Urban Tree Canopy Assessment
of Arlington County, Virginia

June 2023

An Analysis of Forest Cover and Benefits

Report created in June 2023, based on imagery flown in 2021.

ACTS

Prepared for the citizens of Arlington County
by Green Infrastructure Center Inc.

Green Infrastructure Center

This report and analysis were funded by citizens of Arlington County, Virginia, represented by Mary Glass. The report and mapping work were produced by the staff at the Green Infrastructure Center Inc. (GIC), a Virginia-based nonprofit company that supports the use of high-quality, scientific data for community decision making. The mention of trade names, commercial productions, services, or organizations does not imply endorsement. All images, graphics, and maps were produced by GIC, unless otherwise credited.

This report has been forwarded to the Arlington Consortium for Tree Sustainability (ACTS) for use by its members and the general public. Publication Date: June 2023.

ACTS

Report by the
Green Infrastructure Center Inc.

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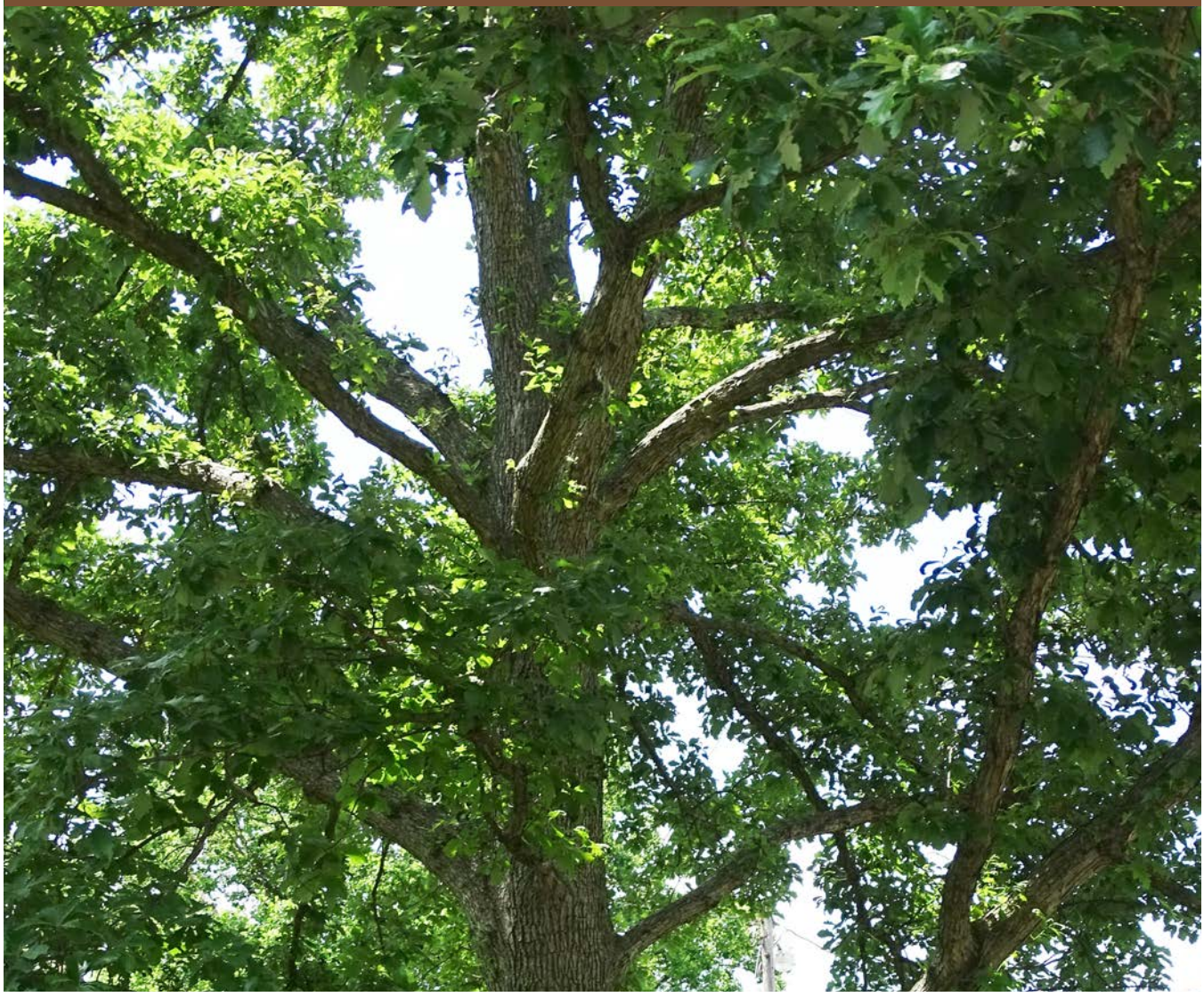

