution removal**, **carbon sequestration** and **stormwater capture**.

EACH YEAR, APEX'S TREES:

REMOVE 451 TONS
OF POLLUTANTS FROM THE AIR

CO_2

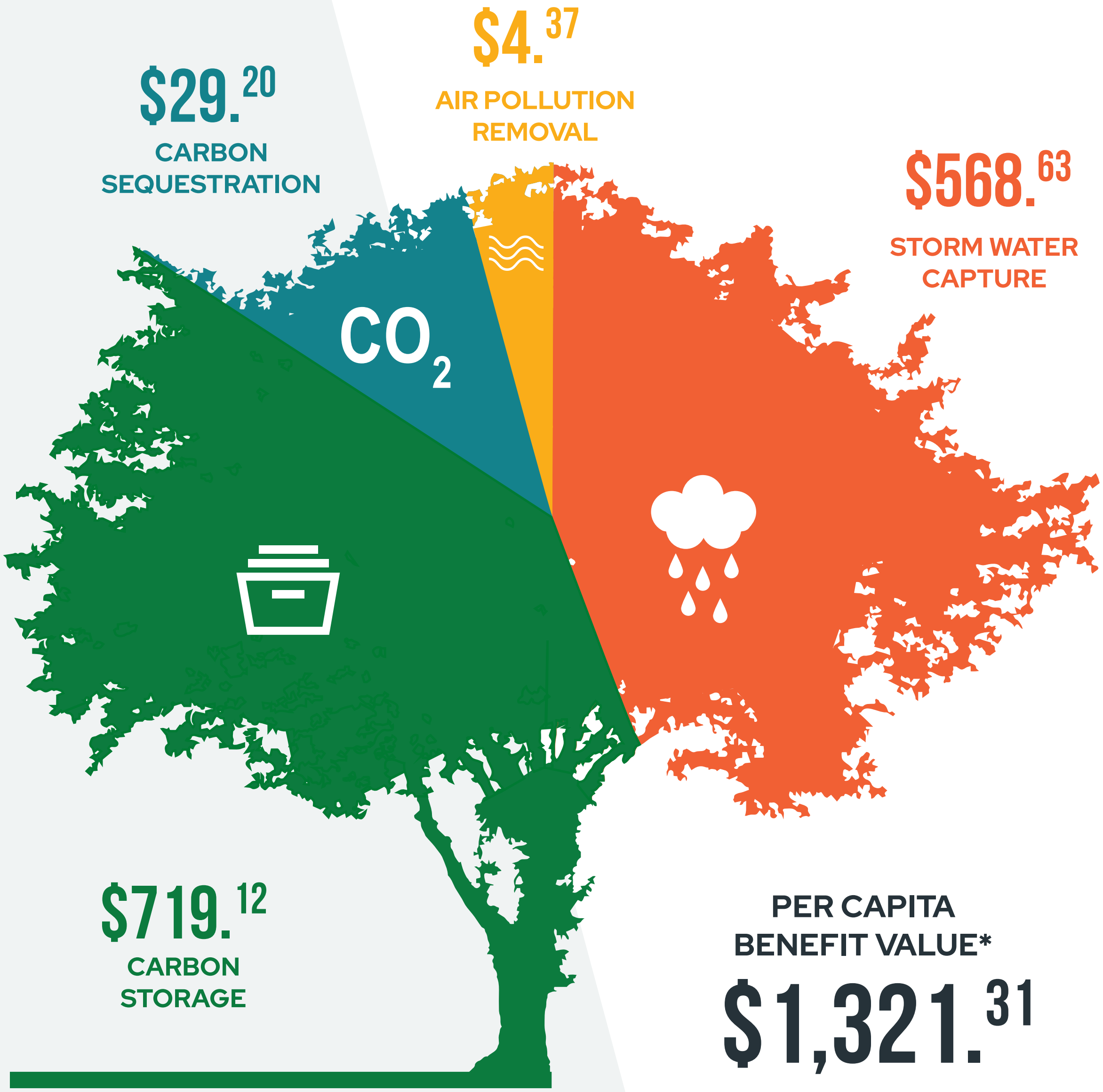
ABSORB 16,984 TONS
OF CARBON DIOXIDE

INTERCEPT 331.8 MILLION
GALLONS OF STORMWATER

Additional, less quantifiable canopy benefits include, but are not limited to:

- Increased property values.
- Shade and cooler air in the summer.
- Energy conservation.
- Improved physical health.
- Improved mental well-being.
- Increased biodiversity and habitat.

SPENDING TIME AROUND TREES AND LOOKING AT TREES REDUCES STRESS, LOWERS BLOOD PRESSURE AND IMPROVES MOOD.



What do your community's trees do for you?

Trees provide substantial added value to the quality of life of Apex's residents. The ecosystem services contributed to the community by its tree canopy infrastructure can be quantified and valued on an individual level.

Over their lifespan, Apexs trees have stored an estimated accumulated total of 4.22 tons of carbon per resident, translating to a per capita carbon storage value of $719.12.

Per resident, Apex's tree canopy annually removes nine pounds of air pollution, capture 3,345 gallons of stormwater and absorbs 342 pounds of carbon. These vital eco-services translate to an annual per capita value of $602.20.

The combined per capita benefit value of Town of Apex's tree canopy is estimated to be $1,321.31.

**Per capita refers to the average value per Apex resident. As of 2020, Apex had a resident population of 58,780 with a tree canopy valuation, , specific to the corporate limits, of $77,666,790.*

Planting Opportunities

A key aspect of the study used the land cover data and additional remote sensing methods to perform a priority planting analysis which identified realistic Potential Planting Area (PPAs) throughout the entirety of the Apex planning jurisdiction.

Identification

Possible planting locations were initially identified from land area classified by the LCA as Bare Soil or Vegetation. These locations were then filtered by size to only include locations greater than or equal to an area of 200 square feet — the approximate size of a standard parking lot island.

To further refine the analysis, the possible planting locations were filtered to exclude “no planting” areas where tree planting is either prohibited or otherwise not desirable. The exclusionary layer of “no planting” locations included utility easements, access easements, public rights-of-way, recreational fields and active agriculture or horticulture sites. The remaining locations are the Potential Planting Area.

The priority planting analysis identified 23,235 individual PPAs totaling 4,616 acres.

Assessment

The PPAs are individually assessed across three separate measures of community vulnerability:

1. Heat Islands

Heat islands are generally found in urbanized areas that experience higher temperatures than outlying areas. Impervious surfaces such as buildings, roads and other infrastructure absorb and re-emit the sun’s heat. In urbanized areas, where these structures are highly concentrated and greenery is limited, this phenomenon creates “islands” of higher temperatures relative to outlying areas. Known as the urban heat island effect, daytime temperatures can range from approximately 1–7°F higher than temperatures in outlying areas and nighttime temperatures range from 2–5°F higher.

2. Stormwater

Stormwater refers to water that originates from a precipitation event, such as rain, that does not soak into the ground. The excess water is runoff that flows over land and carries soil, pollutants and other materials into our rivers, lakes and bays.

3. Social Equity

Social equity refers to the concept of fairness and justice in the distribution of resources and opportunities in a society, particularly as it relates to historically marginalized and disadvantaged groups.

Prioritization

The individual assessments are then combined to produce a composite vulnerability index. The index provides a total aggregate vulnerability score for each PPA and is used to prioritize the planting locations on a five-category ordinal scale (Very High, High, Medium, Low, Very Low).

The priority ranking corresponds to the assessed need for additional tree canopy to help mitigate the harmful impacts associated with each area of vulnerability and boost overall community resiliency.

The analysis identified 16.9% of PPAs as Very High priority and 23.5% as High priority.

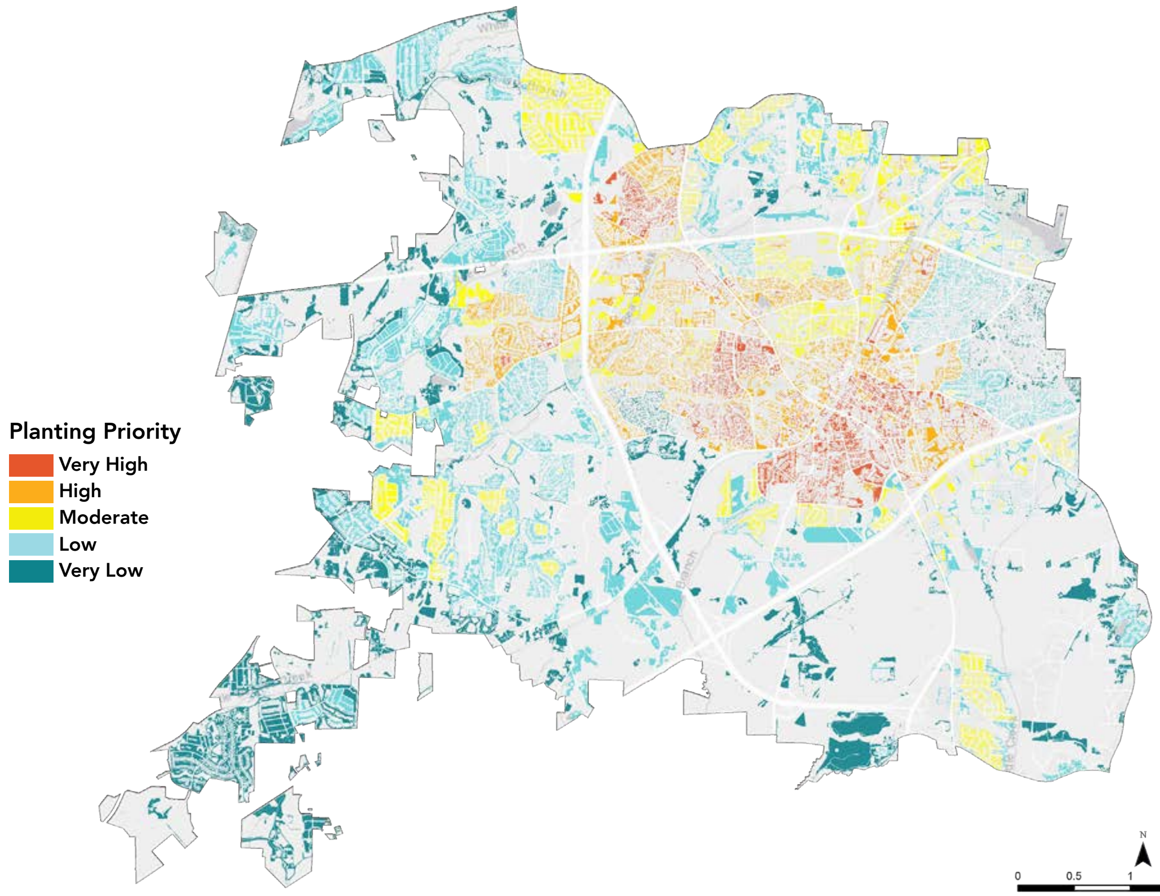
Tree Placement Modeling

A GIS-based algorithm modeled how many trees could be planted within each PPA. The model differentiated between tree canopy size at maturity (large, medium and small), giving preference to large-growing trees and utilizing spacing commonly suggested for a landscape setting (Table 3.3).

The tree placement model identified 229,001 total individual tree planting sites.

- 54.8% of sites suitable for large trees (125,581 sites)
- 12.1% of sites suitable for medium trees (27,658 sites)
- 33.1% of sites suitable for small trees (75,762 sites)

MAP E.3 POTENTIAL PLANTING AREA (2020) PRIORITIZED BY THE COMPOSITE VULNERABILITY INDEX



Looking Ahead

The information in this study establishes baseline statistics for land cover and tree canopy in the Town of Apex planning jurisdiction. It should be considered as a starting point — a springboard for conversations and identification of opportunities that can enhance tree canopy. The data can be leveraged to support tree planting initiatives and tree maintenance. Additionally, the data can assist policymakers, planners and community stakeholders in securing funding to support these activities.

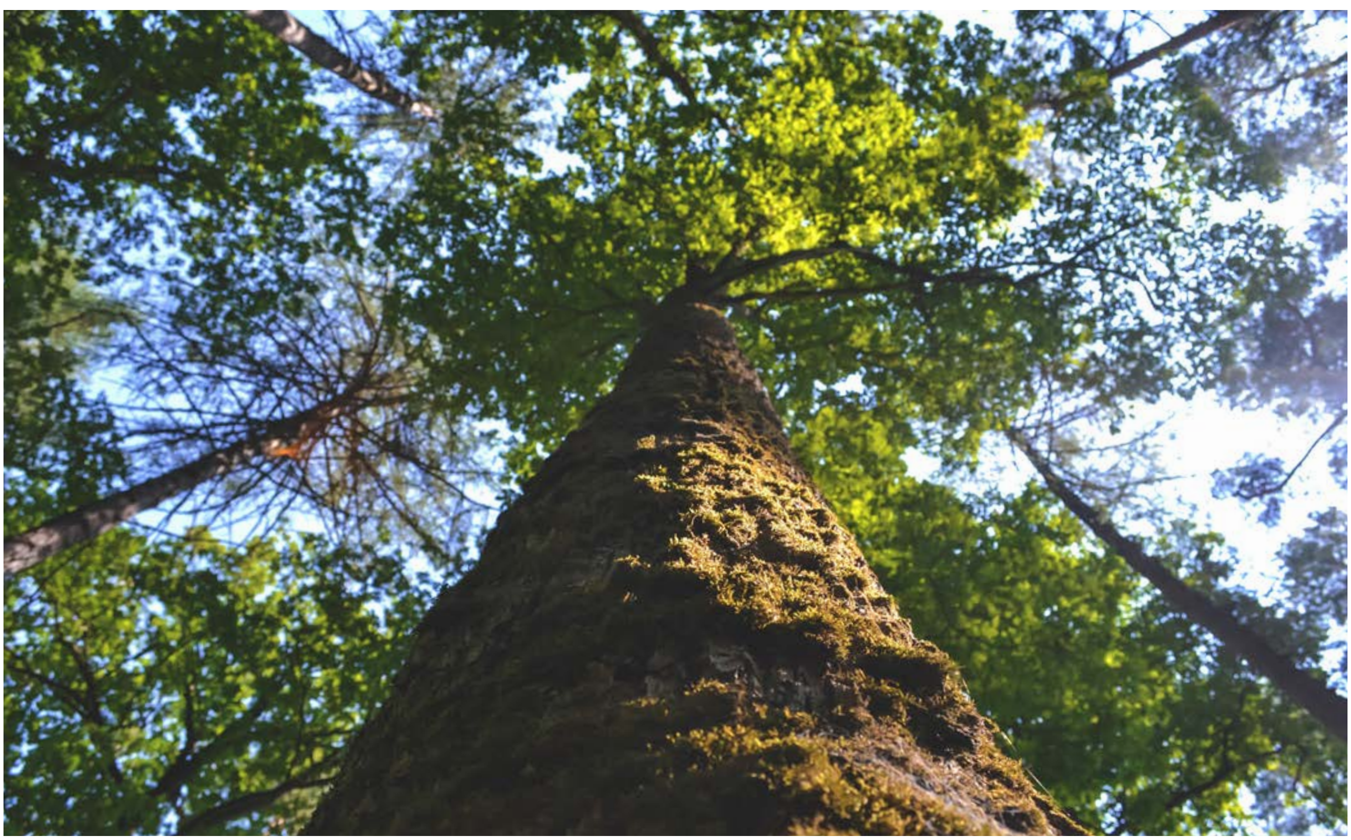
Plant New Trees

This report and the accompanying GIS data provide a tool to help Apex identify and prioritize tree planting based on canopy cover and environmental and socio-economic needs. The information can be used to encourage and support tree planting on both public and private properties.

Review Ordinances and Policies

Existing regulatory and policy documents, such as development ordinances and land use plans, can be evaluated in the context of the data provided by the LCA/TCA project. The data can help identify how and where to incentivize and encourage tree planting, tree protection and other ways to expand tree canopy. Review of internal policies, procedures and current projects' impact on publicly owned trees can also be helpful when identifying ways to increase tree planting and protect existing tree canopy.

Small changes in the design of public projects, including sidewalk installation, street and infrastructure improvements, can improve impacts to trees.



Community Outreach and Involvement

Outreach and education campaigns — including volunteer programs — can encourage residents to care for and retain existing trees. Involving residents in community tree initiatives is a great way to spread the word on the benefits of trees and develop a culture of tree appreciation that can have significant long-term impacts on tree canopy across Apex. Partnering with local organizations to help spread the word is a way to help get the message out.

Seek New Sources of Funding

The information provided in this study can be used to secure new grant funding with government agencies (state/federal) and private foundations. In addition to the traditional grant programs that support trees, exploring grants that connect to the benefits that trees provide to Apex, like improving air quality (public health) and increasing canopy in low-income/low canopy areas (equity and environmental justice) can help broaden the types of funding opportunities available.

Section One

Land Cover

In This Section:

» Land Cover Types
» Geographies of Study
» Apex Land Cover

Introduction

A land cover analysis was conducted by Davey Resource Group, Inc., a national urban forestry consulting firm, in collaboration with the Wake County government. The assessment utilized leaf-on, multispectral aerial imagery, vintage 2020, that was available from the National Agricultural Imagery Program (NAIP) and processed by the United States Department of Agriculture. A full discussion of the analytical methods and data sources can be found in the Methodology.

What is Land Cover?

Land cover describes the physical surface types of a given area, as viewed from above.

Why is Land Cover Important?

The analysis informs our understanding and management of natural resources by providing valuable information about the types and distribution of land cover. The data aids in land-use planning, resource conservation, climate change mitigation and sustainable development.

Where is Land Cover Data Acquired?

Land cover data can be acquired from a variety of techniques including remote sensing, ground surveys and aerial imagery. This study utilized an object-based image analysis (OBIA) semi-automated feature extraction method to process and analyze high-resolution color infrared (CIR) aerial imagery and remotely sensed data.

How is Land Cover Data Useful?

The metrics and resulting maps hold a variety of multidisciplinary practical applications, including within the following areas of interest:

Urban Planning

Land cover data can help identify development trends and patterns. Additionally, the data can aid in identifying land areas suitable for development, wildlife conservation, or other types of land uses.

Environmental Monitoring

Land cover data can be used to monitor changes in the environment, including deforestation, urbanization and the expansion of agricultural areas. It helps in assessing the impact of human activities on the natural environment.

Natural Resource Management

Land cover data can provide information on the distribution and extent of natural resources such as forests, water resources and wildlife habitats. This information can be used to support sustainable management of these resources.

Emergency Preparedness

Land cover data can be used to assess the risk of natural disasters such as floods, landslides and wildfires. It helps in identifying areas that are most vulnerable to these disasters and in planning disaster response and management activities.

Climate Change

Land cover data can be used to track, model and analyze the effects of land cover and land cover changes on climate patterns.

LAND COVER DATA CAN BE USED TO TRACK, MODEL AND ANALYZE CHANGES ON CLIMATE PATTERNS.

Land Cover Types

The analysis utilized the following categories to describe land cover:

Bare Soil

Land areas consisting of exposed soil that lacks vegetation, such as vacant lots, construction sites, agricultural fields and baseball infields.

Grass/Low-lying Vegetation

Pervious land (i.e., surfaces that allow rainwater infiltration) that is covered by shrubs, grasses and other low-lying vegetation that allow rainfall to infiltrate soil. Parks, golf courses and commercial and residential lawns and garden beds are land uses generally characterized by relatively high percentages of grass/low-lying vegetation.

Impervious Surface

Impervious surface describes land area that is covered by buildings, roads, sidewalks and other paved or built areas that do not allow rainfall to infiltrate the soil.

