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Assessing Equitable Distribution of the Urban Tree Canopy at the Neighborhood Scale in Greenville, South Carolina.

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[ASSESSING EQUITABLE DISTRIBUTION OF THE URBAN TREE CANOPY AT THE NEIGHBORHOOD SCALE IN GREENVILLE, SOUTH CAROLINA.]

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by
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ABSTRACT

We are living in an era that necessitates adaptation and resilience. The Earth is warming. Our climate has changed (EPA, 2016). Our planet is also rapidly urbanizing. It is predicted that 68% of people will live in cities by 2050. The City of Greenville is a rapidly growing city in South Carolina that has been losing its tree canopy to development(City of Greenville, 2023). The Urban Tree Canopy (UTC) is a community asset that provides many quality-of-life benefits including improved air quality, stormwater management, carbon sequestration, mental and physical well-being, increased mobility and access, aesthetics, a reduction in energy costs, and increased home values (R. Kaplan, 1989)(Yang et al., 2023)(Ko, 2018)(Ulmer et al., 2016)(Anderson & Cordell, 1988). An intact tree canopy can also reduce the ambient temperature in urban areas, which is increasingly important as global temperatures rise (Schwaab et al., 2021a). Planners have a role in protecting and managing the UTC, to mitigate the effects of climate change. In urban areas, the tree canopy is not always distributed equally across neighborhoods (Volin et al., 2020a). Thus, city planners could benefit from a UTC analysis method to use at the neighborhood scale. Planners can use these analysis tools and methods to address environmental injustice through a more equitable distribution of the tree canopy (Swanson, 2021) to the benefit of the entire city. This study suggests a standardized low-cost method to accurately assess the UTC at the neighborhood scale. First, a qualitative visual analysis was conducted using Google Earth and historical imagery. Next, US Census data and parcel data from the City of Greenville were downloaded from its GIS database to define boundaries and collect demographic and spatial information. Then the UTC percent for each neighborhood was determined with point data using i-Tree Canopy. Next, ANOVA was used to compare UTC percent to the following category data categories in each neighborhood: population density, home value, lot size, race, income, and percent of income spent on housing. The results showed a higher percentage of tree canopy correlated with higher home values and lot sizes amongst the three Greenville neighborhoods.

DEDICATION

I would like to dedicate this to my grandfather, Carlo DeMeo who, along with my grandmother Santina DeMeo always had something growing, even in the shadows of New York City.
I imagine them together, still arm in arm, walking through a heavenly grove of trees.

ACKNOWLEDGMENTS

I would like to thank my committee chair, John Gabor, Ph.D., AICP for his time, patience, and encouragement. I would also like to thank my other committee members Caitlin Dyckman, J.D. Ph.D., L. Enrique Ramos-Santiago, Ph.D., for their input throughout the process. Additionally, I'm grateful for the research guidance so graciously given by Barry Knocks, Professor Emeritus, Clemson University, Leslie Fletcher, Public Engagement Manager, City of Greenville, and Edward Kinney, Principal Landscape Architect for the City of Greenville.

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CHAPTER ONE

AN INTRODUCTION

1.1

Anthropogenic climate change is causing temperatures to rise faster than at any other point in recorded history (EPA, 2023). Climate warming causes flooding, stronger storms, drought, heat waves, and other weather anomalies (State of South Carolina, 2023). Greenville, like the rest of the world, is getting warmer. It will experience extreme heat and other effects of climate change by the year 2050 (Nadeau, 2022). Rising temperatures put people who live in urban areas at increased risk because of the Urban Heat Island (UHI) effect, a phenomenon in which the concrete, asphalt, and other materials in the built environment absorb heat and release it at night resulting in urban areas having higher temperatures than rural areas (Gill et al., 2007).

Heat is the deadliest of all weather-related disasters (Adams-Fuller, 2023). Like many municipalities, the City recognizes the role of the Urban Tree Canopy (UTC) in heat mitigation (Meerow & Keith, 2022). Protection and management of the UTC is partly the responsibility of city planners, who can also inadvertently fail to protect the UTC with land use planning or zoning (Brown & Quinn, 2018). An urban forest, also referred to in this paper as the Urban Tree Canopy (UTC) is made up of all the trees in a municipality, including those on public and private land (Daniel et al., 2016). The legality of tree ordinances is complicated by private property rights and business interests (Clark et al., 2020) (Meadows & Sizemore, 2010).

