**CHARLOTTESVILLE TREE COMMISSION**
**Tuesday, April 5, 2022**
**5:00 – 7:00 pm**
**Virtual|Electronic Meeting**

| | |
|---|---|
| **Call to Order** *(P. Van Yahres)* | **5:00** |

- Approval of March Minutes
- Introduction New Members

| | |
|---|---|
| **Staff Report** *(C. Gensic)* | **5:10** |

- Urban Forester
- Canopy Study

| | |
|---|---|
| **Public Utilities' Energy Saving Trees Program** *(Irene Peterson)* | **5:30** |
| **Committee Reports** *( P. Van Yahres)* | **5:40** |

- Education & Advocacy *(P. Van Yahres)*
  *ReLeaf Arbor Day*
  Arbor *(P. Van Yahres)*
  *Arbor Day*

| | |
|---|---|
| **Codes and Practices** *(V. Metcalf)* | **6:00** |

- *Meeting with NDS & PW Staff*
- *Zoning ordinance*
- *Comp Plan*

| | |
|---|---|
| **General Public Comment** | **6:45** |
| **Items/Announcements Not on Agenda** | **6:50** |
| **Action Items for Next Meeting** | **6:55** |
| **Adjourn** | **7:00** |

(†) At the discretion of the Chair, public comments related to particular agenda items may be solicited at that point in the meeting.

This virtual/electronic meeting is open to the public. You may participate electronically by registering at www.charlottesville.gov/zoom or via telephone by using the number provided with the Zoom registration. Or you may contact staff at 434-970-3182 to receive the dial in number. In addition to the Zoom webinar, this meeting will be available on the City's streaming platforms, including Facebook, Twitter, and www.charlottesville.gov/streaming.

*Individuals with disabilities who require assistance or special arrangements to participate in the public meeting may call the ADA Coordinator at (434) 970-3182 or submit a request via email to ada@charlottesville.gov. The City of Charlottesville requests that you provide a 48-hour notice so that proper arrangements may be made.*

**Tree Commission**

**March 2022 Minutes**

**Date:** March 1, 2022

**Time:** 5:00PM – 7:00PM

**Location:** Remotely via Zoom meeting

**Attending:** Jeffrey Aten, Peggy Van Yahres, Mark Zollinhofter, Jean Umiker-Sebeok, Tim Padalino, Jody Lahendro, Victoria Metcalf, Brian Menard, Mark Rylander

**Absent:** (none)

**Staff:** Riaan Anthony, Chris Gensic (P/T)

The meeting was called to order at 5:05 p.m. by Peggy Van Yahres.

1. **February Minutes** were approved. (Motion by Aten, second by Padalino)

2. **Staff Report** by Riaan Anthony (RA)

- **Urban Forester position**: Candidate has signed the offer letter and will start April 11th. Will meet with TC leadership and then attend May TC meeting.
- **Tree Planting**: Parks & Rec has proceeded with planting- with 132 trees planted so far and contractor expects to be complete next week. Vendor has noted some challenging interaction with residents, particularly with trees adjacent to Right of Way (ROW) where some residents have been surprised or request different species. Typical protocol involves flagging locations in October with species type and Urban Forester's phone number. RA asked TC for ideas to better inform neighbors. Possibly door hang tags or press release. Jean suggested contacts with neighborhood associations. Peggy noted importance of communicating reasons behind City's Tree List. Brian noted one of TC functions is to educate public in this regard.
- **Canopy Study**: RA has transmitted comments back to Consultant. Hopes to have edited study back by end of March and will then post on website.
- **Mall Tree Study**: Once we get the new Urban Forester, we can begin to look into this RFP.
- **TC Zoom Meetings:** RA explained that due to limited staff TC is allotted two zoom meetings per month.

3. Report on **Tree Commission's Annual Presentation to City Council:**

Brian Menard and Peggy Van Yahres co presented to Council on February 22nd. The presentation well received, eliciting interest and discussion from Councilors. The presentation, in powerpoint form, followed the basic outline of the State of the Urban Forest report distributed to TC and link will be shared with Commissioners soon.

Loss of trees in Phase 1 of Friendship Court was discussed. James Freas, new Director of Neighborhood Development Services (NDS) said he will seek to retain the street trees in plans for subsequent phases.

Since TC mission is to advise City Staff, Council, and Planning Commission, it was proposed that the presentation also be made to the Planning Commission.

4. **Public Utilities guest speaker Irene Peterson** has been scheduled for April meeting and will not present at March meeting.

**COMMITTEE REPORTS**

5. Education & Advocacy (Mark R.)

- Mark plans to attend March 21 Council meeting to Advocate for $100k Tree Planting budget and $105K Emerald Ash Borer line item.
- Peggy provided and update of ReLeaf program efforts including upcoming Environmental Career Fair at CHS on April 21 from 1-2 pm. Jeff Aten and Paul Josey will also participate. ReLeaf is developing handouts.
- There was a brief discussion of TC process evaluating requests to partner with other community organizations. Mark R. to follow up with Peggy.

6. Arbor (Jeff A.)

- April 29th develop press release
- CATS event at the American Elm at Sojourners church in Belmont. A request to bring the tree under the Tree Conservation Ordinance would require signed approval from the Church since it is on private property. TC and Urban Forester will follow up if church representatives come forward with a proposal so that the nomination can be included in one of the semi-annual nominations submitted to Council.

7. Codes & Practices (Vicky)

- Committee members include Jeff P., Tim, Brian, Paul Josey (advisor), Keith Prichard (advisor). Plans to schedule mid-March committee meeting on Zoom which will partly be used to prepare for the April meeting with Public Works and NDS representatives.
- Vicky noted general and specific goals of the committee including ways that increasing tree canopy can be baked into the code, engagement with Site Plan Review, enforcement of violations,
- Charlottesville Plans Together meeting March 2. Steering Committee and consultant will issue a “Diagnostic Report” from code review in April to be reviewed by public. After receiving input, next report will outline an “Approach”
- Mark R. suggested the Code refer to Streets That Work Report to establish a minimum overall street section width between buildings in critical downtown areas, below which would require

setbacks. Propose code language to consultant. Brian agreed that the language of the code is the place to start. Details are important.

- Jody added that the Committee needs to identify areas whether Utility placement is constrained by the code to allow for tree placement. Unclear whether there are ANY limitations on utilities.

8. Public Comment: None

9. Peggy reported on the ongoing search to fill vacant seats on the Commission

10. Brian's tenure on the Tree Commission has ended and he was thanked for leadership and contributions to the commission. Commissioners praised Brian's commitment, insight, clear communication, and management skills- helping us to work productively with the city and as an organization. Peggy presented Brian with a parting gift of a handcrafted Mulberry burl bowl.

The meeting was adjourned at 6:30 PM

URBAN TREE CANOPY

# ASSESSMENT

CHARLOTTESVILLE, VIRGINIA

MARCH | 2022

PLANIT GEO
mapping a greener future

# AN ASSESSMENT OF URBAN TREE CANOPY IN CHARLOTTESVILLE, VIRGINIA

**It's the little things citizens do.**

**That's what will make the difference.**

**My little thing is planting trees.**

**-Wangaari Mathai**


**PREPARED BY**
PlanIT Geo, Inc., Arvada, Colorado


**PREPARED FOR**
City of Charlottesville, Virginia


**COMPLETED**
January 2022

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# CONTENTS

**2,771**
**ACRES OF CANOPY**

**40%**
**OF CHARLOTTESVILLE WAS COVERED BY TREE CANOPY IN 2018**

# EXECUTIVE SUMMARY

The urban forest in Charlottesville is a valuable asset providing residents and visitors with many environmental, social, and economic benefits. This assessment mapped urban tree canopy (UTC), possible planting area (PPA), and tree canopy changes from 2014 to 2018 and analyzed how they are distributed throughout the City and its property ownership, parcels, planning neighborhoods, and right-of-way.

## PROJECT METHODOLOGY

The results, based on 2018 and 2014 imagery from the USDA's National Agriculture Imagery Program (NAIP), provide a current and historical look at land cover in Charlottesville and will allow the City to revise and develop existing and new strategies to protect and expand the urban forest. A prior land cover assessment (2014) used 2014 NAIP aerial imagery and object-based image analysis techniques to map and calculate tree canopy and land cover metrics.

However, this study used modern machine learning techniques to create land cover data that are more reproducible and will allow for a more even comparison the next time tree canopy and land cover are assessed.. A point-based analysis was also used to assess the canopy levels from the years 1974 and 1957.

## CHARLOTTESVILLE'S URBAN FOREST

In 2018, Charlottesville had 40% urban tree canopy cover and 22% possible planting area, not including any surface water bodies within the city. The City's total land cover contained 40% tree canopy, 23% non-canopy vegetation; 1% soil/dry vegetation; 36% impervious surfaces, and >1% water. The 2,771 acres of tree canopy in Charlottesville provide a multitude of economic, environmental, and social benefits, valued at just under $15 million annually.

Of the 19 planning neighborhoods in Charlottesville, Barracks/Rugby had the highest canopy coverage at 58%. However, the Greenbrier neighborhood contained the most canopy, overall, containing 427 acres or 15% of all canopy in the City. The Ridge Street neighborhood contained the greatest potential for canopy expansion, offering 188 acres (26% PPA by area and 12% of the City's total plantable space).

## URBAN TREE CANOPY CHANGE

Results from the 2014 assessment indicated there was 45% tree canopy cover in Charlottesville in 2014. This study found that canopy cover changed from 45 to 40% from 2014 to 2018 (-5% or 381 acres) using the current city boundary. Private lands saw a 7% decrease while canopy on public lands decreased in canopy by 3%. Canopy cover within the CRHA (Charlottesville Redevelopment and Housing Authority) decreased by 5%. The overall decrease is due, in part, to the City's stream restoration and Meadow Creek Interceptor projects, as well as development within several neighborhoods throughout the City. Parcels included in the stream line restoration area lost 3% canopy cover.

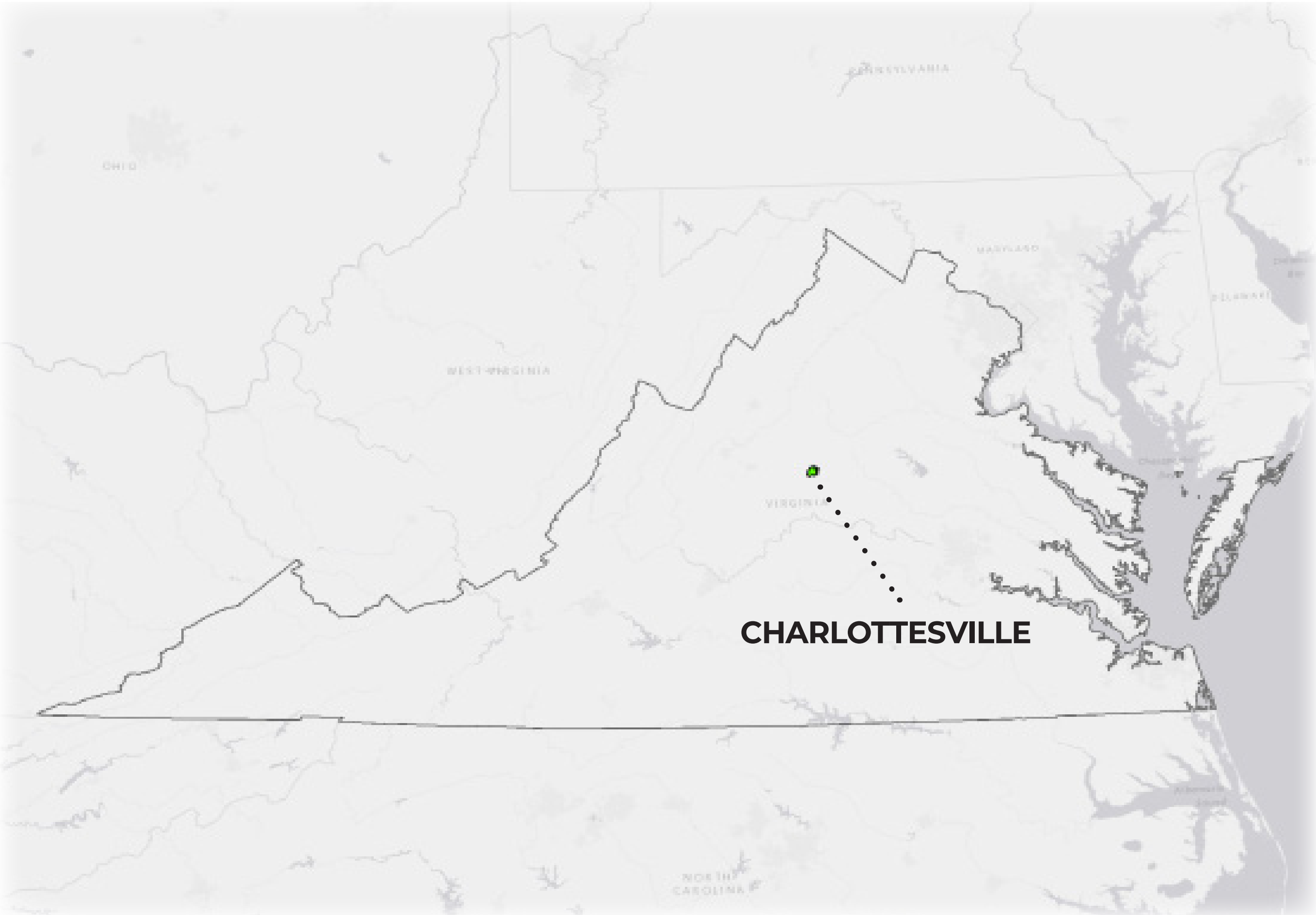



**Figure 1. Charlottesville occupies approximately 10 square miles in central Virginia.**

## PUTTING THE DATA TO WORK

The results of this analysis can be used to develop plans to protect and expand the urban forest in Charlottesville. The UTC and PPA maps and data in this report can be used as a guide to determine where the City has been successful in protecting and expanding its urban forest while also targeting areas to concentrate future efforts based on needs, benefits, and available planting space. Charlottesville can use these results to ensure that their urban forest policies and management practices continue to prioritize its maintenance, health, and growth.


**Figure 2. Based on an analysis of 2018 high-resolution imagery, Charlottesville contains 40% tree canopy, 22% areas that could support canopy in the future, and 36% total impervious areas.**

# PROJECT METHODOLOGY

Land cover, urban tree canopy, and possible planting areas were mapped using the sources and methods described below. These data sets provide the foundation for the metrics reported at the selected geographic assessment scales.

## DATA SOURCES

This assessment utilized high-resolution (60-centimeter) multispectral imagery from the U.S. Department of Agriculture's National Agriculture Imagery Program (NAIP) collected in 2018 to derive the land cover data set. The NAIP imagery was used to classify all types of land cover.

## MAPPING LAND COVER

The land cover data set is the most fundamental component of an urban tree canopy assessment. Tree canopy and land cover data from the EarthDefine US Tree Map (https://www.earthdefine.com/treemap/) provided a five class land cover data set. The US Tree Map is produced using a modern machine learning technique to extract tree canopy cover and other land cover types from the latest available 2018 NAIP imagery. These five classes are shown in Figure 3 and described in the Glossary on page 24.

URBAN TREE CANOPY | OTHER VEGETATION | SOIL AND DRY VEGETATION | IMPERVIOUS SURFACES | SURFACE WATER

**Figure 3. Five (5) distinct land cover classes were identified in the 2018 tree canopy assessment: urban tree canopy, other non-canopy vegetation, bare soil and dry vegetation, impervious (paved) surfaces, and water.**

## CLASSIFYING URBAN TREE CANOPY

The EarthDefine US Tree Map was then used as a mask to extract generalized tree species composition using a Normalized Difference Vegetation Index (NDVI), supervised training, and an iterative machine learning approach. Generalized tree species composition mapping was performed at a scale to classify larger groves of trees but not individual trees. There were no accuracy standards required or assessed for this classification.

## IDENTIFYING POSSIBLE PLANTING AREAS AND UNSUITABLE AREAS FOR PLANTING

In addition to quantifying Charlottesville's existing tree canopy cover, another metric of interest in this assessment was the area where tree canopy could be expanded. To assess this, all land area in Charlottesville that was not existing tree canopy coverage was classified as either possible planting area (PPA) or unsuitable for planting.

Possible planting areas were derived from the non-canopy vegetation layer. Unsuitable areas, or areas where it was not feasible to plant trees due to biophysical or land use restraints (e.g. golf course playing areas, recreation fields, utility corridors, etc.) were manually delineated and overlaid with the existing land cover data set (Figure 4 on the next page).

Other PPA and planting site exclusions included varying width buffers around railroad right-of-way, existing trees and buildings, recent tree plantings, overhead and underground utilities, alleyways, and the Meadow Creek Interceptor. The final results were reported as PPA Vegetation, Unsuitable Vegetation, Unsuitable Impervious, Unsuitable Soil, and Water.

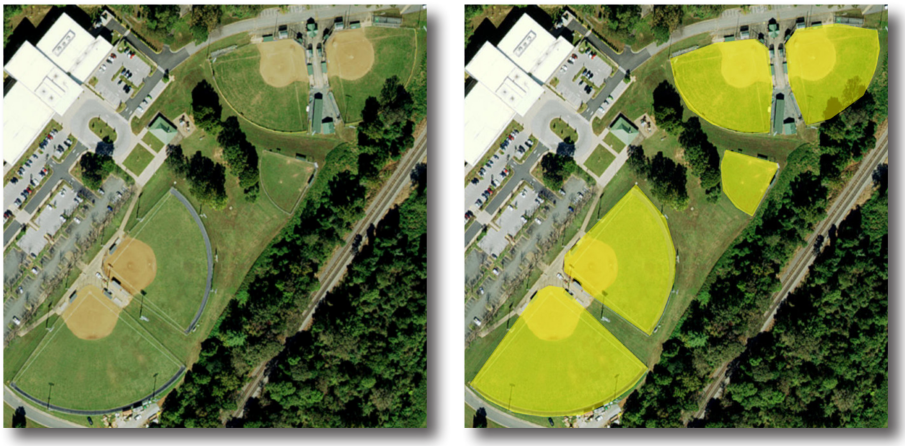


**Figure 4.**
**Vegetated areas where it would be biophysically feasible for tree plantings but undesirable based on their current usage (left) were delineated in the data as "Unsuitable" (right). These areas included recreational sports fields, golf courses, and other open space.**

## URBAN TREE CANOPY CHANGE ANALYSIS

Tree canopy change between 2014 and 2018 was also analyzed across the same geographic assessment boundaries described in the previous section. The City hired PlanIT Geo in 2015 to perform a tree canopy assessment using 2014 NAIP aerial imagery. Results from that assessment indicated there was 45% tree canopy cover in Charlottesville at the time. To measure the changes that have occurred since then, the City decided to re-assess canopy and land cover data using 2018 NAIP imagery and a more modern and repeatable mapping technique that takes advantage of recent technological advancements in artificial intelligence, computer vision, and machine learning.

Urban tree canopy change was also assessed for the years 1957 and 1974 using a point-based analysis. This involved the use of 1,600 randomly distributed points to identify the presence or absence of canopy in both years using historical imagery obtained from the University of Virginia Library. Percent UTC cover was derived based on the total canopy points compared to non-canopy points, and change was assessed by the difference in canopy percentages. This technique yielded a 1.2% standard error in the UTC estimates for both 1957 and 1974.

## URBAN HEAT MAP OVERLAY

Pre-existing urban heat island data from the Trust for Public Land was used to identify local hotspots where tree plantings can be focused to help cool hotter areas in the city. This heat map data set was created using the thermal band of a Landsat 8 satellite image collected in the summer of 2018 and 2019. The mean surface temperature within the City was calculated. Areas that are 1.25 F° or greater than the citywide average were then categorized from low to high severity based on a Jenks Natural Breaks classification scheme. Planting sites were created within a refined version of the PPA classification which removed utilities, railroad right of-way, and existing & recently planted trees. Each site was then assigned a value based on the heat severity of where the point was located. The average severity at the planning neighborhood scale was then calculated and correlated with tree canopy cover to identify areas that could benefit from the cooling shade that additional trees can provide.

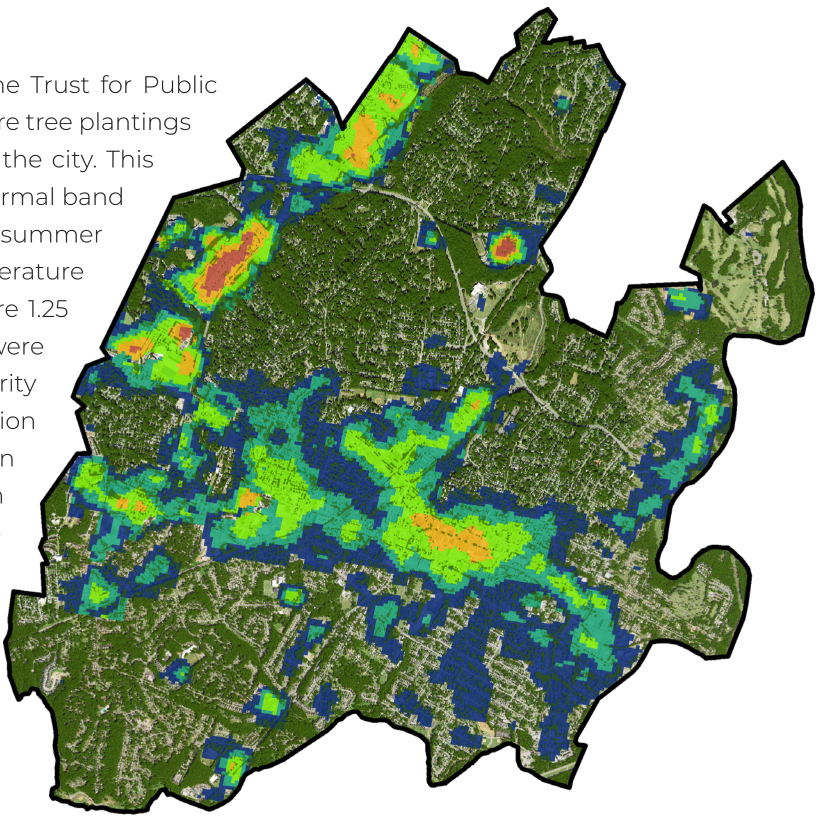
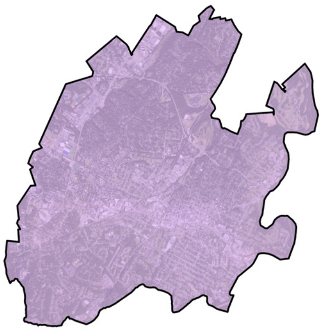


**Figure 5. Trust for Public Land urban heat island severity.**

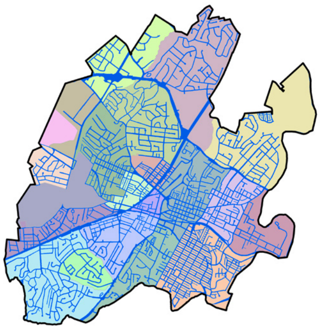
## DEFINING ASSESSMENT LEVELS

In order to best inform the City of Charlottesville's various stakeholders, urban tree canopy and other associated metrics were tabulated across a variety of geographic boundaries. These boundaries include the city boundary, property ownership, planning neighborhoods, right-of-way (citywide and within each planning neighborhood), and parcels..