Tree Canopy

Tree canopy describes land area that is covered by tree trunks, branches and leaves, as seen from above. Tree canopy can be further divided into two types:

Coniferous

Land area that is covered predominately by coniferous trees, such as pines and spruce. In general, conifers retain their leaves year-round. Wax-leaf evergreens, such as hollies and magnolias, are included in this category.

Deciduous

Land area that is covered predominately by deciduous trees, such as oaks and maples. Deciduous trees shed their leaves seasonally.

Water

Lakes, ponds, streams, wetlands and other water features.

Geographies of Study

The study examined land cover within the following geographic areas of interest:

Planning Jurisdiction

Land area over which a municipality has zoning control. The planning jurisdiction is comprised of a municipality's corporate limits and extra-territorial jurisdiction (Map 1.1).

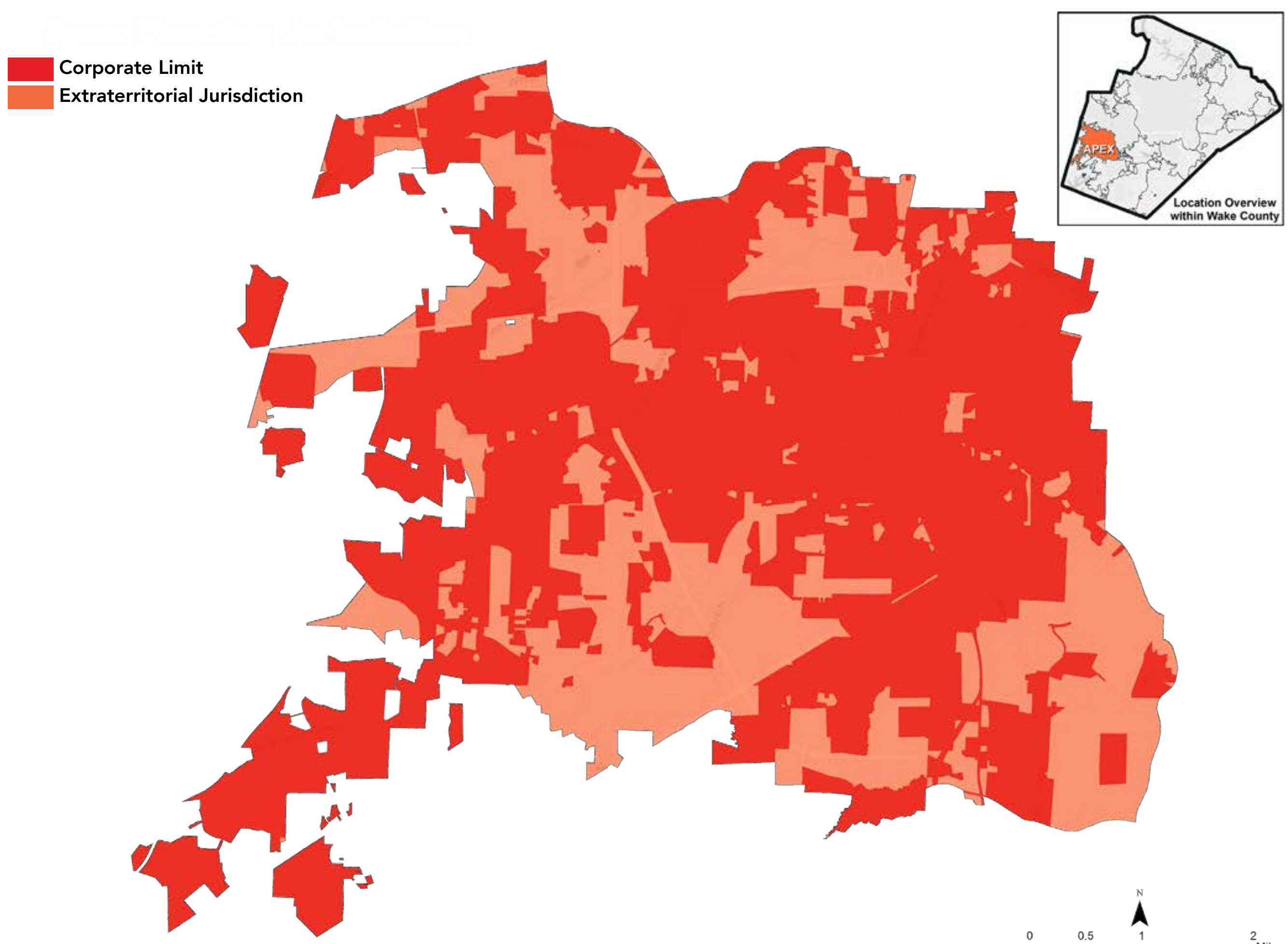
Corporate Limits

The incorporated land area belonging to each municipality.

Extra-Territorial Jurisdiction (ETJ)

ETJ describes land that is physically located outside of municipal corporate limits but where a municipality holds regulatory authority over land development and building construction.

MAP 1.1 PLANNING JURISDICTION (2022)



Census-Based

Census-based geographies are useful units of analysis due to the wealth of demographic and socio-economic information collected by the U.S. Census Bureau (Map 1.2).

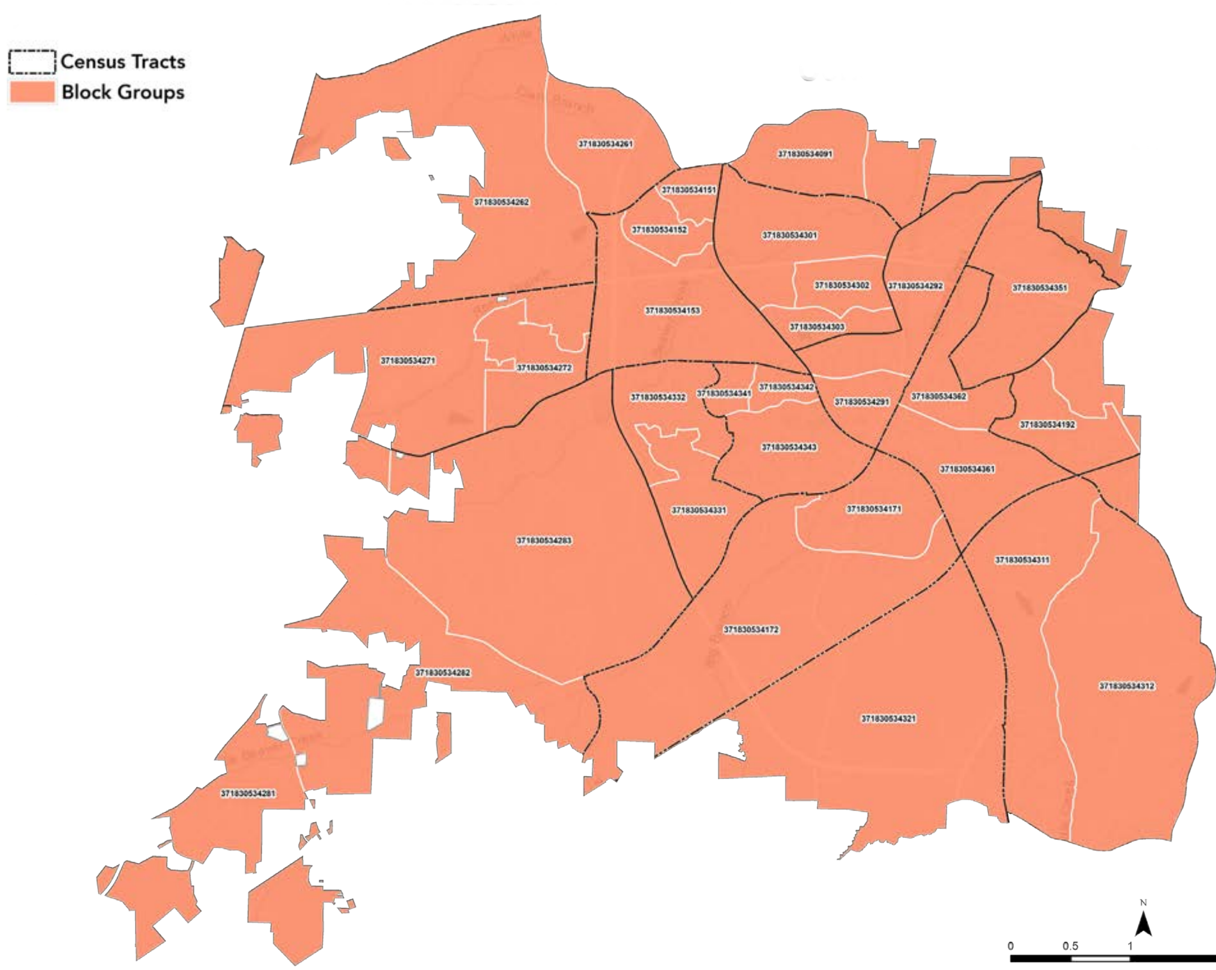
Census Tracts

Census Tracts (CTs) are small, relatively permanent statistical subdivisions of a county or statistically equivalent entity. The primary purpose is to provide a stable set of geographic units for the presentation of statistical data. CTs generally have a population size between 1,200 and 8,000 people, with an optimum size of 4,000 people. A CT usually covers a contiguous area; however, the spatial size varies widely depending on population density.

Block Groups

Block Groups (BGs) are statistical divisions of census tracts that are generally defined to contain between 600 and 3,000 people. BGs are used to present data and usually cover a contiguous area. Within the standard census geographic hierarchy, BGs never cross state, county, or census tract boundaries, but may cross the boundaries of any other geographic entity, such as municipal corporate limits.

MAP 1.2 CENSUS TRACTS AND BLOCK GROUPS (2022)



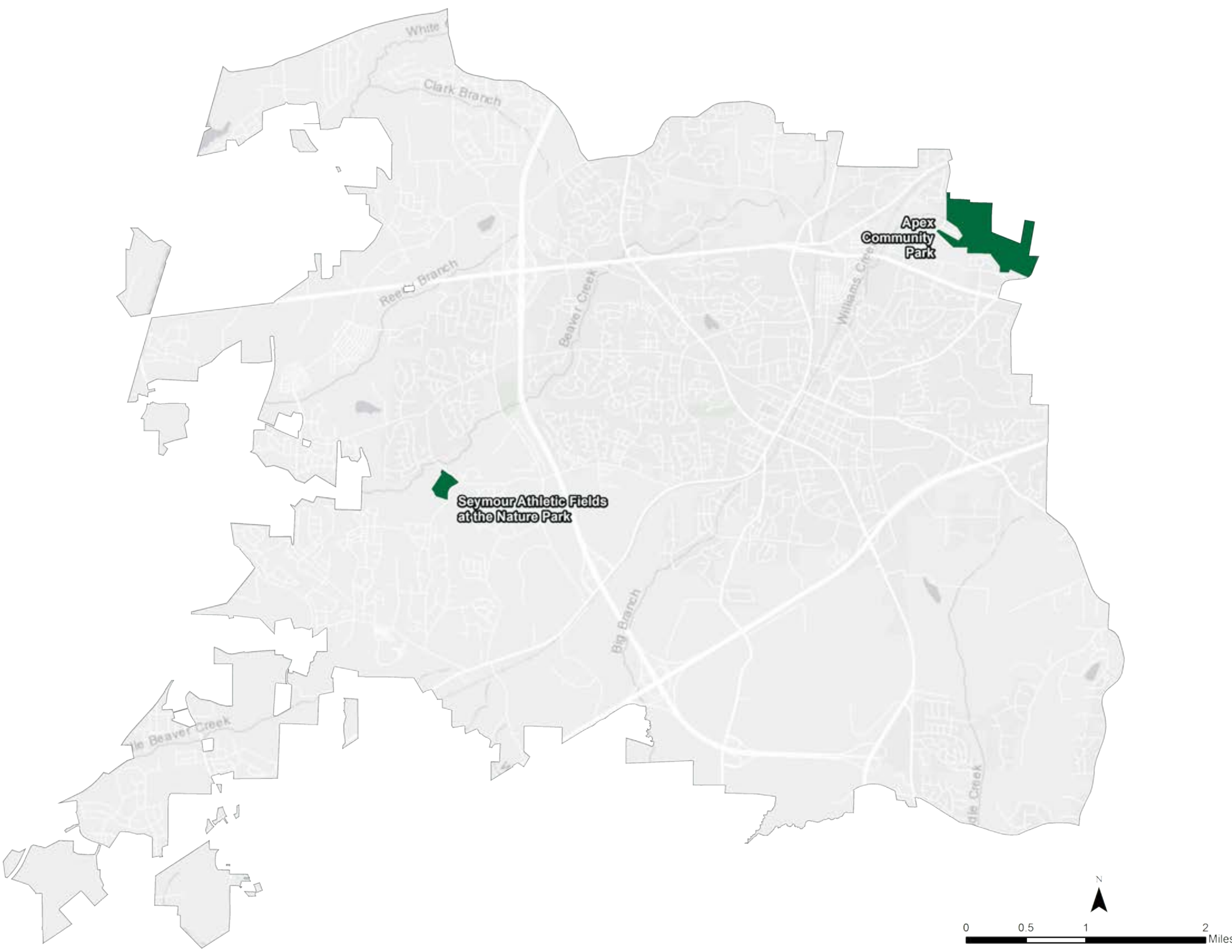
Green Spaces

Green spaces generally refer to areas designed or preserved for their environmental, social, or recreational benefits. The Wake LCA/TCA project specifically looked at land designated as one of three primary green space types: Parks, Open Spaces and Greenways.

The dataset utilized in the analysis was obtained from Wake County in July 2022 and is not considered to be inclusive of all community green spaces throughout the county. As such, land cover metrics and resulting summary statistics should not be considered as an authoritative or exhaustive representation of Wake County's green spaces.

Map 1.3. exhibits the location of the individual green space highlighted within this report: Apex Community Park and Seymour Athletic Fields.

MAP 1.3 GREEN SPACE FOCUS: APEX COMMUNITY PARK AND SEYMOUR ATHLETIC FIELDS (2022)

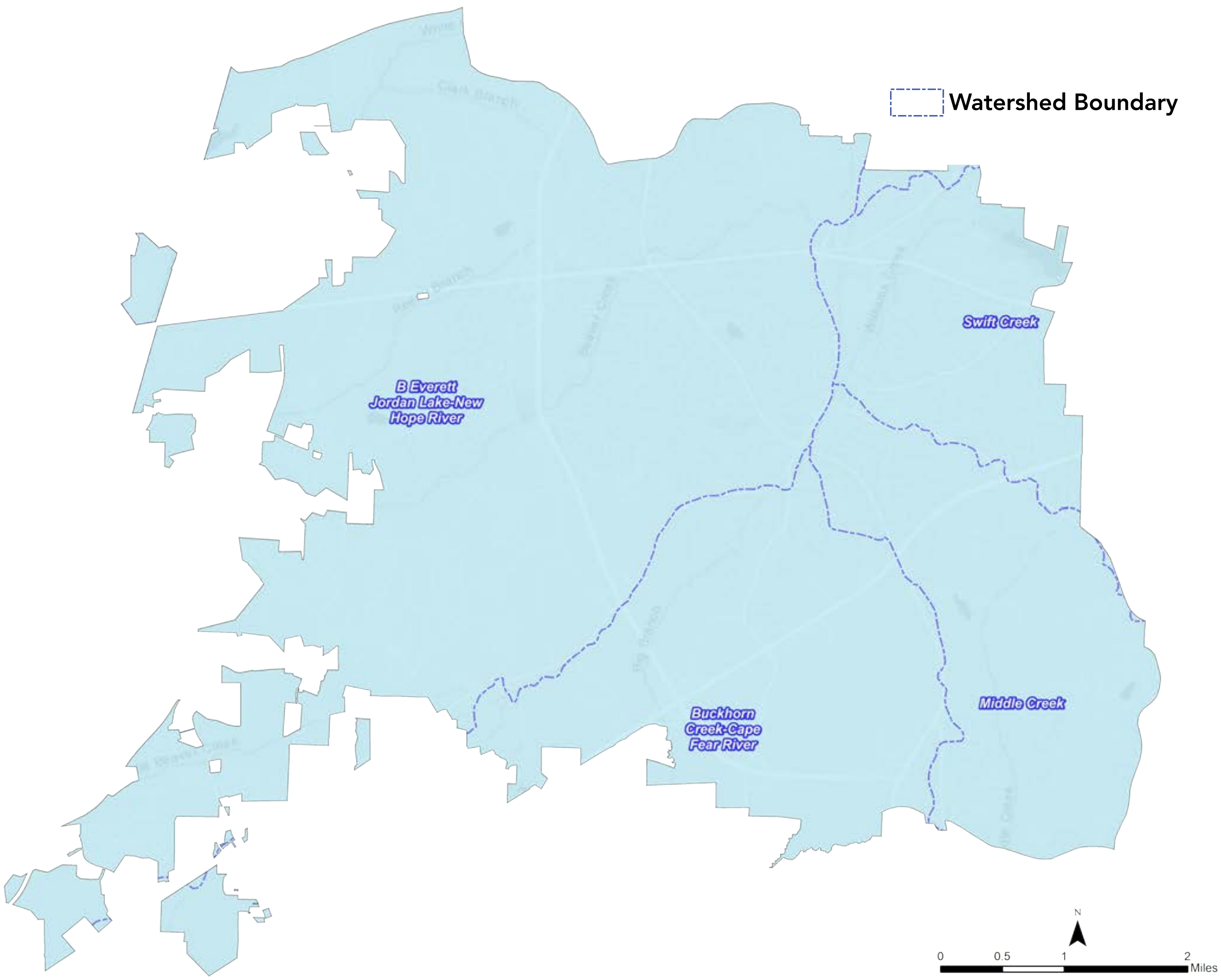


Watersheds

A watershed is the land area that drains to a common body of water, such as a stream, lake, bay, or ocean. Also called a drainage basin, a watershed includes hills, lowlands and the body of water into which runoff drains. Apex's planning jurisdiction contains portions of five watersheds: Crabtree Creek, B. Everett Jordan Lake, Middle Creek, Swift Creek and Buckhorn Creek-Cape Fear River (Map 1.4).

Watersheds that contain a reservoir or proposed reservoir used for drinking water are classified as Water Supply Watersheds (WSWS). Apex contains portions of two WSWS within its jurisdiction: B. Everett Jordan Lake and Swift Creek. The Apex Utilities Department uses Jordan Lake to provide water and utility services to its residents.

MAP 1.4 WATERSHEDS (2022)



Land Cover

The Apex planning jurisdiction encompasses a total land area of 24,199 acres. Summarized below are the findings of land cover analysis (Table 1.1).

Observations

The corporate limits contain significantly more impervious surface than the ETJ (25.5% compared to 8.9%, respectively).

Impervious surface is concentrated in urbanized areas, particularly along major roadway corridors (e.g., NC Highway 55, U.S. Highway 64 and U.S. Highway 1) and commercial, industrial and high-density residential land use types.

Large concentrations of canopy are found in the south and southeast (near the NC Highway 55 and U.S. Highway 1 Interchange).

