Tree Resiliency Plan

City of Brunswick, Georgia

AUGUST 2025

PLAN BY THE GREEN INFRASTRUCTURE CENTER INC. FOR THE CITY OF BRUNSWICK, GEORGIA.

https://www.brunswickga.org

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Prepared by the Green Infrastructure Center Inc.
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Executive Summary

The urban forest is a critical asset for healthy, resilient, and sustainable cities. Trees provide benefits that directly support public health by cleaning the air and filtering and reducing stormwater runoff, reducing urban temperatures, and fostering greater economic development. However, these benefits are at risk because tree canopy cover is declining across many U.S. localities. This Brunswick Tree Resiliency Plan provides data and strategies for maintaining and restoring tree canopy in Brunswick.

This plan is the culmination of a year-long planning process that included workshops and strategic planning sessions led by the Green Infrastructure Center, Inc. (GIC) with city staff and community partners. The public was engaged in this process through outreach events at community festivals, a public tree survey, in-person comment stations set up at local, accessible public facilities and a community open house. The extent of urban forest cover was determined by analyzing aerial imagery to map the city's land cover. Open space was evaluated to determine the Potential Planting Area where future trees might be planted, along with assessments of the environmental and social benefits the city's trees provide. In addition, environmental, threats to the tree canopy such as future climate, flooding, heat stress, salt stress, pests and disease, storm surge and sea level rise were analyzed. Based on these maps and data, strategies for retaining, protecting, and restoring tree canopy coverage were created to address these challenges and sustain a resilient urban forest.

Brunswick City Goal—

Maintain 30% tree canopy coverage city-wide with the potential for incremental increases over time.

Top Four Objectives to Achieve This Goal

1. Establish a moratorium on planting palm trees in rights-of-way and in parks.
2. Plant trees at public housing sites in partnership with the Brunswick Housing Authority.
3. Prioritize lower income neighborhoods for tree plantings or tree giveaways during Arbor Day or Earth Day celebrations.
4. Continue to hold Arbor Day celebrations, ensuring engagement and building momentum through these public outreach events.

The Benefits of Brunswick's Trees

Tree canopy provides benefits such as cleaner air, urban cooling, stormwater capture, wildlife habitat, and natural beauty. This plan quantifies and identifies strategies to increase these benefits.

Air Quality

Trees sequester carbon and clean the air of particulate matter and ground-level ozone. Each year Brunswick's trees remove:

- 62,487,824 lbs. of carbon
- 158,677 lbs. of ground-level ozone (O3)
- 55,371 lbs. of airborne particulate matter

Urban Cooling

Excessive pavement and lack of shade create urban heat islands. Brunswick's trees counter urban heating by shading hot areas. Higher tree canopy cover lowers surface temperatures and cools the city.

Stormwater Uptake

Trees capture rainfall and filter pollutants. During a ten-year/24-hour rainfall event (7.06 inches) the city's trees:

- soak up 14.9 million gallons of water
- reduce runoff pollution loads for nitrogen by 8%, phosphorus by 11%, and sediment by 5%

Canopy Goals

Brunswick's goal is to maintain the current tree canopy coverage at 30% with the potential for incremental increases. Assuming an average of 200 trees are lost per year on both public and private property, this goal over a 20-year period requires planting:

- 40 trees on city-owned land annually
- 160 additional trees on private property through tree plantings and tree giveaways

Threats to Brunswick's Tree Canopy

Sea Level Rise

In the year 2060 under a 2-feet rise in sea level, 75 acres of tree canopy (5% of total canopy) and a total of 21 acres (6% of available PPA) is projected to be underwater.

Storms

376 acres of tree canopy are at high-risk from a Category 3 hurricane's storm surge.

The estimated volume of vegetative debris generated during a Category-3 hurricane with heavy rainfall is approximately 240,000 cubic yards.

Inland Flooding

Brunswick's future climate (year 2085) is projected to be wetter in both the summer (4% rainfall increase) and winter (10% rainfall increase) seasons.

81 acres of tree canopy in the city are at high-risk from extreme flooding during a 50-year/24-hour event storm (13 inches).

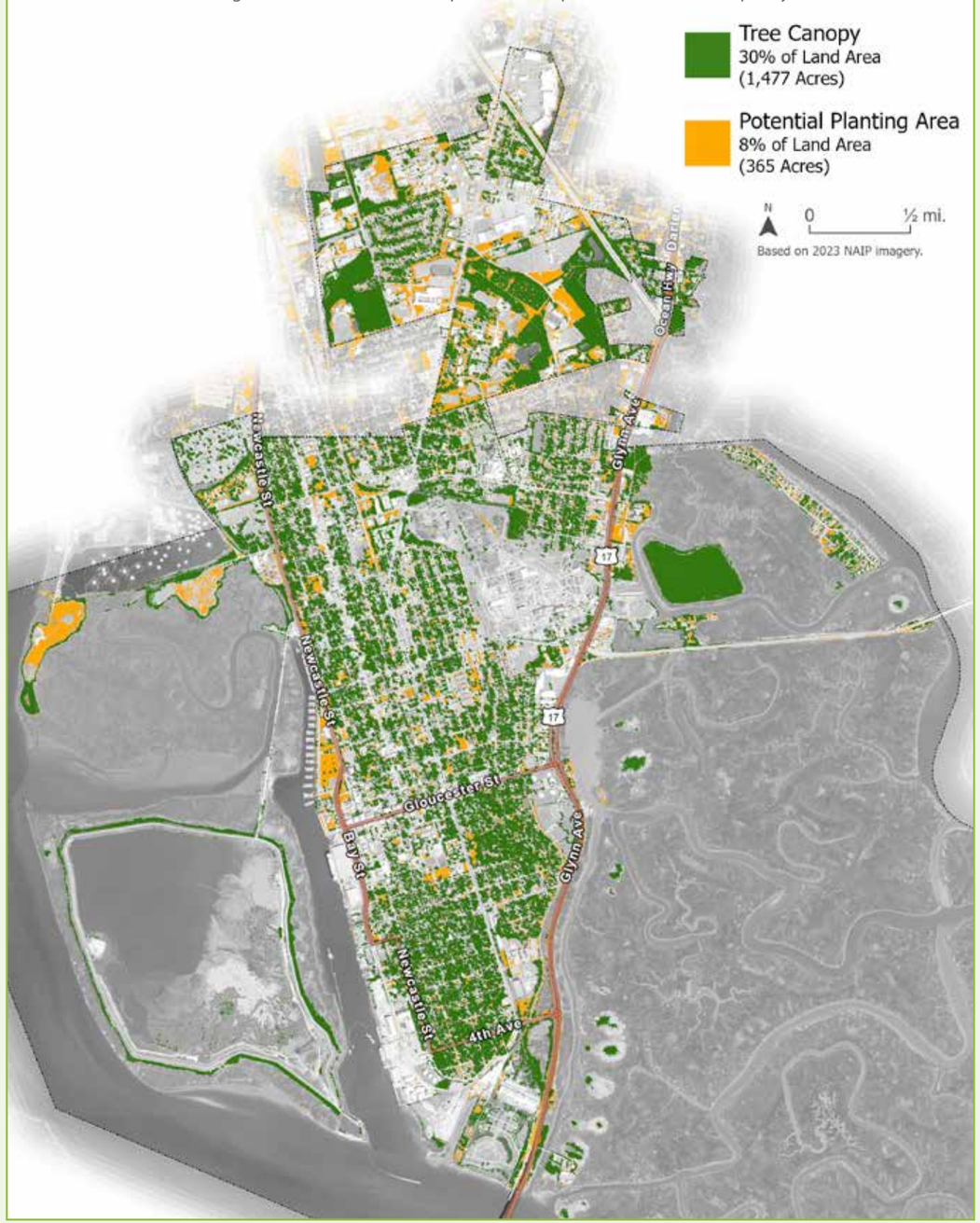
Heat Stress

Summers in 60 years are projected to be 7.5 degrees Fahrenheit warmer, while winter temperatures are expected to be 7.1 degrees Fahrenheit warmer.

23 acres (1.6%) of tree canopy is at very high to high risk of heat stress.

Tree Canopy and Potential Planting Areas

The City of Brunswick now has baseline data to identify opportunities to plant new trees for shade, energy savings, increased stormwater uptake, and improved air and water quality.



Introduction

Located in close proximity to St Simon's and Jekyll Island, the City of Brunswick has served as the gateway to the Golden Isles region for generations. The famous Brunswick stew was first made here back in 1898. Nestled on a peninsula within the coastal salt marsh habitat native to southeastern Georgia, Brunswick is a shipping port with a strong connection to the ocean. Its historic district is shaded by a forest of live oaks draped in Spanish moss and the city has an extensive green space network made up of its Signature Squares. These parks break up the urban landscape with small green spaces for reflection and relaxation. The city landscape is enhanced by its ancient heritage trees which tell stories of the area's history and its people. A sign at Lover's Oak on Albany Street, recounts the story of a romantic tragedy between two lovers kept apart by fate and family. The city also has a wealth of natural features including urban trees, parks, forests, salt marshes and rivers that provide social, economic, and ecological benefits to residents while creating a sense of place. The City of Brunswick has been a Tree City USA member for 24 years, an honor bestowed by the Arbor Day Foundation on cities and towns that meet specific standards of care and protection for public trees.

Brunswick has been a Tree City USA member for 24 years. The initiative to create a tree resiliency plan makes them eligible for a growth award.

Brunswick, Georgia Fast Facts

Total City Area: 25 sq. miles
Land Area: 7.6 sq. miles
Water: 5,550 acres
Wetlands & Marshes: 5,612 acres
Streams/ canals within the Urban Area: 4 miles
Tree Canopy: 1,477 acres
Potential Planting Area: 365 acres
Impervious surfaces: 1,686 acres

Population: 15,520 people*
White: 30.8%
Black: 61.6%
Hispanic or Latino: 7.9%
Two or More Races: 4.5%
Asian: 0.2%
American Indian and Alaskan Native: 0.1%

*(U.S. Census 2024 estimate)
https://www.census.gov/quickfacts/fact/table/brunswickcitygeorgia

Brunswick, tucked away behind barrier islands, is protected from the Atlantic Ocean; however, the city and its tree canopy still face threats from sea level rise, increasing frequency and severity of tropical storms, greater rainfall and localized flooding, and increasing heat. Adapting to these challenges will require proactive planning and management of the urban forest to ensure trees provide sustained benefits to the community. By protecting and restoring its natural features and historic sites, Brunswick can ensure a healthy, green, and vibrant future.

The *Brunswick Tree Resiliency Plan* supports the City's Comprehensive Plan 2023, by encouraging economic growth while conserving its natural assets through the preservation and expansion of the city's tree canopy. The plan calls for the increase of trees in underserved areas that have low tree equity scores and to maintain the character of the city and its neighborhoods. The city's Complete Streets Ordinance prioritizes streetscape designs and infrastructure that favor pedestrians and cyclists. Trees are an important design component for providing safe streets and necessary benefits to the streetscape such as shade, clean air and stormwater management. The plan also tasks the Tree Board with developing a tree ordinance for the protection of specimen trees.

Brunswick Comprehensive Plan

Chapter 3: Needs and Opportunities - Roots

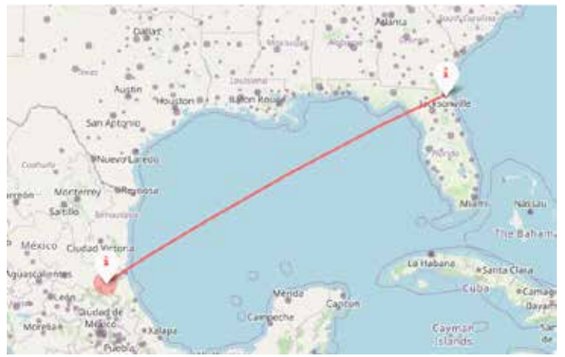
"Protect the City's natural resources, including rivers, marshes, and tree cover."

Chapter 8: Resiliency, Stormwater, Flood Control and Hazard Mitigation

"Guide development in various Character Areas that have low scores in tree canopy coverage to help manage carbon sequestration and storm damage."

Above: This is the pot that the first Brunswick Stew was made on July 2, 1898.

Left: Some of the historic trees in the area like the Lover's Oak have been mapped by the Golden Isle Tree Fund to tell the history of the place.



Brunswick's future climate in 60 years is projected to be more similar to northeastern Mexico along the Gulf Coast.

Brunswick's Climate— Present and Future

The technical advisory committee established a time horizon for the resiliency plan of 40 years, establishing a target date of 2065. The Green Infrastructure Center used various online tools to understand the future climate of Brunswick, GA. The University of Maryland's Center for Environmental Science Appalachian Lab created an app that allows a user to project a city's climate 60 years in the future.
Link: https://fitzlab.shinyapps.io/cityapp/

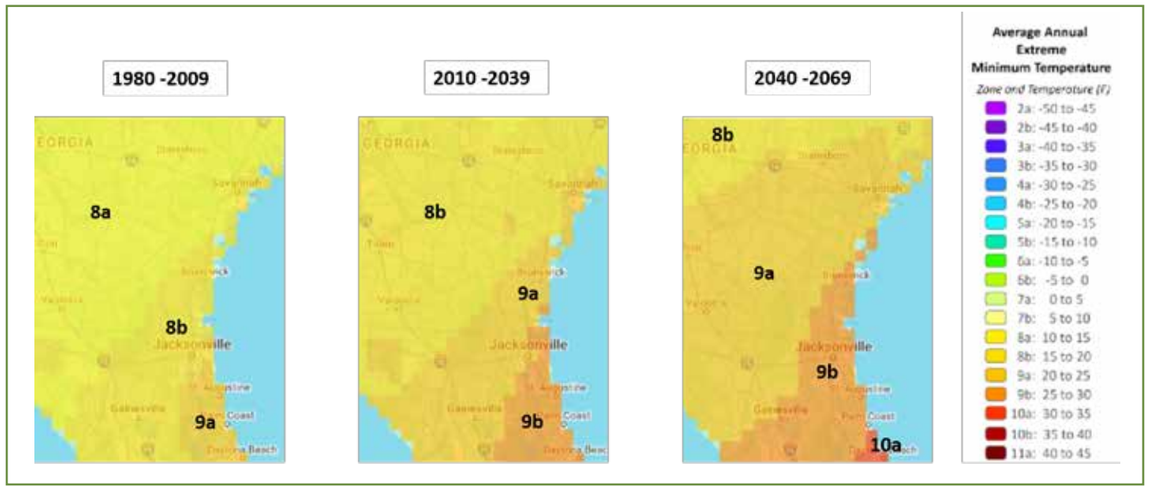
According to the tool, Brunswick's climate in the year 2085 does not have a present day comparison. Jacksonville, FL is the closest city the tool uses to approximate future climate in Brunswick. In 60 years, Jacksonville is projected to have a climate most similar to present day Tantobal, Mexico. Summers are projected to be 7.5 degrees Fahrenheit warmer and 5.6% wetter, while winter temperatures are expected to be 7.1 degrees Fahrenheit warmer and 15% wetter.

The influences of future climate on tree canopy can also be seen in an online tool developed by the Davey Institute and the Arbor Day Foundation that projects future plant hardiness zones. Link: https://hardinesszones.daveyinstitute.com/.

From the time period of 1980 – 2009, Brunswick's plant hardiness zone was an 8b based upon its lowest average temperatures ranging between 15-20 degrees Fahrenheit. Currently and into the near future (2010 – 2039) the hardiness zone has increased to a 9a with the lowest average temperatures ranging between 20-25 degrees Fahrenheit. Looking further into the future (2040-2069) the plant hardiness zone is expected to increase to a 9b or 10a with lowest average temperatures between 25--35 degrees Fahrenheit. Present-day Jacksonville, FL has a plant hardiness zone of 9b and Orlando, Florida is 10a.

Summer temperatures are also expected to rise. According to the American Horticultural Society, Brunswick's current number of heat days (above 86 degrees Fahrenheit) range between 90 to 120 days (zone 8) annually, link: https://www.usbg.gov/blog/heat-zones-plant-health-and-ahs-heat-zone-map. In the future, Brunswick's heat zone will likely increase to either zone 9 (between 120 to 150 days above 86 degrees F) or zone 10 (150 to 180 days above 86 degrees F).

Understanding future climate changes, is essential for determining what species can tolerate future environmental conditions. Some common urban tree species that are on the southern end of their range may need to be avoided

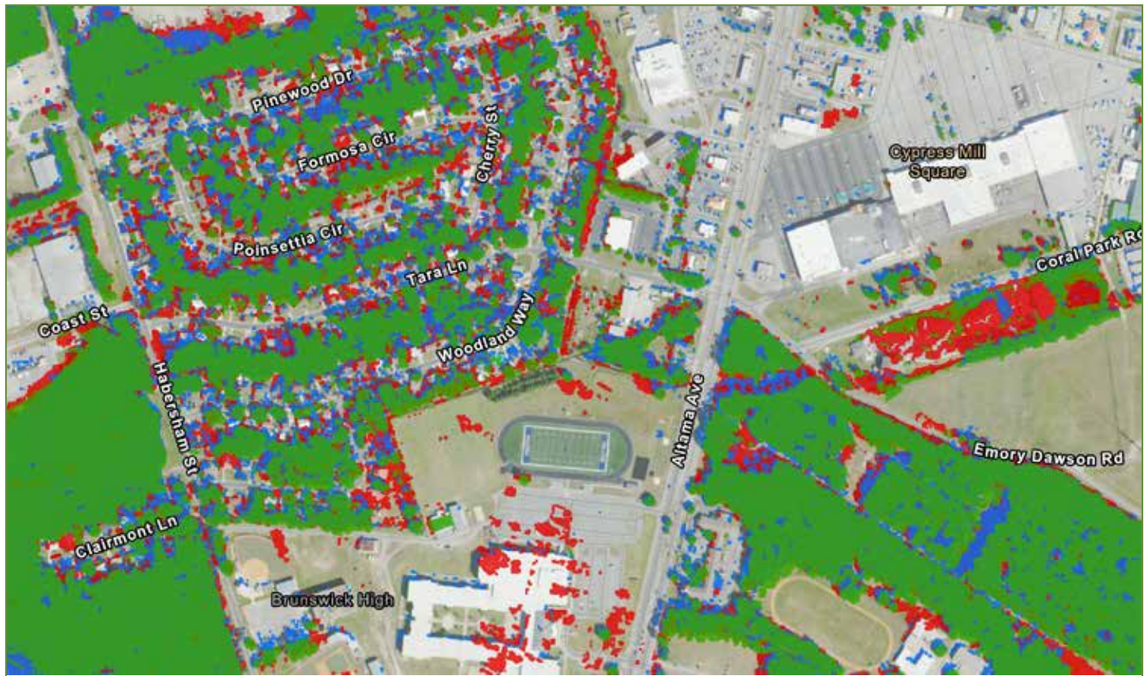


or planted less often. When considering the next generation of tree plantings to include on preferred tree species lists, the city and its tree board should include subtropical species or species adapted to Florida, Texas and Mexico.

The City and its Tree Board also can review preferred tree species lists from Florida cities such as Jacksonville and Orlando, Florida. The city should interview those cities' arborists to learn what species currently do well there and what species of trees perform best in those climates.

Tree Canopy Trends in Brunswick

Trees are declining throughout the United States. The causes of this decline include land conversion for development, storm damage, pests and disease, and lack of tree replacement as older trees die. Many communities in Georgia are looking for ways to protect or expand their tree canopy and community forests. Data describing Brunswick's trees will allow the city to track trends, assess losses and set goals to retain or restore canopy. Fortunately for the City, in addition to the new 2023 tree canopy data GIC provided, Tony Giarrusso, Senior Research Scientist at Georgia Institute of Technology (GA Tech) also mapped tree canopy in the six oceanfront counties along Georgia's coast for 2010 and 2019 (https://storymaps.arcgis.com/stories/562a0696356e42cfbca41e2202f89822) Although canopy mapping methods were not exactly the same between the GA Tech data and GIC's, GIC was able to process the data for a comparative analysis. These additional data helped show trends in canopy cover over a 13-year timespan. The canopy data showed minimal canopy cover losses; only declining by 49 acres between 2010 and 2023 which broke out as a decline of just 1%; 31% in 2010 and 2019 to 30% in 2023. This suggests that Brunswick's tree canopy has been relatively stable over the last 15 years; however, that does not mean the city's urban forest is without risk from future threats that are discussed later in this plan.



Tree Canopy 2023 Tree Canopy 2019 Tree Canopy 2010

GIC focused on evaluating large contiguous patches of urban forest cover that changed between the time periods 2010, 2019 and 2023. This resulted in 49 acres of canopy that were lost between 2010 and 2023.

Tree Benefits

Trees benefit communities ecologically, economically, and socially. Some of the many benefits include:

- Cleaner air and water
- Enhanced natural beauty
- Bird and wildlife habitat
- Reduced urban heat island effect
- Reduced levels of crime
- Reduced traffic accidents
- Increased revenues from sales and property taxes
- Lower vacancy rates
- Improved mental health and focus
- Improved metabolic function
- Increased access to outdoor fitness opportunities

Trees Are Green Infrastructure

Trees and other vegetation serve as the city's "green infrastructure." Just as localities manage grey infrastructure (roads, sidewalks, bridges, and pipes), they should also manage vegetation as infrastructure. Trees support a vibrant, safe, and healthy community while adding to its historic character. They enhance sustainability by filtering stormwater and reducing runoff, cooling streets, cleaning the air, capturing carbon emissions, and increasing property values.

Gray vs Green

The image on the left shows the City of Brunswick's gray infrastructure, including buildings and roads. Classified high-resolution satellite imagery (on the right) adds the city's green infrastructure data layer (trees and other vegetation). This green infrastructure provides cleaner air and water, energy savings, and natural beauty.

The City's trees provide a beautiful backdrop for residents and tourists.

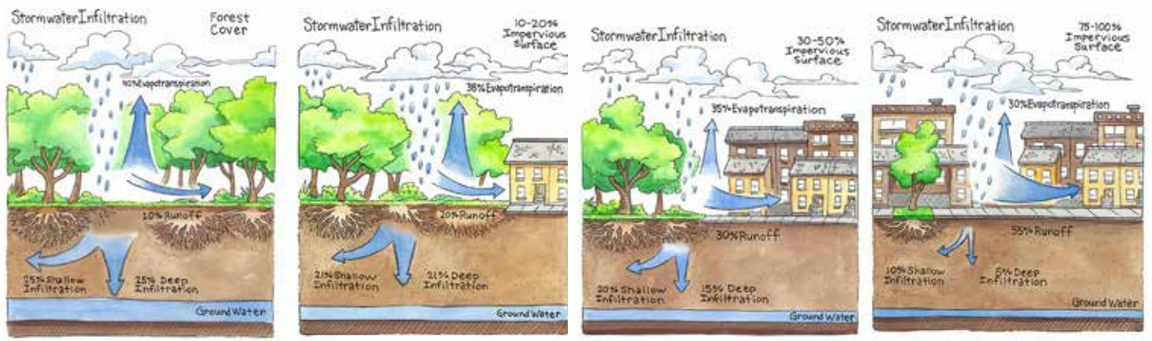
Reducing Stormwater Runoff and Filtering Pollutants

Trees protect communities from problems associated with stormwater runoff. As forested land is converted to impervious surfaces, such as roads, buildings and parking lots, urban stormwater runoff increases. Excess stormwater runoff can cause temperature spikes in receiving waters, increased pollution of surface and ground waters, and greater potential for flooding.