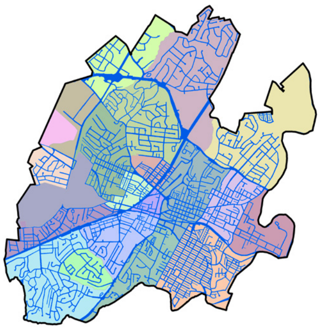
### City Boundary

The City of Charlottesville **citywide boundary** is the one (1) main area of interest over which all metrics are summarized.



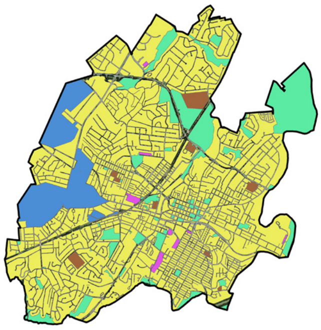
### Planning Neighborhoods

**Planning Neighborhoods** include twenty one (21) areas for which the UTC results were summarized. This reflects the 19 Planning Neighborhoods of Charlottesville plus two remaining areas within the University of Virginia campus. While the UVA areas are not within the purview of the City to implement change, they were included since they are within the City limit.



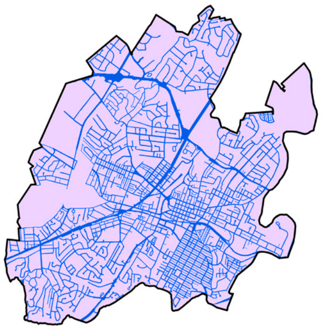
### Right-of-Way by Planning Neighborhoods

**Right-of-Way by Planning Neighborhoods** further dissects the ROW areas by each of the twenty one Planning Neighborhoods so the City can get a better idea of where to focus efforts within the publicly managed land across these different boundaries.



### Property Ownership

**Property ownership** summarizes parcels by ownership type, including schools, city-owned parcels, University of Virginia (UVA) campus property, Charlottesville Redevelopment & Housing Authority (CRHA), and privately owned lands. This allows for the distinction between public and private property, in addition to right-of-way.



### Right-of-Way

**Right-of-Way (ROW)** reports the UTC results within ROW for the entire city, identified as any area not covered by parcels. It should be noted that not all space identified by this study as ROW is city-owned. Some of the area is private alleys and others may be VDOT or railroad company controlled which may limit potential planting area.

### Parcels

The smallest unit of analysis was **parcels**, of which there were over thirteen thousand (13,937) in total. This unit is helpful for assessing the canopy on an individual piece of property.

# STATE OF THE CANOPY AND KEY FINDINGS

The results and key findings of this study, including the tree canopy cover map and canopy analysis results, are presented below. These results can be used to design a strategic approach to identifying existing canopy and future planting areas. Land cover percentages are based on the total area of interest while urban tree canopy, possible planting area, and unsuitable percentages are based on land area. Water bodies are excluded from land area because they are typically unsuitable for planting new trees without significant modification.

**Table 1. Land cover classes in acres and percent in the City of Charlottesville.**

| City of Charlottesville | Acres | % of Total |
|---|---|---|
| **City Boundary** | 7,006 | 100% |
| **Tree Canopy** | 2,771 | 40% |
| **Non-Canopy Vegetation** | 1,610 | 23% |
| **Impervious Surfaces** | 2,512 | 36% |
| **Soil & Dry Vegetation** | 86 | 1% |
| **Water** | 26 | <1% |

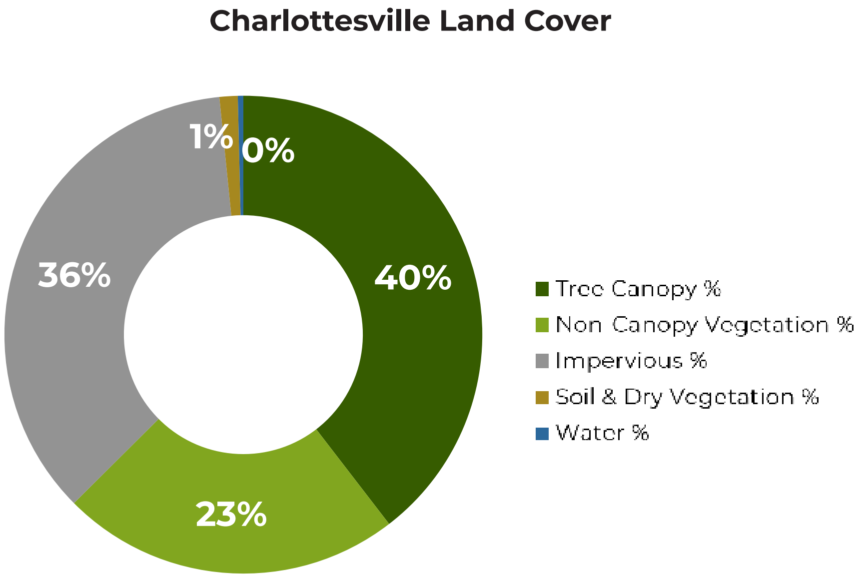
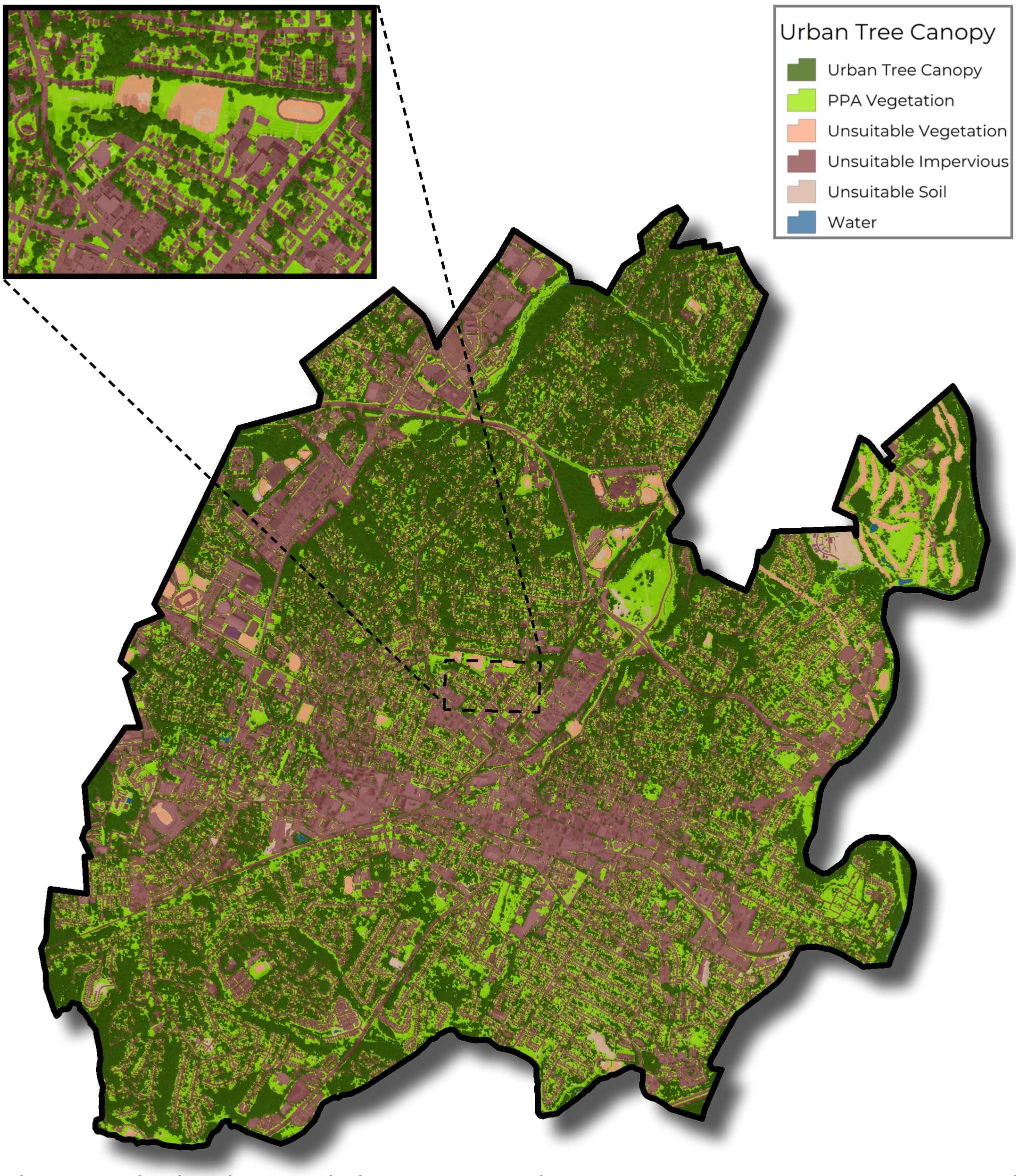



**Figure 6. Land cover classes in percent of total area in Charlottesville, VA.**

## CITYWIDE URBAN TREE CANOPY

This urban tree canopy assessment utilized the land cover data as a foundation to determine possible planting areas throughout the City. Additional layers and areas to be excluded from plantable space were also incorporated into the analysis (e.g., 30 ft. buffer around the Meadow Creek Interceptor sewer line project). Note that the results of this study are based on land area, which excludes water bodies, as opposed to total area, which includes water bodies. Results of this study indicate that within the City of Charlottesville, 2,771 acres are covered with urban tree canopy, making up 40% of the City's 6,980 land acres; 1,505 acres are covered with other vegetation where it would be possible to plant trees (PPA), making up 22% of the City; and the other 2,716 acres were considered unsuitable for tree planting, making up 39% of the City. The unsuitable areas (other than PPA exclusions) include recreational sports fields, golf course playing areas, utility corridors, and impervious surfaces.

In addition to the total amounts of urban tree canopy and possible planting areas contained within each boundary by acres and percent, the City was also interested in the distribution of where it is located throughout the City's total area. Since land ownership plays a large role in the management actions the City can take, UTC and PPA distribution were evaluated by type of land (City-owned, private, Charlottesville Redevelopment & Housing Authority (CRHA), schools, and University of Virginia property). Total area was also evaluated by planning neighborhoods for further analysis into the City's important managed areas.




Currently, 1,896 acres of Charlottesville's urban tree canopy is found on privately owned property, accounting for 76% of all of the City's UTC. Overall, private property in Charlottesville contains 43% UTC, and City-owned property has 49% UTC.

Similarly, private land contains 75% of all PPA, 17% is found on City-owned property, and just 1% on CRHA property. Schools and University of Virginia property contained 27% and 35% UTC, respectively, with schools having 25% possible planting area (or 2% of the overall PPA in the City) and University of Virginia having 16% (or 6% overall PPA).

**Figure 7. Distribution of existing and potential urban tree canopy throughout the City boundary.**

The city's 2,771 acres of urban tree canopy were further divided into subcategories based on whether their canopy had an impervious or pervious understory. Tree canopy overhanging an impervious surface can provide many benefits through ecosystem services such as localized cooling provided by shading of impervious surfaces and increased stormwater absorption. Results indicated that Charlottesville's UTC was predominantly overhanging pervious understory at 87%, while 13% is overhanging impervious surfaces.

**Table 2. Urban tree canopy assessment results by acres and percent. (Percentages based on land acres.)**

| City of Charlottesville | Acres | % |
|---|---|---|
| **Total Area** | 7,006 | 100% |
| **Land Area** | 6,980 | 99% |
| **Urban Tree Canopy** | 2,771 | 40% |
| **Total Possible Planting Area** | 1,505 | 22% |
| **Total Unsuitable Area** | 2,716 | 39% |

**Table 3. Detailed urban tree canopy classifications.**

| City of Charlottesville | Acres | % |
|---|---|---|
| **Overhanging Pervious Surfaces** | 2,425 | 87% |
| **Overhanging Impervious Surfaces** | 347 | 13% |
| **Totals** | **2,771** | **100%** |

**Charlottesville Urban Tree Canopy Potential**

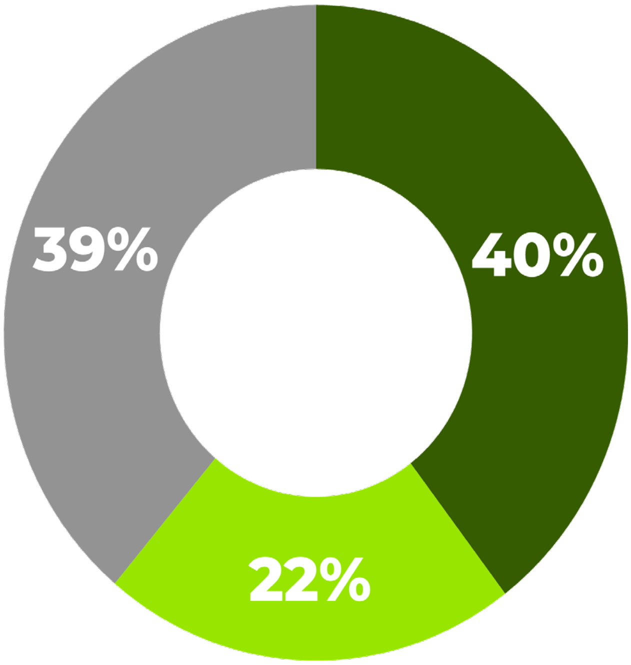



**Figure 8. Urban tree canopy, possible planting area, and area unsuitable for UTC in the City of Charlottesville.**

## CITYWIDE URBAN TREE CANOPY CHANGE

There was a decrease in Charlottesville's tree canopy over the four-year study period. Tree canopy decreased by approximately 380 acres citywide, yielding a 5% raw decrease (12% relative to 2014 acreage) since 2014. This decrease in canopy can be attributed to development of certain areas around the City as well as stream restoration projects around the City and the Meadow Creek Interceptor sewer line project. Reforestation efforts associated with the project have yet to be measured and will appear in future assessments Although there was an overall decrease in canopy, further analysis revealed that there were also some small increases in certain parcels. The increase in tree canopy in Charlottesville can be attributed to crown growth of maturing trees and growth of newly planted trees since 2014.

Current levels of urban tree canopy in Charlottesville can be maintained with careful planning and planting efforts. Charlottesville's urban forest includes many large-stature mature trees which may eventually succumb to old age, stress, and other environmental factors. It is important that the City continue to plant tree species which have potential to reach a large stature. These will eventually replace current large-stature trees, help to maintain and grow current canopy levels and, the valuable ecosystem services provided. The City also contains thousands of smaller trees which must be cared for and maintained properly by the respective entity to ensure crown growth and maturity.

Using the point-based urban tree canopy change analysis, it was determined that the percentage of urban tree canopy from the years 1957 and 1974 were 45% and 29%, respectively. This shows that from 1957 to 2018 there was a 5% decrease in canopy and an 11% increase from 1974. Canopy levels showed to have been the same in 1957 as in 2014, at 45% UTC. To deter from a downward trend in canopy coverage, Charlottesville should focus on the possible planting areas in areas where the most canopy has been lost.

## URBAN TREE CANOPY BY PLANNING NEIGHBORHOODS

UTC and PPA were assessed in Charlottesville's 21 planning neighborhoods. This reflects the 19 Planning Neighborhoods of Charlottesville plus two remaining areas within the University of Virginia (UVA) campus. While the UVA areas are not within the purview of the City to implement change, they were included since they are within the City limit and identified as UVA1 and UVA 2 to be consistent with the 2014 urban canopy assessment. The planning neighborhood with the highest UTC percent was the Barracks/Rugby neighborhoods at 58% UTC, while the lowest was Star Hill with 14% UTC. Possible planting area was highest in the Ridge Street and Woolen Hills neighborhoods which both contained 31% PPA, with the next highest being Belmont at 28%.

## URBAN TREE CANOPY BY RIGHT-OF-WAY BY PLANNING NEIGHBORHOODS

The right-of-way (ROW) by planning neighborhood boundaries was also assessed for UTC and PPA. UTC in the ROW was shown to be relatively evenly distributed throughout the City. UVA1 and UVA2 were not included in the ROW analysis. Out of the 19 neighborhoods, Barracks/Rugby also had the highest UTC in the ROW at 20%, while Barracks Road had the lowest at 4%. The Belmont neighborhood contained the highest PPA at 11% which accounts for 16% of all PPA in the ROW. Barracks Road, the neighborhood with the lowest UTC, also contained 11% PPA within its ROW.

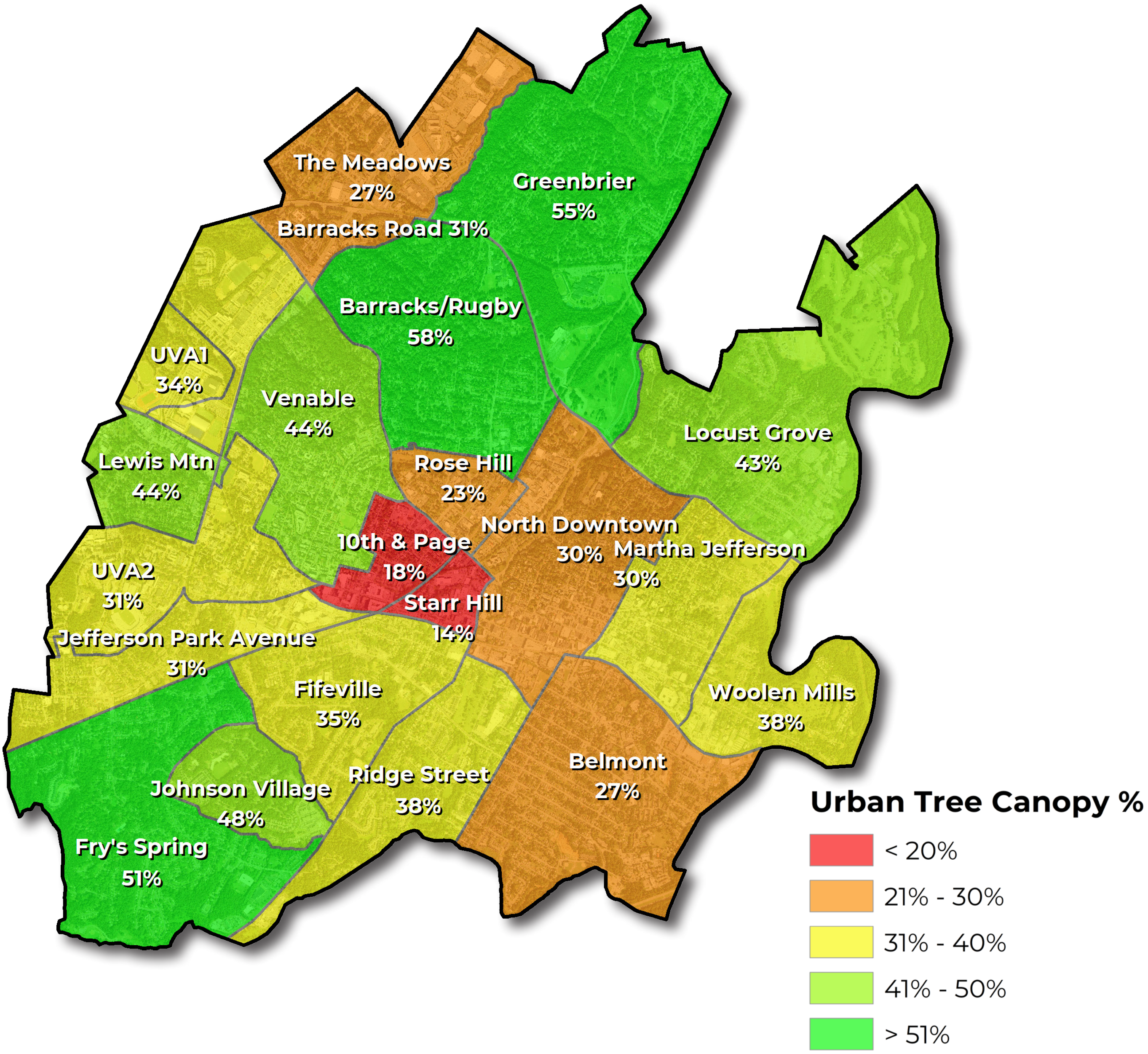



**Figure 9. Urban tree canopy in Charlottesville's planning neighborhoods.**

## CANOPY CHANGE BY PLANNING NEIGHBORHOODS

Along with the decrease in overall city-wide canopy, planning neighborhoods also had a decrease in canopy. All 21 of the planning neighborhoods within Charlottesville had a small to moderate decrease in canopy. From 2014-2018, UTC in most planning neighborhoods decreased between 1 and 8%. The planning neighborhood with the largest amount of land area, Belmont, had a decrease in canopy of 10%, with Johnson Village having the largest decrease of 12%.

## CANOPY CHANGE BY RIGHT-OF-WAY BY PLANNING NEIGHBORHOODS

The ROW in 18 of the 21 neighborhoods had decreases in canopy of between 1 and 7%. Three neighborhoods' ROW in the City had small increases in canopy; 10th & Page, Star Hill, and Venable at 2%, 2%, and 1%, respectively. Johnson Village ROW had the largest decrease in canopy at 7%, followed by Belmont and Woolen Mills at 6%. In the ROW, it will be especially important to plant in areas with the lowest UTC and highest amount of PPA due to the limited space available.

**Table 4. Total urban tree canopy, right-of-way tree canopy, and tree canopy change from 2014-2018 in Charlottesville's Planning Neighborhoods.**

| Planning Neighborhoods | UTC % | ROW UTC % | UTC % Change |
|---|---|---|---|
| 10th & Page | 18% | 9% | -1% |
| Barracks Road | 31% | 20% | -1% |
| Barracks/Rugby | 58% | 4% | -7% |
| Belmont | 27% | 12% | -10% |
| Fifeville | 35% | 10% | -9% |
| Fry's Spring | 51% | 15% | -8% |
| Greenbrier | 55% | 16% | -3% |
| Jefferson Park Avenue | 31% | 12% | -6% |
| Johnson Village | 48% | 7% | -12% |
| Lewis Mtn | 44% | 8% | -3% |
| Locust Grove | 43% | 10% | -8% |
| Martha Jefferson | 30% | 8% | -6% |
| North Downtown | 30% | 11% | -3% |
| Ridge Street | 38% | 9% | -8% |
| Rose Hill | 23% | 13% | -1% |
| Starr Hill | 14% | 10% | 0% |
| The Meadows | 27% | 12% | -1% |
| UVA1 | 34% | 0% | 0% |
| UVA2 | 31% | 5% | -2% |
| Venable | 44% | 10% | -2% |
| Woolen Mills | 38% | 12% | -7% |
| **City of Charlottesville** | **40%** | **12%** | **-5%** |

## URBAN TREE CANOPY BY PROPERTY OWNER

UTC and PPA were assessed across land ownership types including schools, city-owned parcels, University of Virginia (UVA) campus property, Charlottesville Redevelopment & Housing Authority (CRHA), and privately owned lands. UTC varied across the different land ownership types. City-owned property had 49% canopy coverage, while private property contained 43% UTC. University of Virginia property and CRHA both had 35% UTC while there was only 27% within the other school properties. PPA ranged from 16% on UVA property to 33% on CRHA property. Private properties contained 24% PPA , while City-owned property contained 30%. Private property makes up 75% of land area in Charlottesville and, thus, contained 1,896 acres or 75% of all UTC and 1,051 acres or 75% of all PPA in the City.