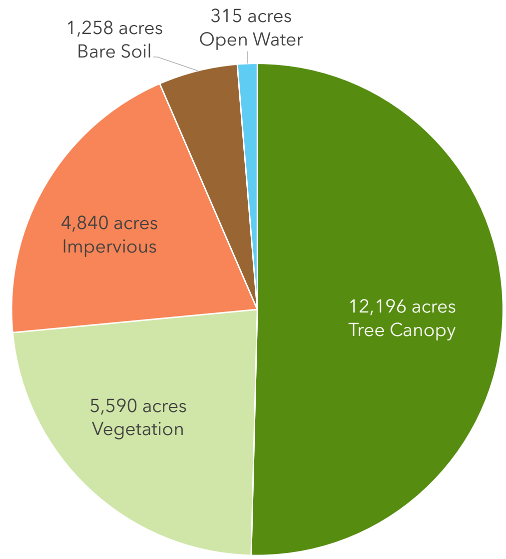


FIGURE 1.1 PLANNING JURISDICTION LAND COVER (2020)

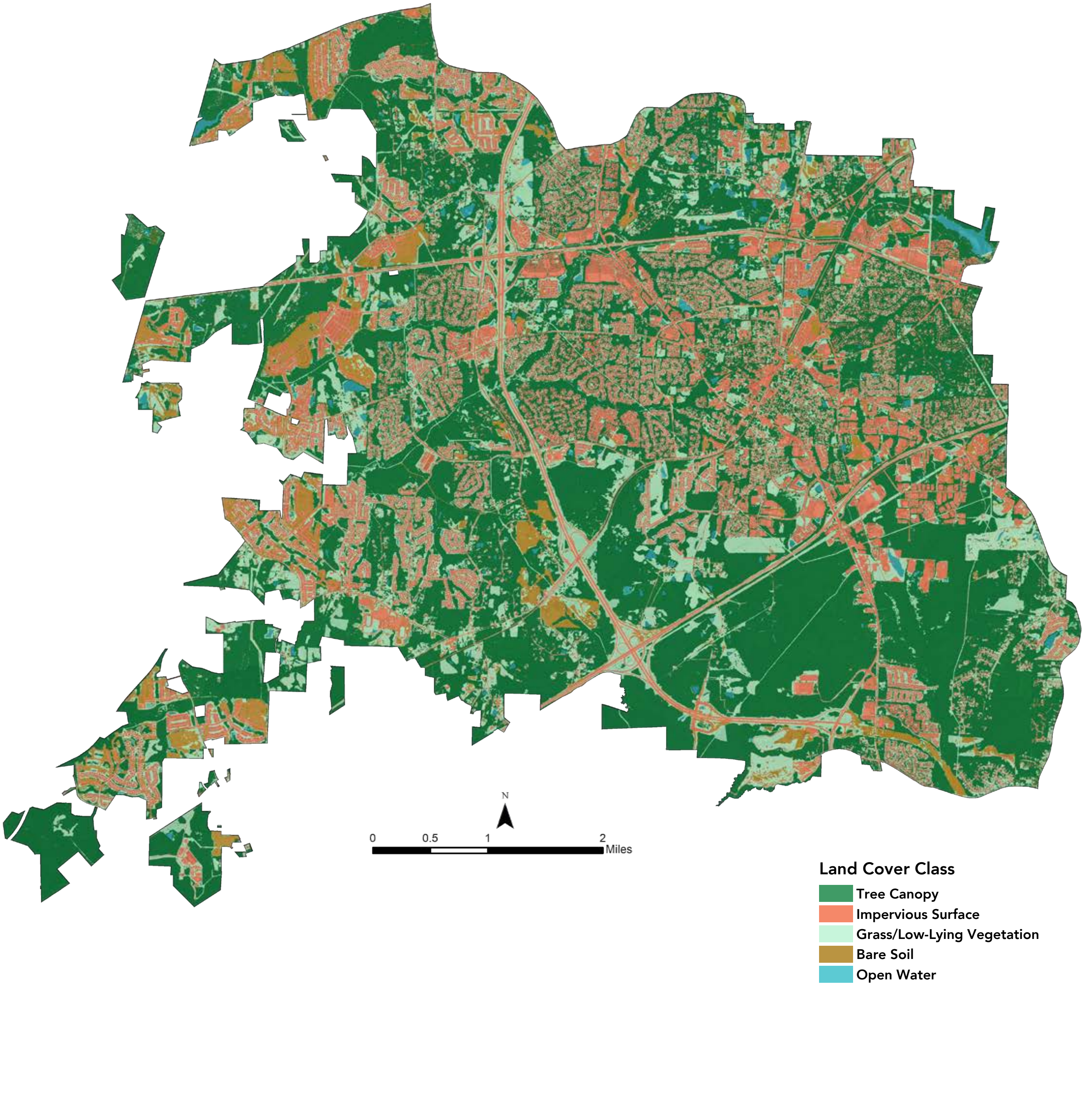
Vintage 2020

As the summary presented here is a snapshot of 2020, it is likely that the land cover composition has changed in favor of the characteristics associated with urban growth and land development: less tree canopy and more impervious surface.

TABLE 1.1 LAND COVER COMPOSITION (2020) BY JURISDICTION TYPE

JURISDICTION	TOTAL ACRES	TREE CANOPY	IMPERVIOUS	VEGETATION	BARE SOIL	OPEN WATER
Corporate Limits	16,217	44.6%	25.5%	22.0%	6.6%	1.3%
ETJ	7,981	62.2%	8.9%	25.3%	2.2%	1.4%
Planning Jurisdiction	24,199	50.4%	20.0%	23.1%	5.2%	1.3%

MAP 1.5 LAND COVER (2020)



Section Two

Canopy Assessment

In This Section:

Overview

What is a Tree Canopy Assessment?

A Tree Canopy Assessment (TCA) measures and evaluates the amount and extent of tree canopy cover within a particular geographic area of interest (AOI).

Why Study Tree Canopy?

Our community forests are integral to the function and well-being of daily life. Trees provide critical environmental services and a myriad of socioeconomic benefits that improve and enhance quality of life.

Canopy assessments offer insight into the health, diversity and distribution of tree canopy.

TCAs can determine where residents are benefitting from the presence of trees, the monetary value of those benefits, how benefits change over time and where trees can be planted or preserved to maximize the positive impacts trees make on everyday life while simultaneously mitigating the adverse impacts of the built environment.

While it may not seem like one tree can make a substantial difference, collectively, Apex's trees play a significant role in supporting and enhancing community livability and resilience.

Canopy Type

Summary

Canopy types are not evenly distributed; deciduous and coniferous forest types prevail in different areas due to historical land use patterns and tree species preferences across a range of environmental factors, including topography, microclimates, soil pH and permeability and other geographical and geological characteristics.

The analysis classified tree canopy cover into two distinct forest-type classifications: coniferous or deciduous.

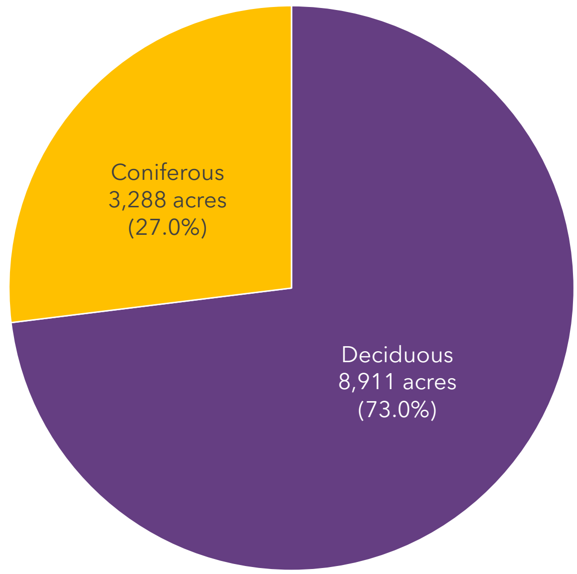


FIGURE 2.1 PLANNING JURISDICTION CANOPY TYPE (2020)

Observations

Tree canopy across Apex is a mix of 73.0% deciduous and 27.0% coniferous.

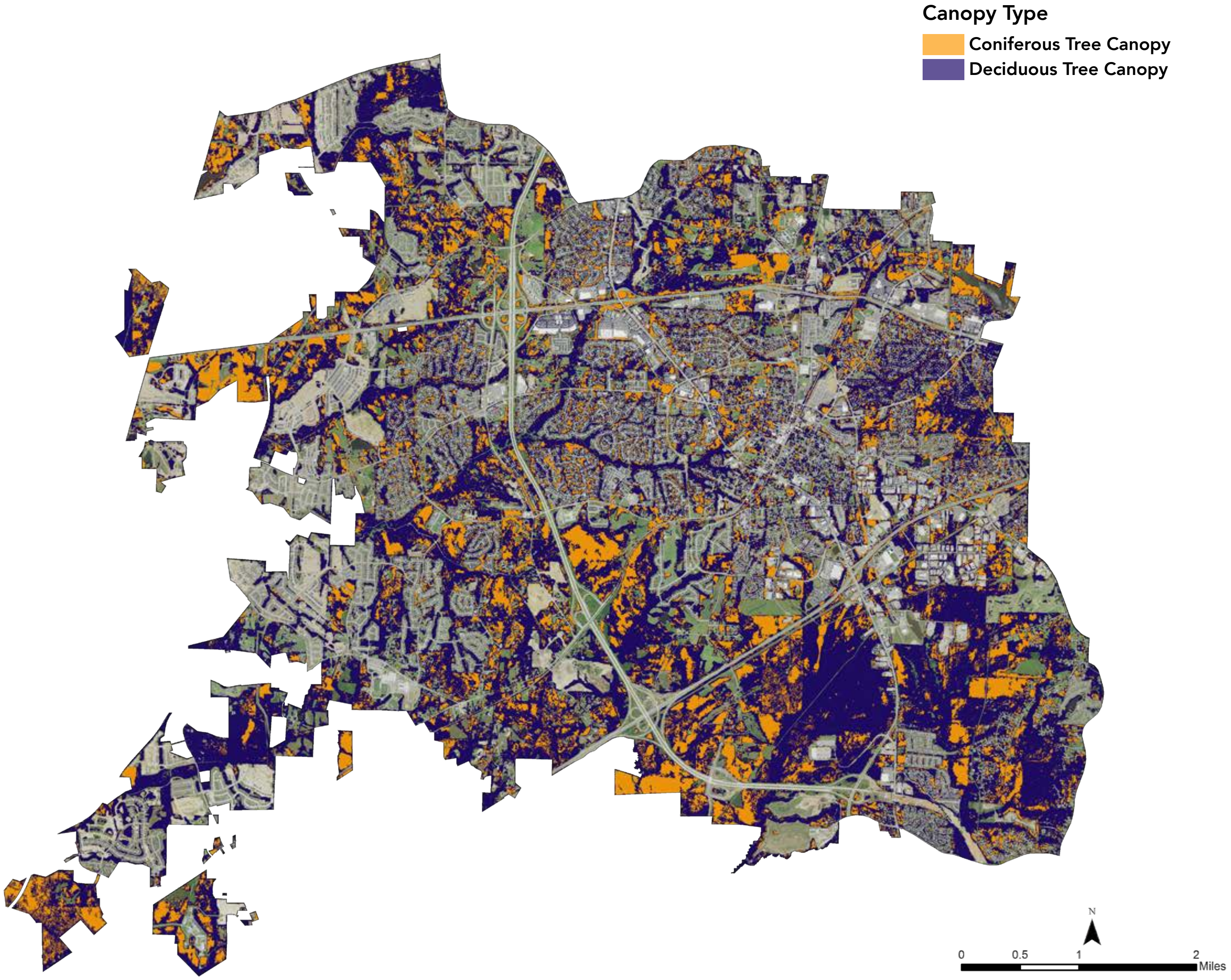
The largest concentrations of coniferous canopy appear to be primarily within or adjacent to the ETJ. It is likely some of these areas are pine stands currently or previously utilized for harvesting timber.

As growth and development within Apex continues at the current trajectory, it is expected that the overall proportion of coniferous canopy within the planning jurisdiction will decline.

TABLE 2.1 CANOPY TYPE (2020) BY JURISDICTION

JURISDICTION	DECIDUOUS			CONIFEROUS	
	ACRES	PERCENT		ACRES	PERCENT
Corporate Limits	5,349	74.0%		1,884	26.0%
ETJ	3,562	71.7%		1,404	28.3%
Planning Jurisdiction	8,911	73.0%		3,288	27.0%

MAP 2.1 CANOPY TYPE (2020)



Canopy Health

Summary

A comprehensive canopy assessment provides data on tree health and overall condition. Knowledge of where healthy canopy exists relative to less healthy canopy allows for further investigation of localized "hotspots" (e.g., concentrated areas of canopy in declining health). Targeted ground-truthing to explore areas of piqued interest or potential concern is an efficient and proactive step in maintaining and preserving the community forest (Map 2.2).

Once ground conditions are confirmed, appropriate solutions and action steps can be implemented.

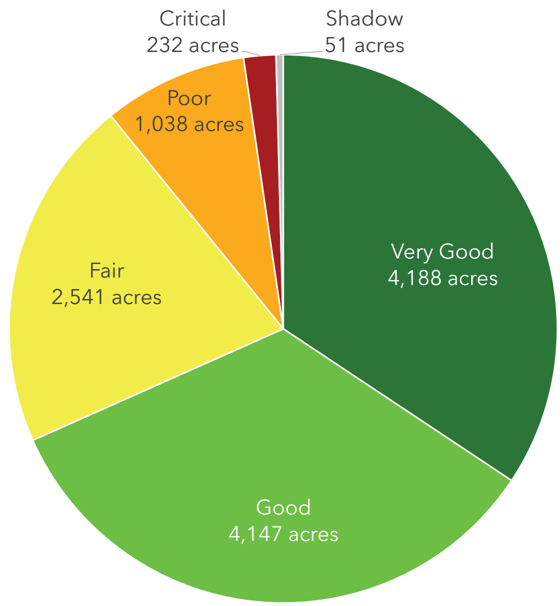


FIGURE 2.2 PLANNING JURISDICTION CANOPY HEALTH (2020)

Observations

The predominant canopy health rating within the planning jurisdiction is Very Good and Good, accounting for approximately 4,188 and 4,147 canopy acres, respectively (Figure 2.2).

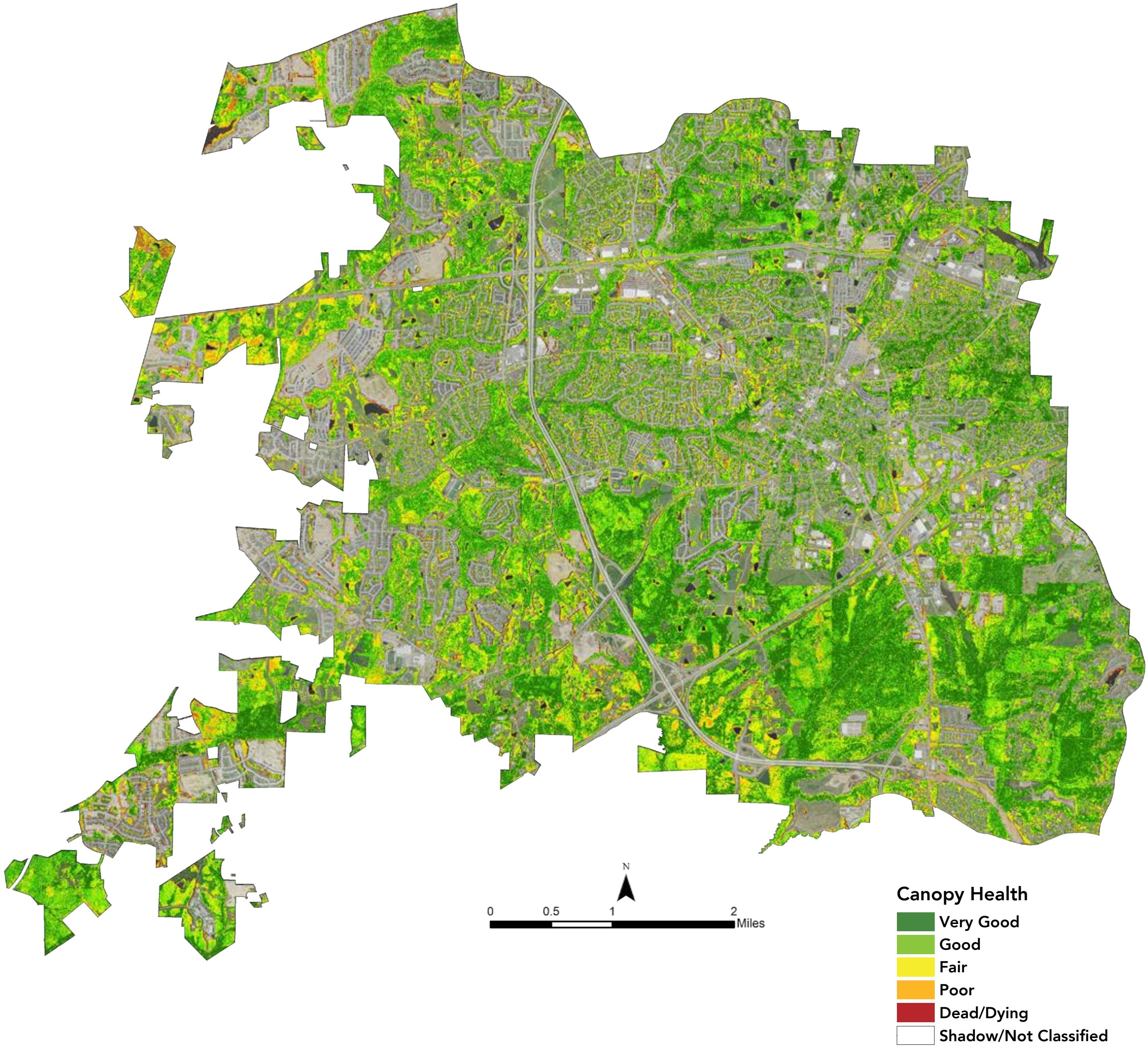
The ETJ contains a larger proportion of trees rated Fair or better than is found within the corporate limits (90.6% to 86.9%).

In general, tree canopies in and around more recent development sites are found to be less healthy. As Apex experienced a significant amount of development over the past decade, it is reasonable to anticipate that canopy health in those areas will improve over time as remaining trees adjust to the changed environment and newly planted trees become established in the landscape.

TABLE 2.2 CANOPY HEALTH (2020) BY JURISDICTION

JURISDICTION	CANOPY HEALTH					
	VERY GOOD	GOOD	FAIR	POOR	CRITICAL	SHADOW
Corporate Limits	32.6%	33.7%	21.3%	9.5%	2.3%	0.5%
ETJ	36.8%	34.4%	20.2%	7.0%	1.3%	0.3%
Planning Jurisdiction	34.3%	34.0%	20.8%	8.5%	1.9%	0.4%

MAP 2.2 CANOPY HEALTH (2020)



Canopy Benefits

Tree canopy positively impacts daily life in ways both seen and unseen. From pollution removal to aesthetic enhancement to habitat provision, the benefits that tree canopy provide to humanity and the built environment are numerous and wide-ranging. Research increasingly demonstrates the crucial role trees play in supporting individual well-being and overall community health and vitality.

The Wake LCA & TCA project took a specific look at a variety of ecosystem services provided by tree canopy. Specifically, i-Tree was utilized to quantify and value the role that trees play in cleaning the air, sequestering carbon and mitigating stormwater runoff (Table 2.3). Details on how i-Tree calculates benefits are provided in the Methodology.

The findings presented below emphasize that the value of tree canopy extends beyond the role of a tree as an aesthetic amenity — the natural, biological functions of trees provide critical infrastructure.

Total Value of $131.1 Million

Collectively, the tree canopy within the Apex planning jurisdiction holds an estimated value of $131,088,842. Total value is a combination of structural value and annual value of the annual ecosystem service benefits that trees provide.

