Athens-Clarke County Community Tree Study Executive Overview

Findings, Forecast, and Future Considerations

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PURPOSE AND EXECUTIVE SUMMARY

The purpose of this report is to present results of the Athens-Clarke County (ACC) Community Tree Study, with management and policy implications, to the Mayor and Board of Commissioners so they may accept the results as public record.

The Community Tree Study, conducted in summer of 2021, was designed to produce reliable data and information that identified key characteristics about the trees in Athens-Clarke County on both private and public lands on a countywide scale. Athens-Clarke County covers approximately 76 thousand acres of land and has a population of about 127 thousand permanent residents. The Community Tree Study was commissioned by the Central Services Department to better understand the characteristics and benefits of ACC's public trees as well as the community forest as a whole, including private trees.

The project employed the urban forest inventory software application, i-Tree (i-treetools.org), developed by the U.S. Forest Service, Northern Research Station. The project team measured trees and landscape features on 316 tenth-acre plots. The plots were distributed randomly by computer mapping software according to ACC land management categories, including several subcategories of public and private properties.

Study results included composition, structure, and functions of ACC trees. In summary, 58.2% of the county contains tree canopy consisting of almost 13.5 million trees. The most common species are sweetgum, loblolly pine, and water oak. Fifty-seven percent of the trees are under six inches in diameter at breast height (DBH), suggesting a young community forest that will be changing over the next decades. Among the many benefits of the community are annual functions including $2.8 million in pollution removal, $15.8 million in carbon sequestration, $10 million in avoided runoff, and $4.7 million in building energy savings.

Results inform residents about the community's trees and provide local government decision-makers and managers better information about the ACC's community trees so that more informed decisions may be made in the dimensions of tree planting, maintenance, and updates to tree-related policies and governance.

STUDY OBJECTIVE

Definition of the Community Forest

The community forest is defined as all public and private trees within the municipal boundary. Private trees include, for example, trees on single family residential property and industrial areas. Public trees include trees located on city Right-of-Way (ROW), municipal facilities, and parks, among other public properties.

Problem Statement

There were several challenges that motivated the ACC Community Tree Study. First, managers did not have precise data on the structure of the community forest in terms of estimated number of trees, species composition, and other characteristics. This lack of information made it difficult to have productive conversations about policy and management. Furthermore, managers did not fully understand the Community Forest regarding public and private lands on a countywide scale. Managers and residents could see changes happening in the community forest due to development, but were uncertain as to the extent and impact of such changes. Because managers had limited comprehensive understanding of the structure and function of the forest, they were unable to accurately assess the ecosystem and replacement value of the County's trees. Without an understanding of the structure, function, and value of the trees, effective forecasting and goal-setting is impossible. No clear goals or associated management plan limits resource allocation and delays maintenance and care; thus, the community becomes vulnerable to receiving less benefits, undergoing higher costs, and enduring higher associated tree failure risks. A community tree inventory provides the vehicle by which to gather and effectively communicate factual information about the community forest.

Objective

*The **objective** of this study was to better understand the structure and functions of the ACC community forest to improve the management of trees in public spaces.*

Accomplishing this objective will lead to development of a plan to effectively manage public trees. Besides quality information on the community forest, this will require consensus among stakeholders to develop management goals.

BACKGROUND

Athens has a long history of appreciation for its trees. The Land Conservation Program, formerly the Greenspace Program, is a Mayor and Commission-Approved program initiated in 2001 to preserve and protect land and water in undeveloped ("natural") states. The program essentially creates environmental buffers that shield ecosystem services from some of the negative impacts of commercial and residential development, which are inherent to a growing human population. Also in response to development pressure, the ACC Tree Ordinance was passed in 2005 to sustain and enhance the benefits of trees for its residents. The ordinance strives to maintain 45% canopy cover in Athens-Clarke County by requiring conservation and replanting of street and parking lot trees during development. The ordinance includes an acceptable species list, best management practices, new tree establishment, and information on the landmark tree program.

Citizen groups have advocated for trees in Athens since the 1970s. These groups included the Citizen Tree Stewards, Founders Tree Trust, Athens Tree Commission, Urban Tree Advisory Committee, and most recently, the ACC Community Tree Council (CTC). The CTC is a partner in the Community Tree Study and is instrumental in residents with the results and implications.

The hiring of a dedicated staff is an indication of a strong community tree management program. ACC has a planning arborist and a city forester, and several departments involved in the management of ACC trees, including Central Services, Planning, Sustainability Office, Leisure Services, and Public Works. In addition, Sandy Creek Nature Center, Bear Hollow Zoo, and other ACC units help to promote a culture of natural resource conservation advocacy.