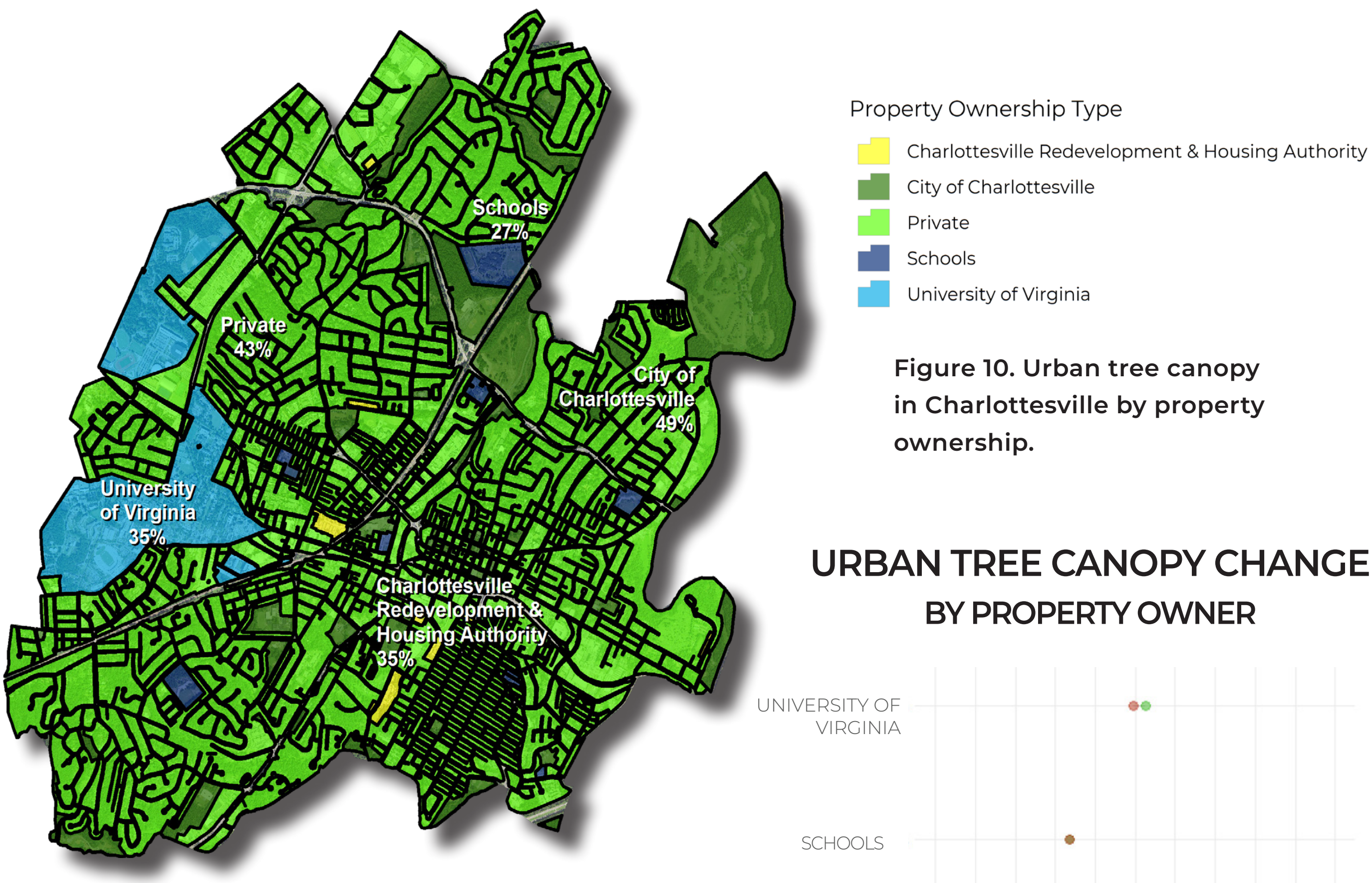



**Figure 10. Urban tree canopy in Charlottesville by property ownership.**

## CANOPY CHANGE BY PROPERTY OWNER

When UTC change since 2014 was assessed, private property ownership had a decrease of 305 acres, or 7%, of tree canopy from 2014 to 2018. The 7% decrease in canopy on private properties was the highest percentage decrease in land ownership types, with the second largest decrease being on CRHA property. The decrease in canopy in these two areas highlights the amount of development that has occurred in the City since 2014. City-owned property had a decrease in canopy of 27 acres or 3%, while University of Virginia and schools had decreases of 2% and <1%, respectively.

## URBAN TREE CANOPY CHANGE BY PROPERTY OWNER

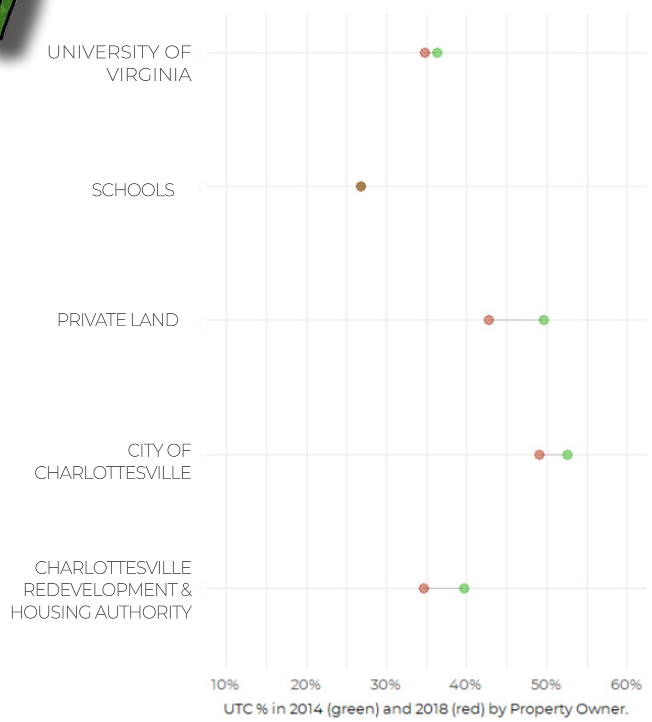
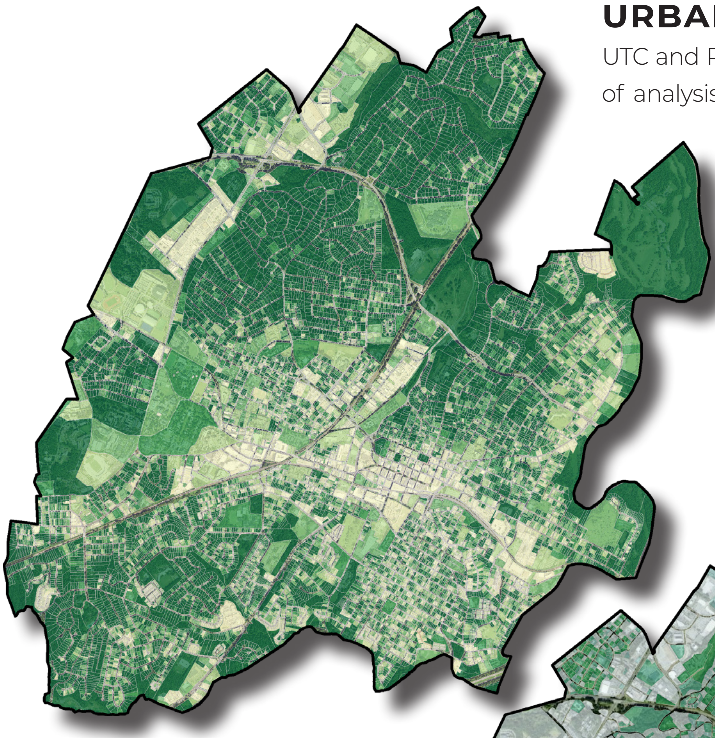
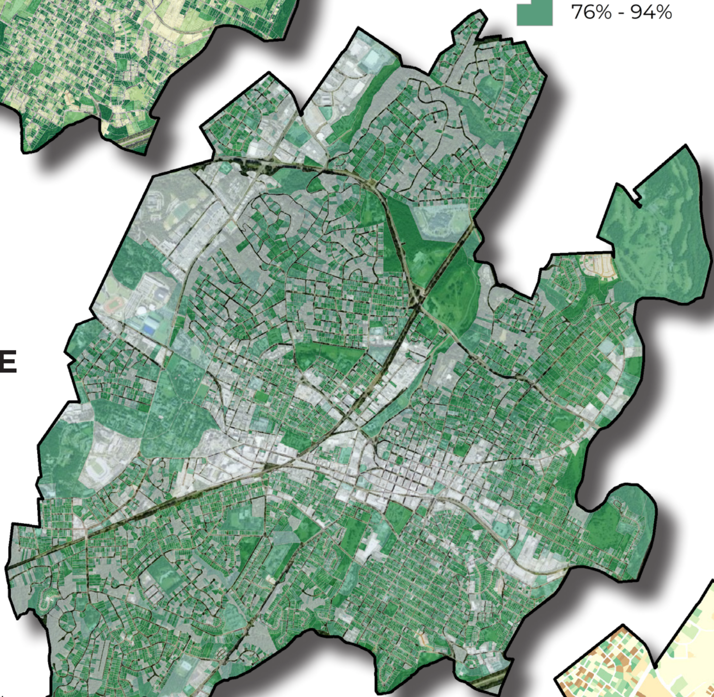



**Figure 11. Urban tree canopy change in Charlottesville by property ownership.**

## URBAN TREE CANOPY BY PARCELS

UTC and PPA were assessed by parcels, representing the smallest unit of analysis. Due to their small size, the parcel data were reported in square feet instead of acres. A 66% majority of parcels ranged from 0-50% UTC and 34% ranged from 50-100%. Parcels containing over 80% UTC represented 8% of all parcels. A 57% majority of parcels ranged from 0-30% PPA. Both PPA and UTC percentages varied significantly by parcels.




## CANOPY CHANGE BY PARCELS

In this smallest geographic scale used in this study, finer details on where specific changes are occurring are evident and best viewed in GIS desktop software or an interactive web mapping application such as TreePlotter CANOPY.

Tree canopy change within the 13,937 parcels, again, consisted of both losses and gains. Losses in canopy ranged from 1 to 100%, and gains in canopy also ranged from 1 to 100%. Just over 1,500 parcels had no or very little change in canopy coverage due to their small size and lack of trees in both 2014 and 2018.

Parcels within the boundaries of the Charlottesville stream restoration project were also evaluated for UTC change. Between 2014 and 2018, the six parcels included in the project, located in Greenbrier and Meadow Valley parks, lost 3% of their total UTC combined.

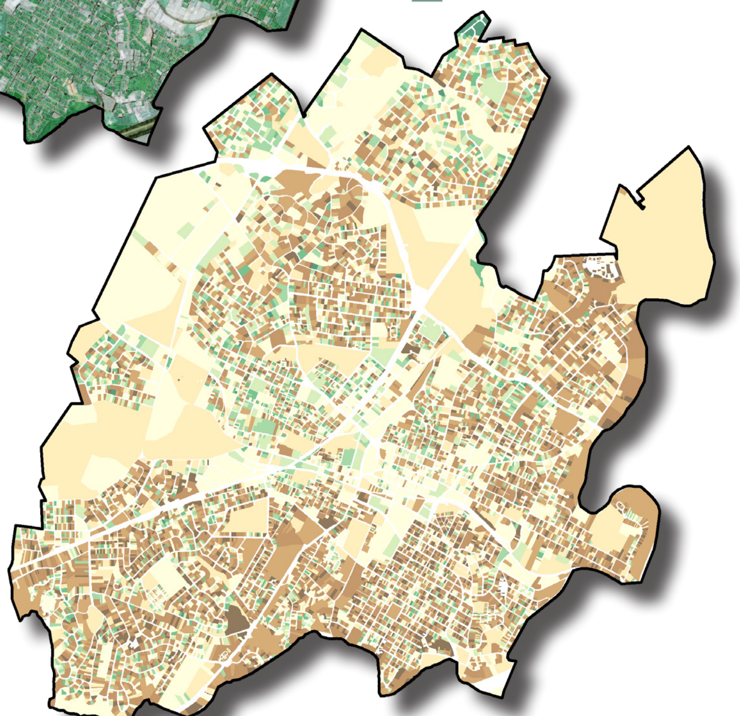



**Figure 12. Urban tree canopy, total plantable space, and canopy change percent by parcels.**

# ASSESSMENT OF ECOSYSTEM BENEFITS

Using the best available science from i-Tree tools, values were calculated for some of the benefits and functions provided by the urban tree canopy in Charlottesville. The urban forest holds millions of dollars of savings in avoided infrastructure costs, pollution reduction, and stored carbon. The following values were calculated using the USDA Forest Service's iTree Landscape tool with Charlottesville's total acres of urban tree canopy as the input data.

## AIR QUALITY

Trees produce oxygen, indirectly reduce pollution by lowering air temperature, and improve public health by reducing air pollutants which cause death and illness. The existing tree canopy in Charlottesville removes 170K pounds of air pollution annually, valued at over $600K.

## STORMWATER AND WATER QUALITY

Trees and forests mitigate stormwater runoff which minimizes flood risk, stabilizes soil, reduces sedimentation in streams and riparian land, and absorbs pollutants, thus improving water quality and habitats. The tree canopy in Charlottesville absorbs 44 million gallons of water per year. Extrapolated citywide, this means that Charlottesville's existing canopy provides over $395K annually in stormwater benefits.

## CARBON STORAGE AND SEQUESTRATION

Trees accumulate carbon in their biomass; with most species in a forest, the rate and amount increase with age. Charlottesville's trees store approximately 169 million pounds of carbon, valued at over $14 million, and each year the tree canopy absorbs and sequesters approximately 169 million pounds of carbon dioxide, valued at over $460K.

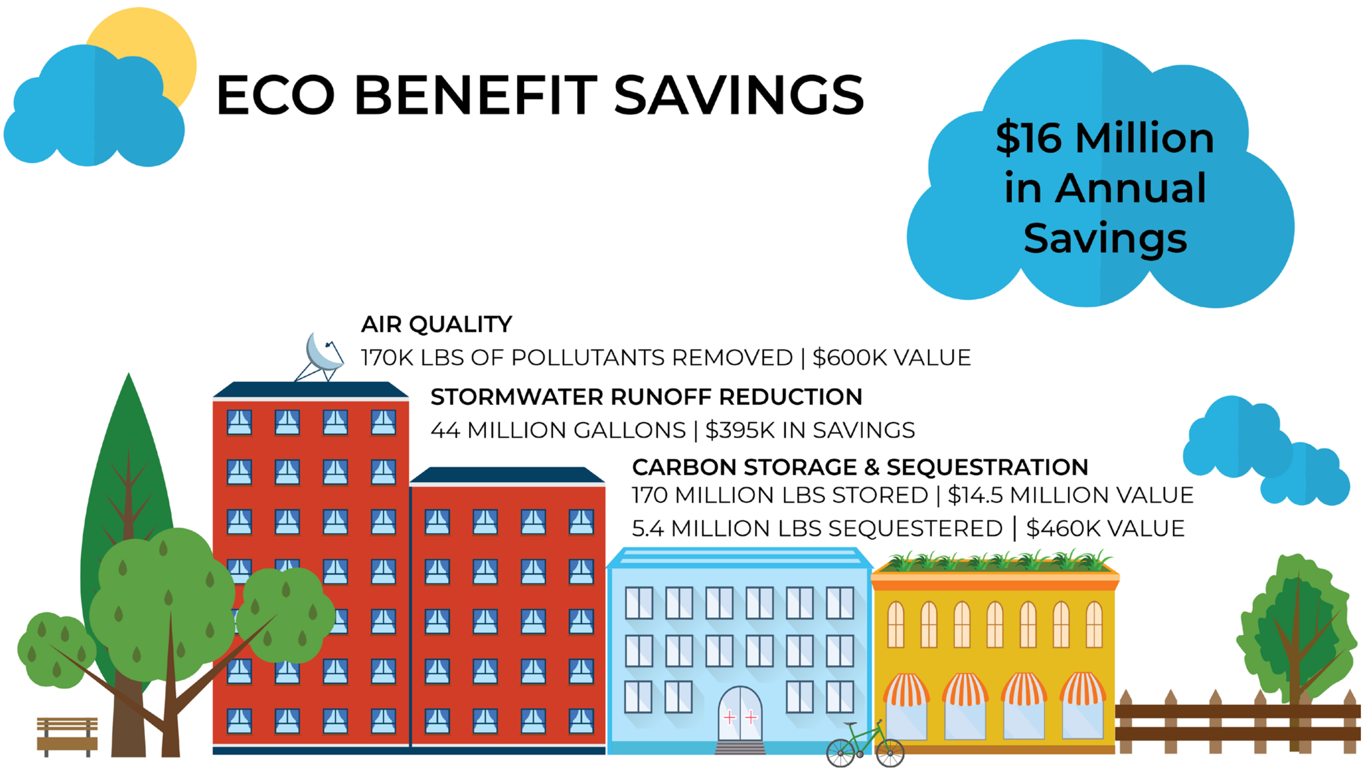



**Figure 13. Eco-benefits of Charlottesville's urban forest.**

**Table 5. Comparison of selected urban tree canopy benefits in Charlottesville in 2014 and 2018.**

| City of Charlottesville | *2014 Canopy* Amount (lbs) | Value ($) | *2018 Canopy* Amount (lbs) | Value ($) |
|---|---|---|---|---|
| **Carbon Monoxide** | 3,360 | $2,240 | 3,245 | $2,164 |
| **NO2** | 15,778 | $4,116 | 14,865 | $5,813 |
| **O3** | 143,144 | $133,405 | 133,416 | $224,216 |
| **PM2.5** | 5,850 | $213,824 | 4,741 | $345,149 |
| **SO2** | 5,736 | $287 | 5,594 | $469 |
| **PM10** | 30,977 | $97,088 | 24,990 | $78,327 |
| **CO2 Sequestration** | 30,190,551 | $548,109 | 22,218,800 | $516,744 |
| **Totals** | **30,395,396** | **$990,071** | **22,405,653** | **$1,172,882** |

## BENEFITS OF PUBLIC TREES

In addition to assessing the value of ecosystem services provided by Charlottesville's generalized complete urban forest, values were also calculated for (some of) its individual trees. This assessment was performed using the iTree Eco tool with the City's public tree inventory as the input data. By estimating the benefits that specific trees are contributing, the City can both determine the approximate proportion of its total benefits that are derived from the trees that it directly manages (e.g. the public tree population), and also determine which species are giving the greatest benefits compared to other trees to inform future planting efforts. The full results with specific values per-tree have been provided.

The assessment of the vegetation structure, function, and value of the Charlottesville's urban forest was conducted using the i-Tree Eco model developed by the U.S. Forest Service, Northern Research Station and yielded the following results:

- Most common species of trees: Flowering dogwood, Eastern red cedar, Eastern white pine
- Pollution Removal: 2.622 tons/year ($26.8 thousand/year)
- Carbon Storage: 4.438 thousand tons ($757 thousand)
- Carbon Sequestration: 97.73 tons ($16.7 thousand/year)
- Oxygen Production: 260.6 tons/year
- Avoided Runoff: 285.2 thousand cubic feet/year ($19.1 thousand/year)
- Replacement values: $29.1 million

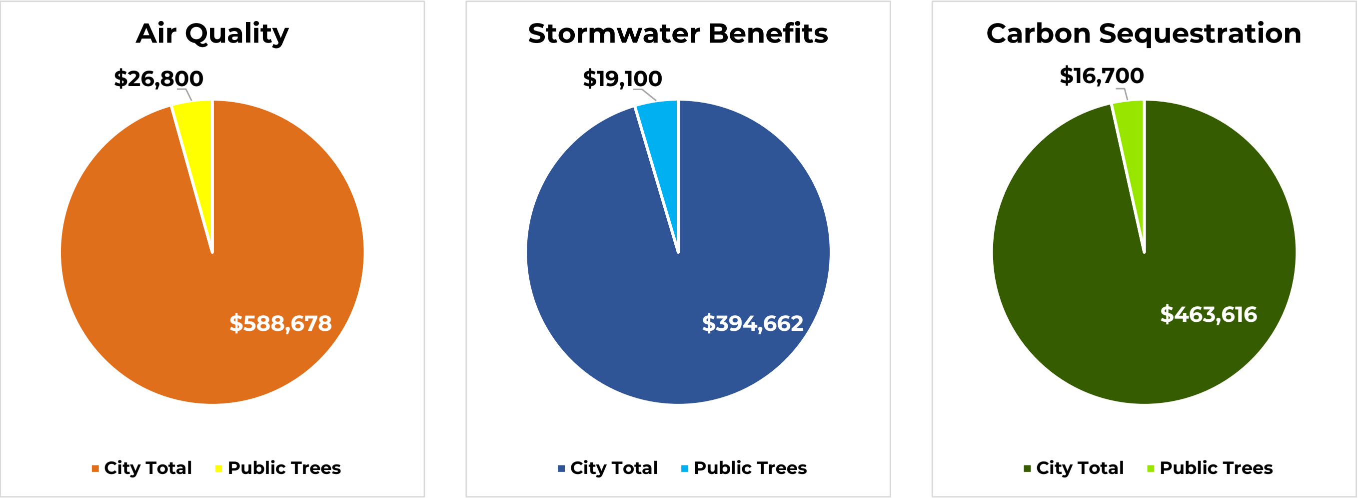



**Figure 14. Eco-benefits of Charlottesville's full urban forest and public tree population.**

# TREE PLANTING PRIORITIZATION

## PRIORITIZATION CRITERIA DESCRIPTIONS

Urban tree canopy provides a multitude of direct and indirect benefits. To provide the most complete understanding of where those benefits are lacking, tree planting priorities were identified based on environmental, socio-demographic, and public health data sets.

Tree planting prioritization ranking is needs-based and designed to rank each planning neighborhood based on each area's need for a particular benefit that trees can provide. Rankings are sorted from high (red) to low (green) and were calculated for each individual criteria as well as overall to show where multiple needs overlap. Viewing combined ranks show where tree canopy benefits can have the greatest impact by addressing multiple needs.