Structural Value of $71.3 Million

Over their lifespan, the trees within Apex's planning jurisdiction have collectively removed and stored more than 418,000 tons of carbon from the atmosphere. This removal and storage service capacity has an estimated value of $71,344,176 million.

Annual Benefit Value of $59.7 Million

Apex's trees provide annual benefits totaling $59,744,666 million in air pollution removal, carbon sequestration and stormwater capture.

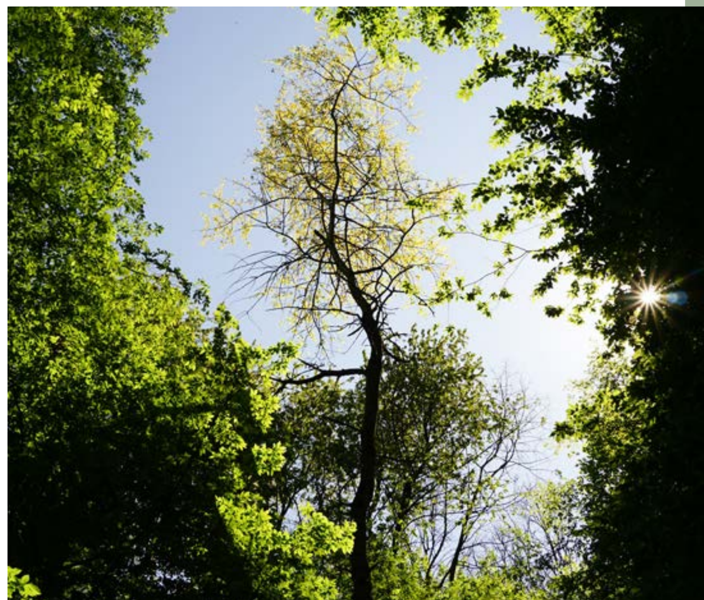
TABLE 2.3 ANNUAL BENEFITS AND STRUCTURAL VALUE OF APEX'S TREE CANOPY (2020)

	ANNUAL TREE BENEFITS									
JURISDICTION	AIR POLLUTION REMOVAL									
	CO		NO_2		O_3		SO_2		PM_{10}	
	ton	$	ton	$	ton	$	ton	$	ton	$
Corporate Limits	5	4,550	20	3,429	195	109,675	6	277	41	139,199
ETJ	3	3,130	14	2,359	134	75,439	4	191	28	95,746
Planning Jurisdiction	9	7,680	34	5,787	329	185,114	11	468	70	234,945

Annual Ecosystem Service Benefits

Air Quality Improvement

Apex's trees collectively remove 451 tons of pollutants from the air each year. This includes 9 tons of carbon monoxide (CO), 34 tons of nitrogen dioxide (NO_2), 329 tons of ozone (O_3), 11 tons of sulfur dioxide (SO_2) and 70 tons of dust, soot and other particulate matter (PM_{10}).



Water Quality Improvement

Trees improve water quality by intercepting and absorbing rainwater, reducing soil erosion and filtering pollutants. Apex's canopy captures over 331 million gallons of stormwater each year. This amount of water could fill almost 503 Olympic sized swimming pools!

Carbon Sequestration

Trees sequester (i.e., absorb) carbon and store it in their trunks, branches, leaves and roots. Each year, the trees within the Apex planning jurisdiction sequester 16,984 tons of carbon dioxide (CO_2) from the atmosphere.

	ANNUAL TREE BENEFITS					**STRUCTURAL VALUE**	
	CARBON (CO_2) SEQUESTRATION		**STORMWATER CAPTURE**		**TOTAL ANNUAL BENEFITS**	**CARBON STORAGE**	
	ton	**$**	**gallon**	**$**	**$**	**ton**	**$**
	10,062	1,716,128	196,611,345	33,423,929	35,397,188	247,842	42,269,602
	6,921	1,180,416	135,236,457	22,990,198	24,347,478	170,475	29,074,574
	16,984	2,896,544	331,847,802	56,414,126	59,744,666	418,316	71,344,176

Canopy Cover

At the time of analysis, 2020, the Apex planning jurisdiction contained 12,199 acres of tree canopy, accounting for 50.4% of total land cover. Of that total, approximately 59% of all canopy is located within the town corporate limits (Figure 2.3).

Vintage 2020

It is important to keep in mind that this analysis is a snapshot of conditions existing in 2020 and may not be representative of the current canopy percent.

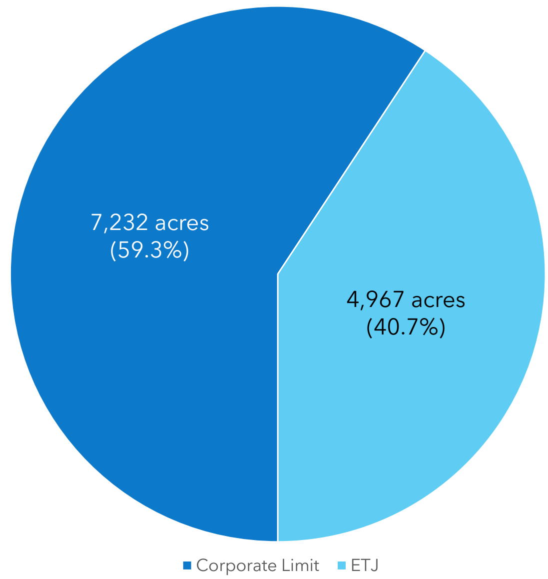


FIGURE 2.3 CANOPY COVER (2020) BY JURISDICTION

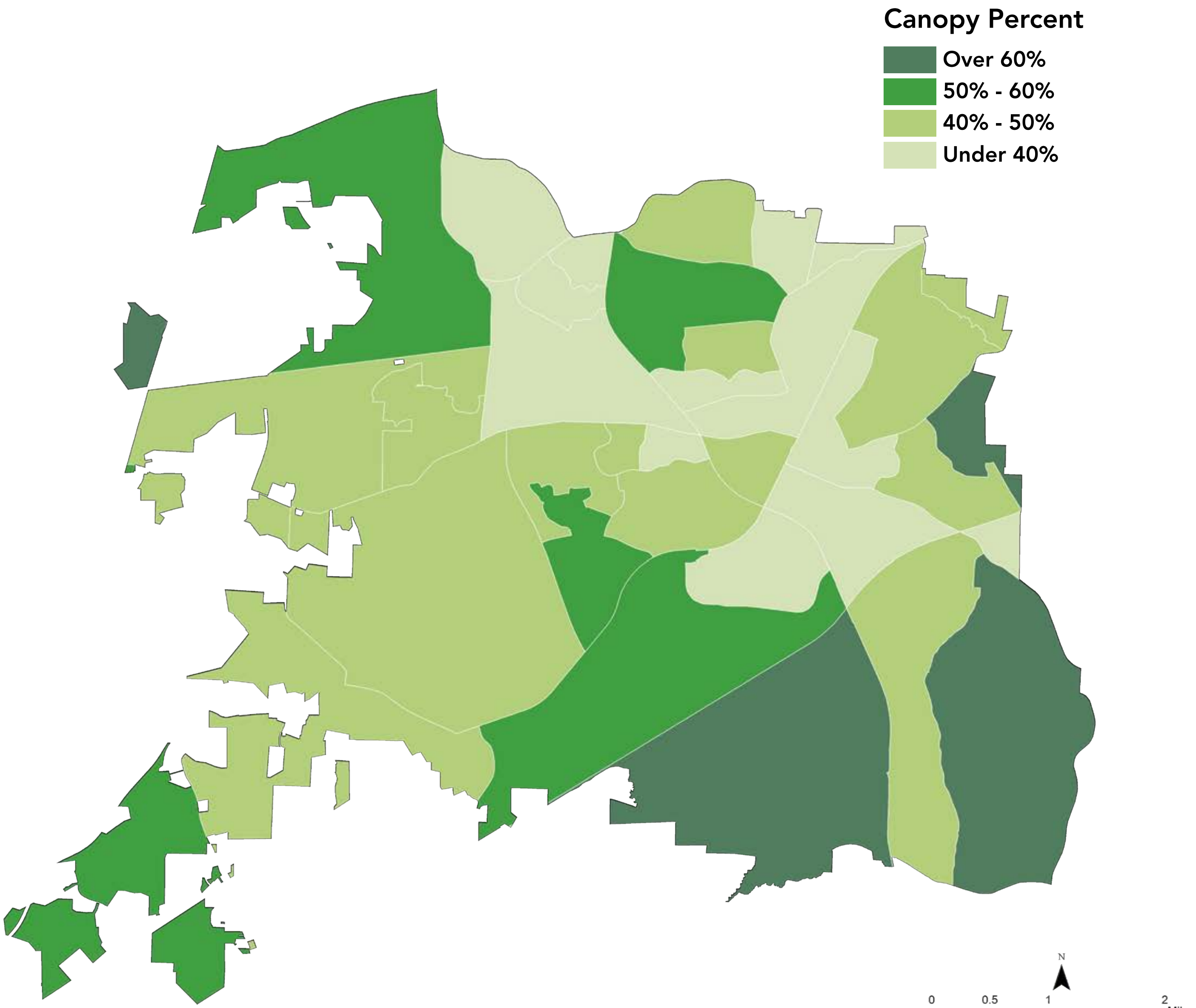
Canopy by Block Group

Map 2.3 and Map 2.4. focus on tree canopy at the block group (BG) level. As the smallest unit of analysis in the study, mapping at the BG level offers an illustration of the distribution of canopy percent and canopy change within the planning jurisdiction.

Block groups with higher percent canopy cover generally contain or overlap land area designated as ETJ or containing designated green space; BGs reporting lower canopy percents are often found to contain in-progress or recently completed development projects.

Map 2.3 visually demonstrates the correlation between population density and canopy cover. The physical size of the BG is directly related to population; the smaller the BG the more dense the resident population.

MAP 2.3 CANOPY COVER (2020) BY BLOCK GROUP



Canopy Change (2010-2020)

Summary

The Wake LCA/TCA project examined how tree canopy changed over the ten-year span from 2010 to 2020. The analysis utilized 2010 NAIP imagery to determine the historical baseline metrics for comparison.

Observations

From 2010-2020, a period marked by significant population growth and economic development, Apex lost approximately 2,200 acres of tree canopy — a 15.2% decline in the overall amount of canopy within the planning jurisdiction.

Canopy cover within the corporate limits declined by 13.6 percentage points, from 58.2% in 2010 to 44.6% as measured in 2020.

Vintage 2010 and 2020

It is important to keep in mind that this analysis is a snapshot of conditions existing in 2010 and 2020 and may not be representative of the current canopy percent within a given block group or other geographic area. To assess canopy change over time, the study performed a land cover analysis of the project area using 2010 NAIP imagery and then compared the resultant land cover data to the 2020 analysis.

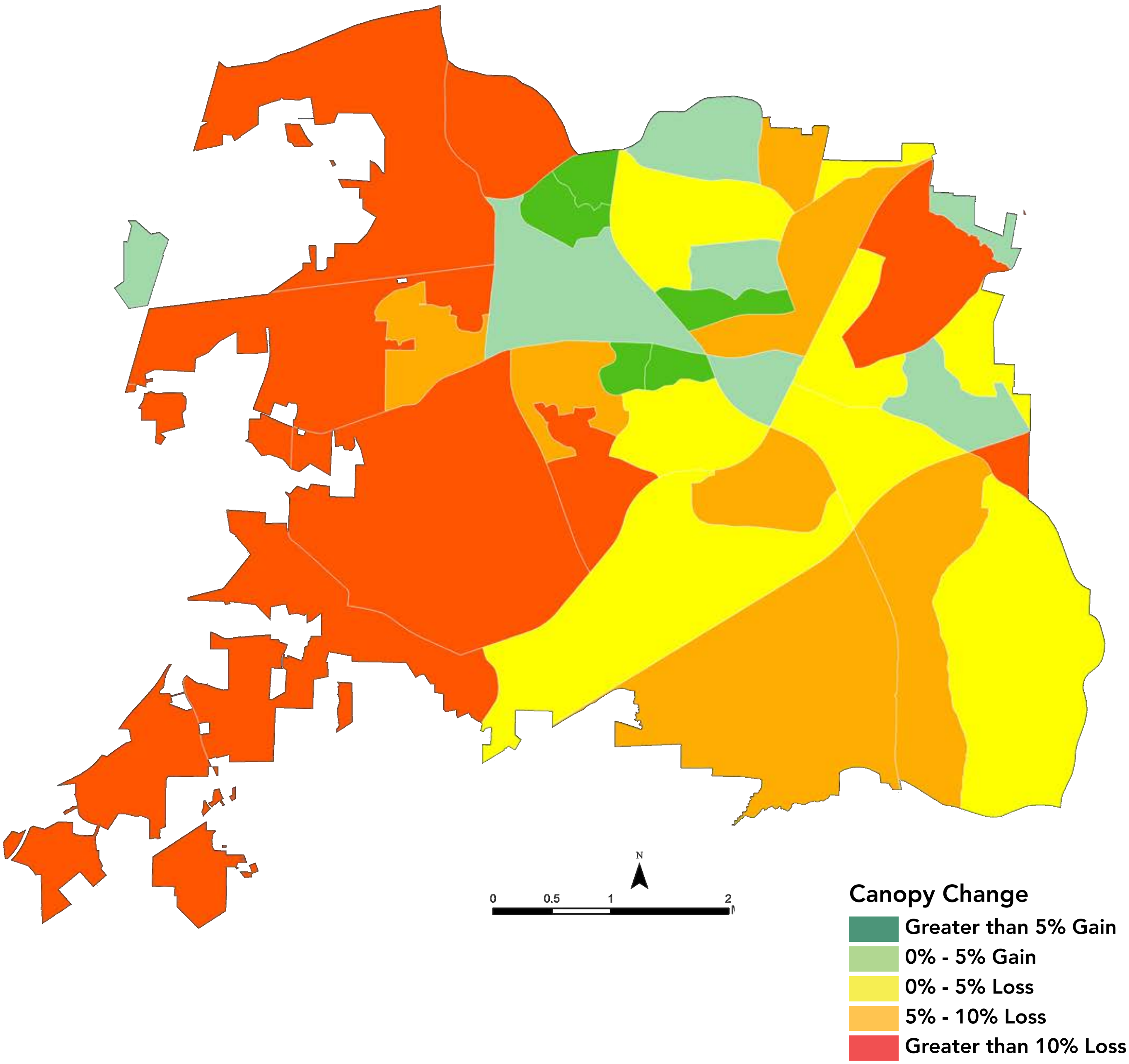
Canopy Change by Block Group

Map 2.4 provides an idea of the general location and percent of canopy change within the planning jurisdiction. Of the BGs located either entirely or partially within jurisdictional bounds, ten experienced a canopy decline in excess of 10%, primarily in western portions of the municipality.

TABLE 2.4 CANOPY PERCENT AND CANOPY CHANGE (2010-2020)

JURISDICTION	CANOPY ACRES 2020	CANOPY PERCENT 2020	CANOPY ACRES 2010	CANOPY PERCENT 2010	CANOPY CHANGE (Acres)	CANOPY CHANGE (Relative)	CANOPY CHANGE (Absolute)
Corporate Limits	7,232	44.6%	9,432	58.2%	-2,200	-23.3%	-13.6%
ETJ	4,967	62.2%	4,947	62.0%	20	0.4%	0.2%
Planning Jurisdiction	12,199	50.4%	14,379	59.4%	-2,180	-15.2%	-9.0%

MAP 2.4 CANOPY CHANGE (2010-2020) BY BLOCK GROUP



Apex Community Park

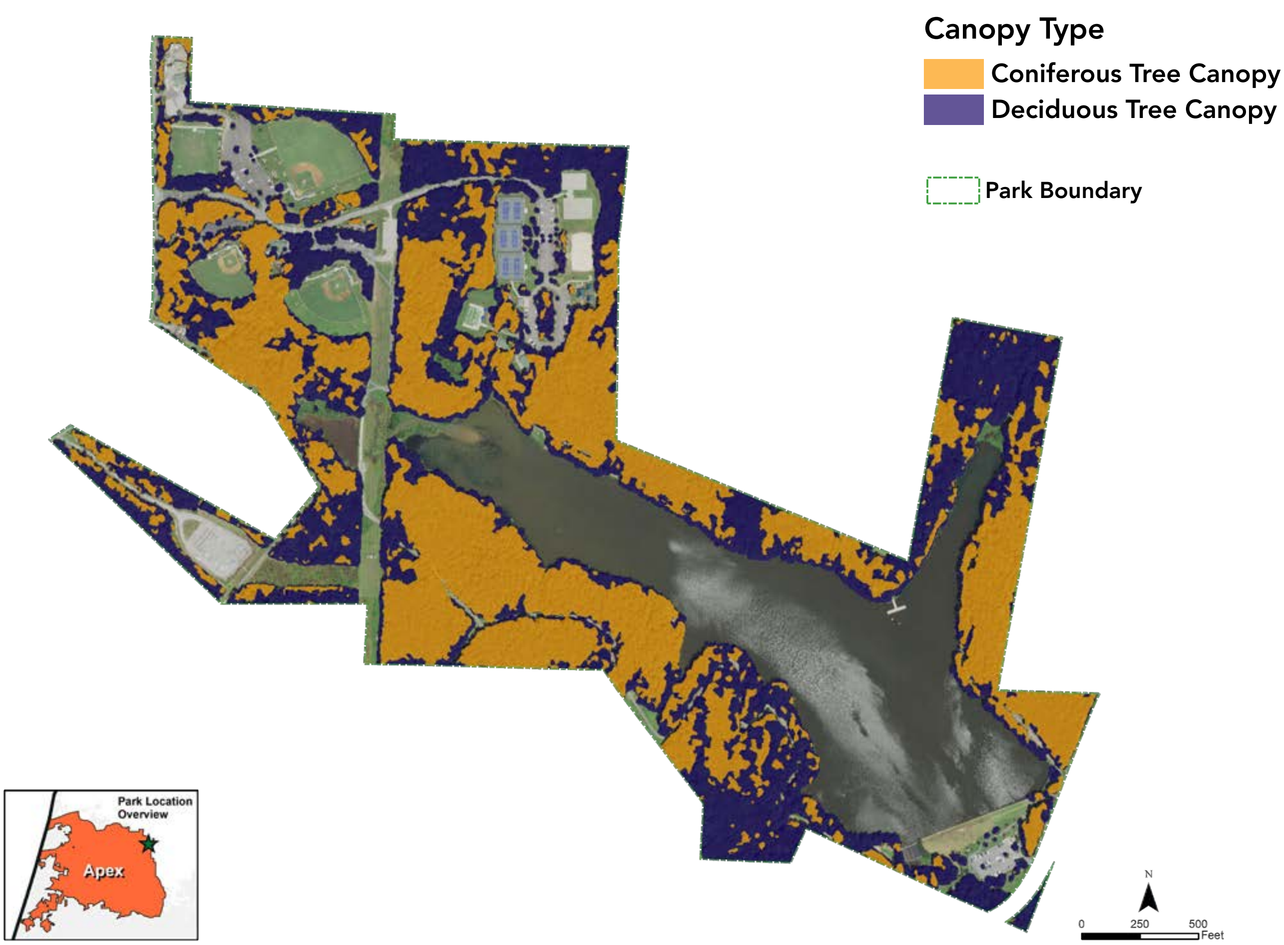
Land cover analysis is useful at the micro level (e.g., individual parks or parcels) as well as the macro (e.g., countywide). Canopy type and health mapping can be utilized to identify and investigate potential areas of concern or to help select locations for future park amenities.

