URBAN TREE CANOPY
ASSESSMENT

ROANOKE VALLEY, VIRGINIA
FEBRUARY | 2024

ROANOKE VALLEY, VIRGINIA

TREE CANOPY ASSESSMENT

> **To be without trees would, in the most literal way, to be without our roots.**
>
> **-RICHARD MABEY**

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132,569
ACRES OF CANOPY

67%
OF ROANOKE VALLEY'S LAND AREA WAS COVERED WITH CANOPY IN 2021

EXECUTIVE ━━━
SUMMARY

BACKGROUND OF THIS ANALYSIS

Urban tree canopies are in perpetual motion. New tree plantings and existing tree growth add canopy, while development, natural disasters, disease, and pests take it away. These changes can be difficult to gauge from the ground, but tree canopy change can be precisely tracked by analyzing aerial imagery from the past and present. This assessment evaluated urban tree canopy (UTC) and possible planting area (PPA) in 2021 within the Roanoke Valley Region, located in the heart of western Virginia's Blue Ridge Mountains. This metropolitan area is one of the largest urban expanses in Virginia, home to over 300,000 residents.

The Roanoke Valley boundary encompasses four distinct jurisdictions - the City of Roanoke, Roanoke County, the City of Salem, and the Town of Vinton. Each municipality has been individually recognized as a Tree City member for many years, Roanoke City for 28 years, Roanoke County for 25 years, Salem City for 24 years, and Town of Vinton for 21 years. This award shows their commitment to their trees and natural environment. The urban forest is an invaluable asset for the Roanoke Valley Region that encompasses these jurisdictions, providing residents and visitors

with meaningful, quantifiable environmental, social, and economic benefits. Individual Roanoke Valley jurisdictions and their stakeholders can utilize the results of this assessment by creating or amending canopy goals, policies, ordinances, management practices, and priorities. This assessment serves as a strategic compass for future planning efforts by highlighting areas where current efforts work well and where improvement is needed.

PROJECT METHODOLOGY

Based on 2021 imagery from the USDA's National Agriculture Imagery Program (NAIP), the results provide a near-current look at the land cover in Roanoke Valley. They will allow the area to revise existing and develop new strategies to protect and expand the urban forest. This study utilized modern machine learning techniques to create reproducible land cover data and allow a more uniform comparison in future tree canopy and land cover assessments. **This assessment report will follow the standards established by the US Forest Service and report tree canopy metrics as a percentage of the land area (excluding water bodies) unless stated otherwise.**

ROANOKE VALLEY'S URBAN FOREST

In 2021, Roanoke Valley's boundary (which includes Roanoke County, the City of Roanoke, the City of Salem, and the Town of Vinton), excluding bodies of water, had 67% of its land covered with urban tree canopy and 19% available for potential planting. The remaining 14% of the County's land area was deemed unsuitable for planting without substantial land modification. Roanoke Valley,

including water bodies, was categorized by 67% tree canopy, 20% other vegetation, 11% impervious surfaces, and less than 1% each of soil/dry vegetation, water, and shrubs.

Roanoke County covers 80% of the Roanoke Valley area and 90% of the total tree coverage. Of the unified land use types, Single Family Residential and Multi-Family residential accounts for 36% of the overall UTC and 60% of the overall PPA. Out of 155 census block groups, 17 had tree canopy percentages above the Roanoke Valley average of 67%. However, these 17 block groups account for almost 70% of the total land area.
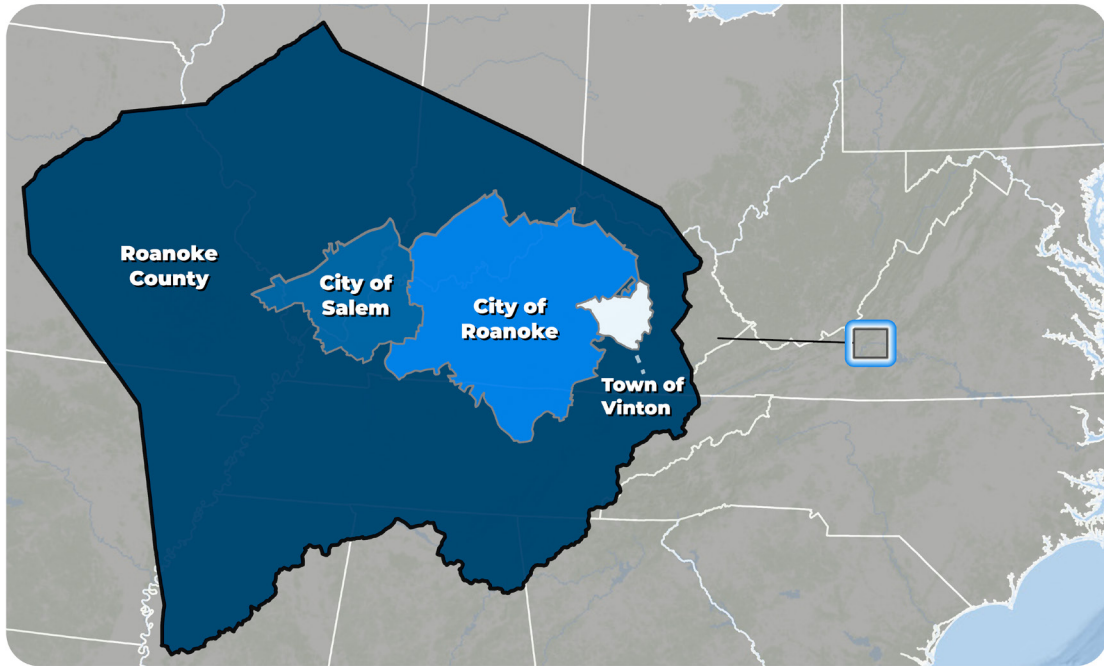

Figure 1. The Roanoke Valley Region occupies approximately 309 square miles in the Blue Ridge Mountains of western Virginia.

RECOMMENDATIONS

Jurisdictions and stakeholders should use this analysis to develop a strategy to protect and expand Roanoke Valley's urban forest. This study revealed that the Roanoke Valley Region contains 132,569 acres of tree canopy. However, together the jurisdictions within Roanoke Valley have a chance to boost tree coverage by nearly a third of its current level, potentially reaching 86% canopy cover. These improvements are made possible by the Region's 37,643 acres of land suitable for planting more trees on public and private properties. Through partnerships, education, and outreach programs to private landowners, Roanoke Valley and its various stakeholders can aim to plant native trees to provide shade in urban areas and increase environmental equity. The Roanoke Valley Region has an exciting opportunity to expand the quality and quantity of its current tree canopy to benefit future generations.
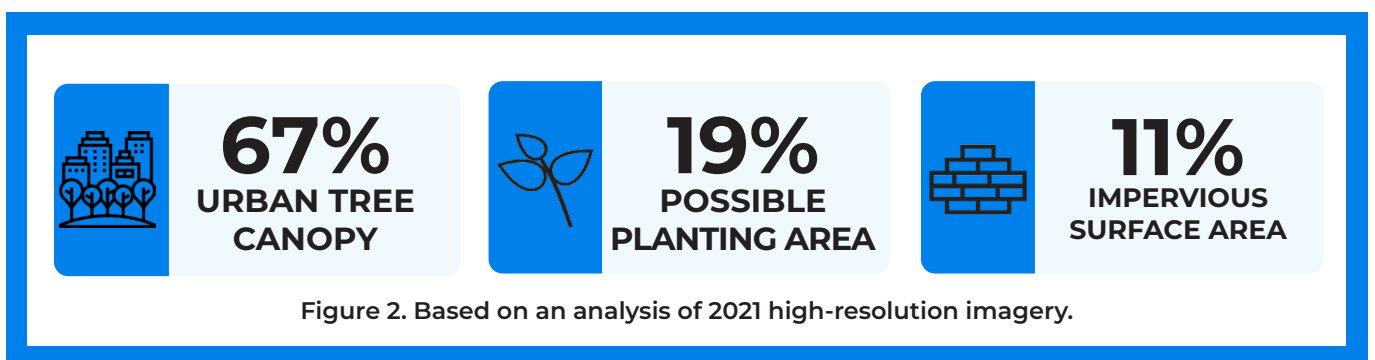

67% URBAN TREE CANOPY   **19%** POSSIBLE PLANTING AREA   **11%** IMPERVIOUS SURFACE AREA

Figure 2. Based on an analysis of 2021 high-resolution imagery.

PROJECT
METHODOLOGY

This study mapped land cover, urban tree canopy, and possible planting areas 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) multi-spectral imagery from the U.S. Department of Agriculture's National Agriculture Imagery Program (NAIP), collected in 2021. The study used NAIP imagery to derive the land cover data and classify all types of land cover described below. Additionally, LiDAR was used to train the AI classification model used in this analysis.

MAPPING LAND COVER

The land cover data set is the most fundamental component of a tree canopy assessment. Tree canopy and land cover data from the EarthDefine US Tree Map (https://www.earthdefine.com/treemap/) provided a six-class land cover data set. EarthDefine produces the US Tree Map using a machine-learning technique to extract tree canopy cover and other land cover types from the latest 2021 NAIP imagery. Figure 3 below describes the six land cover classes identified by this process.

URBAN TREE CANOPY   **SHRUB**   **OTHER VEGETATION**

SOIL AND DRY VEGETATION   **IMPERVIOUS SURFACES**   **SURFACE WATER**

Figure 3. This study identified six (6) unique land cover classes within the 2021 assessment imagery: tree canopy, shrubs, other vegetation, bare soil and dry vegetation, impervious surfaces, and water.

IDENTIFYING POSSIBLE PLANTING AREAS AND UNSUITABLES AREAS FOR PLANTING

In addition to quantifying Roanoke Valley's existing tree canopy cover, the methods of this study also identified possible planting areas (PPA) for new trees by analyzing all non-canopy areas and reclassifying them as either PPA or areas otherwise unsuitable for planting. The process derived PPA from shrubs and other vegetation land cover classes. Unsuitable areas, or areas where it was not feasible to plant trees (e.g., recreation fields, utility corridors, landfills, airports, wastewater treatment areas, golf courses, etc.), were manually delineated and overlaid with the existing land cover data set (Figure 4). This report describes the final classifications as PPA Vegetation, Unsuitable Impervious, Unsuitable Vegetation, Unsuitable Soil, and Water.