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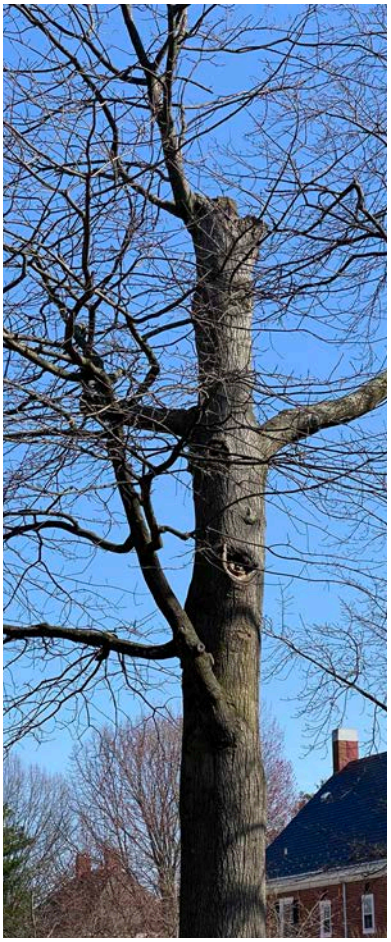
Project Overview and Summary Findings

Introduction

In the fall of 2022, a small group of Arlington County citizens hired the nonprofit firm, the Green Infrastructure Center Inc. (GIC) to analyze the tree canopy cover of Arlington County, Virginia. The impetus for this project was the desire to document and track the state of forest cover in the County. Many citizens and members of the Arlington County Civic Federation expressed their concern that the canopy appeared to be on a downward trend. Visual observations, such as these trees in Fairlington (*see image right*), damaged by ice storms, showed a canopy in decline. Other images taken throughout the County show numerous trees at risk of failure.

Although lacking canopy data for the last several years, the County Government noted in its draft Forestry and Natural Resources Plan that the canopy appeared to be "relatively stable over time." To determine if this was the case, GIC was contracted to calculate the current canopy cover. GIC was also to provide an analysis of the future plantable area, in order to document whether there was room to add new trees to make up for those lost to storms, development, landowner removals, and old age as trees weaken and die. This report's purpose is to provide data at a level of detail sufficient to provide actionable information, by neighborhood, on environmental impacts, and to identify potential planting locations. This report provides an overview of those findings, citizen comments collected at public meetings, and recommended next steps to protect and grow Arlington's urban forest.



This storm damaged tree in Fairlington presents a hazard to residents and should be inspected and treated to ensure limbs pose no further risks.

Large trees that have died should be removed since they pose a danger to people and property in densely developed Arlington County.

Planting for the Future

All urban forests require both care and active replanting to ensure that next generation trees can grow up to replace lost trees.

To learn more about this topic and how to make convincing arguments for tree canopy mapping, monitoring, and replacement, see the *Tree Planning and Planting Campaigns Guide* prepared for the US Forest Service at: http://www.gicinc.org/PDFs/TreePlantingCampaignGuide_GIC_June2022.pdf

Newly planted trees are necessary to ensure canopy for the future.

Findings

Excluding land within Reagan National Airport and Department of Defense properties, **Arlington's Tree Canopy is 33%.** This is based on imagery flown in 2021 and processed in the fall of 2022.

As noted, most of the city's plantable area is privately owned (excluding large federal lands, such as Arlington Cemetery). The greatest potential for keeping the County green is to ensure the following:

- Disallow lot-line-to-lot-line building that removes mature trees and precludes future opportunities to replant.
- Maintain older trees with selective pruning and the removal of dangerous limbs.
- Take rapid advantage of planting opportunities currently available in open spaces.
- Plant new understory to ensure a well-canopied County of the future.

While urban density and affordability are important needs, a County that is hotter with less trees and less open-space will become progressively less desirable and healthful for people, birds, and wildlife. Enforcing existing codes and upgrading street planting boxes are two examples of actions that can help ensure the longevity of the existing tree canopy. For more details, see the Recommendations Section on page 28.

Arlington County
Potential Tree Planting

132,660 trees
could be planted in Arlington County.

Schools
5,315
Trees

Analysis of open spaces (bare earth or turf grass) revealed an area of 714 acres of open space where:

132,660 trees could be planted –
(45 % on public land and 55% on private land.)