Increased loads of nutrients in stormwater runoff reduce oxygen in surface water, causing harm to fish and other aquatic life. Nitrogen and phosphorus can cause harmful algal

Trees filter and clean land runoff before it enters surface waters, ensuring healthy rivers and creeks for recreation and habitat.

Water Infiltration Rates with Development



Stormwater runoff increases as land is developed. Data Source: U.S. EPA Watershed Academy 2025.

blooms, while sediment can clog fish gills, smother aquatic life, and necessitate additional dredging of canals and waterways. As tree cover is lost and impervious areas expand, excessive urban runoff of these harmful pollutants greatly increases. The presence of trees means fewer pollutants enter the city's many watersheds, including the Turtle River, Mackay River, Saint Simons Sound and eventually the Atlantic Ocean.

Excess impervious areas cause hotter temperatures and increased runoff. This parking lot could be retrofitted to add more trees, bioswales, and pervious surfaces that let water seep into the ground.

This bioswale is a best management practice that includes planting trees to increase the amount of pollutants removed, while also providing habitat for wildlife.

The average annual precipitation in Brunswick is 47.76 inches (National Weather Service 2025). Much of this runoff flows into the stormwater system transporting surface pollutants from the land to local waterways. Large paved areas contribute significant volumes to this runoff. While stormwater ponds and other best management practices (BMPs) are designed to mimic natural land cover by detaining and filtering runoff, they do not fully replicate pre-development hydrology. In addition, older parts of the city may lack updated stormwater management practices required for new developments, so not all runoff is captured or treated before it flows into open waterways.

A typical street tree's crown can intercept between 760 and 4,000 gallons of water per year.

Since trees filter stormwater and reduce overall flows, planting or conserving trees is a natural, cost-effective way to mitigate stormwater. Each tree plays an important role in stormwater management. Based on the GIC's review of canopy rainfall interception studies, a typical street tree's crown can intercept between 760 and 4,000 gallons of water per year, depending on species and age.

Buffering Storms and Flooding

Another benefit of conserving trees and forests is buffering against storms and losses from flooding. According to the U.S. Environmental Protection Agency (EPA), excessive stormwater runoff accounts for more than half of the pollution in the nation's surface waters and causes increased flooding and property damages, as well as public safety hazards. The EPA recommends a number of ways to use trees to manage stormwater in the book *Stormwater to Street Trees*. https://www.epa.gov/sites/default/files/2015-11/documents/stormwater2streettrees.pdf

Retaining trees and forests along streams provides a wind break and helps reduce standing water.

Riparian buffers prevent stream erosion and reduce the risk of flooding.

Improving Air Quality, Public Health, and Economic Values

Trees Clean the Air

Higher tree canopy cover is correlated with better air quality. Trees reduce ground-level ozone (O3) while filtering out fine particulate matter, which can damage lungs and lead to respiratory distress and conditions such as asthma. In fact, well-treed neighborhoods have lower rates of respiratory illness (Rao et al. 2014). Trees capture such greenhouse gases as sulfur dioxide and carbon dioxide. These gases contribute to a warming planet and are associated with health problems from excessive heat. Trees also sequester carbon by storing it as wood, preventing its release into the atmosphere and mitigating the impact of climate change.

Trees Cool the City

Tree shade provides important refuge for children and the elderly during hot summers. Excessive heat can lead to heat stress, especially affecting infants and children up to four years of age, those 65 years of age and older, those with obesity issues, and those on certain medications (Center for Disease Control 2024).

Tree canopy shades streets, sidewalks, parking lots, and homes, making urban locations cooler and more pleasant for outdoor activities, such as hiking, gardening and playing in city parks. Multiple studies have found significant cooling (2-7°F) and energy savings from shade trees in cities (McPherson et al. 1997, Akbari et al. 2001). Individual trees can transpire hundreds of liters of water per day, creating a cooling effect equivalent to the energy needed to power two average household central air-conditioning units (Ellison et al. 2017). Proper tree placement can reduce summer air conditioning costs by up to 35%. (Arbor Day Foundation 2025).

The city's trees provide essential shade for playgrounds.

Lastly, shaded pavement has a longer lifespan than pavement in full sun, reducing maintenance costs associated with roadways and sidewalks (McPherson and Muchnick 2005).

Trees Improve Walkability

Trees result in people walking more and walking farther. The cooler temperatures, aesthetics, and traffic calming effect increase a community's walkability, which is a priority of the City of Brunswick. When trees are not present on a street, people perceive distances to be longer, hotter, and less pleasant, making pedestrians less inclined to walk than if streets are well-treed (Tilt, Unfried, and Roca 2007).

People are more likely to shop longer and spend more money in well-treed business districts.

Exposure to green spaces for 20 minutes a day can improve cognitive function.

Trees Improve Cognitive Function

Exposure to green spaces such as parks or treed landscapes for just 20 minutes a day can significantly improve cognitive function, emphasizing the need for green spaces around schools to allow children to learn to their best ability. Children with Attention Deficit Hyperactivity Disorder (ADHD) benefit from exposure to greenspace. According to research, children who regularly play in green spaces have milder symptoms of ADHD (Faber Taylor and Kuo 2011).

Trees Increase Property Values

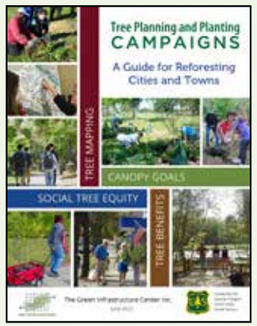
Developments that include green space or natural areas in their plans sell homes faster and for higher profits than those that take the more traditional approach of building over an entire area without conserving natural space (Benedict and McMahon 2006). Individual trees and forested open spaces make lots more valuable. Trees on developed lots add about 18% to property assessments and real estate value. (Wolf 2007). [*See the "Nature Sells" graphic, opposite page.*]

Trees Pay Us Back

As the City considers the cost of planting and caring for more trees, it's important to note that "every dollar invested in planting a tree, results in an average return on investment of $2.25" (Endreny 2018). In fact, even a newly planted tree will immediately begin to provide benefits. So, while the City will need to expend more funds to increase and maintain its canopy coverage, those trees will more than pay their way. This includes increases in property values, and thus property taxes, the rejuvenation of business districts, more tourist dollars, and makes the city more attractive to new businesses. For example, people were seen to shop longer and spend more in treed commercial shopping districts, which benefits the city through increased sales revenues (Wolf, 2007).

Planting trees should not be seen in isolation, but as part of a wider cycle of urban renewal and growth, in which trees spur development and raise incomes, business sales and that 'feel-good factor', which can, in turn, lead to a desire for more trees, parks and outdoor leisure facilities. Trees help turn a downward spiral into an upward spiral, as part of a city's renewed sense of pride and prosperity.

Fear of Gentrification



The fear of gentrification is often a concern when it comes to community planting projects in lower-income neighborhoods. The concern is that beautifying a neighborhood with numerous shade trees, adding street medians with more trees, planting trees in front yards, and having more parks and other open spaces nearby will raise property values and make houses unaffordable for low-income families, spur landlords to raise rents and result in property tax increases. As a result, some people have argued against planting trees in low-income and minority communities. However, that really is a counter-productive argument. Should we use that same argument to deny those neighborhoods streetlights, sidewalks or good policing? Everyone has the right to cleaner air, cooler summers, less flooding, lower energy costs and the general social wellbeing that trees provide – regardless of their race or income. Higher house prices actually help those who already own their homes to accumulate capital for their retirement. To learn more about how to prevent "green gentrification", see the GIC's Tree Campaign Guide: https://gicinc.org/books/tree-planning-and-planting-campaigns/

Instead of keeping places less treed and more polluted, cities should address the sources of those problems associated with affordability. One example would be an agreement with landlords not to raise rents within five years of a planting project; another would be to engage the community housing and development staff in providing more affordable housing. One city put a moratorium on raising real estate taxes in the low-income neighborhood surrounding a new park built with extensive community input. The GIC has worked to improve public housing and partnered with housing authorities to provide more affordable housing.

Tree Canopy Analysis Methods

The tree canopy analysis was performed to map current tree canopy, quantify the ecosystem services these trees provide, map potential planting areas, and estimate potential future canopy based on plantable areas. These new tree canopy data can be used to analyze urban cooling, walkability, and street tree plantings; or to inform area plans, urban forestry planning, and the City's Comprehensive Plan updates.

Satellite imagery from the National Agricultural Imagery Program (NAIP) distributed by the USDA Farm Service Agency was classified to determine the types and extent of different land covers in Brunswick. The land cover map was created at 1 meter resolution using NAIP imagery, from October 9, 2023. LiDAR[1] (light detection and ranging) data were used to determine height, in order to distinguish between large shrubs and trees. This allows the GIS analyst to separate bushes from trees and other vegetation. This distinction of tree/non-tree vegetation is very important when modeling tree benefits, since the modeled pollution-removal benefits are based on trees, and do not necessarily translate to smaller, non-woody vegetation. The tree canopy was mapped at 93% accuracy, with an overall land cover accuracy of 86%.

[1] LiDAR is a remote sensing method that uses light in the form of a pulsed laser to measure ranges (variable distances) to the top of the vegetation, compared to the underlying surface of the Earth. The farther the laser beam travels, the shorter the vegetation.

Determining Plantable Acreage

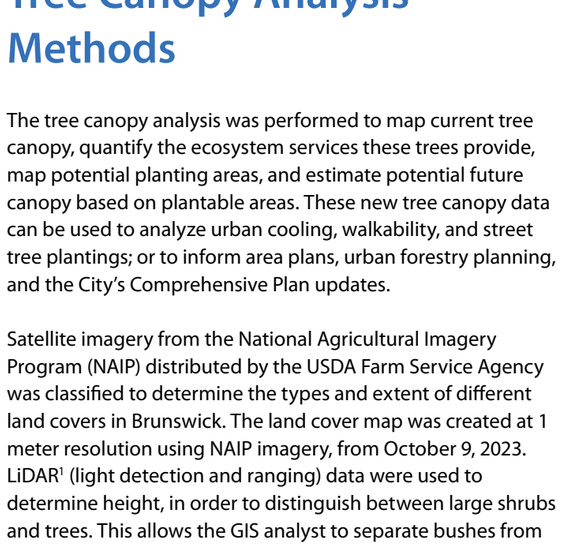
Potential Planting Areas (PPA)

In urban areas, a realistic goal for expanding urban canopy depends on an accurate assessment of the total plantable open area. A Potential Planting Area (PPA) map estimates areas where it may be feasible to plant trees. The PPA is estimated by selecting land cover types that have space available for planting trees and accounts for the overlap of canopy (canopy that is intermingled or a large canopy tree that partially covers an understory tree).

Of the nine land cover types mapped, only pervious and bare earth were considered for the PPA. However, some paved areas could be removed or reduced, soils conditioned, and then used to plant new trees. For example, a parking lot could be redesigned in order to accommodate more tree canopy to absorb and clean stormwater runoff and provide shade for cars.

Eligible planting areas are also limited by their proximity to features that interfere with a tree's natural growth (such as buildings) or where a tree might affect the feature, such as power lines, street signs, or road junctions. The GIC buffers potential planting areas to exclude trees from these features. City staff and the GIC reviewed the draft PPA map and removed playing fields, cemeteries, and other land uses where trees would not be appropriate. The resulting PPA represents the maximum potential places trees can be planted and grow to full size.

Based on an analysis of existing pervious surfaces, 7.5% of the City's land area, or 365 acres, could be planted with additional trees. The GIC recommends that no more than half the available PPA, 3.75% or 182 acres, is realistic to plant, since many other uses, such as vegetable gardens or swimming pools, require full sun.

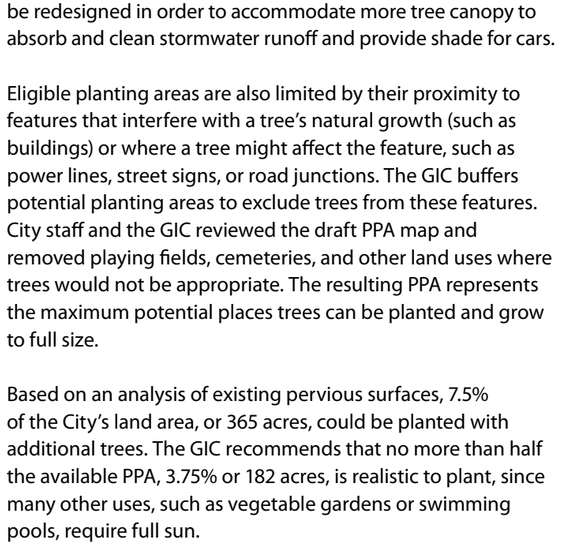


NAIP Aerial Image 2023

Potential Planting Area (PPA)

Potential Planting Spots (PPS)

Potential Planting Spots (PPS) are created from the PPA. A GIS modeling process is applied to select spots where a tree can be planted, depending on the desired mature size. For this analysis, expected canopy spreads of 20ft. and 40ft. diameter for individual mature trees were used, with priority given to 40 ft. diameter trees, since larger trees provide more benefits.



Potential Planting Spots (PPS)

There are many places where new trees can be planted in the City such as at the Risley Annex (*above*) and the Abbott Andrews Terrace Public Housing site (*below*).

Potential Canopy Area (PCA)

The Potential Canopy Area (PCA) is created from the PPS. Once the PPS are selected, a buffer around each point is created to represents the mature canopy spread. For this analysis, that buffer radius is either 10ft. or 20ft., which represents a 20ft. or 40ft. diameter canopy. These individual tree canopies are then merged to form a Potential Canopy Area.

Potential Canopy Area (PCA)

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

Tree Canopy Analysis Maps and Findings

The Tree Canopy Analysis has been used to plan the City's target tree canopy goal and will act as a benchmark to gauge the future status of the city's tree canopy. An ArcGIS geodatabase with digital shape files produced during the study has been provided to the City.

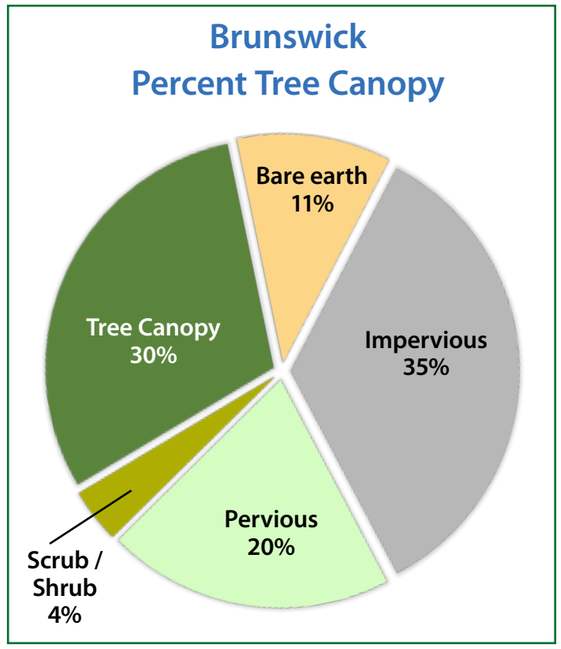
In addition, the City received tree canopy statistics for the following areas:

- Streets
- Neighborhoods
- Schools
- Parcels

The Tree Canopy Analysis can inform tree planting decisions to meet many goals, such as walkability, greenhouse gas emission reduction, energy savings, urban heat reduction, and economic revitalization.

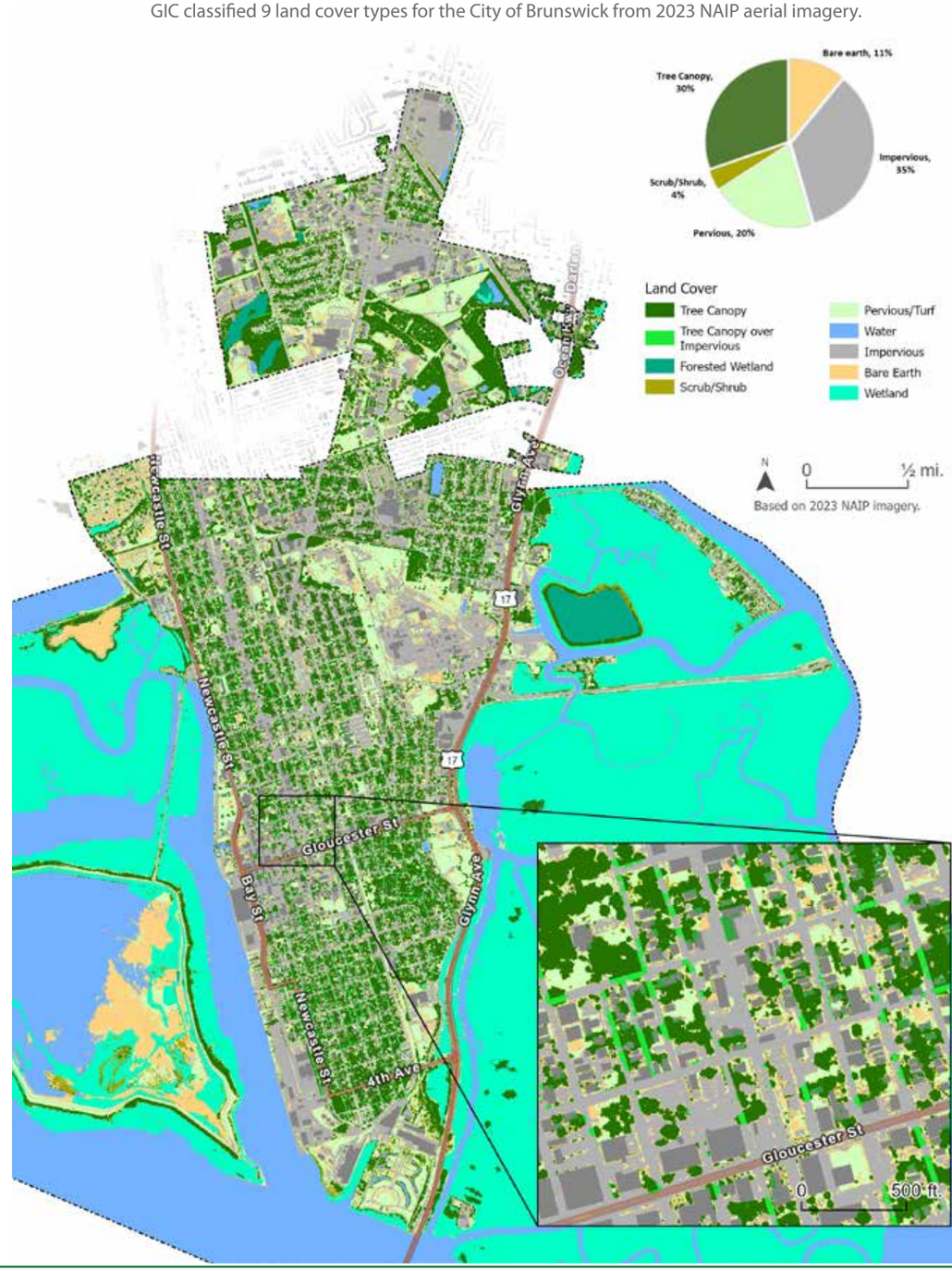
Maps

The following seven pages contain Brunswick's Tree Canopy Analysis Maps.



City Land Cover

GIC classified 9 land cover types for the City of Brunswick from 2023 NAIP aerial imagery.



Tree Canopy and Potential Planting Areas

Existing tree canopy (green) and potential planting area (orange) were determined based on land cover data and input from the City. Potential planting areas (PPA) depict areas where it may be possible to plant trees. All sites would need to be confirmed in the field prior to planting. The map shows PPA on both private and public lands.

On average, publicly owned land makes up 20%, while privately owned land makes up 80%, of the total land in a city. To successfully meet Brunswick's tree canopy goal to maintain 30% tree canopy, saving existing trees and planting trees must occur on both public and private land.

Existing Tree Canopy Coverage Along Streets

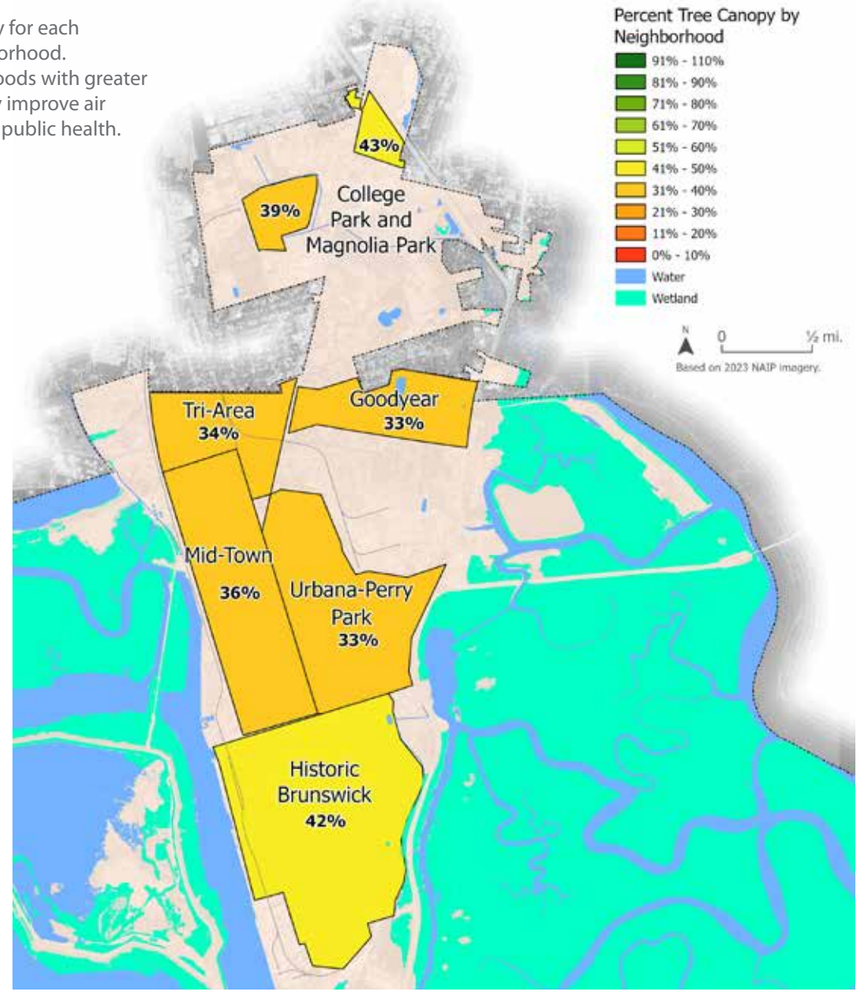
Streets that have the most canopy (dark green) and those that have the least canopy (red). Streets that lack good tree coverage can be targeted as appropriate for planting to facilitate specific City goals, such as safe routes to school or beautifying a shopping district.