Targeted ground-truthing of “hotspots” (concentrated areas of canopy in declining health) is an efficient and proactive step in maintaining and preserving community forest. Hotspots in and around high-occupancy public areas, such as greenways or playgrounds, are of particular interest when prioritizing field-checks.

Park Overview

Apex Community Park encompasses 164 acres and is a marquee park for the Town of Apex. One of the primary attractions is the park’s extensive trail system, which includes both paved and unpaved paths that wind through the park's scenic natural areas. Additional amenities include athletic fields, tennis, volleyball and basketball courts, picnic areas, playground, trails, greenways and a lake.

MAP 2.5 APEX COMMUNITY PARK: CANOPY TYPE (2020)



Canopy Cover

Approximately 57.7% of the park is covered by tree canopy.

Canopy Type

The park contains 94.6 canopy acres, of which 46% is deciduous and 54% is coniferous.

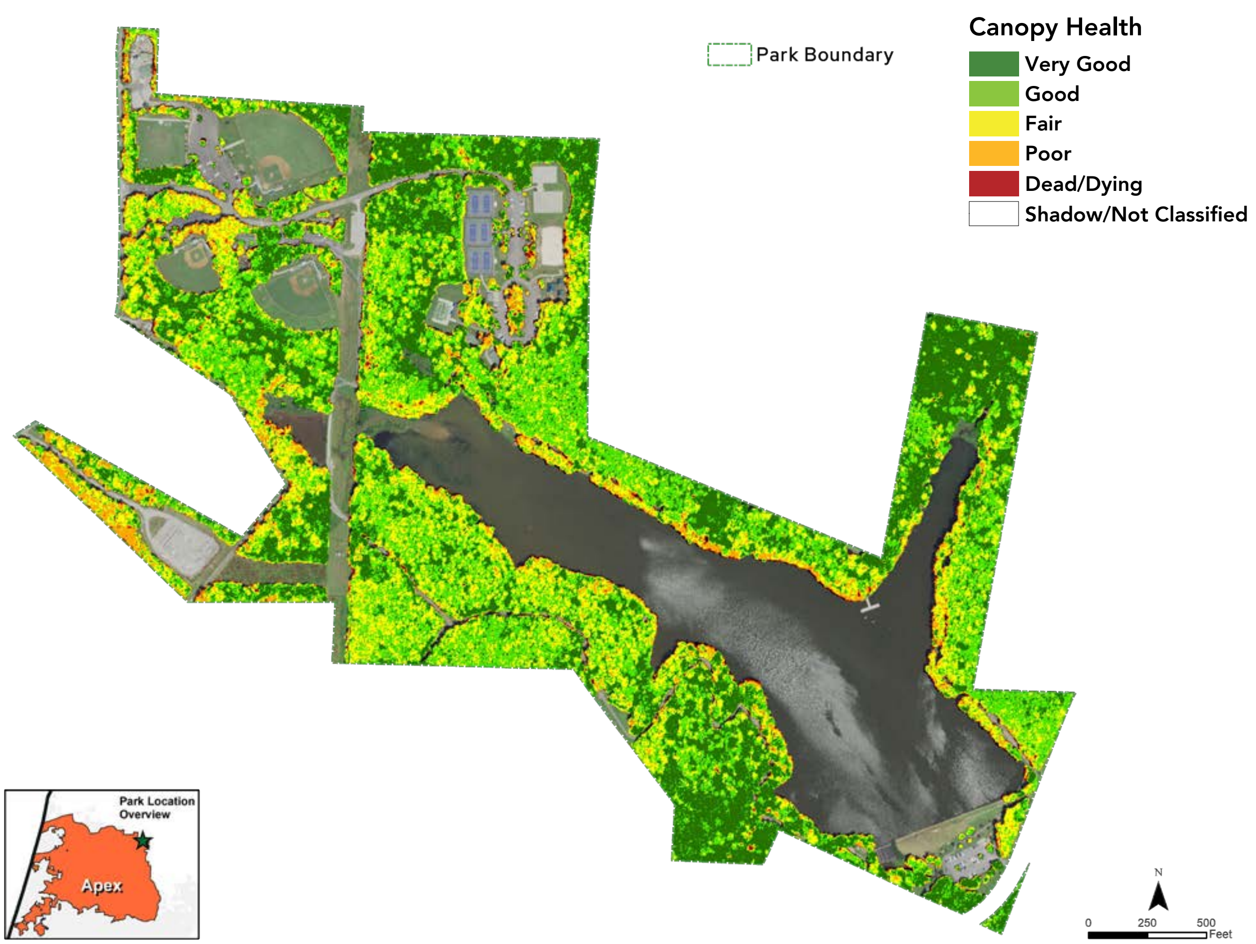
Canopy Health

The median health rating of deciduous canopy within Apex Community Park is Very Good while the median rating for coniferous canopy is Good.

TABLE 2.5 APEX COMMUNITY PARK: CANOPY TYPE AND HEALTH (2020)

CANOPY TYPE	TREE HEALTH RATING BY PERCENT OF CANOPY					
	VERY GOOD	GOOD	FAIR	POOR	CRITICAL	SHADOW
DECIDUOUS	50.1%	21.8%	14.5%	9.8%	2.7%	1.0%
CONIFEROUS	17.5%	45.3%	30.2%	4.0%	0.3%	0.1%

MAP 2.6 APEX COMMUNITY PARK: CANOPY HEALTH (2020)



Section Three

Planting Opportunities

In This Section:

Where Should Trees be Planted?

Land cover analysis helps identify opportunities to plant new trees and expand canopy cover to increase and more evenly distribute the benefits of trees. While vacant planting sites present opportunities to plant trees, not all open spaces are candidates for tree planting — examples include roads, sport and recreation areas and agricultural fields.

Ultimately, trees should be planted in sensible and suitable locations, after a thorough assessment of the site and desired outcomes for the planting.

The priority planting analysis sought to identify potential planting area, eliminate those areas most likely to be unfit for planting trees and then prioritize the remaining areas based on optimizing community benefits derived from tree canopy.

The analysis followed a three-step process:

Step 1. Identify realistic Potential Planting Area

» The results from the land cover analysis are used to identify potential planting areas.
» The potential planting area are then refined by filtering through an exclusionary layer of "no planting" areas.
» The result is a GIS polygon layer of realistic Potential Planting Area (PPA).

Step 2. Perform vulnerability assessments

» The PPA is individually assessed across three separate measures of community vulnerability: urban heat islands, stormwater and social equity.
» The three individual measures are combined into a single composite vulnerability index.

Step 3. Prioritize the PPAs

» The PPA is prioritized by the vulnerability index and assigned a priority rank on a five-category ordinal scale (Very High, High, Medium, Low, Very Low).
» The priority rank for each PPA corresponds to the contribution of tree canopy in mitigating the identified vulnerabilities.

Identifying Planting Areas

Potential Planting Area

The identification of potential tree planting locations follows from the land cover analysis. First, the Bare Soil and Vegetation land cover types are combined into a single dataset. The dataset is then refined by excluding areas deemed not suitable for planting trees.

The assessment identified 23,235 areas totaling 4,616 acres for planting.

The smallest areas identified were 200 square feet, approximately the size of a parking lot island.

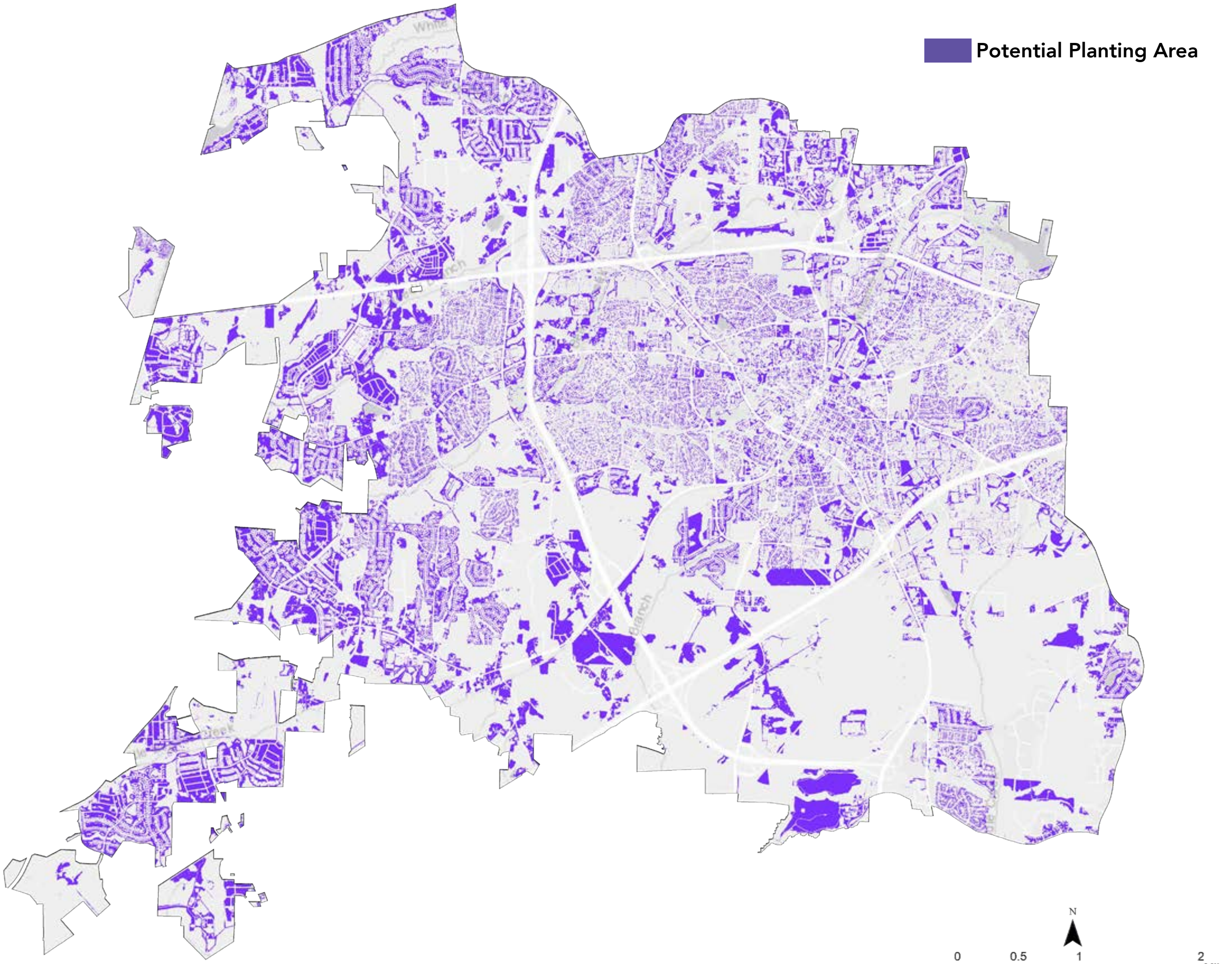
Vintage 2020

It is important to note that the analysis reflects planting areas as they were in 2020. Given the pace of development within Apex, some of the identified planting areas may no longer be suitable. For example, a tract of land under development in 2020 may have been classified as Bare Soil and therefore may be identified by this analysis as a PPA.

"No-Planting Areas"

- Sports fields (soccer, football, baseball, softball, etc.)
- Playgrounds
- Major utility corridors
- Golf courses
- Airports
- Wetland areas
- Substations
- Visible cropland
- Water treatment facilities
- Major Utility Easements
- Access Easements
- Parcels with agriculture, horticulture, or water/sewer system as current land use
- Rights-of-Way ("ROW")

MAP 3.1 POTENTIAL PLANTING AREA (2020)



Assessing Vulnerability

What is Vulnerability?

Vulnerability refers to the degree to which a system, community, or individual is susceptible to harm, damage, or negative impacts from an identified hazard. Vulnerability is influenced by various factors, such as socioeconomic status, physical and environmental conditions and access to resources and services.

Assessment

A vulnerability assessment is a process of identifying, analyzing and evaluating the vulnerabilities and risks of a system, community, or organization to potential hazards. The assessment informs decision-making and helps prioritize actions to reduce vulnerabilities and enhance resilience.

The Wake LCA/TCA project individually assessed three distinct measures of community vulnerability: urban heat islands, stormwater and social equity.

Urban Heat Islands

The urban heat island (UHI) effect refers to the phenomenon of urban areas being significantly warmer than surrounding rural areas. The sun heats impervious surfaces faster and to a higher temperature than land covered by tree canopy or vegetation. Impervious surface also takes longer to cool once the sun sets.

Areas with less tree canopy and more impervious surface are more susceptible to the UHI effect and residents within those areas are at greater risk of harm from the adverse impacts of the phenomenon.

Community Impacts

Health risks: Extreme heat increases the risk of heat-related illnesses, such as heat exhaustion and heatstroke, particularly for vulnerable populations such as the elderly, young children and those with pre-existing health conditions.

Reduced air quality: The UHI effect worsens air quality by increasing the concentration of air pollutants, such as ozone and particulate matter, which exacerbates respiratory diseases such as asthma.

Increased energy consumption: The demand for cooling can increase energy consumption, which can lead to higher greenhouse gas emissions.

Infrastructure damage: High temperatures can cause damage to infrastructure, particularly roads and buildings, due to thermal expansion and contraction.

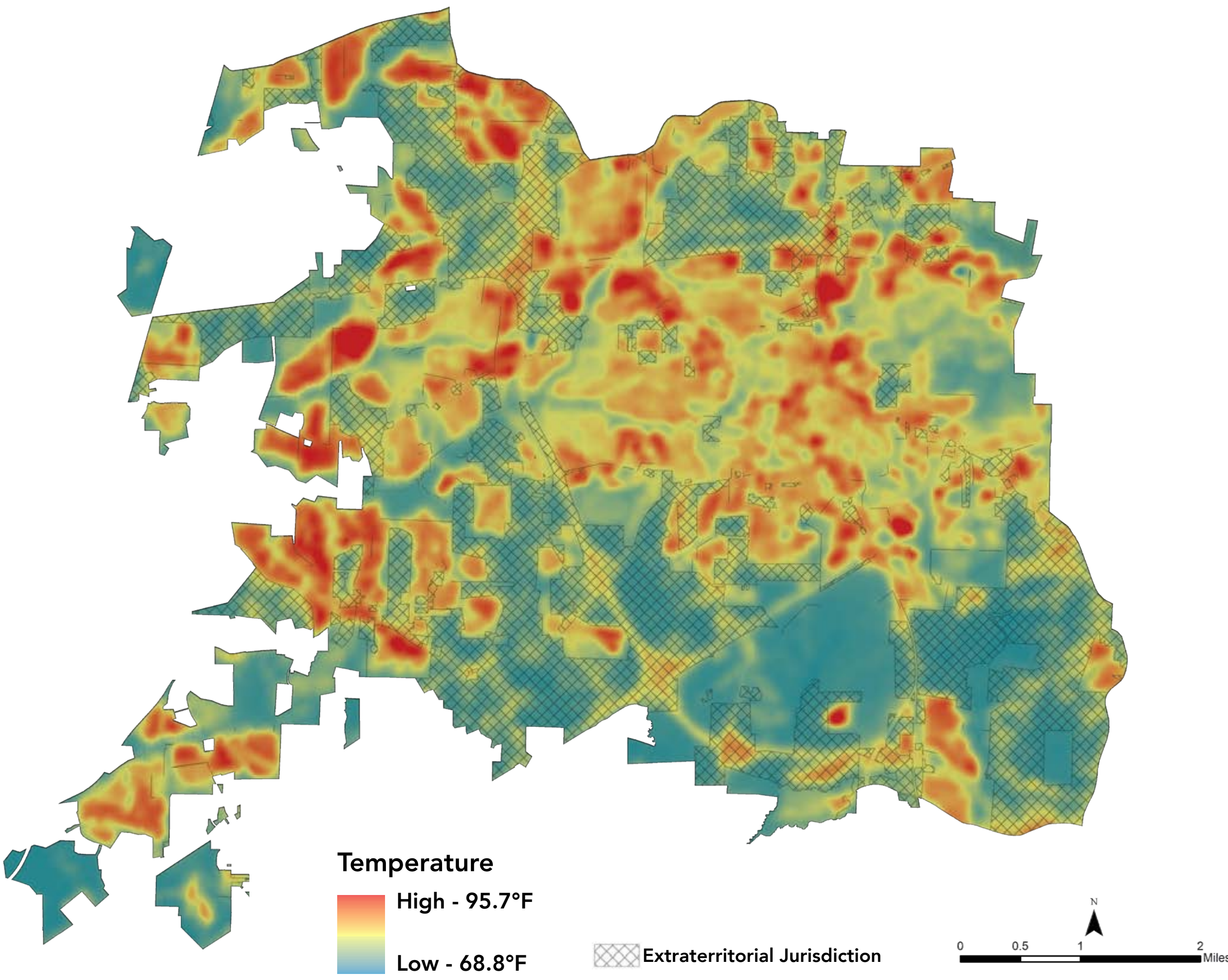
Measurement

A land surface temperature analysis identified urban heat islands within the planning jurisdiction.

Observations

The analysis visually demonstrates the UHI effect; the hottest areas align with areas of less canopy and more impervious surface. The map further shows that cooler areas are associated with areas of greater canopy coverage, many of which are located within the ETJ.

MAP 3.2 AVERAGE LAND SURFACE TEMPERATURE (2020-2022)



Stormwater

Rain that does not soak into the ground becomes runoff and carries soil, pollutants and other materials from the land into our rivers, lakes and bays. Areas with greater amounts of impervious surface relative to tree canopy generally have more pollution and less tree canopy.

The assessment identifies areas in greatest need of tree canopy to mitigate the impacts and consequences of stormwater runoff.

Community Impacts

Pollution: Stormwater runoff can carry pollutants such as oil, pesticides and fertilizers into rivers, lakes and oceans. This harms aquatic life and can make water unsafe for human use.

Soil erosion: Runoff can lead to streambank and shoreline instability, loss of habitat and decreased water quality.

Public health: Runoff can carry bacteria and other pathogens from animal waste, septic systems and other sources, leading to water supply contamination.

Flooding and infrastructure damage: Stormwater can cause damage to roads, bridges and other infrastructure, leading to costly repairs and maintenance.