Figure 4. The study identified vegetated areas where it would be feasible for tree plantings but undesirable based on their current usage (left) in the data as "Unsuitable" (right).

DEFINING ASSESSMENT LEVELS

Urban tree canopy and other associated metrics were tabulated across several geographic boundaries to inform Roanoke Valley and its stakeholders best. These assessment levels include the **(1) Roanoke Valley Boundary (AOI), (4) jurisdictions, (4) floodplains summarized by jurisdictions, (8) unified land use types, and (155) census block groups.**
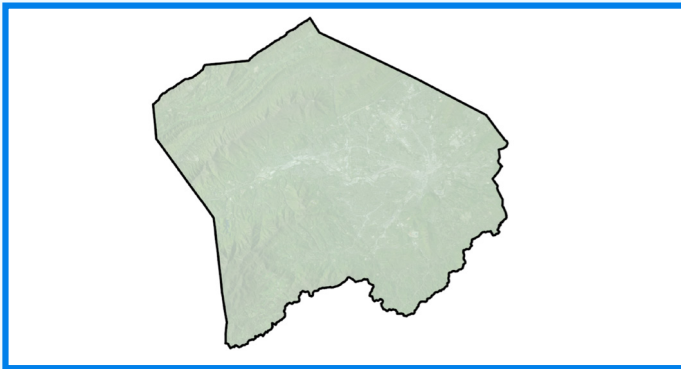

Roanoke Valley (AOI)
The Area of Interest is defined the Roanoke Valley Region boundary that encompasses the jurisdictions of Roanoke County, the City of Roanoke, the City of Salem, and the Town of Vinton. It is the one (1) main AOI over which all metrics are summarized.
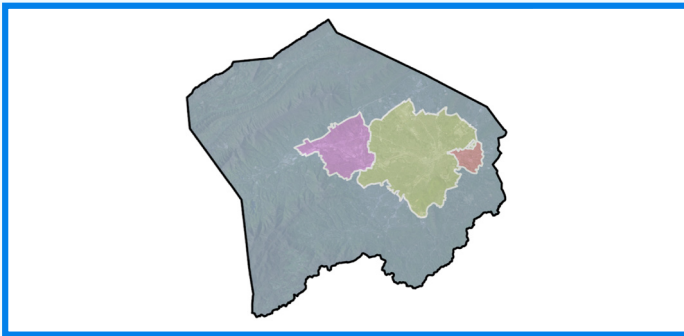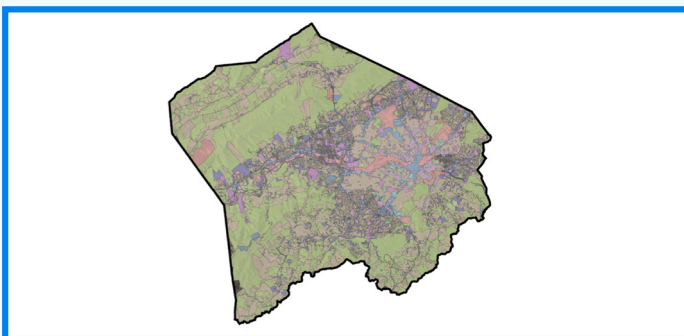

Jurisdictions
Four (4) jurisdictions were assessed to understand how urban forest metrics differ under different management authorities within Roanoke Valley.
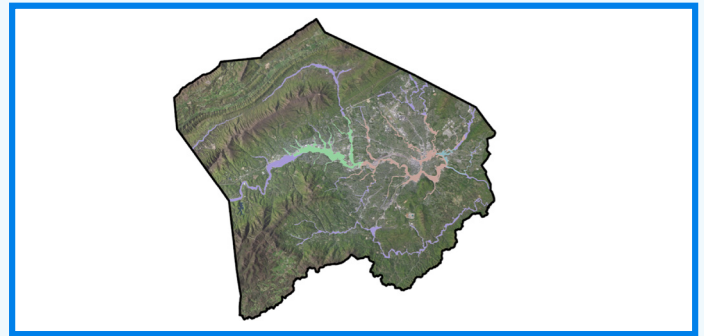
Floodplains by Jurisdictions
Because trees play an important role in stormwater and flood management, floodplains and flood hazard areas were assessed for each of the four (4) jurisdictions.

Unified Land Use
Tree canopy was assessed on eight (8) unified land use types to assess how humans impact our natural surroundings.
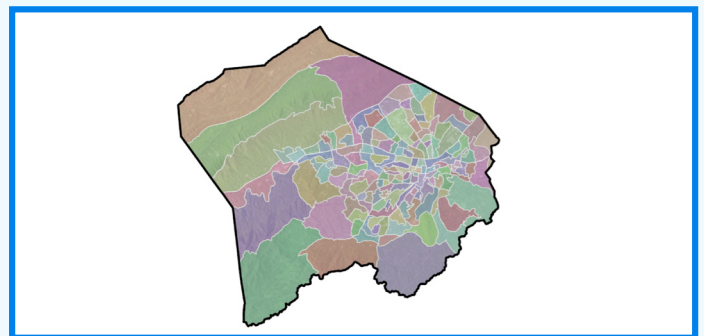
Census Block Groups
One hundred and fifty-five (155) census block groups were assessed to show relationships between canopy and sociodemographic factors, and highlight potential environmental justice issues.

Figure 5. The tree canopy study explored five (5) distinct geographic boundaries in this analysis: Roanoke Valley Boundary (AOI), jurisdictions, floodplain by jurisdiction, unified land use types, and census block groups.

STATE OF THE CANOPY AND
KEY FINDINGS

Decision-makers of each jurisdiction should use the results of this study to design a strategic approach to identifying existing canopy and future planting areas. Land cover data and maps presented below are based on the assessment's entire AOI (Roanoke Valley Region). The area includes six land cover classes: tree canopy (over impervious and pervious surfaces), shrub/scrub, soil and dry vegetation, other vegetation, impervious surfaces, and water. The Region-wide land cover data below outlines the basic types of land cover classes, including surface water. This land cover data is distinct from the urban tree canopy data, including Potential Planting Areas and unsuitable areas based on land area excluding water bodies (explained in more detail in the following pages).

ROANOKE VALLEY LAND COVER

Legend:
- ■ Tree Canopy Over Pervious %
- ■ Tree Canopy Over Impervious %
- ■ Non-Canopy Vegetation %
- ■ Shrub/Scrub %
- ■ Impervious %
- ■ Soil & Dry Vegetation %
- ■ Water %
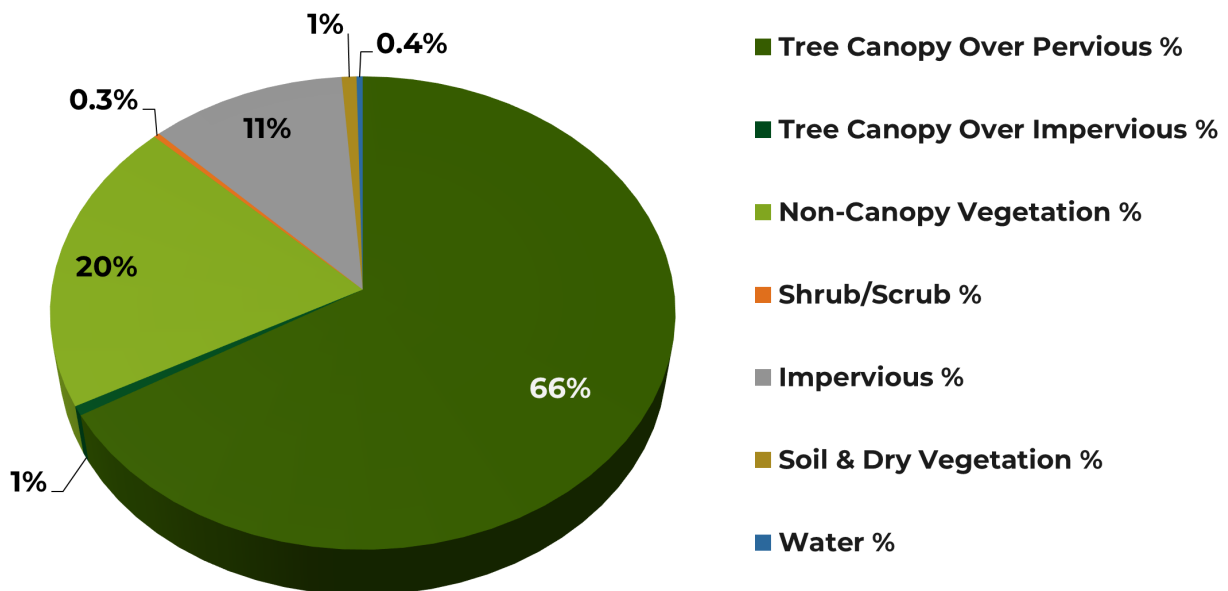
Figure 6. Land cover classification results (percentages based on total area of Roanoke Valley's AOI including water bodies).

Table 1. Land cover classes in acres and percent in Roanoke Valley.