The Central Services Office has conducted community tree assessments for several years. Each of these assessments have enabled managers to learn a little more about the tree canopy. For example, assessments have coincided with the ACC Legacy Forest Project, which works to ensure the longevity of ACC's forest. A legacy forest is a forest that is at least one acre and at least 80 years old. The Legacy Forest Project uses historical aerial photos to show the changes in historic forest coverage. By knowing which historic forests remain, land planners and developers are able to improve building practices on these sites, therefore preserving forests for future generations. Through this process, it has been determined that, in 1938, approximately 32 percent of the total land area of Athens-Clarke County was forested. Today, although total forest canopy has increased, less than 18 percent of the county contains forests that are at least 80 years old. The most common causes of forest loss were residential development, urban sprawl, and commercial logging.

In addition, the ACC Tree Inventory is performed every ten to fifteen years to as a limited risk management tool. Important details are unknown such as the canopy age and productivity by land use. Similarly, a 20,000 dot grid canopy analysis is conducted every five years. While very informative, it only shows canopy gain or loss. The Landscape Management Department also assesses Land Conservation Areas and ACC Parks, but these canopies cannot be considered the community forest. In short, while managers have used a number of tools to learn about ACC's community trees, only the 2021 Community Tree Study provides comprehensive county-wide information on all land management uses.

MATERIALS AND METHODS

Materials

The project used iTree Eco software to collect and analyze data. Eco is a free software application created by the US Forest Service. Having been employed in thousands of tree inventory projects, Eco uses field plots, air pollution removal, and meteorological data to quantify urban forest structure, environmental effects (e.g., carbon storage and sequestration), and value (Figure 1). Eco can forecast structure, carbon benefits, and pollution services over the next 30 or more years.

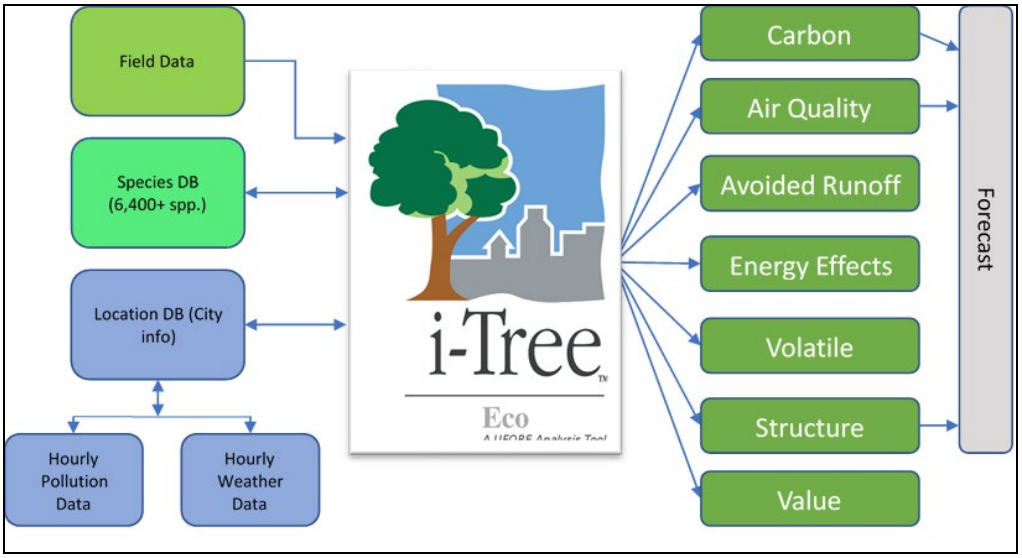

Figure 12. i-Tree Eco model

Plot Sampling

Sample plots were distributed across the county using random stratification to better understand community forest representation on ACC government land management areas[1] (Figure 2). i-Tree studies have demonstrated that around 200 tenth acre plots result in a 10 percent standard error, which is appropriate a municipality the size of Clark County (Nowak et al. 2008). This study sampled 316 plots with at least 20 plots per stratum. The project slightly oversampled ACC ROW (28), ACC Natural & Undeveloped Lands (26), Private Ag & Natural Lands (26), and Single Family Residential (28).

Inventory crews performed a number of measurements at ground level, such as diameter and crown width, which allowed the software application to map tree benefits. Thus, a critical component of the project was gaining access to private properties. To assist with this, and to communicate with the public about the project, the ACC Public Information Office created a web site with relevant information. Two awareness videos, including one that explained in detail

[1] Single Family Residential, Multi-Family Residential, Industrial & Commercial, Private Ag & Natural Lands, UGA Undeveloped Agriculture & Natural Lands, ACC Buildings & Facilities, ACC ROW, ACC Parks Serviced Areas, ACC LS Natural & Undeveloped Lands, Other (Churches, Schools, Hospitals, Airport, State, Federal)

data collection crews' actions when accessing homeowners' properties, were posted to the ACC website (Figure 3).

In addition, residents could complete the property access waiver on the website. The website waivers complemented two phases of mailings sent to owners of the properties for potential measurement. The letters explained the project, the benefits to the community and property owner, and requested permission to enter the property with the owner present or not present. A waiver was included which was collected by or mailed to project coordinators.