Trees offer many ecological services that improve the quality of urban life, both directly and indirectly. They help prevent flooding and erosion and help protect the watershed. They remove CO2 from the air and store it in their leaves, trunk, and branches. They produce the oxygen we breathe, and they provide a habitat for wildlife. They help save money on energy costs. They also have a positive effect on our physical health and mental well-being and add aesthetic beauty to our neighborhoods. Trees can lower the ambient temperature in urban areas through evapotranspiration and shade.

The population of Greenville, South Carolina has grown exponentially since the early 2000s. Between 2000 and 2023 it gained about 18,000 new residents (Mcmillan, 2022). During that time, it has also experienced a reduction of its tree canopy (City of Greenville, 2021). Between 2001 and 2016 it lost 14% of its forested land to development (City of Greenville, 2021). Part of what attracted those newcomers to Greenville are its parks, and tree-shaded Main Street, both the result of decades of city planning that included planting more trees. As the city grew, it began losing the very thing that brought people here. This change in land use was dramatic enough for the city to take notice and they developed a new tree protection ordinance in 2021 (City of Greenville, 2023a). As a community asset, the tree canopy should benefit the entire community, but some neighborhoods are left out when it’s not distributed equally across the city, Furthermore, the neighborhoods with less tree cover, are usually a lower income and have a higher proportion of minority residents, which raises the question of environmental injustice, both past and present.

Technological advancements have made studying the changes to land cover over time, quicker, easier, and more accurate, giving municipalities a new awareness of how much canopy loss is occurring and where to allocate resources (Kowe et al., 2021). Trees take decades to reach the size when they can offer the greatest benefits (Dwyer et al., 2003). All three neighborhoods in this study were established more than 100 years ago. This gives us a longitudinal view of what results from nurture and care versus neglect and disinvestment.

To sample how the UTC may influence the socio-economic success of a neighborhood and the well-being of its residents, this research will include these three established Greenville neighborhoods to serve as case studies: Alta Vista, Nicholtown, and Overbrook. Alta Vista and Overbrook were both planned developments that were built in the 1920s when Greenville was a thriving textile town. Nicholtown was a settlement that was established in the late 1880s. These neighborhoods are adjacent to each other and similar in size, density, and proximity to the urban core. However, they represent different socio-economic, cultural, and spatial realities. All three neighborhoods have parks. All three neighborhoods have commercial zones on an outer boundary. Two of the neighborhoods, Overbrook and Nicholtown contain a public school, but Alta Vista does not. The resident populations in each are varied in size and the categories of income, lot size, home value, and race.

Figure 1 & 2. Aerial view of Alta Vista from the early 1920s
(above)
and present-day (below).

1.2 *Alta Vista*

Alta Vista was developed in 1924. It was advertised as a being up above the dust and noise of the city; far enough away but still close enough to benefit from city services. The lots were large, and they had tree-lined streets (Steadings, 2022). The neighborhood is .74 square miles and has a population of 2,407 with 89.3% white, 4% Black, and 6.7% some other race. The median household income is $155,361. The percent of household incomes over 100k is 60.9 and the percent with income under 50k is 14.5. The lot sizes are large. The largest residential lot is 12 acres. The median home value is $716,440, and the average is slightly higher at $757,267. People in Alta Vista spend 27.7% of their income on housing costs.

Figure 2. Nicholtown has a mix of single-family and multifamily apartments as pictured above.

1.3 *Nicholtown*

Nicholtown is between the other two neighborhoods geographically. It was first settled by freed slaves on what was previously agricultural land. It developed slowly over time. Nicholtown contains the largest commercial district of the three. It has commercial zoning on two of its boundaries and more commercial development within the neighborhood. Its lot sizes are smaller than the other two neighborhoods on average. In addition to single-family homes, Nicholtown has multi-family housing. Nicholtown has a population of 3,808. At 1.04 square miles, it is the biggest of the three neighborhoods. It has a density of 3661. The population is 24.8% White and 68.7% black. The median household income is $30,573. Those who earn over 100k total 11.8% and those earning under 50k equal 56.1%. The average home value is $204,935 and the median is $261,136. People in Nicholtown spend 51.3% of their income on housing costs.