Potential Tree Canopy Coverage Along Streets

If all potential planting areas within 50ft. of every road's center line were planted, this is what the canopy coverage along streets would look like.

Tree Canopy Coverage by Neighborhood

Tree canopy for each city neighborhood. Neighborhoods with greater tree canopy improve air quality and public health.

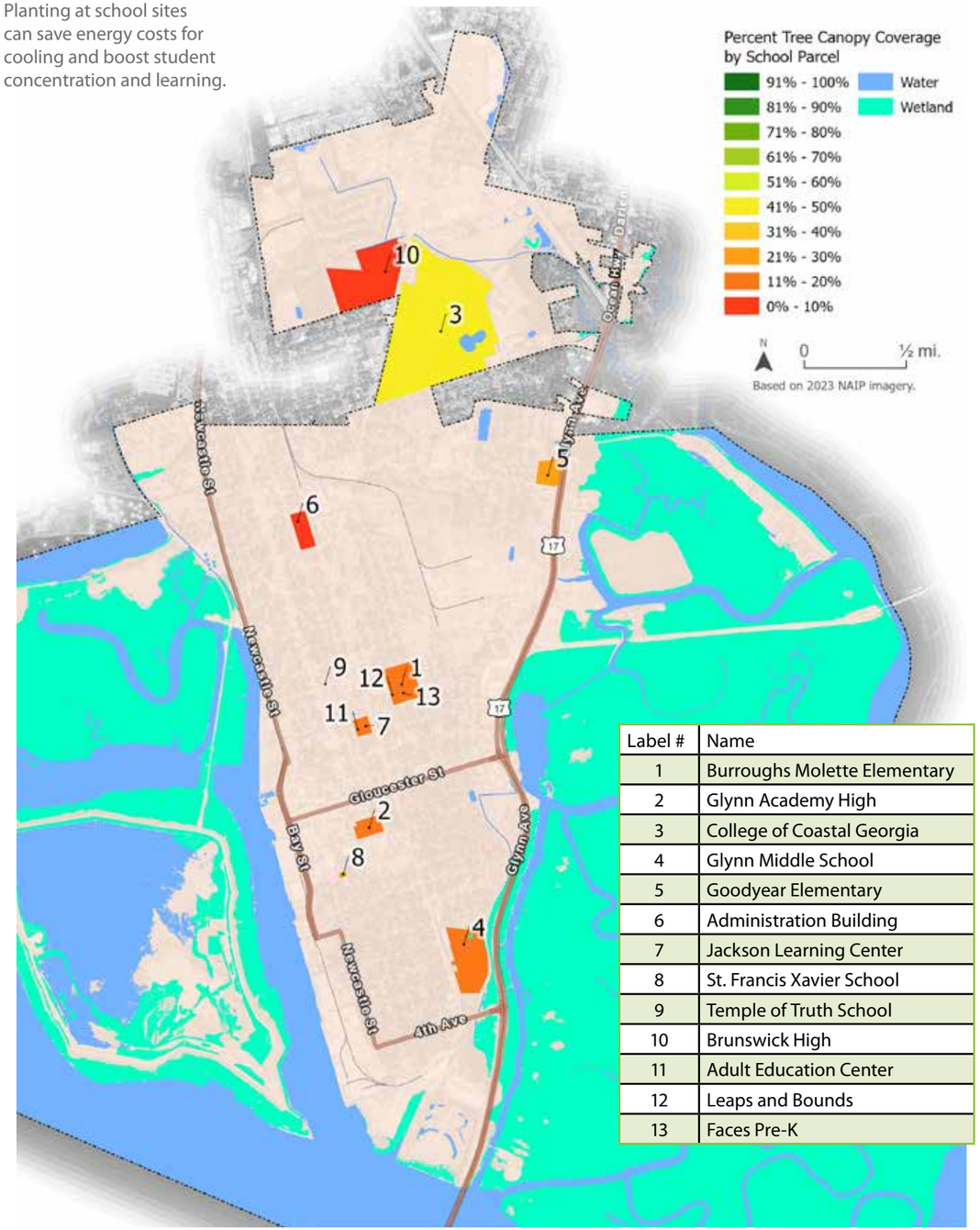


Neighborhoods

NPA Names	% TC	% Potential TC	PPA acres	Small trees	Large trees	Total trees
Urbana-Perry Park	33%	43%	26.0	2235	1470	3705
Tri-Area	34%	46%	17.2	1147	940	2087
Mid-Town	36%	46%	25.2	2121	1378	3499
Historic Brunswick	42%	51%	38.6	3416	2150	5566
Goodyear	33%	43%	10.8	1068	620	1688
Magnolia Park	39%	51%	4.7	539	257	796
College Park	43%	58%	3.9	402	202	604

Tree Canopy Coverage by School

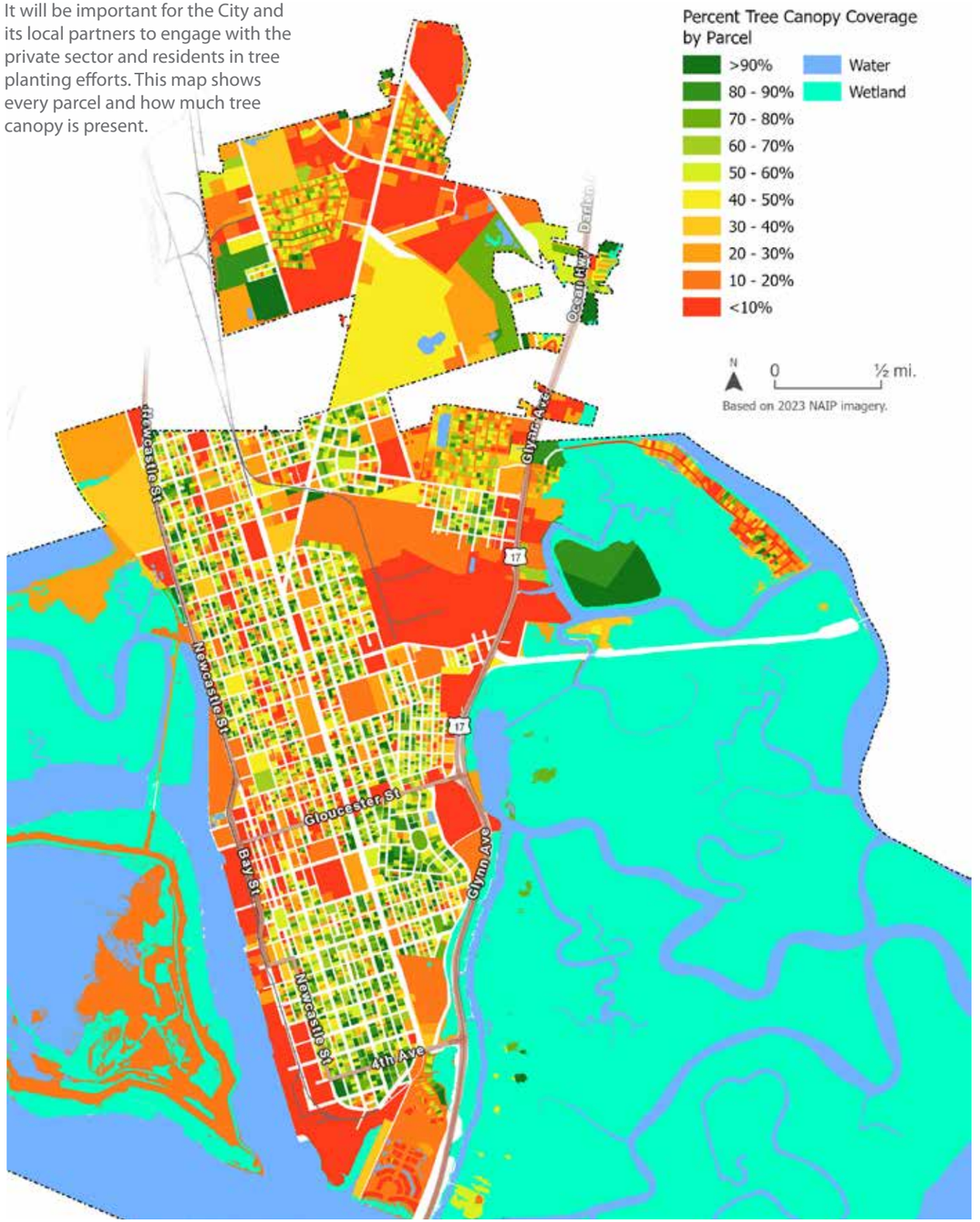
Planting at school sites can save energy costs for cooling and boost student concentration and learning.



Label #	Name
1	Burroughs Molette Elementary
2	Glynn Academy High
3	College of Coastal Georgia
4	Glynn Middle School
5	Goodyear Elementary
6	Administration Building
7	Jackson Learning Center
8	St. Francis Xavier School
9	Temple of Truth School
10	Brunswick High
11	Adult Education Center
12	Leaps and Bounds
13	Faces Pre-K

Tree Canopy Coverage Parcel

It will be important for the City and its local partners to engage with the private sector and residents in tree planting efforts. This map shows every parcel and how much tree canopy is present.

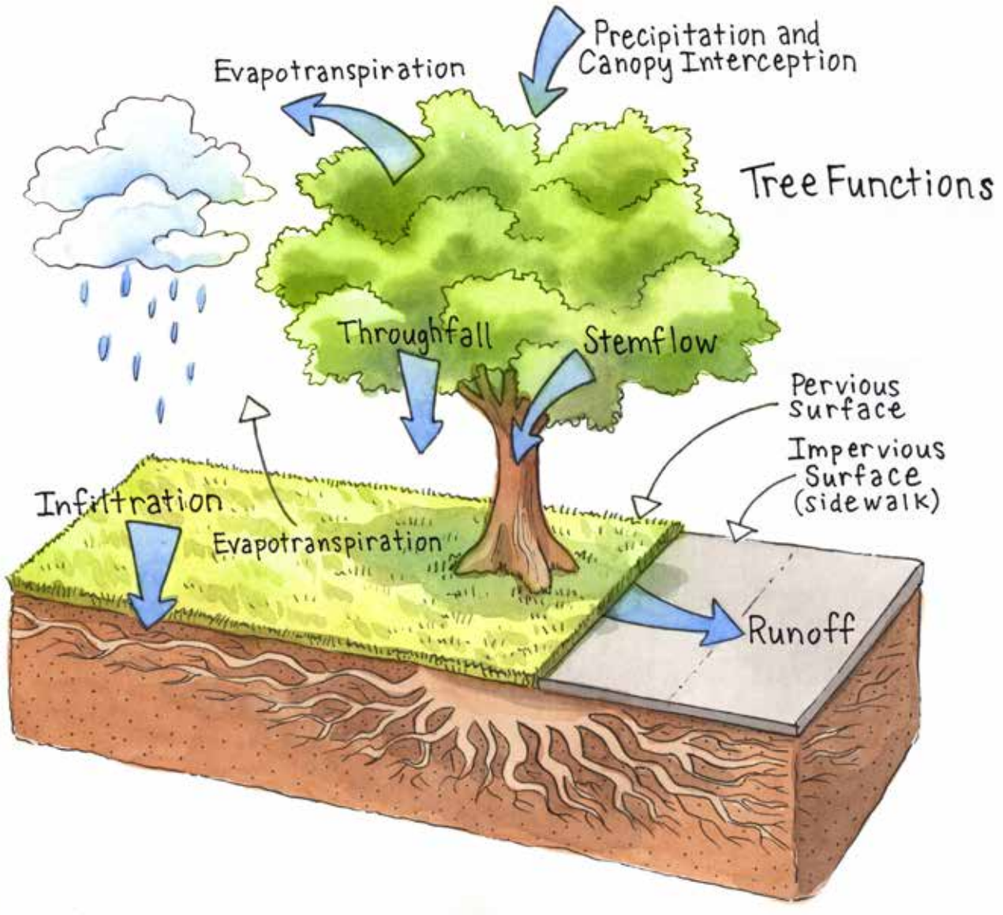


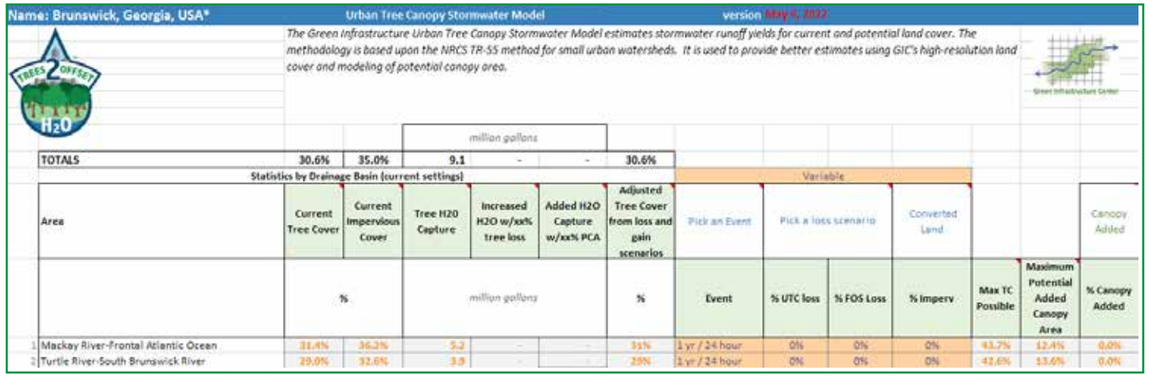
Calculating Environmental Benefits

Stormwater Uptake

Trees and forests are the best land cover for taking up urban stormwater and are recognized as such by forestry scientists and civil engineers (Kuehler 2017, 2016). Tree canopy stormwater interception varies from 100% at the beginning of a rainfall event to about 3% at maximum rain intensity. (Xiao et al, 2000).

Trees help capture and filter stormwater runoff. The Trees and Stormwater Calculator (TSW) Tool developed by the GIC estimates the stormwater interception, infiltration, and runoff of different land cover types. This methodology uses a modified version of the "curve number" approach, originally developed by the Natural Resources Conservation Service (NRCS) which factors in impacts of hydrologic soil groups, land cover types, hydrologic condition, and design/ management practices that impact runoff. The modified TR55 curve numbers (CN) provided by GIC include a factor for canopy interception. This approach allows for more detailed assessments of stormwater uptake based on the landscape conditions of the city's forests. It distinguishes whether the trees are within a forest, a lawn setting, a forested wetland, or over pavement, such as streets or sidewalks. This is because the conditions and the soils in which the tree is living affect the amount of water the tree can intercept.





Name: Brunswick, Georgia, USA* — Urban Tree Canopy Stormwater Model — version May 6, 2022

The Green Infrastructure Urban Tree Canopy Stormwater Model estimates stormwater runoff yields for current and potential land cover. The methodology is based upon the NRCS TR-55 method for small urban watersheds. It is used to provide better estimates using GIC's high-resolution land cover and modeling of potential canopy area.

			million gallons			
TOTALS	30.6%	35.0%	9.1	-	-	30.6%

Statistics by Drainage Basin (current settings) — Variable

	Area	Current Tree Cover	Current Impervious Cover	Tree H2O Capture	Increased H2O w/xx% tree loss	Added H2O Capture w/xx% PCA	Adjusted Tree Cover from loss and gain scenarios	Pick an Event	Pick a loss scenario		Converted Land		Canopy Added
		%		million gallons			%	Event	% UTC loss	% FOS Loss	% Imperv	Max TC Possible	Maximum Potential Added Canopy Area	% Canopy Added
1	Mackay River-Frontal Atlantic Ocean	31.4%	36.2%	5.2	-	-	31%	1 yr / 24 hour	0%	0%	0%	43.7%	12.4%	0.0%
2	Turtle River-South Brunswick River	29.0%	32.6%	3.9	-	-	29%	1 yr / 24 hour	0%	0%	0%	42.6%	13.6%	0.0%

The TSW Tool allows the City to model water uptake by the existing canopy and impacts from changes, whether positive (adding trees) or negative (removing trees).

The TSW model is a tool for seeing the stormwater impacts of adding or losing tree canopy and the resulting pollution increases or decreases.

For more about this methodology, please visit: https://gicinc.org/projects/resiliency/trees-and-stormwater
The GIC used its Trees and Stormwater Calculator (TSW) Tool to model stormwater and pollution reductions by city tree canopy. The model shows that, during a 10-year/24-hour rainfall event (7.06 inches), trees take up 14.9 million gallons of runoff, or about 23 Olympic swimming pools of water.

Brunswick's trees capture:

- 7,060 lbs./year of nitrogen
- 575 lbs./year of phosphorus
- 592 tons/year of sediment

The TSW Tool takes into account the interaction of land cover and hydrologic soil conditions within each watershed. The TSW Tool can also be used to run 'what-if' scenarios, specifically losses of tree canopy from development or storm damage, or increases in tree canopy from additional tree planting.

The conditions under and around a tree, such as the size of its planting box, the amount and type of open space, surface soils, drainage and root spread affect the infiltration of water. The TSW Tool uses plantable open spaces to determine how many more trees could be planted and how much additional nitrogen, phosphorus, and sediment pollutants new trees and their surrounding soils could absorb.

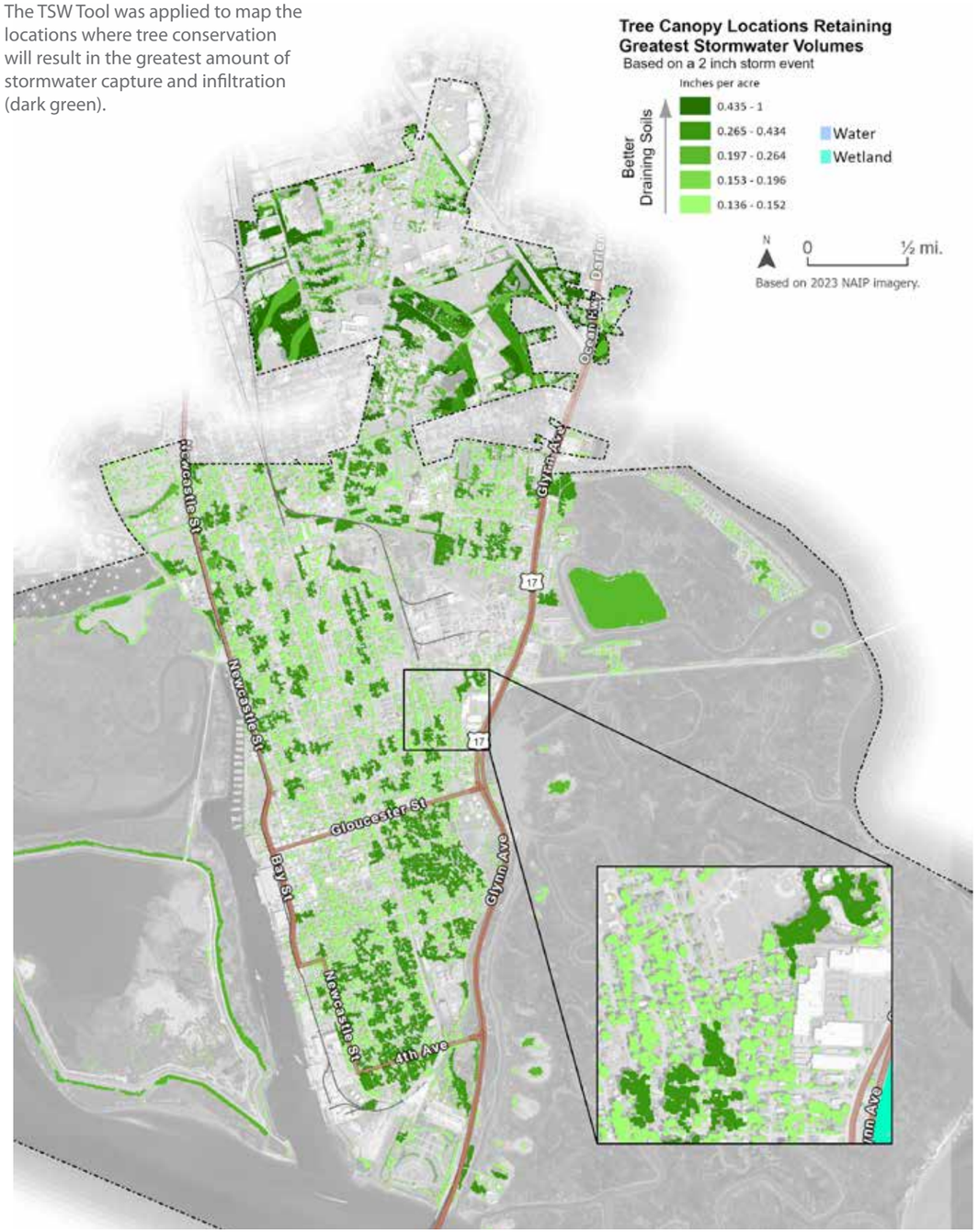
Removal of mature trees and existing forest results in the greatest increase in stormwater runoff. As more land is developed, the City should maximize tree conservation and encourage new tree plantings to maintain surface water quality and groundwater recharge. The following maps use soil types and tree cover to show the areas where it is most important to retain trees for stormwater uptake and areas where tree planting will have the most benefits for stormwater uptake.