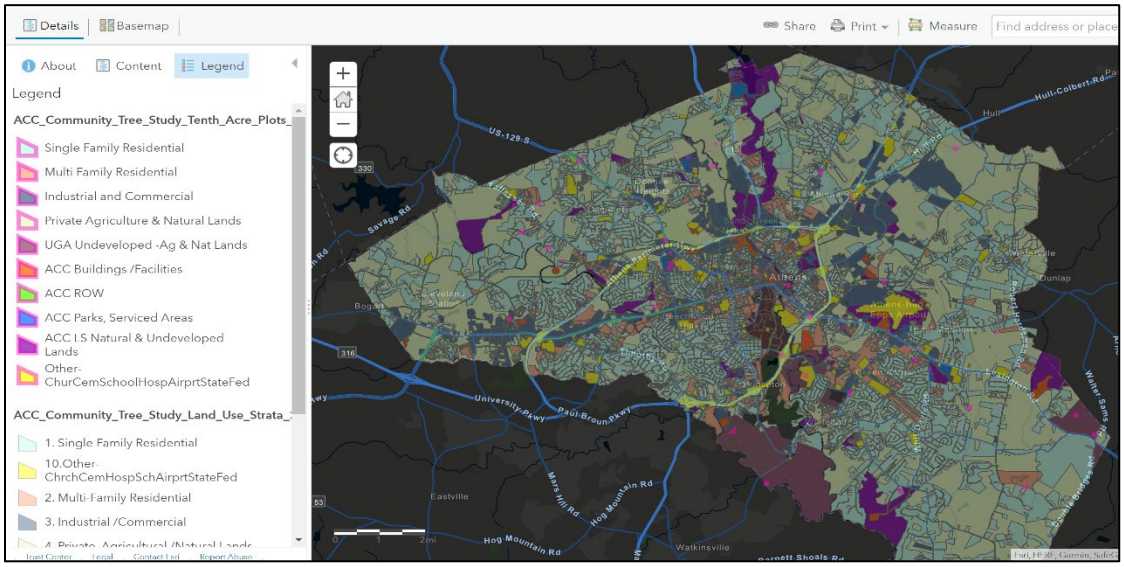

Figure 13. Sample map (created by R. Walters)

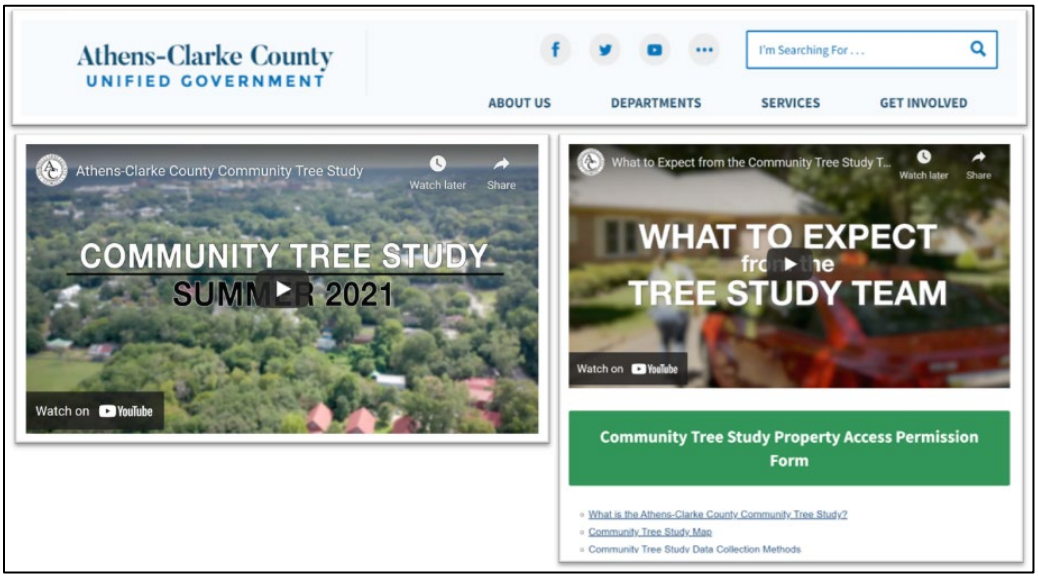

Figure 14. Community tree study website with videos (https://www.accgov.com/communitytreestudy)

RESULTS

Results

The Athens-Clark County Community Forest consisted of 13.5 million trees which covered 58.2 percent of the county (74,240 acres; Figure 4). Private Agriculture and Natural Lands had the largest proportion on tree canopy (44 percent) followed by Single and Multi-Family Residential properties (37 percent)[2]. Public trees (ACC Buildings and Facilities, ACC ROW, ACC LMD Parks Serviced, ACC LS Natural and Undeveloped Lands, and UGA Undeveloped Lands) were 12 percent of the total canopy. Industrial/Commercial land uses constituted 5 percent, while the Other category was the smallest percentage. ACC ROW is 3 percent of all public trees.

