ABSTRACT

LORENZO MAGGIO LAQUIDARA. Assessing Urban Forests: A Systematic Review of Data Availability for Urban Forest Management in the Southeastern US. (Under the direction of Dr. Meredith Martin, Dr. Justin Baker, and Dr. Jennifer Richmond-Bryant)

Urban forests provide essential ecosystem services and enhance the livability of cities, yet the extent to which municipal governments in the Southeastern United States collect, maintain, and share data to support urban forest management remains poorly understood. This study presents a systematic review of urban forest data availability across 159 cities with populations exceeding 50,000 residents in nine Southeastern states. Drawing on municipal documents, public websites, and survey responses from local urban forest managers, we assess the presence, accessibility, and timing of key management tools—urban tree canopy (UTC) assessments and street tree inventories—and analyze factors associated with their adoption. Results reveal marked disparities among states and municipalities: 56% of cities maintain a tree inventory and 64% have conducted a UTC assessment, yet only 27% publicly share their inventory data. Larger cities and those with higher institutional capacity are more likely to maintain inventories, with population size emerging as the strongest statistical predictor of adoption. Qualitative findings highlight additional barriers, including limited staffing, funding instability, and uneven collaboration among governmental and non-governmental actors. Despite these constraints, many urban foresters express ambitions to expand monitoring efforts, standardize data collection, and engage residents through public platforms. The findings underscore that data availability is not merely a technical issue but a key dimension of urban infrastructural development and adaptive governance. Strengthening data transparency and coordination across municipalities will be crucial to building climate-resilient urban forests in the Southeastern United States.

Assessing urban forests: A systematic review of data availability for urban forest management in the Southeastern US

by

Lorenzo Maggio Laquidara

A thesis submitted to the Graduate Faculty of North Carolina State University
in partial fulfillment of the requirements for the degree of

Master of Science

Forestry

Raleigh, North Carolina

2025

APPROVED BY

Dr. Meredith Martin Committee Chair	Dr. Justin Baker Committee Member	Dr. Jennifer Richmond-Bryant Committee Member

BIOGRAPHY

Lorenzo Maggio Laquidara is an MS student at North Carolina State University's Forestry and Natural Resources Program. His key research interest is understanding the ways historical race and class segregation practices impact modern-day ecosystem service distribution in South U.S. cities. He is also interested in understanding how low-income immigrant communities navigate marginalization in the U.S. and Europe, especially in his native Italy. He completed his Bachelor of Science in Environmental Science and Public Policy at Duke Kunshan University and Duke University, where he first learned how to identify tree species.

ACKNOWLEDGMENTS

First and foremost, I would like to thank Dr. Martin, Dr. Richmond-Bryant, and Dr. Baker, for having trusted me with their ideas and time.

Madi and Jacob, thank you for embarking on this adventure together. Ale, Lau, Jóse, Brook, Tim, Robinson, Maggie, and Danny, thank you for acting as unofficial older siblings. Raj, Lucie, and Renata, for not having lost your patience.

Thank you immensely to Cari Furiness, Michelle Jewell, Rebecca Irwin, Maira Brondizio, Lydia Campbell, Joe Peters, the Southeastern Climate Change Adaptation Science Center, and all those who have made this project practically possible.

Nemmanco a dirlo, questa piccola fermata lungo la Rotta Maggiore è dedicata a Gabriele, che diventa sempre più saggio; a Maya, che non smette di crescere all'improvviso; e a Jona, che sta vivendo questi giorni con la rabbia di un giovane uomo intelligente.

Queste righe sono anche un'altra occasione per ringraziare i miei genitori, tutti. A Mary, che è diventata la mia migliore amica. A Mamma, che per fortuna non è cambiata mai. E a Papà, che rimane irragiungibile.

Finally, I wish to share this sense of lightness with the person I love the most. So little time has past, and yet I am already tempted to look back and feel touched.

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1 Research Background

1.1 Defining urban forests and their importance

Urban forests include "trees along streets, in yards, parks, abandoned spaces, and natural areas" Wolch et al. [2014]. While urban ecologists normally encourage municipal policymakers to prioritize urban forest expansion Wolch et al. [2014], some studies suggest that even cities with high vegetative canopy may exhibit an a unbalanced distribution of nature's positive and nature's contributions to people (NCPs) Roman et al. [2021]. What makes urban forests stand apart from other forms of green infrastructure is a position that facilitates interactions between humans and nature Halpenny [2010], which typically entail positive contributions to human users Díaz et al.. Positive NCPs, an extension of the *ecosystem service* framework Daily and Matson [2008], include carbon sequestration Fuller et al. [2025], air pollution management Saverino et al. [2021], biodiversity conservation Halpenny [2010], erosion control and stormwater management Berland et al. [2017], and urban heat island effect mitigation Saverino et al. [2021]. Urban forests also promote recreation Tyrväinen et al. [2007], Halpenny [2010], Wolch et al. [2014], socialization Sennett [2018], and psychological wellness Mitchell and Popham [2008]. Urban forests can also impact city dweller lives in negative ways, exposing urbanites to treefall hazards Roman et al. [2021], and a perceived lack of safety associated with secluded illicit activities Wolch et al. [2014]. Urban forestry instruments like UTC assessments and street tree inventories represent the most reliable way for urban managers to visualize and quantify interactions between residents and the urban forest. UTC assessments are instrumental to understanding where vegetation and the NCPs associated with it concentrate, and where they are lacking Nowak et al. [2022]. Street tree inventories offer urban foresters with an additional level of insights into the ways in which each individual tree contributes to the well-being of the humans how live, work, and play around it Wolch et al. [2014]. Being aware of a tree's age, species, successional guild, site type, and land cover allows tree carers to make inferences on the way this tree interacts with its surrounding environment, whether it represents a benefit for human and non-human city dwellers, or a potential source of risk. Similarly, it gives policy makers perspective over the services that need the most development and those urban forests are already contributing to.

1.2 Proactive urban forest management and its importance to NCPs

Urban forests and urban green space (UGS) represent an invaluable source of environmental services for city systems. Urban ecology scholarship has used UGS and urban forests as proxies to study the distribution of ecosystem services Nowak. UGS is broadly defined as vegetated urban areas managed by some social stakeholders, such as urban governments, private entities, community organizations, or single individuals Wolch et al. [2014]. Research instruments like *urban tree canopy assessments* (UTCs) and *city tree inventories* represent valuable ways to observe these distributional patterns within urban forests. A UTC assessment is a systematic, GIS- and/or imagery-based analysis that quantifies the proportion of a community's land surface covered by tree canopy, usually expressed as a percentage of total area. A street tree inventory is a field- or database-driven catalog of individual trees located in the public right-of-way (and sometimes other public lands) that records attributes such as location, species, size (DBH or trunk diameter), condition, and maintenance needs Saverino et al. [2021], Tate [1985]. Because these instruments have been in the urban ecologist and the urban forest manager's toolbox for quite some time O'Herrin et al. [2020], they represent an effective way to assess urban forest practice across a region or municipality Hoffman et al. [2020]. UTCs normally rely on airborne imagery collection or statistical analysis of existing geospatial data Nowak et al. [2022]. When geospatial data are already available, municipal GIS specialists or local data managers can develop an UTC measures in their allotted work time, making UTC assessment development virtually free Nowak et al. [1996]. However, assessment costs rise sharply when remote imagery is required. Urban governments normally lack access to airborne photography drones and specialists who can operate them, so they normally rely on external contractors. State and federal governmental agencies rarely provide this type of data collection performance, creating a market space for specialized private contractors Hoffman et al. [2020]. Additionally, UTC assessments survey vegetation on private and public land alike, capturing information on vegetation that municipal urban forests do not actively manage Nowak. They also do not provide much insight into which ecosystem services a given piece of green infrastructure provides, and in which quantity. Nevertheless, UTC assessments remain much less expensive than tree inventories, making it possible for them to cover entire municipalities Nowak et al. [2022].