Each year, Brunswick's trees capture:

- **7,060 lbs. of nitrogen**
- **575 lbs. of phosphorus**
- **592 tons of sediment**

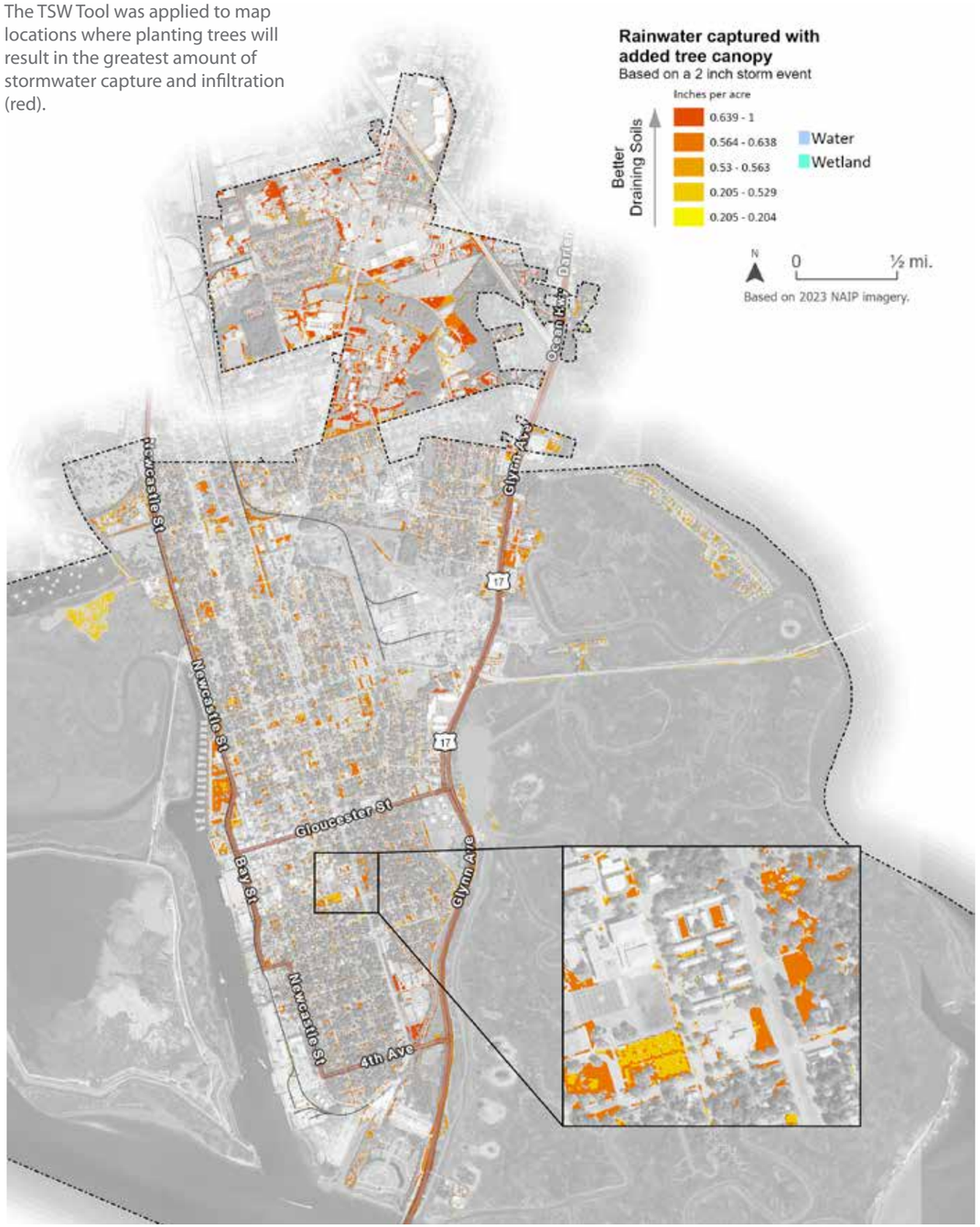
Best Tree Canopy to Save for Stormwater Infiltration

The TSW Tool was applied to map the locations where tree conservation will result in the greatest amount of stormwater capture and infiltration (dark green).



Best Tree Planting Locations for Stormwater Infiltration

The TSW Tool was applied to map locations where planting trees will result in the greatest amount of stormwater capture and infiltration (red).



Urban Heat and Equity

Urban heat is a growing concern as extreme heat continues to increase in Georgia with the changing climate. In Brunswick, the number of days above 100˚F is projected to rise from the historic average of 23 per year to 121 per year by the year 2070. To reduce temperatures, Brunswick can plant trees to cool the landscape. Inequities in the distribution of tree canopy and opportunities to correct them can be identified through tree canopy data, surface temperature data, and U.S. Census data that provides race and income statistics.

Extreme Heat

Average days per year temperatures over 100˚F

Where we are now	Where we are currently headed		If bold action is taken
Historically 1971-2000	Midcentury 2036-2065	Late Century 2070-2099	Extreme heat limited to
23 days	**90** days	**121** days	**73** days

In this table "bold action" refers to reductions in greenhouse gases through energy conservation. It does not consider the effects of planting more trees.
Source: Union of Concerned Scientists.
2019, Killer Heat Interactive Tool.

How much hotter is your hometown now than when you were born?

This interactive online tool allows a user to put in their hometown and birthdate to see how their hometown has changed since then and how much hotter it may get. The tool provides the average number of days over 90°F.

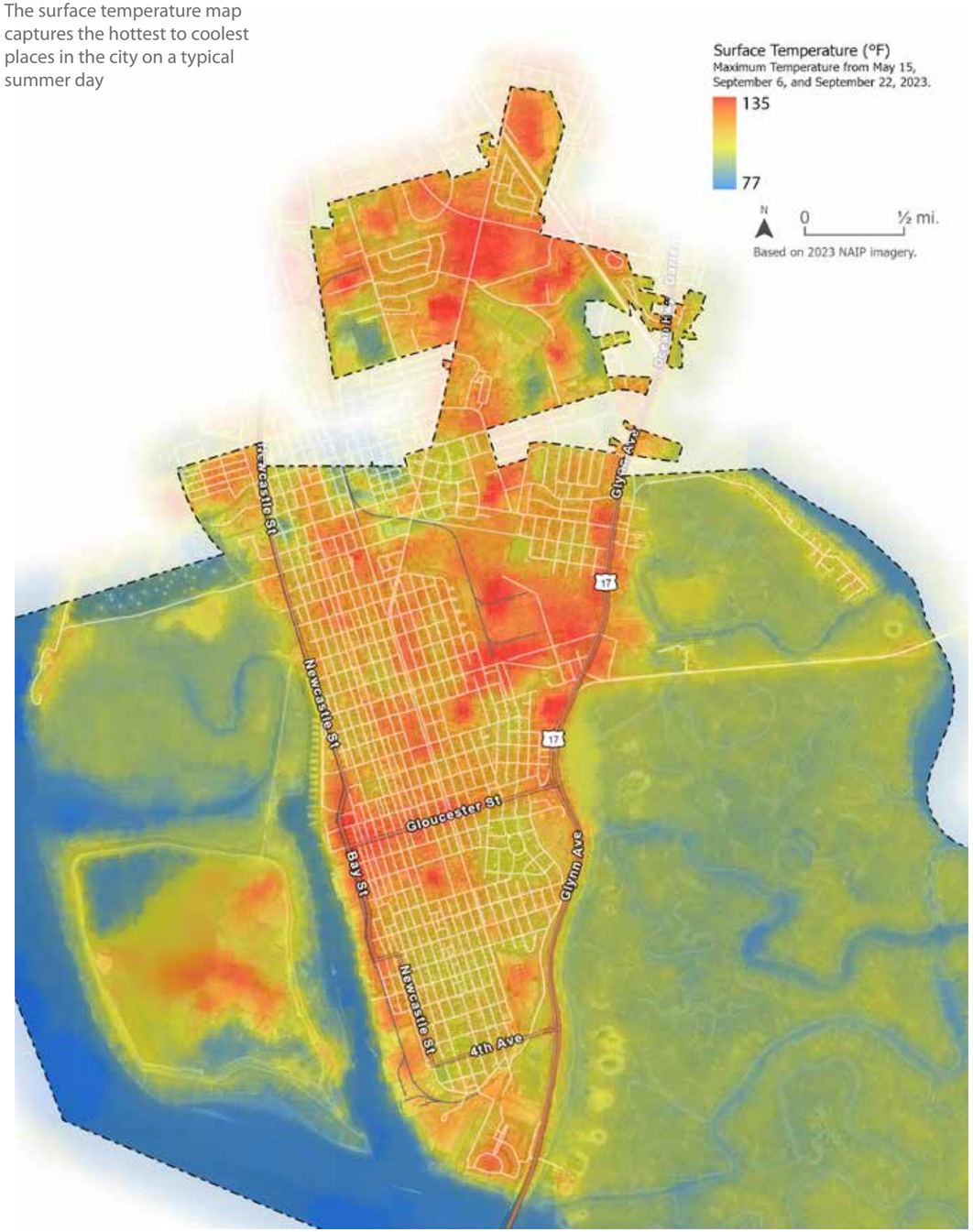
https://www.nytimes.com/interactive/2018/08/30/climate/how-much-hotter-is-your-hometown.html

What is Tree Equity?

Tree equity ensures all communities have access to the benefits that trees provide. Areas that have been under-resourced, having fewer trees and more heat than the rest of the City, are the focus of tree-planting efforts.

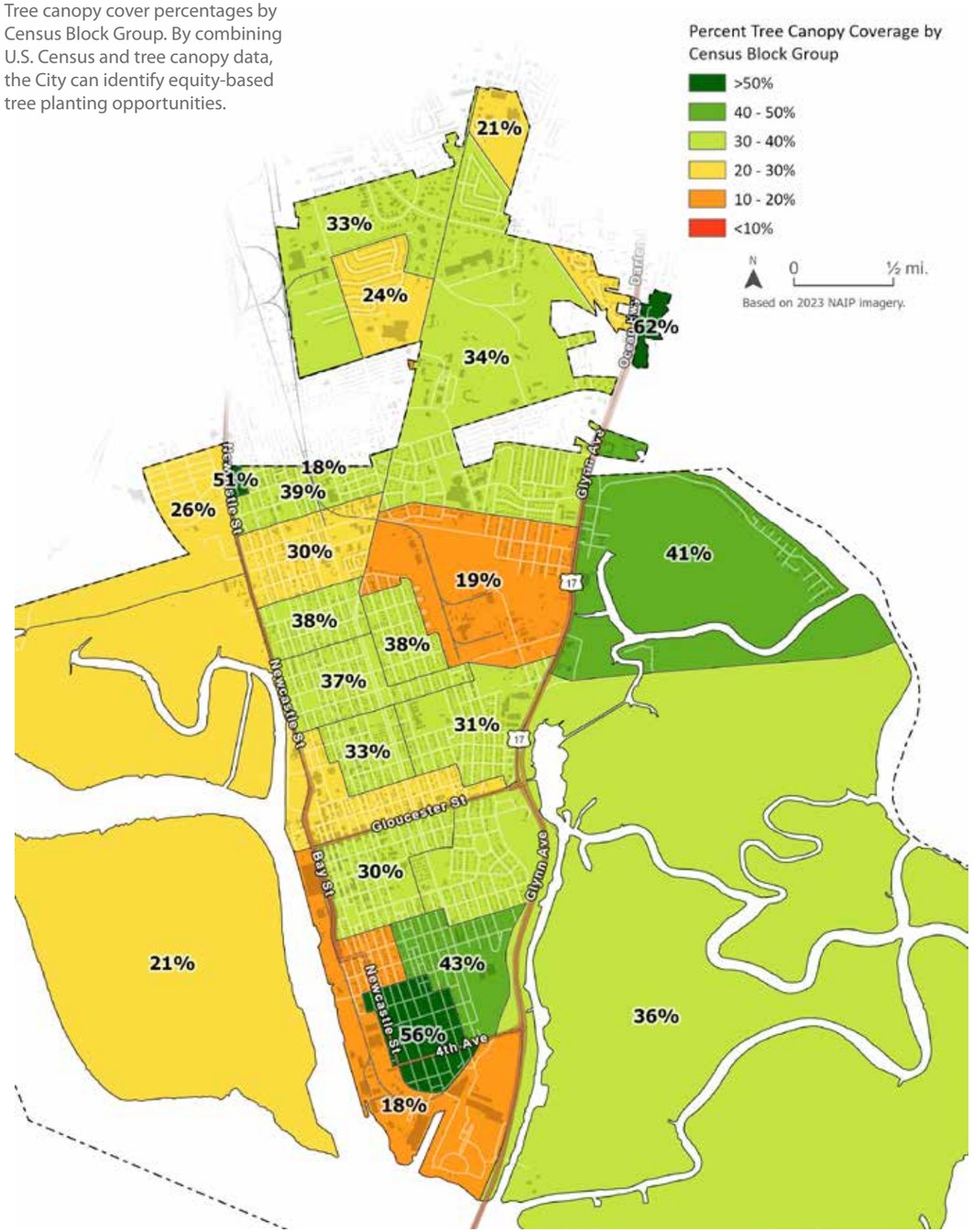
Surface Temperature

The surface temperature map captures the hottest to coolest places in the city on a typical summer day



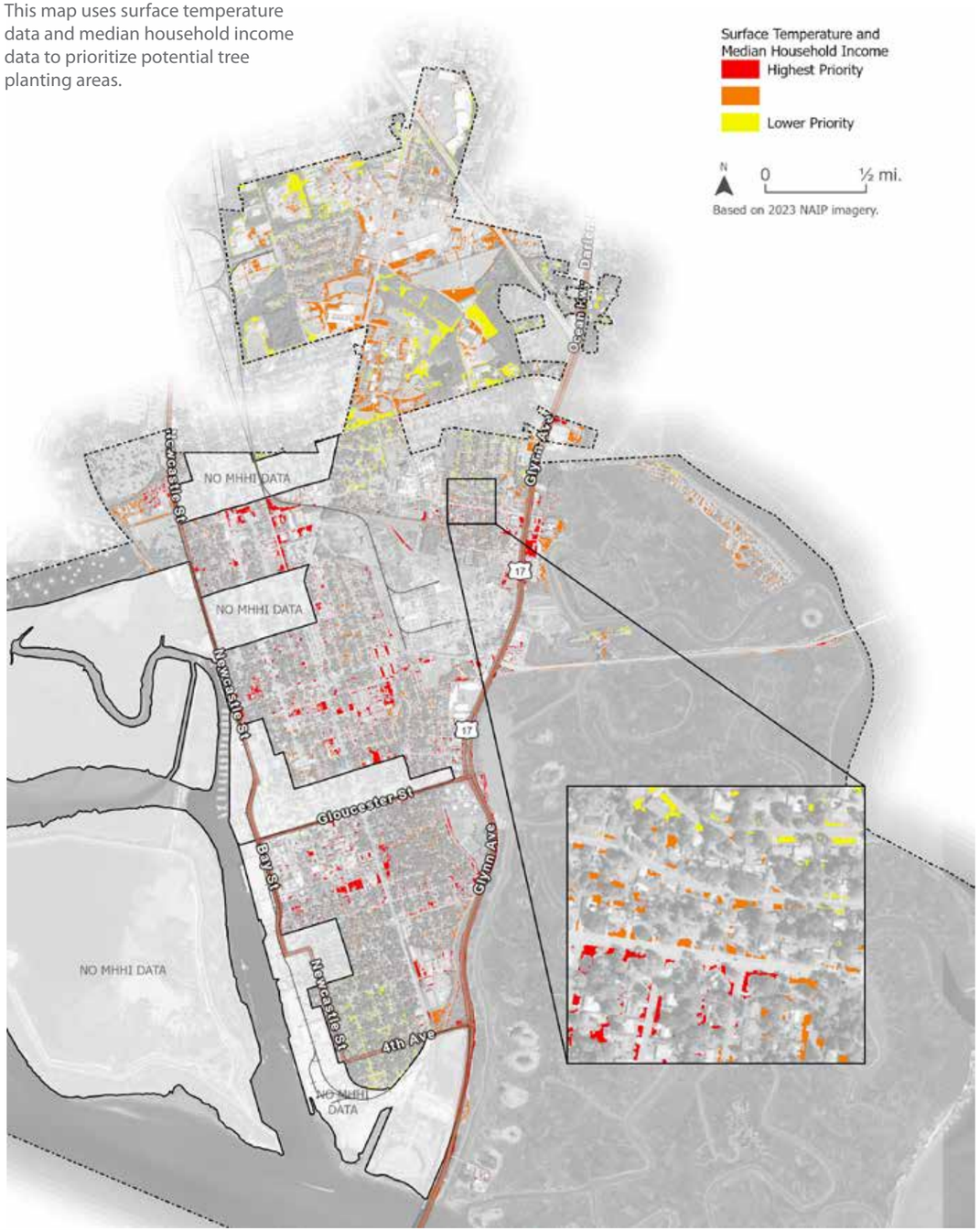
Tree Canopy Coverage by Census Block Group

Tree canopy cover percentages by Census Block Group. By combining U.S. Census and tree canopy data, the City can identify equity-based tree planting opportunities.



Heat and Income Priority Tree Planting Locations

This map uses surface temperature data and median household income data to prioritize potential tree planting areas.



Pounds of air pollution and greenhouse gases removed annually by all trees in Brunswick						
CO (carbon monoxide)	**NO_2** (nitrogen dioxide)	**O_3** (ozone)	**PM_{10}*** (particulate matter 10 microns)	**$PM_{2.5}$** (particulate matter 2.5 microns)	**SO_2** (sulphur dioxide)	**C seq** (carbon sequestered) in lbs
1,199	**23,434**	**158,677**	**48,177**	**7,194**	**7,194**	**62,487,824**

Air Quality

Air pollution removal values were calculated by applying the pollution removal values for each acre of tree cover from the i-Tree model. i-Tree is a peer-reviewed software suite from the USDA Forest Service that provides urban and rural forestry assessment tools.

Trees mitigate climate change by storing carbon in their tissue and sequestering atmospheric carbon from carbon dioxide (CO_2) in new tree growth. Current trees in the city are storing 125,783 metric tons of carbon that will be released back into the atmosphere when these trees die. Trees also capture particulate matter, ground-level ozone (O_3), nitrogen dioxide, and sulfur dioxide from the air, resulting in better air quality and healthier neighborhoods.

Investments in canopy at the neighborhood level can improve the respiratory health of residents.

Codes, Ordinances and Practice Review

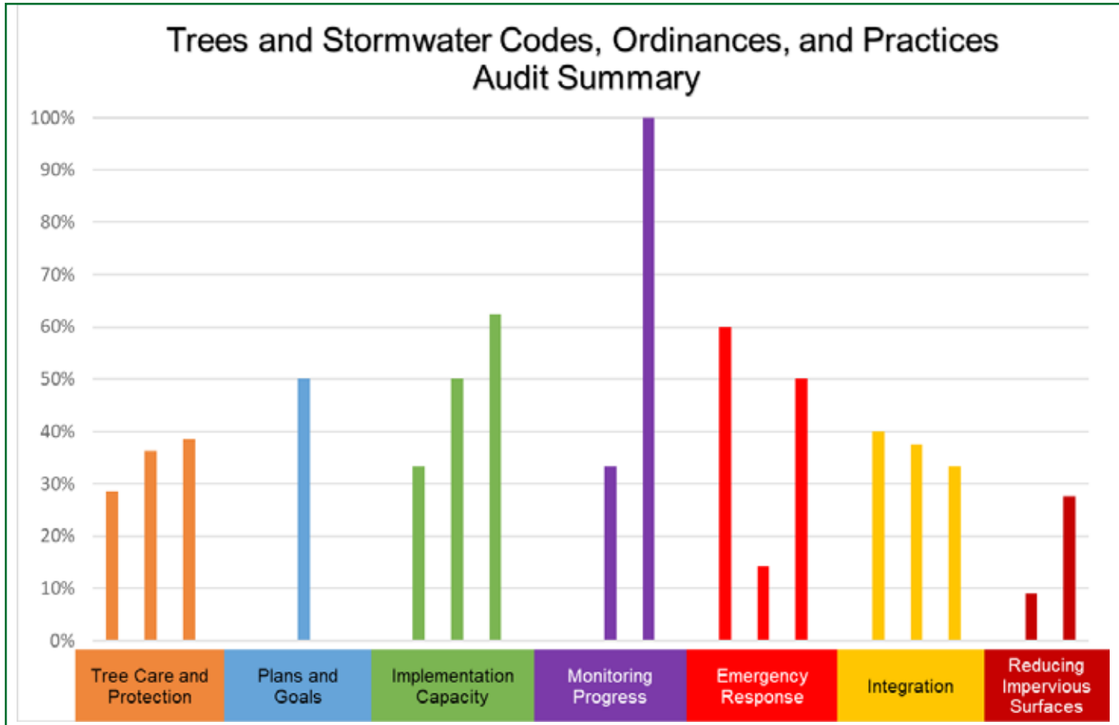
GIC performed a review of the city's codes, ordinances and practices to identify what policies and practices create more impervious surfaces (e.g., too much parking required), protect or restore pervious surfaces (e.g., conserving trees or requiring open spaces), and create a healthy urban forest (e.g., tree planting and care standards). Documents reviewed during the codes, ordinances and practices analysis for the project include relevant sections of the city's code that influence urban forest practices, runoff and infiltration. Additional data were gathered through interviews with city staff, whose input was incorporated directly into the spreadsheet summary prepared by the GIC. The spreadsheet provided to the city lists all the codes reviewed, interviews held and relevant findings. Points were assigned to indicate what percentage of urban forestry and planning best practices have been adopted to date by the city. The spreadsheet tool created for city codes can also serve as a tracking tool and for determining other practices or policies the city may want to adopt in the future to strengthen the urban forestry program or to reduce impervious land cover. The less city land that is paved, the more room there is to add trees.

IMPLEMENTATION CAPACITY

Codes and ordinances that specify tree planting and care are great but without property resources, implementation of codes and goal achievement will be almost impossible. Implementation capacity includes well-trained staff, funding, and community/advisory groups.

			Present?	Municipality Comments	Reviewer Comments	Source	What to Look For	Score	Potential Score
Advisory Boards/Groups									
		Is there a Tree Commission/Urban Forestry Commission/Tree Board?	yes		The tree board is codified in city ordinance	municode: part I article V division 4 section 2-346 Tree Board	Tree Commissions can organize and guide tree planting and conservation efforts. Members typically have more time devoted to specific tree initiatives than the average municipality staff member can. Members also typically have different perspectives, resources, and scopes of influence than the municipality staff members. Having a Tree Commission can expand the reach of urban forestry and can also serve a role in approving or rejecting requests to remove trees. Municipalities with an active Tree Commission/Urban Forestry Commission/Tree Board, score three points.	3	3
		Do the members of the Tree Commission/Urban Forestry Commission/Tree Board include representative from various occupations and areas of the municipality?	yes		It is to have 5 members that serve 3 year terms	municode: part I article V division 4 section 2-346 Tree Board	Ensure demographic and geographic representation of municipality areas by the Tree Commission. Tree Commissions representing geographic and demographic variations in the municipality score one point. Ensure that the tree board has met within the past year (if not, award no points).	1	1
Staff									
		Is a certified arborist on staff or retainer?	no	We use one on a part time, as needed basis. Not on retainer. Project bids require an arborist to be named if tree removals will be required		Chris Jones interview	A certified arborist on staff aids municipalities in making informed decisions regarding tree health and tree placement. Municipalities with at least one certified arborist on staff or a consultant hired via contract score three points.	0	3
		Is at least half of one staff member's job duties devoted to managing grants?	yes	There is a grant manager			Grants are a viable and creative way to achieve targeted missions in a municipality. However, grant management and the paperwork that accompanies most grants is time consuming. Municipalities with at least half of one staff member's job duties devoted to managing grants or other funding sources score one point.	1	1
		Is there a full time regular staff member that has authority over day-to-day urban forestry activities?	no	It is not anyone's primary duty but that usually falls on one particular person		Chris Jones interview	Urban forest management is a full time job even in a relatively small municipality. Municipalities employing at least one full time staff member with authority over day-to-day urban forestry activities score three points.	0	3
		If there is no arborist on staff, is there an allied professional (such as a	no		there is not	Chris Jones interview	Allied professionals knowledgeable about trees, design, soil, and/or wetlands are able to provide urban forest management expertise. Municipalities with at least one allied professional score one point.	0	1

A snapshot of the types of questions or sections of code evaluated.