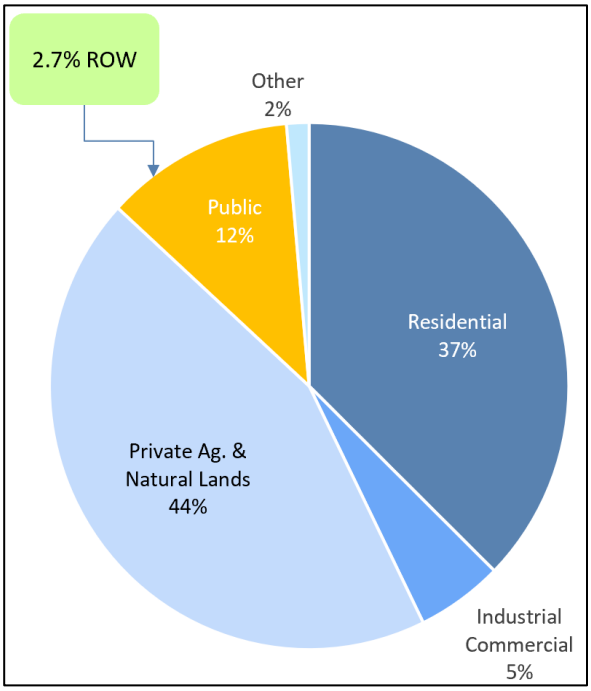

Figure 15. Number of trees by ownership

Overall, the ACC Community Forest was about 175 trees per acre, which is fairly dense (Figure 5). Private Ag. and Natural Lands (227 TPA) were by far the densest forests, although Residential was also dense (143 TPA). Most (55%) of the density in public property was contained in the UGA Undeveloped and ACC LS Natural and Undeveloped lands. Public lands might appear to have been underperforming, but they included parks, the airport, water treatment areas, and ROW trees, so it makes sense they are not as dense as Private Ag. & Natural Lands. As such, public lands were comparatively well-stocked due to the usage purposes of those areas. Further, the data suggests the addition of forest land was the only practical way to increase public canopy cover. It would not be possible to achieve a measurable difference planting individual trees on selected interspersed sites.

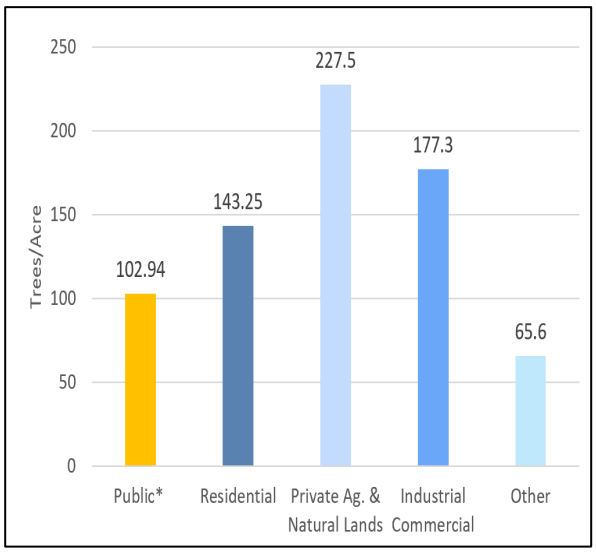

Figure 16. Tree density

However, canopy structure is different from stem production. Public tree leaf area was comparable to private lands on a per acre basis (Figure 6). This is an important finding because leaf area is the powerhouse of the urban forest with the amount of leaf area determining the benefits the forest provides. UGA Undeveloped and ACC Natural Lands were the strongest producers.

[2] Some categories (e.g., Single and Multi-family Residential) were averaged and combined to simplify presentation of results and more clearly compare private versus public trees.

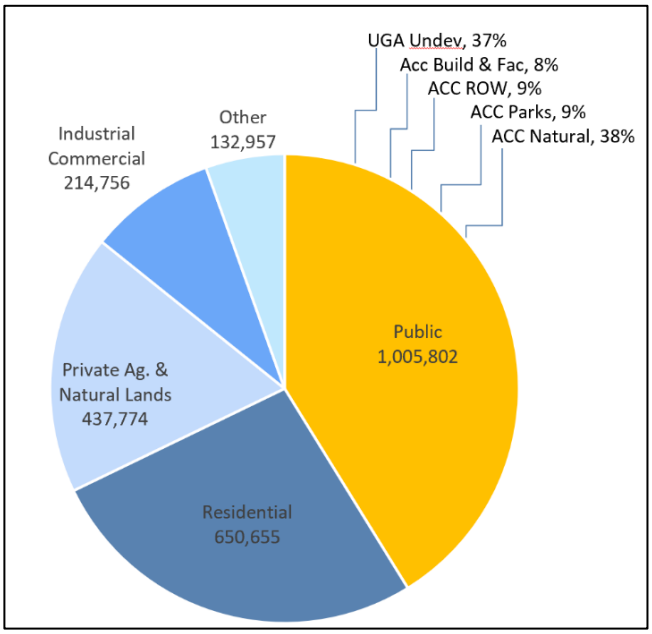

Figure 17. Leaf area (ft2/acre) by ownership

Overall, Clarke County contained 621 thousand acres of leaf area which averaged to eight acres of leaf area for each one acre of terrestrial area.