Of those trees that could be planted:

- **5,315 trees** could be planted at **schools**.
- **10,030 trees** could be planted in **parks**.
- **44,202 trees** could be planted **along streets** within 50 feet of a road centerline.
- **73,113 trees** could be planted on **private property**.

Parks
10,030
Trees

Streets
44,202
Trees

To see how many trees can be planted in each Arlington neighborhood, see the Canopy Map on page 23 of this report.

Private Property—73,113 Trees

Why We Need Trees

The Benefits of Trees

There are many reasons to support robust tree canopy coverage. The statistics in this report are based on research documenting the many benefits that trees provide, and specifically the benefits provided by Arlington's tree canopy.

While this project was able to model air quality and stormwater benefits based on acres of current canopy cover, social values are more difficult to measure. However, the following list of benefits may be useful when making the case to elected officials, policy makers, local business owners, and neighbors as to the potential benefits of an enlarged and maintained urban canopy. To learn more about tree care and making the case for trees, see Appendix C for resources.

Arlington's trees benefit the County in many ways, including ecologically, economically, and socially. This assessment will allow the County Government to measure some of those benefits, preserve them, and increase them by planting more trees. The county's tree canopy can then be utilized to maximize many environmental and social benefits, such as:

- bird and wildlife habitat
- clean air and water
- walkability, fitness, and safety
- enhanced natural beauty
- lower vacancy rates
- lower heating and cooling costs
- increased revenues from sales and property taxes
- attractive locations for jobs, retail shopping, and restaurants

The county's trees and other vegetation serve as its "green infrastructure." Just as we manage our grey infrastructure (roads, sidewalks, bridges, pipes, etc.), we also need to manage our trees as green infrastructure. Trees support a vibrant, safe, and healthful county while adding to its historic character and charm. They enhance sustainability by filtering stormwater and reducing runoff, cooling streets, cleaning the air, capturing carbon emissions, and increasing property values.

Arlington County has been designated a "Tree City USA" by the Arbor Day Foundation for the past 26 years and has won a growth award for achievement over the past 19 years in recognition of the County's efforts to care for its urban trees. Therefore, as the county redevelops, managing and expanding the urban forest will help achieve its vision of preserving resources, so that they remain both sustainable and resilient.

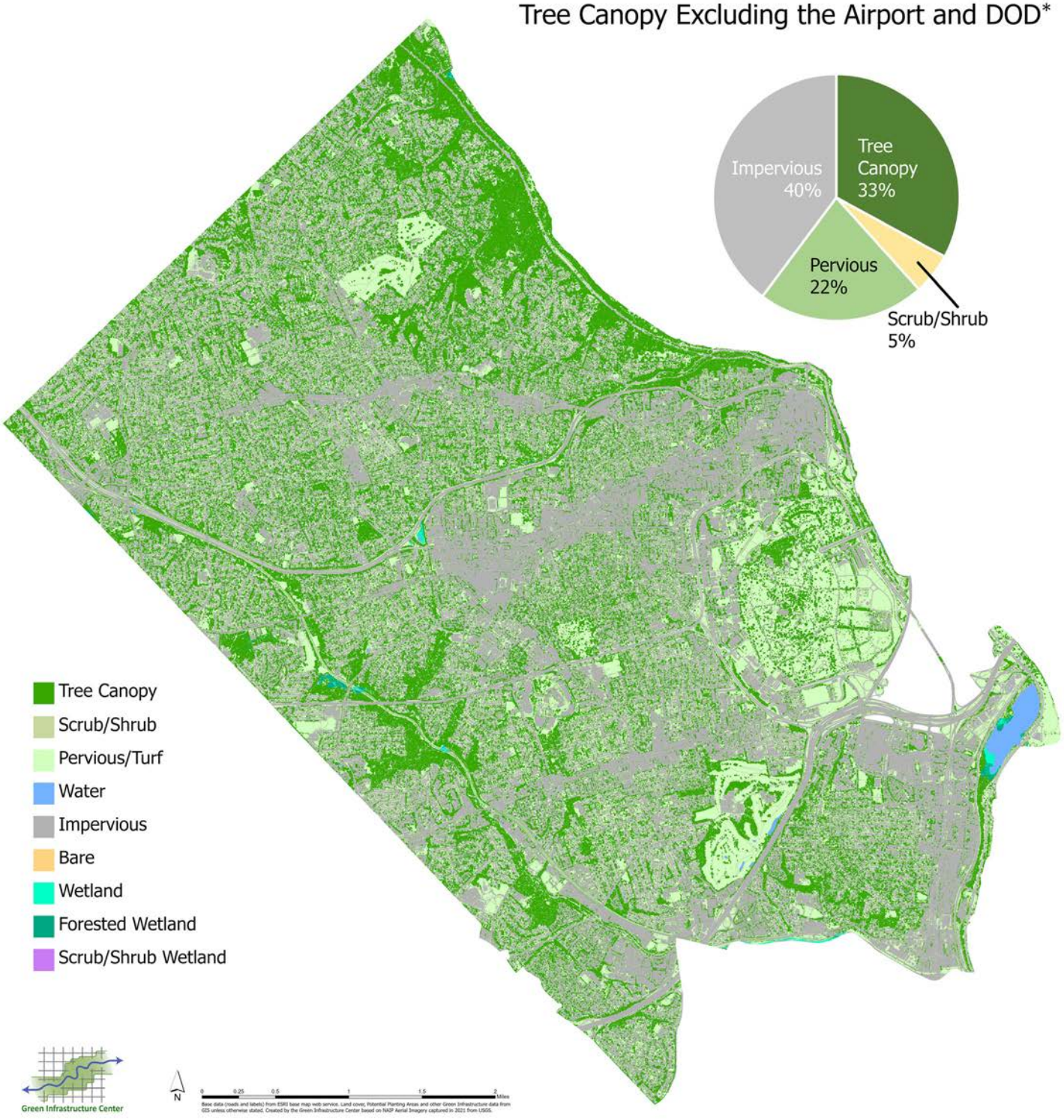
Trees provide a shady, fun setting for community events.

