Town of Jonesborough Canopy Assessment

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The goal of this assessment is to give an overview of tree canopy in Jonesborough, why it's important, and why it's worth protecting, managing, and maintaining. This assessment is broken up into three sections with an introduction, data assessment, and recommendations. The introduction discusses prior land use and town history, the benefits trees provide, why canopy is important, and an explanation of land use types. The data assessment section will discuss how the area was examined, the iTree data, GIS maps and data, and land use observations. Finally, the recommendation section will give potential steps and guidance on areas of concern and how to maintain tree canopy into the future. Although establishing current tree canopy is important, this assessment should be viewed as a first step toward urban tree management. Using this assessment to guide and promote continued tree management will provide the best long-term benefits and ties into full circle management. Full circle management encompasses evaluating, planning, planting, maintaining, managing, and utilizing trees. Canopy assessment is the first step in this process and should be followed by more rigorous tree inventories, expanded planting efforts, managing and maintaining trees, preparing for natural disasters, and finally utilizing your trees to their highest purpose. Trees are vital to our communities as they provide countless benefits and services. Proper management of your trees will have long lasting impacts that keep our cities, towns, and communities comfortable, enjoyable, and safe places to live!

History and Land Use

Before discussing the modern history of the Town of Jonesborough, it is important to discuss those that came before. A look into the pre-colonization history of this region shows how the Cherokee, Chickasaw, and Choctaw peoples lived, managed, and transformed the land. These peoples farmed and managed the land extensively through agriculture, foraging, and settlement. This reliance on agricultural production is thought to have started in North America around 1000BCE. Although agriculture become a large part of Native American life, the scale of farming would be considered small compared to today's standards. Cherokee, for example, often used small patches of cleared land to grow crops for their immediate family or village. These patches had a wide diversity of native plants holding conservation and integration into the landscape as core values. Native Americans used a wide variety of plant and animal materials to make clothing, tools, jewelry, and everyday household items. Prescribed fires were not uncommon with the intent to revitalize the land and create room for new plants to grow and thrive. These impacts on the land could be seen up till the time of colonization with early settlers often using the cleared cropland that the Native Americans left behind. In the area of Jonesborough in particular early settlers from the Watauga Association heavily relied on these pre-established crop and farmland locations to grow their crops. These and other locations would be heavily cleared and expanded to better suit European farm practices in the coming years. The presence and influence of the Native American peoples on these first settlers cannot be understated and many of these impacts can be seen into modern day.

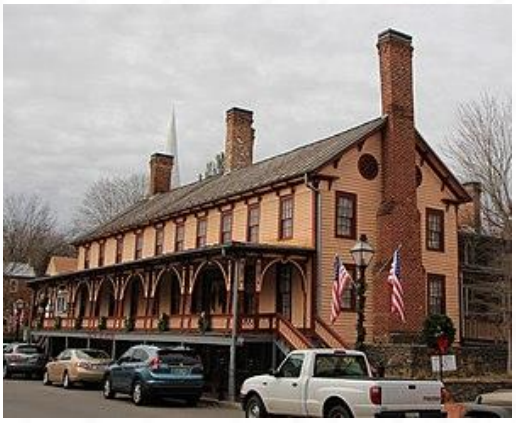
An Artists Depiction of Cherokee Farmers

The Town of Jonesborough has a deep and rich history connecting back to the first European settlers in this area. Founded in 1779, seventeen years before the establishment of Tennessee itself, Jonesborough was the frontiers' economic and social center for much of what would be later East Tennessee. The Town was first established by the Watauga Association, an organization of settlers who negotiated directly with the Cherokee peoples

to lease the land. Comprising initially of trappers and hunters the settlers quickly began to farm small tracts of land that were left cleared by the Cherokee people. These settlers would establish what is sometimes referred to as the Republic of Watauga. A constitutional republic which would sow the seed for much of the idealism that would bring about the American Revolution. Although it failed in only a few years, this is likely the first instance of European settlers attempts to form a sovereign state separate from the British Crown. Jonesborough would officially be established as the county seat of Washington County in the 1777 Act of North Carolina. This would be the first county established west of the mountains and a large step in pushing the frontier ever westward. In 1784 there would be an attempt by the region to succeed from South Carolina and establish the State of Franklin. Although the State of Franklin dissolved in 1790, it would create the seed that would eventually lead to the establishment of the State of Tennessee. The settlers in this area were proudly independent, echoing much of the sentiment felt across the nation during these years. As a result, Jonesborough and the surrounding area remained a backbone of the region and up to present day. Although Jonesborough itself has not expanded greatly in population, as in some of the surrounding regions, the Town of Jonesborough's influence and heritage can be felt across all the communities in East Tennessee.

Mainstreet, Town of Jonesborough

The Town of Jonesborough is home to many historic buildings dating back to the early days of Tennessee. The Tennessee Historical Commission performed a survey of Jonesborough in 1969 and established 72 buildings for preservation. Many of the oldest of these buildings were built in the federal style, a style calling back to some of the earliest days in our country. Buildings under this style include the Chester Inn built in 1797, the Sister's Row built in 1821, and the Green's Mansion built in 1815.



Chester Inn, Town of Jonesborough

Sister's Row, Town of Jonesborough

Greek Revival was a style that followed the federal style with significant buildings of note in Jonesborough being the Baptist church at 201 E. Main Street built in 1840, the Methodist church at 211 W. Main Street built in 1845, the February Hill home built in 1832, and the Cunningham House built in 1840.

Methodist Church, Town of Jonesborough

Cunningham House, Town of Jonesborough

February Hill, Town of Jonesborough

More modern buildings of note are the Washington County Courthouse built in 1913, and the Academy Hill School built in 1926. These large buildings follow the classical revival style and showcase Jonesborough's transition into the 20th century. These large structures were built during a time of expansion in Washington county and the surrounding areas. Although many of these surrounding areas have seen extensive growth, Jonesborough saw a population peak around the start of the 20th century where it has maintained these population numbers to this day.

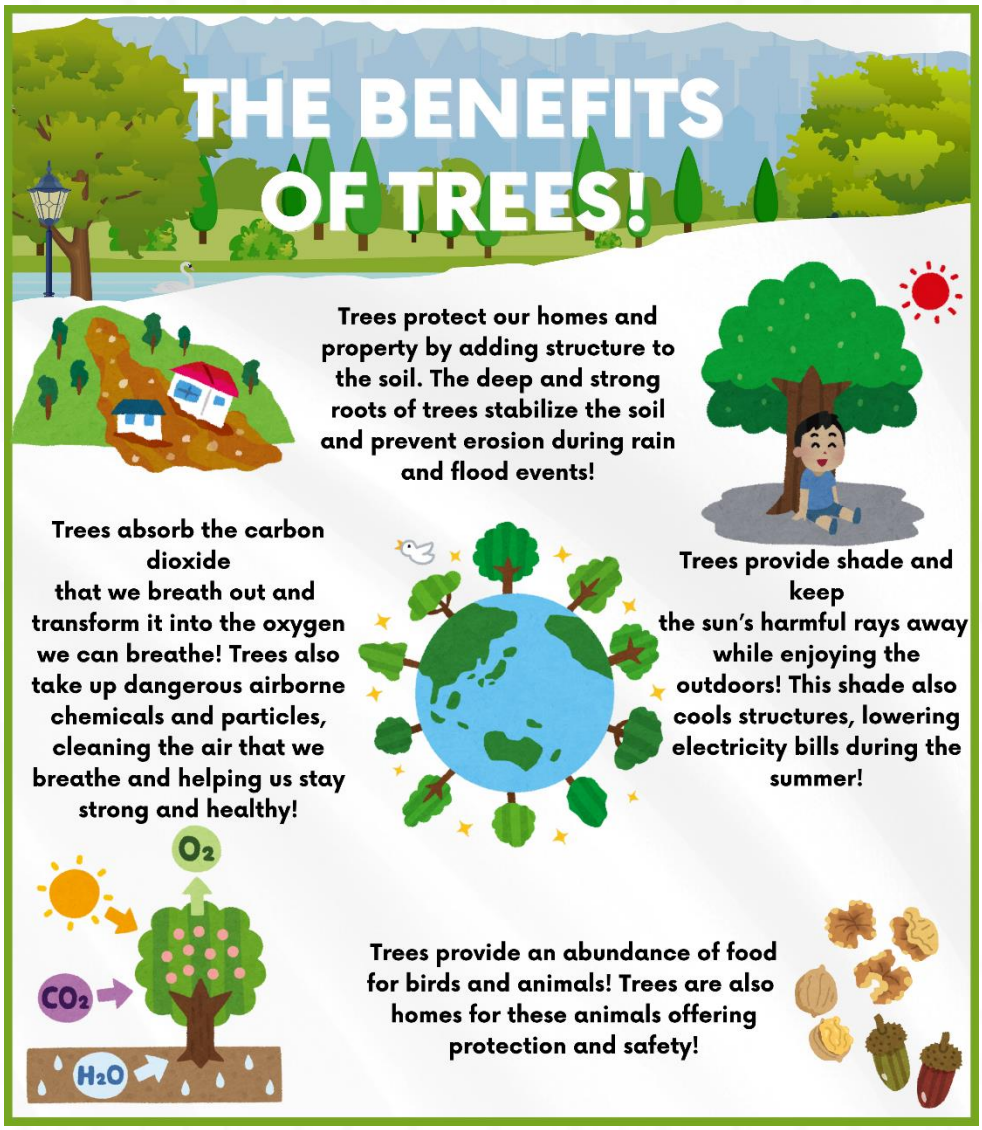
Washington County Courthouse and the Academy Hill School, Town of Jonesborough

History and land use changes play a key role in shaping our modern urban landscape. As farming became the common profession land was cleared of existing forests to make way for fields, homes, and barnyards. Although not as ubiquitous, this lifestyle has survived to modern day with much of the surrounding farmland being preserved. Much of what was cleared in those early days of settlement is still cleared up to current day. The impact that these early farmers had on the cultures and communities that developed cannot be understated. The layout for the Town of Jonesborough can trace its roots back to these early settlers and to the Native Americans that called this region home before them.

Downtown, Town of Jonesborough

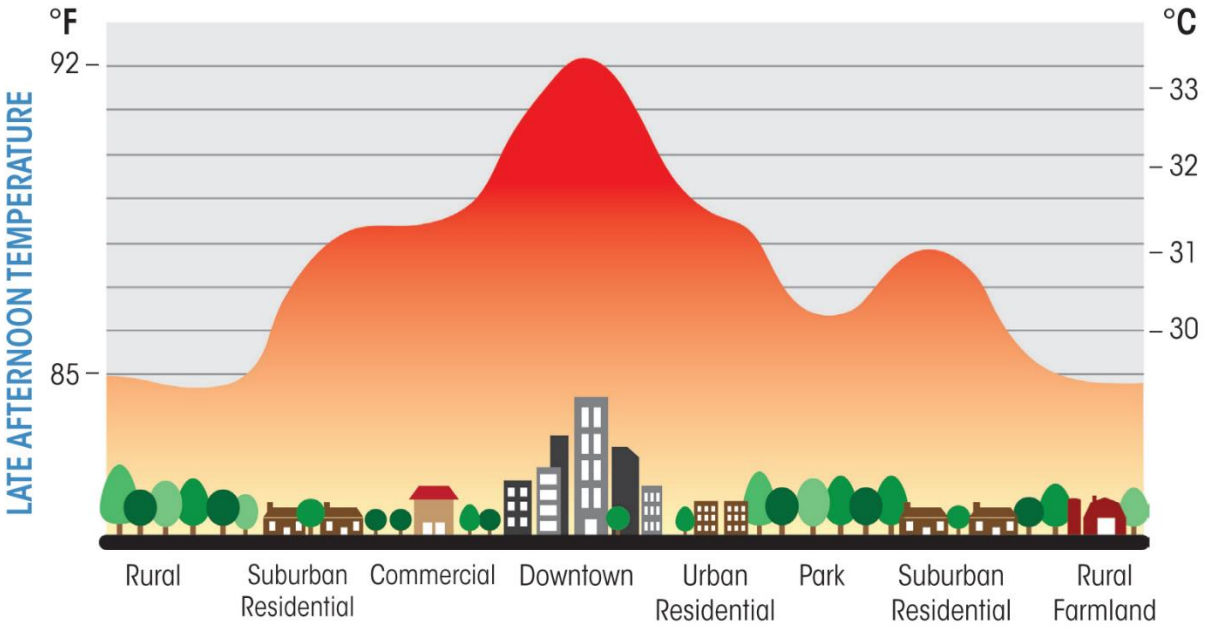
Benefits of Trees

Trees provide countless benefits for the environment, wildlife, human health, and social well-being. They save us money through shade and cooling while providing lumber for long-lasting wood products. Trees act as both the backbone of our natural environment and as the cornerstone of our communities. Trees increase property values and make towns and neighborhoods attractive to prospective businesses and homebuyers alike. Trees capture atmospheric CO2, lowering green-house gas emissions while simultaneously providing the oxygen we breath. They filter our water, making it clean and safe while also preventing erosion and holding the soil together. Each tree in your community is home to thousands of insects, birds, and small mammals. These creatures rely on trees for a source of food, safety from predators, and shelter from the elements.