Notably, leaf area production differs by site and species as some species are better producers than others. The ACC community forest was dominated by loblolly pine, sweetgum, and water oak on both public and private properties (Figure 7). Although water oak and sweetgum produced a lot of leaf area, these species tend to be less tolerant of storms and construction interference. Sweetgum produces a relatively high amount of Volatile Organic Compounds (VOC's), an ozone contributor, compared to other species.

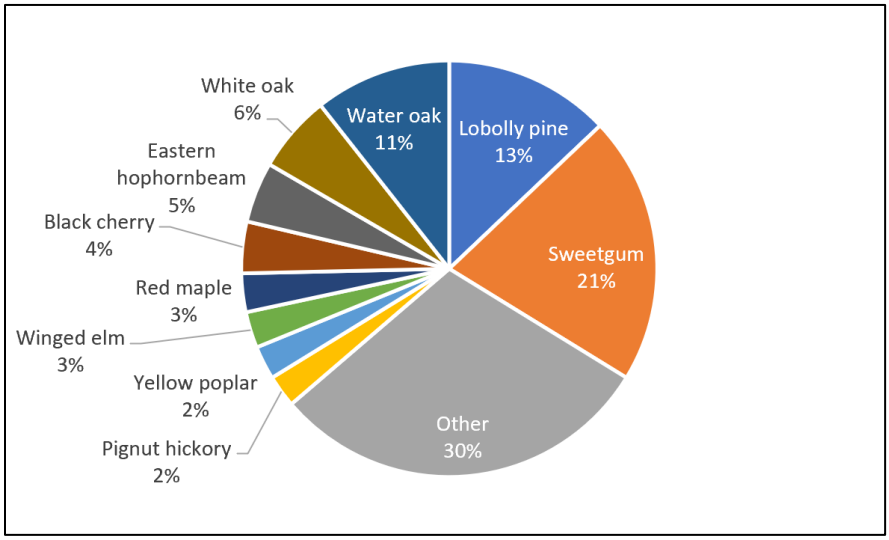

Figure 18. Species distribution

ACC's forest was relatively young as demonstrated by the diameter class distribution (Figure 8). Over 57 percent of trees were less than six inches in diameter. In the ROW, the percentage of trees less than six inches was 60.5 percent while just under 45 percent of trees were under six inches diameter in ACC buildings and facilities. This is important because the forest will thin over time as a result of competition; however, the larger well-maintained trees can carry more leaf area that the small trees and therefore have higher performance.

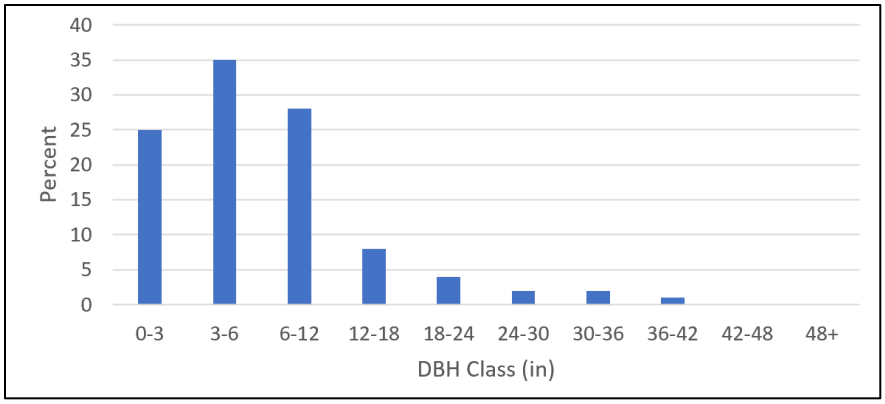

Figure 19. Percent of tree population by diameter class (DBH)

i-Tree Eco emphasizes the structural and functional values community trees provide. ACC's 13.4 million community trees produced $36.3 million in annual benefits and $7.44 billion in structural benefits.[3] Values per species corresponded to species distribution with loblolly pine, sweetgum, and water oak composing most of the overall value, respectively.

Almost two million public trees provided $4.3 million in annual tree benefits (Figure 9).[4] They annually removed $531 thousand of air pollution (i.e., ozone, sulfur dioxide, nitrogen dioxide, carbon monoxide and particulate matter), $1.3 million in avoided runoff, $2.2 million in carbon sequestered, and $240 thousand in energy savings. Regarding structural benefits, public trees were valued at $1 billion in replacement cost and $46 million in carbon storage value.