Roanoke Valley, VA	Acres	% of Total
AOI Boundary	197,480	100%
Tree Canopy	132,569	67%
Non-Canopy Vegetation (not including shrubs)	39,815	20%
Impervious	22,069	11%
Soil & Dry Vegetation	1,664	0.8%
Water	694	0.4%
Shrub/Scrubs	668	0.3%

Land Cover Classification

- Non-Canopy Vegetation
- Soil and Dry Vegetation
- Impervious
- Water
- Tree Canopy
- Shrub
- Tree Canopy Over Impervious
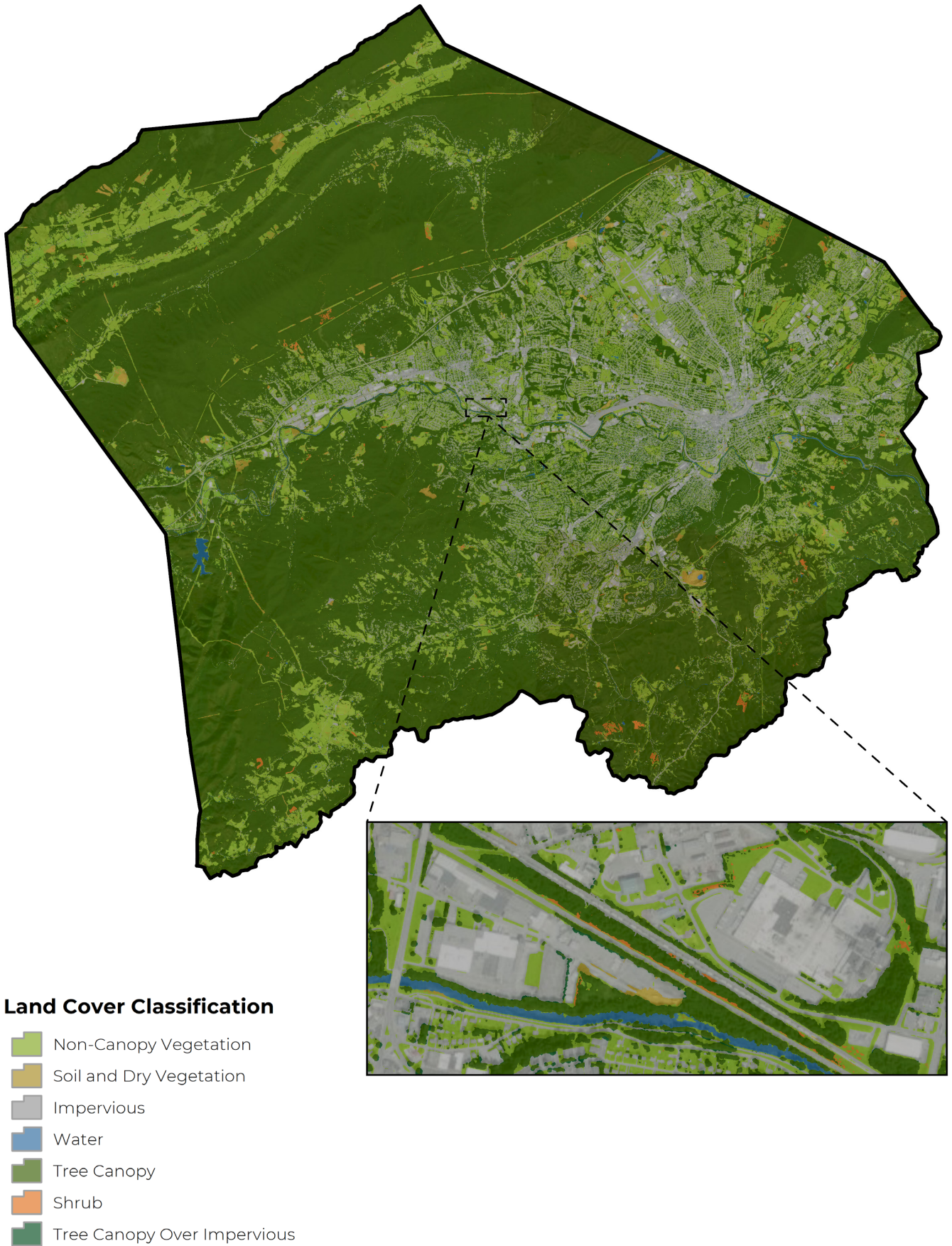
Figure 7. Distribution of land cover classes throughout Roanoke Valley.

Urban Tree Canopy Potential

- Urban Tree Canopy
- PPA Vegetation
- Unsuitable Vegetation
- Unsuitable Impervious
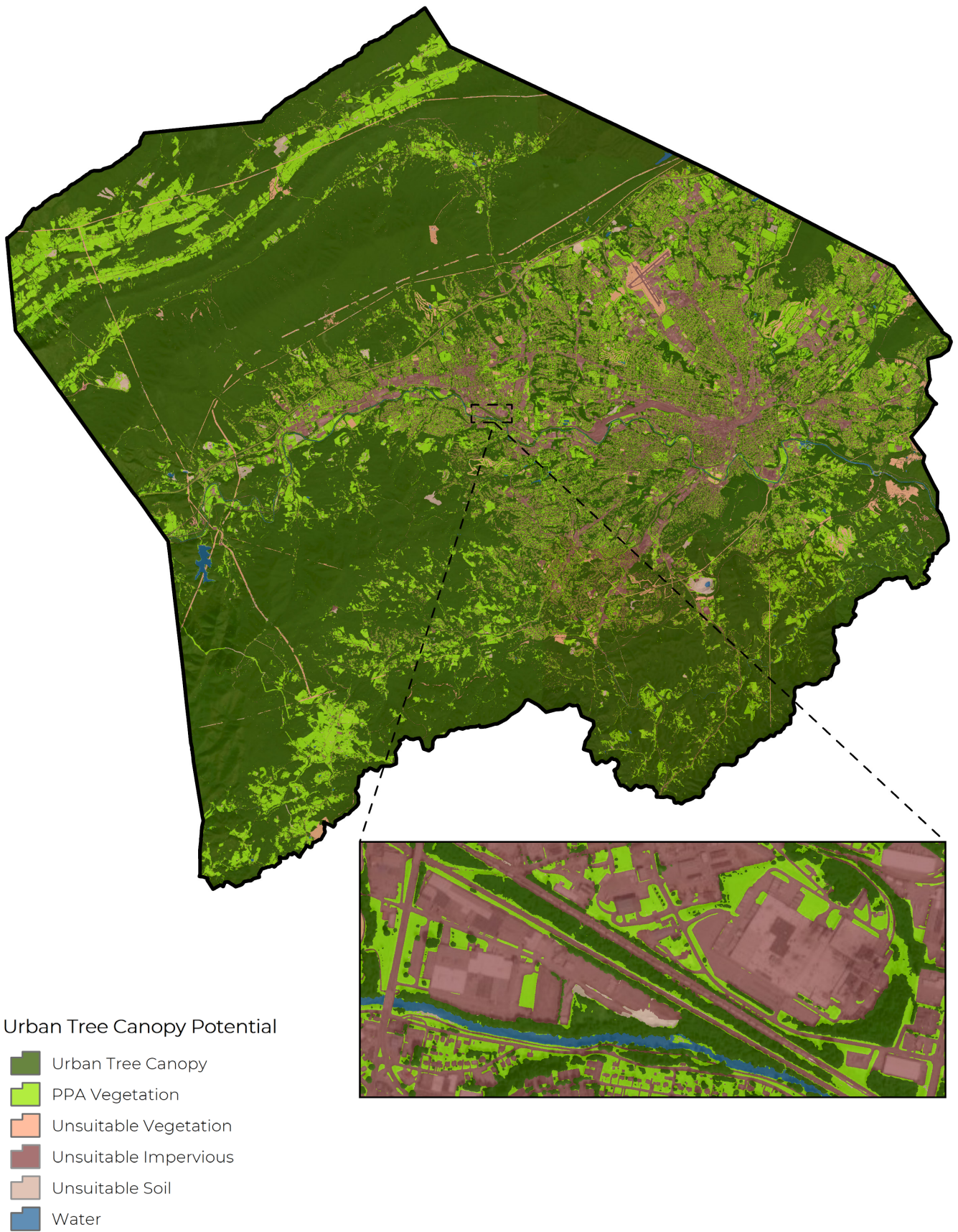- Unsuitable Soil
- Water

Figure 8. Distribution of UTC, possible planting area, and areas unsuitable for UTC throughout Roanoke Valley.

REGION-WIDE TREE CANOPY COVER

This urban tree canopy assessment utilized the land cover data mentioned above as a foundation to determine tree canopy cover and possible planting areas (PPA) throughout the Roanoke Valley Region. Results of this study indicate that within the boundary of the entire Region, 132,569 acres are covered with urban tree canopy, making up 67% of the Region's 196,786 land acres; 37,643 acres are covered with other vegetation where it would be possible to plant trees, making up 19% of the area; and the additional 26,574 acres were considered unsuitable for tree planting, making up 14% of the area. Impervious surfaces comprised 83% (or 22,069 acres) of unsuitable areas.
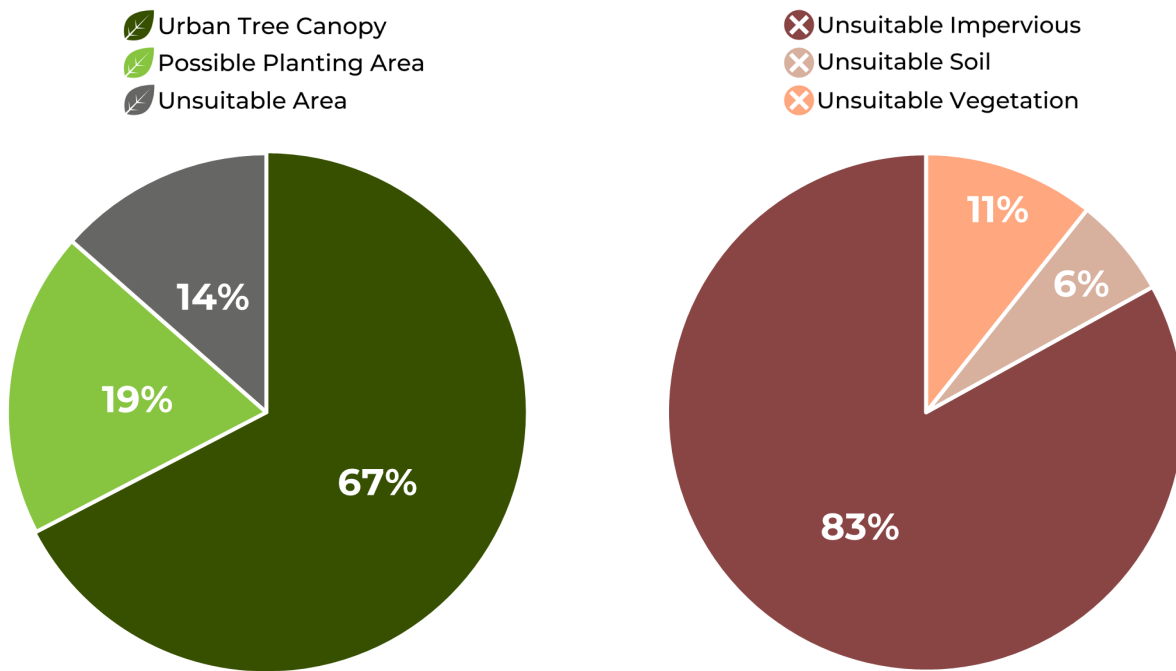

Figure 9. Tree canopy, possible planting area, and area unsuitable for tree canopy (left). The total unsuitable area is broken down by unsuitable soil, unsuitable impervious, and unsuitable vegetation percentages (right) within the Roanoke Valley Region boundary.