The Benefits of Trees! TN U&CF Infographic

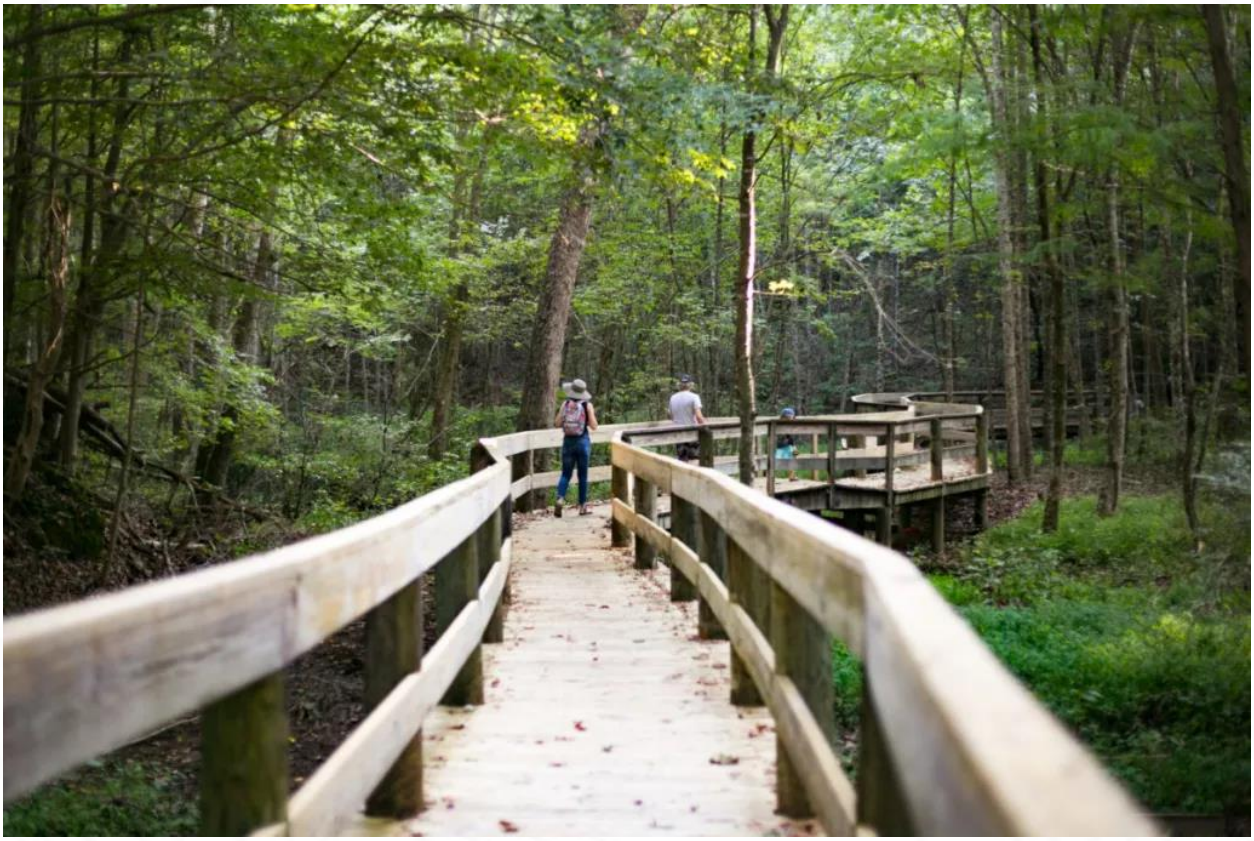
The shade and cooling effects of trees in urban areas cannot be emphasized enough. Urban Heat Island (UHI) is a term used to describe the increased temperatures across the urban landscape. This increase in temperature is caused by multiple compounding factors including car exhaust, heating homes and offices, industrial processes, and the abundance of impervious surfaces such as concrete and asphalt. Trees act as a barrier to the sun, soaking up heat and acting as a sun umbrella for our urban areas, lowing the UHI effect. Additionally, dark surfaces such as roads and structures absorb the heat of the sun, releasing over the course of the day. This forms a sort of bubble or "island" in which urban heat is created by compounding interactions between dark buildings and roads, lack of canopy cover, and heat emissions from vehicles and machinery. The more trees we have intercepting the heat from the sun the cooler our urban environments become!



Urban Heat Island Effect Shown Across Urban, Suburban, and Rural Landscape

Communities with parks, greenways, and natural areas are more enjoyable and interesting places to live. People want to live in communities with an abundance of easy to access green spaces. Plants provide a sense of serenity and connection to nature that isn't found in modern constructed environments. This connection isn't purely theoretical as many studies have shown that green spaces and trees lower the risk of disease and improve health outcomes. Additionally, green space has been shown to reduce the level of crime in cities. This phenomenon is not completely understood but it likely connects back to trees and green spaces lowering anxiety and stress levels. Green space provides a place for people to congregate and helps foster connections between neighbors and the greater

community. People with easy access to green space, particularly canopy cover, are more likely to spend recreational time outdoors. Whether this be as simple as taking a walk down the street or picnicking in a nearby park, people use and enjoy green space.

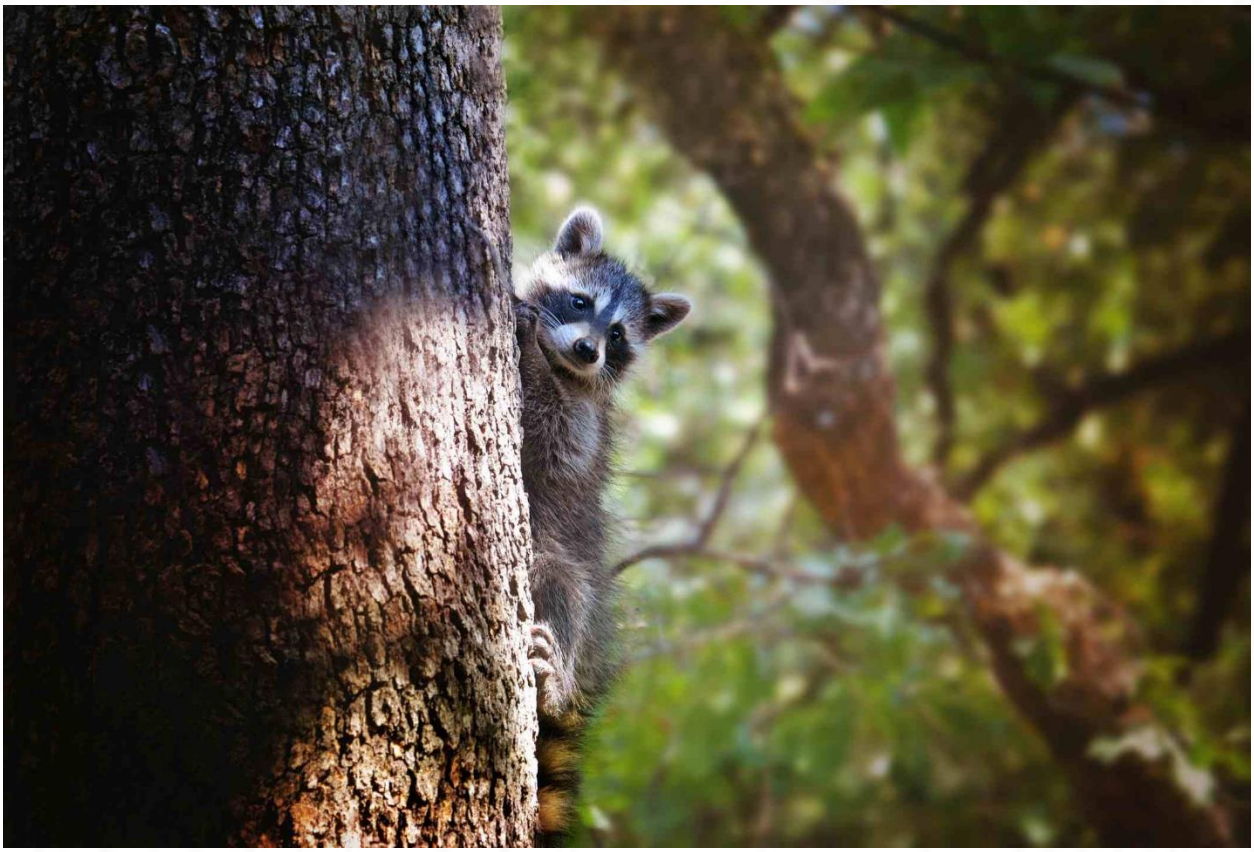


Family Walking the Persimmon Ridge Boardwalk in Jonesborough

Trees provide a great tool for combatting climate change through storage of carbon. As a step in photosynthesis trees uptake carbon dioxide, releasing oxygen back into the atmosphere and storing glucose. This glucose is used to create all parts of the tree such as leaves, branches, wood, and bark. Old wood, often referred to as heartwood, is biologically inert wood that functions as a rigid support for the living parts of the tree such as the cambium, branches, and leaves. This wood is carbon rich, with the tree storing this carbon for the entirety of its lifespan. Additionally, wood products store carbon for the lifespan of their use up until the product is either landfilled or disposed of. This carbon storage makes trees and wood products excellent tools in offsetting emissions. Planting new trees and fully utilizing them when they near the end of their lifespan are key aspects to successfully combatting climate change.

Water filtration and stormwater control are additional benefits provided by trees. The roots of trees grow deep, anchoring the soil and filtering water. Trees keep our waterways clean by absorbing toxic chemicals and pollution while also acting as physical

filters stopping large trash and debris. Trees provide soil anchoring which is essential for soil stability during severe storm and flood events. As seen with hurricane Helene, soil stabilization is a key aspect when preparing for and mitigating severe weather events. Mudslides, rockslides, and bank erosion are costly and damaging events that can take years for communities to recover from.



Racoon Climbing a Tree in a City Park

Urban trees are extremely important as they provide habitat to our urban dwelling insects, birds, and small mammals. An individual city tree can provide extensive habitat, providing refuge to urban dwelling critters. Without pockets of trees and green space our urban landscape would become an ecological desert devoid of both plant and animal life. As with trees, animals and insects bring joy and beauty to our urban landscapes. A city without butterflies, birds, bees, or small mammals would be a depressing place to live. Another benefit urban trees provide is as a corridor for insects, birds, and mammals to travel. These urban tree corridors link larger expanses of forest and natural habitat and provide a resting location as wildlife migrate. In ecological terms a single urban tree is proportionally more valuable than a single tree located in a forest as the scarcity of urban trees increase wildlife reliance. Establishing wilderness areas inside your cities and communities can have an outsized positive impact for our native wildlife.

Importance of Canopy

Examining your current tree canopy is the first step in urban forest management. Although a city-wide canopy assessment is not necessary, it provides a larger picture of your community tree resources. Communities may already prioritize areas of limited or low tree coverage, but a full canopy assessment can be used as an additional tool for designating these areas. Canopy in urban areas provides benefits beyond the general ecosystem services stated above. When a large and healthy tree is established next to parks, homes, or walking paths they act as a barrier between us and potentially harmful sun exposure. Beyond this they also provide a sense of calm serenity that has been shown to lower stress levels and improve health outcomes. Maintaining and establishing new tree canopy should be a goal of any community with a focus on livability and sustainability. Communities need to be continually maintaining mature trees and planting new trees to replace those lost through age, storm events, and new development.

Tree Canopy Over an Urban Soccer Field (artist render)

There are some limitations when examining tree canopy coverage in the urban environment. These can include difficulties in distinguishing between size of individual trees, species of tree, health of canopy, and seasonality of visual coverage. When establishing tree canopy, any green part of a tree is classified as canopy. A canopy point on a large white oak and multiple red maples would be calculated as the same canopy area. When looking at shade, stormwater mitigation, carbon storage, and wildlife habitat the single large white oak provides significantly more benefits. Non-natives provide much less value both in terms of ecosystem services and management costs. Non-native trees are prone to weak branch connections leading to higher risk of fallen limbs and branches during storm events. Additionally, non-native trees don't provide the habitat for our native insects, birds, and small mammals like our native tree species do. This is a limitation to

using satellite imagery and shows the importance of on the ground measurements to fully capture a community's tree resources.

Diversity in Urban Trees, Nashville's Centennial Park

Tree species diversity and health are important aspects when discussing urban canopy coverage. An urban landscape comprised mostly of one or two species of trees is more susceptible to canopy loss. This is due to the spread of pests and disease that often target singular tree species or families. A recent example would be the introduction of the emerald ash borer (EAB). Previously, ash trees were common city trees planted for their resilience, large shade branches, and quick growth. As EAB was introduced to the U.S. many cities found their ash trees dying at alarming rates. This led to some cities losing a large percentage of their tree canopy in only a handful of years. Species diversity increases resilience and allows cities and communities to more effectively respond to pests and diseases. If a threatened tree species only makes up a small percentage of a city or communities' canopy, then both treatment and replanting efforts become easier. A good baseline for species diversity in Tennessee cities and communities would be to keep any single tree species at less than 10% of the total species represented. This should be viewed as a baseline and decreasing this percentage will only increase your cities resilience to pests and disease.

Land Use Types

Understanding the common definitions of land coverage types will help add clarity to this survey and other geospatial studies using cover type designations. These designations give a large-scale view of your current community natural resources. The land use types designated by i-Tree Canopy include grass/herbaceous, impervious buildings, impervious other, impervious road, soil/bare ground, tree/shrub, and water. Although these designations may change from study to study or tool to tool, the basic layout will be similar. The goal of land use designations is to gain the clearest picture possible of a community's natural resources viewable from aerial imagery.

i-Tree Canopy basic land use types

Grass and herbaceous is defined as any green plant covering that can be distinguished from dirt or bare soil and is not tall enough for a shrub or small tree. Impervious is a term used to denote any material that is not permeable or does not allow liquid (e.g., water) to pass through. This designation is extremely important for city planning and urban forestry as impervious surfaces do not allow for rain to penetrate naturally into the soil. A city with too many impervious surfaces will be more susceptible to flooding during extreme weather events. Impervious buildings are any point that lands directly on the roof, overhang, or part of a built structure. If the point lands beside a building on a patio for example, that would be designated as impervious other. Driveways and other paved surfaces, such as parking lots, would be classified under this impervious other designation. Impervious road is any public access road that cars, trucks, or any other motorized vehicle travels on. Tree and shrub are classified as any other vegetation that is too tall to be classified as grass and herbaceous. Forests, single trees, and groups of large shrubs would fall under this classification. Additionally, it can be difficult to distinguish between a large shrub and a small tree when utilizing aerial imagery only. Water is classified as any open body of water that can be seen from aerial imagery. Pools and man-made bodies of water were not classified as they would have an impervious liner or bedding.