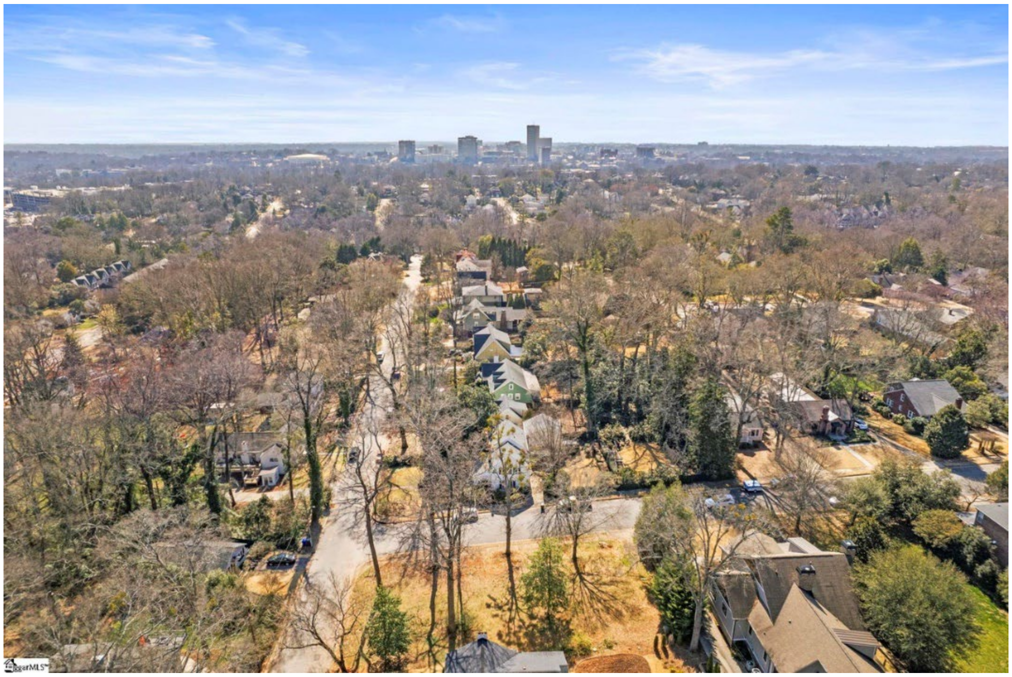

Figure 3. Overbrook (At lower right) is close to downtown Greenville and positioned along I-385.

1.4 Overbrook

Overbrook was a planned development. Greenville had a trolley line that expanded its terminus beyond downtown in 1910. Local businessmen saw this as an opportunity to develop a new neighborhood for middle-class workers. It still has many of the original homes. They're of various sizes, from cottages to very large two-story homes. Overbrook totals .45 square miles and a population of 1,577 which gives it a density of 3,504. Its residents are 62.2% White and 26.3% Black. The median household income is $59,626. 20.9 % households earn over 100k and 37.6% earn under 50k. Lot sizes vary. The median home value is $278,289 and the average is $278,463. Residents here spend 28% of their income on housing.

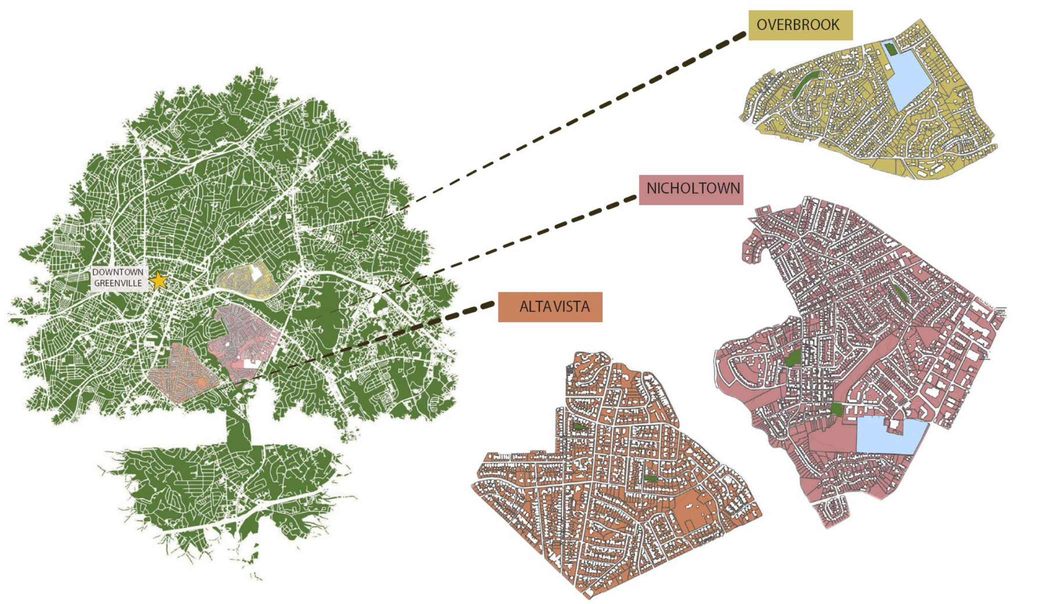

Figure 4.1 An illustration of the three neighborhoods: Alta Vista, Nicholtown, and Overbrook, showing their location, parcel size, their proximity to each other and downtown Greenville.