CANOPY AND IMPERVIOUS SURFACES

The Region's 132,569 acres of urban tree canopy were further divided into subcategories based on whether the canopy was overhanging pervious or impervious surfaces. Tree canopy overhanging an impervious surface offers many ecological advantages, such as localized cooling through shading and increased storm-water absorption. Results indicated that Roanoke Valley's UTC was predominantly overhanging pervious surfaces at 99%, while just 1% was overhanging impervious surfaces. Planting trees in rights-of-ways, along streets and sidewalks, and in other public areas, as well as strengthening ordinances for planting around parking lots in new developments, can help offset the harmful effects of impervious surfaces.

TREE CANOPY COVER BY JURISDICTIONS

Four jurisdictions within Roanoke Valley have joined forces to oversee the expansion and management of their tree canopy cover, fostering a unified effort towards regional canopy goals. The assessment summarized urban forestry metrics for each of these four jurisdictions. Roanoke County covers the largest land area (80%) within the Roanoke Valley boundary, contributing 90% of the UTC distribution for the Region. Roanoke County, with 76% tree canopy coverage within its boundaries, has the highest tree cover among the jurisdictions. The extensive tree canopy in this area is likely due to its more rural setting compared to other jurisdictions. The County jurisdiction also has the least impervious surface coverage at just 6%, a notable contrast to the second smallest coverage in the Town of Vinton, which is at 32% impervious cover.

The City of Roanoke added the second-largest contribution to the Region's total tree canopy, encompassing 27,425 acres (33% UTC). Additionally, the City of Salem contributed 9,358 acres of UTC (35%), while the Town of Vinton contributed 2,018 acres of UTC (35%).

Because of its large land area, the jurisdiction of Roanoke County offers the most acreage in terms of potential planting area (26,157 acres). However, the County has the smallest proportion of plantable space by percentage within its boundaries, at 17%. The Town of Vinton, the City of Salem, and the City of Roanoke have nearly equal PPA percentages at 32%, 30%, and 29% respectively. Together, these three jurisdictions offer 11,486 acres of PPA, equating to approximately 30% of the overall distribution of PPA in the Region. These three jurisdictions have a nearly equal distribution of UTC, PPA, and impervious surface coverage. By implementing practices that encourage more efficient utilization of plantable space, the Town of Vinton, the City of Salem, and the City of Roanoke can each theoretically double their respective canopy coverages.

"BY UTILIZING THEIR PPA, THE CITY OF ROANOKE, CITY OF SALEM, AND TOWN OF VINTON HAVE THE POTENTIAL TO THEORETICALLY DOUBLE THEIR INDIVIDUAL UTC PERCENTAGES."
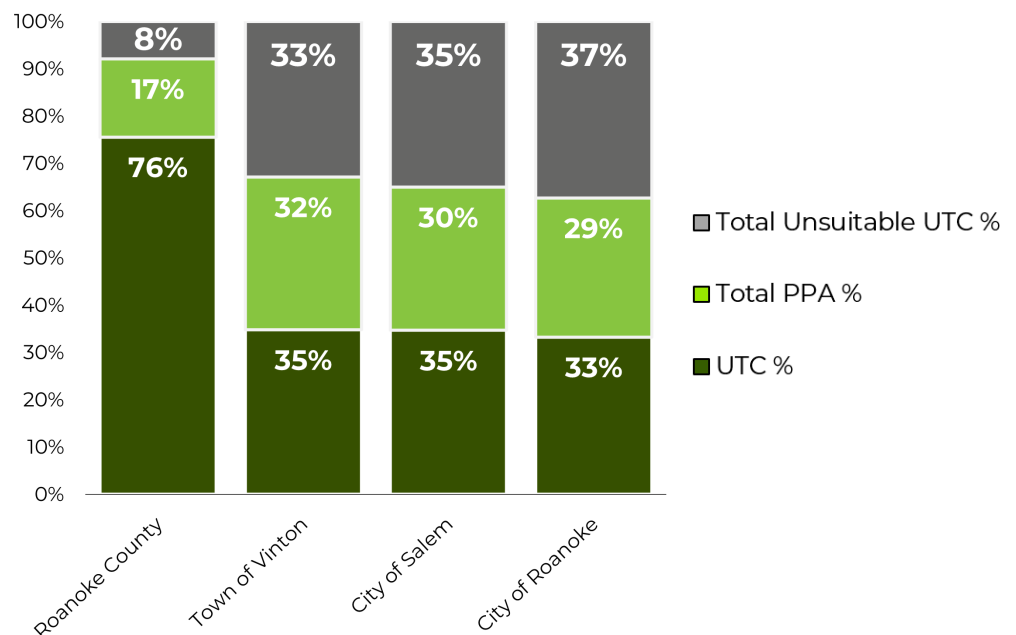
Figure 10. Tree canopy, possible planting area, and area unsuitable for tree canopy by jurisdiction.
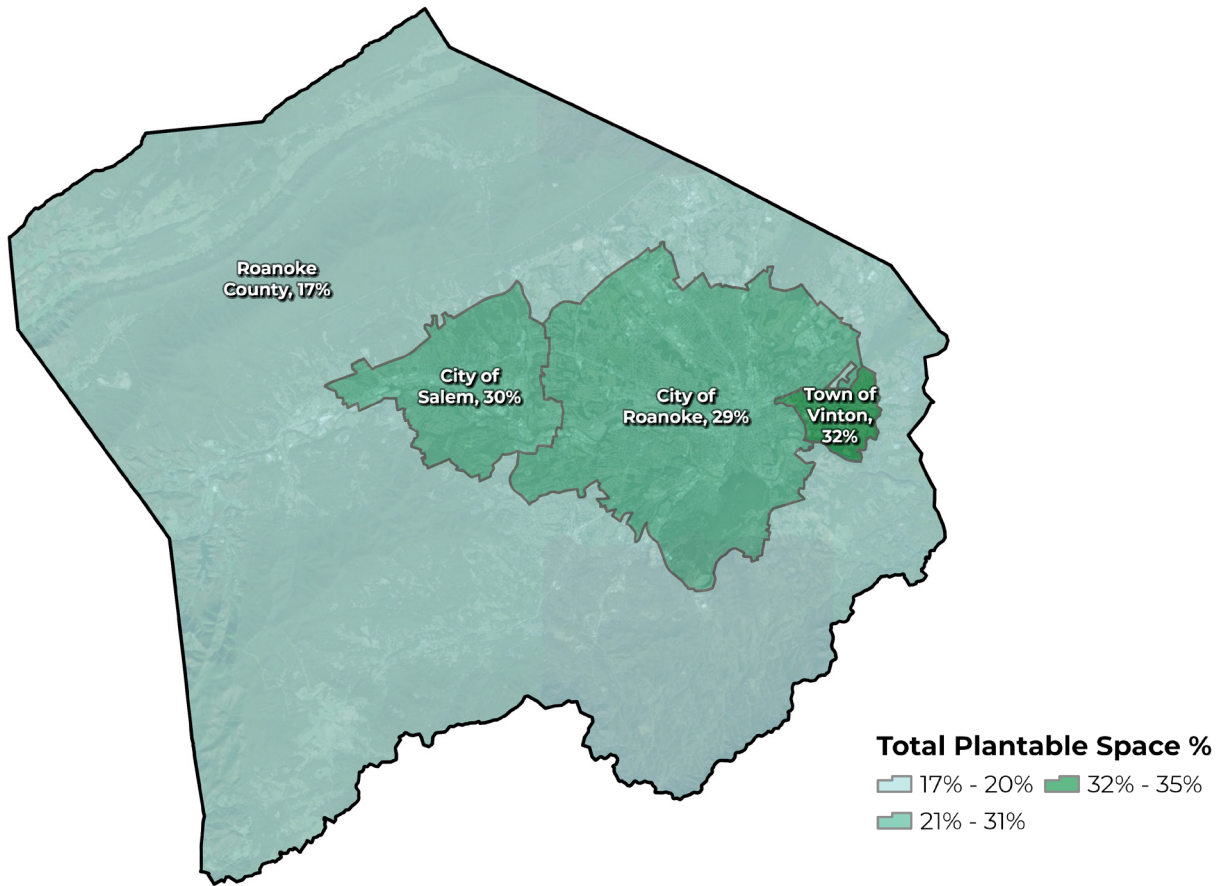
Total Plantable Space %
17% - 20%   32% - 35%
21% - 31%

Figure 11. Possible planting area percent by jurisdictions.

Urban Tree Canopy %
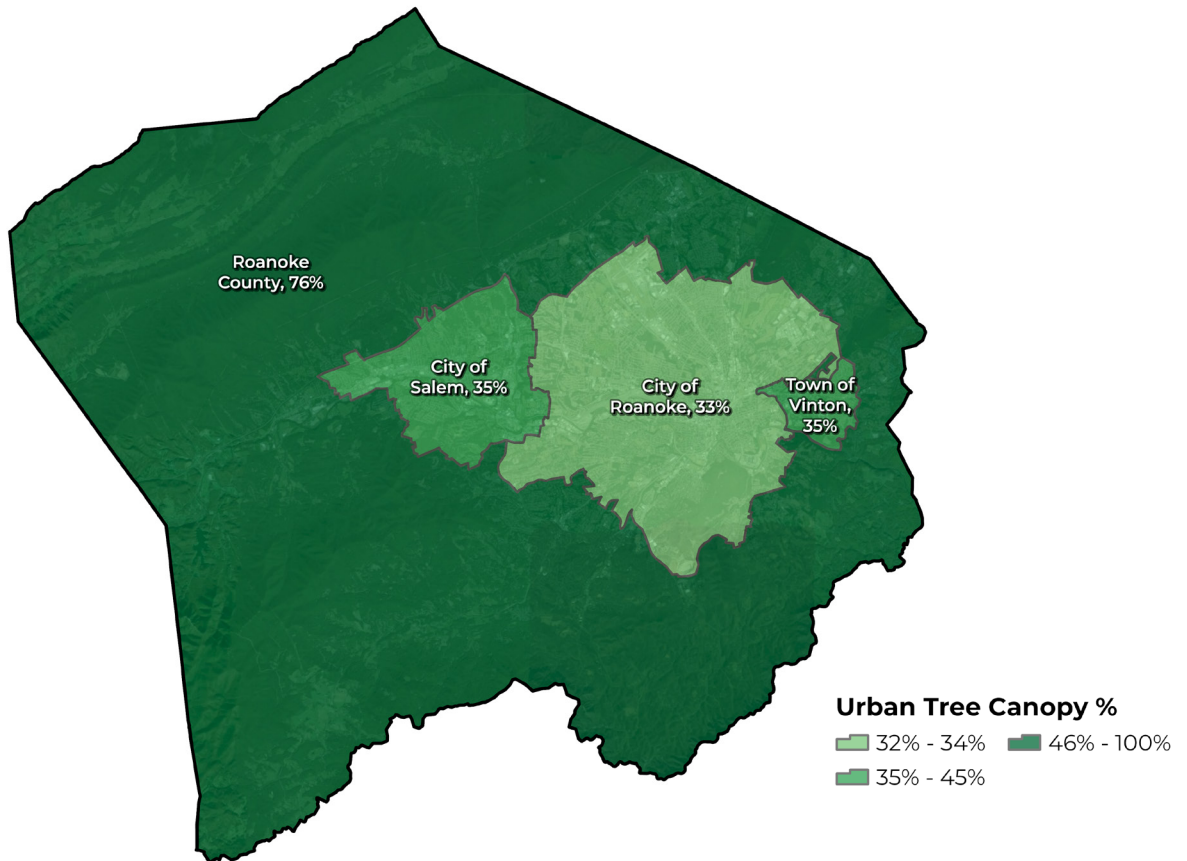32% - 34%   46% - 100%
35% - 45%