## SOCIO-DEMOGRAPHIC

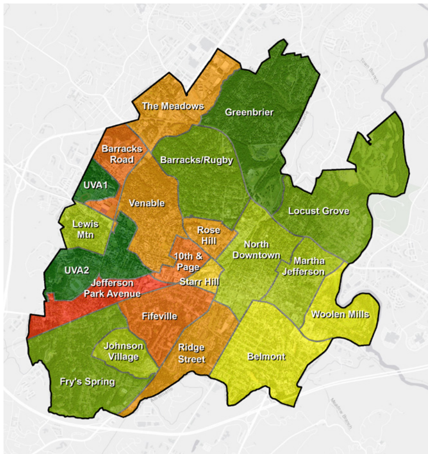
- **Population Below Poverty:** This indicator shows the percentage of residents living below the poverty level according to American Community Survey 2014-2019 5-year estimates

- **Public Property Ownership:** Possible planting area on City-owned, operated, or managed public and public/private land. Values equal the percentage of plantable space within public land within each geographic area.

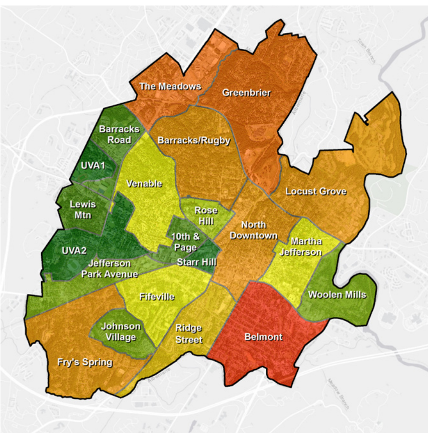
## ENVIRONMENTAL

- **Right-of-Way:** Trees planted along roads can have greater benefits to air quality and noise.

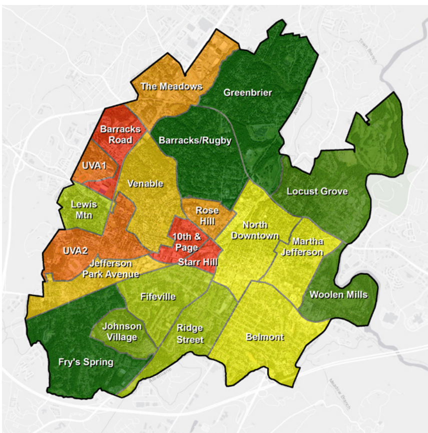
- **Urban Heat Island:** The average temperature value within each feature. Urban heat severity data from the Trust for Public Land derived using the thermal band of a Landsat 8 satellite image were used.



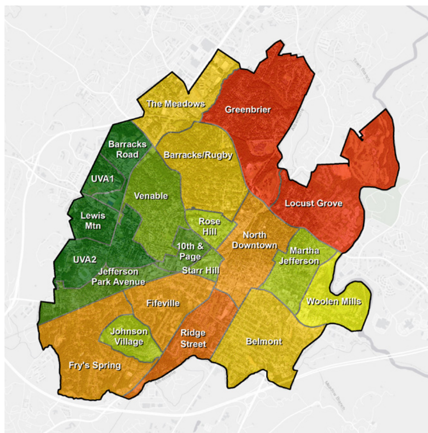

**Population Below Poverty**




**Right-of-Way**




**Urban Heat Island**




**Public Lands**

## Overall Tree Planting Priority by Planning Neighborhoods

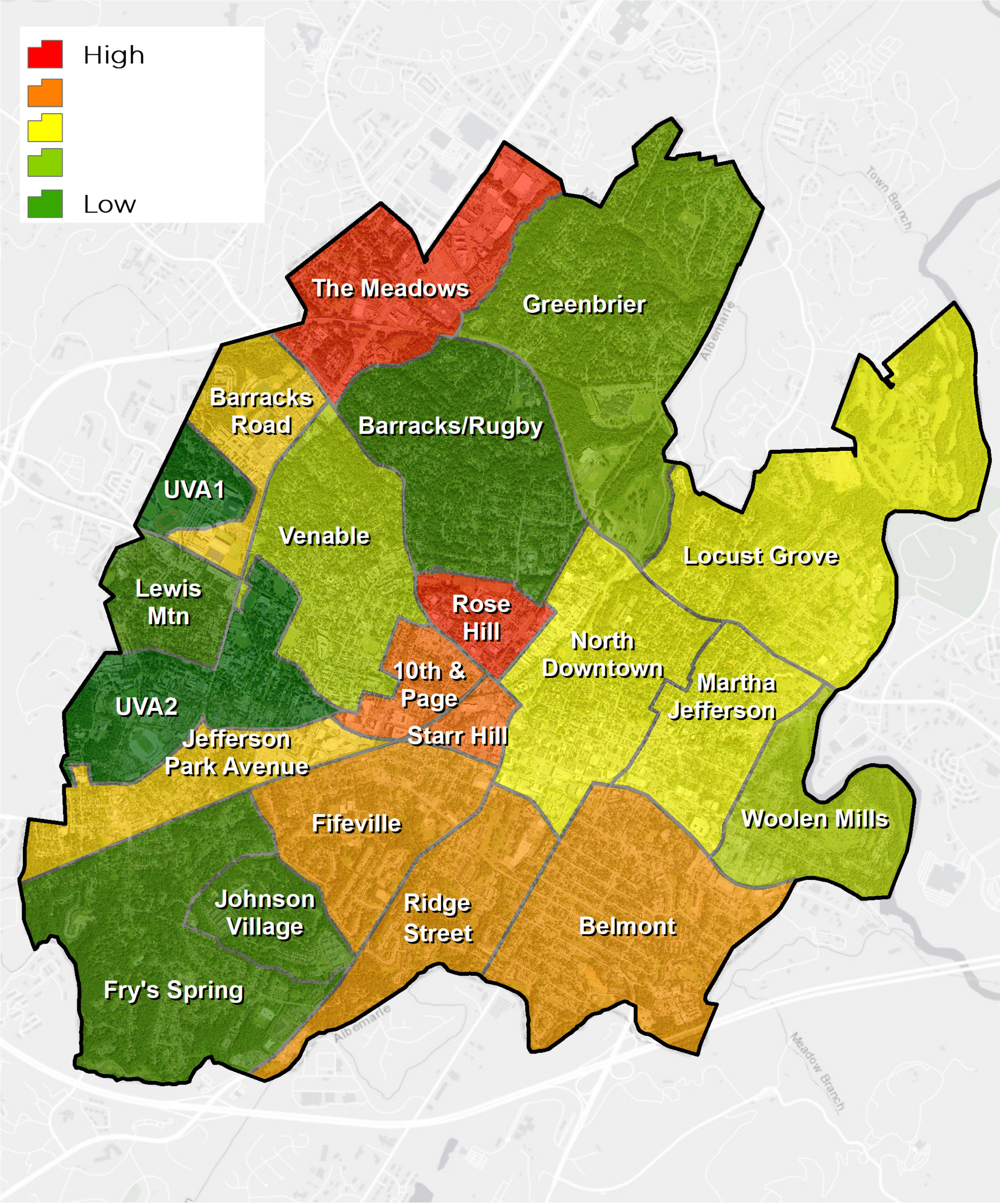



Figure 15. Combined planting prioritization by planning neighborhoods.

# CONCLUSIONS AND RECOMMENDATIONS

The City of Charlottesville has demonstrated that it values its natural resources and wants to maintain a healthy and sustainable urban environment. Recurring assessments of the City's tree canopy represent important steps in ensuring the long-term health of its urban forest. A greater percent of canopy cover can be achieved with proper planning, investment, and care of existing trees. The City should continue to monitor the health of the urban forest and implement the following recommendations to ensure the urban forest is considered during future city planning and development to sustain and enhance the benefits that trees provide to the community.

**Continue to monitor changes in the urban forest using regularly updated data**

To preserve, protect, and maintain Charlottesville's tree canopy, the City should continue to have a tree canopy assessment performed at regular intervals such as through TreePlotter CANOPY subscription or continuing regular projects. As the City grows, they will be able to use these data to ensure that their urban forest policies and management practices prioritize its maintenance, health, and growth. The City's urban forest provides Charlottesville with a wealth of environmental, social, and even economic benefits which relate back to greater community pride and interest in citywide initiatives and priorities. These results can be used to identify where existing tree canopy cover should be preserved, where there are opportunities to continue to expand the City's canopy cover, and which areas would receive the greatest benefits from the investment of valuable time and resources into Charlottesville's urban forest.

**1. Leverage the results of this assessment to promote the urban forest**

The results of this assessment should be used to encourage investment in urban forest monitoring, maintenance, and management; to prepare supportive information for local budget requests/grant applications; and to develop targeted presentations for city leaders, planners, engineers, resource managers, and the public on the functional benefits of trees in addressing environmental issues. The land cover, tree canopy, and urban tree canopy change data should be disseminated to diverse partners for urban forestry and other applications while the data are current and most useful for decision-making and implementation planning. The information from this study can help establish new canopy cover goals for the short- and long-term to continue to expand Charlottesville's urban forest to its known potential.

**2. Use the urban tree canopy change data to identify areas to prioritize canopy expansion**

The City and its various stakeholders can utilize the results of the UTC, PPA, and urban tree canopy change analyses to identify the best locations on City-owned and private property to focus future tree planting and canopy expansion efforts. Trees can play a large role in improving public health by improving air quality, reducing temperatures, and addressing climate change. The City can acquire parcels for public use as part of redeveloped neighborhoods to be used as carbon sinks to address community access to nature, climate, human health, and equity. Plantable space in the right-of-way is often found close to high concentrations of impervious surfaces. Focus on planting the right tree in the right place and planting large-species trees where appropriate to maximize ecosystem services. Results revealed that 17% of all plantable space in Charlottesville is found on City-owned property where the City often has direct management. Planting trees near impervious surfaces can offset the urban heat island effect, stormwater runoff, and energy consumption. The priority planting analysis should be used to identify planting opportunities adjacent to high concentrations of impervious surfaces in these areas. Results revealed that 9% of plantable space is in the right-of-way, adjacent to impervious surfaces. The City can develop a proactive street tree maintenance program to take on the responsibility of planting and managing street trees, ensuring healthy trees are distributed equitably across the city. Given the majority of tree loss was attributed to development, the City should evaluate city codes to increase tree preservation, create space for existing trees during the development process, and set aside space for new larger stature trees to be planted both on private property and within the public right-of-way to maximize the benefits of trees. It will also be important for the City to continue to replant and maintain areas involved in the City's stream restoration projects as well as the Meadow Creek Interceptor project to mitigate the 3% loss in canopy in those areas.

**75%**

**OF ALL PLANTABLE SPACE IN CHARLOTTESVILLE IS LOCATED ON PRIVATE LAND**

**3. Develop outreach programs towards private landowners**

In Charlottesville, 75% of PPA is found in areas designated as Private property. The City should focus on community outreach and education programs to better inform citizens and private landholders of the environmental, health, social, and financial benefits that trees provide and consider other strategies to help preserve existing trees and grow the tree canopy in the 1,000+ acres of plantable space on private properties. The City should explore options to develop grant programs for tree maintenance or removal of hazard or invasive trees within the city to remove barriers for overburdened communities which lack tree canopy. Tree giveaways, tree planting programs, and tree maintenance events can help to promote new tree plantings. To promote new plantings, expand the partnership with local contractors to plant more trees on redeveloped or newly developed property focusing on low-canopy and underserved neighborhoods. The City should also continue to develop partnerships with Community Based Organizations and individual champions throughout neighborhoods to build stewardship at the community level. In addition, the City should continue to conduct volunteer tree planting and tree maintenance events to increase awareness levels in the community.

**4. Focus new plantings in high priority areas**

To maximize impact, see greater return on investment, and provide the greatest number of benefits to the community, we recommend that the City focus planting and management efforts in areas with high weighted priority rankings. Planting priority maps and data, such as the map on page 16, show the areas of highest priority for all planting prioritization criteria and land cover metrics. The City should also use the GIS data provided to create unique weighted scenarios to focus efforts in targeted areas that meet specific criteria. For instance, the City could find areas that have low UTC, high PPA, and would offer the greatest benefits to temperature reduction (UHI). Focusing urban forest management resources on expanding and maintaining tree canopy in these areas will have positive impacts on multiple factors that the City has deemed important. Efforts should focus on outreach to the residents of these neighborhoods, as well as local business and land owners, in order to promote new tree plantings and continued maintenance of existing trees.

# REPORT APPENDIX

## ACCURACY ASSESSMENT

Classification accuracy serves two main purposes. Firstly, accuracy assessments provide information to technicians producing the classification about where processes need to be improved and where they are effective. Secondly, measures of accuracy provide information about how to use the classification and how well land cover classes are expected to estimate actual land cover on the ground. Even with high resolution imagery, very small differences in classification methodology and image quality can have a large impact on overall map area estimations.

The classification accuracy error matrix illustrated in Table A1 contain confidence intervals that report the high and low values that could be expected for any comparison between the classification data and what actual, on the ground land cover was in 2020. This accuracy assessment was completed using high resolution aerial imagery, with computer and manual verification. No field verification was completed.

## THE INTERNAL ACCURACY ASSESSMENT WAS COMPLETED IN THESE STEPS:

1. Five hundred sample points, or approximately 50 points per square mile area in Charlottesville (10 sq. miles), were randomly distributed across the study area and assigned a random numeric value.
2. Each sample point was then referenced using the NAIP aerial photo and assigned one of five generalized land cover classes ("Ref_ID") mentioned above by a technician.
3. In the event that the reference value could not be discerned from the imagery, the point was dropped from the accuracy analysis. In this case, no points were dropped.
4. An automated script was then used to assign values from the classification raster to each point ("Eval_ID"). The classification supervisor provides unbiased feedback to quality control technicians regarding the types of corrections required. Misclassified points (where reference ID does not equal evaluation ID) and corresponding land cover are inspected for necessary corrections to the land cover.[1]
5. Accuracy is re-evaluated (repeat steps 3 & 4) until an acceptable classification accuracy is achieved.

## SAMPLE ERROR MATRIX INTERPRETATION

Statistical relationships between the reference pixels (representing the true conditions on the ground) and the intersecting classified pixels are used to understand how closely the entire classified map represents Charlottesville's landscape. The error matrix shown in Table A1 represent the intersection of reference pixels manually identified by a human observer (columns) and classification category of pixels in the classified image (rows). The blue boxes along the diagonals of the matrix represent agreement between the two-pixel maps. Off-diagonal values represent the number of pixels manually referenced to the column class that were classified as another category in the classification image. Overall accuracy is computed by dividing the total number of correct pixels by the total number of pixels reported in the matrix (189 + 97 + 162 + 6+ 4 = 458 / 500 = 91.6%), and the matrix can be used to calculate per class accuracy percentage's. For example, 197 points were manually identified in the reference map as Tree Canopy, and 189 of those pixels were classified as Tree Canopy in the classification map. This relationship is called the "Producer's Accuracy" and is calculated by dividing the agreement pixel total (diagonal) by the reference pixel total (column total). Therefore, the Producer's Accuracy for Tree Canopy is calculated as: (189/197 = .959), meaning that we can expect that ~96% of all 2018 tree canopy in the Charlottesville, VA study area was classified as Tree Canopy in the 2018 classification map.

Conversely, the "User's Accuracy" is calculated by dividing the total number of agreement pixels by the total number of classified pixels in the row category. For example, 189 classification pixels intersecting reference pixels were classified as Tree Canopy, but 11 pixels were identified as Vegetation and 6 were identified as impervious in the reference map. Therefore, the User's Accuracy for Tree Canopy is calculated as: (189/206 = 0.917), meaning that ~92% of the pixels classified as Tree Canopy in the classification were actual tree canopy. It is important to recognize the Producer's and User's accuracy percent values are based on a sample of the true ground cover, represented by the reference pixels at each sample point. Interpretation of the sample error matrix results indicates this land cover, and more importantly, tree canopy, were accurately mapped in Charlottesville in 2018. The largest sources of classification confusion exist between tree canopy and vegetation.

*1 Note that by correcting locations associated with accuracy points, bias is introduced to the error matrix results. This means that matrix results based on a new set of randomly collected accuracy points may result in significantly different accuracy values.*

*Table A1. | Error matrix for land cover classifications in Washington, D.C. (2020).*

| Classification Data \ Reference Data | Tree Canopy | Vegetation | Impervious | Soil / Dry Veg. | Water | Total Reference Pixels |
|---|---|---|---|---|---|---|
| Tree Canopy | 189 | 11 | 6 | 0 | 0 | 206 |
| Vegetation | 3 | 97 | 6 | 1 | 0 | 107 |
| Impervious | 5 | 10 | 162 | 0 | 0 | 177 |
| Soil / Dry Veg. | 0 | 0 | 0 | 6 | 0 | 6 |
| Water | 0 | 0 | 0 | 0 | 4 | 4 |
| Total | 197 | 118 | 174 | 7 | 4 | 500 |

**Overall Accuracy = 92%**

| Producer's Accuracy | |
|---|---|
| Tree Canopy | 96% |
| Veg. / Open Space | 82% |
| Impervious | 93% |
| Bare Ground / Soil | 86% |
| Water | 100% |

| User's Accuracy | |
|---|---|
| Tree Canopy | 92% |
| Veg. / Open Space | 91% |
| Impervious | 92% |
| Bare Ground / Soil | 100% |
| Water | 100% |

## ACCURACY ASSESSMENT RESULTS

Interpretation of the sample error matrix offers some important insights when evaluating Charlottesville's urban tree canopy coverage and how well aligned the derived land cover data are with interpretations by the human eye. The high accuracy of the 2018 data indicates that regardless of how and when it was achieved, the City's current tree canopy can be safely assumed to match the figures stated in this report (approximately 40%).

## GLOSSARY/KEY TERMS

**Land Acres**: Total land area, in acres, of the assessment boundary (excludes water).

**Non-Canopy Vegetation**: Areas of grass and open space where tree canopy does not exist.

**Possible Planting Area - Vegetation**: Areas of grass and open space where tree canopy does not exist, and it is biophysically possible to plant trees.

**Total Possible Planting Area/Total Plantable Space**: The combination of PPA Vegetation area and PPA Impervious area. In this project no impervious areas were identifies as plantable.

**Soil/Dry Vegetation**: Areas of bare soil and/or dried, dead vegetation.

**Total Acres**: Total area, in acres, of the assessment boundary (includes water).

**Unsuitable Impervious**: Areas of impervious surfaces that are not suitable for tree planting. These include buildings and roads and all other types of impervious surfaces.

**Unsuitable Planting Area**: Areas where it is not feasible to plant trees. Airports, ball fields, golf courses, etc. were manually defined as unsuitable planting areas.

**Unsuitable Soil**: Areas of soil/dry vegetation considered unsuitable for tree planting. Irrigation and other modifiers may be required to keep a tree alive in these areas.

**Unsuitable Vegetation**: Areas of non-canopy vegetation that are not suitable for tree planting due to their land use.

**Urban Tree Canopy (UTC)**: The "layer of leaves, branches and stems that cover the ground" (Raciti et al., 2006) when viewed from above; the metric used to quantify the extent, function, and value of the urban forest. Tree canopy was generally taller than 10-15 feet tall.

**Water**: Areas of open, surface water not including

MARCH | 2022

URBAN TREE CANOPY

# ASSESSMENT

**CHARLOTTESVILLE, VIRGINIA**

## Charlottesville 2022 Tree Canopy Assessment Repot External Comments

PlanIT Geo Responses are in Blue

**Environmental/Public works staff comments:**

I appreciate your question to the consultants about projecting what the parcel associated with the Meadowcreek Stream Restoration Project (and its associated reforestation) would do to the percentages in the report…to the neighborhood? to the overall number? To the reported 3% decrease in canopy on urban land (i.e., if this project's footprint – which is more than the Greenbrier Park parcel – was assumed to be x% canopy, how much would that offset the 3% decrease?). I did not see a response.

As it is presented in the Executive Summary and then on page 8 and again on page 12, it could be misinterpreted that the stream project is responsible for permanent canopy loss versus an investment in the urban forest on public land. This should be corrected.

The Executive Summary contains the following: *The overall decrease is due, in part, to the City's stream restoration and Meadow Creek Interceptor projects, as well as development within several neighborhoods throughout the City. Parcels included in the stream line restoration area lost 3% canopy cover.* As we know, the 7% loss on private property probably did not include unaccounted for reforestation. As such it is unbalanced to attribute the "overall decrease" to an ecosystem restoration project.

-added a sentence on page 8 about reforestation impacts, specifically, growth will be measurable in future assessments.

Urban Heat Map Overlay (pg 4):

· Is the Landsat image from summer 2018 or 2019? Seems that should be known.

-Changed 'or' to 'and' in the report. Data was collected both summers

Pg 7…need to correct whether it is 2,771 or 2,503

-2,503 is the total canopy outside of university owned lands (remove 2,503) we'll just report the acres of canopy on private lands

Page 8

· I'd like to understand the methodology for calculating "overhanging pervious versus impervious"

-Impervious surfaces can be classified even if a tree exists above them (the AI/ML neural networks responsible for creating all land cover data have been trained for this). The area of impervious surfaces covered by tree canopy is calculated as a separate category and combined with tree canopy (to create a total canopy) and impervious (to create total impervious).

· What is the basis for the statement that “Tree canopy overhanging an impervious surface can provide many benefits through ecosystem services …and increased stormwater absorption.”?

-Absorption may be slightly misleading as tree canopy will primarily intercept rainfall. Although there is an assumption that making room for new tree plantings means removing pieces of impervious surfaces. Converting impermeable surfaces to permeable ones is even better that covering with canopy. I can change that sentence to say "decreased stormwater runoff" instead.

- Canopy Cooling Effects: https://www.pnas.org/doi/10.1073/pnas.1817561116
- Stormwater Benefits: https://treecanopybmp.org/tree-canopy-bmps/stormwater-benefits-of-trees AND https://www.itreetools.org/documents/717/K_Bomberger_Trees_for_Stormwater_Mitigation_6-2-21.pdf

· There is an odd statement here: “It is important that the City continue to plant new large stature trees to replace them when they reach the end of their lives in order to maintain and grow current canopy levels and the valuable ecosystem services that they provide.

-The highlighted sentence was rewritten

· It could be helpful to have a simple graph of the data from 1957 and on…would be easier to digest (or supplement) the text.

-No new graphs were created.

Page 12:

· 2nd sentence: “Due to this,…” this what? Methodology?

-Clarification was added

· Figure 12: Is “Total Plantable Space” the same as “Possible Planting Area”? If so – let’s be consistent in terminology.

-Terms can be used interchangeably and are defined in the appendix

· The ranges for the categories presented are odd and it would be easier to understand if the loss % categories were labeled from low to high values (e.g., -25%--98% instead of -98%--25%)

-The current arrangement is numerically logical. The smallest numerical values of each range are on the left and the largest numerical values are on the right.

· There is reference to GIS desktop software or an interactive web mapping application such as TreePlotter CANOPY…do we have/use that?

-TreePlotter CANOPY was not included with this project. Project data can be opened and analyzed using any GIS software (ESRI ArcMap, QGIS, etc.)