Canopy Assessment Overview

For this assessment, the free i-Tree Canopy tool by i-Tree software was used to establish canopy coverage while ArcGIS was used for mapping. The tools that i-Tree provides are widely used across urban forestry, resource management, and landscape design. These tools provide a free option for students, teachers, municipalities, and landowners to help understand and better manage their trees. i-Tree Canopy works by using map and satellite data combined with census and ecosystem services research through the U.S. Forest Service to designate land use types. The land use designations are done by hand with the i-Tree tool generating random “plot locations” to be classified by the user. For this assessment, land use types of canopy/shrub, grass/herbaceous, water, soil/bare ground, impervious building, impervious road, and impervious other were selected in i-Tree Canopy. These types can be changed in the i-Tree Canopy tool to better fit a geographical area. An example of applying land use designations for tree canopy is shown below.

Satellite imagery of canopy cover in Jonesborough, Tennessee

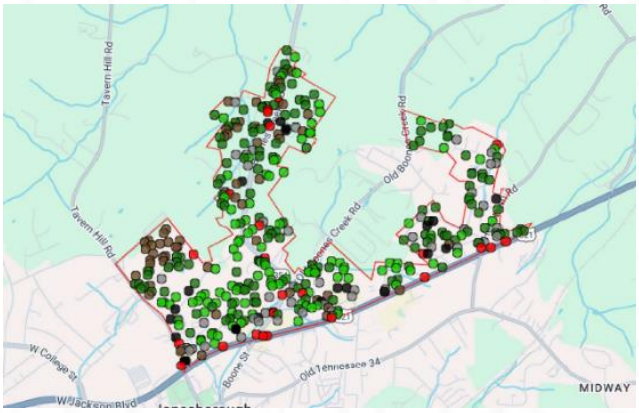
Satellite imagery of impervious road cover in Jonesborough, Tennessee

Classifying tree canopy can be difficult depending on the clarity and definition of the satellite imagery. Individual interpretation can lead to disagreements on where canopy starts and ends. This can cause some disparities between assessments and the individual performing the survey. However, these disparities become less prevalent when large numbers of plot locations and survey points are used. For this survey, 400 points were assigned for each of the four regions across Jonesborough. i-Tree assigns the range in error for 400 plot locations at between 1% and 3% depending on the specific cover type. An example of this is that if canopy cover was classified at 24% but had a +/-1.2% error then the actual canopy percentage would likely fall between 22.8% and 25.2% canopy cover.

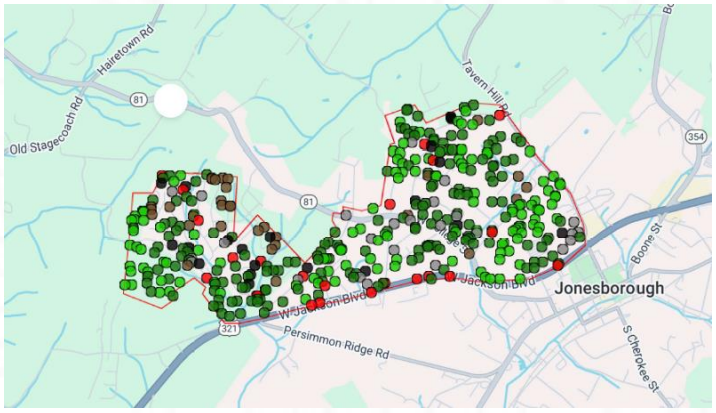
Issues can arise with the other cover types just as easily as with canopy cover. It can be difficult to distinguish between sparse grass cover and bare ground for example. The example below could clearly be seen as grass but what about the small patches of brown to the left? An argument could be made that the area to the left could be mostly bare ground with a small amount of grass coverage. Although this error is likely small it shows the importance of in the field surveys to gain a clearer picture of your natural resources. Additionally, satellite surveys like this do not distinguish between native and planted grasses. A native grassland in your city would be worth protecting due to its' cultural and ecological value to your community. Distinguishing between the specifics within a cover type can be difficult when only utilizing satellite imagery.

Satellite imagery of grass/herbaceous cover in Jonesborough, Tennessee

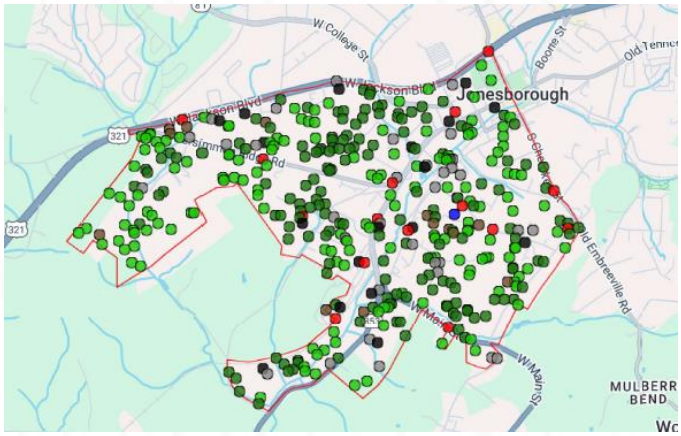
City boundaries are another constraint that don't always align with what we perceive to be a town, city, or community. This survey only looked at land inside the city limits of Jonesborough, leaving some clearly connected communities out. Similar issues arise when looking at census tract data, as with treecanopy.us, and no one solution is perfect. For this survey, Jonesborough was split into four regions designated as northeast, southeast, northwest, and southwest. These regions and survey locations can be seen in the maps below.



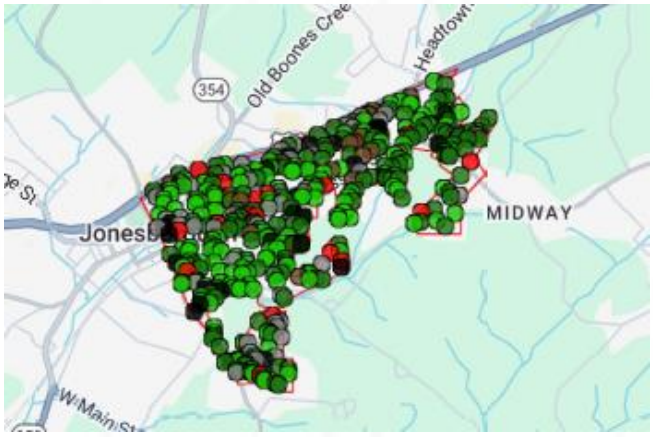
Northeastern Survey Plots in Jonesborough



Northwestern Survey Plots in Jonesborough



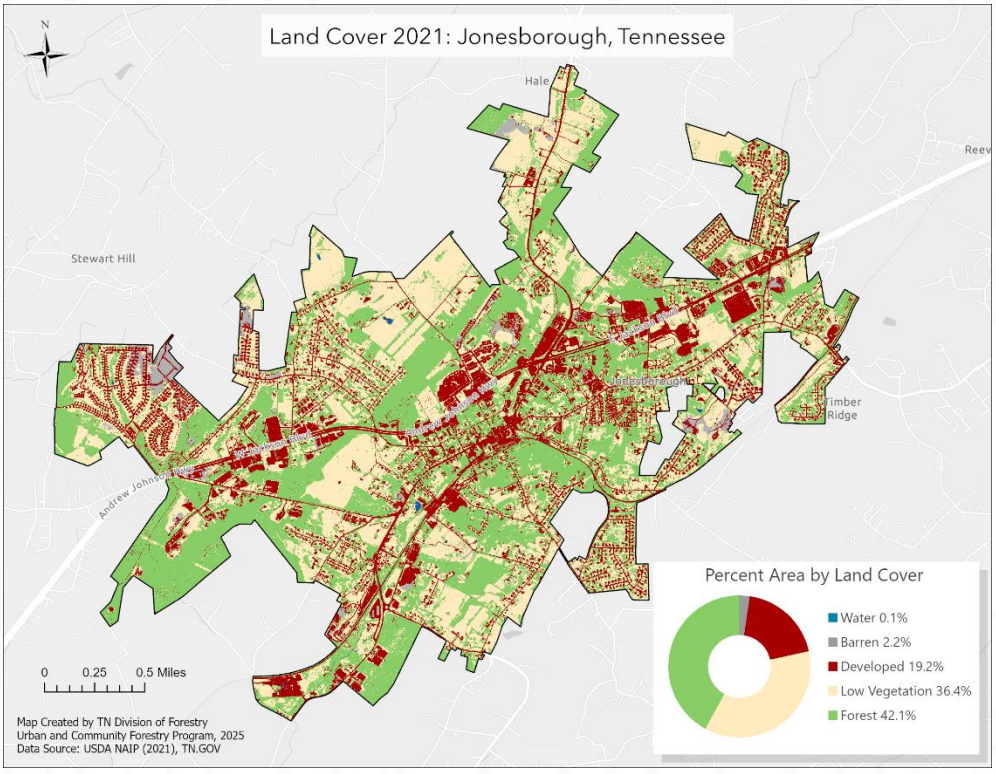
Southwestern Survey Plots in Jonesborough



Southeastern Survey Plots in Jonesborough

Tree Canopy Results

The tree canopy assessment results can be broken down into two sections, the i-Tree Canopy ecosystem services results and GIS Land Cover mapping. The i-Tree Canopy results utilize Forest Service and census data to calculate the amount of ecosystem services and establish a monetary value. This data calculates coverage percentages and connects those to regional data on ecosystem services provided. The air quality benefits include removal of carbon monoxide, nitrogen dioxide, ozone, sulfur dioxide, particulate matter both >2.5 and <2.5 microns, and sequestered carbon. Additionally, values are calculated for hydrological services such as avoided runoff, evaporation, interception, transpiration, and potential for both evaporation and evapotranspiration. The i-Tree survey breaks Jonesborough down into four sections classified as northeast, southeast, northwest, and southwest. The land cover mapping was done using April 2021 NAIP imagery obtained through the U.S. Geological Survey (USGS). The imagery has a spatial resolution of 60 centimeters and was preprocessed in ArcGIS Pro through mosaicking, clipping to the town boundary, and reprojection to ensure spatial accuracy. A supervised classification method was applied to categorize land into five distinct classes: water, developed, barren, forest, and low vegetation (shrubs and grasslands). Following classification, the total area of each land cover class was calculated, and the proportion of each class was expressed as a percentage of the total land area within the municipal boundary.



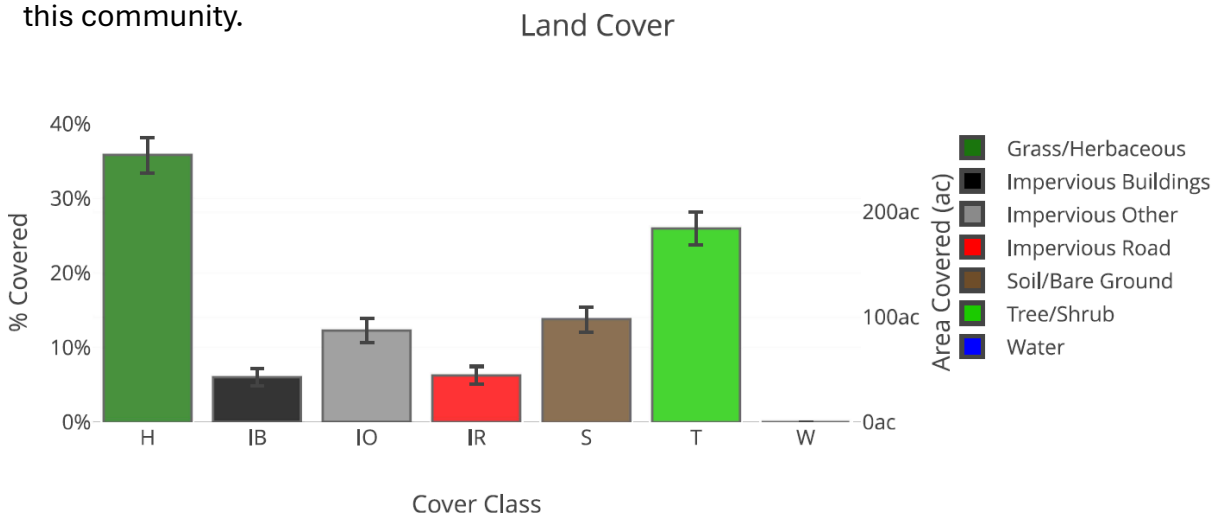
Land Cover Map Utilizing April 2021 NAIP Imagery

The results for the Land Cover mapping utilizing NAIP imagery shows a high canopy coverage of 42.1% across Jonesborough. This is a difference of nearly 9% when compared to the i-Tree canopy data. Both the i-Tree mapping and NAIP Land Cover mapping are higher than other tools such as TreeCanopy.US that puts the canopy coverage at ~30% across Jonesborough. These discrepancies could be due to survey error, time of year of imagery (the NAIP imagery was taken in April), or differences in what each tool categorizes as canopy. It is likely that the actual tree canopy falls somewhere in the middle at ~35% across the entire Town of Jonesborough.