1.5

Purpose of research

Although trees may be only one of many factors in the complicated matrix of inequality, they can be a determining factor in home values, quality of life, and health of the community (Lioubimtseva, 2022). The purpose of this research is to suggest an easily accessible and uncomplicated method that can consistently assess the UTC at the neighborhood scale. Assessment is the first step leading to actionable steps, and it should be as free of barriers as possible. The method in this study meets that measure. It also uses publicly available data and free online tools making it accessible to anyone with a computer and internet.

1.6

Significance of research

Due to land use policies, past and current land development practices, and historic socio-economic inequalities, disparities still reverberate through city neighborhoods to this day. This study highlights the effect the UTC has on home value and the ripple effects of inequality from one Greenville neighborhood to the next. Although the results of this study may not be indicative of conditions in every neighborhood in Greenville, the intent is to demonstrate the benefits of nurture and care in contrast to the negative impacts of neglect and disinvestment. If planners use this method to assess neighborhoods citywide on a case-by-case basis, the results can help them identify and prioritize priority planting and protection areas in a way that delivers spatial and environmental justice. Doing so benefits the entire city because the UTC is of the highest value when it's as whole and connected as possible.

CHAPTER TWO

LITERATURE REVIEW
THE MANY BENEFITS OF THE URBAN TREE CANOPY

2.1

Trees offer many ecosystem services that benefit the community. Some of these are tangible benefits like fresh fruit and others are intangible like cooler air temperatures. Current land development practices, and densification near the urban core and in surrounding neighborhoods put Greenville's UTC in a vulnerable position, despite its value. When the canopy is degraded so are its benefits.

2.2
Carbon Sequestration

Trees are carbon sinks. They can remove CO_2 from the air and store it from leaf to root. Carbon is also stored in the soil of the forest floor (Weir, 2022). We need more trees because we're releasing CO_2 faster than the trees can process it. NOAA found evidence deep in ice sheets, that the CO_2 parts per million (PPM) has reached its highest levels than at any other time in the past 800,000 years(Lindsey, 2023). The increase began with the Industrial Revolution in 1750 and has trended upward every year since. Too much carbon dioxide in Earth's atmosphere traps heat from the sun and increases global temperatures, despite knowing this, we are still dependent on fossil fuels for energy and transportation (Ripple et al., 2022). Anthropogenic activity has also resulted in changes to 50% of land cover globally (Mustard et al., 2012)(Nowak & Greenfield, 2020). Although planting trees won't stop emissions from entering the air, they are part of the solution to slowing global climate change.

2.3
Stormwater Management

Because trees hold water, they can help prevent flooding and erosion. The roots of the tree help hold the soil in place. In South Carolina, bare soil washes into creeks and rivers during storm events, leading to silt pollution which is harmful to wildlife (Ellis, 1936). Trees also help divert non-point surface pollution that would otherwise enter our watershed. If there is flooding, trees can also remove water from the soil (Berland et al., 2017). When used as green infrastructure, trees can complement the urban stormwater management system (Gill et al., 2007).

2.4

Air Quality

Trees produce oxygen and absorb carbon dioxide, but they also absorb other air pollutants, like sulfur dioxide, and nitrogen dioxide (Nowak, n.d.). They also reduce particulate matter. Urban centers have more industry and more air pollution than rural areas. Consequently, people living in urban centers are more apt to have illnesses related to air pollution including bronchitis and asthma (Nowak, n.d.). Poor health can have an economic impact as well, from medical costs to loss of income and productivity (Nowak et al., 2014; OECD, n.d.).

2.5

Wildlife Habitat

Trees are part of an ecosystem that includes other plants and animals. They provide food and cover for birds, insects amphibians, and mammals. Current development practices begin with the removal of large swaths of forest, leveling everything on the site. This reduces available resources for the remaining wildlife. Destruction and fragmentation of the canopy means wildlife must venture outside of the remaining forest which can put them in closer proximity to humans and human activity like roads and highways (Theobald et al., 1997). Wildlife in urban areas can cause conflict, but human and wildlife interaction can also be positive and improve the quality of life. Key species such as bees, whom we rely on to pollinate our crops are part of urban forests (Soulsbury & White, 2015).