· I don’t understand this paragraph…do we deduce that 12,437 parcels had canopy change that was picked up in this assessment?:

- *Tree canopy change within the 13,937 parcels, again, consisted of both losses and gains. Losses in canopy ranged from 1 to 100%, and gains in canopy also ranged from 1 to 100%. Just over 1,500 parcels had no or very* *little change in canopy coverage due to their small size and lack of trees in both 2014 and 2018.*

-Yes, in most projects we find that some areas experience very little measurable change. Especially when looking at areas as small as parcels. For example any parcels with 0% tree canopy in 2014 and 0% in 2018 will have no change to detect.

Small editing items:

- Figure 1 label is as follows: ***Charlottesville occupies approximately 10 square miles in Albemarle County, Virginia.*** Needs to be modified and should not reference Cville **in** AlbCo.
- Greenbrier should be spelled correctly throughout.

-Both items were corrected

**Commissioners Comments**

1. Goal for Canopy CoverageIs there a simple way to estimate how many trees need to be planted to reach our 50%canopy coverage goal or 3500 acres?

Calculate difference from current acreage to goal acreage. Estimate the average crown diameter of trees to be planted (or a range of crown diameters) then calculate the circular area of those diameters in acres and divide by the difference between the goal acreage and the actual acreage.

2. Definition of ROW I note that a neighborhood such as 10 th & Page is listed as having a large amount of ROW. But we think the ROW in that neighborhood is essentially the 4-5' sidewalk,leaving no other ROW for planting trees. How do you define available ROW for planting?

Right of Way was derived from the city parcels layer. Any areas not bounded by a parcel polygon were considered ROW. We are aware this will include some areas that are not 'plantable' such as alleyways. It will also include portions of some front yards. These are the cases where ground truthing is required to verify planting sites.

As for 10th and page I'm a little confused what is suggesting that neighborhood has "a large amount of ROW". The total portion of land area within the ROW in 10th & Page is 2% (25 acres of 111ac total) whereas Belmont (does have a large amount of ROW) contains 12% of the city's right of way (125 Acres). Furthermore the area defined for planting must first of all be in the right of way and second of all be vegetation further refining the planting potential. I believe that our assessment reflects that, based on plantable space in the ROW, 10th & page is not the most ideal neighborhood for tree planting.

3. Some Confusions over Data For example, in some places it is said that there are PPA of 2770 acres and in another place PPA of 2503. Which is correct?

I'm guessing this is referring to UTC, specifically the mention of 2,503ac on the third paragraph of page7. The simplest explanation for this is that the city boundary is slightly larger in a few places than largest perimeter of the land ownership boundary that we derived from the city parcel data. While these parcels were mapped in this assessment and account towards the City's total tree canopy acreage, they are not included in the ownership type boundaries, this means that, in total the area of the property ownership boundary is less than that of the total study area (city boundary).

To remedy this and reduce confusion I removed the reference to 2,503 on page 7.

4. Priority Neighborhoods for PlantingThere is some confusion in the criteria for determining priority. For instance, 10 th andPage seems to rank the highest in all 4 categories, but comes out 2nd in priority.

The map on page 16, shows that 10th and page is a lower priority neighborhood than, The Meadows and Rose hill. This does not mean that it ranks second overall. It is just included in the second highest priority group. When ranked individually it is the 5th highest priority neighborhood. 10th and page ranks low in right of way priority, and in public lands priority. In population below poverty it is second. And it has a very high urban heat island priority. All priorities are ranked equally so a neighborhood with a high score in two priorities will have a higher overall rank.

5. Public Health Benefits of TreesThe Tree Commission cares deeply about this.Our RFP states:"The data shall include a basic analysis of ecosystem services including:….Public health impacts – Health incidence reduction and economic benefit based on the effect of trees on air quality improvement for the United States only."It was probably hard to collect the health impact data, but we want it to factor into determining priority planting neighborhoods. How can we do this?

We calculated air quality impacts using values from i-Tree Landscape. Individual neighborhood benefits can be calculated by using the percentage of overall canopy within each neighborhood. Further detail on ecosystem benefits can be found in the iTree Eco report Completed January of 2022. Public health data is not available at the local neighborhood scale. CDC can offer some insights for larger areas: https://chronicdata.cdc.gov/browse?category=500+Cities+%26+Places

6. Recommendations In order to make it easier to read and to have a bigger impact, would it be possible to bullet the recommendations in each section - 1- 4. Lots of good ideas but they get lost in the long paragraphs.

Re-formatting of recommendations was not completed

7. Graphic Clarity Consider making the UTC percentage text color correlate to the map colors especially for those neighborhoods under 20% UTC.

Done

# i-Tree
# Ecosystem Analysis

## Charlottesville_TCA

Urban Forest Effects and Values
January 2022

# Summary

Understanding an urban forest's structure, function and value can promote management decisions that will improve human health and environmental quality. An assessment of the vegetation structure, function, and value of the Charlottesville_TCA urban forest was conducted during 2022. Data from 7746 trees located throughout Charlottesville_TCA were analyzed using the i-Tree Eco model developed by the U.S. Forest Service, Northern Research Station.

- Number of trees: 7,746
- Tree Cover: 100.7 acres
- Most common species of trees: Flowering dogwood, Eastern red cedar, Eastern white pine
- Percentage of trees less than 6" (15.2 cm) diameter: 26.0%
- Pollution Removal: 2.622 tons/year ($26.8 thousand/year)
- Carbon Storage: 4.438 thousand tons ($757 thousand)
- Carbon Sequestration: 97.73 tons ($16.7 thousand/year)
- Oxygen Production: 260.6 tons/year
- Avoided Runoff: 285.2 thousand cubic feet/year ($19.1 thousand/year)
- Building energy savings: N/A – data not collected
- Avoided carbon emissions: N/A – data not collected
- Replacement values: $29.1 million

Ton: short ton (U.S.) (2,000 lbs)
Monetary values $ are reported in US Dollars throughout the report except where noted.
Ecosystem service estimates are reported for trees.

For an overview of i-Tree Eco methodology, see Appendix I. Data collection quality is determined by the local data collectors, over which i-Tree has no control.

# Table of Contents

# I. Tree Characteristics of the Urban Forest

The urban forest of Charlottesville_TCA has 7,746 trees with a tree cover of Flowering dogwood. The three most common species are Flowering dogwood (12.2 percent), Eastern red cedar (5.9 percent), and Eastern white pine (5.0 percent).

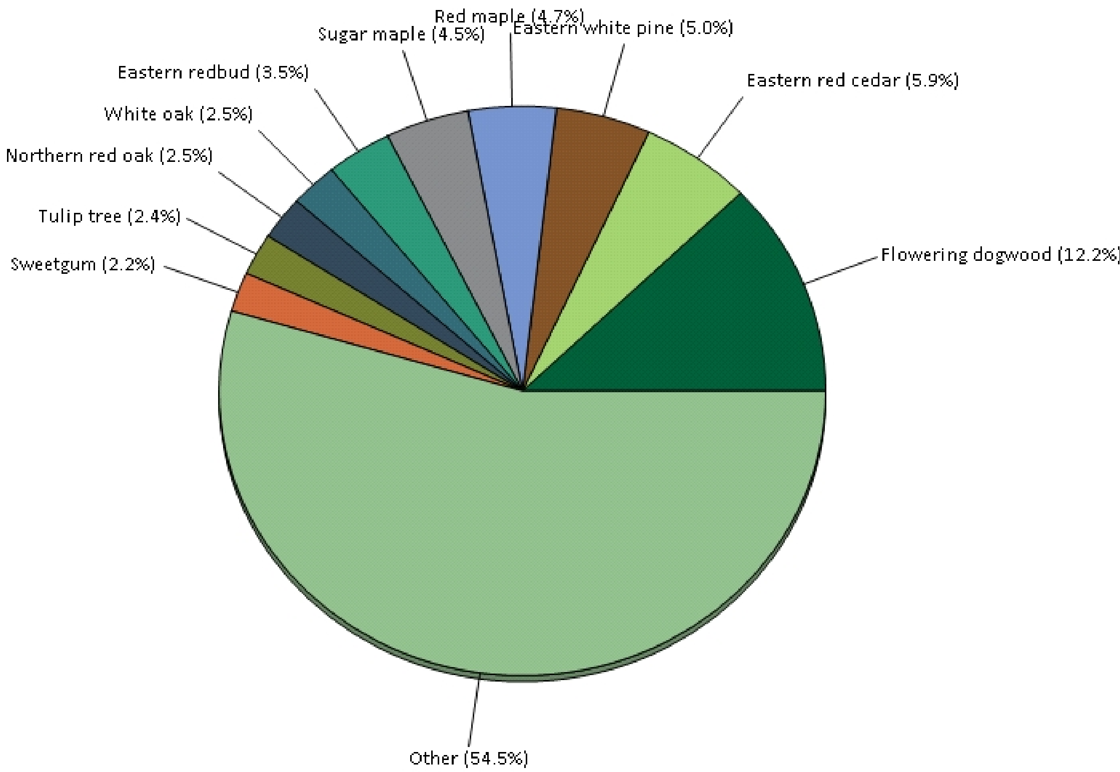



**Figure 1. Tree species composition in Charlottesville_TCA**

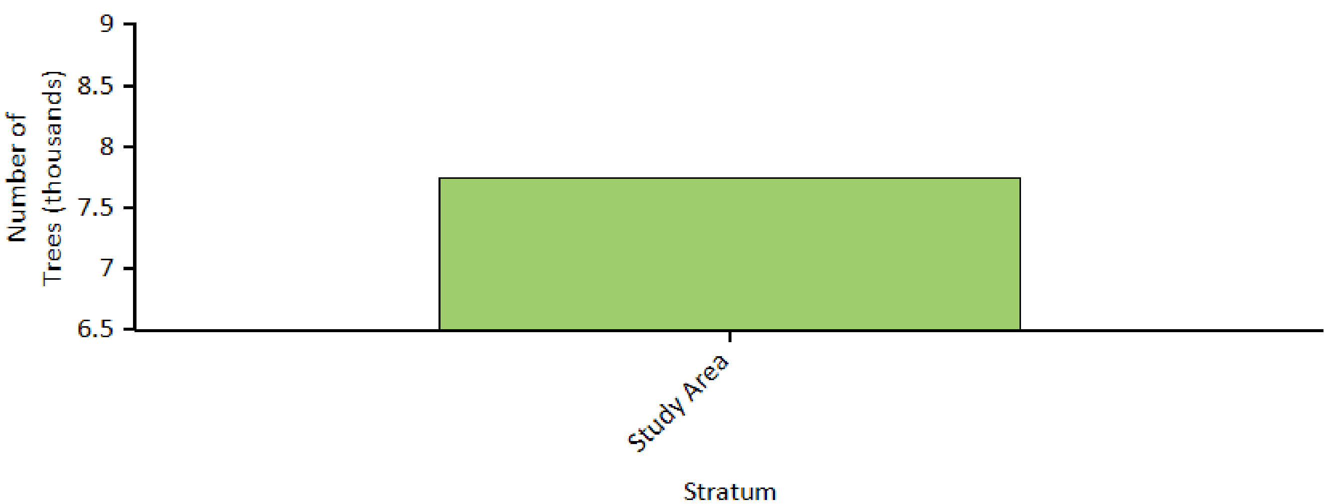



**Figure 2. Number of trees in Charlottesville_TCA by stratum**

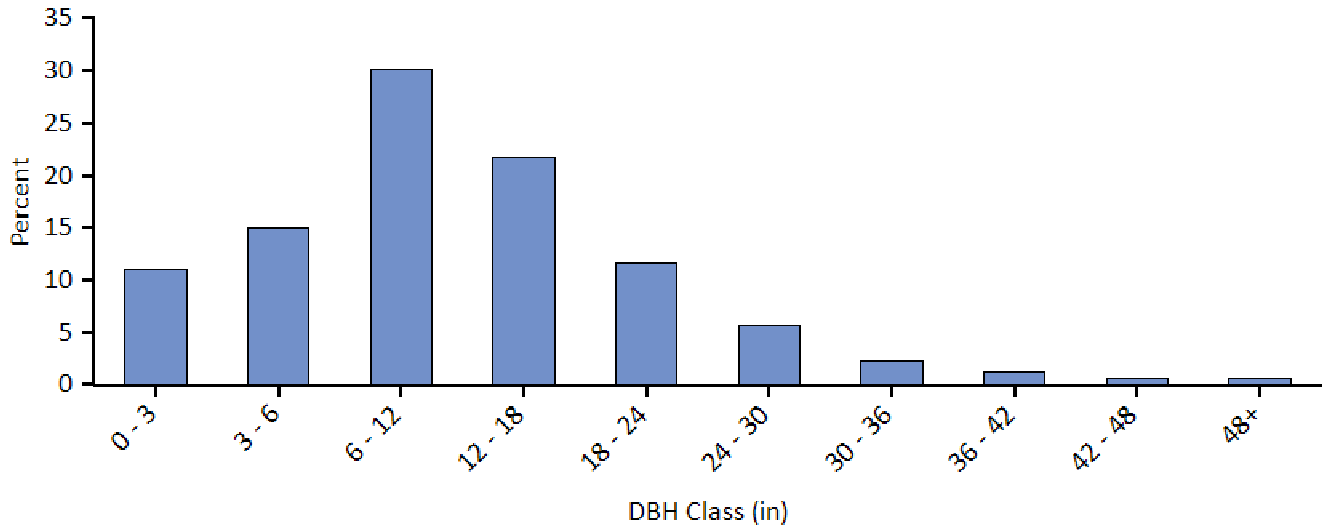



**Figure 3. Percent of tree population by diameter class (DBH - stem diameter at 4.5 feet)**

Urban forests are composed of a mix of native and exotic tree species. Thus, urban forests often have a tree diversity that is higher than surrounding native landscapes. Increased tree diversity can minimize the overall impact or destruction by a species-specific insect or disease, but it can also pose a risk to native plants if some of the exotic species are invasive plants that can potentially out-compete and displace native species. In Charlottesville_TCA, about 81 percent of the trees are species native to North America, while 77 percent are native to Virginia. Species exotic to North America make up 19 percent of the population. Most exotic tree species have an origin from Asia (14 percent of the species).

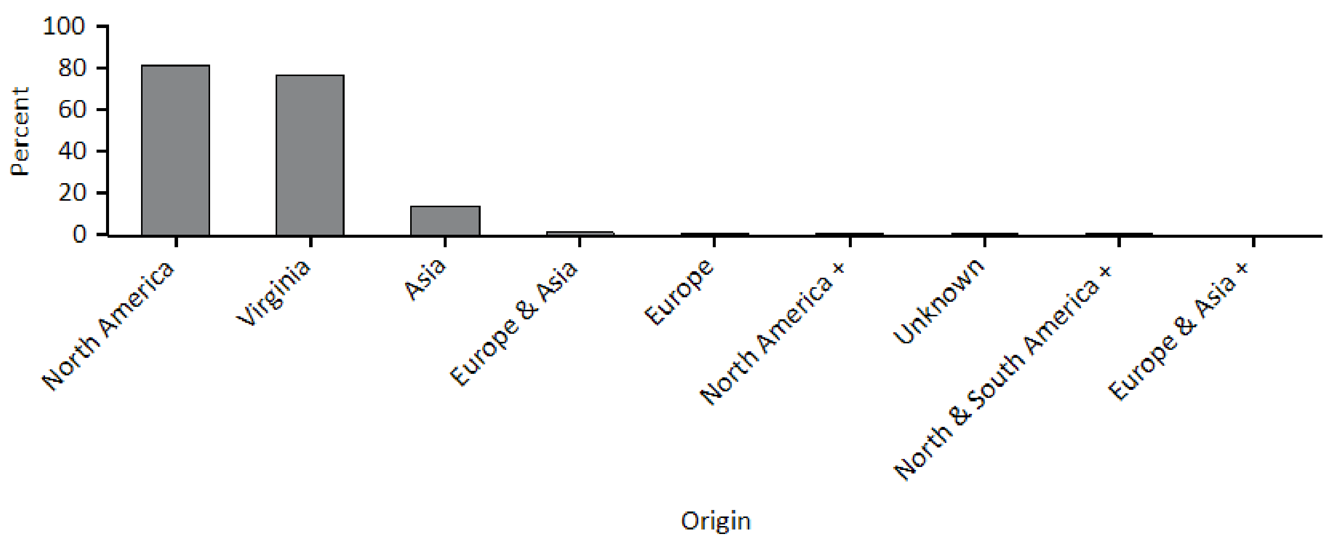



**Figure 4. Percent of live tree population by area of native origin, Charlottesville_TCA**

The plus sign (+) indicates the tree species is native to another continent other than the ones listed in the grouping.

Invasive plant species are often characterized by their vigor, ability to adapt, reproductive capacity, and general lack of natural enemies. These abilities enable them to displace native plants and make them a threat to natural areas. Four of the 165 tree species in Charlottesville_TCA are identified as invasive on the state invasive species list (Virginia Native Plant Society and Department of Conservation and Recreation 2009). These invasive species comprise 0.6 percent of the tree population though they may only cause a minimal level of impact. The three most common invasive species are Norway maple (0.2 percent of population), Tree of heaven (0.2 percent), and Persian silk tree (0.2 percent) (see Appendix V for a complete list of invasive species).

## II. Urban Forest Cover and Leaf Area

Many tree benefits equate directly to the amount of healthy leaf surface area of the plant. Trees cover about 100.7 acres of Charlottesville_TCA and provide 638.2 acres of leaf area.

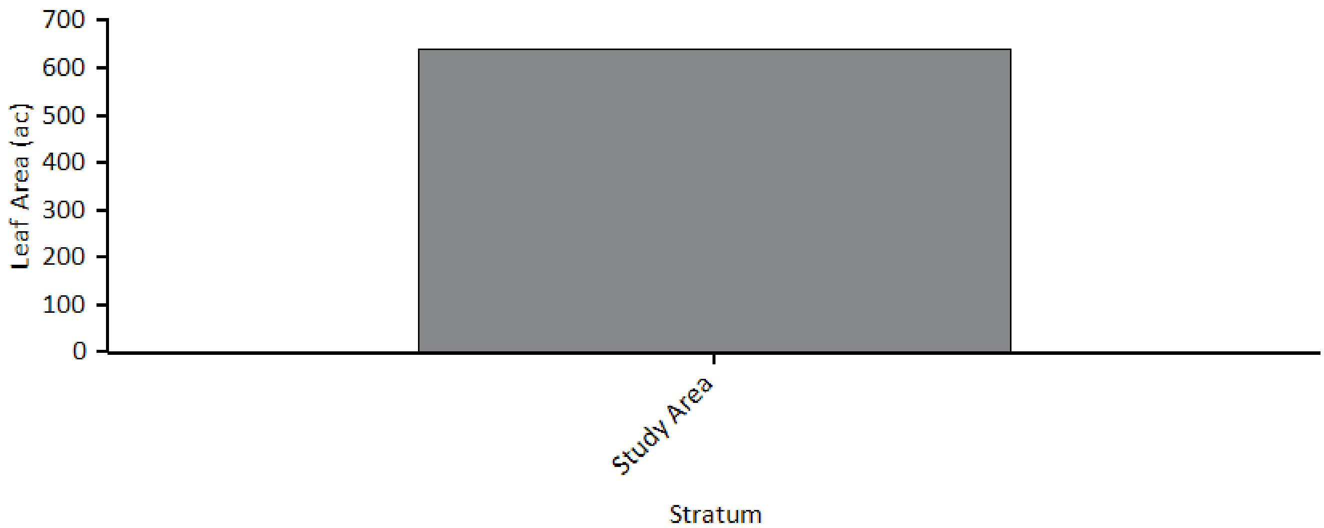



**Figure 5. Leaf area by stratum, Charlottesville_TCA**

In Charlottesville_TCA, the most dominant species in terms of leaf area are Eastern white pine, Eastern red cedar, and Tulip tree. The 10 species with the greatest importance values are listed in Table 1. Importance values (IV) are calculated as the sum of percent population and percent leaf area. High importance values do not mean that these trees should necessarily be encouraged in the future; rather these species currently dominate the urban forest structure.

**Table 1. Most important species in Charlottesville_TCA**

| *Species Name* | *Percent Population* | *Percent Leaf Area* | *IV* |
|---|---|---|---|
| Flowering dogwood | 12.2 | 2.4 | 14.6 |
| Eastern white pine | 5.0 | 9.5 | 14.5 |
| Eastern red cedar | 5.9 | 7.2 | 13.1 |
| Red maple | 4.7 | 6.1 | 10.8 |
| Tulip tree | 2.4 | 6.4 | 8.8 |
| Sugar maple | 4.5 | 4.2 | 8.6 |
| White oak | 2.5 | 6.1 | 8.6 |
| Northern red oak | 2.5 | 3.8 | 6.3 |
| Willow oak | 2.0 | 3.9 | 6.0 |
| American sycamore | 1.8 | 3.6 | 5.4 |

Common ground cover classes (including cover types beneath trees and shrubs) in Charlottesville_TCA are not available since they are configured not to be collected.

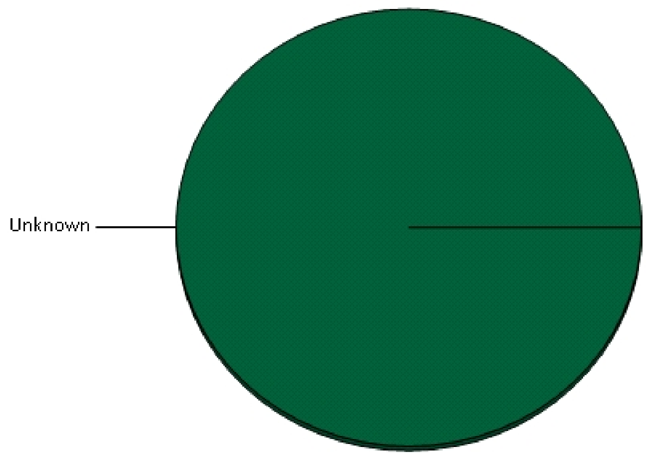



**Figure 6. Percent of land by ground cover classes, Charlottesville_TCA**

## III. Air Pollution Removal by Urban Trees

Poor air quality is a common problem in many urban areas. It can lead to decreased human health, damage to landscape materials and ecosystem processes, and reduced visibility. The urban forest can help improve air quality by reducing air temperature, directly removing pollutants from the air, and reducing energy consumption in buildings, which consequently reduces air pollutant emissions from the power sources. Trees also emit volatile organic compounds that can contribute to ozone formation. However, integrative studies have revealed that an increase in tree cover leads to reduced ozone formation (Nowak and Dwyer 2000).

Pollution removal[1] by trees in Charlottesville_TCA was estimated using field data and recent available pollution and weather data available. Pollution removal was greatest for ozone (Figure 7). It is estimated that trees remove 2.622 tons of air pollution (ozone (O3), carbon monoxide (CO), nitrogen dioxide (NO2), particulate matter less than 2.5 microns (PM2.5)[2], and sulfur dioxide (SO2)) per year with an associated value of $26.8 thousand (see Appendix I for more details).