The County's trees provide essential shade for playgrounds. Children are more susceptible to heat-related stress.

TREE CITY USA®

To be recognized as a "Tree City USA" a city is required to:

1. **spend at least $2 per capita on tree care, planting or maintenance**
2. **have a public tree ordinance**
3. **establish a Tree Board, and**
4. **hold an annual Arbor Day Celebration in the community.**



Trees cover 33% of the County's land surface when viewed from above. However, the percentage canopy cover is not the same for every neighborhood.

* Department of Defense properties

Bigger really is better, when it comes to trees!

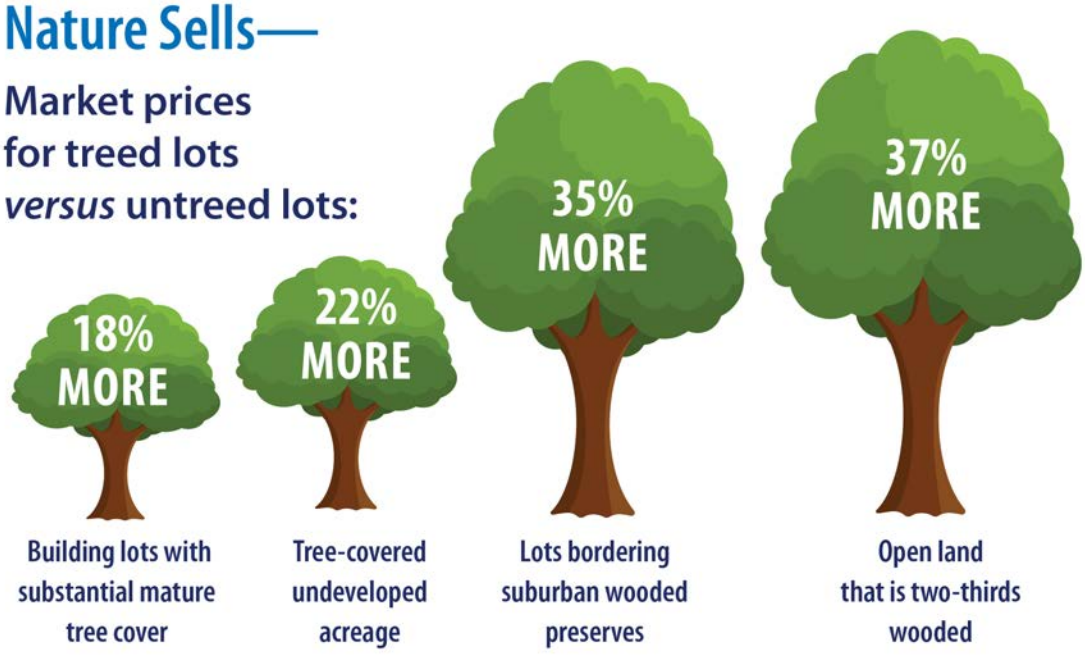
Larger trees intercept more runoff, clean more air, provide more habitat and shade than small stature trees. In fact, the USDA Forest Service finds large trees provide 15 times more community benefits overall than a small tree. So, fit as many large trees as possible into the landscape first! Then plant smaller and understory trees in the remaining open spaces. If large trees are removed and replaced with smaller ones, it can take many decades for those lost values to be replaced.