The NAIP land cover map does a good job of distinguishing what regions of Jonesborough are most heavily developed. Areas along E. Jackson Blvd, W. Jackson Blvd, and W. Main Street show the heaviest development and encompass downtown and surrounding commercial properties. The low vegetation lines up well with the i-Tree canopy assessment, showing the regions of farmland and fields. These farm tracts are clearly visible and show the highest density in the middle-north and south-western sections of the town. The NAIP imagery does tend to overestimate low vegetation which can be seen in industrialized/developing areas along N Cherokee Street and Skyline Dr., South of New Hope Road, and along Boones Creek Rd. These areas are under development and would more clearly be defined as developed under the NAIP Land Cover classifications.

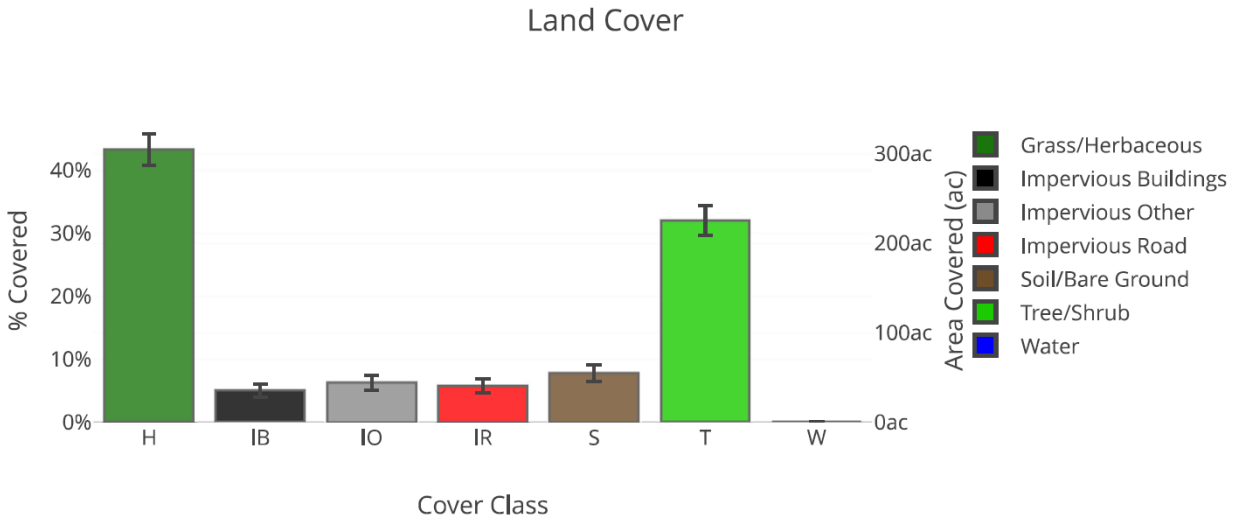
For the i-Tree Canopy data percentages of land cover and ecosystem services were calculated for 4 regions across Jonesborough. The average canopy coverage across the entire town was 33.25% (+/-2.4%). This equates to approximately 1,122 acres of tree canopy across Jonesborough. The area with the most canopy coverage was in the southwestern part of the city at 38.85% (+/-2.4) with the least in the northeast at 26% (+/-2.2). Grass and herbaceous took up the largest coverage area at 38.52% (+/-2.4) and approximately 1275 acres. The total percentage of impervious surface across the entire town was 20.70% (+/-2.0) with the highest at 24.5% (+/-2.0) in the northeast and southeast sections of town. This equates to approximately 669 acres of impervious surface across Jonesborough. The land cover for the northeast section of Jonesborough shows that most of the land is either tree/shrub or grass/herbaceous. More details on land cover percentages are shown for the four areas of Jonesborough below.

The land cover for the northeast region of Jonesborough shows a higher percentage of soil/bare ground at 13.75% (+/-1.72%) as well as the lowest tree canopy coverage at 26% (+/-2.2%). Additionally, this region had one of the highest percentages of impervious surface at 24.5% (+/-1.39%). This is likely due to this area having multiple large new developments. This development can be seen along bird eye view, mountain creek CT, meadow creek lane, and Ida sue drive. The development in this area was extensive and removed almost all the trees and grass coverage leaving bare ground. Although this development will likely start reseeding grasses it may be beneficial to target plantings in this community.



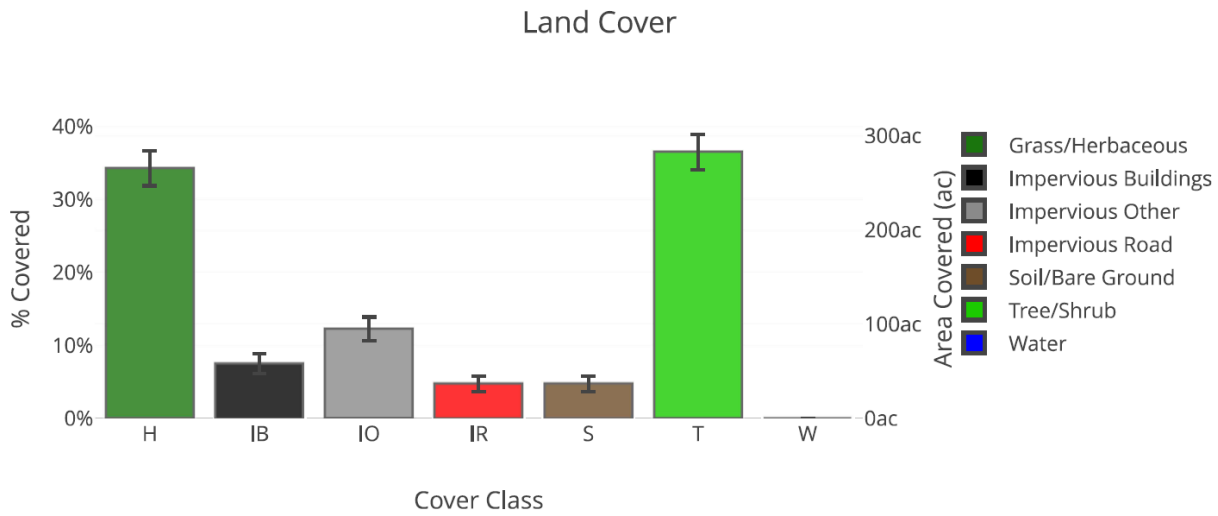
Land Cover Map for Northeastern Region of Jonesborough

The northwestern region of Jonesborough showed an average canopy and grass coverage of 32% (+/-2.3%) and 43.25% (+/-2.5%) respectively. This region of town has one of the lowest percentages of impervious surfaces at 17% (+/-1.14%), likely due to the lower presence of development in this area.



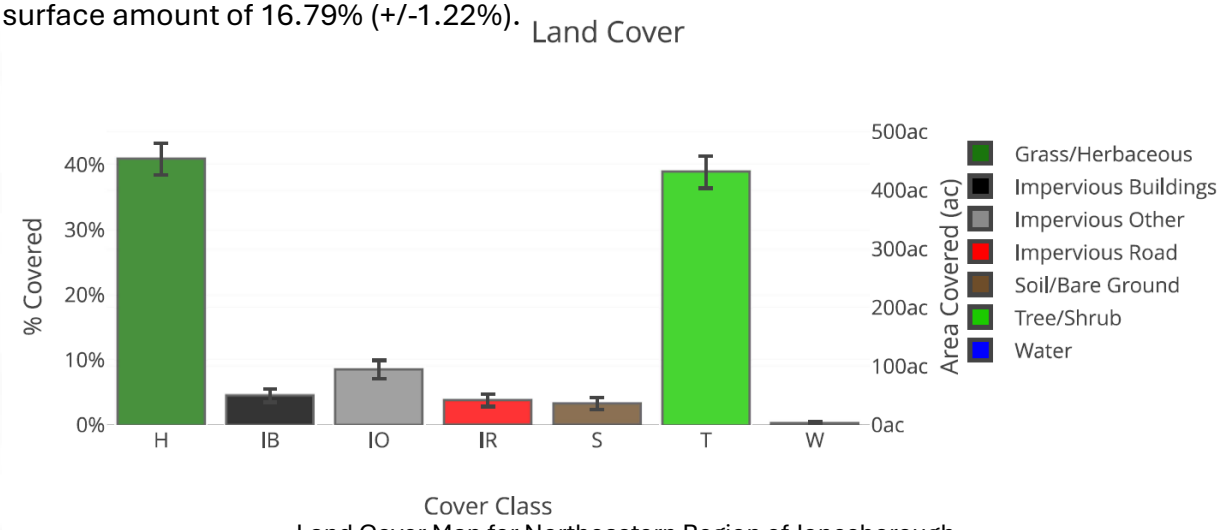
Land Cover Map for Northeastern Region of Jonesborough

For the southeastern region of town, we see the same high impervious surfaces as the northeastern region at 24.5% (+/-1.41%) without the increase in soil/bare ground seen in the northeast region. This makes sense as this area encompasses much of downtown Jonesborough and surrounding neighborhoods. Additionally, this was the only section of town that had a higher percentage of tree/shrub at 36.50% (+/-2.41%) than grass/herbaceous at 34.25% (+/-2.37%).



Land Cover Map for Northeastern Region of Jonesborough

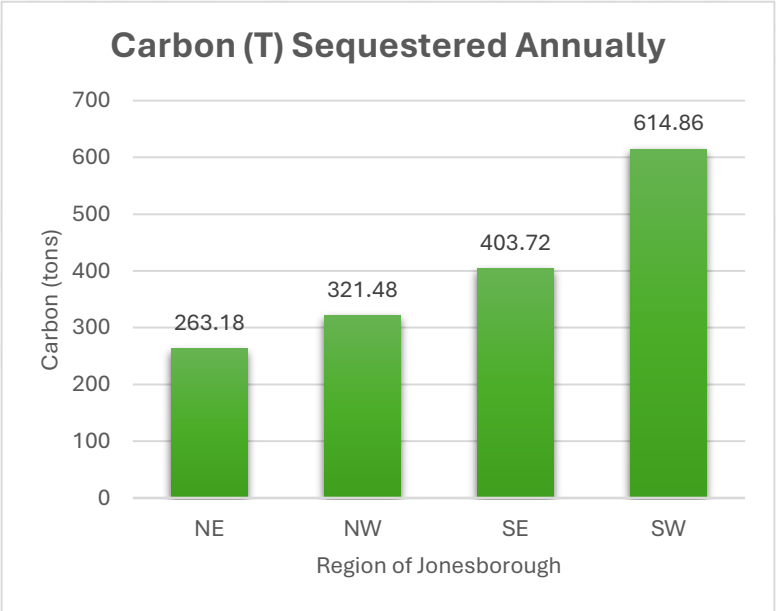
Finally, the southwestern part of Jonesborough we see the highest canopy percentage at 38.85% (+/- 2.44%) and a grass/herbaceous percentage of 40.85% (+/-2.46%). It showed the lowest soil/bare ground percentage at 3.26% (+/- .89%) and the lowest impervious surface amount of 16.79% (+/-1.22%).

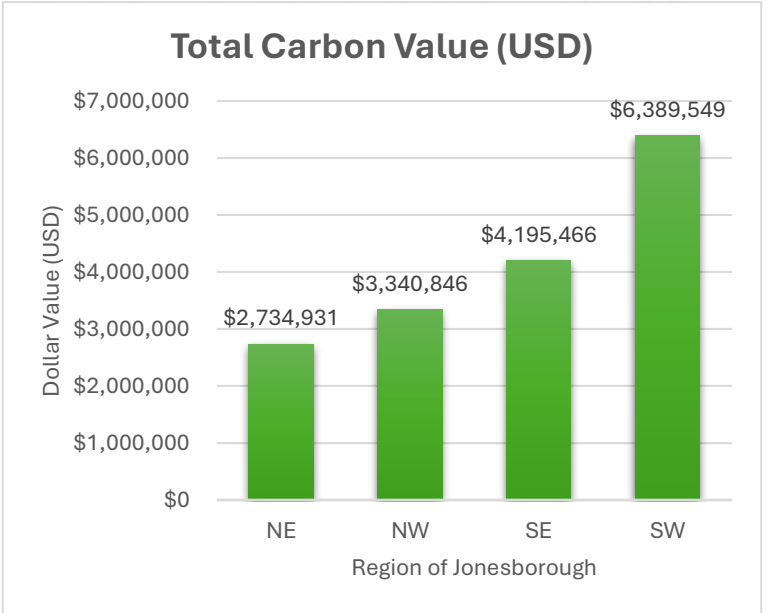


Land Cover Map for Northeastern Region of Jonesborough

The results for the ecosystem services section of the i-Tree Canopy assessment estimate the amount of economic value and services provided to Jonesborough. I-Tree uses forest service and socioeconomic census data to extrapolate the value of these services down to the county level. Washington county will have different values for ecosystem services when compared to surrounding counties such as Greene or Sullivan. These values show what economic value the trees across Jonesborough provide to the town, people, and environment.