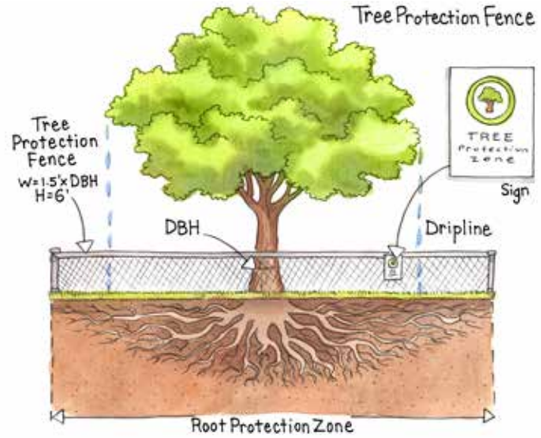


Summary scores for city codes and policies within each category. The city scored best in 'Implementation Capacity', 'Emergency Response', and 'Integration' but had room for improvement in 'Tree Care Protection', 'Plans and Goals, 'Monitoring' and 'Reducing Impervious Surfaces'.

Tree Care and Protection

The city can create better tree protection standards to protect trees and roots in construction zones. The current standard is to protect the Critical Root Zone (CRZ) which is defined to the tree's dripline, the area to the edge of the tree's canopy. However, the current city code does not provide details on how to adequately protect a tree during construction. In urban environments, many trees do not survive to their full potential life span. Factors such as lack of watering or insufficient soil volume put stress on trees, stunt their growth and reduce their lifespans. To encourage proper planning, planting and design for trees, the city can designate root soil volume and soil surface area standards. Tree roots need adequate soil volume and surface area to absorb water and promote gas exchange for healthy root growth. At a minimum, large canopy trees require 1000 cubic feet of soil volume to thrive. The most critical factor for the ability of a tree to withstand hurricane force winds is adequate soil surface area to allow for proper tree anchorage into the ground to reduce the risk of falling over (Duryea 2007). The following table provides recommended soil volume and soil surface area standards for healthy tree growth and resistance to wind. These standards can be compiled into a tree care and design manual that provides the necessary information for developers to create healthier and more resilient spaces in the urban landscape for trees.

Designing spaces where trees have adequate room to grow can avoid situations such as poor root growth, damages to the built space or stress or death of the tree.



Tree Protection Fence and Signage

GIC Recommendations

- Require and define tree protection fencing (TPF) around protected trees in development areas.
- Create a separate tree maintenance and design manual that establishes standards for tree planting and care.
- Require minimum species diversity standards in tree planting and landscaping plans.
- Establish a formula for replacement trees when protected trees are removed.
- Create a tree mitigation bank.

Plans and Goals

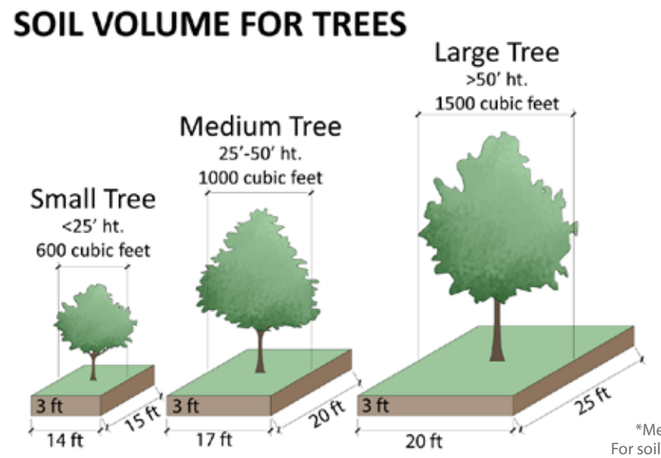
The creation of this tree resiliency plan is an important first step for the city. This plan provides baseline data and goals that will need to be revisited as the city works to meet its goal of maintaining its current tree canopy percentage over the next two decades. In addition, the data from this project can inform other citywide planning efforts such as its next updates to its comprehensive plan, parks and open space plans, greenway planning, stormwater master plans and more. By including trees in all municipal planning projects, trees will start to be seen and prioritized as green infrastructure.

GIC Recommendations

- Develop an Urban Forest Management Plan for public trees.
- Integrate tree canopy and resiliency data into the next comprehensive plan update.

Including trees in all municipal planning projects, trees will start to be seen and prioritized as green infrastructure.

Soil volume and soil surface area standards for various tree sizes



Soil requirements for trees based on their size at maturity

Tree Size at Maturity	Total Soil Area*	Distance From Paved Surface
SMALL TREE Height: shorter than 30 ft	10 ft x 10 ft	2 ft
MEDIUM TREE Height or spread: lesser than 50 ft	20 ft x 20 ft	6 ft
LARGE TREE Height or spread greater than 50 ft	30 ft x 30 ft	10 ft

*Measurements for when rootable soil depth is 3 feet or greater. For soil less than 3 feet deep, smaller maturing trees are recommended

Implementation Capacity

The City scored well on "Implementation Capacity" due to its very active Tree Board which is made up of passionate individuals and tree care professionals who represent the greater community. The city is currently working on contracting with an arborist to support tree maintenance and care of public trees which will also increase capacity.

GIC Recommendations

- Contract with a certified arborist or look into hiring one. (In progress)

Monitoring Progress

The city does require permits to remove or prune trees on public property and the city is working to start a tree inventory of public trees. This tree inventory data will provide valuable information on public trees and allow for better management decisions, particularly through a resiliency lens.

GIC Recommendations

- Conduct a public tree inventory. (In progress)
- Analyze public tree inventory data to assess species and age diversity. Integrate that analysis into an addendum to this plan.

Emergency Response

The city is proactive when it comes to planning for the management of the community forest ahead of natural disasters. The City also has standing contracts for hauling vegetative debris and monitoring in the aftermath of a storm. Critical routes for debris clearing have been pre-identified. These are crucial aspects of a post disaster plan which will assist the community in its recovery after a major storm. Other proactive measures the city can take to plan its urban forest for storms is to integrate this plan's resiliency strategies for trees and other green infrastructure into its next Hazard Mitigation Plan update. By including trees in the plan, it can open federal funding sources to mitigate tree-related hazards pre-storm such as greater tree mitigation and planting trees to reduce localized flooding.

GIC Recommendations

- Annually assess tree hazards along priority streets and around critical public facilities.
- Educate the public on trees as they relate to storms and disasters.
- Include green infrastructure in the hazard mitigation plan.

It is important to educate residents on proper tree care to avoid future problems. This tree was poorly pruned by removing all of the lower branches and increases the risk a branch will break during a wind storm

The city and local partners are implementing built green infrastructure practices to help soak up stormwater such as this large bioswale in the Veteran Memorial Park's parking lot (*left*) or this permeable pavement at Liberty Ship Park (*right*).

Integration

The city recognizes the role that natural areas and other green infrastructure practices contribute to stormwater management. The University of Georgia Extension and Georgia Sea Grant recently completed a feasibility assessment of potential stormwater green infrastructure opportunities in partnership with the city titled "Rethinking Runoff: Green Infrastructure Plan" that identifies sites where low impact development practices can be used to better manage stormwater runoff. The data from this plan can complement that study by integrating trees into those sites for additional stormwater management and infiltration. The wider use of built green infrastructure practices including planting trees can make a significant impact over the entire city landscape and reduce the volume of stormwater entering the stormwater system.

GIC Recommendations

- Include and call attention to trees in the stormwater program for their role in soaking up stormwater.
- Integrate tree plantings into low impact development practices such as bioswales or rain gardens to increase infiltration and stormwater management.
- Create a city webpage with information and links on the urban forest and tree planting efforts.

Reducing Impervious Surfaces

Another avenue for increasing the resiliency of the urban forest is by reducing impervious surfaces in the city. Impervious surfaces or hardscapes limit water infiltration, nutrient uptake and gas exchange, vital biological and chemical processes that affect healthy tree growth. In areas where space is tight or where heavy uses occur above, underground tree support cells can be used to stabilize and direct tree roots towards areas with less conflicts (e.g., away from pipes). In addition, impervious surfaces contribute to many negative environmental impacts such as increased surface temperatures and increased stormwater runoff. Policies and practices the city can pursue to help reduce impervious surfaces or better mitigate the impacts of them are increasing the use of Low Impact Development practices in development projects. Low Impact Developments (LIDs) use built green infrastructure techniques such as bioswales, rain gardens, green roofs, trees and other vegetation to better manage stormwater on site or delay stormwater from entering the municipal sewer stormwater system.

GIC Recommendations

- Incentivize reduction in impervious surfaces during development and update landscaping requirements for parking lots.
- Install structural cells in downtown to create more room for healthy tree growth.

Assessing Threats to Brunswick's Tree Canopy

Climate change is the main driver for many of the threats to Brunswick's urban forest. These threats include sea level rise, storms, flooding, heat and salt stresses, and insects, pests and diseases. GIC modeled the following threats to Brunswick's tree canopy to assess the level of risk each threat poses.

- Sea Level Rise
- Storm Surge
- Salt Stress
- Inland Flooding
- Heat Stress

Understanding the risks to the city's tree canopy, allows local stakeholders to mitigate some of these threats through policy or programmatic steps or to adapt urban forest management practices to respond to these stressors. While tree impacts from insects, pests and diseases were not modeled, findings from a literature review of trends in Coastal Georgia's future pests and diseases is included along with strategies for how the city can use other urban forest datasets (e.g. public tree inventories) to mitigate or adapt the city's tree canopy to be more resilient to future change.

Sea Level Rise

As the climate changes, sea levels are projected to rise in the Atlantic Ocean, Brunswick Sound, and local rivers. Planning for a resilient urban forest of the future requires consideration of sea level rise impacts to the city's urban trees and natural areas. Shorelines and marsh hammocks in Brunswick are experiencing erosion and saltwater inundation, threatening key coastal forest habitat for wildlife. Few species of trees are adapted to saltwater. As sea levels rise, coastal forests are flooded by saltwater, killing trees and leaving behind bleached dead trees (also referred to as "ghost forests").

To assess the impacts of sea level rise on coastal tree canopy, the technical advisory committee chose a 2ft. of sea level rise planning scenario which corresponds to the National Oceanic and Atmospheric Administration's (NOAA) intermediate-high sea level rise projections by the year 2060 for south coastal Georgia based on the Fernandina Beach, Florida gauge station.

The map on page 44 illustrates the extent of tree canopy that will be impacted. Tree canopy highlighted in red and pink will have the greatest risk to salt exposure in the year 2060 under 2 feet rise in sea level during subsequent high tides. Potential Planting Areas (PPA) at risk of sea level rise and high tides are highlighted in orange and light orange respectively. Under a 2ft. sea level rise scenario, 75 acres of tree canopy (5%) will be inundated by saltwater.

Sea Level Rise (2 feet)
Inundated PPA

This map graphic shows the extent of 2-feet of Sea Level Rise on the City's tree canopy and Potential Planting Areas (PPA) in and around Howard Coffin Park.

Sea level rise will also inundate Potential Planting Areas (PPA) in the city making them unsuitable for tree planting. A total of 21 acres (5.8% of available PPA) is projected to be underwater by 2060.

GIC Recommendations

- Avoid planting trees today in Potential Planting Areas (PPA) that may be underwater by 2060.
- Identify areas to replace canopy lost by future sea level rise.

Ghost forests are stands of trees along the coast killed by saltwater or salt spray such as this one in Camden County, Georgia.

Marsh Hammocks

Marsh hammocks are small upland islands nestled among the extensive salt marsh along Georgia's coastline. Marsh hammocks provide important habitat, such as nesting and roosting sites, for resident wading birds and terrapin turtles and serve as stopover locations for migratory birds. These hammock islands range from 1 acre to more than 1,000 acres. According to Georgia's Department of Natural Resources (DNR) Coastal Division, Georgia has approximately 1,200 hammocks totaling over 17,000 acres. Within the jurisdictional boundary of Brunswick, there are approximately 105 acres of hammocks of which, 12% or 13 acres are at high risk of being underwater by a 2ft. rise in sea level.

Salt Stress

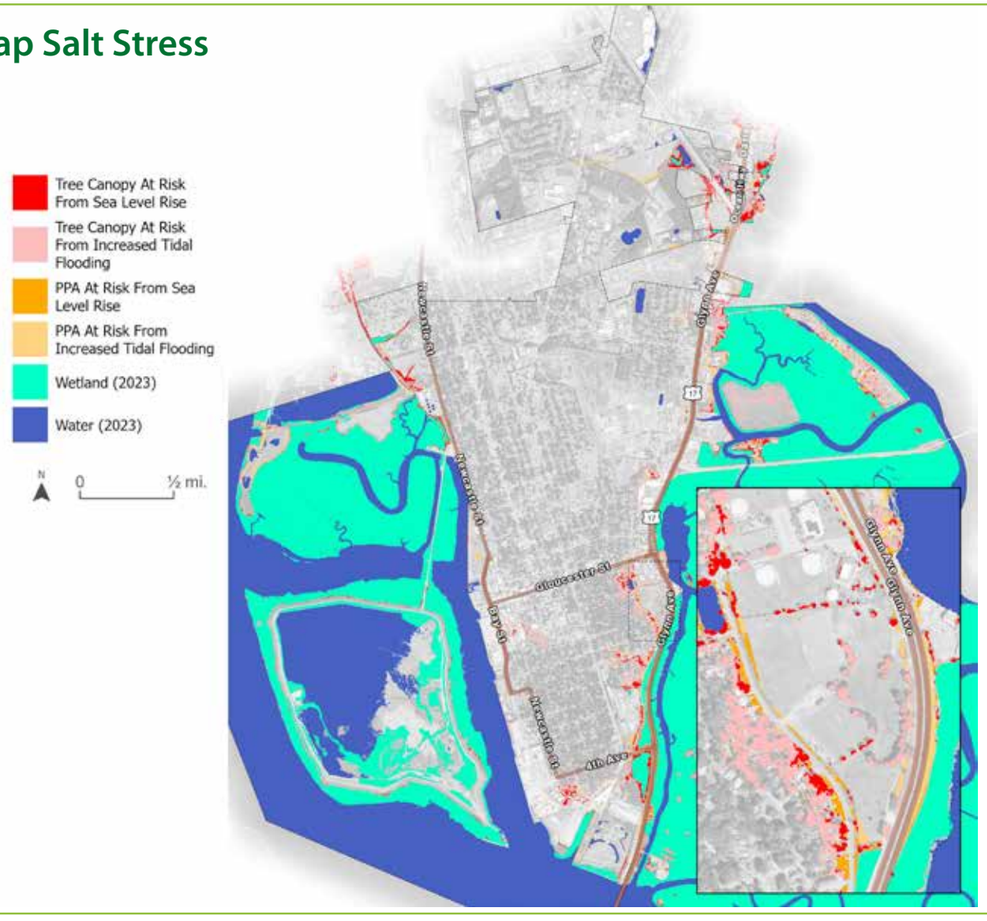
Salt inundation can devastate tree health. While there are a few tree and shrub species that tolerate salt spray and saline soils, most trees will die from too much salt exposure. Storm surge, sea level rise, high tide and wind-driven salt spray have the potential to introduce salt stress for trees. Permanent sea level rise cause decline and death. In addition, sea level rise, excessive pumping of groundwater and drought can lead to saltwater intrusion into underground freshwater aquifers impacting trees further upland. Trees adjacent to the shore will have greater exposure to high tide saltwater and salt spray impacts. Approximately 114 acres of tree canopy (7.7%) and 51 acres of Potential Planting Areas (PPA) (14%) are vulnerable to increased salt exposure due to a future increase in high tides.

Applying a large volume of fresh water to flush the soil of salts is one urban forest management tactic that can relieve salt stress in areas where the impact is temporary. A general rule of thumb for leaching salts from the soil is that 6 inches of freshwater will remove about half of the salt, 12 inches will remove four-fifths of the salt, and 24 inches will remove nine-tenths of the salt (Ruter and Pennisi 2022). The city can monitor trees for signs of salt stress in these high-risk zones and irrigate with freshwater to flush salt. However, this tactic only works in areas where trees are not constantly exposed to salt.

GIC Recommendations

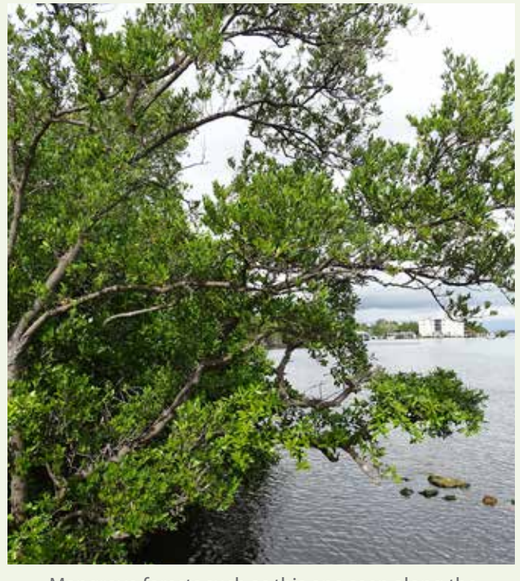
- Plant salt tolerant tree species in zones with high risk of salt stress. (*See list of salt-tolerant tree species, opposite page*).
- Develop a replacement plan for trees that are going to be severely stressed and likely killed by saltwater or salt spray.

Map Salt Stress



Why Not Plant Mangroves?

Mangroves are salt-tolerant wetland trees that form vital near-shore coastal forest habitat for a variety of marine and terrestrial animal species in South Florida. Similar to coastal salt marshes, mangroves also serve as buffers against storms and storm surge by dissipating wave energy before it reaches the mainland. Coastal scientists have found that, as global warming continues, mangroves are migrating northward, beyond their current native range. Mangroves are sensitive to freezing winter temperatures, so as winters become warmer, they can tolerate climates further north. Limited sightings of mangroves have been observed in Georgia, indicating potential range expansion. More time and observation are necessary to understand how these species will adapt to the Georgia coastline. However, natural resource specialists in Georgia are cautious about planting the species more widely in the region because the consequences of large-scale plantings of new mangrove forest habitat are unknown. New mangroves could potentially displace coastal salt marshes that currently provide critical habitat for a variety of indigenous wildlife.



Mangrove forests such as this one seen along the Florida coast provide important forest wetland habitat. However, it is too early to understand how the migration and establishment of mangroves northward will impact Georgia's coastlines.

Salt-Tolerant Tree Species

Street Tree = ST Open Space Tree = OP

Large-Sized Trees

Bald Cypress, *Taxodium distichum* (saline soils & salt spray) (ST, OP)

Blackgum, *Nyssa sylvatica* (salt spray) (ST, OP)

Black Locust, *Robinia pseudoacacia* (saline soils & salt spray) (ST, OP)

Black Walnut, *Juglans nigra* (saline soils & salt spray) (OP)

Catalpa, *Catalpa bignonioides* (salt spray) (ST, OP)

Eastern Red Cedar, *Juniperus virginiana* (saline soils & salt spray) (ST, OP)

Ginkgo, *Ginkgo biloba* (salt spray)** (ST, OP)

Live Oak, *Quercus virginiana* (saline soils & salt spray) (ST, OP)

Longleaf pine, *Pinus palustris* (salt spray) OP

Southern Magnolia, *Magnolia grandiflora* (saline soils & salt spray) (OP)

Sweetgum, *Liquidambar styraciflua* (salt spray) (OP)

Thornless Honeylocust, *Gleditsia triacanthos* var. *inermis* (saline soils & salt spray) (ST, OP)

Willow Oak, *Quercus phellos* (salt spray) (ST, OP)

Small to Medium-Sized Trees

American holly, *Ilex opaca* (salt spray) (ST, OP)

Black Cherry, *Prunus serotina* (salt spray) (ST, OP)

Carolina Cherrylaurel, *Prunus caroliniana* (saline soils) (ST, OP)

Kentucky Coffeetree, *Gymnocladus dioicus* (salt spray) (ST, OP)

Persimmon, *Diospyros virginiana* (saline soils & salt spray) (OP)

Red Buckeye, *Aesculus pavia* (saline soils) (ST, OP)

Sweetbay Magnolia, *Magnolia virginiana* (saline soils) (ST, OP)

Wax Myrtle, *Myrica cerifera* (saline soils & salt spray) (OP)

White Fringetree, *Chionanthus virginicus* (saline soils) (OP)

**Indicates non-native, non-invasive tree species.

Storms

In the Southeastern U.S., storms and severe weather events are increasing in frequency, duration and intensity, along with an increased occurrence of the strongest storms – those of Category 4 and 5 – (Kossin 2007). Tornadoes and other severe thunderstorm phenomena frequently cause as much annual property damage in the U.S. as do hurricanes, and often cause more deaths (Mellilo et al 2014). According to the National Oceanic and Atmospheric Administration's (NOAA) Office for Coastal Management's Historical Hurricane Tracks Tool, since 1853 the City of Brunswick has experienced 112 tropical storms, and most recently in 2024 Hurricane Debby (Category-1. The latest direct impact occurred from Tropical Storm Julia in 2016. Under future climate scenarios, the latest research suggests that favorable conditions for these types of storms will also increase (Diffenbaugh et al 2013).