1.3 Characterizing the U.S. Southeast as a study region

Rather than an area comprising strict geographical boundaries, the Southeast is a cultural region that shares environmental and social challenges Márquez [2023], Baker [2024]. Southeastern states share similar ecological characteristics, forest types, and native plant communities, which are expected to respond to changes in climate in a consistent fashion Fitzpatrick et al. [2021], Koeser et al. [2016]. Those cities that were relatively large in the mid 20th century were shaped by a real-estate loaning practices that broadly follow under term *redlining* Anguelovski et al. [2022], Nowak, Baker [2024]. Urban ecology scholarship demonstrated how in many instances, historical loaning practices are reflected in the way urban development looks like in the modern United States Mikati et al. [2018], Schell et al. [2020], Saverino et al. [2021], Baker [2024]. Accelerated and often sudden urbanization Gill [2018], large-scale deforestation at the urban-wildland interface Fuller et al. [2025], air pollution, urban heat island, and extreme weather events represent shared issues across the region Saverino et al. [2021]. As urbanization catalyzes these environmental policy issues Gill [2018], municipal governments have expressed growing interest in using urban forests as instruments for ecosystem service provision Koeser et al. [2016], O'Herrin et al. [2020]. However, tree-planting and maintenance initiatives are subject to many informational, technical, and financial challenges Koeser et al. [2016].

1.4 Existing urban forestry research in the U.S. Southeast and its importance to the region

Understanding the state of the art of urban forestry across the Southeast requires us to know something about what urban ecology scholars have written on the topic. UGS distribution studies have been conducted at the national level, but little literature focuses on urban forest distribution patterns across Southeastern cities. Anguelovski and colleagues conducted a systematic review of UGS plot distribution across multiple large cities in the United States, revealing an association between redlining grade and green space at the census tract level Anguelovski et al. [2022]. Nowak and Greenfield famously confirmed this pattern across the entire United States Nowak et al. [1996], Nowak and Greenfield [2012]. Doroski and colleagues conducted a similarly comprehensive study across the entire Northeast, taking an interest in all cities with more than 50,000 residents Doroski et al. [2020]. While similar municipal-level studies have been replicated in some Southern cities like Richmond, VA Hoffman et al. [2020], Saverino et al. [2021], Atlanta, GA Immergluck [2022], and Durham, NC Poulton Kamakura et al. [2024], and across multiple cities in state of Florida Koeser et al. [2016], no study considered all cities across the region uniformly. Growing interest has arisen among professional associations and academia in mapping urban forest inventory and UTC assessment occurrence and development at the municipal level across the region to assess gaps in information that are essential for forest management. In 2014, Koeser and Hauer compiled tree management information for all cities with more than 50,000 residents across the country Koeser et al. [2016]. Their studies included a sample of smaller cities from different cultural and ecological regions across the nation. To our knowledge, this is the first study that takes an interest in mapping urban forests and urban forest management with a specific focus on the U.S. Southeast.

2 Aims and Objectives

This study aims to be the first comprehensive overview of all the available public data on urban forestry across the Southeast. Considering that this pursuit is no small feat, our investigation starts from three questions. Firstly and as mentioned above, this study wishes to provide a synthetic and coherent answer to the question: **What is the status of urban forestry inventory and UTC assessment data in the U.S. Southeast?**. In a region where industrial forestry has such a long history and major present importance, but where urbanization feels so recent and explosive, we expect for urban forestry inventory and UTC assessment availability and collection to be very heterogeneous, and to feature unique peculiarities.

We also hypothesize that urban forest inventory and UTC assessment distribution among cities is not a product of chance or coincidence. We are also curious to have a sense of the ways early urban development patterns are reflected on city structure today. Our second question to this study is **What factors are correlated with UTC assessment and street tree inventory adoption across the U.S. Southeast?**

Finally, we hope to know more about all those who are at the forefront of the relationship between humans and forests in cities across the region. We would like to understand **what challenges, plans, and ambitions does urban forestry express across the region?**

3 Methods

3.1 Geographic delineation and definition of sample cities

Our study region includes all cities with more than 50,000 residents across the U.S. Southeast. Figure 1 shows this study's full regional extent. We followed the USGS Southeast Climate Adaptation Science Center (SE CASC)'s definition of the region's boundaries, and included Arkansas, Mississippi, Alabama, Tennessee, Florida, Georgia, South Carolina, and North Carolina in our sample. We also included municipalities in the state of Virginia, due to its cultural, historical, and physiognomic similarities with other states in the region [Hoffman et al., 2020]. We excluded SE CASC regions Puerto Rico and the U.S. Virgin Islands from our investigation on the grounds of their historical, cultural, ecological, and urbanistic separateness from the rest of the U.S. Southeast.

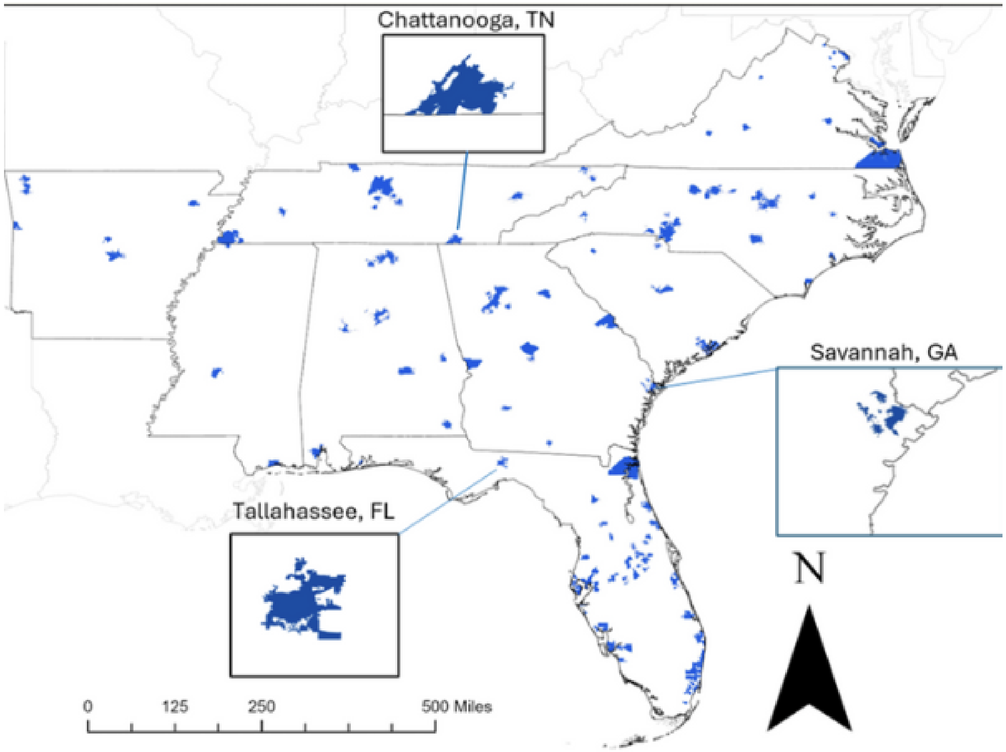


Figure 1: This study's geographic sample included all cities with 50,000 residents or more across the states of Arkansas, Mississippi, Alabama, Tennessee, Florida, Georgia, South Carolina, North Carolina, and Virginia.

3.2 Public information review

We collected data on each city's demographic, socioeconomic, climatic, and ecological characteristics, as well as information about urban tree management from public-facing municipal governments websites, NGO pages, municipal and state-level legislative documentation, and federal agency archives. Table 1 represents a summary of all the variables this study took into consideration. Demographic information provides important insights about urban forests' ecosystem service user base [Fuller et al., 2023, 2025]. In fact, population size is typically used to estimate natural contribution to people (NCP) scope in urban settings [Díaz et al., Anguelovski et al., 2022, Nowak et al., 2022]. While population size can effectively estimate how many residents would rely on a given municipality's urban forest [Koeser et al., 2016], it fails to acknowledge differences in municipality size and urbanization degree. This is especially true in sprawled metropolitan areas, where suburban development and commuting mask population size effects [Fei et al., 2017]. We also collected information on total land area, barren land area, developed land area, and forested land area in miles for each city to estimate urban forest density and accessibility, as well as to perform spatial analysis modules.

Table 1: Description of the variables measured in this study and considered in modeling stage.