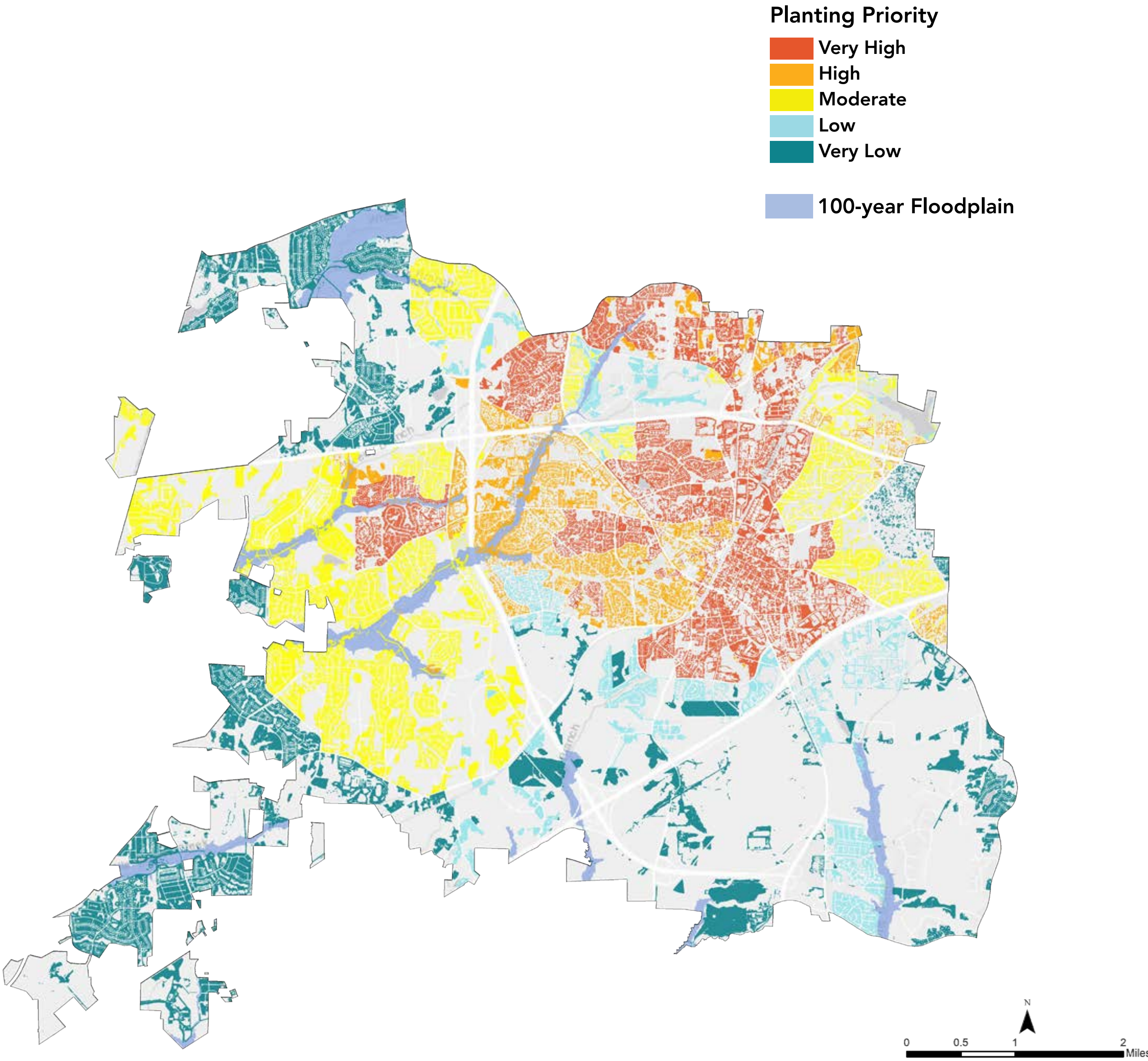
Measurement

Community vulnerability to the impacts of stormwater were measured by a multivariate analysis which measures of the following inputs: distance to hardscape, soil erosion, soil permeability, floodplain proximity, existing tree canopy and possible tree canopy.

Observations

PPAs rating Very High, High and Moderate are distributed throughout the town. Concentrations of Very High and High priority PPAs are clustered in areas with high population density and relatively high proportions of impervious surface, as compared to the bulk of the Low and Very Low PPAs. Significant concentrations of Very High and High priority PPAs are also seen in proximity to the 100-year floodplain (Map 3.3).

MAP 3.3 POTENTIAL PLANTING AREA (2020) PRIORITIZED BY STORMWATER VULNERABILITY INDEX



Social Equity

Social equity refers to the concept of fairness and justice in the distribution of resources and opportunities in a society, particularly as it relates to historically marginalized and disadvantaged groups. It recognizes that not all individuals or communities have equal access to the resources, opportunities and benefits that society has to offer and seeks to address these disparities through policy and practice.

The assessment identifies areas where tree canopy cover can be expanded to reduce vulnerability to the harmful impacts associated with social inequity.

Community Impacts

Health Risks: People in socially disadvantaged communities are more likely to experience poor health outcomes, including chronic diseases, mental health issues and shorter life expectancies.

Economic Disadvantages: Social inequity can limit access to education and job opportunities, which contributes to persistent poverty and income inequality.

Political Disengagement: People in socially disadvantaged communities are less likely to participate in political processes and civic engagement, leading to reduced representation and less investment, both public and private, in these communities.

Environmental Injustice: Social inequity leads to disproportionate impact from environmental hazards (e.g., pollution) and other forms of environmental degradation (e.g., development characterized by high population density and relatively high and low amounts of impervious surfaces and tree canopy, respectively).

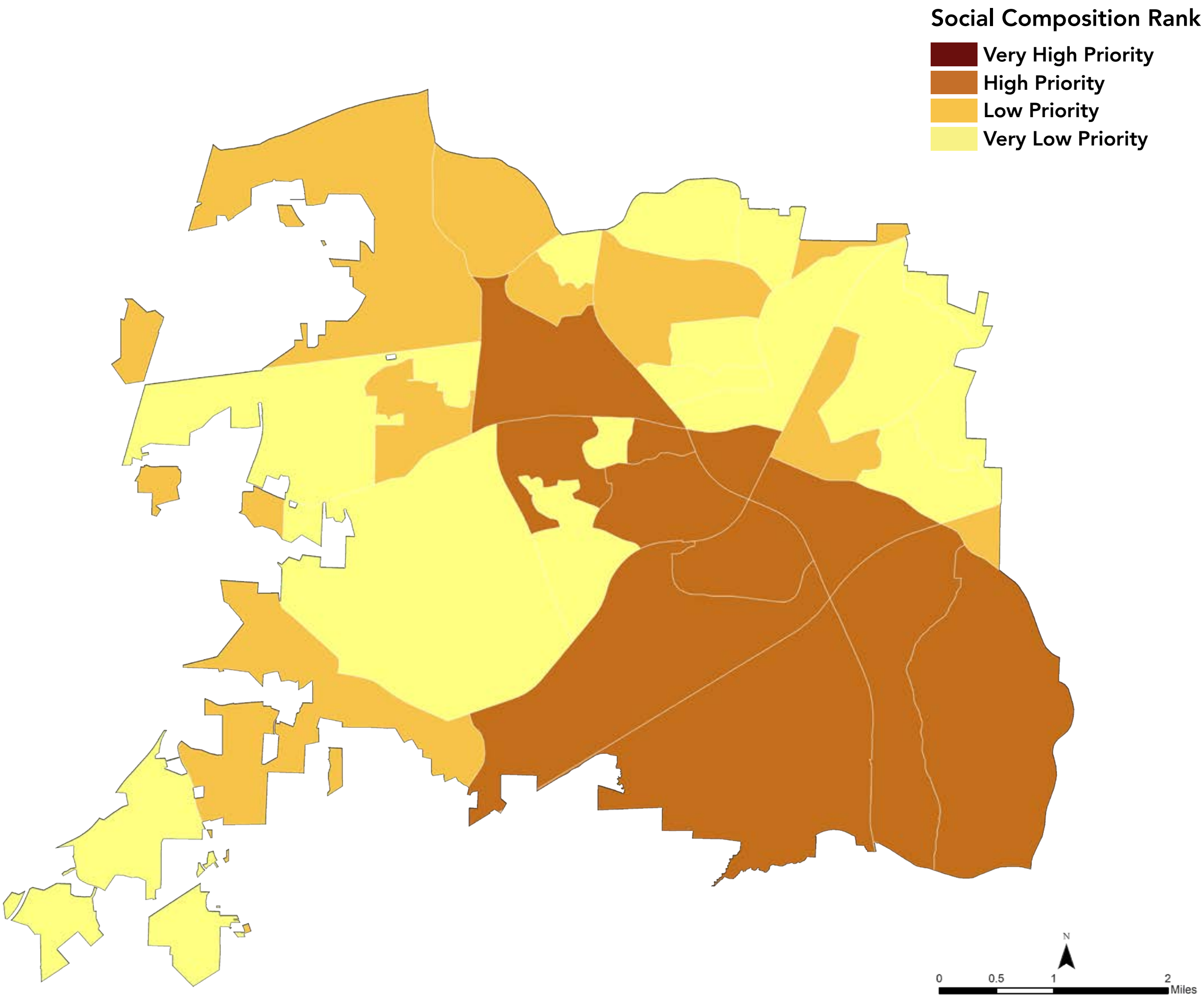
Measurement

A social equity prioritization index was generated by incorporating socioeconomic and demographic data from Wake County's Social Equity Atlas and health data from the CDC PLACES study. Areas scoring higher on the social equity index are in greater need of the environmental and socioeconomic benefits that trees can provide.

Observations

Map 3.4. illustrates the social equity index score distribution by Block Group within the Apex planning jurisdiction. The highest priority BGs are clustered in the southeastern portion of the planning jurisdiction. Higher priority BGs are where new tree plantings would make the most impact in mitigating the negative consequences of social inequity.

MAP 3.4 DISTRIBUTION OF SOCIAL EQUITY INDEX BY BLOCK GROUP



Prioritizing Planting Areas

Composite Vulnerability Index

Summary

The planting analysis ultimately prioritized the identified PPAs using a composite vulnerability index that combined ten measures of community vulnerability (Table 3.1). Each individual planting area was assigned a priority rank from Very High to Very Low. (Table 3.2).

The index is a tool for prioritizing potential planting opportunities according to where the growth and expansion of tree canopy will make the greatest contribution to mitigating vulnerability and boosting community resilience.

Observations

A total of 292 acres of land area across 3,917 individual planting areas rated as Very High priority. An additional 494 acres across 5,461 individual PPAs rated as High priority.

The greatest concentration of Very High and High priority PPAs are observed east of I-540 and south of U.S. 64 (Map 3.4).

Vintage 2020

It is important to reiterate that this analysis utilized 2020 NAIP imagery as the foundation for identifying PPAs. Some of the identified planting areas may no longer be suitable for planting. This tool should be used as a first pass at coordinating and prioritizing canopy replacement and restoration efforts.

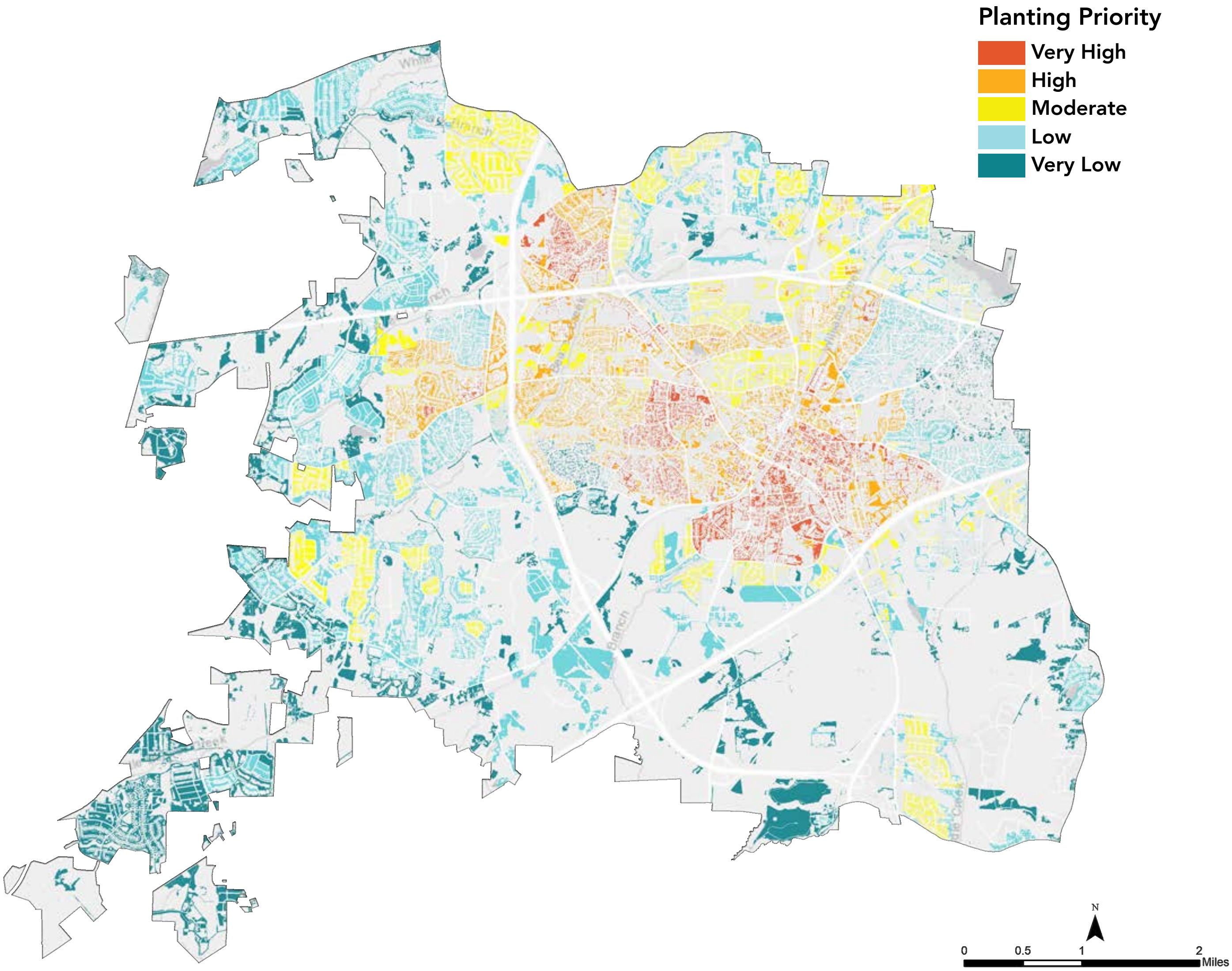
TABLE 3.1 COMPOSITE VULNERABILITY INDEX INPUT CRITERIA

COMPOSITE INDEX CRITERIA
Tree Canopy Percent
Possible Canopy Percent
Heat Islands
Social Equity Index: Score 300+ vulnerability
Mental Health
Air Quality
Stormwater
Asthma Prevalence
Soil Erosion
FEMA Floodplain

TABLE 3.2 POTENTIAL PLANTING AREA (2020) PRIORITIZED BY COMPOSITE VULNERABILITY INDEX

PRIORITY	PLANTING AREAS	TOTAL ACREAGE
Very High	3,917	292
High	5,461	494
Moderate	4,005	688
Low	6,685	1,719
Very Low	3,167	1,423

MAP 3.5 POTENTIAL PLANTING AREA (2020) PRIORITIZED BY COMPOSITE VULNERABILITY INDEX



Tree Placement Modeling

Summary

Building from the planting area analysis, a GIS-based tree placement model utilized an algorithm to determine how many trees could potentially fit within each of the identified PPAs. The model differentiates between tree size at maturity (large, medium and small), giving preference to larger canopy trees while utilizing spacing commonly suggested for a landscape setting (Table 3.3)

The tree placement model found 229,001 individual planting sites throughout the planning jurisdiction:

- » 54.8% are suitable for large-growing trees (125,581 sites).
- » 12.0% are suitable for medium-growing trees (27,568 sites).
- » 33.2% are suitable for small-growing trees (75,852 sites).

When prioritized by the Composite Vulnerability Index, the model ranked 18,914 sites as Very High and 30,697 sites as High (8.3% and 13.4% of all sites, respectively).

Targeted Planting

To demonstrate the utility of the tree placement analysis, we took a closer look at one of Apex's Green Spaces: Seymour Athletic Fields (Map 3.5).

Within the park, the highest priority planting sites are clustered around the buildings and parking lots (i.e., impervious surfaces).

Table 3.3 Tree Placement Model: Crown Size & Spacing Parameters. A total of 58 Moderate priority tree locations were identified, including 26 sites deemed suitable for a large-maturing shade tree.

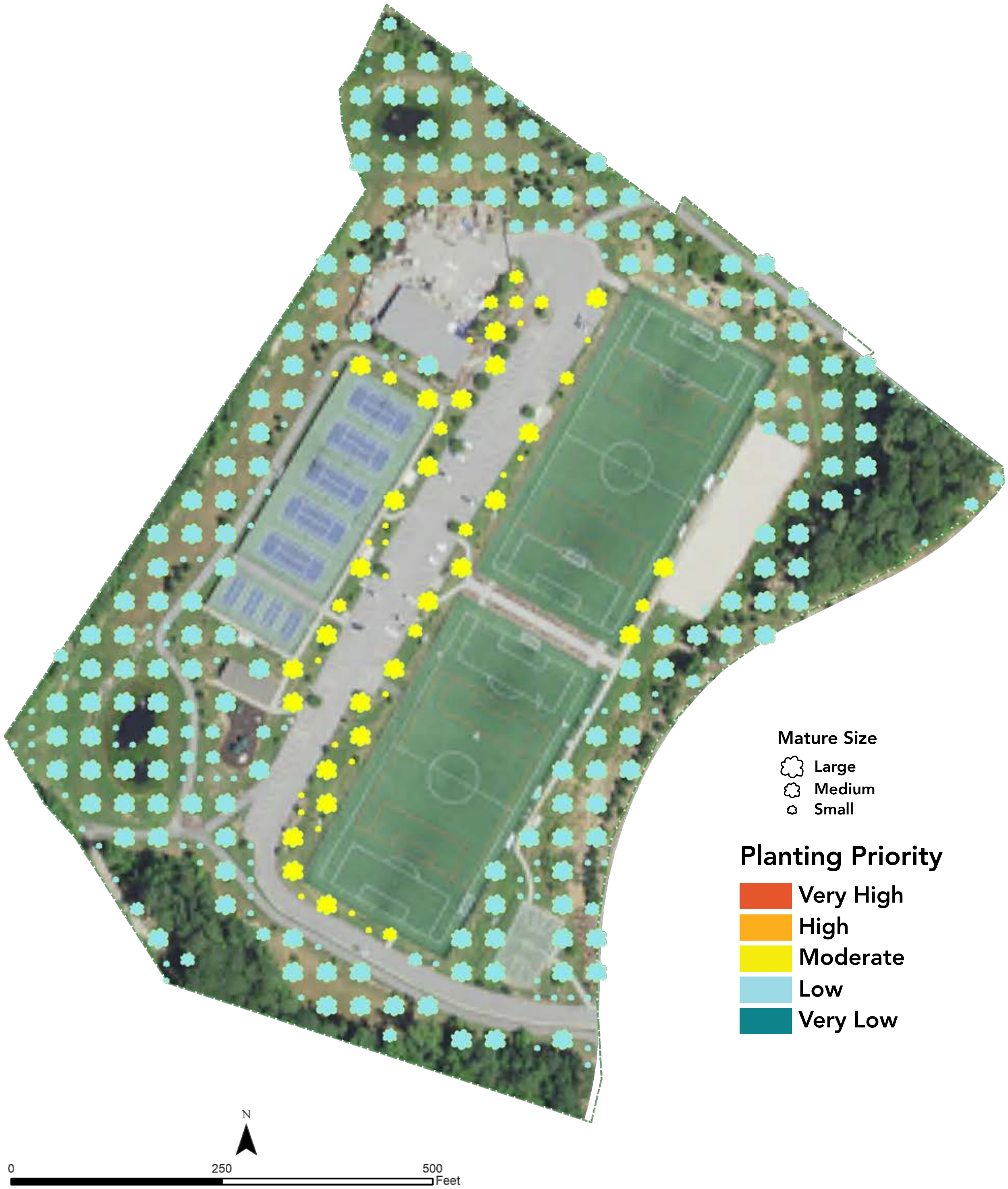
TABLE 3.3 TREE PLACEMENT MODEL CROWN SIZE & SPACING PARAMETERS

Tree Placement Model Tree Spacing		
Planting Site Size	**Mature Crown Diameter**	**No Other Trees Placed Within:**
Small	20 Feet	10 Feet
Medium	30 Feet	15 Feet
Large	40 Feet	20 Feet

TABLE 3.4 SEYMOUR ATHLETIC FIELDS: PRIORITY TREE PLANTING SITES (2020)

MATURE CROWN SIZE	PLACEMENT SITE PRIORITY		
	MODERATE	LOW	TOTAL
Small	20	98	118
Medium	12	22	34
Large	26	160	186
Total	58	280	338

MAP 3.6 SEYMOUR ATHLETIC FIELDS: PRIORITIZED TREE PLACEMENT MODELING (2020)



Methodology

Land cover analyses are crucial for understanding the distribution and composition of different land cover types. The following methodology outlines the steps taken to conduct a land cover assessment for a tree canopy assessment:

1. Project Study Area Description:

   The Wake LCA/TCA project study area consisted of the entirety of land area within the county limits. Additionally, the project included the entire planning jurisdiction for each of the county's twelve core municipalities, including jurisdictional land areas that extend beyond county limits. Within the defined boundary there are several parks and open spaces, watersheds, agricultural, industrial and residential areas.