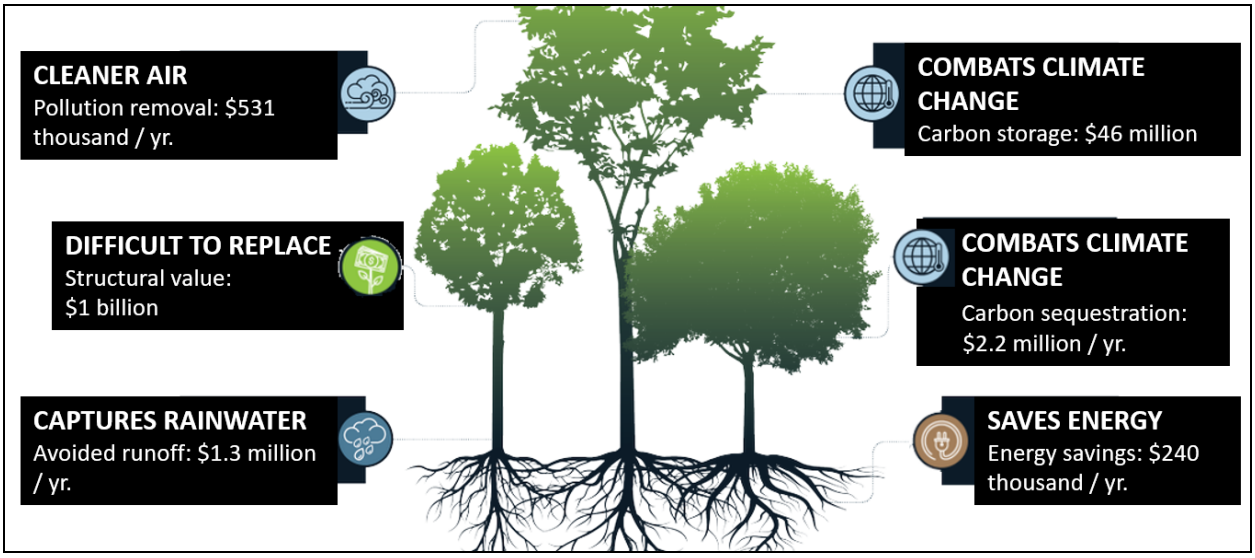

Figure 20. Structural and functional values of public trees (Graphic source: https://twitter.com/missoulaparks/status)

[3] Annual benefits include carbon sequestration, avoided runoff, pollution removal, energy costs and carbon emission values. Structural benefits include structural values (i.e., replacement cost) and carbon storage.

[4] Energy savings calculated on basis of $122.6 per MWH and $15.37 per BTU. Avoided runoff calculated based on the price of $0.07 per ft^3. Pollution removal calculated based on the prices of $1,327 per ton (carbon monoxide), $768 per ton (ozone), $146 per ton (nitrogen dioxide), $55 per ton (sulfur dioxide), $23,739 per ton (particulate matter less than 2.5 microns).

By contrast, nearly 12 million private trees provided $32 million in annual tree benefits. Private trees stored $275 million of carbon and had $6 billion in replacement value. Annually, they removed $5.4 million in pollution, captured $8.6 million in stormwater, sequestered $13.6 million in carbon, and saved $4.5 million in energy costs.

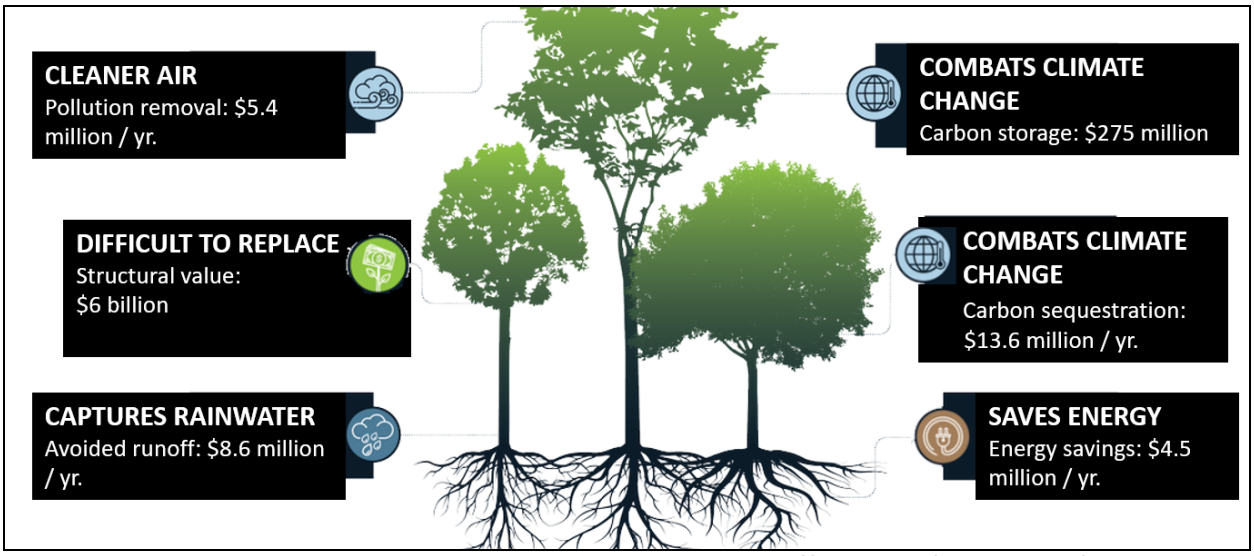

Figure 21. Structural and functional values of private trees (Graphic source: https://twitter.com/missoulaparks/status)

ACC must maintain 45 percent of its canopy cover to be in compliance with the tree ordinance; thus, the municipality is doing fairly well at 58 percent estimated by the ACC Community Tree Study, even when compared to other cities. This is a unique opportunity to be thoughtful about how to better manage ACC trees.