Variable	Type	Description / Meaning	Treatment in Model
`Inventory_bin`	Categorical (factor, binary)	Presence/absence of a tree inventory (outcome variable)	Dependent variable (response)
`Population`	Continuous	Total population of the city/tract	Scaled (standardized) predictor
`PopDensity`	Continuous	Population density (people per unit area)	Scaled predictor
`Tree_Equity`	Continuous	Tree Equity Score (distribution of canopy vs. need)	Scaled predictor
`University`	Categorical (factor)	Whether the city/tract hosts a university (Yes/No)	Predictor (factor)
`Redlining`	Categorical (factor)	Historical redlining status (HOLC grades or binary)	Predictor (factor)
`Survey_Response`	Categorical (factor)	Whether a city/tract responded to a survey	Included in dataset but **not in final regression**

We performed a detailed web search to gauge whether cities had conducted a UTC assessment or developed a street tree inventory. We also recorded the year of tree inventory development and its degree of public accessibility (private, public, or mixed), as well as qualitative notes on data content, planted species, and year in which a certain forestry practice was launched. We also documented the governmental bodies, non-governmental organizations (NGO), or community-based organizations (CBO) responsible for urban forest management across each city. For cities with tree inventories developed by NGOs, we noted the organization's name and the governmental department responsible for maintaining relationships with it. In addition, we recorded cases where smaller "satellite towns" outsourced their urban forest management to a larger surrounding municipality, which was be especially relevant to studying metropolitan areas that spanned multiple jurisdictions (e.g., Miami and Washington D.C.), "twin city" conurbations (e.g., Tampa and St. Petersburg), cities encompassing multiple statistical areas (e.g., Little Rock and North Little Rock), or areas with high levels of urban sprawl (e.g., Charlotte and Miami).

3.3 Urban forest manager survey

To address gaps and validate information, we collected contact information for each city's designated urban foresters. Forest managers wear highly varied "hats" across U.S. cities and hail from diverse professional vocations and government departments [O'Herrin et al., 2020]. We therefore made every effort to identify the professional figure responsible for public tree management in each city, drawing on contextual information, government statements, and local digital news articles. We then contacted urban forest managers in charge via email, sending them Google Form survey comprised of 30 questions on which urban forest practices were in place in their municipality, when they had adopted these practices, what trees were present in their city, whether they collaborated with other entities, and which challenges and opportunities felt the most relevant to their work. The survey was also advertised by the North Carolina State University Cooperative Extension, the Southern Regional Extension Forestry (SREF), the Southern Group of State Foresters (SGSF), and the Southern Chapter of the International Silviculture Association (ISA). Those urban foresters who were initially contacted received two follow-up emails, unless they had completed the survey or stated their unwillingness to participate any further.

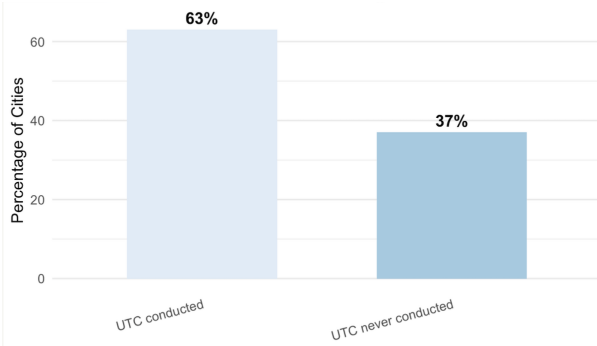
3.4 Semi-structured interviews

We conducted semi-structured interviews with some of the urban forest managers who answered our survey. The survey contained an invitation to participate in a short interview to expand on the questions we had covered. The semi-structured interview took place over the phone or by video-conference, and lasted between 45 minutes and an hour and a half. Interviewees were prompted to provide further detail about urban forestry in their city, their professional position, the challenges their city was facing, their own projects, and collaborations with other urban forestry actors. The interviews were not recorded, due to to the anecdotal and non-confidential nature of the conversation. Also, because the interviews did not touch on any sensitive topic and the interviewees responded as public officials, no formal approval was needed from North Carolina State University's Internal Review Board. Some responses pointed to other urban forester managers who would be open to participate in similar conversations, effectively serving as intermediaries in a snowball sampling process Noy [2008].

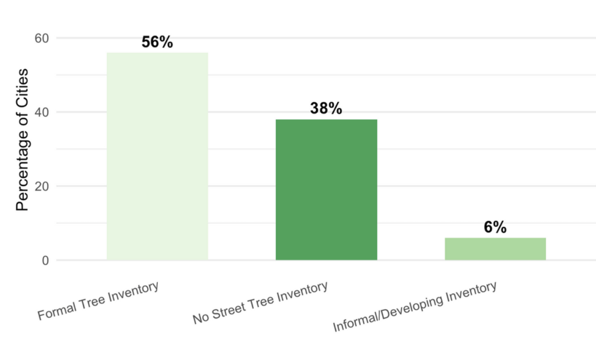
Aside from information on urban forestry practices, we also collected data on socioeconomic variables that could reflect patterns in ecosystem service accessibility and green infrastructure distribution. We collected census tract– and municipality-level Social Vulnerability Index (SVI) values for each city. The Centers for Disease Control and Prevention's (CDC) Agency for Toxic Substances and Disease Registry develops SVI as a community-level measure of financial wealth and social well-being. SVI values range from 0 to 1, with lower values suggesting below-average household income and employment rates, and higher values indicating greater vulnerability. In addition, we used American Forests' Tree Equity Score (TES) as a measure of urban green space (UGS) accessibility across resident groups. American Forests is a nationwide NGO advocating for forest protection and conservation, with a special focus on urban forests. TES ranges from 0 to 100, with higher values indicating more equitable access to UGS across neighborhoods. We also incorporated the Reforestation Hub's Tree Planting Potential (TPP) as an indicator of municipalities' ability to expand their existing urban forests. A high TPP suggests potential to improve UGS accessibility by adding trees. Finally, we collected information on the presence of environmental community-based organizations (ECBOs) and universities. Universities have frequently been documented as key promoters of tree planting projects in U.S. cities [Roman et al., 2021].

3.5 Data analysis: Correlation tests

All the independent variables in the dataset were tested for collinearity. Figure 4 represents the final outcome of our entry-level correlation tests. Pair-wise Pearson correlations were computed



(a) Bar chart showcasing proportion of cities that did and did not conduct UTC assessments, by the time of our public review.



(b) Bar chart showcasing proportion of cities that did and did not adopt street tree inventories, by the time of our public review.

for numerical variables, and investigated for direction and magnitude. The Bonferroni correction was applied to adjust for possible Type I errors. A mock linear regression with TES as the response variable was fitted to produce variance inflation faction (VIF) scores to investigate multicollinearity patterns. TES was selected as the response variable because it would later serve as one of the study's response variables. Also, it showcased a high Pearson correlation with SVI. VIF was chosen as multicollinearity metric over eigenvalue analysis because of its higher clarity. Thresholds were established at Pearson's $r > 0.8$ and VIF > 5.0. Variables would be excluded from analysis at such high correlation or multicollinearity levels. Variable pairs with high Pearson's r were still tested for VIF to tease pair-wise collinearity with possible instances of multicollinearity. LASSO regularization was excluded even for variable pairs that exhibited high collinearity, because it would likely obscure effects in later regressions. This approach to correlation entry-testing was favored over ordinations techniques like principal component analysis (PCA) because of its greater interpretability, and ability to retain factors as substantive constructs. By using Pearson's pairwise correlation test, relations among numerical variables were assumed to be linear. A limitation of this approach to correlation entry-testing was its inability to account for spatial autocorrelation phenomena. This consideration is especially relevant for municipalities that fall in the same metropolitan area or physiognomic region.