2.6

Energy and Economics

Low-income and minority households have higher energy cost burdens, partly due to energy-inefficient housing (Kontokosta et al., 2020). Trees can reduce the cost of cooling in summer when they are planted strategically to shade homes from the sun. They can also be planted as windbreaks to protect homes from winter storms. There is a direct correlation between the percentage of tree canopy in a neighborhood and its home value (Anderson & Cordell, 1988).

2.7

Health and Well-being

Trees have a positive effect on physical and mental health(S. Kaplan, 1995). The many ways they improve quality of life are well-documented (Turner-Skoff & Cavender, 2019) Ulmer et al., 2016)(R. Kaplan & Ulrich, 1989). Workers are more productive, and patients recover sooner if they have a view of nature outside their windows(S. Kaplan, 1995b; Ulrich, 1984). Trees on campus improve student performance at school (Kuo et al., 2018). Sidewalks shaded by trees are safer and more ‘walkable’ (Lee et al., 2022). Bus stops that are shaded with canopy trees have higher summer ridership than ones that don’t (Lanza & Durand, 2021).

2.8

Heat Mitigation

A well-cared-for tree canopy will be invaluable as we face a future of rising temperatures. 2023 was the warmest year on record globally (Dahlman & Lindsey, 2024). The planet is on track to experience a 3-degree Celsius temperature increase this century (Hansen et al., 2006). The mean high temperature in Greenville already reaches above 90(F) five months out of the year (NOAA, 2024). Trees can lower the air temperature in urban areas by 10 percent (Schwaab et al., 2021b). Trees can cool better together when the canopy reaches about 40% (Ziter et al., 2019).

CHAPTER THREE

METHODOLOGY

3.1

Three neighborhoods were selected that were similar in size, population, and proximity to the downtown core. To capture a snapshot of each neighborhood, I used data from The US Census and ESRI community profiles as well as their 2020 Census profile and The City of Greenville parcel data. The parcel data was available for download from the City of Greenville GIS database. In ArcGIS, I clipped the data by drawing a polygon for each neighborhood boundary. This was important since there were multiple census tracts in Alta Vista and I only wanted data from parcels within the neighborhood boundaries. After defining the boundaries, I then extracted data from relevant categories. I discarded the categories that were not important to the study such as the number of bedrooms per home. From the selected categories I took the mean and average. I grouped these into related sets and then moved to the next step; using remote sensing to determine the UTC of each neighborhood.

3.2

A plethora of tools and data are available to measure land cover and land cover change remotely (without going into the field). The two main method categories are random point sampling and remote sensing. Frequently mentioned in research is LIDAR (Light Detection and Ranging) a remote sensing method that can produce high-resolution digital elevation models (DEMs) in 2D or 3D. LIDAR data can be expensive and take longer to process and it requires a level of expertise to use. I-Tree uses random point sampling. One of the goals of this study is to that the method easy to use and low or no cost. I-Tree is a free web-based tool and Google Earth is mostly free although some Google products such as Google Earth Engine and Google Environmental Insights are not available to everyone, (Zurqani et al., 2019). LIDAR is more accurate than iTree by less than 5%, which is an acceptable compromise given the ease and cost of iTree (Parmehr et al., 2016).

Before deciding to use the i-Tree, I reviewed other methods from multiple sources. The most difficult aspect was finding data at the neighborhood scale. Neighborhoods can be smaller than census block groups or contain more than one block group. The current data sets such as the NLCD can show large swaths of land cover but are not high enough resolution to distinguish a single tree. Google Earth Engine (GEE) has features that could be used in UTC assessment: GEE 3D and GEE Time-lapse. Google 3D could be used on a small scale such as one street or city block. The tool is clear enough to distinguish an individual an area and trees and estimates crown size and height. When adding a polygon, it visually separates the ground level from vertical features making the tree inventory clear as seen in Figure 5.

Figure 5. A screenshot from Google Earth 3D with a polygon (orange) at ground level.)

Google Environmental Insights uses aerial imagery and machine learning to calculate tree canopy for select cities. It can be estimated per census block but is not customizable for use at the neighborhood scale.