	Existing Canopy			
City, State	**UTC Cover**	**Year Assessed**	**Population**	**City Size (mi²)**
Athens, GA	58%	2021	127,315	118
Tallahassee, FL	55%	2015	190,894	103
Atlanta, GA	48%	2008	472,522	134
Charlotte, NC	47%	2012	842,051	298
Gainesville, FL	47%	2015	131,591	63
Pittsburgh, PA	40%	2011	303,625	58
Jacksonville, FL	38%	2002	880,619	747
Tampa, FL	32%	2011	377,165	175
Boston, MA	29%	2007	673,165	90
Baltimore, MD	20%	2006	621,849	92
Philadelphia, PA	20%	2011	1,568,000	142
Miami, FL	20%	2016	453,579	55

Table 3. Comparison of canopy cover using i-Tree Eco (Source: Tallahassee Urban Forest Management Plan 2018)

In terms of budget (Table 2), ACC spent over $1 million on its tree care program in 2021, a little higher than the Southern Region according to a survey of municipalities conducted in 2009 (Hauer and Peterson 2010). According to research by the U.S. Forest Service (McPherson et al. 2006), the average annual costs over 40 years for tree care range from $8 to $36 per tree (depending on factors such as age of tree).

In ACC, cost per tree has been derived in two ways. ACC has been operating on the assumptions from the online tree inventory with the annual cost per tree calculated at a little over $12 based on just over 29,000 ROW trees. However, the i-Tree based ACC Community Tree Study showed that ACC has far more ROW trees than previously thought with 324,000 trees. This translates to an approximate cost of $1.16 per tree. Most of this expense occurs in the winter when crews and contractors spend about four to five weeks with a rented bucket truck to conduct hazard tree removals.

It is important to note that some of the differences in costs and budgets in Table 2 are because many of these places have units dedicated to tree work, whereas Athens's tree work is split among departments. The Landscape Management Department is the only ACC entity that has line item allocations for tree work. Most of Landscape Management's budget is utilized for ROW mowing, beautification, and sight line clearance maintenance.

Description	Athens (total of departments, 2021)	Southern Region, 2014	Cities with Pop. 100,000 - 249,999 (National, 2014)
Average tree program budget*	$1,197,591	$829,105	$1,368,607
Average annual budget per public tree**	$12.96	$60.52	$44.85
Average annual budget per capita	$9.28	NA	$9.05

*In ACC, this is the best estimate across all departments doing tree work
**ROW trees only; other public trees costs are not significant

Table 4. Comparison of costs/budgets between ACC, Southern region, and cities of 100,000-249,999 residents (Sources: Tallahassee Urban Forest Management Plan 2018, ACC internal documents)

DISCUSSION

Lessons Learned

With a 58.2 percent tree canopy cover in summer of 2021, the ACC forest was mostly private but surpasses other communities in terms of its overall cover. A good communications plan helped data collectors gain access to the private forest, which was critical to obtaining a comprehensive measure of the community forest. An important lesson learned was there were far more trees in ACC than previously thought. However, ACC has a young forest that will need increasing care over time. Results suggest ACC is likely underspending on a per tree basis, and may still not be covering its liability regarding tree hazards.

Several important lessons are linked with the need to promote the growth of certain species because they have lower risk and increased benefits than some of the most common species currently in ACC. For example, managers should plant long-lived species in place of removed water oaks, loblolly pines, and sweetgums. Besides longer-lived species, which store more carbon and require less carbon for maintenance and removal, the community forest would benefit from more diversity that mitigates risk of significant forest loss due to pest outbreaks and increases various canopy benefits. Perhaps most importantly, ACC needs to preserve its soils by ensuring adequate soil volume for root growth, protecting pervious surface area, and promoting soil health for growing vigorous trees.