Figure 12. Urban tree canopy percent by jurisdictions.

TREE CANOPY COVER BY JURISDICTION FLOODPLAINS

Trees mitigate stormwater runoff, filter pollutants and sediment and, as a result, reduce flooding and enhance water quality. To help target stormwater protection efforts, UTC and PPA were assessed across floodplains and flood hazard areas within each of Roanoke Valley's jurisdictions. Areas with a high risk of flooding account for 3% of the overall land in Roanoke Valley. The assessment revealed that every jurisdiction had a lower percentage of tree canopy in floodplains than in their broader area, except the Town of Vinton. Vinton's floodplain UTC stood at 39%, 4% higher than its overall canopy coverage.

Surprisingly, Roanoke County's UTC experienced a comparative decrease from 76% in the overall jurisdiction boundary to just 49% in floodplain areas. The County jurisdiction's floodplains had proportionally higher impervious surface coverage of 12% compared to the jurisdiction boundary as a whole (6%).

The City of Roanoke and the City of Salem's floodplains had a canopy cover that is slightly below their overall jurisdiction UTC levels with 31% and 28%, respectively. It's worth noting that floodplain areas make up 20% of the City of Salem's overall area. Still, it has the lowest UTC percent within floodplains and the highest impervious surface coverage (42%).

The City of Salem should prioritize using its 503 acres of PPA, which, in theory, could increase its canopy coverage to 54%. Similarly, Roanoke County, the City of Roanoke, and the Town of Vinton should make use of their respective 1,585 acres (35%), 755 acres (27%), and 68 acres (25%) of PPA. Planting native trees that can withstand long periods of wet soil and occasional flooding can reduce the harmful effects of floods. These trees can absorb large volumes of rainwater, increase soil permeability, and help prevent erosion along riverbanks.

> **"AMONG THE FOUR FLOODPLAINS, SALEM'S FLOODPLAIN HAS THE LOWEST UTC PERCENTAGE AND THE HIGHEST IMPERVIOUS SURFACE COVERAGE."**
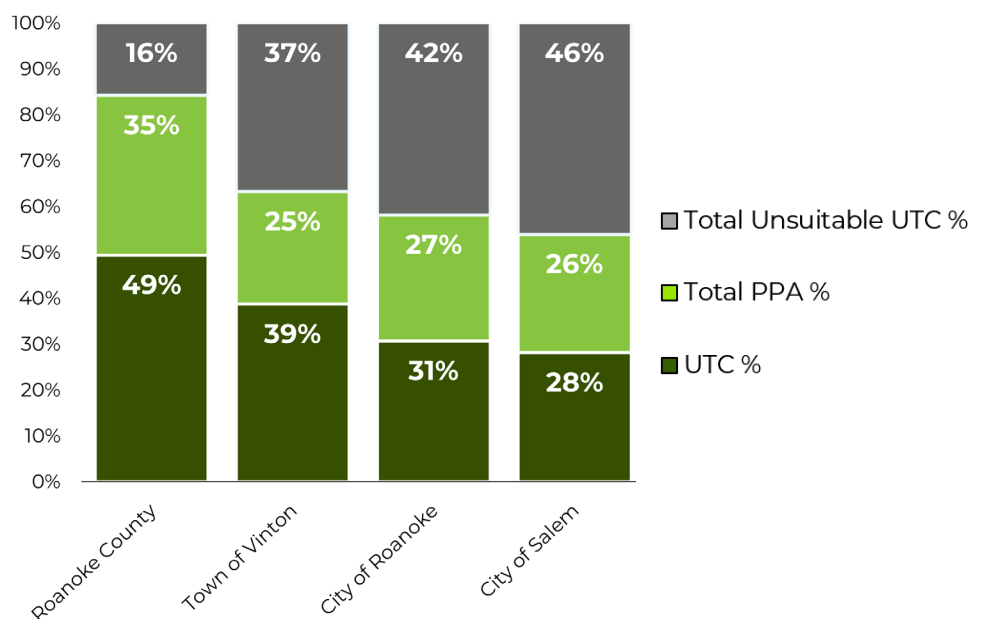

Figure 13. Tree canopy, possible planting area, and area unsuitable for tree canopy by each jurisdiction's floodplain.
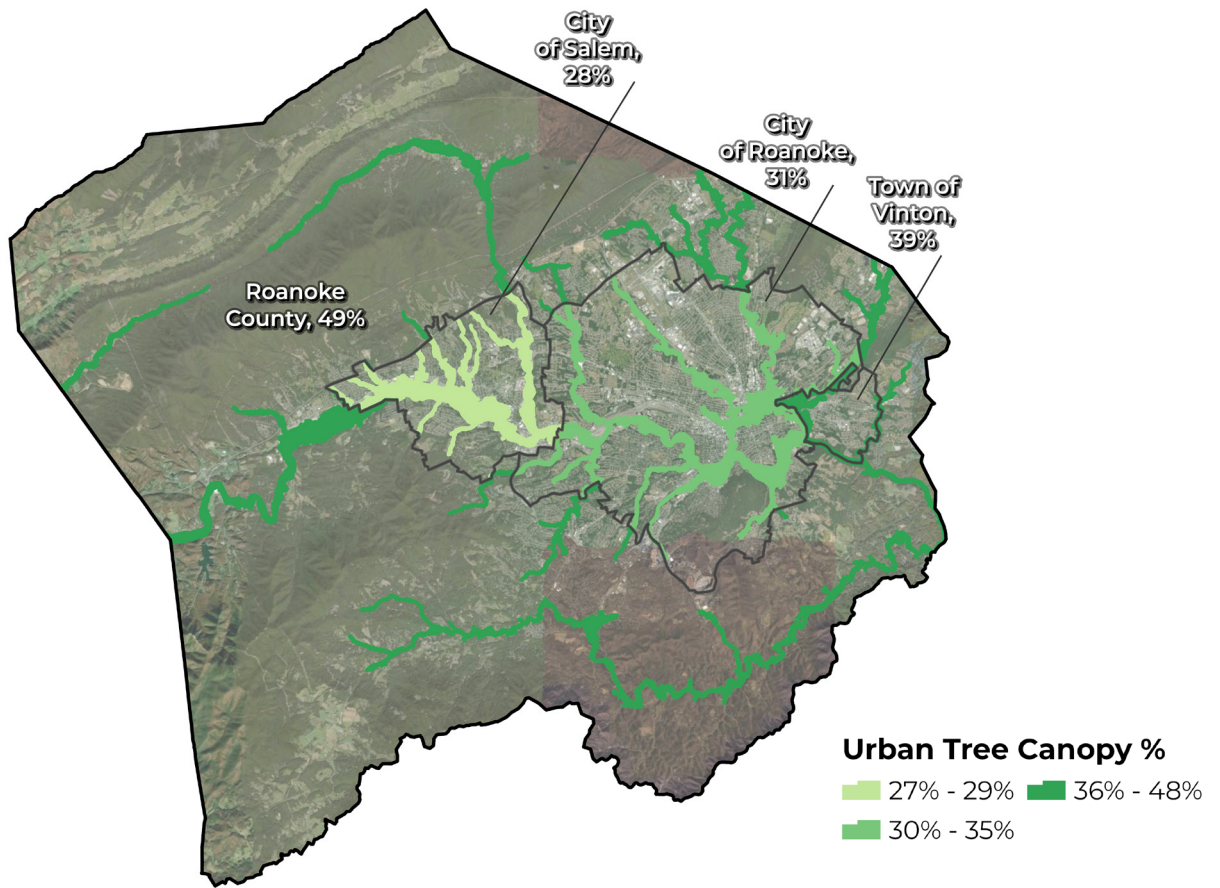
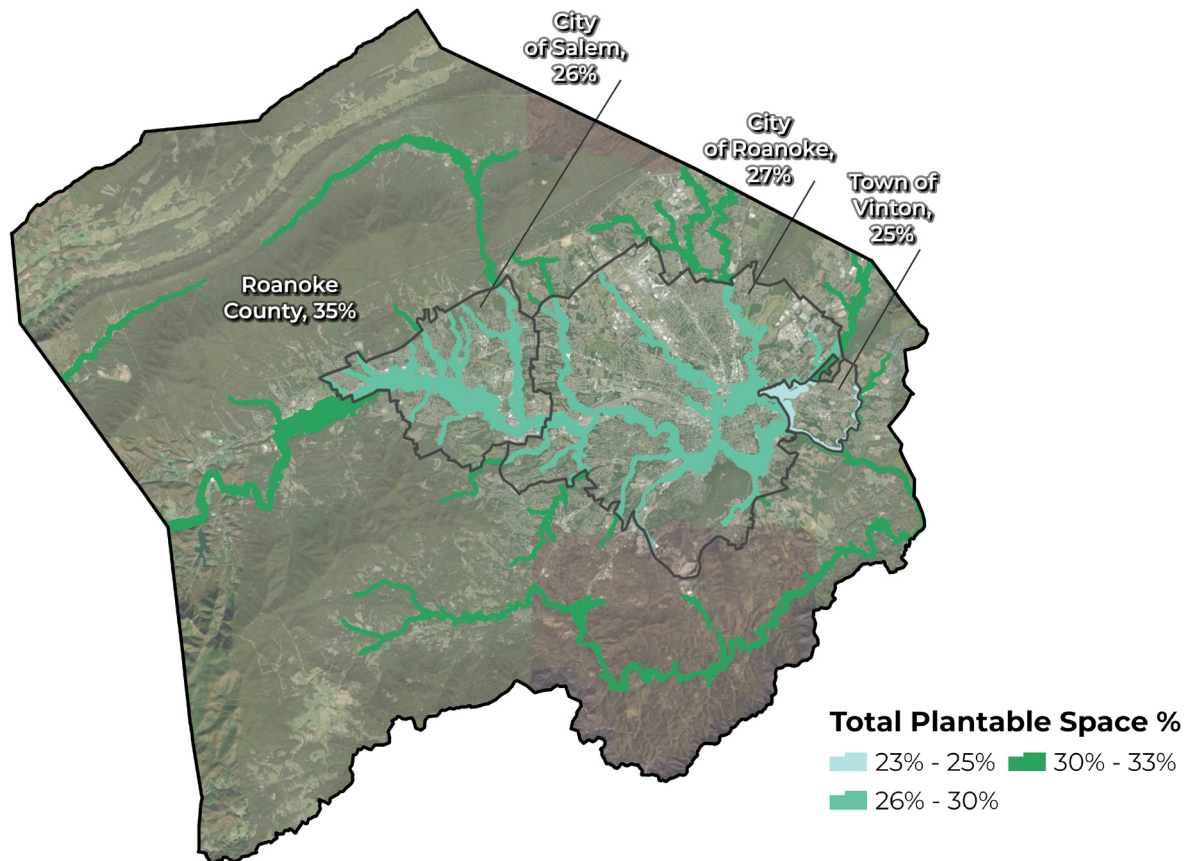**Figure 14. Urban tree canopy percent by each jurisdiction's floodplain.**