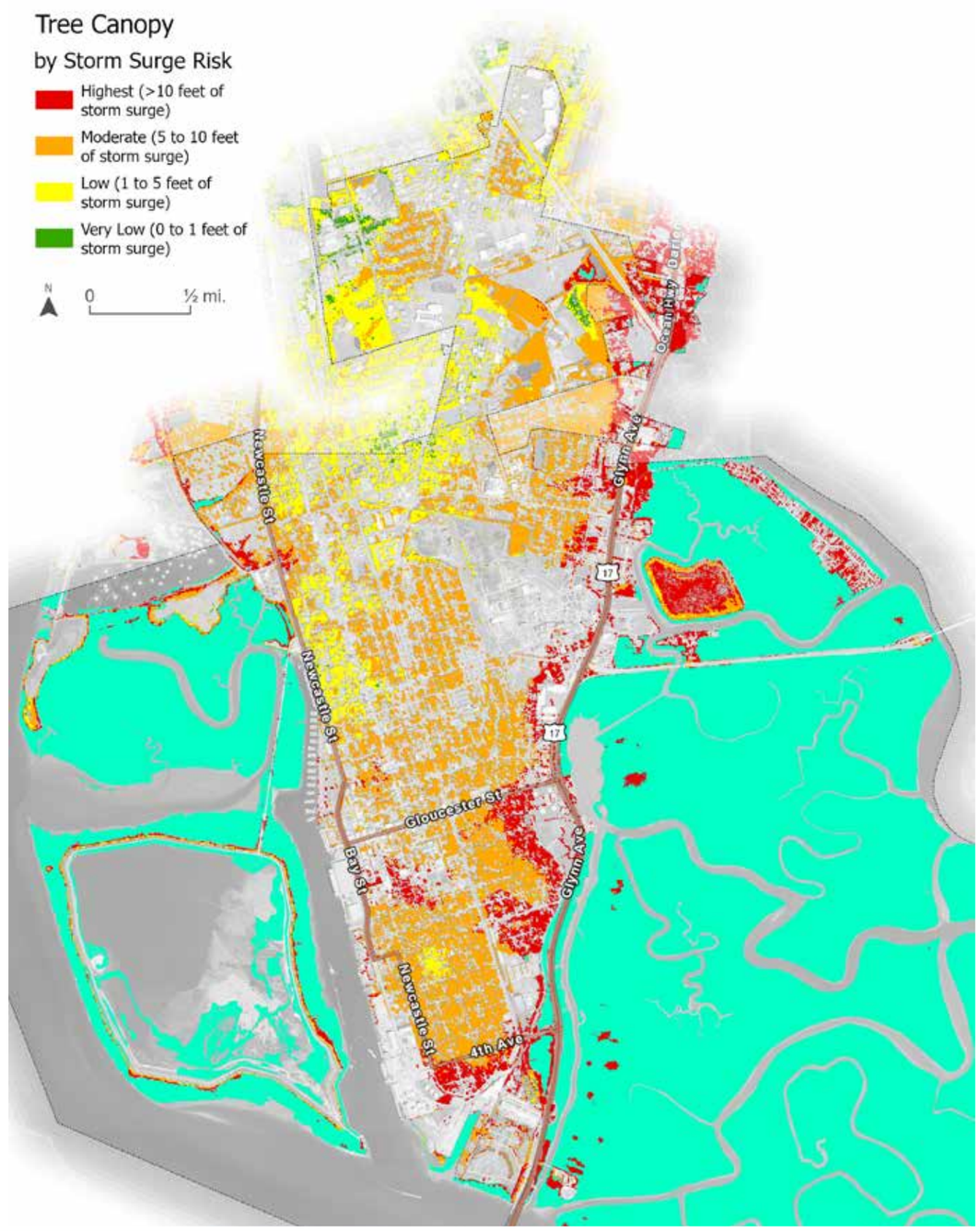
Storm Risk Stats:

- **376 acres** of tree canopy are at high-risk from a Category 3 hurricane.
- **688 acres** are at a moderate risk.
- **284 acres** are at a low risk.
- **16 acres** are at a very low risk.

Based on the historical record, a Category-3 hurricane was determined to be the most likely extreme tropical storm that could hit the city and was used to model storm surge impacts to existing tree canopy. Using NOAA's model data for a Category-3 hurricane, storm surge risk values ranged from the high-risk end of greater than 10 feet tall waves to the low end of between 0-1 feet of waves.

This sign in downtown Brunswick shows how high and far storm surge could drive inland during a Category-3 Hurricane.

Tree Canopy by Storm Surge Risk



Preparing the Urban Forest for the Next Storm

Research shows a sizeable upward trend in the number of storms that have caused substantial financial and other losses (Herring et al 2013). Storms often damage city and town infrastructure, requiring significant repair or replacement. These new climate trends elevate the importance of emergency preparedness and community disaster planning with a focus on mitigating risk to the city's infrastructure.

Another type of infrastructure that is often overlooked, and just as likely to be damaged by storms, is the urban forest. Most communities have experienced the challenges of blocked roads, downed power lines and flash floods caused by debris buildup and overflowing stream banks. But this problem can be drastically reduced, or even avoided through better care of our "green infrastructure." Collaborative storm planning between arborists and emergency management personnel reduces tree related damage, blockages, and debris that slow recovery time from storms while also improving the health and resilience of the urban forest.

Costs for cities are twice as high on a per unit basis for tree maintenance performed during crisis mode management than when conducted as part of routine tree maintenance (World Forestry Center 1993). And it's not only higher costs

Identifying potentially hazardous trees like this dying tree, the city can prioritize removals and reduce risk before the next storm.

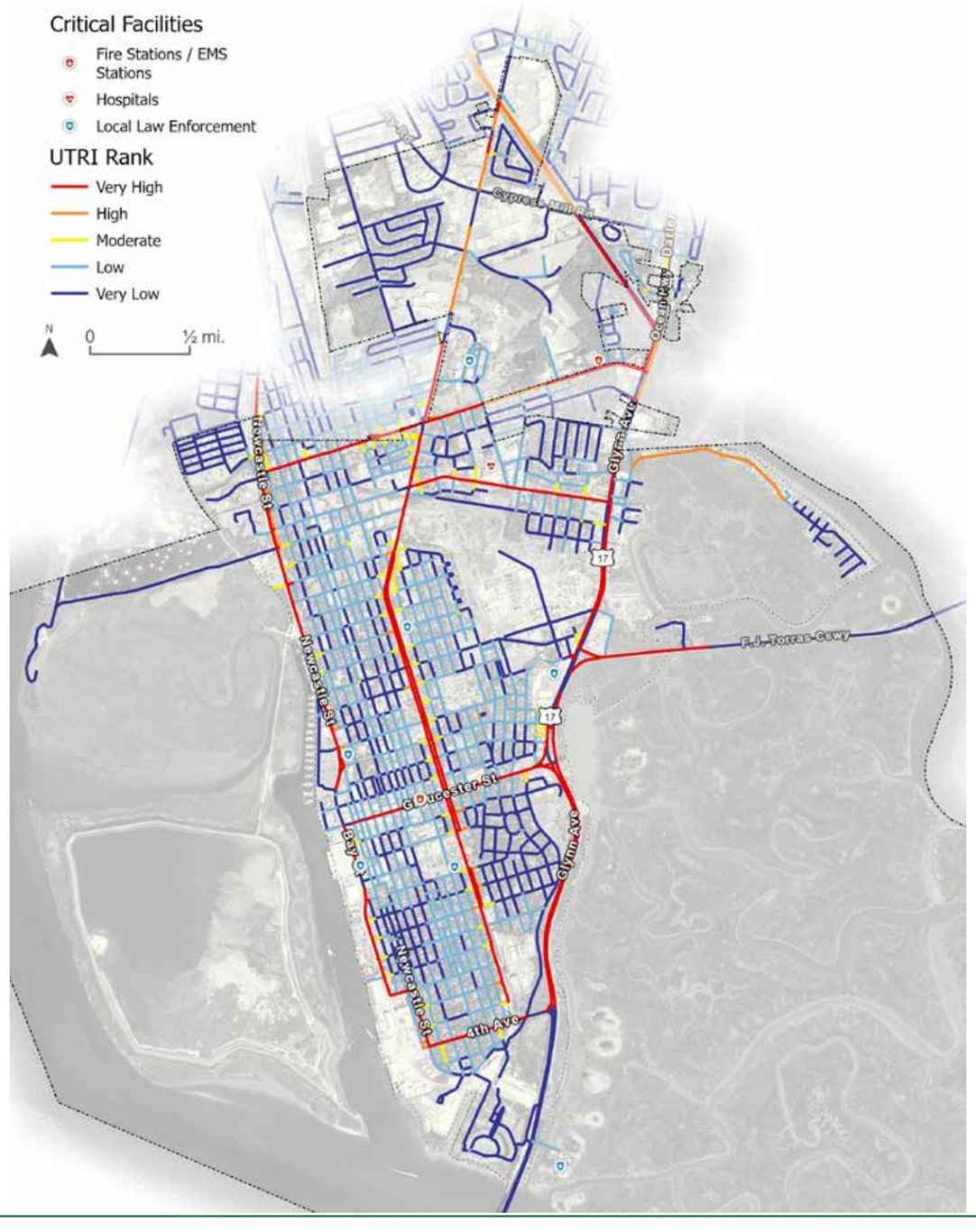
that are a concern. Cities need to be aware of the elevated liability associated with a lack of sound care and management of public trees. Investments in routine tree care and risk management can reduce property damage and personal injury caused by tree failure, thereby reducing the number of lawsuits, legal fees and settlement costs facing a community.

Less tree damage also translates to lower cleanup costs. Vegetative debris makes up approximately 30% of total debris generated during a storm. Using a formula developed the U.S. Army Corp. of Engineers to estimate debris from storms, GIC estimated the volume of vegetative debris that would be generated during a heavy rainfall Category-3 hurricane to be about 240,000 cubic yards (±30% margin of error). The less debris generated through proper tree pruning and maintenance, means less debris that needs to be picked up, processed and disposed of after a storm.

The Urban Tree Risk Index (UTRI) is a GIS tool that can help community arborists and emergency management personnel define, rank and map the areas of greatest need for tree risk assessment. It can rank areas of a community, from high to low priority, for tree risk assessment and can also establish routine inspection schedules. The tool analyzes such spatial data as roads, parcels, facilities and land cover data, in order to determine areas where the highest risk of tree failure overlaps with major corridors and prioritized routes.

The GIC modeled the Urban Tree Risk Index (UTRI) along city rights-of-way (ROW) and ranked them in importance for

Urban Tree Risk Index (UTRI) and Critical Facilities



Sample Tree Inspection Schedule

Name	Length (fee	Length (mil	UTRI Raw Sco	UTRI Rank	Inspection Schedu	Tree Canopy (%	Field Check and Verify Indi	Mitigation	Mitigation Complete Date
Martin Luther King Jr Blvd	582	0.110	137	5	Very High - Annual	12%			
F J Torras Cswy	2,121	0.402	147	5	Very High - Annual	2%			
G St	33	0.006	337	5	Very High - Annual	14%			
Parkwood Dr	892	0.169	132	5	Very High - Annual	9%			
Bay St	744	0.141	136	5	Very High - Annual	6%			
Altama Ave	633	0.120	89	4	High - 1-2 years	2%			
Mansfield St	158	0.030	82	4	High - 1-2 years	25%			
Riverside Dr	4,713	0.893	91	4	High - 1-2 years	21%			
N St	235	0.045	89	4	High - 1-2 years	40%			
4th St	1,017	0.193	96	4	High - 1-2 years	2%			
Norwich St Exd	734	0.139	82	4	High - 1-2 years	2%			
Lanier Blvd	283	0.054	52	3	Moderate - 3-5 years	61%			
Stacy St	311	0.059	71	3	Moderate - 3-5 years	4%			
Darien Hwy	775	0.147	50	3	Moderate - 3-5 years	2%			
Norwich St Exd	255	0.048	60	3	Moderate - 3-5 years	14%			
Darien Hwy	1,823	0.345	56	3	Moderate - 3-5 years	6%			
Richmond St	527	0.100	28	2	Low - 5-7 years	62%			
Wolfe St	516	0.098	29	2	Low - 5-7 years	42%			
Lee St	508	0.096	38	2	Low - 5-7 years	21%			
Martin Luther King Jr Blvd	512	0.097	32	2	Low - 5-7 years	6%			
Hardee Ave	492	0.093	44	2	Low - 5-7 years	41%			
New Jesup Hwy	2,485	0.471	31	2	Low - 5-7 years	11%			
Darien Hwy	1,189	0.225	31	2	Low - 5-7 years	5%			
Macon Ave	297	0.056	23	1	Very Low - 7-10 years	16%			
Lee St	430	0.081	25	1	Very Low - 7-10 years	35%			
Maple St	445	0.084	17	1	Very Low - 7-10 years	35%			

The city can use this tool to prioritize tree risk assessments on the highest priority streets and better plan and incorporate lower priority monitoring and management into long-term urban forest management plans.

routine inspections and tree risk mitigation. High priority streets are roads that lead to evacuation routes and provide access to emergency services and facilities such as fire stations, hospitals, police, or call centers. Active tree care and management significantly can reduce the risk of fallen trees or debris along these corridors and minimize the severity of consequences from blockages of critical routes.

A tree inspection schedule generated from the Urban Tree Risk Index analysis identifies which routes to prioritize for risk assessment. This spreadsheet helps with planning and annual budgeting for the urban forest program and can be useful for a future arborist hired by the city.

GIC Recommendations

- Conduct annual risk assessments to flag trees with defects along high priority streets and conduct follow up maintenance on high-risk trees.
- Plant wind-resistant trees along high priority streets that lead to critical infrastructure and emergency response facilities.
- Invest in proactive and routine tree care and maintenance to ensure trees are more resilient to storms.
- Educate the public on how they can make their trees storm ready.

Residents have experienced the major impacts storms have on trees.

Wind-Resistant Tree Species

Street Tree = ST; Open Space Tree = OP

Large-Sized Trees

Bald Cypress, *Taxodium distichum* (ST, OP)

Blackgum, *Nyssa sylvatica* (ST, OP)

Live Oak, *Quercus virginiana* (ST, OP)

Overcup Oak, *Quercus lyrata* (ST, OP)

Pond Cypress, *Taxodium ascendens* (OP)

River Birch (single-trunk), *Betula nigra* (ST, OP)

Sabal Palm, *Sabal palmetto* (ST, OP)

Sand Live Oak, *Quercus geminate* (ST, OP)

Southern Magnolia, *Magnolia grandiflora* (OP)

Sweetgum, *Liquidambar styraciflua* (OP)

Small to Medium-Sized Trees

American Holly, *Ilex opaca* (ST, OP)

Crape Myrtle, *Lagerstroemia indica*** (ST, OP)

Eastern Redbud, *Cercis canadensis* (ST, OP)

Flowering Dogwood, *Cornus florida* (OP)

Myrtle Oak, *Quercus myrtifolia* (ST, OP)

Persimmon, *Diospyros virginiana* (OP)

Sweetbay Magnolia, *Magnolia virginiana* (ST, OP)

Wax Myrtle, *Myrica cerifera* (OP)

White Fringetree, *Chionanthus virginicus* (OP)

Yaupon Holly, *Ilex vomitoria* (OP)

**Indicates non-native, non-invasive tree species.

Proactive and strategic tree care and maintenance can reduce the likelihood of trees or tree parts failing during a storm.

Inland Flooding

Brunswick's future climate is projected to be wetter in both the summer (4% rainfall increase) and winter (10% rainfall increase) seasons. Brunswick already suffers from drainage issues during heavy rain events resulting in ponding in residential yards and community spaces such as parks. With a wetter climate and increasingly severe storm events, the city's 1,686 acres of impervious surfaces will create more runoff and increase the risk of inland coastal flooding. The GIC modeled a 50-year storm event over a 24-hour period (13 inches of rain in 24 hours) to assess where stormwater runoff would possibly create localized flooding and pose greater flood risk to the tree canopy. The GIC did not account for existing grey stormwater infrastructure or Low Impact Development (LID) practices (rain gardens, bioswales, etc.) present in the city. The map (*opposite page*) illustrates the areas at higher risk of extreme flooding for a 50-year/24-hour storm event.

- 81 acres of tree canopy in the city are at high-risk from extreme flooding during a 50-year/24-hour event storm (13 inches).
- 19 acres of Potential Planting Areas (PPA) are at high-risk during this same event.

Trees can play an important role in mitigating some of these impacts by capturing, delaying and infiltrating stormwater before it becomes surface runoff. The GIC modeled the Potential Planting Areas (PPA) where tree planting efforts would be most beneficial to stormwater infiltration based on the underlying soils.

GIC Recommendations

- Plant more trees in areas with the highest infiltration capacity based on soils.
- Integrate trees and other green infrastructure practices into the City's Stormwater Master Plan.

Trees, Storms and Stormwater Scenario in Brunswick

An average 50-year/24-hour storm event in Brunswick would generate 10.3 inches of rain.

During this storm, the city's tree canopy would capture 19 million gallons of stormwater.

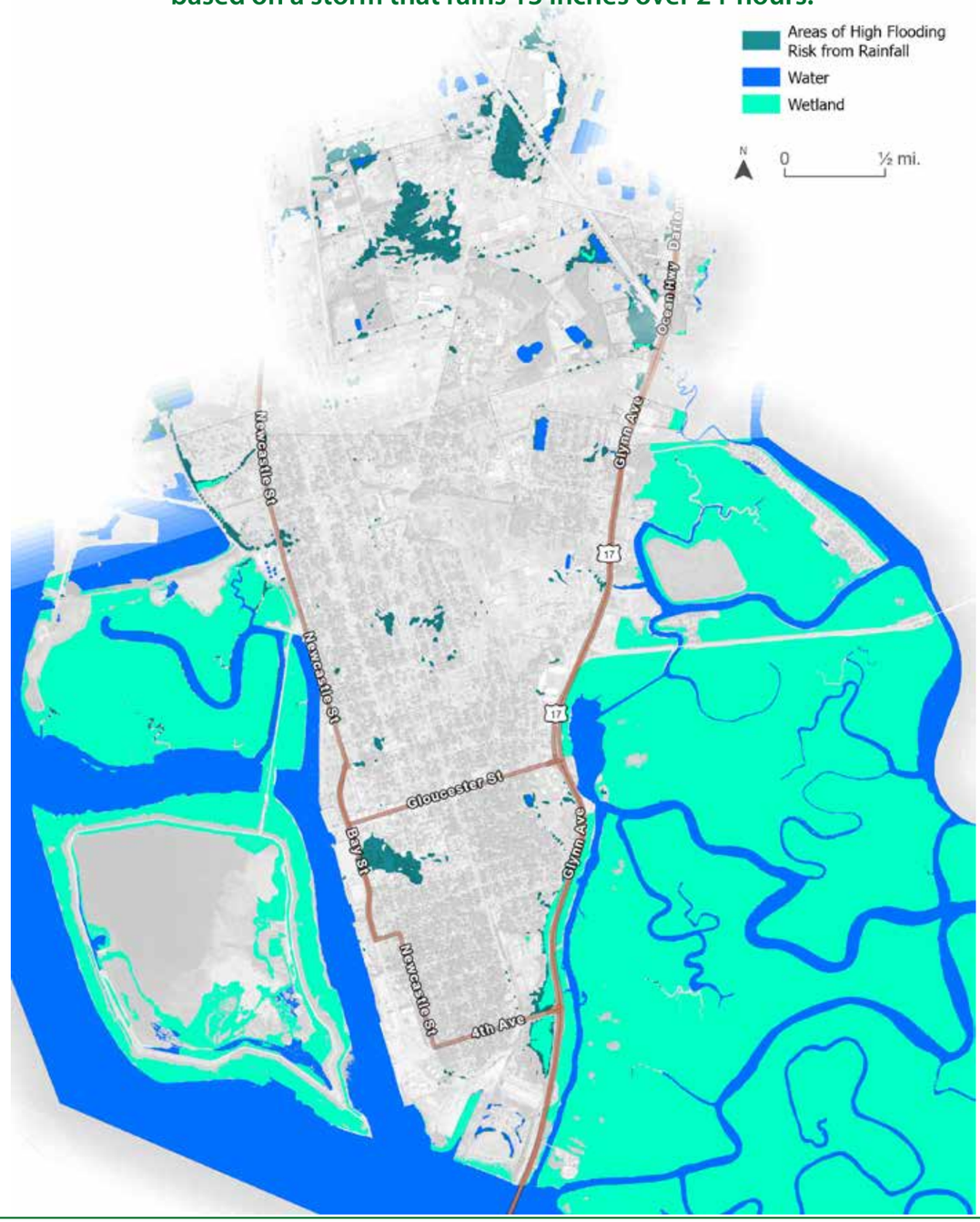
If Brunswick were to lose 1% of its tree canopy (52 acres) evenly across the city, it would generate an additional 440,000 gallons of stormwater runoff.

Conversely, if the city gained 1% tree canopy by planting 49 acres of new tree canopy across the city, then it would mitigate 750,000 gallons of stormwater runoff.

Parts of Brunswick already suffer from poor drainage and localized flooding. Trees can play an important role to help mitigate some of those impacts.

Inland Flooding

based on a storm that rains 13 inches over 24-hours.



Flood-Tolerant Tree Species

Street Tree = ST; Open Space Tree = OP

Large-Sized Trees

Bald Cypress, *Taxodium distichum* (ST, OP)

Blackgum, *Nyssa sylvatica* (ST, OP)

Overcup Oak, *Quercus lyrata* (ST, OP)

Red Maple, *Acer rubrum* (OP)

River Birch (single-trunk), *Betula nigra* (ST, OP)

Swamp White Oak, *Quercus bicolor* (ST, OP)

Sweetgum, *Liquidambar styraciflua* (OP)

Sycamore, *Platanus occidentalis* (ST, OP)

Tulip-tree, *Liriodendron tulipifera* (OP)

Weeping Willow, *Salix babylonica* (OP)

Willow Oak, *Quercus phellos* (ST, OP)

Small to Medium-Sized Trees

American Holly, *Ilex opaca* (ST, OP)

Carolina buckthorn, *Frangula caroliniana* (OP)

Hackberry, *Celtis occidentalis* (OP)

Ironwood, *Ostrya virginiana*, (OP)

Musclewood (American Hornbeam), *Carpinus caroliniana* (OP)

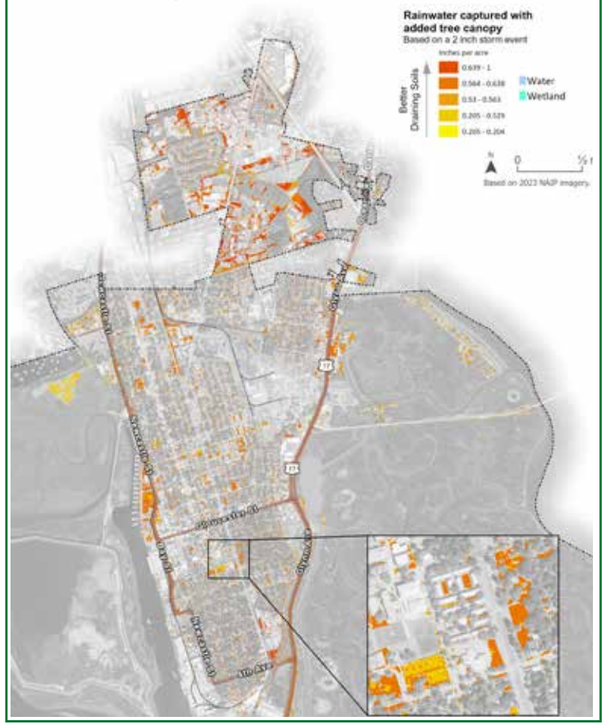
Persimmon, *Diospyros virginiana* (OP)

Red Mulberry, *Morus rubra* (OP only)

Sweetbay Magnolia, *Magnolia virginiana* (ST, OP)

Best Tree Planting Locations for Stormwater Infiltration

See page 31 for full size version of this map.



Heat Stress

More days of extreme heat will impact the people who live, work and play in Brunswick, as well as its trees. Tree species have a wide range of adaptability to heat. For example, flowering dogwoods and red maples are negatively impacted by heat while live oaks are found thriving on hot sites in many southern cities. Planting location and the surrounding urban environment are important factors to consider for certain tree species. The GIC modeled heat stress on Brunswick's tree canopy by using surface temperature data and the impervious land cover data to identify clusters of tree canopy that are more vulnerable to heat stress based on their surroundings. Impervious surfaces not only radiate heat from the surface but they also inhibit healthy root growth from proper irrigation and gas exchange. By identifying canopy at risk from heat stress, the city can proactively replace tree species that are ill-suited for high-stress environments with species that can tolerate higher temperatures or urban environments.