After being transformed into true categorical factors and a contingency table was constructed,

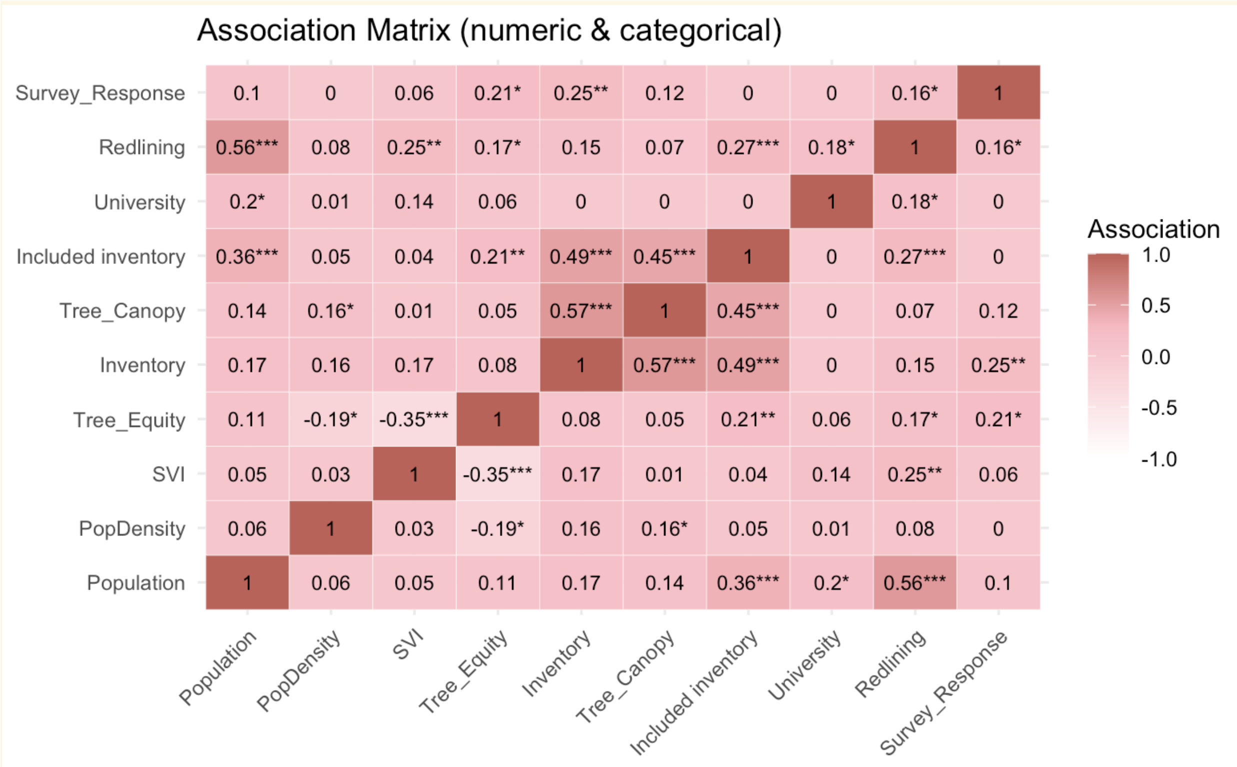


Figure 3: Correlation heatmap showcasing association metrics and significance among numeric and non-numeric variables.

non-numerical variables were checked for statistical independence with a Chi-square independence test. Their association strength was then assessed by computing Cramer's V. Because the number of variables was small, bias correction was applied. Combining Chi-square independence test and Cramer's V computation ensured that significant but trivial associations were parsed from significant association with strong effects. Because some variables had more than two levels, a ϕ coefficient was excluded from use. Log-linear modeling and mutual information approaches were also avoided due to their complexity, compared to the easily interpretable Chi-square and Cramer's V. On the other hand, Chi-square dependency tests suffer from their inability to test for multicollinearity and display association direction. Also, we assumed full independence among each record, failing to reflect the sample's spatial geospatial structure.

Following the collinearity tests within numeric and non-numeric variables only, η^2 co-variation coefficients were computed for numeric-categorical variable pairs. The coefficients were generated via a custom ANOVA test. The ANOVA test was considered appropriate because reducing categorical variables to dummy numerical variables, or reducing numerical variables to categorical factors, would have incurred a critical loss of information. Naturally, Pearson's r, Cramer's V, and η^2 coefficients cannot be compared perfectly, let alone due to the latter two's inability to show direction. Also, pair-wise p coefficients cannot be used for inferences based on multiple testing, which this approach used. Figure 2 showcases all these forms of collinearity on a single heatmap, with statistical significance levels.

Due to its high collinearity with the TES, SVI was excluded from any later regression model. Whereas the TES and SVI do not encompass each other, they share much of the same source data. Even though SVI takes more demographic factors than TES (sixteen, as opposed to six), the former does not pay any consideration to tree canopy, tree health, location, climate, public health, and ecosystem service-related factors. Considering its relative extensiveness and its relevance to urban forestry, TES was included in regression models. Additionally, a Box-Tidwell model with an interaction factor was fit for all numerical variable to test for their linearity. Linearity assumptions were robust for all variables, except for SVI ($p < 0.01$). Thus, excluding SVI made it possible to develop regression models that assumed linearity of the factors.

3.6 Linear mixed-effect model

A linear mixed-effect model (LMER) was fitted through the selected factors, with street tree inventory adoption as a binary response variable. The `glmer` function from the `lme4` R package was used to fit the model. In addition for the selected factors, state was construed as a random effect term. Considering that the response variable was binary and many of the factors were not, we modeled the LMER with a binary logistical function. Bound optimization by quadratic approximation was used as control. The model did not reveal significant associations between any of the factors, safe for historical redlining occurrence, which was associated with inventory adoption with a confidence level such as $\alpha = 0.90$. The model has a marginal performance such as $R^2 = 0.82$. However, state did not have any random effect on the response variable. We also fit the factors and response using a stepwise selection model.

4 Results

4.1 State-level UTC assessment and street tree inventory adoption

Several inconsistencies emerge when comparing street tree inventory adoption and urban tree canopy (UTC) development across Southeastern cities. For example, Arlington, VA, Clarksville, TN, and Winter Haven, FL report having inventories but no UTC development, while Chesapeake, VA, Conway, AR, Gainesville, FL, and multiple Florida and Virginia cities show the opposite—UTC efforts without formal inventories. Some locations, such as Johnson City, TN and Roanoke, VA, reflect uncertainty (”Unsure”) in inventory reporting, which complicates evaluating their commitment. These mismatches suggest that adopting one practice does not guarantee the other, and local priorities or resource constraints may drive different approaches. When considered alongside adoption timing—where states like Arkansas and Virginia average early adoption years (2002), and Florida adopts more recently (2014)—it appears that even long-established programs can show gaps in integrating inventories and canopy planning. Conversely, some recent adopters may prioritize canopy studies over formal inventories. These patterns align with broader trends observed earlier: many municipalities participated in symbolic programs like Tree City USA decades ago but formalized their data tracking later. The clustering of recent adoption in the Carolinas and Alabama may reflect heightened awareness of urban forestry's benefits, new funding streams, or regional initiatives encouraging consistent inventory practices.

4.2 UTC assessment and street tree inventory occurrence among the sample cities

Figure 2 and Table 2 both illustrate proportions of urban forestry practice adoption for each state in the studied region. Among the surveyed municipalities, about 56% maintain formal tree inventories, while 38% report none and 6% indicate probable or informal efforts. Our public information review also revealed that participation in the Arbor Day Foundation's Tree City USA program is higher than official urban forestry practice adoption, with roughly 71% of cities involved. Many cities have participated for decades, with a median tenure of 27 years, and some cities exceeding 45 years of membership. Florida stands out, hosting the largest number of inventories and Tree City programs, while North Carolina, Georgia, and Virginia also display robust participation. In contrast, states like Tennessee show inventories but no Tree City recognition. Out of the 159 municipalities whose public information and official statements were reviewed, 119 (74%) express an explicit intention to develop a street tree inventory. 35 cities (36% of the cities with a street tree inventory) enlisted GIS analysis and remote sensing instruments in their official urban forestry infrastructure. Multiple cities cite partnerships with consultants (e.g., Davey Tree) or county-level programs, while others reference comprehensive plans or commemorative planting programs instead of full inventories.

Table 2: Summary of urban forest tool adopted across each state in the studied region.