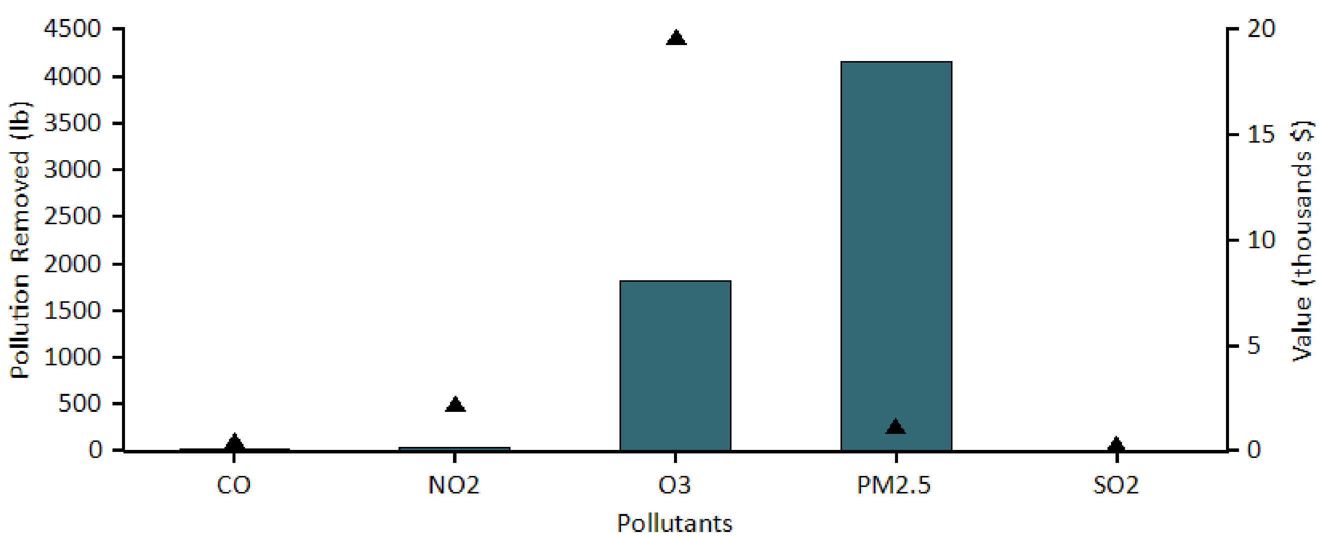



**Figure 7. Annual pollution removal (points) and value (bars) by urban trees, Charlottesville_TCA**

[1] Particulate matter less than 10 microns is a significant air pollutant. Given that i-Tree Eco analyzes particulate matter less than 2.5 microns (PM2.5) which is a subset of PM10, PM10 has not been included in this analysis. PM2.5 is generally more relevant in discussions concerning air pollution effects on human health.

[2] Trees remove PM2.5 when particulate matter is deposited on leaf surfaces. This deposited PM2.5 can be resuspended to the atmosphere or removed during rain events and dissolved or transferred to the soil. This combination of events can lead to positive or negative pollution removal and value depending on various atmospheric factors (see Appendix I for more details).

In 2022, trees in Charlottesville_TCA emitted an estimated 3.978 tons of volatile organic compounds (VOCs) (1.667 tons of isoprene and 2.311 tons of monoterpenes). Emissions vary among species based on species characteristics (e.g. some genera such as oaks are high isoprene emitters) and amount of leaf biomass. Thirty percent of the urban forest's VOC emissions were from White oak and Willow oak. These VOCs are precursor chemicals to ozone formation.[3]

General recommendations for improving air quality with trees are given in Appendix VIII.

[3] Some economic studies have estimated VOC emission costs. These costs are not included here as there is a tendency to add positive dollar estimates of ozone removal effects with negative dollar values of VOC emission effects to determine whether tree effects are positive or negative in relation to ozone. This combining of dollar values to determine tree effects should not be done, rather estimates of VOC effects on ozone formation (e.g., via photochemical models) should be conducted and directly contrasted with ozone removal by trees (i.e., ozone effects should be directly compared, not dollar estimates). In addition, air temperature reductions by trees have been shown to significantly reduce ozone concentrations (Cardelino and Chameides 1990; Nowak et al 2000), but are not considered in this analysis. Photochemical modeling that integrates tree effects on air temperature, pollution removal, VOC emissions, and emissions from power plants can be used to determine the overall effect of trees on ozone concentrations.

## IV. Carbon Storage and Sequestration

Climate change is an issue of global concern. Urban trees can help mitigate climate change by sequestering atmospheric carbon (from carbon dioxide) in tissue and by altering energy use in buildings, and consequently altering carbon dioxide emissions from fossil-fuel based power sources (Abdollahi et al 2000).

Trees reduce the amount of carbon in the atmosphere by sequestering carbon in new growth every year. The amount of carbon annually sequestered is increased with the size and health of the trees. The gross sequestration of Charlottesville_TCA trees is about 97.73 tons of carbon per year with an associated value of $16.7 thousand. See Appendix I for more details on methods.

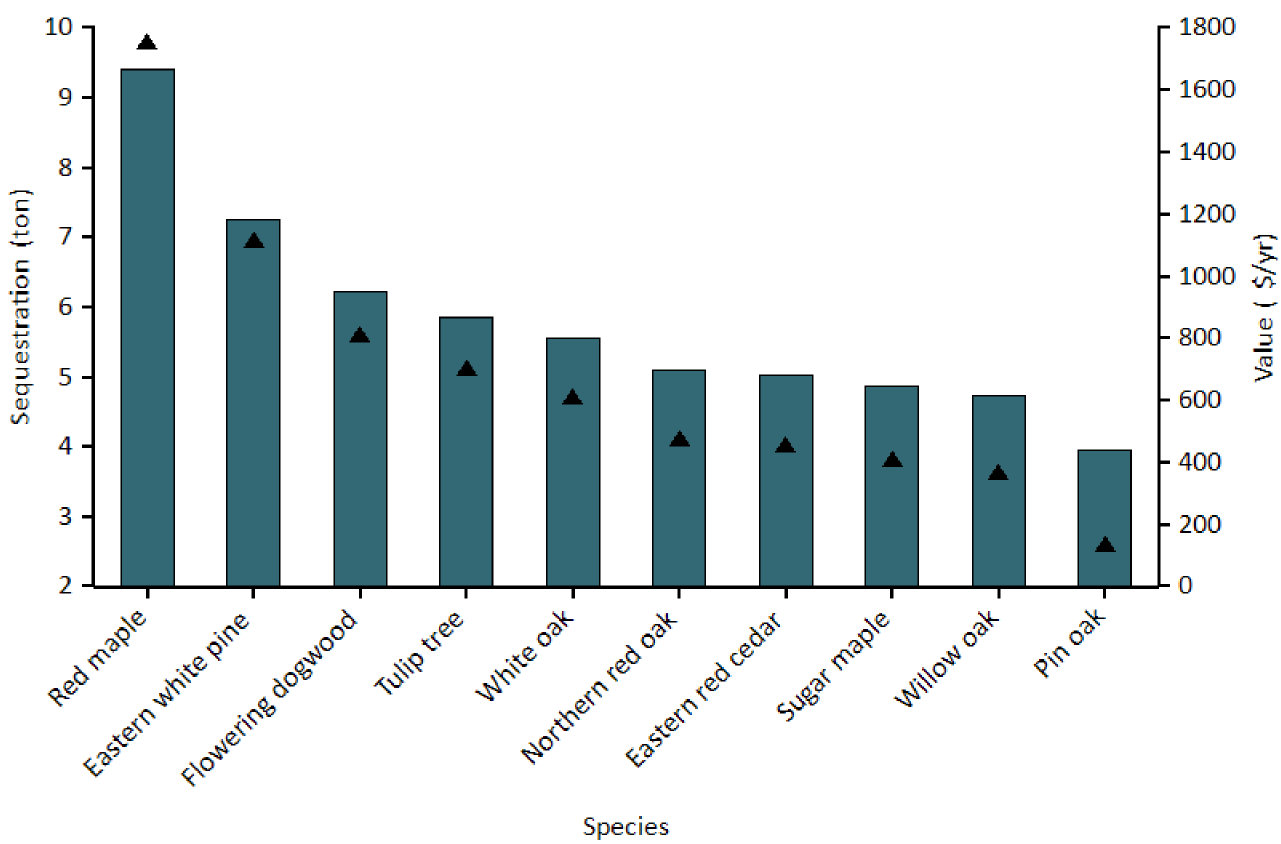



**Figure 8. Estimated annual gross carbon sequestration (points) and value (bars) for urban tree species with the greatest sequestration, Charlottesville_TCA**

Carbon storage is another way trees can influence global climate change. As a tree grows, it stores more carbon by holding it in its accumulated tissue. As a tree dies and decays, it releases much of the stored carbon back into the atmosphere. Thus, carbon storage is an indication of the amount of carbon that can be released if trees are allowed to die and decompose. Maintaining healthy trees will keep the carbon stored in trees, but tree maintenance can contribute to carbon emissions (Nowak et al 2002c). When a tree dies, using the wood in long-term wood products, to heat buildings, or to produce energy will help reduce carbon emissions from wood decomposition or from fossil-fuel or wood-based power plants.

Trees in Charlottesville_TCA are estimated to store 4440 tons of carbon ($757 thousand). Of the species sampled, White oak stores the most carbon (approximately 10.1% of the total carbon stored) and Red maple sequesters the most (approximately 10% of all sequestered carbon.)

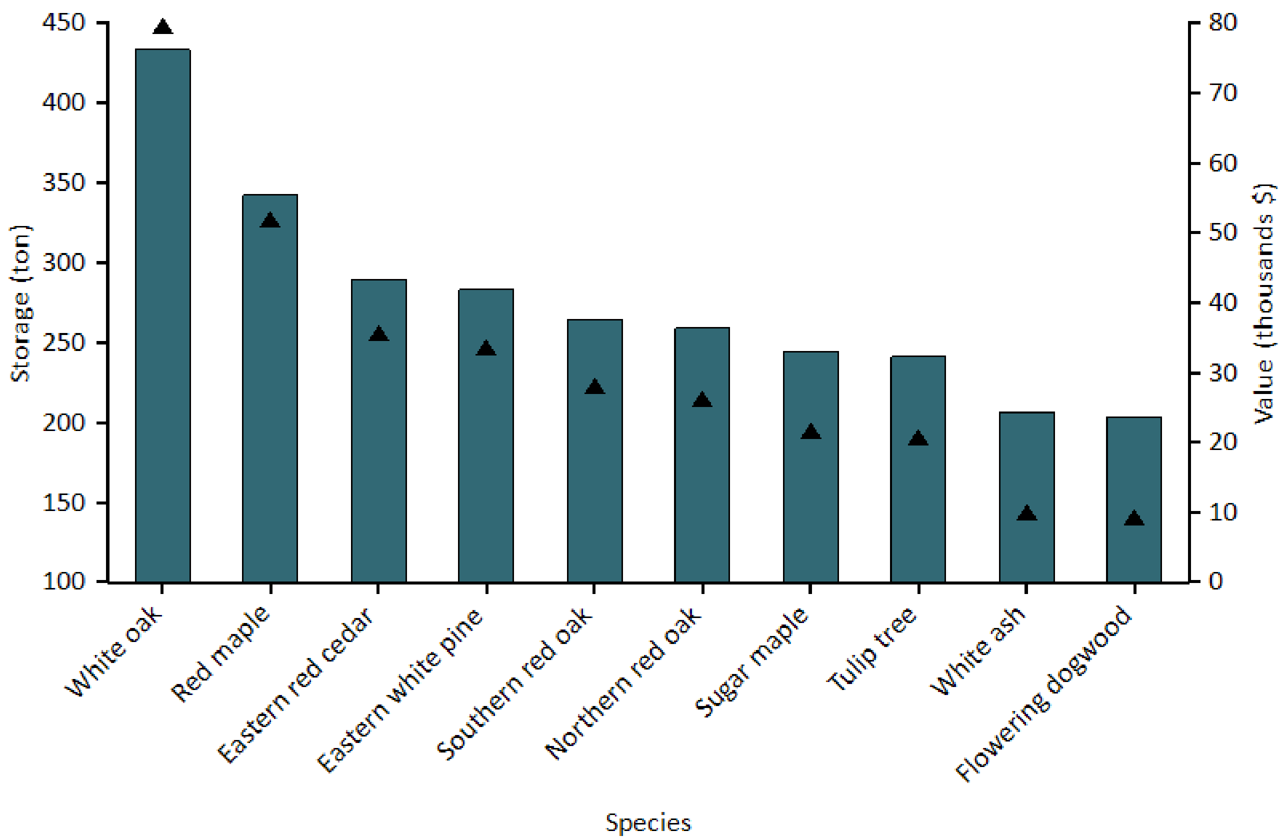



**Figure 9. Estimated carbon storage (points) and values (bars) for urban tree species with the greatest storage, Charlottesville_TCA**

# V. Oxygen Production

Oxygen production is one of the most commonly cited benefits of urban trees. The annual oxygen production of a tree is directly related to the amount of carbon sequestered by the tree, which is tied to the accumulation of tree biomass.

Trees in Charlottesville_TCA are estimated to produce 260.6 tons of oxygen per year.[4] However, this tree benefit is relatively insignificant because of the large and relatively stable amount of oxygen in the atmosphere and extensive production by aquatic systems. Our atmosphere has an enormous reserve of oxygen. If all fossil fuel reserves, all trees, and all organic matter in soils were burned, atmospheric oxygen would only drop a few percent (Broecker 1970).

**Table 2. The top 20 oxygen production species.**

| *Species* | *Oxygen (ton)* | *Gross Carbon Sequestration (ton/yr)* | *Number of Trees* | *Leaf Area (acre)* |
|---|---|---|---|---|
| Red maple | 26.05 | 9.77 | 362 | 38.94 |
| Eastern white pine | 18.45 | 6.92 | 391 | 60.50 |
| Flowering dogwood | 14.86 | 5.57 | 947 | 15.28 |
| Tulip tree | 13.58 | 5.09 | 184 | 40.96 |
| White oak | 12.49 | 4.68 | 196 | 38.85 |
| Northern red oak | 10.92 | 4.09 | 191 | 24.35 |
| Eastern red cedar | 10.63 | 3.99 | 460 | 45.99 |
| Sugar maple | 10.08 | 3.78 | 345 | 26.64 |
| Willow oak | 9.63 | 3.61 | 158 | 24.96 |
| Pin oak | 6.87 | 2.58 | 102 | 19.47 |
| White ash | 6.27 | 2.35 | 103 | 13.52 |
| Black cherry | 6.15 | 2.31 | 63 | 5.05 |
| Southern red oak | 5.50 | 2.06 | 94 | 19.61 |
| American sycamore | 5.23 | 1.96 | 137 | 23.28 |
| River birch | 3.89 | 1.46 | 58 | 6.92 |
| American elm | 3.79 | 1.42 | 42 | 6.47 |
| Shumard oak | 3.75 | 1.41 | 122 | 9.33 |
| Swamp white oak | 3.69 | 1.38 | 155 | 2.75 |
| Sweetgum | 3.66 | 1.37 | 174 | 10.00 |
| Eastern redbud | 3.38 | 1.27 | 272 | 9.95 |

# VI. Avoided Runoff

Surface runoff can be a cause for concern in many urban areas as it can contribute pollution to streams, wetlands, rivers, lakes, and oceans. During precipitation events, some portion of the precipitation is intercepted by vegetation (trees and shrubs) while the other portion reaches the ground. The portion of the precipitation that reaches the ground and does not infiltrate into the soil becomes surface runoff (Hirabayashi 2012). In urban areas, the large extent of impervious surfaces increases the amount of surface runoff.

Urban trees and shrubs, however, are beneficial in reducing surface runoff. Trees and shrubs intercept precipitation, while their root systems promote infiltration and storage in the soil. The trees and shrubs of Charlottesville_TCA help to reduce runoff by an estimated 285 thousand cubic feet a year with an associated value of $19 thousand (see Appendix I for more details). Avoided runoff is estimated based on local weather from the user-designated weather station. In Charlottesville_TCA, the total annual precipitation in 2016 was 35.0 inches.

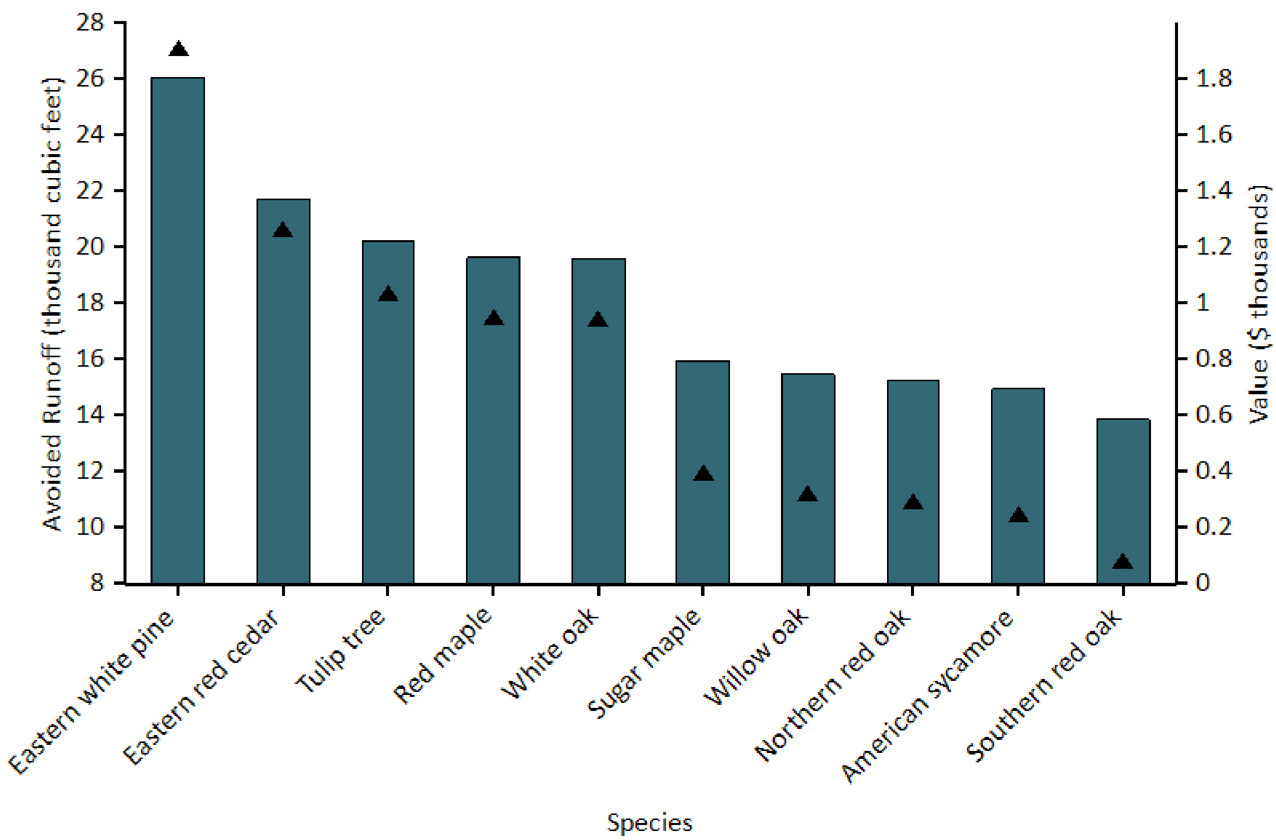



**Figure 10. Avoided runoff (points) and value (bars) for species with greatest overall impact on runoff, Charlottesville_TCA**

## VII. Trees and Building Energy Use

Trees affect energy consumption by shading buildings, providing evaporative cooling, and blocking winter winds. Trees tend to reduce building energy consumption in the summer months and can either increase or decrease building energy use in the winter months, depending on the location of trees around the building. Estimates of tree effects on energy use are based on field measurements of tree distance and direction to space conditioned residential buildings (McPherson and Simpson 1999).

Because energy-related data were not collected, energy savings and carbon avoided cannot be calculated.

**Table 3. Annual energy savings due to trees near residential buildings, Charlottesville_TCA**

| | *Heating* | *Cooling* | *Total* |
|---|---|---|---|
| MBTU[a] | 0 | N/A | 0 |
| MWH[b] | 0 | 0 | 0 |
| Carbon Avoided (pounds) | 0 | 0 | 0 |

[a]MBTU - one million British Thermal Units
[b]MWH - megawatt-hour

**Table 4. Annual savings [a]($) in residential energy expenditure during heating and cooling seasons, Charlottesville_TCA**

| | *Heating* | *Cooling* | *Total* |
|---|---|---|---|
| MBTU[b] | 0 | N/A | 0 |
| MWH[c] | 0 | 0 | 0 |
| Carbon Avoided | 0 | 0 | 0 |

[b]Based on the prices of $127.4 per MWH and $12.0901200338443 per MBTU (see Appendix I for more details)
[c]MBTU - one million British Thermal Units
[c]MWH - megawatt-hour

[5] Trees modify climate, produce shade, and reduce wind speeds. Increased energy use or costs are likely due to these tree-building interactions creating a cooling effect during the winter season. For example, a tree (particularly evergreen species) located on the southern side of a residential building may produce a shading effect that causes increases in heating requirements.

# VIII. Replacement and Functional Values

Urban forests have a replacement value based on the trees themselves (e.g., the cost of having to replace a tree with a similar tree); they also have functional values (either positive or negative) based on the functions the trees perform.

The replacement value of an urban forest tends to increase with a rise in the number and size of healthy trees (Nowak et al 2002a). Annual functional values also tend to increase with increased number and size of healthy trees. Through proper management, urban forest values can be increased; however, the values and benefits also can decrease as the amount of healthy tree cover declines.