Heat Stress Stats

- 2.5 acres (0.2%) of tree canopy at very high risk of heat stress are located primarily downtown and within large commercial districts in the northern part of the city.
- 20.4 acres (1.5%) of tree canopy at high risk
- 85.3 acres (6.2%) of tree canopy at moderate risk
- 421 acres (31%) at low risk
- 840 acres (61%) at very low risk*

*Based on canopy (1,376 acres) within urban areas of the city, not counting hammocks in salt marshes.

PPA stats by temperature:

- 316 acres of Potential Planting Areas (PPA) registered hotter than 80 degrees Fahrenheit based on three dates (May 17th, September 6th, and September 22nd 2023).

The City now has data on the hottest planting areas and can select appropriate species that can withstand hotter summer temperatures.

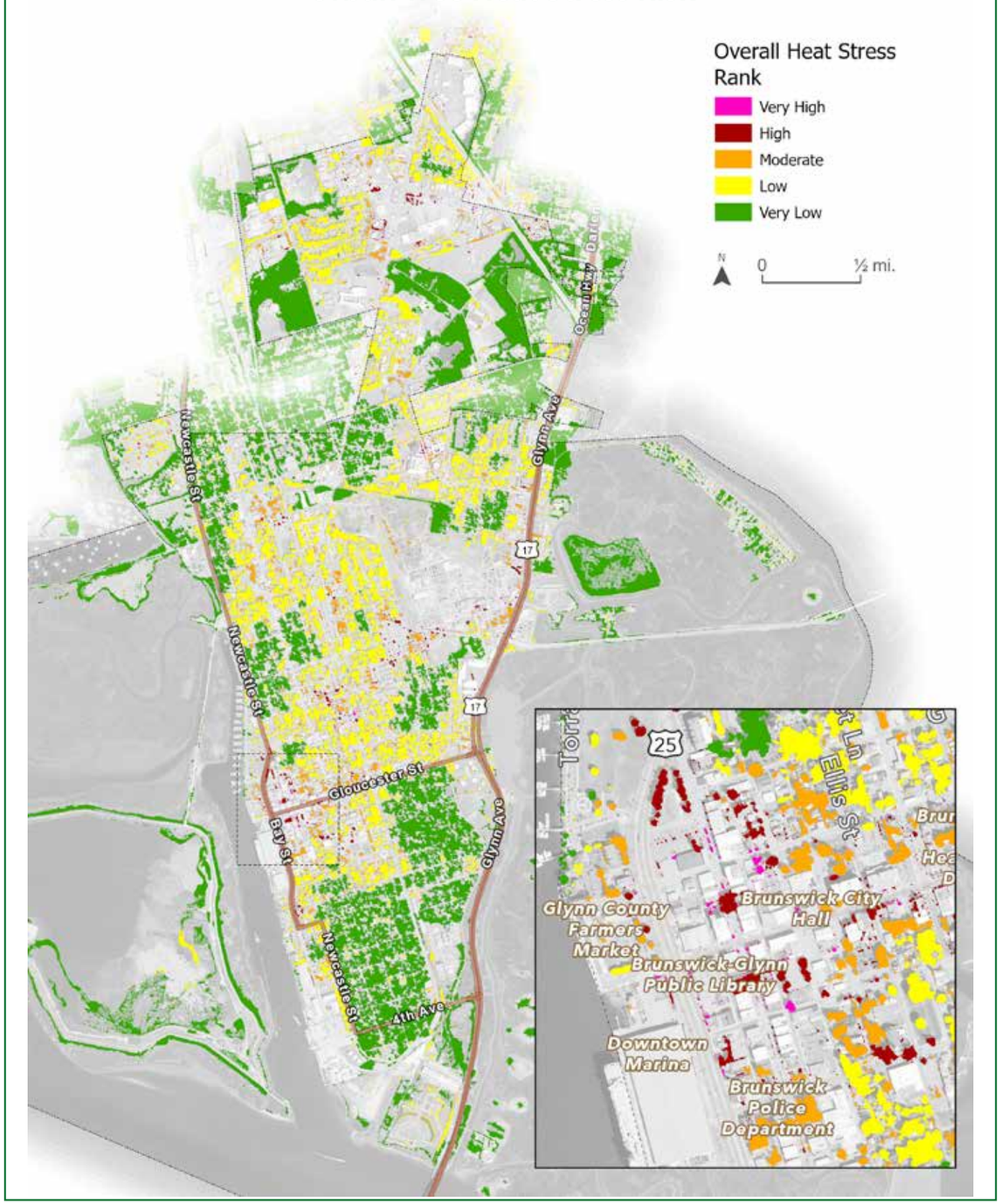
Hottest PPA

Degrees Fahrenheit

125 F

81 F

Urban Tree Heat Stress Risk



GIC Recommendations

- Mulch city park trees to reduce water stress during hot summer months.
- Irrigate trees during long periods of drought in high heat zones in the city such as downtown.
- Ensure adequate planting space (soil surface area and soil volume) for trees based on tree size.

Mulching trees in parks can reduce water stress by keeping the soil moist longer during hot summer months.

Heat-Tolerant and Drought-Tolerant Tree Species

Street Tree = ST; Open Space Tree = OP

Large-Sized Trees

Bald Cypress, *Taxodium distichum* (ST, OP)

Black Locust, *Robinia pseudoacacia* (ST, OP)

Catalpa, *Catalpa bignonioides* (ST, OP)

Eastern Red Cedar, *Juniperus virginiana* (ST, OP)

Ginkgo, *Ginkgo biloba*** (ST, OP)

Live Oak, *Quercus virginiana* (ST, OP)

Overcup Oak, *Quercus lyrata* (ST, OP)

Southern Magnolia, *Magnolia grandiflora* (OP)

Sweetgum, *Liquidambar styraciflua* (OP)

Thornless Honeylocust, *Gleditsia triacanthos var. Inermis* (ST, OP)

White Oak, *Quercus alba* (ST, OP)

Small to Medium-Sized Trees

American Holly, *Ilex opaca* (ST, OP)

Crape Myrtle, *Lagerstroemia indica*** (ST, OP)

Hackberry, *Celtis occidentalis* (OP)

Ironwood, *Ostrya virginiana*, (OP)

Japanese *Zelkova, Zelkova serrata*** (ST, OP)

Kentucky Coffeetree, *Gymnocladus dioicus* (ST, OP)

Persimmon, *Diospyros virginiana* (OP)

Sweetbay Magnolia, *Magnolia virginiana* (ST, OP)

Trident Maple, *Acer buergeranum*** (ST, OP)

Wax Myrtle, *Myrica cerifera* (OP)

Yaupon Holly, *Ilex vomitoria* (OP)

**Indicates non-native, non-invasive tree species.

Pests & Diseases

The impact of insect pests and diseases on the future of Brunswick's urban forest is difficult to quantify. There are many different species of insect pests and diseases, each with their own preferred hosts, mechanisms of injury and associated environmental conditions in which they thrive. However, the urban forest has several vulnerabilities which can make insect pests or disease outbreaks more severe. In many communities, the urban forest, particularly public trees, is less diverse than natural forests. The lack of diversity can make a pest outbreak more severe by creating pathways for pests to spread and increase the pest population dramatically due to the overplanting of single tree species. A recent example for many Eastern U.S. communities is the introduction of the Emerald Ash Borer (EAB), a non-native, invasive beetle that chews into the trunks of ash trees and kills them. Ash trees were a popular street tree planted in many U.S. cities after another common and widespread street tree, the American Elm, was killed by Dutch Elm Disease in the mid-20th century. Within a few years of EAB's introduction, communities along the Eastern seaboard saw a dramatic loss in tree canopy, in some places 20-30% canopy loss. Tree species diversity can limit the spread and impact an insect pest or disease can have over the entire urban forest.

Another vulnerability for the urban forest is the harsh environment in which the trees are located. Cities contain a lot of impervious surfaces (asphalt, concrete, rooftops) which generate greater heat and temperature, and restrict gas and water exchange with the trees' root systems. These harsher environmental conditions cause significant stress on trees which makes them more vulnerable to invasion from pests. In urban areas, street trees have the greatest exposure of tree mortality from pests due to harsher environmental conditions and vector pathways. A study looking at street trees in Raleigh, North Carolina found 70% more trees were in poor condition on warmer sites than cooler sites, and there was also an increase in abundance of armored scale insects on red maple (Dale et al 2014). Tree genera that are projected to be the most vulnerable to pests include maples, oaks, cherries and pines (Hudgins et al, 2022). The three types of pests most likely to cause problems are scale insects, beetles/borers and caterpillars, with Asian wood boring beetles as the highest future risk (Hudgins et al 2022).

Environmental stressors mapped in this plan (e.g. urban heat, flooding, salt, etc.) increase the susceptibility of woody plants to pests. These data can be used to site proper tree species in locations based on environmental conditions and their tolerances. Below are some general takeaways about managing urban forest pests through cultural practices, urban site design and best management practices.

Scale Insects

Scale insects are small insects that have a waxy armor in their adult life stage that protects them from predators and makes them difficult to treat with insecticides. Scale insects tend to weaken trees and not kill them, although they can kill a stressed tree or contribute to its decline. Scale insect infestations tend to develop faster in hot urban areas on heat stressed trees. The Gloomy Scale insect is a native pest that preys on red maples and is known to thrive in urban areas. Observations show gloomy scale expanding its range, possibly due to climate change.

The most effective treatment to guard against harm from pests is to maintain plant health. Irrigation of trees maintains health and reduces stress, especially during long hot, dry periods and in locations susceptible to heat island such as downtowns and parking lots. As new trees are planted in these high stress areas, it is important to ensure there is adequate soil volume for root growth and proper site preparation and installation.

Scale insects are covered with a waxy shield that makes them hard to kill. These scale insects are attacking and feeding on a crape myrtle.

Beetles & Borers

Several different beetle species are a potential threat to the Brunswick's trees. Many of these are borers, meaning these beetles chew into the trunks or branches of a tree and attack the vascular system, disrupting the flow of water or sugar transport from the leaves to the roots. Ambrosia beetles are a significant threat to Georgia trees, and the Red Bay Ambrosia beetle a particular concern for red bay trees (*Persea borbonia*) and spreading laurel wilt disease along Georgia's coast. Ambrosia beetle attacks are more likely in stressed trees, especially trees impacted by floods or planted too deep. Asian Longhorned Beetles (ALB) are another potential threat to Brunswick's hardwood trees. ALB prefers to feed on maples but can also attack a wide variety of other hardwoods such as birch, buckeye, elms and willows. According to the University of Georgia (UGA) Extension, while the species has not been detected to date in Georgia, it is currently under quarantine not too far away in Charleston and Dorchester Counties, South Carolina. This species is commonly found in urban and suburban areas and once trees are infested, they will eventually die. Early detection and monitoring are key for many beetle and borer species.

Photo credit: USDA.gov

The Asian Longhorned Beetle is a significant potential threat to Brunswick's urban forest. Monitoring for early signs can prevent an outbreak and minimize how much damage and mitigation is required.

Caterpillars

Caterpillar is a general term for the larval stage of many different species of moths and butterflies. Some of these species are known pests of trees with many caterpillar species having a preference to attack oak species. Caterpillars are defoliators, they voraciously eat the leaves of trees, weakening them and causing further stress. A caterpillar infestation will not likely kill a well-established healthy tree, but it could defoliate, weaken and kill a young tree, so young infested trees should be treated with an insecticide. Cultural practices that encourage healthy tree growth such as adequate irrigation, mulching, fertilizing and reducing tree stress are key preventative measures for managing caterpillars as urban forest pests.

Many varieties of caterpillars can defoliate trees. The trick is to identify and treat young trees quickly to avoid tree mortality.

General Best Practices for Urban Forest Pest Management

Species Diversity

The greatest preventative measure for limiting the damage of a pest or disease outbreak is for the city to maintain a diverse urban forest. The urban forest relies on similar principles of crop management where monocultures are more susceptible to pest outbreaks. A good rule of thumb is a 10-20-30 composition, where no more than 10% is any one species, no more than 20% from a specific genus and no more than 30% from a family. To illustrate as example, no more than 10% of the city's public trees should be live oaks (*Quercus virginiana*), no more than 20% in the genus *Quercus* which includes all species of oaks (Northern red, Scarlet, Water, Laurel, etc.) and no more than 30% should be from the Fagaceae family which includes oaks, beeches and chestnuts.

Other measures include promoting and encouraging native species diversity where appropriate. Native species support a greater diversity and abundance of insects and wildlife than non-native, non-invasive species and can help boost populations of beneficial predators which can limit pest outbreaks. Native species, in general, are also more tolerant and resilient to local climates which means they require less watering and artificial inputs such as fertilizers and pesticides.

GIC Recommendations

- Complete a public tree inventory for the city and analyze species' composition of public trees.
- Update the City's Tree Species list to reflect greater tree diversity.
- Increase tree species diversity in street tree and park plantings in the city.
- Regularly rotate tree species selection offered for tree giveaway events.

Routine Maintenance of Trees

The routine care and maintenance of trees promotes good structure and health of existing trees making them more resilient to pest outbreaks. Healthy trees are able to cope and recover from intermittent environmental extremes (heat, flooding, salt). Regular and proper pruning removes dead tissue, promotes a strong structure and invigorates new growth. Regular pruning on trees in several studies has been shown to reduce the incidence of storm damage and tree parts failing during high wind events (Duryea et al, 1996, Duryea et al 2007). Mulching, irrigation during periods of drought, adequate planting space and nutrient management are all maintenance practices that contribute to healthy trees.

GIC Recommendations

- Develop an Urban Forest Management Plan for the City's public trees to support routine maintenance.
- Create a line-item in the city budget for urban forestry that supports the city arborist and continued maintenance, plantings and removals.

Routine Monitoring of Trees Through Annual Assessments

Detection of new pest introductions or discovering pest outbreaks in the early stages can reduce the likelihood of further spread through quarantine and eradication. Annual monitoring for pest species on public trees and reporting systems for the public to alert officials of possible pests can help the city and other state and local partners proactively manage pests.

GIC Recommendations

- Conduct annual monitoring of street and park trees for pests.
- Partner with the University of Georgia Extension to share information with the public on tree pests and how to report potential sightings.

Planning and Engagement Process

The City of Brunswick and the GIC partnered in a year-long effort to create this Tree Resiliency Plan. A technical advisory committees made up of representatives from city staff, state agencies, academic institutions and local community partners met to review data and discuss priorities. They engaged in a series of seven workshops from the spring of 2024 to the spring of 2025. In March of 2025, the GIC and the city held an open house. City leadership was briefed throughout the process and a presentation and work session to city commissioners on June 4th 2025.

The committee reviewed and contributed to maps and findings. Maps beginning on page 21 show the results of the Tree Canopy Analysis. GIC staff conducted a codes and ordinances audit to evaluate the impact of city policies and ordinances on trees, tree care and tree protection. An assessment of the ecosystem services provided by city trees included:

- A stormwater analysis.
- A surface temperature map.
- An air quality analysis.

Results of these analyses are found on pages 30-35. They were then used to identify opportunities to maximize benefits from future tree planting and retention.

Technical Advisory Committee

In order to create the plan, a technical advisory committee composed of city staff and local community partners was created to work together for a healthier, greener city. Committee members attended workshops and check-ins throughout the planning process and assisted with event organization, information gatherings, and a public open house event. The committee reviewed the maps, data, and community input to develop the Brunswick Tree Resiliency Plan goals and strategies for a healthier Brunswick.

Community partner organizations included:

- The Nature Conservancy
- Georgia Forestry Commission
- City of Brunswick
- Brunswick Tree Board
- Georgia Tech
- Georgia Department of Natural Resources – Coastal Resources Division
- University of Georgia Marine Extension & Sea Grant – Stormwater
- Glynn Environmental Coalition
- Forward Brunswick
- One Hundred Miles
- Georgia Power
- Golden Isle Fund for Trees (GIFT)
- Signature Squares
- Keep Golden Isles Beautiful
- Tree Works Inc.

Photo credit: Jill Wright

The public open houses included a mix of information sharing, discussion, and opportunities for feedback.

Public Engagement

Community input and feedback are foundational to the Brunswick Tree Resiliency Plan. In addition to the planning work undertaken by the technical advisory committee, this planning process included opportunities for public learning, engagement, and feedback.

In March 2025, the City of Brunswick hosted an open house at the Old City Hall, which included poster stations at which members could provide comments relevant to maps of the current tree canopy, ecosystem services, potential planting areas and threats to the existing urban forest. The open house was organized with support from the advisory committee, the city and the GIC.

In addition to the open house, the GIC created a tree resiliency survey to be distributed to the public. This survey was advertised by committee members with a link and QR code. The survey itself was hosted on Survery123, an ArcGIS product. The code and information about the project which included a full-size tree canopy map was displayed at the Brunswick Library as well as City Hall. Lastly, paper copies of the survey were handed out and taken up at Coast Fest 2025 and the April "First Friday" event in downtown. These physical surveys were administered by committee members and were accompanied by the same tree canopy maps displayed at the other two locations. In total, 95 participants took the survey ranging from city residents and local business owners to people who work in the city and county residents who either do business or spend leisure time in the city.

Summary of Community Findings

During the year-long planning process, the stakeholder committee and GIC staff gathered public comments at the Brunswick Open House and through the public tree survey (CoastFest 2025 and First Fridays in April). In total, 22 attendees came to the two sessions of the open house on March 27, 2025, and the survey received 95 responses. The questions below received the most input.

The following is a summary of public input, while a full set of comments can be found in Appendix C.

Q1: Where would you like to see more trees planted?

Survey respondents were instructed to choose their top three. These were the results (in order of most votes to least):

- Public property such as parks (64%)
- Along streets (58%)
- Underserved neighborhoods (45%)
- Parking lots (35%)
- Schools (28%)
- Public housing (21%)
- Private property (12%)
- Commercial property (7%)
- Other (4%)

Q2: What concerns do you have about planting trees?

Survey respondents were instructed to choose their top three. These were the results (in order of most votes to least):

- Long term tree care (38%)
- Unsure what species to plant (35%)
- Property damage (28%)
- Trees falling over (27%)
- Cost of tree care (26%)
- Lack of space (22%)
- Cost of tree purchase (21%)
- Trees interfering with utilities (20%)
- Trees are messy (7%)
- Other (9%)

Q3. What do you value most about trees?

Survey respondents were instructed to choose their top three. These were the results (in order of most votes to least):

- Shading streets and neighborhoods (58%)
- Reducing air pollution (57%)
- Providing wildlife habitat (47%)
- Filtering stormwater/reducing runoff and flood risks (34%)
- Beautifying neighborhoods (33%)
- Capturing/storying greenhouse gases (16%)
- Reducing heating and cooling costs (13%)
- Provide food sources (fruits/nuts) (12%)
- Improving community health (11%)
- Increasing property value (6%)
- Improving walkability (6%)
- Other (1%)

Q4. The best strategies for increasing tree canopy and resiliency in Brunswick are:

Survey respondents were instructed to choose their top four. These were the results (in order of most votes to least):

- Require developers to plant more trees (41%)
- More trees planted in public spaces (38%)
- Tree giveaways (37%)
- Update city codes (35%)
- Tree care workshops (32%)
- Hire a city arborist (28%)
- Apply for grants for tree plantings (27%)
- Better maintenance of public trees (26%)
- Create local tree stewardship program (23%)
- Homeowners plant more trees (22%)
- Business owners plant more trees (20%)
  Increase funding for public tree care (16%)
- Other (1%)

Q5. What are the greatest challenges facing trees in Brunswick?

Survey respondents were instructed to choose their top three. These were the results (in order of most votes to least):

- Storms (71%)
- Development (66%)
- Lack of maintenance (53%)
- Hotter climate (27%)
- Pest and disease (19%)
- Flooding (18%)
- Sea level rise (17%)
- Other (7%)

Tree Canopy Goals and Strategies

Recent national data show urban and suburban tree canopy cover is trending downwards at a rate of 175,000 acres lost per year – approximately 36 million trees lost annually (Nowack and Greenfield 2012). Trees are lost due to development, disease, storms, and old age. Brunswick is no exception. Fortunately, this loss can be reversed and this plan outlines strategies to do so.

Brunswick's urban tree canopy is 30%. The City's goal is to maintain this tree canopy coverage city-wide with the potential for incremental increases over time. Assuming an average of 200 trees lost per year on both public and private property, the city will need to plant 40 trees on city-owned land annually with an additional 160 trees getting planted on private property through education and tree giveaways.

Tree planting event.
Photo Credit: Eliot Van Otteran

The tree resiliency goal, objectives and strategies for Brunswick's urban forest follow:

GOAL: Maintain tree canopy cover at 30% over the next 20 years with the potential for incremental increases in tree canopy over time as the City and its partners build a stronger and more resilient urban forest program.

Room to Grow— Potential Planting Areas—Parks, Streets and Private Yards

Many streets and public properties, such as Harold E. Jennings Wellness Park, private yards and road frontages have room for more trees to add shade, beauty, and improve air quality.

Photo credit: Anne Baptista

The City and its Tree Board members organize tree giveaway events and Arbor Day Celebrations to plant trees. These kinds of activities are important to get trees into the hands of residents and plant new trees in public spaces, which all support the establishment of the next generation of trees.

Strategies to Reach Canopy Goal

Canopy Goal: Maintain 30% tree canopy with potential for incremental increases over time.