2. Data Collection:

   The data collection process involved the use of high-resolution aerial imagery provided by the U.S. Department of Agriculture's National Agriculture Imagery Program (NAIP).The one-meter resolution imagery was captured in the Spring, when trees are in full leaf. The imagery was processed using photogrammetric techniques to generate a high-resolution orthophoto, which was used to identify tree canopy cover.

3. Image Analysis:

   The image analysis was conducted using a combination of manual and automated methods. The manual analysis involved visual interpretation of the orthophoto to identify individual trees and their canopy cover. The automated analysis involved the use of computer algorithms to extract information on the tree canopy cover from the orthophoto.

4. Data Analysis:

   The final dataset was used to generate several maps of the canopy cover for the municipality which illustrate a wide range of useful data including land cover types, canopy percentage, canopy health and land use types. The tree canopy cover was calculated as the percentage of the municipality covered by the crowns of the trees.

5. Interpretation and Reporting:

   The results were reported using maps, figures and tables, to facilitate understanding by the public, stakeholders and decision-makers.

Land Cover Analysis

Classification Methodology

Davey Resource Group utilized an object-based image analysis (OBIA) semi-automated feature extraction method to process and analyze current high-resolution color infrared (CIR) aerial imagery and remotely sensed data to identify tree canopy cover and land cover classifications. The use of imagery analysis is cost-effective and provides a highly accurate approach to assessing your community's existing tree canopy coverage. This supports responsible tree management, facilitates community forestry goal setting and improves urban resource planning for healthier and more sustainable urban environments.

Advanced image analysis methods were used to classify, or separate, the land cover layers from the overall imagery. The semi-automated extraction process was completed using Feature Analyst, an extension of ArcGIS®. Feature Analyst uses an object-oriented approach to cluster together objects with similar spectral (i.e., color) and spatial/contextual (e.g., texture, size, shape, pattern and spatial association) characteristics. The land cover results of the extraction process were post-processed and clipped to each project boundary prior to the manual editing process to create smaller, manageable and more efficient file sizes. Secondary source data, high-resolution aerial imagery provided by Wake County iMAPS and custom ArcGIS® tools were used to aid in the final manual editing, quality checking and quality assurance processes (QA/QC). The manual QA/QC process was implemented to identify, define and correct any misclassifications or omission errors in the final land cover layer.

Classification Workflow

1. Prepare imagery for feature extraction (resampling, rectification, etc.), if needed.
2. Gather training set data for all desired land cover classes (canopy, impervious, grass, bare soil, shadows).
3. Extract canopy layer only; this decreases the amount of shadow removal from large tree canopy shadows. Fill small holes and smooth to remove rigid edges.
4. Edit and finalize canopy layer at 1:2000 scale. A point file is created to digitize-in small individual trees that will be missed during the extraction. These points are buffered to represent the tree canopy. This process is done to speed up editing time and improve accuracy by including smaller individual trees.
5. Extract remaining land cover classes using the canopy layer as a mask; this keeps canopy shadows that occur within groups of canopy while decreasing the amount of shadow along edges.
6. Edit the impervious layer to reflect actual impervious features, such as roads, buildings, parking lots, etc. to update features.
7. Using canopy and actual impervious surfaces as a mask; input the bare soils training data and extract them from the imagery. Quickly edit the layer to remove or add any features. Davey Resource Group tries to delete dry vegetation areas that are associated with lawns, grass/meadows and agricultural fields.
8. Assemble any hydrological datasets, if provided. Add or remove any water features to create the hydrology class. Perform a feature extraction if no water feature datasets exist.
9. Use geoprocessing tools to clean, repair and clip all edited land cover layers to remove any self-intersections or topology errors that sometimes occur during editing.
10. Input canopy, impervious, bare soil and hydrology layers into Davey Resource Group's Five-Class Land Cover Model to complete the classification. This model generates the pervious (grass/low-lying vegetation) class by taking all other areas not previously classified and combining them.
11. Thoroughly inspect final land cover dataset for any classification errors and correct as needed.
12. Perform accuracy assessment. Repeat Step 11, if needed.

Automated Feature Extraction Files

The automated feature extraction (AFE) files allow other users to run the extraction process by replicating the methodology. Since Feature Analyst does not contain all geoprocessing operations that Davey Resource Group utilizes, the AFE only accounts for part of the extraction process. Using Feature Analyst, Davey Resource Group created the training set data, ran the extraction and then smoothed the features to alleviate the blocky appearance. To complete the actual extraction process, Davey Resource Group uses additional geoprocessing tools within ArcGIS®. From the AFE file results, the following steps are taken to prepare the extracted data for manual editing.

1. Davey Resource Group fills all holes in the canopy that are less than 30 square meters. This eliminates small gaps that were created during the extraction process while still allowing for natural canopy gaps.
2. Davey Resource Group deletes all features that are less than 9 square meters for canopy (50 square meters for impervious surfaces). This process reduces the number of small features that could result in incorrect classifications and also helps computer performance.
3. The Repair Geometry, Dissolve and Multipart to Singlepart (in that order) geoprocessing tools are run to complete the extraction process.
4. The Multipart to Singlepart shapefile is given to GIS personnel for manual editing to add, remove, or reshape features.

Accuracy Assessment Protocol

Determining the accuracy of spatial data is of high importance to Davey Resource Group and our clients. To achieve the best possible result, Davey Resource Group manually edited and conducted thorough QA/QC checks on all urban tree canopy and land cover layers. A QA/QC process was completed using ArcGIS® to identify, clean and correct any misclassification or topology errors in the final land cover dataset. The initial land cover layer extractions were edited at a 1:2000 quality control scale in the urban areas and at a 1:2500 scale for rural areas utilizing the most current high-resolution aerial imagery to aid in the quality control process.

To test for accuracy, random plot locations were generated throughout the area of interest and verified to ensure that the data meet the client standards. Each point was compared with the most current NAIP high-resolution imagery (reference image) to determine the accuracy of the final land cover layer. Points were classified as either correct or incorrect and recorded in a classification matrix. Accuracy was assessed using four metrics: overall accuracy, kappa, quantity disagreement and allocation disagreement. These metrics were calculated using a custom Excel® spreadsheet.

TABLE 1. LAND COVER CLASSIFICATION CODE VALUES

LAND COVER CLASSIFICATION	CODE VALUE
Tree Canopy	1
Impervious	2
Pervious (Grass/Vegetation)	3
Bare Soil	4
Open Water	5

Land Cover Accuracy

The following describes Davey Resource Group's accuracy assessment techniques and outlines procedural steps used to conduct the assessment.

1. **Random Point Generation –** Using ArcGIS, 1,000 random assessment points are generated.
2. **Point Determination –** Each point is carefully assessed by the GIS analyst for likeness with aerial photography. To record findings, two new fields, CODE and TRUTH, are added to the accuracy assessment point shapefile. CODE is a numeric value (1–5) assigned to each land cover class (Table 1) and TRUTH is the actual land cover class as identified according to the reference image. If CODE and TRUTH are the same, then the point is counted as a correct classification. Likewise, if the CODE and TRUTH are not the same, then the point is classified as incorrect. In most cases, distinguishing if a point is correct or incorrect is straightforward. Points will rarely be misclassified by an egregious classification or editing error. Often incorrect points occur where one feature stops and the other begins.
3. **Classification Matrix –** During the accuracy assessment, if a point is considered incorrect, it is given the correct classification in the TRUTH column. Points are first assessed on the NAIP imagery for their correctness using a "blind" assessment – meaning that the analyst does not know the actual classification (the GIS analyst is strictly going off the NAIP imagery to determine cover class). Any incorrect classifications found during the "blind" assessment are scrutinized further using sub-meter imagery provided by the client to determine if the point was incorrectly classified due to the fuzziness of the NAIP imagery or an actual misclassification. After all random points are assessed and recorded; a classification (or confusion) matrix is created. The classification matrix for this project is presented in Table 2. The table allows for assessment of user's/producer's accuracy, overall accuracy, omission/commission errors, kappa statistics, allocation/quantity disagreement and confidence intervals (Figure 1 and Table 3).

TABLE 2. CLASSIFICATION MATRIX

REFERENCE DATA

CLASSES	TREE CANOPY	IMPERVIOUS SURFACES	GRASS & LOW-LYING VEGETATION	BARE SOILS	OPEN WATER	ROW TOTAL	PRODUCER'S ACCURACY	ERRORS OF OMISSION
Tree Canopy	521	3	14	1	0	539	96.66%	3.34%
Impervious	3	151	6	1	0	161	93.79%	6.21%
Grass/ Vegetation	11	1	207	1	0	220	94.09%	5.91%
Bare Soils	1	0	6	36	0	43	83.72%	16.28%
Water	0	0	0	0	37	37	100.00%	0.00%
Column Total	536	155	233	39	37	1,000		
User's Accuracy	97.20%	97.42%	88.84%	92.31%	100.00%		Overall Accuracy	95.20%
Errors of Commission	2.80%	2.58%	11.16%	7.69%	0.00%		Kappa Coefficient	0.9240

The following are descriptions of each statistic as well as the results from some of the accuracy assessment tests.

4. **Overall Accuracy –** Percentage of correctly classified pixels; for example, the sum of the diagonals divided by the total points ((521+151+207+36+37)/1,000 = 95.20%).
5. **User's Accuracy –** Probability that a pixel classified on the map actually represents that category on the ground (correct land cover classifications divided by the column total ([521/536= 97.20%]).
6. **Producer's Accuracy –** Probability of a reference pixel being correctly classified (correct land cover classifications divided by the row total ([521/539 = 96.66%]).
7. **Kappa Coefficient –** A statistical metric used to assess the accuracy of classification data. It has been generally accepted as a better determinant of accuracy partly because it accounts for random chance agreement. A value of 0.80 or greater is regarded as "very good" agreement between the land cover classification and reference image.
8. **Errors of Commission –** A pixel reports the presence of a feature (such as trees) that, in reality, is absent (no trees are actually present). This is termed as a false positive. In the matrix below, we can determine that 2.8% of the area classified as canopy is most likely not canopy.
9. **Errors of Omission –** A pixel reports the absence of a feature (such as trees) when, in reality, they are actually there. In the matrix below, we can conclude that 3.34% of all canopy classified is actually classified as another land cover class.
10. **Allocation Disagreement –** The amount of difference between the reference image and the classified land cover map that is due to less than optimal match in the spatial allocation (or position) of the classes.
11. **Quantity Disagreement –** The amount of difference between the reference image and the classified land cover map that is due to less than perfect match in the proportions (or area) of the classes.
12. **Confidence Intervals –** A confidence interval is a type of a population parameter and is used to indicate the reliability of an estimate. Confidence intervals consist of a range of values (interval) that act as good estimates of the unknown population parameter based on the observed probability of successes and failures. Since all assessments have innate error, defining a lower and upper bound estimate is essential.

CONFIDENCE INTERVALS

CLASS	ACREAGE	PERCENTAGE	LOWER BOUND	UPPER BOUND
Tree Canopy	298,110.0	54.1%	54.1%	54.2%
Impervious Surfaces	82,191.6	14.9%	14.9%	15.0%
Grass & Low-Lying Vegetation	128,567.1	23.4%	23.3%	23.4%
Bare Soils	22,864.8	4.2%	4.1%	4.2%
Open Water	18,796.9	3.4%	3.4%	3.4%
Total	550,530.4	100.00%		

STATISTICAL METRICS SUMMARY

Overall Accuracy =	95.20%
Kappa Coefficient =	0.9240
Allocation Disagreement =	4%
Quantity Disagreement =	1%

ACCURACY ASSESSMENT

CLASS	USER'S ACCURACY	LOWER BOUND	UPPER BOUND	PRODUCER'S ACCURACY	LOWER BOUND	UPPER BOUND
Tree Canopy	97.2%	96.5%	97.9%	96.7%	95.9%	97.4%
Impervious Surfaces	97.4%	96.1%	98.7%	93.8%	91.9%	95.7%
Grass & Low-Lying Vegetation	88.8%	86.8%	90.9%	94.1%	92.5%	95.7%
Bare Soils	92.3%	88.0%	96.6%	83.7%	78.1%	89.4%
Open Water	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Canopy Type

A separate geospatial analysis was done to identify and classify all the forests within Wake County as either coniferous or deciduous forests. A supervised classification method was used to classify, or separate coniferous forests from deciduous forests. This semi-automated classification was done in ArcMap using the Feature Analyst extension and a 2021-high resolution leaf off imagery provided by Wake County. The leaf off imagery used for the analysis was a high-resolution imagery with a spatial resolution of 0.5 feet. The imagery was later resampled to 3.2808 feet (1-meter) to allow for easy processing in ArcMap.

Advanced image interpretation methods were used by a GIS Analyst to take training set data samples from areas of the leaf off imagery that were considered as conifers. Conifers are easy to distinguish from deciduous forests in a leaf off imagery due to their distinct dark green color. The deciduous forests on the other hand have light to deep gray hues. The Feature analyst software was then used to extract the coniferous forests and finally edited by GIS Technicians.

Prior to editing the extracted coniferous forests, the conifer layers were clipped to the overall canopy layer (Which includes both conifer and deciduous forests) to stamp out all the areas that are grass but misclassified as tree canopy due to their spectral similarities. This process is done to speed up editing time, improve accuracy and enable the inclusion of smaller individual trees in the final canopy layer.

Canopy Health

Methodology

Canopy health can be determined using near-infrared imagery and Normalized Difference Vegetation Index (NDVI) transformation. The NDVI is used to find the health of the tree canopy and to locate areas of stress in the tree's foliage. This is used by cities to assess the health of their trees and to locate areas of canopy stress in order to find problem areas. This allows identification of where plants are in very good condition and where they are in decline.

This data set should be considered as a relative health of trees compared to the surrounding trees. Some tree species have different reflectance in multispectral imagery so they could show slightly less healthy. As a part of our process, the separation of deciduous and coniferous trees is necessary due to the spectral differences. If this process was not used, most of the health data would show coniferous trees in a dead, dying, or poor health state, which would not be the case.

Process

The NAIP imagery, collected for the landcover analysis and gathered from the United States Department of Agriculture (USDA), was used to create an NDVI by utilizing the red band (Red) from the natural color image and the near infrared band (NIR) from the colored infrared image. These bands were then extracted from their images and the following equation was run.

$$\text{NDVI} = \frac{(\text{NIR} - \text{Red})}{(\text{NIR} + \text{Red})}$$

This returned a raster that ranges from -1 to 1, with values close to -1 being non-vegetated areas and values close to 1 are healthy vegetation. This raster was then clipped to the canopy layer derived from the landcover layer. In the case of Wake County, the NDVI was clipped to the deciduous and coniferous canopy layers, resulting in two NDVI layers.

These layers were classified into 6 classes using the natural breaks (jenks) classification methods, which is the minimization of each class's standard deviation from the class mean, while maximizing deviation from the other classes. The layers were reclassified using these 6 classes into the ranks of the tree health analysis. Below is the breakdown of the NDVI values in each health rank for both the coniferous and deciduous canopy.

DECIDUOUS CANOPY HEALTH	
NDVI Value	Health Rank
-1 - -0.105	Not Classified
-0.105 – 0.098	Dead/Dying
0.098 – 0.223	Poor
0.223 – 0.309	Fair
0.309 – 0.396	Good
0.396 - 1	Very Good

CONIFEROUS CANOPY HEALTH	
NDVI Value	Health Rank
-1 - -0.176	Not Classified
-0.176 – 0.035	Dead/Dying
0.035 – 0.168	Poor
0.168 – 0.255	Fair
0.255 – 0.349	Good
0.349 - 1	Very Good

How are Tree Canopy Benefits Are Calculated?

Air Quality

The i-Tree Canopy v7.1 Model was used to quantify the value of ecosystem services for air quality. i-Tree Canopy was designed to give users the ability to estimate tree canopy and other land cover types within any selected geography. The model used the estimated canopy percentage and reports air pollutant removal rates and monetary values for carbon monoxide (CO), nitrogen dioxide (NO_2), ozone (O_3), sulfur dioxide (SO_2) and particulate matter (PM) (Hirabayashi 2014).

Within the i-Tree Canopy application, the U.S. EPA's BenMAP Model estimates the incidence of adverse health effects and monetary values resulting from changes in air pollutants (Hirabayashi 2014; US EPA 2012). Different pollutant removal values were used for urban and rural areas. In i-Tree Canopy, the air pollutant amount annually removed by trees and the associated monetary value can be calculated with tree cover in areas of interest using BenMAP multipliers for each county in the United States.

To calculate ecosystem services for the study area, canopy percentage metrics from UTC land cover data performed during the assessment were transferred to i-Tree Canopy. Those canopy percentages were matched by placing random points within the i-Tree Canopy application. Benefit values were reported for each of the five listed air pollutants.

Carbon Storage and Sequestration

The i-Tree Canopy v7.1 Model was used to quantify the value of ecosystem services for carbon storage and sequestration. i-Tree Canopy was designed to give users the ability to estimate tree canopy and other land cover types within any selected geography. The model uses the estimated canopy percentage and reports carbon storage and sequestration rates and monetary values. Methods on deriving storage and sequestration can be found in Nowak et al. 2013.

To calculate ecosystem services for the study area, canopy percentage metrics from UTC land cover data performed during the assessment were transferred to i-Tree Canopy. Those canopy percentages were matched by placing random points within the i-Tree Canopy application. Benefit values were reported for carbon storage and sequestration.

Stormwater

The i-Tree Hydro v6.1 Model was used to quantify the value of ecosystem services for stormwater runoff. i-Tree Hydro was designed for users interested in analysis of vegetation and impervious cover effects on urban hydrology. This most recent version (v6.1) allows users to report hydrologic data on the municipal level rather than just a watershed scale giving users more flexibility. For more information about the model, please consult the i-Tree Hydro v6.1 manual (http://www.itreetools.org).

To calculate ecosystem services for the study area, land cover percentages derived for the project area and all municipalities that were included in the project area were used as inputs into the model. Precipitation data from 2005–2012 was modeled within the i-Tree Hydro to best represent the average conditions over an eight-year time period. Model simulations were run under a Base Case as well as an Alternate Case. The Alternate Case set tree canopy equal to 0% and assumed that impervious and vegetation cover would increase based on the removal of tree canopy. Impervious surface was increased 6.04% based on a percentage of the amount of impervious surface under tree canopy and the rest was added to the vegetation cover class. This process was completed to assess the runoff reduction volume associated with tree canopy since i-Tree Hydro does not directly report the volume of runoff reduced by tree canopy. The volume (in cubic meters) was converted to gallons to retrieve the overall volume of runoff avoided by having the current tree canopy.