State	Total cities	Cities with inventory	Cities with UTC	Cities with both	Proportion with inventory	Proportion with UTC
Alabama	10	6	6	5	0.600	0.600
Arkansas	9	3	5	3	0.333	0.556
Florida	60	38	43	32	0.633	0.717
Georgia	19	12	11	11	0.632	0.579
Mississippi	3	1	2	1	0.333	0.667
North Carolina	22	17	20	17	0.773	0.909
South Carolina	7	3	5	3	0.429	0.714
Tennessee	16	7	2	2	0.438	0.125
Virginia	13	11	10	10	0.846	0.769
Total / Mean	**159**	**98**	**104**	**84**	**0.557**	**0.637**

Urban Tree Canopy (UTC) mapping across the U.S. Southeast reveals a similar pattern of uneven but expanding adoption. As shown in Table 1, approximately 64% of the surveyed cities have conducted a UTC analysis, a proportion slightly higher than that of formal inventory adoption. This finding suggests that canopy assessments may represent a lower-barrier entry point into urban forestry practice, often facilitated by the increasing availability of remotely sensed data and open-access geospatial tools. States such as North Carolina (90.9%) and Florida (71.7%) stand out as regional leaders, combining large numbers of active cities with consistently high UTC coverage.

Virginia and South Carolina also show strong adoption, while Tennessee and Arkansas lag behind, with only 12.5% and 55.6% of cities reporting canopy assessments, respectively. Across the region, many municipalities rely on partnerships with state forestry agencies, regional planning organizations, and universities to develop canopy maps that guide policy interventions. In several cases, UTC studies are integrated into broader sustainability frameworks or hazard mitigation plans, signaling a shift toward data-informed management of urban forest resources.

4.3 Data accessibility

Public data accessibility varies widely across municipalities and states. 45 cities (46% of the municipalities with a street tree inventories) explicitly mention publicly available data, while the others noted private or outdated inventories in their public statements. Of the cities that shared street tree inventory data with the public, 13 were in Florida, 12 in North Carolina, and 10 in Georgia. Proportionally, approximately half of North Carolina (55%) and Georgia's (53%) cities shared their urban forestry data. Conversely, no South Carolina city left data open to the public, and only one city in Arkansas and Mississippi, respectively. Table 3 shows a proportion of the municipalities that open their street tree inventory data to the public.

Table 3: Summary of municipalities that share street tree inventory data with the public across each state in the studied region.

State	**Total number of cities**	**Data shared with the public**	**Proportion**
Alabama	10	3	0.30
Arkansas	9	1	0.11
Florida	60	13	0.22
Georgia	19	10	0.53
Mississippi	3	1	0.33
North Carolina	22	12	0.55
South Carolina	7	0	0.00
Tennessee	16	2	0.12
Virginia	13	4	0.31
Total / Mean	**159**	**46**	**0.27**

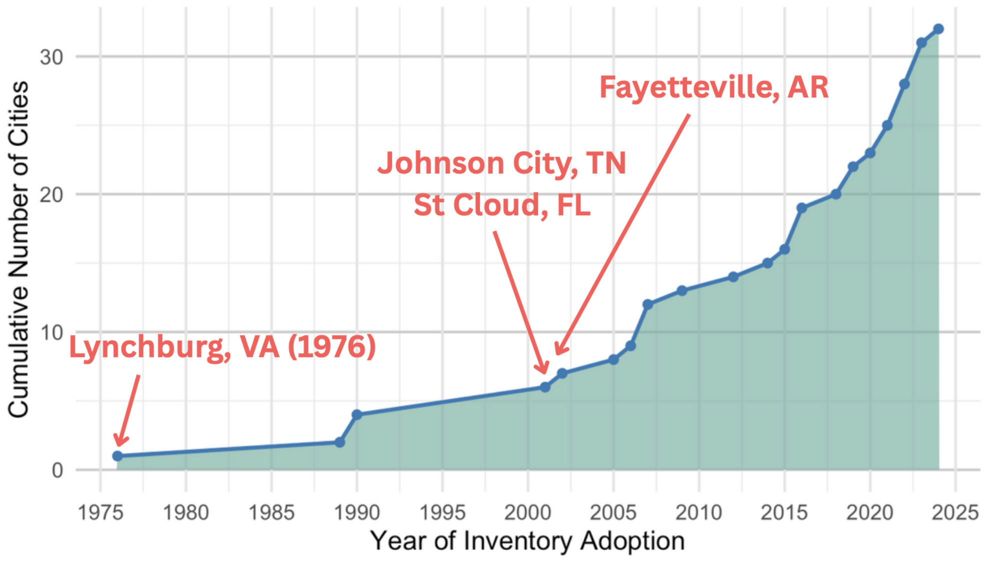


Figure 4: Street tree inventory adoption accumulation curve, with early adopters highlighted.

4.4 UTC assessment and street tree inventory adoption timing

The public information review and the survey both reveal that the many municipalities had their first formal contact with urban forestry in recent times. Table 4 summarizes the timing of urban forestry tool development across each state, while Figure 3 offers a visual representation of street tree inventory adoption timing as an accumulation curve, with early adopters highlighted. The timing of public tree ordinance and inventory adoption in the Southeast reveals distinct waves of engagement. Early adopters such as Arkansas and Virginia show average adoption years around 2002, with Virginia displaying wide variability (SD $\approx$ 16.2), suggesting a mix of long-established programs and newer efforts. Georgia also fits this early pattern, averaging 2006. A mid-adoption phase appears in Tennessee (2008, SD $\approx$ 8.9) and Florida (2014, SD $\approx$ 7.9), indicating that many cities strengthened their urban forestry practices during the late 2000s and early 2010s. In contrast, North Carolina (2019), Alabama (2021), and South Carolina (2022) represent a recent surge in inventory adoption, marked by low variability and suggesting coordinated, up-to-date efforts. It appears that the four cities that first adopted public tree inventories are all in Virginia. Lynchburg, VA is the city that launched a street tree inventory first, in 1976. Asheville, NC launched its first inventory in 2024, presenting itself as the municipality that launched its inventory at the latest in this study's sample. The state with the earliest mean adoption year is Virginia, with a mean adoption year of 2002. The only city with a reported public tree inventory launch date in Arkansas, Fayetteville, also launched the program in 2002. On average, Alabama cities launched their urban forest inventories in 2021, while Mount Pleasant, SC started its program in 2022. Across 2014–2024, reported public-land tree plantings show both consistency and periodic surges. Small-scale efforts (1–100 trees) appear in nearly every year, indicating that many municipalities or organizations maintain steady, modest programs. Mid-range plantings (101–250 and 251–500 trees) occur throughout the period, with occasional clusters suggesting targeted campaigns or funded projects. Larger plantings (501–1000) persist across almost all years, pointing to a core group of communities capable of sustained, organized planting at a significant scale. Notably, very large efforts (1,001–2,000 and above) became more common after 2016 and particularly toward the late 2010s and early 2020s, with several entries exceeding 2,000 trees. The surge of high-volume efforts in 2019–2024 may reflect maturing urban forestry programs, increased funding, or heightened climate and canopy-equity initiatives.

Table 4: Mean year for the first urban forestry instrument development action in each state across the studied region.

State	Mean adoption year	sd
Arkansas	2002	—
Virginia	2002	16.2
Georgia	2006	—
Tennessee	2008	8.9
Florida	2014	7.9
North Carolina	2019	4.3
Alabama	2021	2.0
South Carolina	2022	—
Mean / SD	**2009**	**7.9**

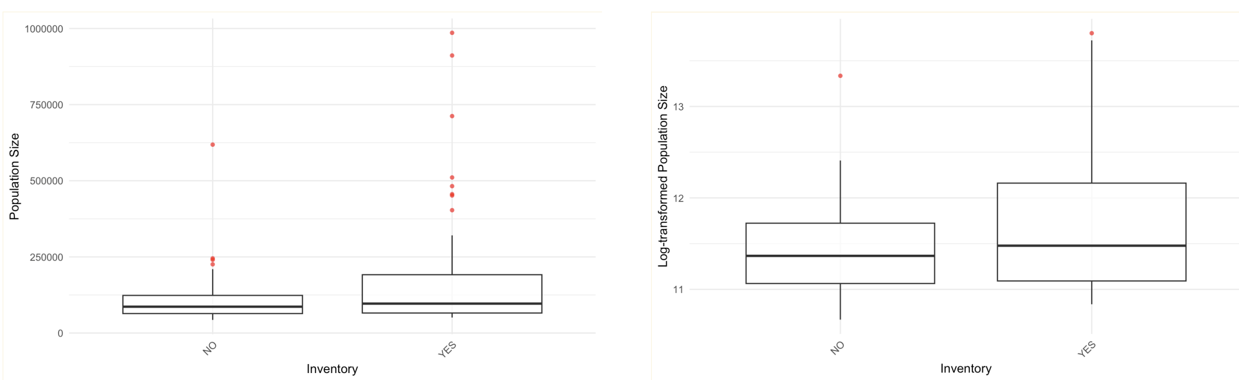
4.5 Associations among factors

The association tests revealed that a large population is associated with having historically enacted redlining policies (η^2 = 0.56, $p < 0.05$), as well as a lower TES (η^2 = 0.25, $p < 0.10$). Intuitively, a larger population implies a higher chance of hosting a university (η^2 0.20, $p < 0.15$). Interestingly, populous cities seem to be associated with publicly accessible databases (η^2 = 0.36, $p < 0.05$). It also appears that cities that responded to the survey are associated with a higher Tree Equity Score (η^2 = 0.21, $p < 0.15$).