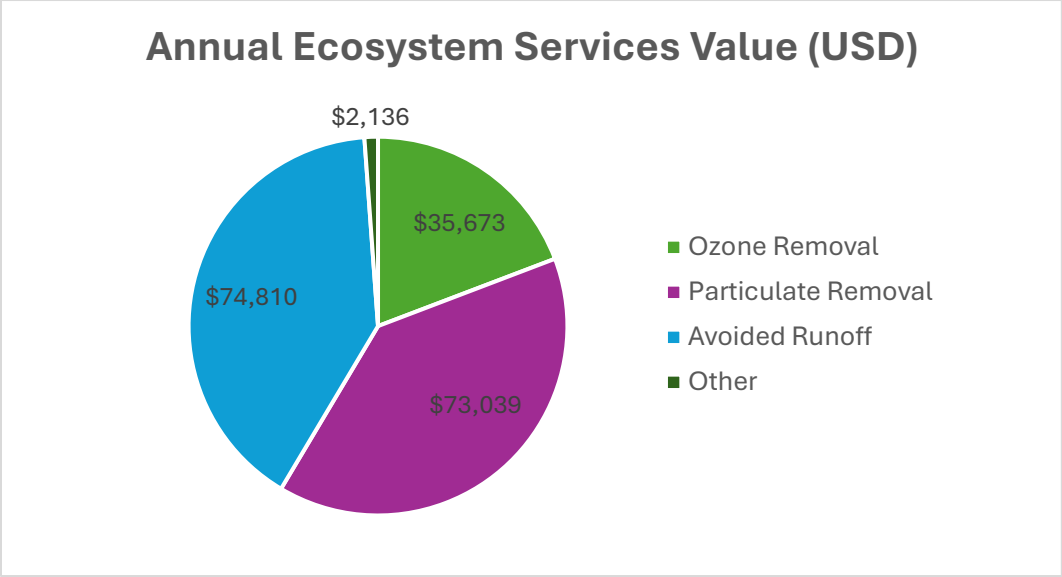
Looking at carbon stored in trees is an important and valuable aspect when considering ecosystem services provided by trees. Due to this benefit, we can assign a value to the carbon stored in a tree over its lifetime. This value for the i-Tree canopy tool is estimated using U.S. Forest Service research on regional carbon markets. The total carbon stored annually in trees across Jonesborough equates to nearly 40,000 tons. This annual stored carbon has an estimated value of $693,000 or $17.33 per ton of carbon. The total value for carbon stored in all trees across Jonesborough is estimated to have a value of over 16 million dollars. Graphs for carbon sequestered annually and total value of carbon across the four regions of Jonesborough are shown below.





Carbon (T) Sequestered Annually and Total Carbon Value in USD for the Town of Jonesborough

The most economically valuable services provided by community trees include removal of ozone, air particulates, and avoided runoff. Other important services include removal of nitrogen dioxide, sulfur dioxide, evaporation, transpiration, and water interception. The total annual value of these ecosystem services across Jonesborough equates to just over $185,000. Avoided runoff is the largest benefit at over $74,000 with particulate and ozone removal at $73,000 and $35,000 respectively. These ecosystem services are visualized in the pie chart below.



Annual Ecosystem Services Provided by Trees in Jonesborough

These services are vital for our ability to adapt and combat climate change while additionally making our parks, homes, and communities more enjoyable places to live. Carbon sequestered annually is significant, but most of the carbon value comes from the mature trees present across much of Jonesborough. Carbon stored across the trees in Jonesborough shows the importance of conserving and protecting our urban forests. Additionally, other ecosystem services provided such as avoided runoff and air quality cannot be overstated. Trees do an amazing job of mitigating and controlling for stormwater during severe weather events. City stormwater infrastructure is extremely expensive, hard to maintain, and prone to getting overwhelmed during extreme events. Trees are a cheap and effective way of bolstering a community's resilience to extreme weather events. Additionally, the benefits trees provide to air quality in urban environments is important for both health and comfort. Cities, towns, and communities are often directly impacted by increased car exhaust, manufacturing emissions, and other air quality issues. Trees act as a filter for these harmful particulates, passively cleaning the air that we breath. Expanding and maintaining your urban forest helps mitigate these risks while providing all the other services that we have discussed.

Tree Canopy Goals

There are multiple ways of thinking about and utilizing your canopy assessment data. Many cities and towns use canopy assessments as a way of establishing where they are currently at to guide future tree projects in their communities. This can take the form of city-wide canopy percentage goals in which a city or town makes a statement such as “We will raise canopy coverage by x percent over x number of years”. Although this type of canopy goal can be a successful in increasing overall canopy it isn’t the best way. Canopy assessments alone shouldn’t be used as the only tool but be added to a community’s toolbox to help make better decisions regarding trees and green spaces. Utilizing canopy assessments, demographic data, and in the field observations to establish goals will lead to the best long-term outcomes for your community. Any successful city-wide canopy goal should consider not only city owned trees but all trees within the city limits, whether they be private, commercial, or public.

Narrowing in on development, for example, can have large positive impacts to conserving your communities canopy coverage. New development is one of the leading causes of canopy loss across our state. Although a small amount of this canopy may be replaced by new plantings it does not make up for the services provided by the existing mature trees. It is often cheaper for new development to fully clear an area rather than work around existing trees or green spaces. Cities can choose between several options on how to address loss of canopy due to new development. The first is do nothing, this leaves the recovery of canopy entirely on the developers and the future residents of that area. The second is implementing plantings in other areas around the city. This can be successful if done proactively but may be difficult as the cost is put entirely on the city itself. The third is develop ordinances that require developers pay for the cost of removed trees or plant new trees to replace those cut down. This option helps to conserve tree numbers, but you lose many services that the mature trees provided. The fourth is to require new developments to conserve a given number of mature trees. This is the best option for conserving canopy but puts more of the cost and requires greater effort on the part of the developer.

A simple tree canopy goal is better than no goal at all. General goals can be helpful to get people on board with the idea of bettering a community's tree canopy. Early on, for example, goals can be simple and straightforward with the intention of expanding goals as projects and efforts develop. It is also good to set easy and achievable goals at the start to capture early wins and inspire future action. This is especially important when looking at community engagement as frequent and impactful successes can keep attention and encourage further efforts. More expansive and long-term goals can be established for the

city and community level once an understanding of what is needed is more fully understood. Canopy goals are an important aspect of any community tree management and lead into discussing aspects such as full circle management and disaster mitigation.

Full Circle Management

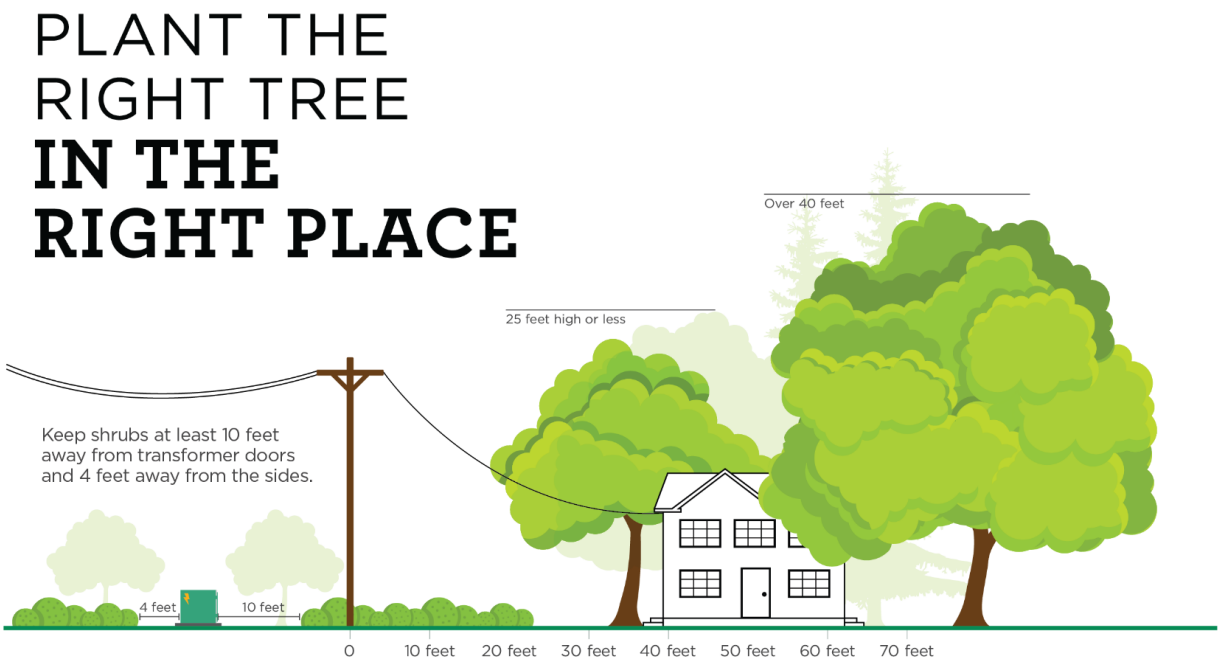
Full circle management is a term used in urban and community forestry to showcase how management of our community forests is an ongoing process. It encompasses evaluating, planning, planting, maintaining, managing, and utilizing your trees and natural resources. Although all these steps are important, they do not need to be done in this exact order and should be implemented when and where needed. It is also possible that different parts of your community will be undergoing different aspects of the process at any given time. You may be evaluating a natural area in your city while also managing an already established park in another location. There is an abundance of resources on each of these aspects with many listed in the resources section below. Communities that implement all stages of full circle management are more likely to accomplish long-term goals and projects. Additionally, full circle management helps communities become more resilient to all forms of change and disturbance, whether that be from natural disasters, disease, or ongoing development.

The first step in full circle management is evaluation. This step is crucial as if you don't know where you are you can't decide what direction to move in. A canopy assessment is a good place to start in evaluating your trees. Canopy assessments tell you where your trees are, how much canopy you have, where you can't plant trees (e.g., roads, homes, parking lots), and most importantly where you can plant more trees! Canopy assessments also act as a good reference to past city canopy coverage. Canopy assessments should be untaken every few years to see how your canopy has changed, acting as an early warning sign of canopy loss. This allows communities to develop strategies and plans to better adapt to the ever-changing urban landscape. The next step in evaluation is to conduct an on-the-ground tree inventory. This inventory is much more rigorous than the canopy assessment and records specific tree information such as geographical location, species, size, height, and if any abnormalities or issues are present. This inventory should be done on a single tree basis for street trees and a forest basis for more natural areas. Inventories on heavily forested areas should follow stand level measurements, often utilizing plots and extrapolating data from there to encompass a larger area. Tree condition and issues can be recorded at the same time as the initial inventory, allowing for easier transition to a more rigorous management and work plan. Cities and communities should always return to evaluation if current conditions change or if there is a large disturbance event (e.g., natural disaster, large development, disease, pest).

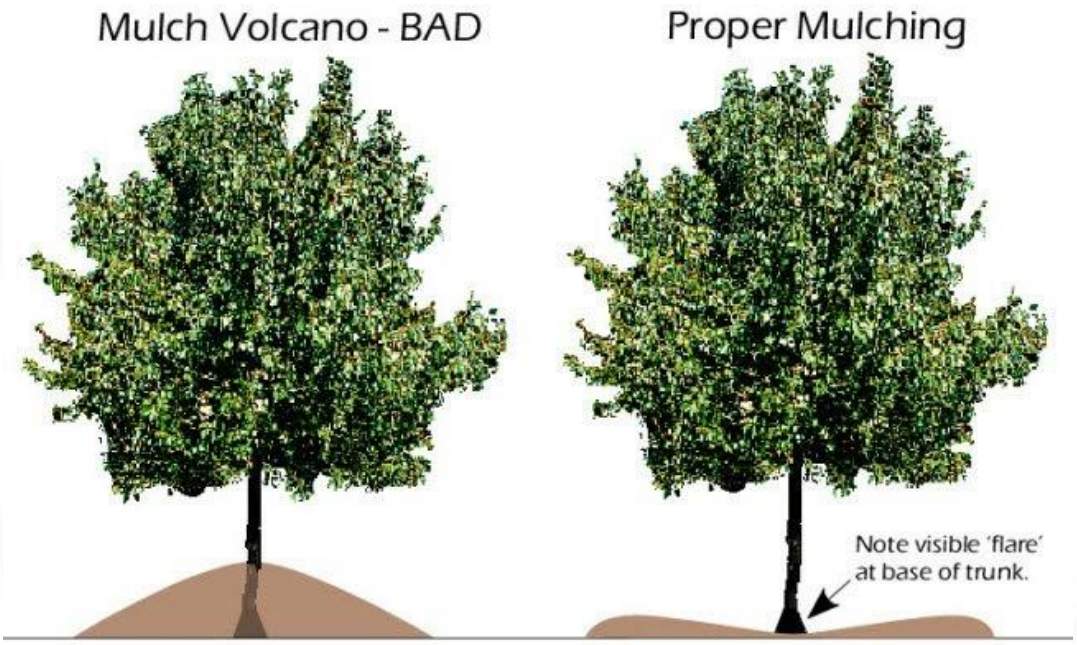
Planning is the next step in full circle management and potentially the most important. Utilizing your previous inventories and assessments, planning is where a community decides what direction they want to take their urban forests. This process should be tailored to the specific community or city you live in and should leverage your communities' specific strengths. Some cities will possess a strong and mature urban canopy, in which case preservation of current trees should take priority. Other cities may lack in mature canopy but make up for it in an abundance of open space with potential to plant more trees. Still other communities may have active volunteer organizations and groups that make planting and tree care easier. It is important for you to establish your communities' strengths and weaknesses to better inform planning. Once you have established your strengths and weaknesses you can move on to developing work, planting, and management plans. It is often beneficial to split your city or community up into areas that share similar geographics, uses, or cultural distinctions. For example, downtown should be managed and planned for differently than a sprawling suburban area. All planning should be catered to the given areas needs and what will best serve your community.