Figure 15. Possible planting area percent by each jurisdiction's floodplain.

TREE CANOPY COVER BY UNIFIED LAND-USE TYPES

To better understand how humans impact our natural surroundings, tree canopy, and plantable space were assessed across Roanoke Valley's eight unified land use types. Two land use types, Single Family Residential and Forest and Natural Area, together made up 80% of the total unified land use area. They also account for 88% of UTC distribution, with Single Family Residential covering 45,439 acres and Forest and Natural Area spanning 68,093 acres. Unsurprisingly, areas designated as Forest and Natural Areas boasted the highest canopy coverage of all land use types.

Land use areas designated as vacant had the second highest UTC percentage at 73%, which is worth considering if these vacant lots are to be redeveloped. If these lots were to be cleared entirely, over 6,500 acres of tree canopy could be lost (5% of Roanoke Valley's total UTC).

Commercial and Mixed-Use land use areas had the lowest UTC levels at 25% and 26%, respectively. These land use types also had the highest impervious surface coverage (55% and 49%). Together, these land use categories contain 1,200 acres PPA that could be leveraged to mitigate the adverse effects of high impervious surface coverage, such as increased localized temperatures and heightened flooding risk.

Residential areas had the highest percentage of PPA at 32%, and the Institutional land use type had the second highest percentage at 30%. The two residential land use types (Single Family Residential and Multi-Family Residential) contain 60% of Roanoke Valley's entire distribution of PPA. These areas offer ample opportunity to connect with local neighborhoods and community-based organizations to expand canopy coverage, especially on private property.

> **"COMBINED, SINGLE FAMILY RESIDENTIAL AND MULTI-FAMILY RESIDENTIAL LAND USE CATEGORIES ACCOUNT FOR 60% OF THE TOTAL DISTRIBUTION OF PPA IN THE ROANOKE VALLEY REGION."**

Table 2. Urban tree canopy metrics by unified land use types.

Unified Land Use Type	Land Area (Acres)	Distribution of Land Area %	UTC Acres	UTC %	Distribution of UTC %	Total PPA (Acres)	Total PPA %	Distribution of PPA %
Commercial	5,501	3%	1,381	25%	1%	972	18%	3%
Forest and Natural Areas	78,308	42%	68,093	87%	53%	7,265	9%	20%
Industrial	8,282	4%	2,608	31%	2%	1,700	21%	5%
Institutional	7,201	4%	3,157	44%	2%	2,155	30%	6%
Mixed Use	1,227	1%	324	26%	0%	296	24%	1%
Multi-Family Residential	5,656	3%	1,753	31%	1%	1,797	32%	5%
Single Family Residential	72,923	39%	45,439	62%	35%	19,863	27%	55%
Vacant	9,172	5%	6,664	73%	5%	2,002	22%	6%
Totals	***188,868**	**100%**	**129,418**	**69%**	**100%**	**36,049**	**19%**	**100%**

Please note that the total area covered by zoning classes is less than the overall area of interest. This discrepancy is because the zoning classifications do not extend fully to the roads or along the right-of-way.

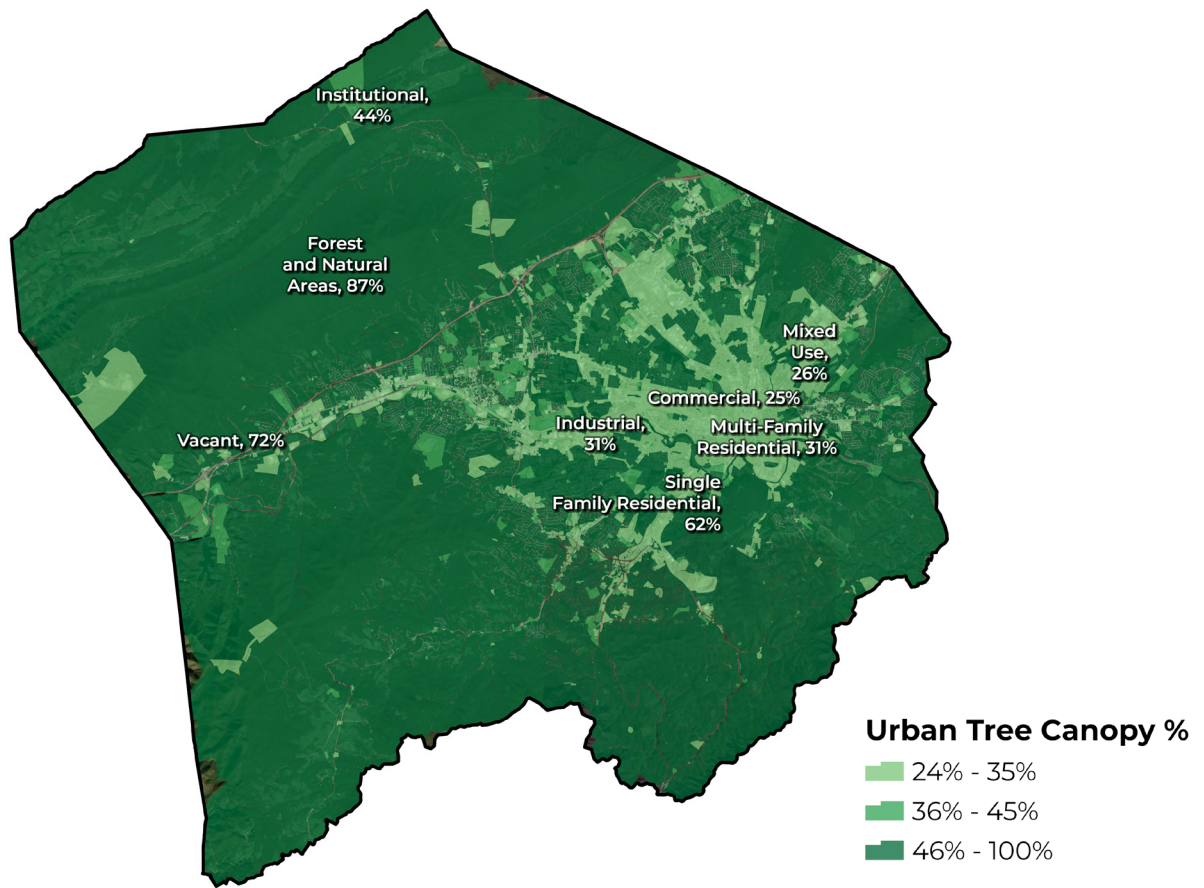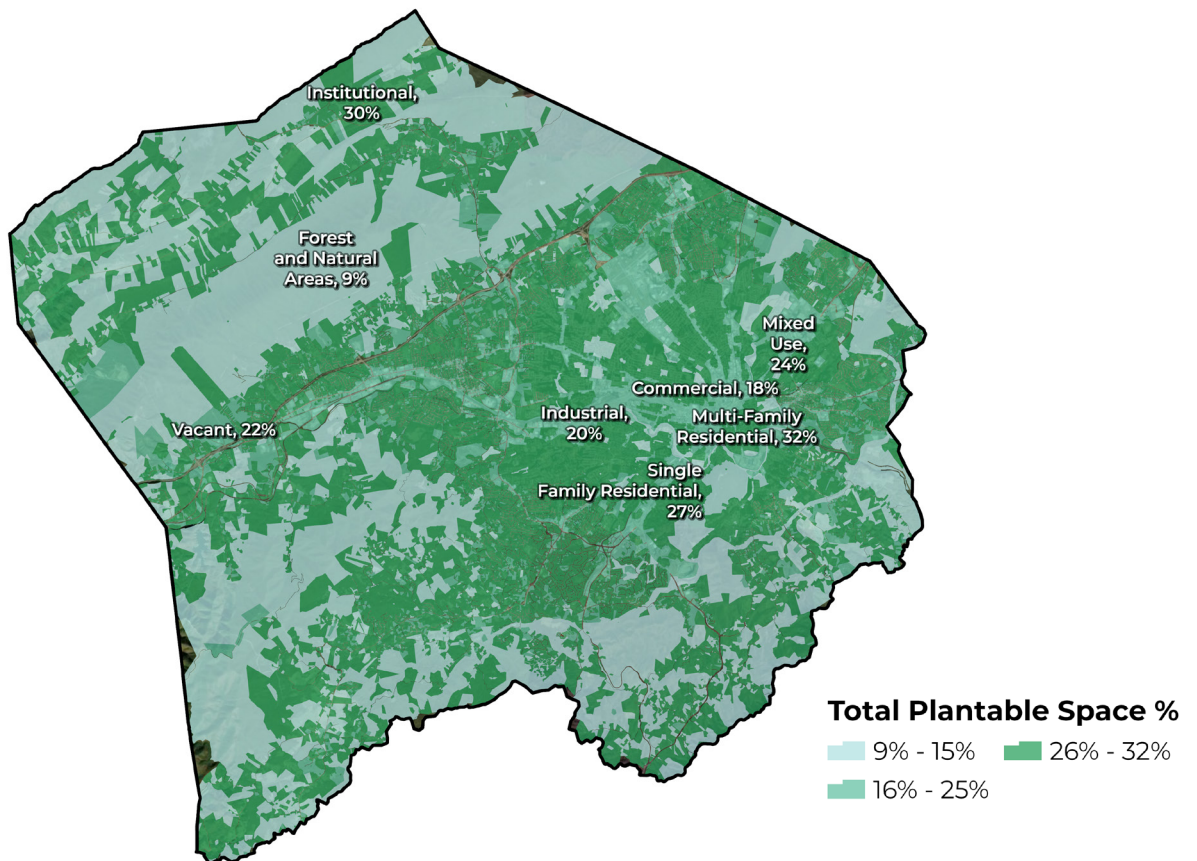Figure 16. Urban tree canopy percent by unified land use.