4.6 Factors correlated with street tree inventory adoption

A bidirectional stepwise selection procedure was employed to identify the most parsimonious set of predictors for the presence of a tree inventory. This approach was selected to systematically evaluate multiple candidate predictors, while balancing model complexity and goodness of fit. Table 1 summarizes the characteristics of all the factors included in the stepwise model. Stepwise selection guided by the Akaike Information Criterion (AIC) provides a framework for reducing overfitting and retaining variables that contribute meaningfully to the explanation of variance in the dependent variable. Alternative approaches could have included theory-driven selection, in which all predictors are retained based on prior knowledge, penalized regression methods such as LASSO or Ridge regression that perform variable selection through coefficient shrinkage, or hierarchical models that account for nested data structures while incorporating all predictors. The stepwise selection was implemented using the `stepAIC` function in R with bidirectional elimination (`direction="both"`). Starting from a full logistic regression model containing all candidate predictors, variables were iteratively removed or added to minimize AIC. At each step, AIC values were evaluated, and predictors were excluded if their removal resulted in a lower AIC, indicating minimal contribution to model fit. The procedure converged on a model retaining only population size as a predictor (Table 1), while all other factors were sequentially removed. This method provides a parsimonious and interpretable framework emphasizing the primary influence of population on the presence of a tree inventory.

In the final regression model from the stepwise selection process, only the coefficient for population size was positive (Estimate = 0.835) with an SE of 0.481, suggesting that municipalities with a larger population are more likely to have a documented tree inventory. The z-value for Population was 1.736 with a p-value of 0.083, indicating a trend toward statistical significance with $\alpha = 0.1$. Overall, the residual deviance of 109.99 compared to a null deviance of 114.67, alongside a reduced AIC of 113.99, demonstrates an improvement over the null model. An ANOVA test of street tree inventory adoption by population size has a p value of 0.046, also significant with $\alpha = 0$. Figure 4(a) displays bi-variate descriptive statistics for population size and street tree inventory adoption. Even though p was significant for $\alpha = 0.1$, the two groups overlap, suggesting little real significance. This was also true after population size was log-transformed to hone homogeneity (Figure 4(b), with $p = 0.045$). These results highlight the dominant influence of population size in predicting whether a municipality maintains a tree inventory, while other demographic or equity-related variables did not meaningfully enhance predictive power in this dataset.



(a) Population size by street tree inventory adoption group.

(b) Log-transformed population size by street tree inventory adoption group.

Figure 5: Pair-wise comparisons for population and street tree inventory adoption.

5 Discussion

5.1 Research Question 1: Urban forestry data in the U.S. Southeast

5.1.1 Early urban forest assessments and inventories and their evolution in the U.S. Southeast

This study sheds light on which areas still represent gaps in our understanding of urban forest inventories and canopy assessments in the Southeastern U.S. Urban forestry made its entry in the region as early as the late 19th Century, thanks to initiatives launched by NGOs like American Forests and the Arbor Day Foundation. However, Southeastern municipal governments lagged behind national trends, only starting to develop their own urban forestry inventory and assessment instruments after in the 1980s and in restricted areas like coastal Virginia and the Washington D.C. metropolitan area. It was only in the past fifteen years that urban forest management entered the official policy agenda in most municipalities across the region. While adoption was slow, urban forest management practices have *sprouted* in small towns just like in large metropolises. As of 2025, more than half of the municipalities with more than 50,000 residents (i.e., 56%) have run their own street tree inventory, and even more have surveyed their tree communities at least once. We suspect that this rapid change in approach dependents on the sudden and accelerated urbanization the whole region is experiencing. Some of urbanization's implications, like regional socio-economic development, deforestation, air and water pollution, and urban heat, may all serve to justify keeping urban forestry under closer scrutiny.

5.1.2 Technological and conceptual innovation in the region's urban forestry sector

While urban forest management and mapping techniques are increasingly advanced, very few municipalities have a precise understanding of the way urban forests contribute to their residents' livelihoods. In spite of the increasing availability of instruments like i-Tree Eco Nowak, urban forest managers seldom take the time to assess ecosystem service provision capacity in the forests they manage. This hesitation may possibly depend on the those instruments tendency to overestimate ecosystem service provision Kais et al. [2025]. It is also possible that NCPs still represent an overly abstract concept in the real of urban forest practice, which may intentionally refrain from framing nature infrastructure development in budgetary terms O'Herrin et al. [2020]. Understanding the way urban forests contributes to urban livelihoods is a key component of urban environmental policy, because it justifies governmental spending and directs future investment. Also, it represents useful knowledge in the wake of likely climate change-driven challenges to the urban forests' well-being.

5.1.3 Data sharing and accessibility

This study noted that smaller municipalities with limited inventories were hesitant to share data publicly, fearing pressure to expand tree planting. Larger cities with older inventories were more likely to release their data, a trend weakly supported by the records review (population size was significantly but modestly correlated, $p = 0.1186$). Cities like Arlington, VA, which falls within Washington, D.C.'s large metropolitan area, opened its inventory to the public in 1999. Now, the city reaps the benefits of three years of community urban forestry engagement, and can justify large investments in tree maintenance and planting initiatives. Despite concerns about sharing data with their broad constituencies, interviewees were eager to share data with researchers. Many were also open to future volunteer involvement, which has been essential in expanding inventories beyond public land in some cities [Boyce, 2010]. St. Petersburg, FL's public TreePlotter platform has been made public after the urban managers paid for a publishing fee, enabling rapid growth of its tree inventory since 2018 via citizen volunteerism. The city's experience aligns with previous findings on volunteer contributions and their role in green infrastructure policy. In keep with such literature, St. Petersburg's urban forestry officials notes that volunteers often require oversight and attract participation primarily from high-SES, ethnic majority groups. Community champions were highlighted as effective intermediaries for participation [Fitzpatrick et al., 2021, Eisenman et al., 2025].

5.1.4 Limitations in data collection

Several limitations should be acknowledged when interpreting these findings. Data availability and accuracy represent a critical constraint. Urban forest inventories, canopy assessments, and master plans vary widely in completeness, quality, and update frequency across municipalities. While some cities maintain highly detailed, publicly accessible inventories, others provide only partial or outdated information, and a subset lack formal documentation altogether. This unevenness may introduce reporting bias, with better-resourced municipalities more likely to have robust data, skewing regional comparisons toward places with stronger management capacity. In fact, running a street tree inventory was positively associated with having responded to the survey, although with no statistical significance. Furthermore, the study's sampling frame—cities with populations over 50,000—while consistent with prior research, inherently excludes smaller municipalities that may have distinct management practices or face different challenges. The decision to admit a few smaller settlements opportunistically introduces selection bias, as these towns may not represent the broader population of small urban centers. Similarly, the Southeast is treated here as a culturally and ecologically coherent region, but intra-regional variation (e.g., coastal vs. inland climates, or fast-growing Sun Belt metros vs. legacy cities) may obscure important local dynamics. This consideration is especially relevant to *college towns*, smaller municipalities that often host large populations of non-resident university students, staff, and faculty. Urban forestry literature supports the urban forest manager interviewee's remark that universities often spearhead urban forestry in the state where they are located.