3.3

i-Tree was selected as part of the methodology for this study for its level of accuracy, accessibility, ease of use, and customization. i-Tree is a web-based tool provided to the public at no cost via the USDA Forest Service. Within it are more tools, subcategorized for different purposes. This study used the iTree Canopy tool that's designed for urban forest managers, urban planners, and advocacy groups. After locating the study areas on the satellite map, I uploaded shape files that were drawn in ArcGIS. Each neighborhood was loaded and individually analyzed before the next one was loaded. After loading the shape file, I chose which land cover categories I wanted to analyze. The categories I selected were as follows: tree/shrub, grass/herbaceous, water, impervious road, impervious building, impervious other, and sand/bare soil. The next step was the most tedious and time-consuming but critical to a successful report. Using the satellite image, the platform auto-generated random points within the neighborhood. I visually identified and categorized each type of land cover and then saved each one to a project file within the platform. I-Tree recommends 500-1000 points for a reliable result. I made 500 points for each neighborhood, separately running each report. For 'impervious road', I included parking lots because they're the same asphalt material as roads. For 'impervious other' I included sidewalks, driveways, patios, and the occasional fence wall made of concrete.

Figure 6. i-Tree Canopy point data visualization for Alta Vista, Nicholtown, and Overbrook (L-R).

Table 1

	Alta Vista	Nicholtown	Overbrook
Percent UTC%	52	46	47
Median home value	716440	261136	278289
Average home value (FMV)	757267	304835	278463
Average lot size	0.57	0.19	0.39
Race - Percent White	88.8	24.8	53.7
Race - Percent Black	4.1	68.7	21.2
Race- Percent Other	5.1	6.5	10.7
Income over 100k	60.9	11.8	37.6
Income under 50K	14.5	56.1	20.9
Percent of income spent on housing	27.7	51.3	28

3.4

Once the UTC percent was determined for each neighborhood, I used analysis of variable (ANOVA) to compare potential relationships among the categories. I found that a higher percentage of UTC correlated with higher home values (Table 1 &2). Lot size also showed a UTC % correlation with a p-value even higher than the home value at .00012.

Table 2

Median Home Value

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Median home value	3	1255865	418621.6667	66595376104
UTC %	3	137.6	45.86666667	18.29333333

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	2.62809E+11	1	2.62809E+11	7.892696635	0.048346725	7.708647422
Within Groups	1.33191E+11	4	33297688061			
Total	3.95999E+11	5				

Additionally, I-Tree calculated the quantity and monetary value of ecological services provided by the UTC in each neighborhood, such as the removal of carbon monoxide annually and how much stormwater is captured. Previously, these amounts may have been abstract concepts that were hard to communicate. Having this quantitative data can be invaluable to planners when they are working with the council or community (Volin et al., 2020b).

Table 3

Average Home Value

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Average home value	3	1340565	446855	72440577904
UTC %	3	137.6	45.86666667	18.29333333

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	2.99458E+11	1	2.99458E+11	8.267675688	0.045223952	7.708647422
Within Groups	1.44881E+11	4	36220288961			
Total	4.44339E+11	5				

Table 4

INCOME UNDER 50K						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
Income under 50K	3	91.5	30.5	501.76		
UTC %	3	137.6	45.86666667	18.29333333		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	354.2016667	1	354.2016667	1.362174392	0.307992096	7.708647422
Within Groups	1040.106667	4	260.0266667			
Total	1394.308333	5				

Table 5

INCOME OVER 100K						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
Income over 100k	3	110.3	36.76666667	603.2233333		
UTC %	3	137.6	45.86666667	18.29333333		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	124.215	1	124.215	0.399715749	0.561570886	7.708647422
Within Groups	1243.033333	4	310.7583333			
Total	1367.248333	5				

Table 6

PERCENT OF INCOME SPENT ON HOUSING						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
UTC%	3	137.6	45.86666667	18.29333333		
Percent of income spent on housing	3	107	35.66666667	183.3233333		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	156.06	1	156.06	1.548086302	0.281346361	7.708647422
Within Groups	403.2333333	4	100.8083333			
Total	559.2933333	5				

Table 7

LOT SIZE						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
Average lot size	3	1.15	0.383333333	0.036133333		
	0	0	#DIV/0!	#DIV/0!		
UTC%	3	137.6	45.86666667	18.29333333		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	3103.100417	2	1551.550208	126.9717966	0.00126161	9.552094496
Within Groups	36.65893333	3	12.21964444			
Total	3139.75935	5				

Table 8

PERCENT WHITE						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
Race - Percent White	3	167.3	55.76666667	1027.203333		
UTC %	3	145	48.33333333	10.33333333		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	82.88166667	1	82.88166667	0.159766241	0.709796029	7.708647422
Within Groups	2075.073333	4	518.7683333			
Total	2157.955	5				