Urban Tree Canopy %
- 24% - 35%
- 36% - 45%
- 46% - 100%

Figure 17. Possible planting area percent by unified land use.

Total Plantable Space %
- 9% - 15%   26% - 32%
- 16% - 25%

TREE CANOPY COVER BY CENSUS BLOCK GROUPS

UTC and PPA were also assessed at the census block group level, which is valuable for determining the equitable distribution of tree canopy throughout Roanoke Valley, as the block groups are linked to readily available demographic and socio-economic data. Census block groups contain clusters of census block boundaries. This geographic scale is the second smallest unit of measure at which the U.S. Census publishes statistical data within a state and represents between 600 and 3,000 people. Census block groups with the lowest UTC are found in the City of Roanoke. The further away you get from downtown Roanoke, there is a general trend of increasing canopy coverage among census block groups. The largest census block groups are found in more rural areas of Roanoke County and generally have the highest canopy coverage overall.

The three block groups with the least amount of tree coverage are situated near downtown Roanoke, just south of the Roanoke District railroad. These areas contain landmarks such as the First Baptist Church on Luck Avenue SW, Elmwood Park, Carilion Roanoke Community Hospital, and River's Edge North Park.

Census block groups identified with the most potential for planting trees are primarily located in the northeast part of the Roanoke Valley Region. Out of the 155 census block groups in the Region, 58 have 20% to 30% of their land suitable for planting. There are 52 block groups that have between 30% to 40% of their land available for new trees. However, none of the block groups have more than 50% of their land identified as PPA.

"IN GENERAL, CENSUS BLOCK GROUPS IN THE NORTHEAST PORTION OF ROANOKE VALLEY HAVE THE HIGHEST PERCENTAGE OF POTENTIAL PLANTING AREA."
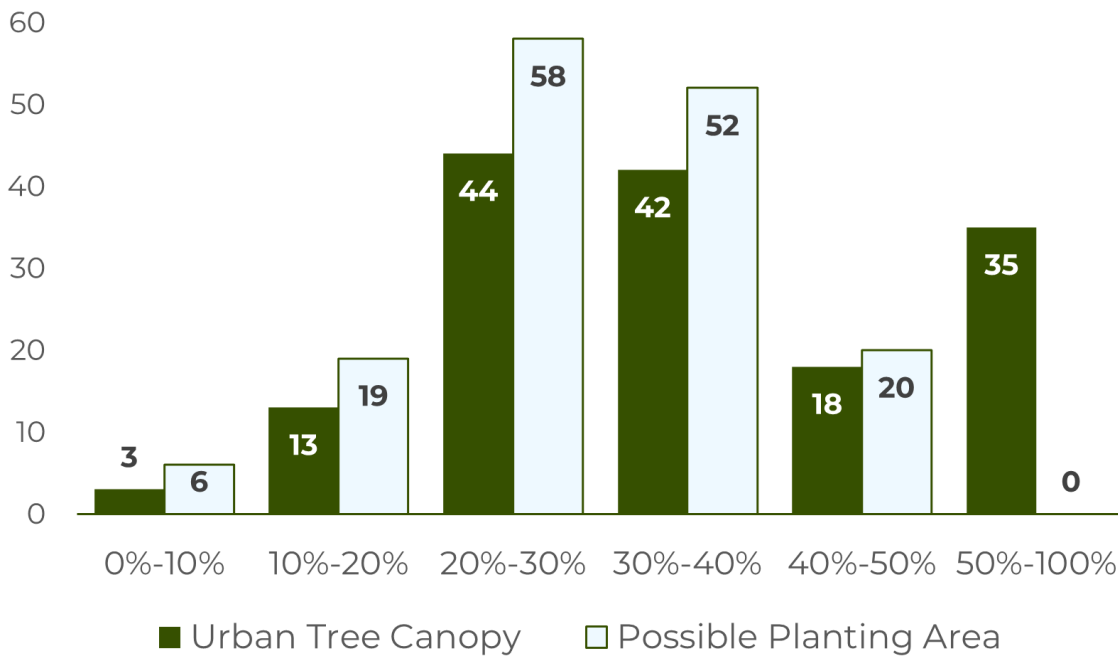
Figure 18. Number of census block groups within UTC and PPA ranges.

Urban Tree Canopy %

- 4% - 15%
- 16% - 25%
- 26% - 35%
- 36% - 45%
- 46% - 92%
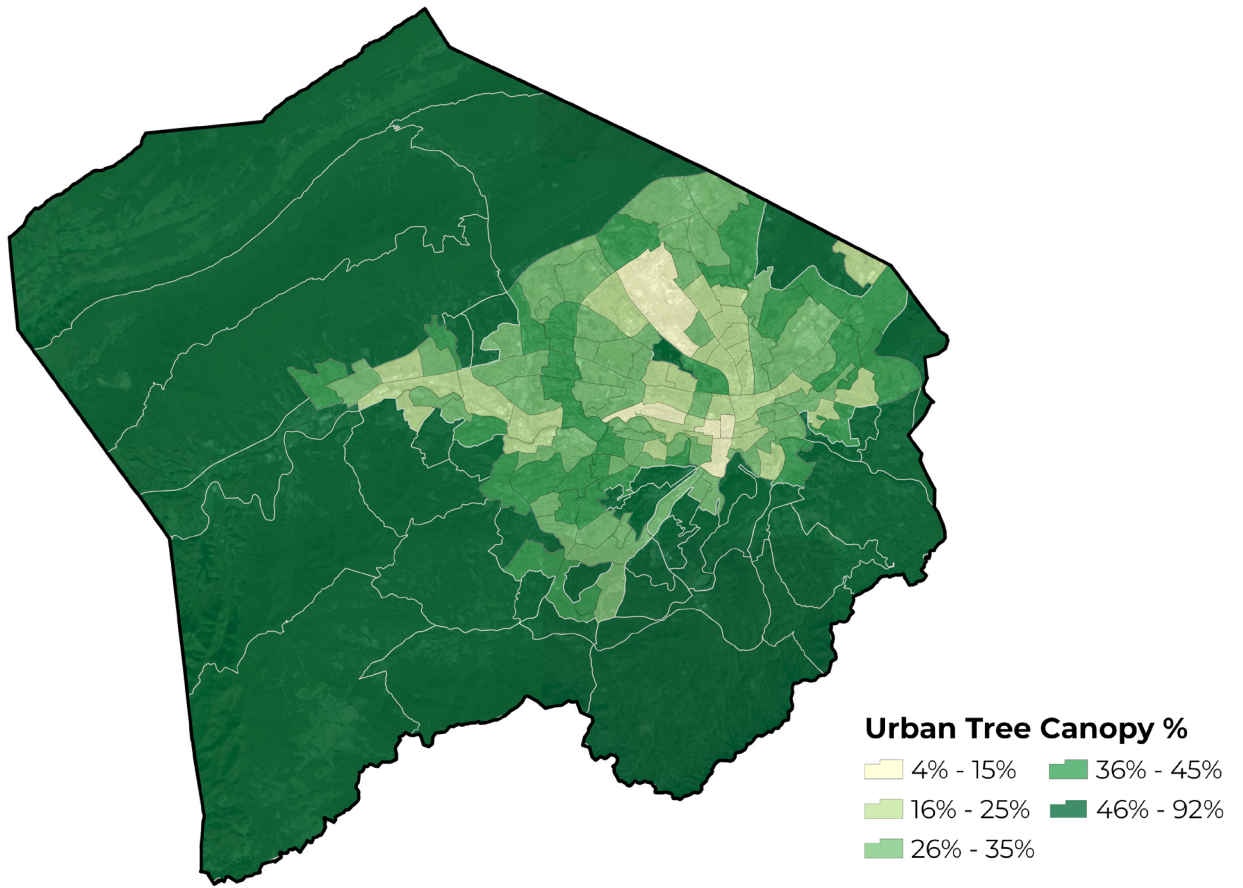
Figure 19. Urban tree canopy percent by census block groups.