5.2 Research Question 2: Population size, urbanization, and urban forestry management

5.2.1 Population size and interactions among factors

Bidirectional step-wise selection produced a logistical regression model with population size as the only predictor for street tree inventory adoption. The selection process excluded population density, TES, university presence, and historical redlining, even though all these variables had not shown critical collinearity levels during entry-level association tests. The model exhibits a statistically significant positive effect of population size on street tree inventory development, with $\alpha = 0.1$. These results suggest that population size likely interacts with population density, the presence of a university, a high TES, and the possibility of a city having embraced historical redlining practices. In fact, population size seldom figures as the rationale justifying the development of a street tree inventory or the conduction a UTC in urban forestry master plans. It may be more likely that the development of urban forestry tools depends on the composite effect of urbanization, a growing population, and the concentration of non-governmental population like environmental NGOs, CBOs, and universities.

5.2.2 Limitations in statistical analysis

We should note that our analytical approach to association analysis, consisting of pairwise correlations, VIF testing, ANOVA, and stepwise logistic regression—while transparent and interpretable, does not fully account for spatial autocorrelation or nested data structures (e.g., multiple cities within the same metropolitan area or physiographic province). Spatial econometric models or hierarchical frameworks could better capture these dependencies. Additionally, stepwise AIC-based selection, though widely used, is sensitive to sample size and multicollinearity, potentially excluding theoretically relevant predictors or overemphasizing statistical artifacts. Finally, qualitative insights—such as local forestry staff input or NGO involvement—were incorporated descriptively but not systematically analyzed. These contextual details are crucial for understanding on-the-ground dynamics but remain underexplored in the quantitative framework. Together, these limitations highlight the need for caution when generalizing findings across all Southeastern cities. They also underscore opportunities for future work, including longitudinal studies of urban forest change, mixed-methods research integrating stakeholder perspectives, and spatially explicit modeling of inequities in canopy access and management capacity.

5.3 Research Question 3: Urban forestry challenges, opportunities, and knowledge gaps across the region

5.3.1 Snowball sampling, word-of-mouth, and survey response

39 cities answered our survey, and ten urban forest managers participated in a follow-up interview. Survey response included municipalities from all the states under study. However, the cities that agreed to participate in follow-up interviews only represented the states of Virginia, North Carolina, Georgia, and Florida. Snowball sampling was especially important in gaining access to further survey responders and interviewees. This greatly explains state-level concentration among follow-up interview participants. 36 survey responders agreed to share public urban forest information with our research team, while three municipal administrators expressed that they preferred not to share any additional data. With the exception of one city, all responders agreed to receive updates and follow-up information.

5.3.2 Limited resoureces, understaffing, and voluntary participation

Six municipal forest managers agreed to participate in interviews with the research team. In accordance with findings from the public information review, many municipal governments do not enlist an official urban forester position. Instead, interviewees explained that urban forest management typically represents a collaborative effort among multiple government departments. Departments that enlist certified arborists often include Public Works, Water Works, and Compliance. Medium-sized towns such as Athens, GA and Cary, NC employ teams of certified arborists hired by various departments, but who operate under the guidance of a unique urban forester. The urban forester is responsible for cooperative action and for providing training to the arborists. Most managers described training sessions as aligned with formal International Society of Arboriculture (ISA) standards, while emphasizing that attendance is generally voluntary. Managers linked this structural flexibility to the relative novelty of urban forestry programs in their municipalities. For example, the Town of Cary, NC hired its first urban forester in 2023; St. Petersburg, FL's Maintenance and

Stormwater Department conducted its first canopy assessment in 2017 and appointed an official forester in 2022; and Durham, NC established an Urban Forestry Division in 2017. Some municipalities, however, represent exceptions in timing: Arlington, VA hired its first forester in 1964, after increasing interest in urban green spaces in nearby Norfolk and Washington D.C. Arlington developed its first inventory in 1988, beginning with 7,000 trees and later expanding to more than 20,000. The official records review revealed that 50% of the municipalities in the study inaugurated their first street tree inventories between 2009 and 2021, with 84.6% launching after 2019.

5.3.3 Species selection and diversity

The survey responses reveal a clear pattern in species choice across Southeastern cities. The most frequently cited species include *Quercus virginiana*, *Quercus austrina*, *Quercus shumardii*, *Ulmus alata*, *Magnolia grandiflora*, *Pinus palustris*, *Taxodium distichous*, *Ilex cassine*, *Acer rubrum*, and *Juniperus virginiana*. More general responses—such as ”crape myrtle, oak, elm” or ”75% of inventoried trees are oaks, maples, elms, and zelkovas” further confirm that a selected few genera dominate urban forests across the region. Interviews with urban foresters revealed that species choice is primarily informed by nursery accessibility and NCP trade-offs. Species choices always reflect a balance of goals: long-lived canopy trees like oaks, elms, and bald cypress provide extensive shade and ecological benefits, while ornamentals such as crape myrtle and magnolia contribute aesthetic value and seasonal interest. Balancing the varied services that different species can offer while retaining high survival rates often restricts the range of species urban forest managers perceive as available. In fact, availability may even be limited at the nursery level. Some interviewees reported that municipalities across different states often rely on the same handful of tree nurseries. Even though nursery owners are receptive to the need to expand the range of species they offer, their capacity for adaptation lags several years behind urban forestry agenda. Sourcing seedlings, experimenting with adequate growing conditions, and securing demand for new tree species all represent time- and resource-consuming tasks for commercial nurseries. A recent recurrence of native species like longleaf pine, Kentucky yellowwood, pawpaw, and downy serviceberry (typically sourced from small-scale, non-commercial local nurseries) suggests a deliberate effort to support biodiversity and local ecosystems.

5.3.4 Justifying urban forestry initiatives

Managers stressed that early initiatives often relied on city beautification agendas, consistent with discursive traditions in green space development, sustainability, and branding policy. For example, Cary, NC developed its first tree inventory to beautify and conserve its historical downtown district. Concerning tree inventories, survey responses were sometimes inconsistent with the public information review. In four cases (Arlington VA, Clarksville TN, Johnson City TN, and Winter Haven FL), municipalities ran an inventory even if public information on it was not publicized. Winter Haven urban forest manager explained that the inventory was intended for government employees only. Because the inventory was so small, the municipal government saw no benefit to making it available for public use. They also believed city residents not to be interested in voluntary data collection projects that would have expanded the inventory. Conversely, Arlington's urban forest manager explained that the city government was waiting until the inventory was large and detailed enough to publicize with its constituency. Such hesitation was based on the expectation that residents would be very interested in using the inventory for citizenship science and community projects, and would be disappointed by an incomplete inventory. In ten cases, municipalities that had announced the project to the public did not have a functioning inventory, yet. In Gainesville, FL, the city government had widely advertised urban forestry activities on the city's inventory. However, that inventory was not under their jurisdiction, but under the University of Florida's, which had launched the first street tree inventory in the state. Arkansas capital Little Rock did rely on a very expansive inventory, which was entirely run by a local environmental CBO. In Marietta, GA, some public trees had been inventoried by environmental NGO Trees Atlanta, which operated a very large inventory across the Atlanta Metropolitan Area. The City of Atlanta had itself ceded any tree inventory development initiatives to the NGO, which effectively acted as contractor for municipal governments in the area. In Palm Beach Gardens, Palm Beach County was in charge running a volunteer tree inventory on software iPlant, and pay for its owner company PlantIT GEO. Responding urban forest managers stated that they plan to develop a public tree inventory in their city.