Through model simulation, it was determined that tree canopy decreases the runoff volume in the project area by 8,103,138,458 gallons per year using precipitation data from 2005–2012. This equates to approximately 27,182 gallons per acre of tree canopy (8,103,138,458 gals/298,109.95 acres).

To place a monetary value on storm water reduction, the cost to treat a gallon of storm/wastewater was taken from McPherson et al 1999. This value was $0.17 per gallon. Tree canopy was estimated to contribute roughly $1,377,533,538 to avoid runoff annually to the project area.

References for Canopy Benefit Methodology

Hirabayashi, S. 2014. i-Tree Canopy Air Pollutant Removal and Monetary Value Model Descriptions. http://www.itreetools.org/canopy/resources/iTree_Canopy_Methodology.pdf [Accessed 29 December 2022]

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McPherson, E.G., Simpson, J.R.; Peper, P.J.; Xiao, Q. 1999. Tree Guidelines for San Joaquin Valley Communities. U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station, Center for Urban Forest Research.

U.S. Environmental Protection Agency (US EPA). 2012. Environmental Benefits Mapping and Analysis Program (BenMAP). http://www.epa.gov/air/benmap [Accessed 29 December 2022]

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Priority Planting Assessment

Summary

This analysis was conducted to assess priority planting locations within Wake County. Analysis included data sets from Wake County Open Data, The US Geological Survey, The US Department of Agriculture, The US Census Bureau and the Federal Emergency Management Agency. The resulting analysis found plantable areas in both public and private properties across the municipality.

Description

An urban tree canopy assessment was conducted by Wake County to assess land cover using 2020 aerial imagery. The study was completed in 2023. An analysis to identify the most suitable locations was conducted by analyzing each planting location to assign a priority ranking for stormwater and urban heat island.

Each data source utilized the most current version available and described in the subsequent sections. Stormwater uses the most recent NAIP imagery, soil data, flood data and benefit data. Heat islands were derived from averaging Landsat 8 surface temperature data from May 31, 2022 and Sept. 6, 2020 data to find hotspots at varying points in time to locate areas of potential heat mitigation. And social equity and health data were used to prioritize planting in area to create social equity

Methodology

In order to create a priority planting plan, the locations for planting must first be determined. Planting location polygons were created by taking all grass/open space and bare ground areas and combining them into a single dataset. Non-feasible planting areas such as agricultural fields, recreational fields, major utility corridors, airports, ROWs, etc. were removed from the possible grass and bare soil locations. This layer was reviewed and approved by Wake County before the analysis proceeded. The remaining planting space was consolidated into a single feature and then, exploded to multipart features creating separate, distinct polygons for each location.

Planting Area Exclusions:

Davey Resource Group identified and removed the following areas from the planting analysis:

- Sports fields (soccer, football, baseball, softball, etc.)
- Playgrounds
- Major utility corridors
- Golf courses
- The airport
- Wetland areas
- Substations
- Visible cropland
- Water treatment facilities

The planting area exclusions were then further refined by use of the following data layers:

Additional Exclusionary Layers

- Major Utility Easements
- Access Easements
- Parcels (Land use descriptions used: Agriculture, Horticulture, Water/Sewer System)
- ROW (This layer was created using the empty space from the parcel layer)
- Completed540_PermanentROWEasements
- Raleigh_Easement
- UtilityEasements_Wake Forest
- APEX_UtilityEasement

Stormwater:

To identify and prioritize planting potential based on the stormwater analysis, locations were assessed with several environmental features, including canopy percent, possible canopy percent, air quality, distance to hardscape, soil erosion and FEMA floodplain. These factors are based on numerous historic projects completed by DRG for stormwater analysis. Each factor was assessed using data from various sources and analyzed using separate grid maps. Values between zero and four (with zero having the lowest priority) were assigned to each grid assessed. A value of zero indicates that this classified piece of information yielded little or no overall value within the dataset. The grids were overlain with the values averaged to determine the priority levels at an area on the map. A priority ranging from Very Low to Very High was assigned to areas on the map based on the calculated average of all grid maps using quantile classification breaks within ArcGIS. This step of the process was completed to statistically subset data evenly into five classes of increasing importance. Areas of higher potential for runoff and erosion were considered higher priority due to their ability to diminish water quality within urban areas.

Urban Heat Island:

To identify and prioritize planting potential based on heat islands, a land surface temperature analysis was conducted using Landsat 8 imagery data. This data was provided via the United States Geological Survey (USGS). Specifically Landsat 8 thermal bands were used to calculate land surface temperatures. Imagery from May 31, 2022 and September 6, 2020 were used to find the radiance, at-satellite brightness and proportion of vegetation coverage. This data was then used to calculate the land surface temperature for both dates. Surface temperatures were then averaged and a priority ranking of “Very Low” to “Very High” was assigned based on the averaged temperatures using natural (Jenks) breaks classification within ArcGIS. Natural breaks create class breaks so that similar values were grouped together and maximized class differences. Classes with higher surface temperatures were considered higher priority due to the adverse effects of elevates microclimates within urban areas.

Social Equity:

Values were developed to identify and priority planting potential to improve social equity amongst the community. Analysis was conducted using the Social Equity Index data provided by Wake County and health data gathered from the CDC PLACES study. Each factor was separated into its own grid map. Values from each factor were then sorted into five classes ranked from 0–4 with zero being the lowest priority and 4 representing the highest priority. The factors were classified into five final rankings from "Very Low" to "Very High" for each of the social equity and public health criteria using quantile classification breaks within ArcGIS. Quantile is defined as classes which contain an equal number of data features with no empty classes. Areas with a higher rating are areas with higher planting priority to provide equal access to trees and tree canopy to all citizens regardless of social status.

Composite Priority:

A composite priority was created utilizing the raster calculator tool and the provided weighting scheme. Each raster dataset for stormwater, heat island and social equity were used to calculate a total aggregate value for each individual planting location polygon. The values were then binned into five classes utilizing quantile classification within ArcGIS. Quantile classification distributes values into groups where all five groups have an equal number of values. Values were binned such that higher numbers were grouped into bins representing a higher priority planting area. These bins ranged from "Very Low" on the low end to "Very High" on the upper end to mirror criteria group rankings mentioned above. Rankings were then used to combine all criteria to create a composite ranking based on all analytical factors pertaining to the municipality.

Group	Criteria	Data Origin	Last Update	Weighting	Full Weighting
Stormwater	Distance to Hardscape (Stormwater)	Wake County Urban Tree Canopy Assessment	2020	0.13	0.07
	Canopy Percent	Wake County Urban Tree Canopy Assessment	2020	0.3	0.18
	Possible Canopy Percent	Wake County Urban Tree Canopy Assessment	2020	0.25	0.16
	FEMA Floodplain	FEMA Natural Hazard	2022	0.05	0.02
	Soil Erosion	Natural Resource Conservation Service	2022	0.07	0.04
	Air Quality	i-Tree Canopy	2021	0.2	0.09
Urban Heat Island	Heat Islands – Sept. 6, 2020	Earth Explorer – USGS	2020		0.14
	Heat Islands – May 31, 2022	Earth Explorer – USGS	2020		
Social Equity	Social Equity Index	Wake County	2022	0.45	0.13
	Asthma Prevalence	CDC PLACES 2021	2021	0.2	0.06
	Mental Health Prevalence	CDC PLACES 2021	2021	0.35	0.11

Weighted Overlay Equation for Stormwater priority:

("ImperviousDistance" * 0.13) + ("Floodplain" * 0.05) + ("CanopyPercent" * 0.3) + ("SoilErosion" * 0.07) + ("PossibleCanopyPercent" * 0.25) + ("AirQuality" * 0.2)

Weighted Overlay Equation for Social Equity priority:

("SocialEquityIndex" * 0.45) + ("AsthmaPrevalence" * 0.2) + ("MentalHealthPrevalence" * 0.35)

Weighted Overlay Equation for Composite priority:

("ImperviousDistance" * 0.07) + ("Floodplain" * 0.02) + ("CanopyPercent" * 0.18) + ("SoilErosion" * 0.04) + ("PossibleCanopyPercent" * 0.16) + ("AirQuality" * 0.09) + ("HeatIslands" * 0.14) + ("SocialEquityIndex" * 0.13) + ("AsthmaPrevalence" * 0.06) + ("MentalHealthPrevalence" * 0.11)

Vulnerability Assessment Data Details

Stormwater

Distance to Hardscape (Stormwater)

Source: Wake County Urban Tree Canopy Assessment

Data: Distance to Impervious

Distance to hardscape was derived by selecting the impervious surfaces data from the landcover layer. This impervious raster layer is used as an input layer into the Euclidean Distance tool within ArcGIS to create a layer that measure straight-line distance from each impervious surface location within the municipality. These distances were grouped into five classes from 0–4. A value of 0 was given to locations that are currently represented as impervious surfaces in the land cover data while a value of 4 indicated that the open area next to the impervious surface is available for planting trees to reduce the amount of runoff and sedimentation. The table below provides exact distances to impervious surfaces per rank.

Distance to Hardscape	
Rank	**Distance to Impervious (ft)**
0	0
1	Over 100
2	51–100
3	26–50
4	1–25

Canopy Percent

Source: Wake County Urban Tree Canopy Assessment

Data: Canopy Percent

Canopy percent is a derived calculation that is determined by first calculating the total canopy acreage within each census block group (CBG). The total canopy acreage is then divided by the total area of the census block group. The resulting canopy percentage values were then grouped into five classes from 0–4 based on percent coverage. A rank of 4 was assigned to areas with the least amount of canopy percent coverage. The remaining categories are organized such that block groups with higher canopy coverage receive a lower rank. Higher rankings prioritize areas that have a low percentage of canopy coverage, therefore a higher need for tree plantings to increase canopy coverage. This will amplify the benefits the tree canopy benefits currently provide.

Canopy Percent	
Rank	**Canopy Percent**
0	Over 60.1%
1	53.45%–60.1%
2	46.81%–53.45%
3	38.7%–46.81%
4	Under 38.7%

Possible Canopy Percent

Source: Wake County Urban Tree Canopy Assessment

Data: Possible Canopy Percent

Possible canopy percent was derived by first calculating the amount of available plant acres within each census block group and then dividing the available plant acres by the total area of the CBG. The resulting percentage groups were divided into five classes from 0–4 based on percentage with 4 representing areas with the largest percentage of possible canopy. The lower the possible canopy percent, the lower the ranking received. 0 rankings were areas with the lowest percent of plantable area or the lowest among possible canopy. Prioritizing plantings in areas with a high ranking will increase canopy coverage in areas that are not currently benefiting from high amount of canopy.

Possible Canopy Percent	
Rank	**Possible Percent**
0	Under 12.5%
1	12.45%–15.64%
2	15.64%–18.6%
3	18.6%–23.0%
4	Over 23.0%

FEMA Floodplain

Source: FEMA Flood Hazard Layer

Link: https://www.fema.gov/flood-maps/national-flood-hazard-layer

Data Attribute: ZONE_LID_V & ZONESUB_LI

FEMA Flood data was collected from the FEMA website. This data is categorized first by a letter and then by a sub-ranking. Special flood hazard areas in the municipality are labeled with an AE, moderate areas are labeled with an X and a sub-category, the next denotation is labeled as 0.2% annual chance and low risk areas are noted with a X and no sub-category. These were then ranked 0–4, with 4 being the highest priority. A ranking of 4 is given to the AE & Floodway category. Planting in these locations will increase stormwater uptake and therefore reduce the amount of runoff. Lower rankings are given to the X, 1% future conditions and 0.2% annual chance and non-risk areas. Planting in areas of a higher flood risk can help decrease the amounts of standing water and runoff.

Soil Permeability — HSG	
Rank	**Threat**
0	X & Areas not included in the layer
1	0.2 PCT ANNUAL CHANCE FLOOD HAZARD
2	X & 1 PCT FUTURE CONDITIONS
3	AE
4	AE & FLOODWAY

Soil Erosion

Source: Natural Resource Conservation Service – USDA Web Soil Survey

Link: https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx

Data Attribute: K-factor

Soil erosion was determined by analyzing the K-factor information from the USDA Soil Surveys. The data is classified into decimal numbers ranging from 0.02-0.69 with higher numbers within the range indicating the area is more susceptible to sheet and rill erosion by water. 0 rankings were given to areas that had little to no risk of erosion such as quarries, pits and other hard surface types. The ranking increases as the risk of erosion increases with the highest ranking being 4. Planting in priority areas with high rankings will help decrease erosion vulnerability.

Soil Erosion — K-factor	
Rank	**K-factor (expressed as whole numbers)**
0	0–10
1	11–20
2	21 –30
3	31–37
4	Over 38

Air Quality

Source: i-Tree Canopy

Link: https://canopy.itreetools.org/

Data Attribute: Air Pollution Removed Annually (CO – Carbon Monoxide, NO_2 – Nitrogen Dioxide, O_3 – Ozone, SO_2 – Sulfur Dioxide, PM_{10} – Particulate Matter)

Data shows the amount of air pollution in pounds that were removed annually in each block group. Amounts were classified into five groups using quantile classification within ArcGIS and ranked from 0–4 based on the amount of pollution removed. A ranking of 0 was given to areas with more pollution removed annually. This ranking increased as the pollution removed decreased. Planting in these high priority areas may help address areas of concern regarding air quality and may help to reduce pollution.

Air Quality	
Rank	**Units (lbs.)**
0	Over 46,000
1	19,300–46,000
2	10,900–19,300
3	5,800–10,900
4	0–5,800

Urban Heat Island

Land Surface Temperature (LST)

Source: Earth Explorer (USGS) Landsat 8 Thermal Imagery

Link: https://earthexplorer.usgs.gov/

Data Attribute: Land Surface Temperature (LST)

Land surface temperature was calculated using Landsat 8 imagery thermal bands. Using both thermal bands, a conversion from Digital Number (DN) to radiance, at-satellite brightness temperature and proportion of vegetation can be calculated. These values were used to find the land surface temperature. Imagery from May 31, 2022 and Sept. 6, 2020 was used to create two separate surface temperature raster datasets. The two years were averaged and binned into five classes from 0–4 based on a quantile classification with ArcGIS. Rankings were determined by the surface temperature ranges. The lowest surface temperature range received a 0 ranking. The ranking increased as the surface temperature increases with the high rank being 4. Planting in areas of high surface temperature helps mitigation urban heat islands by providing more shade to cool not only air temperature but heat absorbed by pavements.

Land Surface Temperature — 2 Year Average (2020–2022)	
Rank	**Temperature (Fahren-heit)**
0	64.88–72.15
1	72.15–75.05
2	75.05–78.2
3	78.2–81.96
4	81.96–95.77

Social Equity

Vulnerable Populations

Source: Wake County Social Equity Index

Data Attribute: Combined_S

The social equity data was curated and provided by Wake County. The higher the score given to a block group, the higher the equity need. The social equity score is classified into five groups using info provided by Wake County and ranked from 0–4 based on this score. A ranking of 0 was given to areas with a low equity score. The higher the equity score, the higher the ranking. A ranking of 4 was given to areas that have a score of 300 and over.

Wake County Social Equity Index	
Rank	**Equity Score**
0	1–75
1	150–76
2	151–225
3	226–299
4	300 and Over

Asthma

Source: Center for Disease Control (CDC) PLACES

Link: https://chronicdata.cdc.gov/browse?q=PLACES%202022

Data Attribute: Crude Prevalence

Crude Prevalence was calculated using respondents of the Behavioral Risk Factor Surveillance System (BRFSS) survey or National Survey of Children's Health. This number is a percentage that is calculated by dividing the weighted total of people who have asthma or who have been told they have asthma from a doctor by the weighted number of people who responded to either survey excluding the answers of "don't know" or "refused" in regard to Asthma. Data was recorded by census tract. The asthma rates were grouped into five classes using quantile classification within ArcGIS and ranked from 0–4. A ranking of 0 was given to the lowest prevalence recorded. This ranking increased as the asthma rates increase with the highest ranking being 4. Planting in these priority areas will potentially help decrease asthma prevalence.

CDC — Asthma	
Rank	**Crude Prevalence**
0	0.0–7.5
1	7.6–8.0
2	8.1–8.6
3	8.7–9.2
4	9.3–12.8

Mental Health

Source: Center for Disease Control (CDC) PLACES

Link: https://chronicdata.cdc.gov/browse?q=PLACES%202022

Data Attribute: Crude Prevalence

Crude Prevalence was calculated using respondents of the BRFSS survey or National Survey of Children's Health. This number is a percentage that was calculated by dividing the weighted total of people who have reported 14 or more days during the past 30 in which their mental health was not good by the weighted number of people who responded to either survey excluding the answers of "don't know" or "refused" in regard to mental health. Data was recorded by census tract. The mental health rates were grouped into five classes using quantile classification within ArcGIS and ranked from 0-4. A ranking of 0 was given to the lowest prevalence. This ranking increased as the mental health rates increased with the highest ranking being 4. Planting in these priority areas will potentially help decrease poor mental health prevalence.

CDC — Mental Health	
Rank	**Crude Prevalence**
0	0.0–10.9
1	11.0–12.3
2	12.4–13.5
3	13.6–14.6
4	14.7–22.8

Tree Placement Modeling

Summary

The purpose of this feature class was to create a tree planting placement guide for Wake County. This layer identifies possible locations for tree placement based on the placement analysis.

Description

An urban tree canopy assessment was conducted to determine the current land cover. This landcover was used to find the most suitable locations to plant trees. These locations were narrowed down to spaces over 200 square feet within cities limits and 1 acre on county lands. This analysis creates locations to plant trees based on the Tree Placement Analysis.

Use Limitations

As determined by Wake County Government.

Data Quality

Planting sites and their tree sizes were generalized based on data derived from the Priority Planting analysis and the Tree Placement model. No field verification of planting sites was conducted. Before planting, the Municipality will need to conduct site assessments to ensure planting locations can adequately sustain planting trees.

Lineage

This process used the priority planting areas to create points for tree placement. Grid area created over the designated area and points were placed within these grids within the priority planting areas. The size of the trees is determined by what is able to fit within both the grid and planting area. The model places large trees first and then uses the remaining area to place medium trees and then again for small trees.

Data Attribute Fields

ET_X – X coordinate

ET_Y – Y coordinate

Crown – The diameter of the crown

CrownSize – The size (small, medium, large) of the tree crown

UNIQUEID – unique identifying number

City_County – Specifies the city the tree falls in or if it falls in county land.

Subdivision – Specifies if it falls within a subdivion (subdivisions and planned subdivisions provided by wake county)

PublicLand_Owner – Specifies the owner (city/county/state/federal/park) of the public land. All null values are private land.

StormMean – Stormwater mean rank (mean rank of 0–4)

StormPri – Stormwater priority rank

TempMean – Heat Island mean rank (mean rank of 0–4)

TempPri – Heat Island priority rank

SocialEquMean – Social equity index mean rank (mean rank of 0–4)

SocialEquPri – Social equity index priority rank

AsthmaMean – Asthma prevalence mean rank (mean rank of 0–4)

AsthmaPri – Asthma prevalence priority rank

MentalHMean – Mental Health Prevalence mean rank (mean rank of 0–4)

MentalHPri – Mental health prevalence priority rank

SocialCompMean – Social equity composite (Social equity index, asthma and mental health) mean rank (mean rank of 0–4)

SocialCompPri – Social equity composite (Social equity index, asthma and mental health) priority rank

CompositeMean – Overall composite (Stormwater, heat island, social equity) mean rank (mean rank of 0–4)

CompositePri – Overall composite (Stormwater, heat island, social equity) priority rank