Table 9

RACE- PERCENT BLACK						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
Race - Percent Black	3	94	31.33333333	1120.303333		
canopy% (500 points method)	3	137.6	45.86666667	18.29333333		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	316.8266667	1	316.8266667	0.556521332	0.497120103	7.708647422
Within Groups	2277.193333	4	569.2983333			
Total	2594.02	5				

CHAPTER FOUR

DISCUSSION AND CONCLUSON

4.1

Although an urban tree canopy can be thought of as a community asset, individual property rights and business interests often supersede those of less powerful stakeholders, and therefore, they control access to the many benefits it can provide. This study found a connection between home value and UTC. This is an opportunity to deliver environmental justice. Assessment is only the first step in reaching the goal of an equitably distributed Urban Tree Canopy. Attention should be given to growing the tree canopy in Nicholtown.

The UTC percent correlates to home value and not income. However, when comparing income to housing cost, residents of Nicholtown spend the most as a percent of their income: 51.3%. Residents of Alta Vista spend 27.7% and residents of Overbrook spend 28%. Affordable housing is defined as 30% of income or less (HUD, 2017). After paying more than your income for housing, and then other essentials there would not be much, if any left over to buy and maintain new trees.

4.2

Trees have associated maintenance costs that could also be funded by the city from the recently established tree fund (City of Greenville, 2023). This would potentially encourage tree planting on private land. Organizations like Trees Upstate already give away and plant thousands of trees (*Trees Upstate*, 2024), filling the gap toward equitable distribution, which gives city planners space to allocate the public resources that would have been spent on trees.

While trees offer value in several ways, planners specifically recognize them as a tool in heat resilience planning (Meerow & Keith, 2022), because trees can lower the urban temperature (Carter et al., 2015). Future studies could examine energy costs in relation to neighborhood UTC.

Protection of the UTC is a critical issue facing many cities in southern regions around the globe just like Greenville. Planners in many US cities are developing, enacting, or strengthening tree protection ordinances to manage their urban forests (Daniel et al., 2016) (Meadows & Sizemore, 2010).

Assessing the neighborhood UTC with a simple easy-to-access method integrating point data and readily available demographic data could help planners address inequities while helping their city adapt and prepare for climate change.

APPENDICES

Appendix A

iTree Report

Location Information	Type	Name	ID	Equity		Area		
Dataset				CEJST	Tribal Land	acre		% of all
				N/A	N/A		1,385.70	100
Selection Total:	Block Group	N/A	4.5045E+11	No	No		344.3	24.84
NLCD 2011	Block Group	N/A	4.5045E+11	Yes	No		393.5	28.39
NLCD 2011	Block Group	N/A	4.5045E+11	Yes	No		401.1	28.95
NLCD 2011	Block Group	N/A	4.5045E+11	No	No		246.8	17.81
NLCD 2011								

Canopy & Impervious (High Resolution UTC)	Type	Name	ID	Equity		Area		
Dataset				CEJST	Tribal Land	acre		% of all
				N/A	N/A		1,385.70	100
Selection Total:	Block Group	N/A	4.5045E+11	No	No		344.3	24.84
NLCD 2011	Block Group	N/A	4.5045E+11	Yes	No		393.5	28.39
NLCD 2011	Block Group	N/A	4.5045E+11	Yes	No		401.1	28.95
NLCD 2011	Block Group	N/A	4.5045E+11	No	No		246.8	17.81
NLCD 2011								
	Type	Name	ID	Equity		Area		
Dataset				CEJST	Tribal Land	acre		% of all
				N/A	N/A		1,385.70	100
Selection Total:	Block Group	N/A	4.5045E+11	No	No		344.3	24.84
NLCD 2011	Block Group	N/A	4.5045E+11	Yes	No		393.5	28.39
NLCD 2011	Block Group	N/A	4.5045E+11	Yes	No		401.1	28.95
NLCD 2011	Block Group	N/A	4.5045E+11	No	No		246.8	17.81
NLCD 2011								
Canopy & Impervious (High Resolution UTC)								

Carbon and CO_2 (High Resolution UTC)	Type	Name	ID	Carbon Storage		Carbon Sequestration	
Dataset				$	Short Ton	$/yr	t/yr
				3,961,349	23,226.80	153,909	902.5
Selection Total:	Block Group	N/A	4.5045E+11	1,002,060	5,875.40	38,924	228.2
NLCD 2011	Block Group	N/A	4.5045E+11	746,270	4,375.60	29,373	172.2
NLCD 2011	Block Group	N/A	4.5045E+11	1,341,445	7,865.30	49,805	292
NLCD 2011	Block Group	N/A	4.5045E+11	871,574	5,110.30	35,807	210
NLCD 2011							

Table 09. I-Tree Canopy Report results.