5.3.5 Public-private collaborations

In keep with the considerations above, interviewed urban foresters pointed to higher-level governmental and non-governmental actors as initiators of early forestry efforts. State university cooperative extensions often pioneered canopy assessments and inventories, providing models for later municipal programs. The University of Florida Cooperative Extension, for instance, conducted its first inventory in Gainesville in 2016, which in turn informed programs across Tampa Bay municipalities after 2020. Nonprofits also played critical roles. The Arbor Day Foundation and the Tree Champion Program raised awareness and created early successes, which helped municipalities like Winter Haven, FL secure funding and public support for larger urban forestry projects. All managers stressed the importance of collaborating with actors outside municipal government. Athens, GA' forester emphasized partnerships with local nurseries, which provide records useful for assessing municipal responses to tree diseases and biodiversity policy. Nurseries also support biodiversity by cultivating native species more readily than larger industrial operations. Private contractors were also seen as indispensable for specialized operations such as large-scale removals and hazard pruning. Some municipalities considered outsourcing inventories to private firms, facilitating integration of LiDAR, remote sensing, and advanced storage systems. Universities contribute students, scientific expertise, and independent forest holdings (e.g., Durham's Duke Forest), integrating municipal forestry into broader ecological networks. NGOs likewise play central roles: Keep America Beautiful, for instance, maintains a strong presence in Durham, NC but is less active in municipalities with established local organizations like Winter Haven, FL.

5.3.6 Ambitions and future plans among urban foresters in the U.S. Southeast

All the urban foresters who responded to the survey plan to develop an inventory, and state that they would rely on the urban forest diversity studies they have conducted. Also, all the cities that already have developed a UTC assessment plan to use it as a starting point for inventory development. While most cities plan to develop one piece of urban forestry infrastructure at a time, some municipalities anticipate multi-leveled resource development programs. Examples include Gainesville and Coral Springs, FL, and Alexandria, VA, which plan to conduct urban forest diversity studies, UTC assessments, and inventory development actions in one, integrated sequence. While few of these cities anticipate that they would be able to run a full inventorying of their forests, some plan to include at least a partial inventory. Gainesville, FL, for example, is planning as many as eight sequential inventions, all save for a complete public tree inventory. UTC assessments appear to be the most common urban forest assessment tool. However, a few municipal governments do not seem to be interested in conducting preliminary assessments as much as they do in developing an inventory. Johnson City, TN and Roanoke, VA urban forester managers stated that they only plan to complete their urban forest inventories. Inventories seem to be a priority in Alabama and Tennessee, whose cities tend to lag behind other states in the region in terms of inventory development. The survey confirms the public information review's insight that some states, like Virginia and North Carolina, have already very advanced urban forestry monitoring programs. Very few municipalities expressed an interest in investigating the stormwater management, carbon storage, and energy conservation dimensions of urban forest infrastructure development.

5.3.7 Funding as a challenge

Finally, there is no challenge that interviews underscored more consistently than funding. Federal programs such as the Inflation Reduction Act, micro-grants, and cooperative extensions were frequently cited as enabling tree planting and maintenance. Arbor Day Foundation awards also played pivotal roles. Managers voiced concerns about rigid funding requirements, which often pressured municipalities to accelerate planting schedules at the expense of careful planning. They emphasized that gradual investment streams might better support equity, especially in low-SES and minority communities. All managers also endorsed investment in team cohesion and state-level collaboration. Organizations such as the Urban and Community Forestry Society, the ISA Southern Chapter, and the Southern Group of State Foresters were described as crucial venues for exchanging techniques, data, and ideas. Most municipalities see complete public tree inventory as the endpoint of a series of urban forest infrastructure development actions. All interviewees agreed that developing a master plan is the fundamental starting point for systematic green space management. They emphasized the importance of enacting ordinances and compiling suitable species lists prior to a master plan, as these laid the groundwork for sustainable management. In Athens, GA, ordinances guided tree management for years before the city launched a formal plan in 2022. Managers described master plans as essential tools for reconciling competing agendas: socio-economic goals, investment decisions, biodiversity and wildlife concerns, and ecosystem service provision. Following the adoption of a master plan, most municipalities conducted urban tree canopy assessments. Greensboro, NC foresters highlighted their role in setting standards for tree density and identifying policy gaps. PlanIT GEO, a consulting agency, was consistently mentioned as the pioneer in affordable canopy assessments nationwide. Municipalities often engaged PlanIT GEO for their first assessments and, in some cases, for the development of official inventories. St. Petersburg, FL, for example, later commissioned the company to host its public tree inventory on TreePlotter, a proprietary interactive mapping platform also used in Miami and Fort Lauderdale.

6 Conclusion

6.1 Takeaway considerations

Urban forestry in the Southeastern United States has undergone significant transformation over the past two decades, evolving from scattered early initiatives to increasingly formalized municipal programs. This study reveals that while the region has made substantial progress in developing urban forest management infrastructure—with over half of cities with more than 50,000 residents now maintaining street tree inventories, critical gaps remain in understanding how urban forests contribute to residents' livelihoods and in addressing persistent urban forest maintenance concerns. Very few UTC, street tree inventories, and other urban forestry mapping instruments measure NCPs or ecosystem services, leaving much potential for development. In the wake of accelerating urbanization and the looming threat of climate change, urban forestry instruments may need to expand to support larger forest communities and more sophisticated information.

Our quantitative analysis identified population size as the primary statistical predictor of street tree inventory adoption, though qualitative evidence suggests this relationship reflects broader urbanization dynamics rather than population alone. The composite effects of urban growth, institutional capacity, university presence, nonprofit engagement, and constituency interest in addressing historical inequities likely drive forestry program development more meaningfully than any single demographic factor. This finding underscores the limitations of purely statistical approaches to understanding urban forestry adoption and highlights the importance of institutional networks—including state cooperative extensions, environmental NGOs, and private contractors—in catalyzing municipal action.

Interviews with urban forest managers consistently identified funding constraints as the most pressing challenge, with concerns that accelerated planting schedules imposed by grant requirements may compromise equity goals in underserved communities. Managers emphasized that systematic urban forestry development follows a characteristic progression: ordinances and species lists precede master plans, which in turn guide canopy assessments and ultimately comprehensive public inventories. This sequential approach reflects growing professionalization of the field, though resource limitations continue to constrain smaller municipalities' ability to participate fully.

6.2 Limitations

This thesis is, after all, only the first step of a longer series of investigations. Several important limitations qualify this study's findings. Data availability varies dramatically across municipalities, potentially biasing results toward better-resourced cities with robust management capacity. The analytical approach, while transparent, does not account for spatial autocorrelation or nested data structures that may influence urban forestry patterns across the region. The next steps of this study will include a case-study investigation of tree planting and urban forest management in Durham, NC. A smaller-scale study will hopefully clarify the ways non-governmental actors like environmental NGOs, CBOs, resident volunteer groups, and universities play in guiding and supporting urban forestry at the municipal level. A municipality-level approach will also be more adequate to support a more fine-grained lens, investigating urban forest distribution, accessibility, and tree health patterns across different residential areas. A future study will also treasure this initial study review to model ideal species and sites for future urban forestry expansions across the region.

6.3 Future steps

Looking forward, Southeastern urban forestry stands at a critical juncture. Rapid urbanization creates both opportunities and pressures for expanding tree canopy, while growing awareness of NCPs and gree infrastructure development demands more sophisticated management approaches. The reluctance of municipalities to assess ecosystem service provision—whether due to methodological concerns or conceptual abstraction—represents a significant barrier to justifying investments and achieving equitable distribution of urban forest benefits. Overcoming this hesitation, expanding collaborative networks across municipal boundaries, and securing stable long-term funding streams will be essential for realizing the region's urban forestry potential. In Summer of 2025, we conducted a comprehensive survey of Durham, NC's urban forest, using the city as a case study for how planting and management decisions impact urban forest structure and the NCPs it provides to city residents. Close collaboration with Durham's municipal government and environmental

NGO Keep Durham Beautiful allowed us to gain field insights into the challenges and opportunities entailed in urban forest management. We plan to build on these collaborations to develop actionable recommendations that municipal governments, NGOs, and CBOs can take into consideration as they aim to expand and care for their city forest. We will also make treasure of the open urban forestry data we could access via the public information review, survey, or after conducting semi-structured interviews with urban forest managers. In the future, we plan to gather insights into how tree species composition shapes the ways urban nature interacts with city dwellers across the region. Finally, we hope to develop a digital instrument capable of recommending urban forest managers tree planting locations that optimize positive NCPs. We hope these small efforts will represent a *contribution to people*, as well as to all of the Southeast's city-dwelling trees and those who care for them.

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