Total Plantable Space %

- 5% - 15%
- 16% - 25%
- 26% - 35%
- 36% - 47%

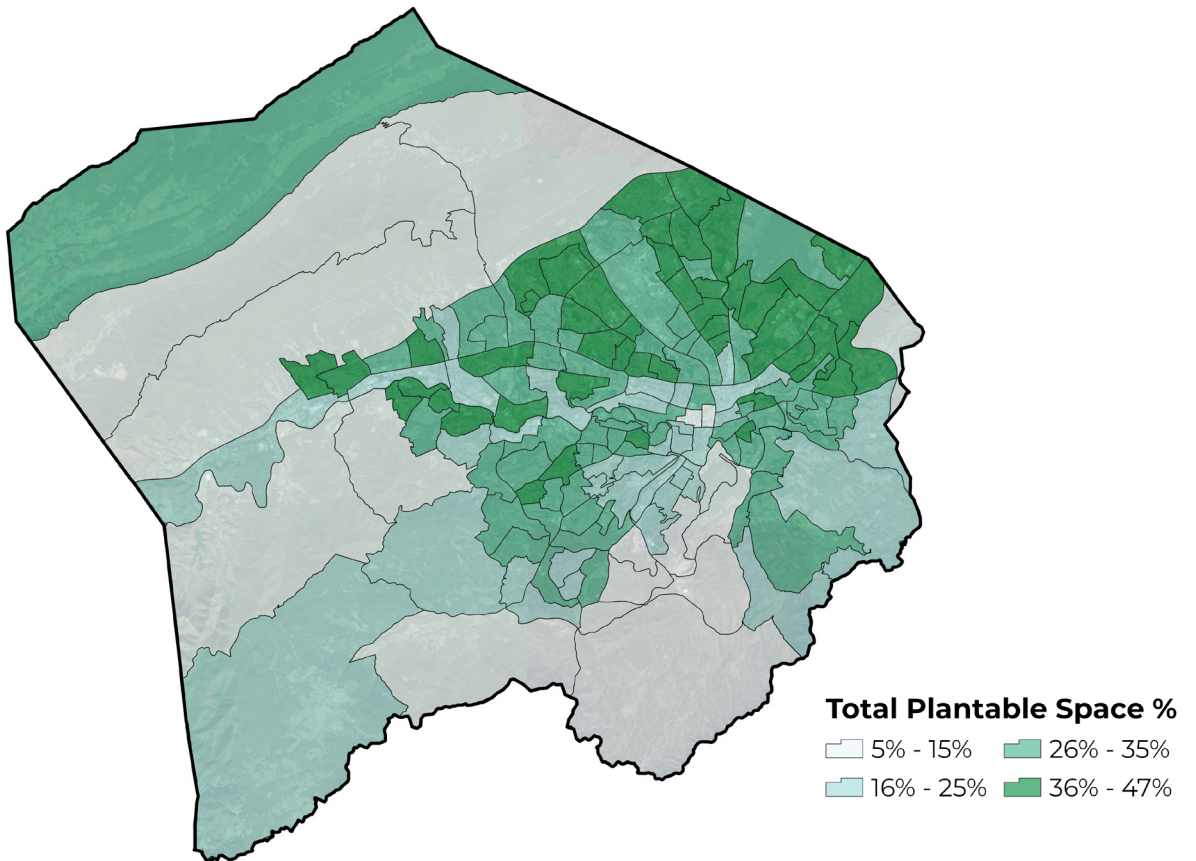**Figure 20. Possible planting area percent by census block groups.**

CONCLUSIONS AND RECOMMENDATIONS

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

To protect tree canopy, the Region should continue to have tree canopy assessments performed regularly through a TreePlotter CANOPY subscription or continue traditional projects. As the area grows, these data will be able to be used to ensure that urban forest policies and management practices prioritize its maintenance, health, and growth. Roanoke Valley's urban forest provides the Region with a wealth of environmental, social, and even economic benefits related to increased community pride and interest in region-wide initiatives and priorities. These results can be used to identify where the Region should preserve existing tree canopy cover, where there are opportunities to expand canopy cover, and which areas would benefit most from investing valuable resources into the urban forest.

RECOMMENDATIONS

1. **Leverage the results of this assessment to promote the urban forest and set evidence-based canopy goals.**
   The findings of this assessment are pivotal for promoting investment in urban forest monitoring, maintenance, and management and offer essential support for state, county, and local budget requests and grant applications. These results can be used to craft targeted presentations and resources for government leaders, planners, engineers, resource managers, and the public to make an empirical case for urban forest needs and benefits.

   As Roanoke Valley's population grows and urbanization expands, preserving and growing the existing canopy is vital. These assessment findings can be used to develop short and long-term goals, such as establishing annual tree planting targets, improving the quality of tree cover by planting a wider variety of large maturing trees or setting specific canopy coverage goals by a future date.

2. **Identify areas to prioritize canopy expansion.**
   The Region and its various stakeholders can utilize the results of the UTC and PPA analyses to identify the best locations for jurisdiction-owned property canopy expansion efforts. Planting in jurisdictions' rights-of-way could provide significant shading for walkways and roadways. Planting trees adjacent to impervious surfaces within floodplains could be particularly valuable and limit the risks of floods. The Region's jurisdictions can develop collaborative or individual proactive street tree maintenance programs to take on the responsibility of planting and managing street trees, ensuring healthy trees are distributed equitably across the Region. Each jurisdiction within Roanoke Valley should evaluate county/city/town codes to increase tree preservation, create space for existing trees during the development process, and set aside space for large-stature trees to be planted within the public right-of-way to maximize the benefits of trees. Adopting ordinances and policies reflecting a "complete green streets" design methodology can help harmonize gray and green infrastructure, maximizing public functionality and environmental benefits while reducing associated costs.

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

   Residential unified land use areas (Single Family Residential and Multi-Family Residential) accounted for 36% of the Region's tree canopy and 60% of all region-wide PPA. When considering tools to increase canopy in Roanoke Valley, it's essential to understand that most urban forests are often situated on private land. Incorporating these findings into community outreach and education programs for citizens and private landholders is crucial. Disseminating this information and data will help residents understand the changes in their local urban forests and the numerous benefits trees offer. Pairing educational programming with tree giveaways, tree planting programs, and tree maintenance events can help increase urban tree canopy in the 21,500+ acres of plantable space on residential unified land areas.

4. **Use TreePlotter to identify areas needing tree canopy, prioritize planting efforts, and continue monitoring the urban forest.**

   Utilization of TreePlotter™ CANOPY enables Roanoke Valley jurisdictions and other urban forest stakeholders to create detailed planting priority maps. Users can create uniquely weighted scenarios to target areas based on specific criteria such as low UTC, high PPA, or specific socio-demographic criteria. By focusing on these areas, the allocation of urban forest management resources can be maximized, offering a greater return on investment.

REPORT ―――――――――――――
APPENDIX

ACCURACY ASSESSMENT

Classification accuracy serves two primary purposes. Firstly, accuracy assessments provide information to technicians producing the classification about where processes need to be improved and where they are effective. Secondly, accuracy measures 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, slight differences in classification methodology and image quality can significantly impact overall map area estimations. The classification accuracy error matrix illustrated in Table 3 contains confidence intervals reporting the high and low values that could be expected to compare the classification data and the actual on-ground land cover in 2021. This accuracy assessment was completed using high-resolution aerial imagery, with computer and manual verification. This study did not include field verification.

THE INTERNAL ACCURACY ASSESSMENT WAS COMPLETED IN THESE STEPS:

1. Seven hundred and seventy-five, or approximately 2.5 points per square mile area in Roanoke Valley (309 sq. miles), were randomly distributed across the study area and assigned a random numeric value by a trained technician.
2. Each sample point was then referenced using the NAIP aerial photo and assigned one of the five generalized land cover classes ("Ref_ID") mentioned above.
3. If the technician could not discern the reference value 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 actual conditions on the ground) and the intersecting classified pixels are used to understand how closely the entire classified map represents Roanoke Valley's landscape. The error matrix in Table 3 represents the intersection of reference pixels manually identified by a human observer (columns) and the 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 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 (501 + 142 + 92 + 24 + 11 = 770/775 = 99.3%), and the matrix can be used to calculate per class accuracy percentages. For example, technicians manually identified 142 points in the reference map as non-canopy vegetation, and 145 of those pixels were classified as non-canopy vegetation 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 non-canopy vegetation is calculated as "142/145 = 0.979",

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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.

meaning that we can expect that ~98% of all 2021 non-canopy vegetation in the Roanoke Valley study area was classified as non-canopy vegetation in the 2021 classification map. This same procedure was utilized for tree canopy classifications as well.

Conversely, the "User's Accuracy" is calculated by dividing the number of agreement pixels by the number of classified pixels in the row category. For example, classification pixels intersecting reference pixels were classified as Tree Canopy, and 1 pixel was identified as canopy in the reference map. Therefore, the User's Accuracy for Tree Canopy is calculated as "501/502 =.998", meaning that ~100% 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 based on a sample of the existing ground cover, represented by the reference pixels at each sample point. Interpretation of the sample error matrix results indicates this assessment accurately mapped land cover and, more importantly, tree canopy in Roanoke Valley in 2021.

Table 3. Accuracy matrix for the Roanoke Valley Region.

Classification Data	Reference Data					
	Tree Canopy	Vegetation	Impervious	Soil / Dry Veg.	Water	Total Reference Pixels
Tree Canopy	501	1	0	0	0	502
Vegetation	1	142	0	0	0	143
Impervious	0	2	92	0	0	94
Soil / Dry Veg.	0	0	1	24	0	25
Water	0	0	0	0	11	11
Total	502	145	93	24	11	775

Overall Accuracy =	**99%**
Overall Margin of Error=	**1.4%**
Canopy Margin of Error =	**1.5%**

Producer's Accuracy		**User's Accuracy**	
Tree Canopy	100%	Tree Canopy	100%
Veg. / Open Space	98%	Veg. / Open Space	99%
Impervious	99%	Impervious	98%
Bare Ground / Soil	100%	Bare Ground / Soil	96%
Water	100%	Water	100%

Margin of error values reported at 90% confidence interval

ACCURACY ASSESSMENT RESULTS

Interpreting the sample error matrix offers some critical insights when evaluating Roanoke Valley's urban tree canopy coverage and how well-aligned the land cover data are with interpretations by the human eye. The high accuracy of the 2021 data indicates that Roanoke Valley's current tree canopy can be safely assumed to match the figures stated in this report (approximately 67%).

GLOSSARY/KEY TERMS

Land Acres: The 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.

Shrub: Areas of shrub or other leafy and woody vegetation (smaller than 6ft tall) that are not classified as tree canopy.

Soil/Dry Vegetation: Bare soil and 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, 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 soil augmentation may be required to keep trees 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. The tree canopy was generally taller than 10-15 feet tall.

Water: Areas of open, surface water, not including swimming pools.

URBAN TREE CANOPY

ASSESSMENT

ROANOKE VALLEY, VIRGINIA