Urban trees in Charlottesville_TCA have the following replacement values:

- Replacement value: $29.1 million
- Carbon storage: $757 thousand

Urban trees in Charlottesville_TCA have the following annual functional values:

- Carbon sequestration: $16.7 thousand
- Avoided runoff: $19.1 thousand
- Pollution removal: $26.8 thousand
- Energy costs and carbon emission values: $0

(Note: negative value indicates increased energy cost and carbon emission value)

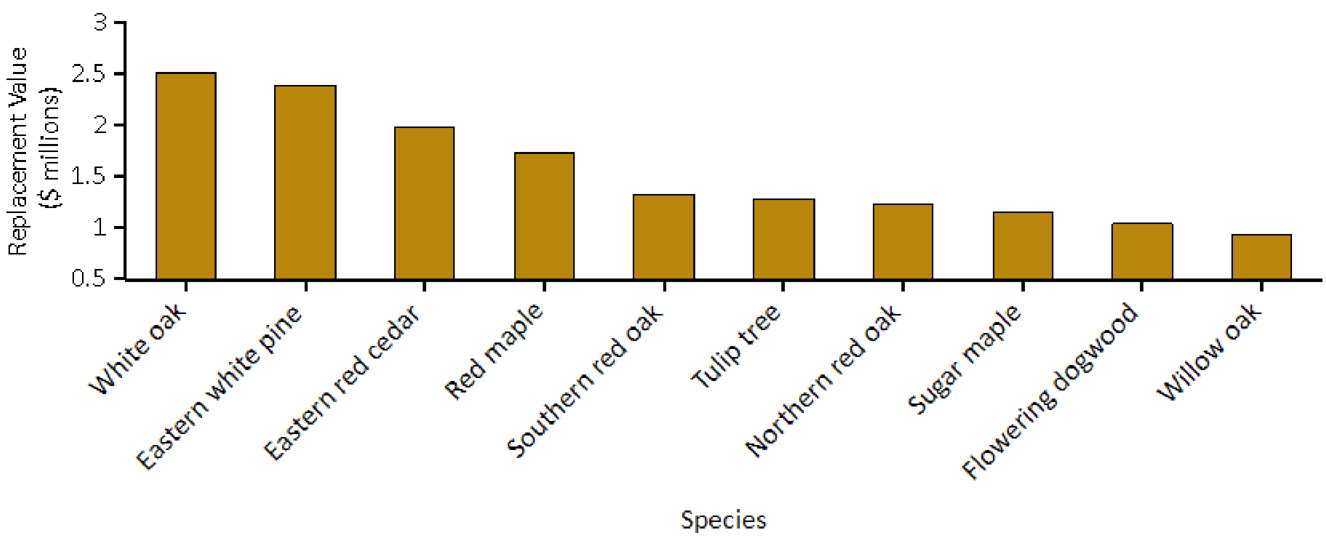



**Figure 11. Tree species with the greatest replacement value, Charlottesville_TCA**

## IX. Potential Pest Impacts

Various insects and diseases can infest urban forests, potentially killing trees and reducing the health, replacement value and sustainability of the urban forest. As pests tend to have differing tree hosts, the potential damage or risk of each pest will differ among cities.Thirty-six pests were analyzed for their potential impact and compared with pest range maps (Forest Health Technology Enterprise Team 2014) for the conterminous United States to determine their proximity to Charlottesville County. Nine of the thirty-six pests analyzed are located within the county. For a complete analysis of all pests, see Appendix VII.

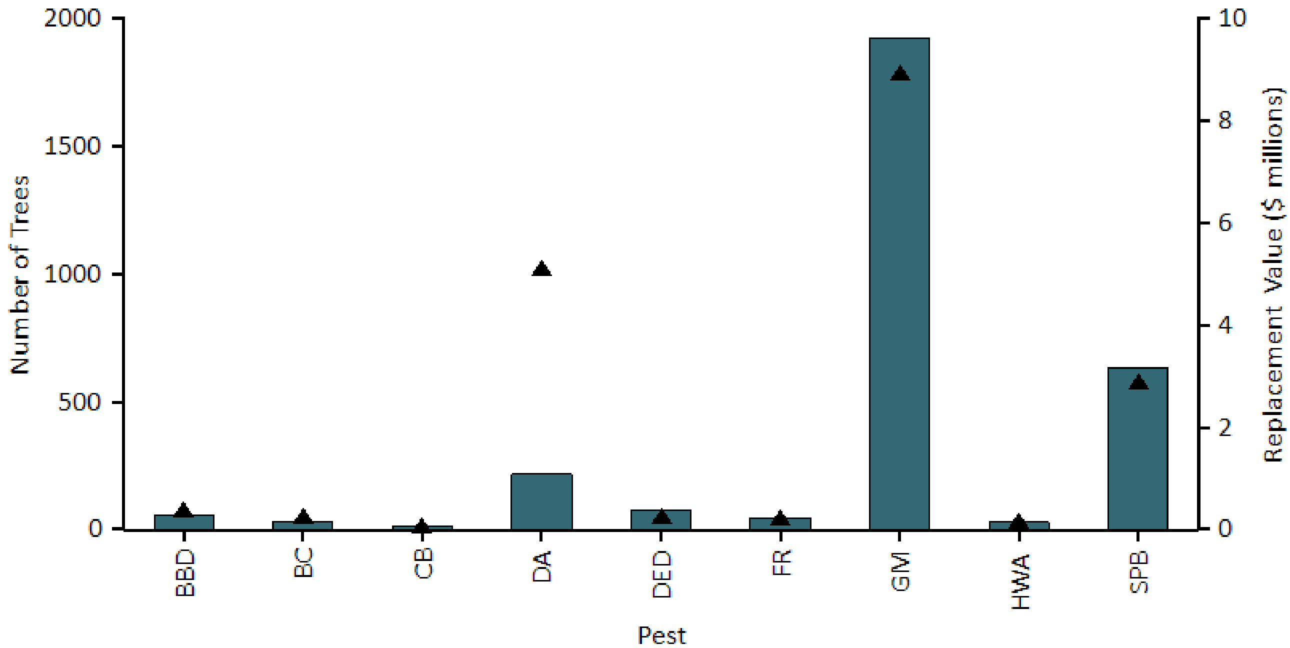



**Figure 12. Number of trees at risk (points) and associated compensatory value (bars) for most threatening pests located in the county, Charlottesville_TCA**

Beech bark disease (BBD) (Houston and O'Brien 1983) is an insect-disease complex that primarily impacts American beech. This disease threatens 0.9 percent of the population, which represents a potential loss of $289 thousand in replacement value.

Butternut canker (BC) (Ostry et al 1996) is caused by a fungus that infects butternut trees. The disease has since caused significant declines in butternut populations in the United States. Potential loss of trees from BC is 0.5 percent ($169 thousand in replacement value).

The most common hosts of the fungus that cause chestnut blight (CB) (Diller 1965) are American and European chestnut. CB has the potential to affect 0.1 percent of the population ($49.1 thousand in replacement value).

Dogwood anthracnose (DA) (Mielke and Daughtrey) is a disease that affects dogwood species, specifically flowering and Pacific dogwood. This disease threatens 13.1 percent of the population, which represents a potential loss of $1.09 million in replacement value.

American elm, one of the most important street trees in the twentieth century, has been devastated by the Dutch elm disease (DED) (Northeastern Area State and Private Forestry 1998). Since first reported in the 1930s, it has killed over 50 percent of the native elm population in the United States. Although some elm species have shown varying degrees of resistance, Charlottesville_TCA could possibly lose 0.5 percent of its trees to this pest ($367 thousand in replacement value).

Fusiform rust (FR) (Phelps and Czabator 1978) is a fungal disease that is distributed in the southern United States. It is particularly damaging to slash pine and loblolly pine. FR has the potential to affect 0.5 percent of the population ($228 thousand in replacement value).

The gypsy moth (GM) (Northeastern Area State and Private Forestry 2005) is a defoliator that feeds on many species causing widespread defoliation and tree death if outbreak conditions last several years. This pest threatens 23.0 percent of the population, which represents a potential loss of $9.64 million in replacement value.

As one of the most damaging pests to eastern hemlock and Carolina hemlock, hemlock woolly adelgid (HWA) (U.S. Forest Service 2005) has played a large role in hemlock mortality in the United States. HWA has the potential to affect 0.3 percent of the population ($148 thousand in replacement value).

Although the southern pine beetle (SPB) (Clarke and Nowak 2009) will attack most pine species, its preferred hosts are loblolly, Virginia, pond, spruce, shortleaf, and sand pines. This pest threatens 7.3 percent of the population, which represents a potential loss of $3.16 million in replacement value.

# Appendix I. i-Tree Eco Model and Field Measurements

i-Tree Eco is designed to use standardized field data and local hourly air pollution and meteorological data to quantify urban forest structure and its numerous effects (Nowak and Crane 2000), including:

- Urban forest structure (e.g., species composition, tree health, leaf area, etc.).
- Amount of pollution removed hourly by the urban forest, and its associated percent air quality improvement throughout a year.
- Total carbon stored and net carbon annually sequestered by the urban forest.
- Effects of trees on building energy use and consequent effects on carbon dioxide emissions from power sources.
- Replacement value of the forest, as well as the value for air pollution removal and carbon storage and sequestration.
- Potential impact of infestations by pests, such as Asian longhorned beetle, emerald ash borer, gypsy moth, and Dutch elm disease.

Typically, all field data are collected during the leaf-on season to properly assess tree canopies. Typical data collection (actual data collection may vary depending upon the user) includes land use, ground and tree cover, individual tree attributes of species, stem diameter, height, crown width, crown canopy missing and dieback, and distance and direction to residential buildings (Nowak et al 2005; Nowak et al 2008).

During data collection, trees are identified to the most specific taxonomic classification possible. Trees that are not classified to the species level may be classified by genus (e.g., ash) or species groups (e.g., hardwood). In this report, tree species, genera, or species groups are collectively referred to as tree species.

Tree Characteristics:

Leaf area of trees was assessed using measurements of crown dimensions and percentage of crown canopy missing. In the event that these data variables were not collected, they are estimated by the model.

An analysis of invasive species is not available for studies outside of the United States. For the U.S., invasive species are identified using an invasive species list (Virginia Native Plant Society and Department of Conservation and Recreation 2009) for the state in which the urban forest is located. These lists are not exhaustive and they cover invasive species of varying degrees of invasiveness and distribution. In instances where a state did not have an invasive species list, a list was created based on the lists of the adjacent states. Tree species that are identified as invasive by the state invasive species list are cross-referenced with native range data. This helps eliminate species that are on the state invasive species list, but are native to the study area.

Air Pollution Removal:

Pollution removal is calculated for ozone, sulfur dioxide, nitrogen dioxide, carbon monoxide and particulate matter less than 2.5 microns. Particulate matter less than 10 microns (PM10) is another significant air pollutant. Given that i-Tree Eco analyzes particulate matter less than 2.5 microns (PM2.5) which is a subset of PM10, PM10 has not been included in this analysis. PM2.5 is generally more relevant in discussions concerning air pollution effects on human health.

Air pollution removal estimates are derived from calculated hourly tree-canopy resistances for ozone, and sulfur and nitrogen dioxides based on a hybrid of big-leaf and multi-layer canopy deposition models (Baldocchi 1988; Baldocchi et al 1987). As the removal of carbon monoxide and particulate matter by vegetation is not directly related to transpiration, removal rates (deposition velocities) for these pollutants were based on average measured values from the literature (Bidwell and Fraser 1972; Lovett 1994) that were adjusted depending on leaf phenology and leaf area. Particulate removal incorporated a 50 percent resuspension rate of particles back to the atmosphere (Zinke 1967). Recent updates (2011) to air quality modeling are based on improved leaf area index simulations, weather and pollution processing and interpolation, and updated pollutant monetary values (Hirabayashi et al 2011; Hirabayashi et al 2012; Hirabayashi 2011).

Trees remove PM2.5 when particulate matter is deposited on leaf surfaces (Nowak et al 2013). This deposited PM2.5 can be resuspended to the atmosphere or removed during rain events and dissolved or transferred to the soil. This combination of events can lead to positive or negative pollution removal and value depending on various atmospheric factors. Generally, PM2.5 removal is positive with positive benefits. However, there are some cases when net removal is negative or resuspended particles lead to increased pollution concentrations and negative values. During some months (e.g., with no rain), trees resuspend more particles than they remove. Resuspension can also lead to increased overall PM2.5 concentrations if the boundary layer conditions are lower during net resuspension periods than during net removal periods. Since the pollution removal value is based on the change in pollution concentration, it is possible to have situations when trees remove PM2.5 but increase concentrations and thus have negative values during periods of positive overall removal. These events are not common, but can happen.

For reports in the United States, default air pollution removal value is calculated based on local incidence of adverse health effects and national median externality costs. The number of adverse health effects and associated economic value is calculated for ozone, sulfur dioxide, nitrogen dioxide, and particulate matter less than 2.5 microns using data from the U.S. Environmental Protection Agency's Environmental Benefits Mapping and Analysis Program (BenMAP) (Nowak et al 2014). The model uses a damage-function approach that is based on the local change in pollution concentration and population. National median externality costs were used to calculate the value of carbon monoxide removal (Murray et al 1994).

For international reports, user-defined local pollution values are used. For international reports that do not have local values, estimates are based on either European median externality values (van Essen et al 2011) or BenMAP regression equations (Nowak et al 2014) that incorporate user-defined population estimates. Values are then converted to local currency with user-defined exchange rates.

For this analysis, pollution removal value is calculated based on the prices of $1,327 per ton (carbon monoxide), $3,681 per ton (ozone), $742 per ton (nitrogen dioxide), $195 per ton (sulfur dioxide), $159,134 per ton (particulate matter less than 2.5 microns).

Carbon Storage and Sequestration:

Carbon storage is the amount of carbon bound up in the above-ground and below-ground parts of woody vegetation. To calculate current carbon storage, biomass for each tree was calculated using equations from the literature and measured tree data. Open-grown, maintained trees tend to have less biomass than predicted by forest-derived biomass equations (Nowak 1994). To adjust for this difference, biomass results for open-grown urban trees were multiplied by 0.8. No adjustment was made for trees found in natural stand conditions. Tree dry-weight biomass was converted to stored carbon by multiplying by 0.5.

Carbon sequestration is the removal of carbon dioxide from the air by plants. To estimate the gross amount of carbon sequestered annually, average diameter growth from the appropriate genera and diameter class and tree condition was added to the existing tree diameter (year x) to estimate tree diameter and carbon storage in year x+1.

Carbon storage and carbon sequestration values are based on estimated or customized local carbon values. For international reports that do not have local values, estimates are based on the carbon value for the United States (U.S. Environmental Protection Agency 2015, Interagency Working Group on Social Cost of Carbon 2015) and converted to local currency with user-defined exchange rates.

For this analysis, carbon storage and carbon sequestration values are calculated based on $171 per ton.

Oxygen Production:

The amount of oxygen produced is estimated from carbon sequestration based on atomic weights: net $O_2$ release (kg/yr) = net C sequestration (kg/yr) × 32/12. To estimate the net carbon sequestration rate, the amount of carbon sequestered as a result of tree growth is reduced by the amount lost resulting from tree mortality. Thus, net carbon sequestration and net annual oxygen production of the urban forest account for decomposition (Nowak et al 2007). For complete inventory projects, oxygen production is estimated from gross carbon sequestration and does not account for decomposition.

Avoided Runoff:

Annual avoided surface runoff is calculated based on rainfall interception by vegetation, specifically the difference between annual runoff with and without vegetation. Although tree leaves, branches, and bark may intercept precipitation and thus mitigate surface runoff, only the precipitation intercepted by leaves is accounted for in this analysis.

The value of avoided runoff is based on estimated or user-defined local values. For international reports that do not have local values, the national average value for the United States is utilized and converted to local currency with user-defined exchange rates. The U.S. value of avoided runoff is based on the U.S. Forest Service's Community Tree Guide Series (McPherson et al 1999; 2000; 2001; 2002; 2003; 2004; 2006a; 2006b; 2006c; 2007; 2010; Peper et al 2009; 2010; Vargas et al 2007a; 2007b; 2008).

For this analysis, avoided runoff value is calculated based on the price of \$0.07 per $ft^3$.

Building Energy Use:

If appropriate field data were collected, seasonal effects of trees on residential building energy use were calculated based on procedures described in the literature (McPherson and Simpson 1999) using distance and direction of trees from residential structures, tree height and tree condition data. To calculate the monetary value of energy savings, local or custom prices per MWH or MBTU are utilized.

For this analysis, energy saving value is calculated based on the prices of \$127.40 per MWH and \$12.09 per MBTU.

Replacement Values:

Replacement value is the value of a tree based on the physical resource itself (e.g., the cost of having to replace a tree with a similar tree). Replacement values were based on valuation procedures of the Council of Tree and Landscape Appraisers, which uses tree species, diameter, condition, and location information (Nowak et al 2002a; 2002b). Replacement value may not be included for international projects if there is insufficient local data to complete the valuation procedures.

Potential Pest Impacts:

The complete potential pest risk analysis is not available for studies outside of the United States. The number of trees at risk to the pests analyzed is reported, though the list of pests is based on known insects and disease in the United States.

For the U.S., potential pest risk is based on pest range maps and the known pest host species that are likely to experience mortality. Pest range maps for 2012 from the Forest Health Technology Enterprise Team (FHTET) (Forest Health Technology Enterprise Team 2014) were used to determine the proximity of each pest to the county in which the urban forest is located. For the county, it was established whether the insect/disease occurs within the county, is within 250 miles of the county edge, is between 250 and 750 miles away, or is greater than 750 miles away. FHTET did not have pest range maps for Dutch elm disease and chestnut blight. The range of these pests was based on known occurrence and the host range, respectively (Eastern Forest Environmental Threat Assessment Center; Worrall 2007).

Relative Tree Effects:

The relative value of tree benefits reported in Appendix II is calculated to show what carbon storage and sequestration, and air pollutant removal equate to in amounts of municipal carbon emissions, passenger automobile emissions, and house emissions.

Municipal carbon emissions are based on 2010 U.S. per capita carbon emissions (Carbon Dioxide Information Analysis

Center 2010). Per capita emissions were multiplied by city population to estimate total city carbon emissions.

Light duty vehicle emission rates (g/mi) for CO, NOx, VOCs, PM10, SO2 for 2010 (Bureau of Transportation Statistics 2010; Heirigs et al 2004), PM2.5 for 2011-2015 (California Air Resources Board 2013), and CO2 for 2011 (U.S. Environmental Protection Agency 2010) were multiplied by average miles driven per vehicle in 2011 (Federal Highway Administration 2013) to determine average emissions per vehicle.

Household emissions are based on average electricity kWh usage, natural gas Btu usage, fuel oil Btu usage, kerosene Btu usage, LPG Btu usage, and wood Btu usage per household in 2009 (Energy Information Administration 2013; Energy Information Administration 2014)

- CO2, SO2, and NOx power plant emission per KWh are from Leonardo Academy 2011. CO emission per kWh assumes 1/3 of one percent of C emissions is CO based on Energy Information Administration 1994. PM10 emission per kWh from Layton 2004.
- CO2, NOx, SO2, and CO emission per Btu for natural gas, propane and butane (average used to represent LPG), Fuel #4 and #6 (average used to represent fuel oil and kerosene) from Leonardo Academy 2011.
- CO2 emissions per Btu of wood from Energy Information Administration 2014.
- CO, NOx and SOx emission per Btu based on total emissions and wood burning (tons) from (British Columbia Ministry 2005; Georgia Forestry Commission 2009).

# Appendix II. Relative Tree Effects

The urban forest in Charlottesville_TCA provides benefits that include carbon storage and sequestration, and air pollutant removal. To estimate the relative value of these benefits, tree benefits were compared to estimates of average municipal carbon emissions, average passenger automobile emissions, and average household emissions. See Appendix I for methodology.

Carbon storage is equivalent to:

- Amount of carbon emitted in Charlottesville_TCA in 6 days
- Annual carbon (C) emissions from 3,140 automobiles
- Annual C emissions from 1,290 single-family houses

Carbon monoxide removal is equivalent to:

- Annual carbon monoxide emissions from 0 automobiles
- Annual carbon monoxide emissions from 1 single-family houses

Nitrogen dioxide removal is equivalent to:

- Annual nitrogen dioxide emissions from 34 automobiles
- Annual nitrogen dioxide emissions from 15 single-family houses

Sulfur dioxide removal is equivalent to:

- Annual sulfur dioxide emissions from 294 automobiles
- Annual sulfur dioxide emissions from 1 single-family houses

Annual carbon sequestration is equivalent to:

- Amount of carbon emitted in Charlottesville_TCA in 0.1 days
- Annual C emissions from 100 automobiles
- Annual C emissions from 0 single-family houses

# Appendix III. Comparison of Urban Forests

A common question asked is, "How does this city compare to other cities?" Although comparison among cities should be made with caution as there are many attributes of a city that affect urban forest structure and functions, summary data are provided from other cities analyzed using the i-Tree Eco model.

## I. City totals for trees

| *City* | *% Tree Cover* | *Number of Trees* | *Carbon Storage (tons)* | *Carbon Sequestration (tons/yr)* | *Pollution Removal (tons/yr)* |
|---|---|---|---|---|---|
| Toronto, ON, Canada | 26.6 | 10,220,000 | 1,221,000 | 51,500 | 2,099 |
| Atlanta, GA | 36.7 | 9,415,000 | 1,344,000 | 46,400 | 1,663 |
| Los Angeles, CA | 11.1 | 5,993,000 | 1,269,000 | 77,000 | 1,975 |
| New York, NY | 20.9 | 5,212,000 | 1,350,000 | 42,300 | 1,676 |
| London, ON, Canada | 24.7 | 4,376,000 | 396,000 | 13,700 | 408 |
| Chicago, IL | 17.2 | 3,585,000 | 716,000 | 25,200 | 888 |
| Phoenix, AZ | 9.0 | 3,166,000 | 315,000 | 32,800 | 563 |
| Baltimore, MD | 21.0 | 2,479,000 | 570,000 | 18,400 | 430 |
| Philadelphia, PA | 15.7 | 2,113,000 | 530,000 | 16,100 | 575 |
| Washington, DC | 28.6 | 1,928,000 | 525,000 | 16,200 | 418 |
| Oakville, ON , Canada | 29.1 | 1,908,000 | 147,000 | 6,600 | 190 |
| Albuquerque, NM | 14.3 | 1,846,000 | 332,000 | 10,600 | 248 |
| Boston, MA | 22.3 | 1,183,000 | 319,000 | 10,500 | 283 |
| Syracuse, NY | 26.9 | 1,088,000 | 183,000 | 5,900 | 109 |
| Woodbridge, NJ | 29.5 | 986,000 | 160,000 | 5,600 | 210 |
| Minneapolis, MN | 26.4 | 979,000 | 250,000 | 8,900 | 305 |
| San Francisco, CA | 11.9 | 668,000 | 194,000 | 5,100 | 141 |
| Morgantown, WV | 35.5 | 658,000 | 93,000 | 2,900 | 72 |
| Moorestown, NJ | 28.0 | 583,000 | 117,000 | 3,800 | 118 |
| Hartford, CT | 25.9 | 568,000 | 143,000 | 4,300 | 58 |
| Jersey City, NJ | 11.5 | 136,000 | 21,000 | 890 | 41 |
| Casper, WY | 8.9 | 123,000 | 37,000 | 1,200 | 37 |
| Freehold, NJ | 34.4 | 48,000 | 20,000 | 540 | 22 |

## II. Totals per acre of land area

| *City* | *Number of Trees/ac* | *Carbon Storage (tons/ac)* | *Carbon Sequestration (tons/ac/yr)* | *Pollution Removal (lb/ac/yr)* |
|---|---|---|---|---|
| Toronto, ON, Canada | 64.9 | 7.8 | 0.33 | 26.7 |
| Atlanta, GA | 111.6 | 15.9 | 0.55 | 39.4 |
| Los Angeles, CA | 19.6 | 4.2 | 0.16 | 13.1 |
| New York, NY | 26.4 | 6.8 | 0.21 | 17.0 |
| London, ON, Canada | 75.1 | 6.8 | 0.24 | 14.0 |
| Chicago, IL | 24.2 | 4.8 | 0.17 | 12.0 |
| Phoenix, AZ | 12.9 | 1.3 | 0.13 | 4.6 |
| Baltimore, MD | 48.0 | 11.1 | 0.36 | 16.6 |
| Philadelphia, PA | 25.1 | 6.3 | 0.19 | 13.6 |
| Washington, DC | 49.0 | 13.3 | 0.41 | 21.2 |
| Oakville, ON , Canada | 78.1 | 6.0 | 0.27 | 11.0 |
| Albuquerque, NM | 21.8 | 3.9 | 0.12 | 5.9 |
| Boston, MA | 33.5 | 9.1 | 0.30 | 16.1 |
| Syracuse, NY | 67.7 | 10.3 | 0.34 | 13.6 |
| Woodbridge, NJ | 66.5 | 10.8 | 0.38 | 28.4 |
| Minneapolis, MN | 26.2 | 6.7 | 0.24 | 16.3 |
| San Francisco, CA | 22.5 | 6.6 | 0.17 | 9.5 |
| Morgantown, WV | 119.2 | 16.8 | 0.52 | 26.0 |
| Moorestown, NJ | 62.1 | 12.4 | 0.40 | 25.1 |
| Hartford, CT | 50.4 | 12.7 | 0.38 | 10.2 |
| Jersey City, NJ | 14.4 | 2.2 | 0.09 | 8.6 |
| Casper, WY | 9.1 | 2.8 | 0.09 | 5.5 |
| Freehold, NJ | 38.3 | 16.0 | 0.44 | 35.3 |

# Appendix IV. General Recommendations for Air Quality Improvement

Urban vegetation can directly and indirectly affect local and regional air quality by altering the urban atmosphere environment. Four main ways that urban trees affect air quality are (Nowak 1995):

- Temperature reduction and other microclimate effects
- Removal of air pollutants
- Emission of volatile organic compounds (VOC) and tree maintenance emissions
- Energy effects on buildings

The cumulative and interactive effects of trees on climate, pollution removal, and VOC and power plant emissions determine the impact of trees on air pollution. Cumulative studies involving urban tree impacts on ozone have revealed that increased urban canopy cover, particularly with low VOC emitting species, leads to reduced ozone concentrations in cities (Nowak 2000). Local urban management decisions also can help improve air quality.