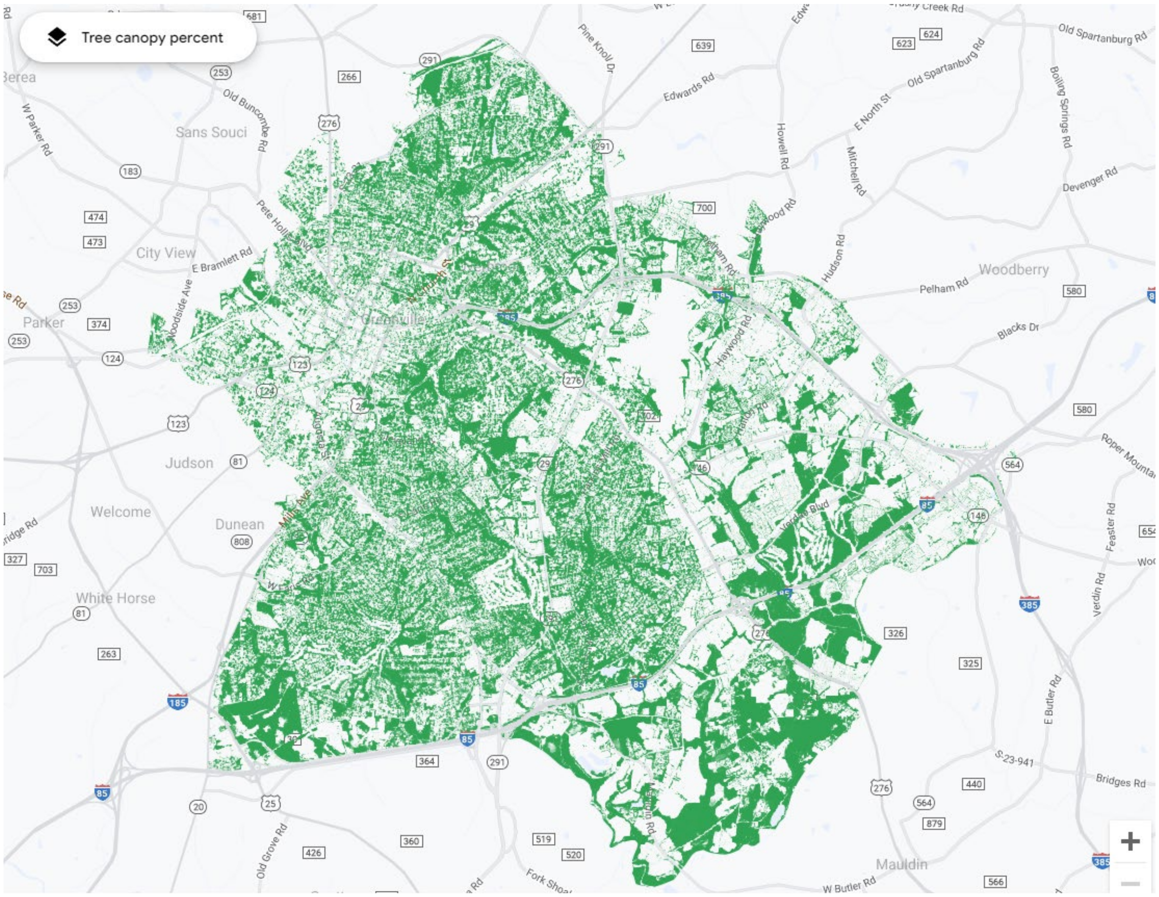

Figure 7. A screenshot from Google Environmental Insights Tree Cover, of Greenville, citywide, made using satellite imagery and machine learning.

Table 10. Demographic data.

	Alta Vista	Nicholtown	Overbrook
Percent UTC%	52	46	47
Median home value	716440	261136	278289
Average home value (FMV)	757267	304835	278463
Average lot size	0.57	0.19	0.39
Race - Percent White	88.8	24.8	53.7
Race - Percent Black	4.1	68.7	21.2
Race- Percent Other	5.1	6.5	10.7
Income over 100k	60.9	11.8	37.6
Income under 50K	14.5	56.1	20.9
Percent of income spent on housing	27.7	51.3	28

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