Future Considerations: Forecast Model

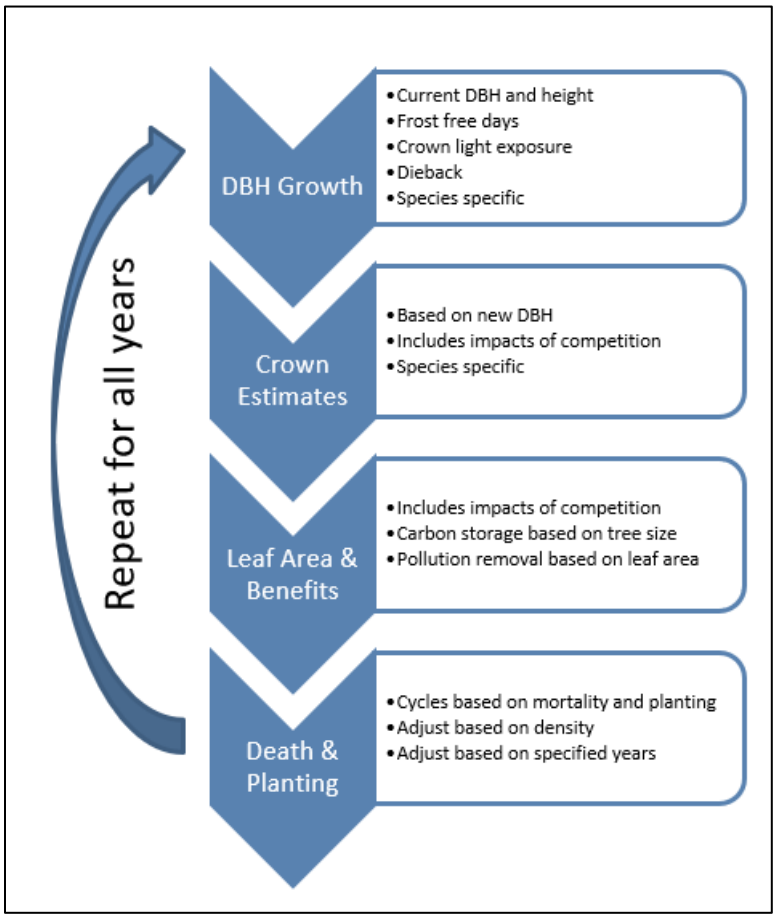

Figure 22. i-Tree Eco Forecast model

i-Tree's Forecast uses structural estimates, environmental and location variables, species characteristics along with growth and mortality rates to forecast future tree DBH and crown size (Figure 11). Forecasted benefits such as pollution removal, carbon storage and carbon sequestration are then estimated based on the projected tree growth and leaf area. Tree planting inputs, pest and disease impacts, and storm effects can also be modeled.

The ACC Community Tree Study forecasted a 30-year projection and 3 percent mortality rate for healthy trees, as well as 13 percent mortality for sick trees and 50 percent for dying trees. Results suggest the number of trees will decrease 58 percent to approximately 5 million trees. The primary decrease will occur in Private Ag & Natural Lands and

Single Family Residences as the stems in these categories thin out over time and trees grow larger. Despite a decrease in number of trees per acre, canopy cover is expected to increase 42 percent, primarily in Private Ag & Natural Lands, Other, Residential areas, ACC LS Natural & Undeveloped Lands, and Industrial/Commercial zones. Further, as those trees grow larger, there will be an increase in carbon storage by 38 percent, which increases the value of those trees. In turn, carbon sequestration will decrease by 3 percent as the tree slows in growth over time.

Future Considerations: Management Plan

ACC is likely at the point where increased public involvement in tree management, particularly goal-setting, is appropriate. Given the history of Athens residents' interest in trees, there are many opportunities for engagement. Public, education, outreach, and engagement are critical components that need to be supported due to the significance of the private tree resource. An ACC multi-department steering committee could be assembled to identify best management practices, review its programs/policies, and develop community feedback questions and sessions for the purpose of engaging the public in canopy goal setting. This would all be incorporated into a public tree management plan. Public participation in the development of a management plan may serve as an example to guide people in the care of their private trees.

Future Considerations: Public Trees

The ACC Community Tree Study demonstrates there are more to the ROW and ACC Ag. & Natural Lands resource that previously thought. This finding presents an opportunity to manage these resources more efficiently and more closely follow best management practices. As areas of high use and visibility, ROW trees area important in terms of public safety, community aesthetics, and a model for good tree maintenance. ACC surveys these resources only every 10-12 years. Given the amount of ROW trees estimated from the i-Tree study, managers should assess this tree category more regularly. As well, they should increase municipal resources for hazard mitigation and maintenance, and planting of desirable species, so the community forest serves as a store of ecosystem benefits and source of resiliency. This is very important because ACC has an early successional forest which will be changing through the next decades.

Future Considerations: Private Trees

Results indicate the need to revisit the current tree species list in the ACC tree ordinance and think about which species provide the most benefits versus those such as water oak that produce more liability. To this end, it is important to enhance education for private landowners given the importance of the private forest resource. This is related to the need to encourage conservation of rare species and habitat on private lands, as well as promote diversity, just as ACC managers have been doing on public lands.

CONCLUSION

Understanding an urban forest's structure, function and value can promote management decisions that will improve human health and environmental quality. An assessment of the vegetation structure, function, and value of the ACC Community forest was conducted during 2021. Data from 316 field plots located throughout ACC Community Tree Study were analyzed using the i-Tree Eco model. ACC's community forest covers 58.2% of the county. Private trees outnumber public trees by almost two to one; yet, public canopy is very productive. ACC has a relatively young forest. ACC's 13.4 million community trees produced $36.3 million in annual benefits and $7.44 billion in structural benefits. Future key activities include disseminating the information from the ACC Community Tree Study to the public and executing on future considerations.

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