After planning we get to the fun part, planting the trees! Although full circle management encompasses many different aspects, planting is still vital for long-term success. There are two general types of planting, general planting and replacement plantings. General plantings are all the new trees going into areas without tree canopy to bolster your communities canopy coverage. These trees can be planted prioritizing underserved areas or areas with limited access to green space. General plantings are great at increasing canopy coverage in an effective and measurable way. Replacement plantings vary from general plantings as we do not prioritize areas of low canopy. These plantings instead focus on areas with older and mature trees to establish young trees that can fill the gap when the older trees die. This is especially important in our parks and city centers as we often don't prepare for natural tree mortality. A city center with an abundance of beautiful mature trees could become a hot tree-less landscape in a relatively short amount time. Planning, planting replacement trees, and recognizing that our mature trees won't last forever are the first steps to ensuring our abundant urban tree landscape is protected well into the future!

Trees should also be planted in correct locations to avoid any future damage to structures, powerlines, or people. Trees are large and heavy objects and when limbs or entire trees fall the damage can be catastrophic. To mitigate these dangers while still benefiting from all the amazing thing's trees do for us, we utilize the phrase "Right Tree, Right Place". This means that we choose the tree that works best for the area, avoiding planting next to powerlines or vulnerable structures. It is important to research the species that you plant and evaluate how large the adult tree will become. Additionally, certain species may be more prone to lose branches during severe weather events. Weak branch connections are especially common with many of our non-native species. It would be best to avoid planting these trees too closely to structures that could be damaged by falling limbs.



Ensuring that your trees are planted and mulched correctly can be just as important as routinely watering. An improperly planted tree is susceptible to disease and heat stress. If planted too deep, below the root flare, the trunk can rot due to high heat and moisture. Girdling roots also become more common in trees planted too deeply. Additionally, if mulch is applied too high on the trunk the tree will suffer from the same problems as if it were planted too deeply. If the tree isn't planted deep enough it could be blown over during a storm or become stressed. A tree with exposed roots will become stressed as those roots are not being protected from the sun or getting the moisture needed to grow. Below is a diagram of proper and improper tree planting techniques.



After planting your trees, it is now time to look at managing your trees. Trees are an investment into your future; it is important we protect that investment. Maintaining our trees will allow them to continue to provide all their good services to our communities for years to come! Providing expert tree care starts on day one after planting a tree. We need to ensure proper mulching and watering takes place immediately as this is the most vulnerable time for a new tree. Watering should take place every 1-2 days for small trees and every 2-3 days for larger trees. This watering schedule should be used for the first growing season to ensure your new trees thrive. After the first growing season you can move on to a weekly watering schedule. Tree pruning is another important task that needs to be done well to ensure the long-term health of your trees. It is not considered good tree stewardship to perform techniques such as tree topping or trunk painting. These damage the trees' natural ability to grow and regulate and in the case of tree topping almost always lead to the eventual death of the tree.

The final aspect of full circle management is utilizing your trees when they near the end of their lifespan. We refer to this process as urban or community wood utilization. Trees age and eventually succumb to natural mortality. When this happens, the trees are often removed by a municipality or tree care company and taken off site. Much of this urban wood ends up in the landfill or is chipped for mulch. This wood is often comprised of high-quality species and in sizes that could be processed by sawmills for wood products. Additionally, urban wood can possess unique growth patterns, making it ideal for local woodworkers and artists. The thought behind urban and community wood utilization is to divert quality wood from the landfill and utilize it to its highest purpose! Whether that be as a construction material, for crafts and furniture, or as biomass energy production, community wood has many uses! If your community is interested in urban wood utilization or any other aspect of full circle management, please reach out to the Tennessee Urban & Community Forestry Team!

Examples of Urban Wood Utilization

Recommendations

This report provides an overview of the Town of Jonesborough and their current tree canopy. This report is intended to give a first step toward expanding urban forest management and sustainability. It is intended to inform the Town of Jonesborough's town officials, workers, and residence on their current tree canopy status.

The findings from this study can be used to:

- **Develop urban tree canopy goals to protect and conserve the current and future canopy in Jonesborough.**
- **Act as a first step to help develop or expand town wide tree inventories, management plans, and work schedules.**
- **Provide a baseline for what the tree canopy in the Town of Jonesborough looks like as of 2025.**
- **Help guide tree planting efforts to focus on areas of potential lacking or limited canopy coverage.**
- **Incentivize expanding legislation and policies to better protect and expand tree canopy.**
- **Showcase the economic benefits that the tree canopy in Jonesborough provides.**

Resources

TN Urban & Community Forestry Page: www.tn.gov/agriculture/forests/urban

Urban and Community Forestry Society – City Trees: www. ucfsociety.org/city-trees

Arbor Day Foundation – Tree Resources: www.arborday.org/tree-resources

i-Tree Canopy: canopy.itreetools.org

Other i-Tree Tools: www.itreetools.org

TreeCanopy.US: treecanopy.us

Arborist Lookup: www.treesaregood.org

SFI Urban and Community Forest Sustainability Standard: www.forests.org/sfi-urban-forestry-standard/

Vibrant Cities Lab Resources: www.vibrantcitieslab.com

USDA Forest Service Urban Forest Management Primer: research.fs.usda.gov/treesearch/65839

Wisconsin DNR Guide to Developing Urban Forest Strategic/Management Plans: dnr.wisconsin.gov/sites/default/files/topic/UrbanForests/UFPlanningGuide.pdf

TN Department of Agriculture | Forestry

Funding for this program provided by the USDA Forest Service, Urban and Community Forestry Program, USDA and TN Department of Agriculture are equal opportunity providers and employers.

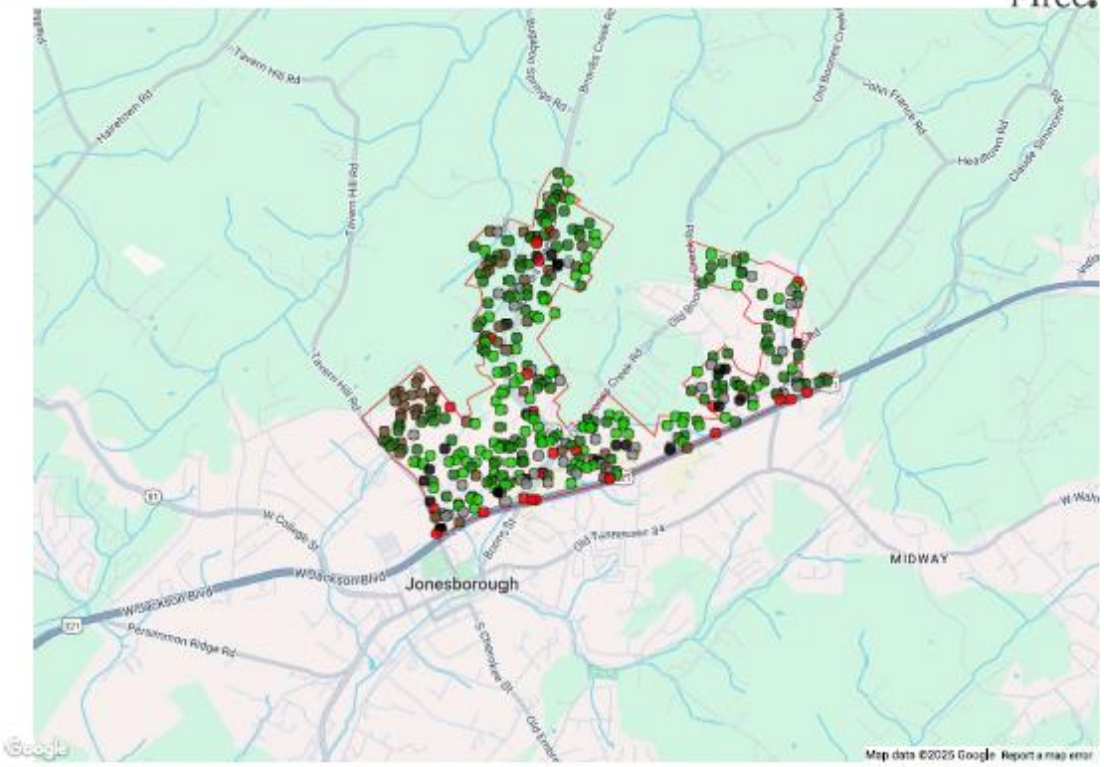
Appendix

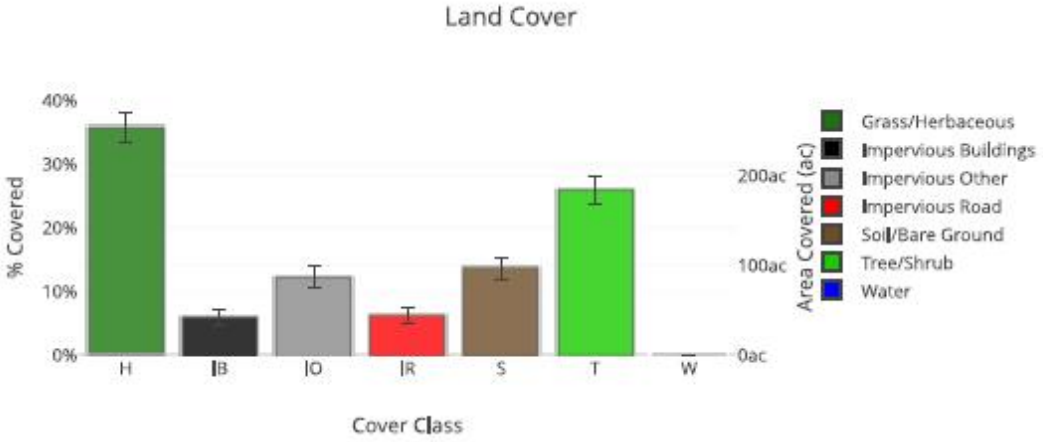
i-Tree Results for NE Jonesborough

i-Tree Canopy Report

i-Tree Benefits and Cover Assessment

Estimated using random sampling statistics on 4/21/2025





Abbr.	Cover Class	Description	Points	% Cover ± SE	Area (ac) ± SE
H	Grass/Herbaceous		143	35.75 ± 2.40	253.50 ± 16.99
IB	Impervious Buildings		24	6.00 ± 1.19	42.55 ± 8.42
IO	Impervious Other		49	12.25 ± 1.64	86.86 ± 11.62
IR	Impervious Road		25	6.25 ± 1.21	44.32 ± 8.58
S	Soil/Bare Ground		55	13.75 ± 1.72	97.50 ± 12.21
T	Tree/Shrub		104	26.00 ± 2.19	184.36 ± 15.55
W	Water		0	0.00 ± 0.00	0.00 ± 0.00
Total			**400**	**100.00**	**709.09**

Tree Benefit Estimates: Carbon (English units)

Description	Carbon (T)	±SE	CO_2 Equiv. (T)	±SE	Value (USD)	±SE
Sequestered annually in trees	263.18	±22.20	964.99	±81.40	$113,684	±9,606
Stored in trees (Note: this benefit is not an annual rate)	6,320.22	±533.13	23,174.14	±1,954.80	$2,734,931	±230,699

Currency is in USD and rounded. Standard errors of removal and benefit amounts are based on standard errors of sampled and classified points. Amount sequestered is based on 1.427 T of Carbon, or 5.234 T of CO_2, per ac/yr and rounded. Amount stored is based on 34.281 T of Carbon, or 125.697 T of CO_2, per ac and rounded. Value (USD) is based on $432.73/T of Carbon, or $118.02/T of CO_2 and rounded. (English units: T = tons (2,000 pounds), ac = acres)

Tree Benefit Estimates: Air Pollution (English units)

Abbr.	Description	Amount (lb)	±SE	Value (USD)	±SE
CO	Carbon Monoxide removed annually	193.60	±16.33	$129	±11
NO2	Nitrogen Dioxide removed annually	1,089.77	±91.92	$104	±9
O3	Ozone removed annually	7,427.92	±626.57	$5,856	±494
SO2	Sulfur Dioxide removed annually	2,337.25	±197.15	$117	±10
PM2.5	Particulate Matter less than 2.5 microns removed annually	358.30	±30.22	$8,385	±707
PM10*	Particulate Matter greater than 2.5 microns and less than 10 microns removed annually	1,150.12	±97.02	$3,605	±304
Total		**12,556.96**	**±1,059.21**	**$18,196**	**±1,535**

Currency is in USD and rounded. Standard errors of removal and benefit amounts are based on standard errors of sampled and classified points. Air Pollution Estimates are based on these values in lb/ac/yr @ $/lb/yr and rounded:
CO 1.050 @ $0.67 | NO2 5.911 @ $0.10 | O3 40.289 @ $0.79 | SO2 12.677 @ $0.05 | PM2.5 1.943 @ $23.40 | PM10* 6.238 @ $3.13 (English units: lb = pounds, ac = acres)

Tree Benefit Estimates: Hydrological (English units)

Abbr.	Benefit	Amount (Mgal)	±SE	Value (USD)	±SE
AVRO	Avoided Runoff	1.37	±0.12	$12,280	±1,036
E	Evaporation	13.06	±1.10	N/A	N/A
I	Interception	13.07	±1.10	N/A	N/A
T	Transpiration	24.92	±2.10	N/A	N/A
PE	Potential Evaporation	103.77	±8.75	N/A	N/A
PET	Potential Evapotranspiration	74.14	±6.25	N/A	N/A