Objective	Strategies	Priority	Potential Actions		Timeframe	Leader	Potential Partners	Metrics	Potential Funding Strategies	Notes
1. Update city policies to create more resilient greenspaces.	Establish a moratorium on planting palm trees in rights-of-way and in parks.	High	A. Revise city public tree ordinance. B. Revise the city's preferred tree species list and/or add them to the city's prohibited list. C. Identify criteria for where and what palms can be planted to replace lost palms (if at all). D. City established policy memo that new tree plantings on city property are not palms.		within a year	City, Tree Board	Signature Squares	Ordinance or lists revised. New city policies created.	In-kind staff, volunteers	
	Limit tree plantings in 100-year flood zones to flood tolerant tree species.	Low	A. Revise the city's preferred tree species list.		within a year	City, Tree Board	DNR, Glynn County Extension, Georgia Forestry Commission	Tree species list revised.	In-kind staff, volunteers	Frederica Township made a list for tree plantings that includes flood-tolerant trees.
	Update development codes to reduce impervious surfaces during the development process.	Medium	A. Examine parking space requirements by land use and reduce minimums as possible. B. Increase tree planting requirements in parking lots. C. Incentivize parking lot retrofits to replace excessive pavement within landscaping, permable pavement or other built green infrastructure. D. Pilot more examples of impervious surface reduction practices in the community.		1-3 years	City	Tree Board, developers, UGA Marine Extension	Number of green infrastructure practices used during development Amount of impervious surface reduced. Amount of new landscaping installed.	In-kind staff	
	Create incentives for developers to use built green infrastructure practices in multi-family and non-residential areas.	Medium	A. Evaluate how often stormwater utility credits are used for BMPs on commercial or residential properties.		1-3 years	City	Tree Board, developers, UGA Marine Extension	Number of green infrastructure installations built	Flood insurance premium reductions (CRS program)	

Objective	Strategies	Priority	Potential Actions		Timeframe	Leader	Potential Partners	Metrics	Potential Funding Strategies	Notes
2. Plant trees to increase resiliency within the city.	Plant trees at public housing sites with the Brunswick Housing Authority. (particularly Abbott-Andrews Terrace).	High	A. Establish a partnership with the Housing Authority (between the city, Tree Board, Land Bank and other organizations). B. Identify funding sources for tree planting and maintenance of trees. C. Use the data to identify sites for planting (or to prioritize planting sites). D. Plant the trees.		1-2 years	City, Tree Board	Housing Authority, local environmental NGOs,	Number of sites planted Number of trees planted	Arbor Day Foundation, Georgia Forestry Commission, GA Tree Council, local business sponsors, City Community Development Block Grant funds	
	Plant legacy trees on school campuses for future generations.	Medium	A. Identify which schools to plant. B. Outreach to teachers, principals and the school district about planting at these schools. C. Connect with students to be involved with the project. D. Identify funding sources for tree plantings.		3-5 years	City, Tree Board	Glynn Environmental Coalition	Number of schools planted. Number of trees planted. Number of students engaged or volunteered.	Georgia Forestry Commission (Make the Shade Program - only for elementary schools)	Georgia Power could be a partner or funder.
	Prioritize lower income neighborhoods for tree plantings or tree giveaways during Arbor Day or Earth Day celebrations.	High	A. Use tree canopy and PPA data to select neighborhoods for events. B. Understand any hesitations or barriers to participation from low-income residents. C. Target outreach or promotions to neighborhood organizations, associations and community groups. D. Build neighborhood capacity to maintain and continue these events.		1-2 years	City	Glynn Environmental Coalition, Glynn County Extension, Neighborhood Planning Assemblies, Joint Water and Sewer Commission	Number of residents that receive a tree. Number of trees planted in low income neighborhoods.	Georgia Forestry Commission grants, Georgia ReLeaf, Arbor Day Foundation grants, local business sponsors, Georgia Power sponsorship	GEC is doing tree education with middle schools for Earth Day. Depending on its success, they can build on this more in the future.
	Host annual tree giveaway events to increase tree canopy on private property	Medium	A. Research best practices on how to host better tree giveaways in the community. B. Gather feedback from the community on how to engage on tree giveaway events. C. Build more community partnerships (particularly with Glynn County) to sustain tree giveaways over the long-term.		Ongoing	City	Glynn County, Neighborhood Planning Assemblies	Number of tree giveaway events held. Number of trees given away.	Georgia Forestry Commission grants, Georgia ReLeaf, Arbor Day Foundation grants, local business sponsors, Georgia Power sponsorship, City of Brunswick	

Objective	Strategies	Priority	Potential Actions		Timeframe	Leader	Potential Partners	Metrics	Potential Funding Strategies	Notes
3. Educate the public on the importance of trees.	Distribute educational materials on proper tree care and maintenance as well as tree benefits at tree giveaways.	Medium	A. Review educational materials for any needed updates. B. Update educational materials for different types of trees (fruit, resilient trees, etc.)		Ongoing	Tree Board	UGA Ag Extension, Neighborhood Planning Assemblies, local colleges, City Public Information Officer	Number of educational materials distributed amongst the community.	In-kind, volunteer	The GIFT has brochures on a variety of topics on trees. The tree board is getting more of these materials printed. They are more general in nature about trees but could be updated with more specific information about Brunswick's urban forest.
	Continue to hold Arbor Day celebrations, ensuring engagement and building momentum through these public outreach events.	High	A. Organize celebrations to include a greater number and diversity of community partners. B. Organize multiple events during the week of Arbor Day.		Ongoing	Tree Board	Keep Brunswick Beautiful, GIFT, CCGA (Environmental Sciences or Office of Community and Belonging), Glynn County School Board, City	Number of partners involved in Arbor Day celebrations. Number of Arbor Day events during the week.	In-kind, volunteer	
	Start a tree education campaign with a focus on public health and the role trees play in cleaning the air.	Medium	A. Identify a community partner to lead the effort. B Create a coalition of community partners interested in a public health campaign. C. Create key messages that resonate with the public around trees and health. D. Create a coordinated public relations media campaign to spread the word.		1-3 years	Tree Board as a temporary leader	Glynn Environmental Coalition, Southeast Georgia Health System, Health Centers, Coastal Community Health, Georgia Department of Health, Bike Walk Golden Isles	Number of community partners in the coalition. Number of media posts about the campaign.	In-kind, volunteer	GEC could be a leader on this strategy depending on getting secured funding on air quality and public health.

Objective	Strategies	Priority	Potential Actions		Timeframe	Leader	Potential Partners	Metrics	Potential Funding Strategies	Notes
4. Increase community tree stewardship.	Recruit school students (for example from environmental clubs) for tree stewardship projects.	Medium	A. Connect with local school teachers about tree stewardship. B. Identify tree planting locations at schools and plant trees with students. C. Educate students on proper tree care and maintenance. D. Create a system of accountability and monitoring of trees. E. Connect these activities to local celebrations such as Earth Day or Arbor Day.		1-3 years	Georgia Power	Glynn County BOE, FFA club GCCA, Boys and Girls Scouts, YoPro, 4-H Clubs, UGA Glynn County Ag Extension and 4-H, Beta Club National Honor Society (all need community service hours) Private Schools	Number of high school students engaged. Number of volunteer hours.	In-kind staff, volunteers	This strategy could also be expanded to local colleges to recruit students in tree stewardship.
	Create neighborhood stewardship groups to help plant and maintain trees in the community.	Low	A. Identify and outreach to neighborhood groups that would be interested in stewardship. B. Implement tree planting projects in neighborhoods with those groups. C. Designate responsible parties for continued implementation and monitoring.		3-5 years	Neighborhood Planning Assemblies	Private tree companies, City	Number of trees planted. Number of volunteer hours.	In-kind staff, volunteers	Private tree companies could help educate residents to set these groups up for success.

Objective	Strategies	Priority	Potential Actions		Timeframe	Leader	Potential Partners	Metrics	Potential Funding Strategies	Notes
5. Develop stronger community partnerships to better manage the urban forest.	Form a collaborative partnership with local environmental group on green infrastructure projects within the city.	Medium	A. Convene local groups to prioritize and focus on specific projects. B. Research opportunities and seek out funding sources for green infrastructure projects. C. Design and implement projects.		3-5 years	City Public Works	GA DNR, UGA Marine Extension, Golden Isles Resiliency Network	Number of community partners. Number of green infrastructure projects implemented.	In-kind, grant programs	Need to research potential funding opportunities for projects.
	Partner with the Chamber of Commerce to encourage businesses to plant more trees on commercial properties.	Low	A. Create an incentive program for businesses to plant more trees. B. Develop key messages on how trees benefit the economy. C. Recruit business leaders that can act as the role of tree advocates. D. Highlight or draw positive media attention to businesses with trees and landscaping. (For example: a "green business of the month" program)		1-3 years	Planning and Codes - City	Chamber of Commerce, local businesses, Downtown Development Authority (DDA), Golden Isles Development Authority, Private Tree Companies, Keep Golden Isles Beautiful, Forward Brunswick	Number of tree advocates in the business community. Number of tree friendly businesses.	In-kind, business sponsors, Georgia Pacific Foundation, Georgia Power Foundation, GA Port Authority	
	Seek out sponsorships from local businesses for new tree plantings in the city.	Low	A. Seek out businesses to provide volunteers for tree planting events. B. Leverage relationships in the community to secure sponsorships.		1-3 years	Planning and Codes - City	Chamber of Commerce, local businesses, Downtown Development Authority (DDA), Golden Isles Development Authority, Private Tree Companies, Keep Golden Isles Beautiful, Forward Brunswick	Amount of funding raised. Number of business sponsors.	In-kind, business sponsors, Georgia Pacific Foundation, Georgia Power Foundation, GA Port Authority	
	Partner with Glynn County Cooperative Extension on educational and tree planting events in the community.	Medium	A. Connect with Glynn County Cooperative Extension on upcoming programming. B. Explore where they can be integrated into other tree planting events.		1-3 years	4-H Club, GIFT	Glynn County Cooperative Extension	Number of events held in the community.	Flood insurance premium reductions (CRS program)	GEC has a connection with the UGA Extension. UGA recently made an update in staffing and now only have one extension agent to cover two counties in the area..

General Timeline for Next Steps

Next Steps

Brunswick has new data and strategies in this plan to guide the management of its urban forest. Implementing these tree strategies will ensure that current and future residents enjoy the continued benefits of trees and a healthy, sustainable, and beautiful city for all.

This plan is a living document that is intended to be integrated into on-going staff work plans, annual budgets, grant proposals, and partnerships with outside agencies. It is recommended that an implementation committee or Tree Board meet at least quarterly to document the plan's progress and adapt its strategies as needed.

In the near-term next steps for this plan include the City Commission formally adopting the plan and local stakeholders organizing, coordinating and start implementation of components of the plan.

Appendixes

Appendix A: Funding Opportunities

For tree campaigns to be successful, there must be dedicated funds. These funds can come from a variety of sources; including federal, state, local, and private resources. Examples of these opportunities are listed below.

Georgia Forestry Commission

- Georgia ReLeaf- funding for municipalities to plant trees in order to improve urban canopies, sustain the health of Georgia's urban forest, improve planning efforts and increase access to health benefits provided by the urban forest. https://gatrees.org/urban-community-forestry/georgia-releaf-grant-program/
- **Making the Shade Program**- funding for trees at playgrounds and schools. https://gatrees.org/urban-community-forestry/making-the-shade-program/
- **Cost Share and Incentive Programs** https://gatrees.org/forest-management-conservation/cost-share-incentive-programs/

Arbor Day Foundation, Tree City USA Designation Benefits

- Access to Grants and Funding opportunities: https://www.arborday.org/our-work

TREE CITY USA®

Wells Fargo Foundation

- A yearly fund awarded to environmental stewardship, educational, and community renewal projects. https://www.wellsfargo.com/about/responsibility-and-impact/community-giving/

Georgia Department of Natural Resources

https://gadnr.org/grants

- Coastal Incentive Grants Program
- Georgia Outdoor Stewardship Program
- Land and Water Conservation Fund (National Park Service)
- Outdoor Recreation Legacy Partnership Program
- Recreational Trails Program

Georgia Emergency Management and Homeland Security Agency

https://gema.georgia.gov/assistance/hazard-mitigation

- Hazard Mitigation Grant Program
- Flood Mitigation Assistance Program
- Building Resilient Infrastructure and Communities Program

National Fish and Wildlife Foundation Grants

- **Five Star Urban Waters Restoration Grant Program**— seeks to address water quality issues in priority watersheds. https://www.nfwf.org/programs/five-star-and-urban-waters-restoration-grant-program
- **National Coastal Resilience Fund**— restores natural infrastructure to protect coastal communities that enhance habitats for fish and wildlife. https://www.nfwf.org/programs/national-coastal-resilience-fund

Appendix B: Table of Tree Species and Stress Tolerances

Tree Species (Large)	Saline Soil Tolerant	Salt Spray Tolerant	Flood Tolerant	Wind Resistant	Heat/Drought Tolerant	Street Tree	Open Space Tree
Bald Cypress	X	X	X	X	X	X	X
Blackgum		X	X	X		X	X
Black Locust	X	X			X	X	X
Black Walnut	X	X					X
Catalpa		X			X	X	X
Eastern Red Cedar	X	X			X	X	X
Ginkgo		X			X	X	X
Live Oak	X	X		X	X	X	X
Overcup Oak			X	X	X	X	X
Longleaf Pine		X					X
Pond Cypress			X	X			X
Red Maple			X				X
River Birch			X	X		X	X
Sabal Palm				X		X	X
Sand Live Oak				X		X	X
Southern Magnolia	X	X		X	X		X
Swamp White Oak			X			X	X
Sweetgum		X	X	X	X		X
Sycamore			X			X	X
Thornless Honeylocust	X	X			X	X	X
Tulip-tree			X				X
Weeping Willow			X				X
White Oak					X	X	X
Willow Oak		X	X			X	X

Tree Species (Small/Medium)	Saline Soil Tolerant	Salt Spray Tolerant	Flood Tolerant	Wind Resistant	Heat/Drought Tolerant	Street Tree	Open Space Tree
American Holly		X	X	X	X	X	X
Black Cherry		X				X	X
Carolina Buckthorn			X				X
Carolina Cherrylaurel	X					X	X
Crape Myrtle				X	X	X	X
Eastern Redbud				X		X	X
Flowering Dogwood				X			X
Ironwood			X		X		X
Japanese Zelkova					X	X	X
Hackberry			X		X		X
Kentucky Coffeetree		X			X	X	X
Myrtle Oak				X		X	X
Musclewood			X				X
Persimmon	X	X	X	X	X		X
Red Buckeye	X					X	X
Red Mulberry			X				X
Sweetbay Magnolia	X		X	X	X	X	X
Trident Maple					X	X	X
Wax Myrtle	X	X		X	X		X
White Fringetree	X			X			X
Yaupon Holly				X	X		X

Appendix C: Bibliography

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Appendix D: Community Feedback

The following questions were posed to the community through two methods in 2025: The Brunswick Tree Resiliency Open House, and the Brunswick Community Survey. Below is a compilation of all questions and public input not included in the Summary of Community Findings.

Q1. I am a....	
I am a…	Votes
City of Brunswick Resident	55
Local business owner	2
Work in city, live elsewhere	11
Other	27

Q2: Where would you like to see more trees planted? (choose 3)	
Locations to plant trees	Votes
Public property such as parks	61
Along streets	55
Underserved neighborhoods	43
Parking lots	33
Schools	27
Public housing	20
Private property	11
Commercial property	7
Other	4

Q3. What concerns do you have about planting trees? (choose 3)	
Concerns about planting trees	Votes
Long term tree care	36
Unsure what species to plant	33
Property damage	27
Trees fall over	26
Cost of tree care	25
Lack of space	21
Cost of tree purchase	20
Trees interfering with utilities	19
Other	9
Trees are messy	7

Q4: What do you value most about trees? (choose 3)	
What do you value most about trees	Votes
Shading streets and neighborhoods	55
Reducing air pollution	54
Provide wildlife habitat	45
Filtering stormwater, reducing flood risk	32
Beautifying neighborhoods	31
Capturing/storing greenhouse gases	15
Reducing heating and cooling costs	12
Provide food sources	11
Improving community health	10
Increasing property value	6
Improving walkability	6
Other	1

Q5: The best strategies for increasing tree canopy and resiliency in Brunswick are: (choose 4)	
Best strategies for increasing tree canopy	Votes
Require developers to plant more trees	39
More trees planted in public spaces	36
Tree giveaways	35
Update city codes	33
Tree care workshops	30
Hire a city arborist	27
Apply for grants for tree plantings	26
Better maintenance of public trees	25
Create local tree stewardship program	22
Homeowners plant more trees	21
Business owners plant more trees	19
Increase funding for public tree care	15
Other	1

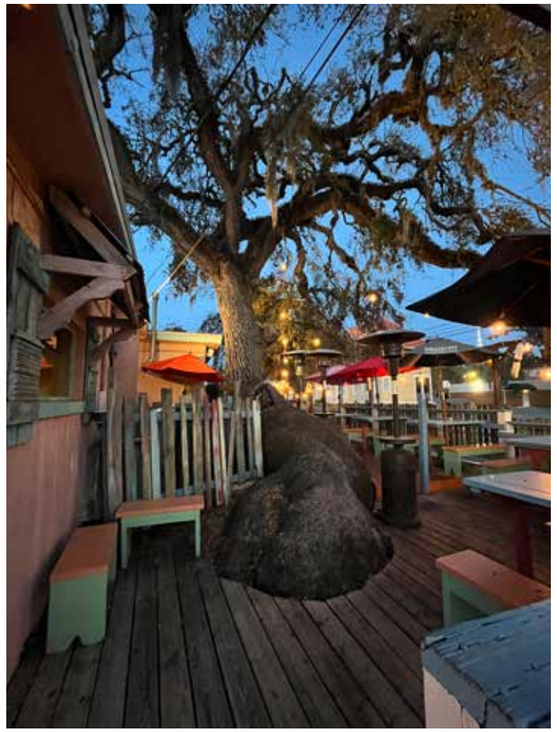
Q6: What are the greatest challenges facing trees in Brunswick? (choose 3)	
What are the greatest challenges facing the tree canopy	Votes
Storms	67
Development	63
Lack of maintenance	50
Hotter climate	26
Pest and disease	18
Flooding	17
Sea level rise	16
Other	7

Q7: Would you be interested in getting involved in tree stewardship?	
Interested in tree stewardship?	Answer
Yes	53
Maybe	26
No	16

Q8: If you would not be interested in tree stewardship, why? (Select 1)	
If not interested in tree stewardship, why?	Answer
Time commitment	20
No prior experience	11
Physical ability	3
Not interested	1

Q9: Would you be willing to plant a tree on your property?	
Willing to plant a tree on your property?	Answer
Yes	66
Maybe	20
No	9

Q10: If you're not willing to plant a tree on your property, why? (select 1)	
If not willing to plant a tree on your property, why?	Answer
I am a renter	6
I have no space for a tree	4
Unsure of what species to plant	2
Worried about the hazards of a tree on my property	2
I can't maintain a tree	1
I can't physically plant a tree	1
I can't afford a tree	0



Appendix E: Trees to Offset Stormwater Calculator

The trees and stormwater calculator (TSW) tool developed by GIC uses modified TR-55 curve numbers to calculate stormwater uptake for different land covers, since they are widely recognized and understood by stormwater engineers. A canopy interception factor is added to account for the role trees play in interception of rainfall based on location and planting condition (e.g., trees over pavement versus trees over a lawn or in a forest).

Cities usually use TR-55 curve numbers developed by the Natural Resources Conservation Service (NRCS) to generate expected runoff amounts. The modified TR55 curve numbers (CN) provided by GIC includes a factor for canopy interception. Cities can use the stormwater calculator tool for setting goals at the watershed scale for planting trees and for evaluating consequences of tree loss as it pertains to stormwater runoff. Curve numbers produced for this study can be utilized in the city's modeling and design reviews.

Tree over street

Trees over forest

Tree over lawn

Tree over parking lot

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

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

Where **R** is runoff, **P** is precipitation, $\mathbf{I_a}$ is the initial abstraction (the fraction of the storm depth after which runoff begins), and **S** is the potential maximum retention after runoff begins for the subject land cover **(S = 1000/CN – 10)**.

Major factors determining **CN** are:

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

This new approach allows for more detailed assessments of stormwater uptake based on the landscape conditions of the city's forests. It distinguishes whether the trees are within a forest, a lawn setting, a forested wetland or over pavement, such as streets or sidewalks because the conditions and the soils in which the tree is living affect the amount of water the tree can intercept.

The analysis can be used to create plans for where adding trees or better protecting them can reduce stormwater runoff impacts and improve water quality. This methodology was developed and tested in 13 communities in the south under a grant from the Southern Region of the USDA Forest Service. For more about the project, please visit : https://gicinc.org/projects/resiliency/trees-and-stormwater/

Appendix F: Urban Tree Risk Index (UTRI)

During natural disasters, trees can become debris that damages or impedes access to critical facilities. Therefore, it is important for communities to take steps to manage this risk. The Urban Tree Risk Index (UTRI) is a method to prioritize street segments for further risk assessment and management of trees. The UTRI "scores" each street segment, which can be used by communities to prioritize their efforts to assess and mitigate risk from trees. Calculating the UTRI score is done in GIS (geographic information system) software.

Data Sources:

Road centerlines – RCL data is the primary unit of analysis for the UTRI. RCL data from The National Map was ranked according to its MAF/TIGER Feature Classification Code (MTFCC) as follows:

- S1100 = 4
- S1200 = 3
- S1300/S1400 = 2
- Others identified as important to the community = 1
- All else = 0

Street segment rankings were then modified based on community input.

Population The model assumes that a higher population density will correspond to a higher likelihood of conflict between tree debris and people traveling through the street network. Census Block Group population data from the American Community Survey (2020) was ranked using five classes using the Jenks Natural Breaks classification scheme.

Tree Canopy The presence of trees is required for there to be risk. 1 meter resolution landcover created using 2023 aerial imagery was used to identify tree canopy.

Facilities Facilities data was sourced from the City of Brunswick and U.S. Department of Homeland Security's Homeland Infrastructure Foundation-Level Data (HIFLD). Facilities were categorized as follows, and then modified based on community input:

- Hospitals=5
- Fire, Police, Emergency Management Centers = 4
- Communication Towers, Water Treatment Plants, Water Towers, Waste Water Treatment Plants = 3
- Schools, Parks, and other locations where people congregate = 2
- Others identified as important to the community = 1
- All else = 0

Data processing

The RCL data was buffered by 50 feet to create a 100-foot-wide swath that corresponds to each street segment in the network. Five raster datasets are created from the source data:

1. Streets primacy

Streets are ranked using their MAF/TIGER Feature Class Code (MTFCC) to identify streets as more or less important for transportation in general. To do this, the RCL buffers are converted to a raster layer. Cell values are assigned based on the UTRI ranking mentioned above (0-4).

2. Access to critical facilities

Streets are scored based on the degree to which primary and secondary roads contribute to accessing hospitals, law enforcement facilities, and fire/EMS facilities ("critical facilities"). Primary and secondary roads are scored based on the sum of the critical facilities that they are near (within 3,000 meters).

3. Facilities buffer

Buffers around all facilities representing the "immediate area" of risk for each facility. Facilities are buffered by 100-200 meters and buffers are assigned a UTRI score based on the ranking mentioned previously (0-5).

4. Population density

Population density is a surrogate for (target) occupancy; that is, the higher the population density the more frequently people (as pedestrians, vehicle operators, or in some type of gathering –think park, school) will be in proximity to the trees (before, during and after a disaster). The Census Block Groups are converted to a raster layer. Cell values are assigned based on the UTRI ranking mentioned above (1 - 5).

5. Tree Canopy

Tree canopy data is processed to produce a raster percent tree canopy raster layer in which the cell value represents the percentage of the area of that cell that is covered by tree canopy. Tree canopy data is ranked using 5 classes to describe the percentage of each raster cell that is covered by tree canopy. The raster is reclassified as follows:

- **0 = 0%**
- **1 = 1-24%**
- **2 = 25-49%**
- **3 = 50-74%**
- **4 = 75-100%**

After processing each of the five input layers, the rasters were summed within each street segment buffer zone to produce the raw UTRI score.

These raw totals are normalized by dividing the summed UTRI score by the length of the street segment. Finally, streets with no tree canopy in their buffer are reduced to a "Very Low" UTRI rank. This ensures that streets with no known trees are not prioritized for field surveys.

The UTRI Score is the Sum of Five Raster Layers

Access to Critical Facilities + Street Primacy + Facilities Buffer + Population Density + Tree Canopy