Urban forest management strategies to help improve air quality include (Nowak 2000):

| *Strategy* | *Result* |
|---|---|
| Increase the number of healthy trees | Increase pollution removal |
| Sustain existing tree cover | Maintain pollution removal levels |
| Maximize use of low VOC-emitting trees | Reduces ozone and carbon monoxide formation |
| Sustain large, healthy trees | Large trees have greatest per-tree effects |
| Use long-lived trees | Reduce long-term pollutant emissions from planting and removal |
| Use low maintenance trees | Reduce pollutants emissions from maintenance activities |
| Reduce fossil fuel use in maintaining vegetation | Reduce pollutant emissions |
| Plant trees in energy conserving locations | Reduce pollutant emissions from power plants |
| Plant trees to shade parked cars | Reduce vehicular VOC emissions |
| Supply ample water to vegetation | Enhance pollution removal and temperature reduction |
| Plant trees in polluted or heavily populated areas | Maximizes tree air quality benefits |
| Avoid pollutant-sensitive species | Improve tree health |
| Utilize evergreen trees for particulate matter | Year-round removal of particles |

# Appendix V. Invasive Species of the Urban Forest

The following inventoried tree species were listed as invasive on the Virginia invasive species list (Virginia Native Plant Society and Department of Conservation and Recreation 2009):

| Species Name[a] | *Number of Trees* | *% of Trees* | *Leaf Area (ac)* | *Percent Leaf Area* |
|---|---|---|---|---|
| Norway maple | 19 | 0.2 | 1.7 | 0.3 |
| Tree of heaven | 17 | 0.2 | 1.3 | 0.2 |
| Persian silk tree | 12 | 0.2 | 0.3 | 0.1 |
| White mulberry | 1 | 0.0 | 0.0 | 0.0 |
| **Total** | **49** | **0.63** | **3.32** | **0.52** |

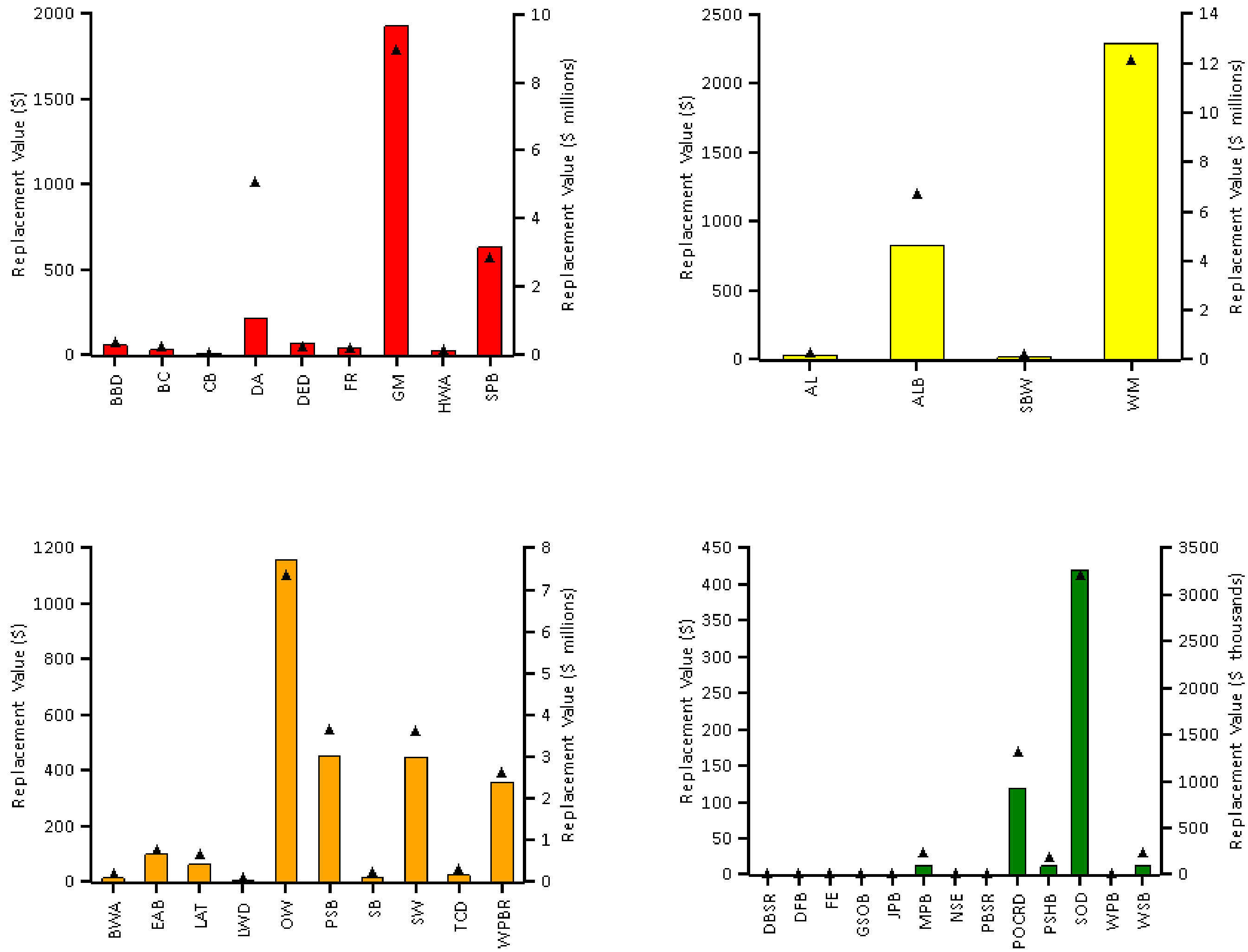
[a]Species are determined to be invasive if they are listed on the state's invasive species list

## Appendix VI. Potential Risk of Pests

Thirty-six insects and diseases were analyzed to quantify their potential impact on the urban forest. As each insect/disease is likely to attack different host tree species, the implications for {0} will vary. The number of trees at risk reflects only the known host species that are likely to experience mortality.

| Code | Scientific Name | Common Name | Trees at Risk (#) | Value ($ millions) |
|---|---|---|---|---|
| AL | Phyllocnistis populiella | Aspen Leafminer | 38 | 0.17 |
| ALB | Anoplophora glabripennis | Asian Longhorned Beetle | 1,194 | 4.62 |
| BBD | Neonectria faginata | Beech Bark Disease | 72 | 0.29 |
| BC | Sirococcus clavigignenti juglandacearum | Butternut Canker | 41 | 0.17 |
| BWA | Adelges piceae | Balsam Woolly Adelgid | 27 | 0.09 |
| CB | Cryphonectria parasitica | Chestnut Blight | 6 | 0.05 |
| DA | Discula destructiva | Dogwood Anthracnose | 1,013 | 1.09 |
| DBSR | Leptographium wageneri var. pseudotsugae | Douglas-fir Black Stain Root Disease | 0 | 0.00 |
| DED | Ophiostoma novo-ulmi | Dutch Elm Disease | 42 | 0.37 |
| DFB | Dendroctonus pseudotsugae | Douglas-Fir Beetle | 0 | 0.00 |
| EAB | Agrilus planipennis | Emerald Ash Borer | 113 | 0.67 |
| FE | Scolytus ventralis | Fir Engraver | 0 | 0.00 |
| FR | Cronartium quercuum f. sp. Fusiforme | Fusiform Rust | 37 | 0.23 |
| GM | Lymantria dispar | Gypsy Moth | 1,783 | 9.64 |
| GSOB | Agrilus auroguttatus | Goldspotted Oak Borer | 0 | 0.00 |
| HWA | Adelges tsugae | Hemlock Woolly Adelgid | 23 | 0.15 |
| JPB | Dendroctonus jeffreyi | Jeffrey Pine Beetle | 0 | 0.00 |
| LAT | Choristoneura conflictana | Large Aspen Tortrix | 96 | 0.42 |
| LWD | Raffaelea lauricola | Laurel Wilt | 9 | 0.03 |
| MPB | Dendroctonus ponderosae | Mountain Pine Beetle | 28 | 0.10 |
| NSE | Ips perturbatus | Northern Spruce Engraver | 0 | 0.00 |
| OW | Ceratocystis fagacearum | Oak Wilt | 1,098 | 7.70 |
| PBSR | Leptographium wageneri var. ponderosum | Pine Black Stain Root Disease | 0 | 0.00 |
| POCRD | Phytophthora lateralis | Port-Orford-Cedar Root Disease | 168 | 0.92 |
| PSB | Tomicus piniperda | Pine Shoot Beetle | 543 | 3.00 |
| PSHB | Euwallacea nov. sp. | Polyphagous Shot Hole Borer | 22 | 0.09 |
| SB | Dendroctonus rufipennis | Spruce Beetle | 32 | 0.11 |
| SBW | Choristoneura fumiferana | Spruce Budworm | 28 | 0.09 |
| SOD | Phytophthora ramorum | Sudden Oak Death | 411 | 3.26 |
| SPB | Dendroctonus frontalis | Southern Pine Beetle | 568 | 3.16 |
| SW | Sirex noctilio | Sirex Wood Wasp | 540 | 2.99 |
| TCD | Geosmithia morbida | Thousand Canker Disease | 41 | 0.17 |
| WM | Operophtera brumata | Winter Moth | 2,155 | 12.80 |
| WPB | Dendroctonus brevicomis | Western Pine Beetle | 0 | 0.00 |
| WPBR | Cronartium ribicola | White Pine Blister Rust | 391 | 2.40 |
| WSB | Choristoneura occidentalis | Western Spruce Budworm | 28 | 0.10 |

In the following graph, the pests are color coded according to the county's proximity to the pest occurrence in the United States. Red indicates that the pest is within the county; orange indicates that the pest is within 250 miles of the county; yellow indicates that the pest is within 750 miles of the county; and green indicates that the pest is outside of these ranges.




Note: points - Number of trees, bars - Replacement value

Based on the host tree species for each pest and the current range of the pest (Forest Health Technology Enterprise Team 2014), it is possible to determine what the risk is that each tree species in the urban forest could be attacked by an insect or disease.

| Spp. Risk | Risk Weight | Species Name | AL | ALB | BBD | BC | BWA | CB | DA | DBSR | DED | DFB | EAB | FE | FR | GM | GSOB | HWA | JPB | LAT | LWD | MPB | NSE | OW | PBSR | POCRD | PSB | PSHB | SB | SBW | SOD | SPB | SW | TCD | WM | WPB | WPBR | WSB |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 20 | Norway spruce | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 14 | Pitch pine | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 14 | Loblolly pine | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 13 | Eastern white pine | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 13 | Coastal plain willow | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 12 | Scots pine | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 11 | River birch | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 10 | Northern red oak | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 10 | Pin oak | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 10 | Southern red oak | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 10 | Virginia pine | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 10 | Shortleaf pine | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 10 | spruce spp | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 10 | Spruce pine | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 10 | Table mountain pine | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 9 | White oak | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 9 | Willow oak | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 9 | Swamp white oak | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 9 | Shumard oak | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 9 | Boxelder | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 9 | Scarlet oak | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 9 | Bur oak | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 9 | Chestnut oak | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 9 | Black oak | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 9 | Overcup oak | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 9 | Post oak | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 9 | Live oak | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 9 | Water oak | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 9 | Chinkapin oak | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 9 | Laurel oak | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 9 | Red spruce | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 8 | American beech | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 8 | American elm | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 8 | Eastern hemlock | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 8 | English oak | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 8 | Carolina hemlock | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 7 | Black walnut | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

| | | |
|---|---|---|
| | 7 | plum spp |
| | 7 | Sawtooth oak |
| | 7 | Green ash |
| | 7 | Texas red oak |
| | 7 | Brewer spruce |
| | 6 | Chinese elm |
| | 6 | apple spp |
| | 6 | American basswood |
| | 6 | Washington hawthorn |
| | 5 | White ash |
| | 5 | European beech |
| | 5 | Witch hazel |
| | 5 | Pacific dogwood |
| | 5 | Black ash |
| | 4 | Flowering dogwood |
| | 4 | Red maple |
| | 4 | Sugar maple |
| | 4 | Sweetgum |
| | 4 | Green hawthorn |
| | 4 | Callery pear |
| | 4 | Kousa dogwood |
| | 4 | Littleleaf linden |
| | 4 | Silver maple |
| | 4 | Eastern service berry |
| | 4 | Norway maple |
| | 4 | Eastern hophornbeam |
| | 4 | European crabapple |
| | 4 | American chestnut |
| | 4 | Alternateleaf dogwood |
| | 4 | Biltmore crabapple |
| | 4 | Indian Summer crabapple |
| | 4 | Striped maple |
| | 3 | Sassafras |
| | 3 | Horse chestnut |
| | 2 | Northern hackberry |
| | 2 | Black cherry |
| | 2 | Green mountain sugar maple |

| | | |
|---|---|---|
| | 2 | Purple blow maple |
| | 2 | Persian silk tree |
| | 2 | Japanese maple |
| | 2 | Katsura tree |
| | 2 | Paperbark maple |
| | 2 | October glory red maple |
| | 2 | Canada plum |
| | 2 | Common plum |
| | 2 | Trident maple |
| | 2 | Yellow buckeye |
| | 1 | Northern white cedar |
| | 1 | Port orford cedar |

Note:
Species that are not listed in the matrix are not known to be hosts to any of the pests analyzed.

Species Risk:

- Red indicates that tree species is at risk to at least one pest within county
- Orange indicates that tree species has no risk to pests in county, but has a risk to at least one pest within 250 miles from the county
- Yellow indicates that tree species has no risk to pests within 250 miles of county, but has a risk to at least one pest that is 250 and 750 miles from the county
- Green indicates that tree species has no risk to pests within 750 miles of county, but has a risk to at least one pest that is greater than 750 miles from the county

Risk Weight:
Numerical scoring system based on sum of points assigned to pest risks for species. Each pest that could attack tree species is scored as 4 points if red, 3 points if orange, 2 points if yellow and 1 point if green.

Pest Color Codes:

- Red indicates pest is within Charlottesville county
- Red indicates pest is within 250 miles county
- Yellow indicates pest is within 750 miles of Charlottesville county
- Green indicates pest is outside of these ranges

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**CHARLOTTESVILLE TREE COMMISSION**
**3/2022**

**The purpose of the City of Charlottesville Tree Commission ("Commission") is to advise and assist City Council, the Planning Commission, and City staff in the planting, protection, preservation of trees located on public right-of-ways and public property.** In monitoring these public trees, the Commission strives to protect and improve the urban forest to provide better quality of life and health outcomes for City residents and to secure meaningful environmental and aesthetic benefits.

**TC Objectives—**

- Advise | Educate | Advocate
- Plant | Preserve | Commemorate
- Monitor | Review | Seek Compliance

**TC Annual Goals—**Committees will establish goals and an action plan for review by the Commission to ensure that its overall objectives are being met

**Committee Structure & Composition—**

***Education & Advocacy***

- Educate community at all levels on the range of benefits of urban trees
- Advocate at all levels of government for funding and support for trees
- Collaborate with groups with aligned goals for the urban forest, sustainability, environment/climate—Cville Climate Collaborative, CATS, Master Naturalists, Public Works
- Monitor and review Tree Commission and Urban Forestry webpages and provide social media and email (Utility Notes) content for city communications office to post
- Develop strategies and execute projects to increase urban canopy through public and private planting initiatives

***Members: Mark Rylander (chair), Peggy Van Yahres ( Chair of Commission), Holly Lafferty, Jean Umiker-Seboek***

***Arbor***

- Maintain and evaluate performance measures for city trees through review of the Commission's annual tree data report
- Review City Arborist's annual tree planting list and work plan and provide input as needed
- Manage tree nominations process to recognize significant trees and encourage preservation
- Work with City Arborist and CATS to commemorate a significant tree on Arbor Day
- Coordinate with City Arborist on Urban Canopy Assessment

***Members: Jeff Aten, (chair and Vice Chair of Commission), Mark Zollinhofer (CATS), Donna Shaunesey, Makshya Tolbert***

*Codes & Practices*

- Provide input to city planning [code/ordinances, Comprehensive Plan, zoning ordinances, SDM, BMPs]
- Work with City Arborist to update and maintain City Tree List and revise Urban Forest Management Plan
- Review tree legislation and ordinances in other localities
- Review and comment on site plans
- Represent TC on roadway projects (esp. entry corridors/gateways)

***Members: Vicky Metcalf, (chair), Tim Padalino, Jeff Pacelli, Brian Menard***

**In general—**

- Committees should meet to review TC and committee objectives and develop a list of attainable goals and an action plan for the year
- Committees lead but all commissioners can participate in supporting the action plan and projects (e.g., tree-planting, serving as liaisons, nominating trees, attending public hearings)

Tree Commission questions for NDS and Public Works

NDS

Site plan application and approval process:

How can you ensure that the site development process includes effective review for natural resource protection and tree preservation? It appears that NDS does not have staff solely or primarily tasked with this. Is there a plan for designating or hiring staff to do this?

When is a landscape plan required to be part of a site plan application? Is the landscape plan done only after the site plan has been approved?

Who applies the Site Plan Checklist? Is there a landscape architect on staff?

Is the BMP checklist for trees used? How do you enforce BMP's? What needs to be changed in the zoning code to make this process work better?

Are the city's Stormwater BMPs ever enforced on projects?

The city has strong BMPs for tree preservation. These include requirements for tree protection plans to show proposed/existing utilities and proposed grading and foundations in preserved root zones, replacement requirements associated with preserved trees that were removed, mulch over tree protection zones, etc. How can these be enforced?

If preserved trees are removed and it is determined there is not enough room to meet BMP replacement quantities, can the contractor pay to a dedicated tree fund?

In 2019 the Tree commission made a number of recommendations concerning the species and locations of the trees on the site plan for Friendship Court. It appears that these recommendations were not considered. Can the Tree Commission still have input into phase one and future phases of Friendship Court?

City Code Section 34-866 requires developers to make reasonable efforts to preserve certain trees and states that "[t]he planning commission or the director shall refuse to approve any site plan that proposes unnecessary destruction of trees or other natural features." Is this provision enforced?

Critical Root Zones:

Tree roots do not all grow in a perfect circle, as there are boundaries in the landscape that redirect roots. What efforts are made to identify such boundaries and to draw Critical Root Zones as they actually appear in the landscape? Circles in many cases are wholly inaccurate and misleading, and lead to tree death.

Sediment and Erosion Control:

How are tree preservation plans coordinated with sediment and control plans to ensure that trees are not damaged when installing sediment fencing? Are trenchless systems required when bisecting critical root zone?

Public Works

Utilities:

How is tree preservation taken into account when installing utilities? Are utility alignments reviewed during tree preservation efforts? Is directional boring required?

UVA (and various city entrance corridors) allows small understory and easily removed trees over top of underground utilities (assuming there is depth to plant the trees). Given the infrequency of major line replacement, would Utilities consider this?

Some urban areas, such as Richmond, have a minimum underground utility offset as low as 3' to encourage more city canopy. Public Works has informally approved as low as 5' in the past if tree root barriers were used to help direct roots away from utility lines although more recent site plan comments have gone back to a hard 10' easement, significantly reducing the ability to plant trees on new projects. Is a more flexible easement definition possible in the new ordinances to encourage more canopy in the city?

Communication and Collaboration

Can we have a representative from Public Works attend our meetings? We so often have not communicated or worked together on common issues particularly with the PWs Sustainability Section.

How can we better collaborate?

# Charlottesville Tree Commission

| ROSTER | | |
|---|---|---|
| **Member** | **Representing** | **Current Term(*)** |
| Jody Lahendro | Planning Commission | 1/1/20—8/31/**22** |
| Mark Zollinhofer | CATS | 6/16/20 – 11/30/**22** |
| Peggy Van Yahres, *Chair* | At Large | 4/1/20 – 3/31/**23** |
| Mark Rylander | At Large | 4/1/20 – 3/31/**23** |
| Jeff Pacelli | At Large | 6/16/20 – 3/31/**23** |
| Makshya Tolbert | At Large | 3/22/22 – 3/31/**23** |
| Jeff Aten, *Vice Chair* | At Large | 4/1/21 – 3/31/**24** |
| Victoria Metcalf | At Large | 4/1/21 – 3/31/**24** |
| Jean Umiker-Sebeok | At Large | 4/1/21 – 3/31/**24** |
| Holly Lafferty | LIN (Belmont) | 4/1/22 – 3/31/**25** |
| Tim Padalino | LIN (10th & Page) | 4/1/22 – 3/31/**25** |
| Donna Shaunesey | At Large | 4/1/22 – 3/31/**25** |
| *Vacant* | *Urban Forester* | *Ex Officio (Staff Liaison)* |

*(*) All members are eligible for an additional term except Padalino, Rylander, and Van Yahres.*

*Planning Commission will select one of its members to replace Lahendro.*

# Charlottesville Tree Commission

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