Currency is in USD and rounded. Standard errors of removal and benefit amounts are based on standard errors of sampled and classified points. Hydrological Estimates are based on these values in Mgal/ac/yr @ $/Mgal/yr and rounded:
AVRO 0.007 @ $8,936.00 | E 0.071 @ N/A | I 0.071 @ N/A | T 0.135 @ N/A | PE 0.563 @ N/A | PET 0.402 @ N/A (English units: Mgal = millions of gallons, ac = acres)

About i-Tree Canopy

The concept and prototype of this program were developed by David J. Nowak, Jeffery T. Walton, and Eric J. Greenfield (USDA Forest Service). The current version of this program was developed and adapted to i-Tree by David Ellingsworth, Mike Binkley, and Scott Maco (The Davey Tree Expert Company)

Limitations of i-Tree Canopy

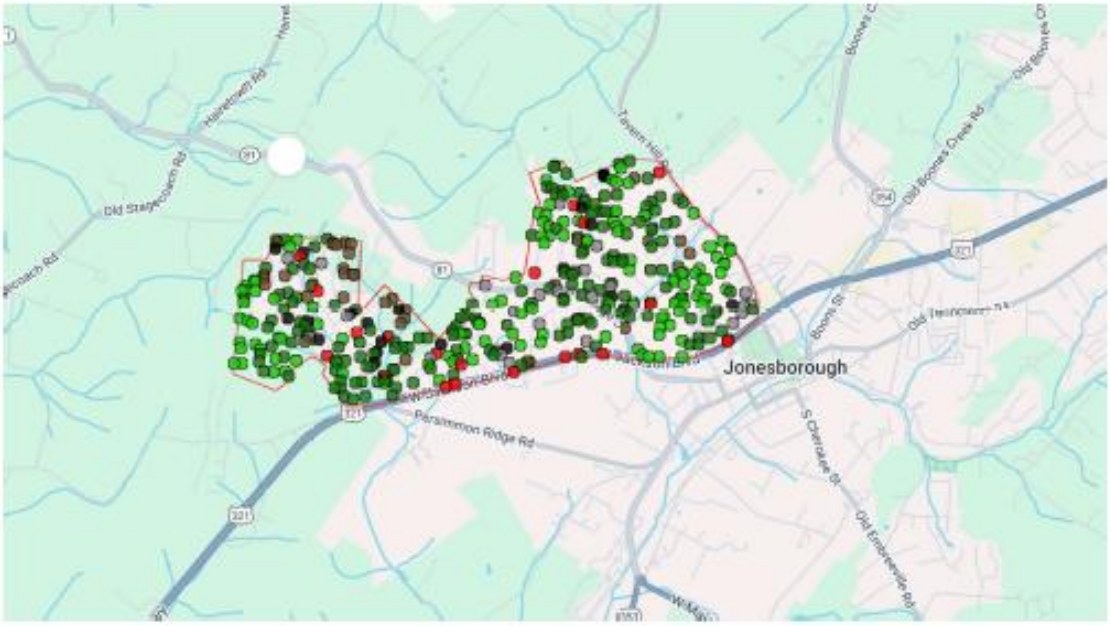
The accuracy of the analysis depends upon the ability of the user to correctly classify each point into its correct class. As the number of points increase, the precision of the estimate will increase as the standard error of the estimate will decrease. If too few points are classified, the standard error will be too high to have any real certainty of the estimate.

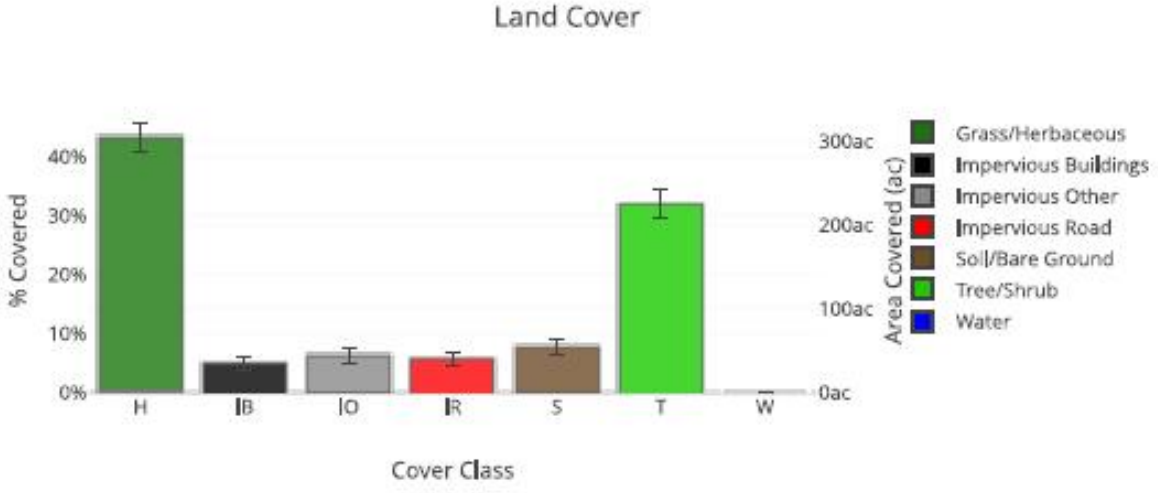
i-Tree Results for NW Jonesborough

i-Tree Canopy Report

i-Tree Benefits and Cover Assessment

Estimated using random sampling statistics on 4/16/2025





Abbr.	Cover Class	Description	Points	% Cover ± SE	Area (ac) ± SE
H	Grass/Herbaceous		173	43.25 ± 2.48	304.39 ± 17.43
IB	Impervious Buildings		20	5.00 ± 1.09	35.19 ± 7.67
IO	Impervious Other		25	6.25 ± 1.21	43.99 ± 8.52
IR	Impervious Road		23	5.75 ± 1.16	40.47 ± 8.19
S	Soil/Bare Ground		31	7.75 ± 1.34	54.54 ± 9.41
T	Tree/Shrub		128	32.00 ± 2.33	225.21 ± 16.41
W	Water		0	0.00 ± 0.00	0.00 ± 0.00
Total			**400**	**100.00**	**703.78**

Tree Benefit Estimates: Carbon (English units)

Description	Carbon (T)	±SE	CO_2 Equiv. (T)	±SE	Value (USD)	±SE
Sequestered annually in trees	321.48	±23.43	1,178.77	±85.92	$139,115	±10,140
Stored in trees (Note: this benefit is not an annual rate)	7,720.44	±562.72	28,308.30	±2,063.30	$3,340,846	±243,504

Currency is in USD and rounded. Standard errors of removal and benefit amounts are based on standard errors of sampled and classified points. Amount sequestered is based on 1.427 T of Carbon, or 5.234 T of CO_2, per ac/yr and rounded. Amount stored is based on 34.281 T of Carbon, or 125.697 T of CO_2, per ac and rounded. Value (USD) is based on $432.73/T of Carbon, or $118.02/T of CO_2 and rounded. (English units: T = tons (2,000 pounds), ac = acres)

Tree Benefit Estimates: Air Pollution (English units)

Abbr.	Description	Amount (lb)	±SE	Value (USD)	±SE
CO	Carbon Monoxide removed annually	236.49	±17.24	$158	±11
NO2	Nitrogen Dioxide removed annually	1,331.20	±97.03	$127	±9
O3	Ozone removed annually	9,073.55	±661.34	$7,153	±521
SO2	Sulfur Dioxide removed annually	2,855.06	±208.10	$144	±10
PM2.5	Particulate Matter less than 2.5 microns removed annually	437.68	±31.90	$10,242	±747
PM10*	Particulate Matter greater than 2.5 microns and less than 10 microns removed annually	1,404.92	±102.40	$4,403	±321
Total		**15,338.91**	**±1,118.01**	**$22,227**	**±1,620**

Currency is in USD and rounded. Standard errors of removal and benefit amounts are based on standard errors of sampled and classified points. Air Pollution Estimates are based on these values in lb/ac/yr @ $/lb/yr and rounded:
CO 1.050 @ $0.67 | NO2 5.911 @ $0.10 | O3 40.289 @ $0.79 | SO2 12.677 @ $0.05 | PM2.5 1.943 @ $23.40 | PM10* 6.238 @ $3.13 (English units: lb = pounds, ac = acres)

Tree Benefit Estimates: Hydrological (English units)

Abbr.	Benefit	Amount (Mgal)	±SE	Value (USD)	±SE
AVRO	Avoided Runoff	1.68	±0.12	$15,001	±1,093
E	Evaporation	15.96	±1.16	N/A	N/A
I	Interception	15.96	±1.16	N/A	N/A
T	Transpiration	30.44	±2.22	N/A	N/A
PE	Potential Evaporation	126.76	±9.24	N/A	N/A
PET	Potential Evapotranspiration	90.57	±6.60	N/A	N/A

Currency is in USD and rounded. Standard errors of removal and benefit amounts are based on standard errors of sampled and classified points. Hydrological Estimates are based on these values in Mgal/ac/yr @ $/Mgal/yr and rounded:
AVRO 0.007 @ $8,936.00 | E 0.071 @ N/A | I 0.071 @ N/A | T 0.135 @ N/A | PE 0.563 @ N/A | PET 0.402 @ N/A (English units: Mgal = millions of gallons, ac = acres)

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Limitations of i-Tree Canopy

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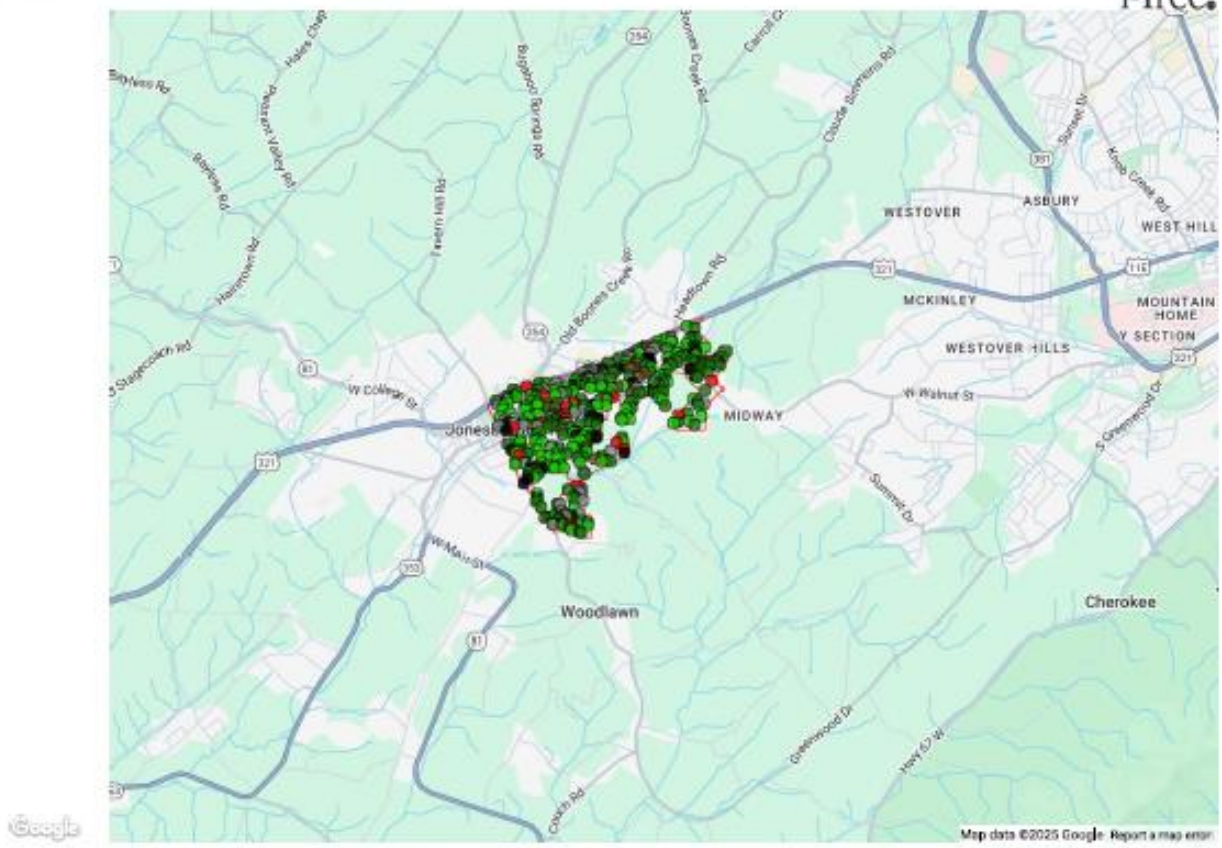
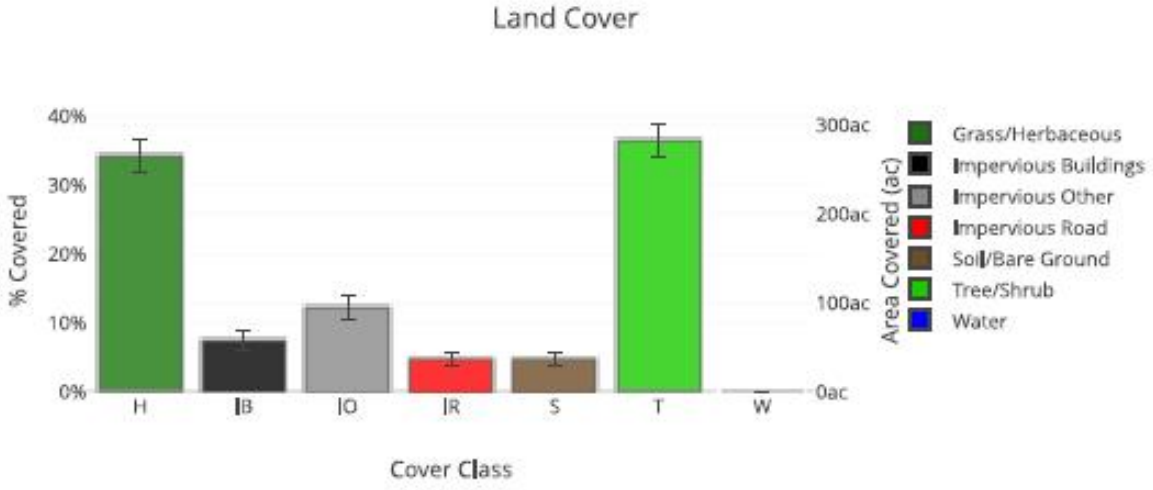
i-Tree Results for SE Jonesborough

i-Tree Canopy Report

i-Tree Benefits and Cover Assessment

Estimated using random sampling statistics on 4/21/2025





Abbr.	Cover Class	Description	Points	% Cover ± SE	Area (ac) ± SE
H	Grass/Herbaceous		137	34.25 ± 2.37	265.39 ± 18.39
IB	Impervious Buildings		30	7.50 ± 1.32	58.11 ± 10.20
IO	Impervious Other		49	12.25 ± 1.64	94.92 ± 12.70
IR	Impervious Road		19	4.75 ± 1.06	36.81 ± 8.24
S	Soil/Bare Ground		19	4.75 ± 1.06	36.81 ± 8.24
T	Tree/Shrub		146	36.50 ± 2.41	282.82 ± 18.65
W	Water		0	0.00 ± 0.00	0.00 ± 0.00
Total			**400**	**100.00**	**774.85**

Tree Benefit Estimates: Carbon (English units)

Description	Carbon (T)	±SE	CO_2 Equiv. (T)	±SE	Value (USD)	±SE
Sequestered annually in trees	403.72	±26.63	1,480.32	±97.63	$174,702	±11,521
Stored in trees (Note: this benefit is not an annual rate)	9,695.41	±639.41	35,549.83	±2,344.49	$4,195,466	±276,688

Currency is in USD and rounded. Standard errors of removal and benefit amounts are based on standard errors of sampled and classified points. Amount sequestered is based on 1.427 T of Carbon, or 5.234 T of CO_2, per ac/yr and rounded. Amount stored is based on 34.281 T of Carbon, or 125.697 T of CO_2, per ac and rounded. Value (USD) is based on $432.73/T of Carbon, or $118.02/T of CO_2 and rounded. (English units: T = tons (2,000 pounds), ac = acres)

Tree Benefit Estimates: Air Pollution (English units)

Abbr.	Description	Amount (lb)	±SE	Value (USD)	±SE
CO	Carbon Monoxide removed annually	296.99	±19.59	$198	±13
NO2	Nitrogen Dioxide removed annually	1,671.74	±110.25	$160	±11
O3	Ozone removed annually	11,394.65	±751.47	$8,983	±592
SO2	Sulfur Dioxide removed annually	3,585.41	±236.46	$180	±12
PM2.5	Particulate Matter less than 2.5 microns removed annually	549.65	±36.25	$12,863	±848
PM10*	Particulate Matter greater than 2.5 microns and less than 10 microns removed annually	1,764.32	±116.36	$5,530	±365
Total		**19,262.75**	**±1,270.37**	**$27,913**	**±1,841**

Currency is in USD and rounded. Standard errors of removal and benefit amounts are based on standard errors of sampled and classified points. Air Pollution Estimates are based on these values in lb/ac/yr @ $/lb/yr and rounded:
CO 1.050 @ $0.67 | NO2 5.911 @ $0.10 | O3 40.289 @ $0.79 | SO2 12.677 @ $0.05 | PM2.5 1.943 @ $23.40 | PM10* 6.238 @ $3.13 (English units: lb = pounds, ac = acres)

Tree Benefit Estimates: Hydrological (English units)

Abbr.	Benefit	Amount (Mgal)	±SE	Value (USD)	±SE
AVRO	Avoided Runoff	2.11	±0.14	$18,839	±1,242
E	Evaporation	20.04	±1.32	N/A	N/A
I	Interception	20.05	±1.32	N/A	N/A
T	Transpiration	38.23	±2.52	N/A	N/A
PE	Potential Evaporation	159.19	±10.50	N/A	N/A
PET	Potential Evapotranspiration	113.74	±7.50	N/A	N/A

Currency is in USD and rounded. Standard errors of removal and benefit amounts are based on standard errors of sampled and classified points. Hydrological Estimates are based on these values in Mgal/ac/yr @ $/Mgal/yr and rounded:
AVRO 0.007 @ $8,936.00 | E 0.071 @ N/A | I 0.071 @ N/A | T 0.135 @ N/A | PE 0.563 @ N/A | PET 0.402 @ N/A (English units: Mgal = millions of gallons, ac = acres)

About i-Tree Canopy

The concept and prototype of this program were developed by David J. Nowak, Jeffery T. Walton, and Eric J. Greenfield (USDA Forest Service). The current version of this program was developed and adapted to i-Tree by David Ellingsworth, Mike Binkley, and Scott Maco (The Davey Tree Expert Company)

Limitations of i-Tree Canopy

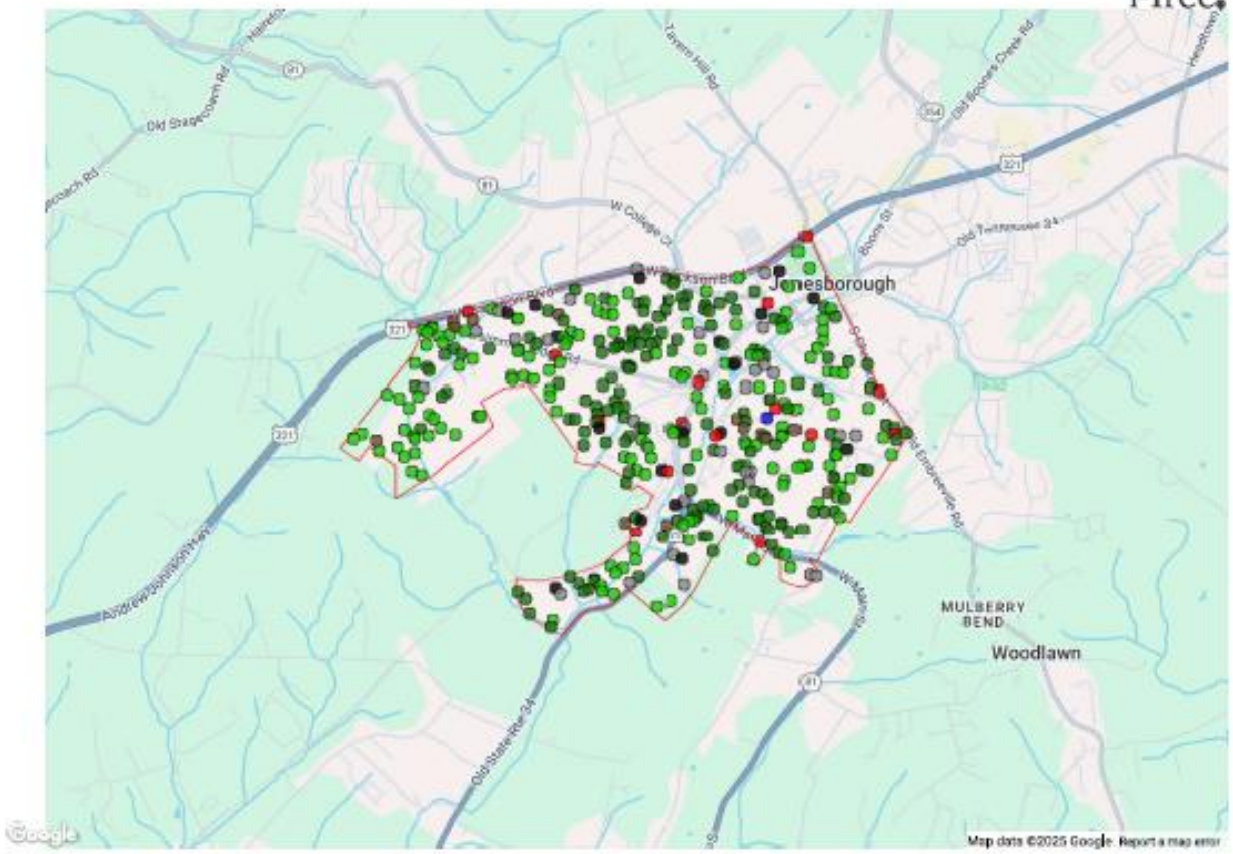
The accuracy of the analysis depends upon the ability of the user to correctly classify each point into its correct class. As the number of points increase, the precision of the estimate will increase as the standard error of the estimate will decrease. If too few points are classified, the standard error will be too high to have any real certainty of the estimate.

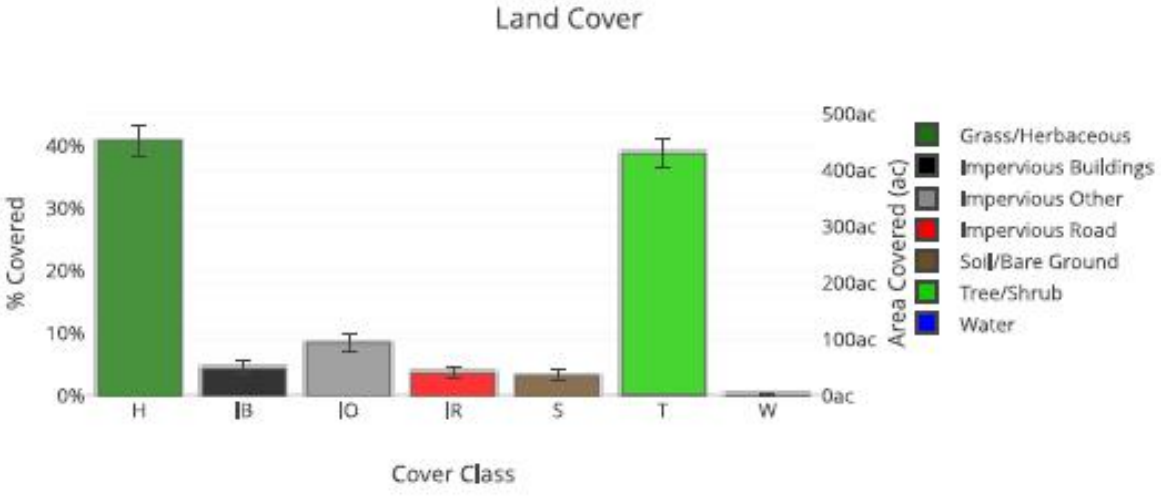
i-Tree Results for SW Jonesborough

i-Tree Canopy Report

i-Tree Benefits and Cover Assessment

Estimated using random sampling statistics on 4/21/2025





Abbr.	Cover Class	Description	Points	% Cover ± SE	Area (ac) ± SE
H	Grass/Herbaceous		163	40.85 ± 2.46	452.96 ± 27.29
IB	Impervious Buildings		18	4.51 ± 1.04	50.02 ± 11.52
IO	Impervious Other		34	8.52 ± 1.40	94.48 ± 15.50
IR	Impervious Road		15	3.76 ± 0.95	41.68 ± 10.56
S	Soil/Bare Ground		13	3.26 ± 0.89	36.13 ± 9.85
T	Tree/Shrub		155	38.85 ± 2.44	430.73 ± 27.05
W	Water		1	0.25 ± 0.25	2.78 ± 2.78
Total			**399**	**100.00**	**1108.77**

Tree Benefit Estimates: Carbon (English units)

Description	Carbon (T)	±SE	CO_2 Equiv. (T)	±SE	Value (USD)	±SE
Sequestered annually in trees	614.86	±38.62	2,254.47	±141.61	$266,065	±16,712
Stored in trees (Note: this benefit is not an annual rate)	14,765.77	±927.47	54,141.16	±3,400.71	$6,389,549	±401,340

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Tree Benefit Estimates: Air Pollution (English units)

Abbr.	Description	Amount (lb)	±SE	Value (USD)	±SE
CO	Carbon Monoxide removed annually	452.31	±28.41	$302	±19
NO2	Nitrogen Dioxide removed annually	2,545.99	±159.92	$243	±15
O3	Ozone removed annually	17,353.65	±1,090.02	$13,681	±859
SO2	Sulfur Dioxide removed annually	5,460.46	±342.98	$274	±17
PM2.5	Particulate Matter less than 2.5 microns removed annually	837.09	±52.58	$19,589	±1,230
PM10*	Particulate Matter greater than 2.5 microns and less than 10 microns removed annually	2,687.00	±168.78	$8,422	±529
Total		**29,336.50**	**±1,842.68**	**$42,511**	**±2,670**

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Tree Benefit Estimates: Hydrological (English units)

Abbr.	Benefit	Amount (Mgal)	±SE	Value (USD)	±SE
AVRO	Avoided Runoff	3.21	±0.20	$28,690	±1,802
E	Evaporation	30.52	±1.92	N/A	N/A
I	Interception	30.53	±1.92	N/A	N/A
T	Transpiration	58.23	±3.66	N/A	N/A
PE	Potential Evaporation	242.44	±15.23	N/A	N/A
PET	Potential Evapotranspiration	173.22	±10.88	N/A	N/A

Currency is in USD and rounded. Standard errors of removal and benefit amounts are based on standard errors of sampled and classified points. Hydrological Estimates are based on these values in Mgal/ac/yr @ $/Mgal/yr and rounded:
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