For more see: https://urbanforestrysouth.org/resources/library/citations/the-large-tree-argument-1-up

This mature large tree provides 16 times more benefits than a newly planted tree.

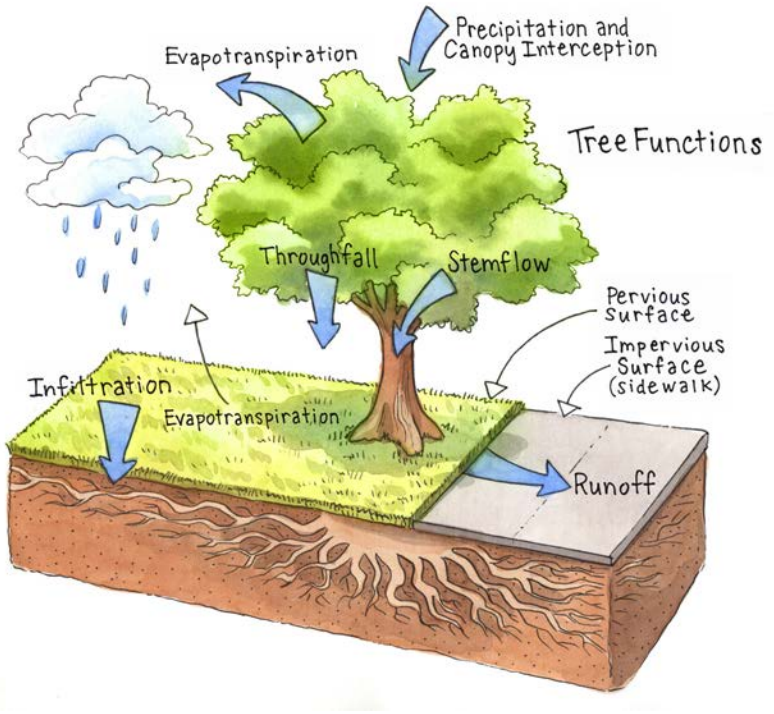
Trees Improve Public Health

Trees improve health, while paying dividends in the form of cooler neighborhoods and streets, cleaner air and less polluted stormwater runoff. When residents and government agencies consider the cost of planting and caring for more trees, it's important to note that studies have shown that "twenty years after planting, average annual benefits for all public trees exceed costs of tree planting and management" (Peper et al, 2010). And of course, even a newly planted tree will immediately begin to sequester carbon, clean the air, and soak up stormwater. So, while the County may need to expend more funds to increase and to maintain its canopy coverage, those trees will more than pay their way. For example, trees planted in commercial shopping districts increase the length of visits and the level of spending, which benefits the County in increased sales revenues from shops and restaurants. Trees also increase the value of residential lots, and mature trees contribute far more to property values than newly planted trees.



Source: Kathleen Wolf, 2007, City Trees and Property Values.

Trees Reduce Stormwater Runoff



The County's trees mitigate stormwater runoff impacts since they capture rainfall in their canopies, trunks, roots, and surrounding soils. Some of that water is released back into the atmosphere through evapotranspiration. One mature, large tree can absorb thousands of gallons of water per year. As tree cover is lost and impervious areas expand, excessive urban runoff results in pollutants, such as oils, metals, lawn chemicals (e.g., fertilizers and herbicides), pet waste, trash, and other contaminants reaching surface waters. Trees help capture and filter that urban runoff. Nitrogen and phosphorus are nutrients that cause harmful algal blooms, while sediment can clog fish gills, smother aquatic life, and necessitate additional dredging of waterways. Algal blooms can also reduce oxygen levels, further harming fish and other aquatic life.

That trees and forests are the best land cover for taking up urban stormwater is recognized by many forestry scientists and civil engineers (Kuehler 2017, 2016). Trees intercept, take up, and slow the rate of stormwater runoff. Canopy interception varies from 100 percent at the beginning of a rainfall event, slowing to about three percent at maximum rain intensity (Xiao et al. 2000). Shrubs are also important as groundcover underneath trees to soak up additional stormwater. However, if the choice is between a tree or a shrub, choose a large tree, which will soak up thousands more gallons of water annually than a bush.

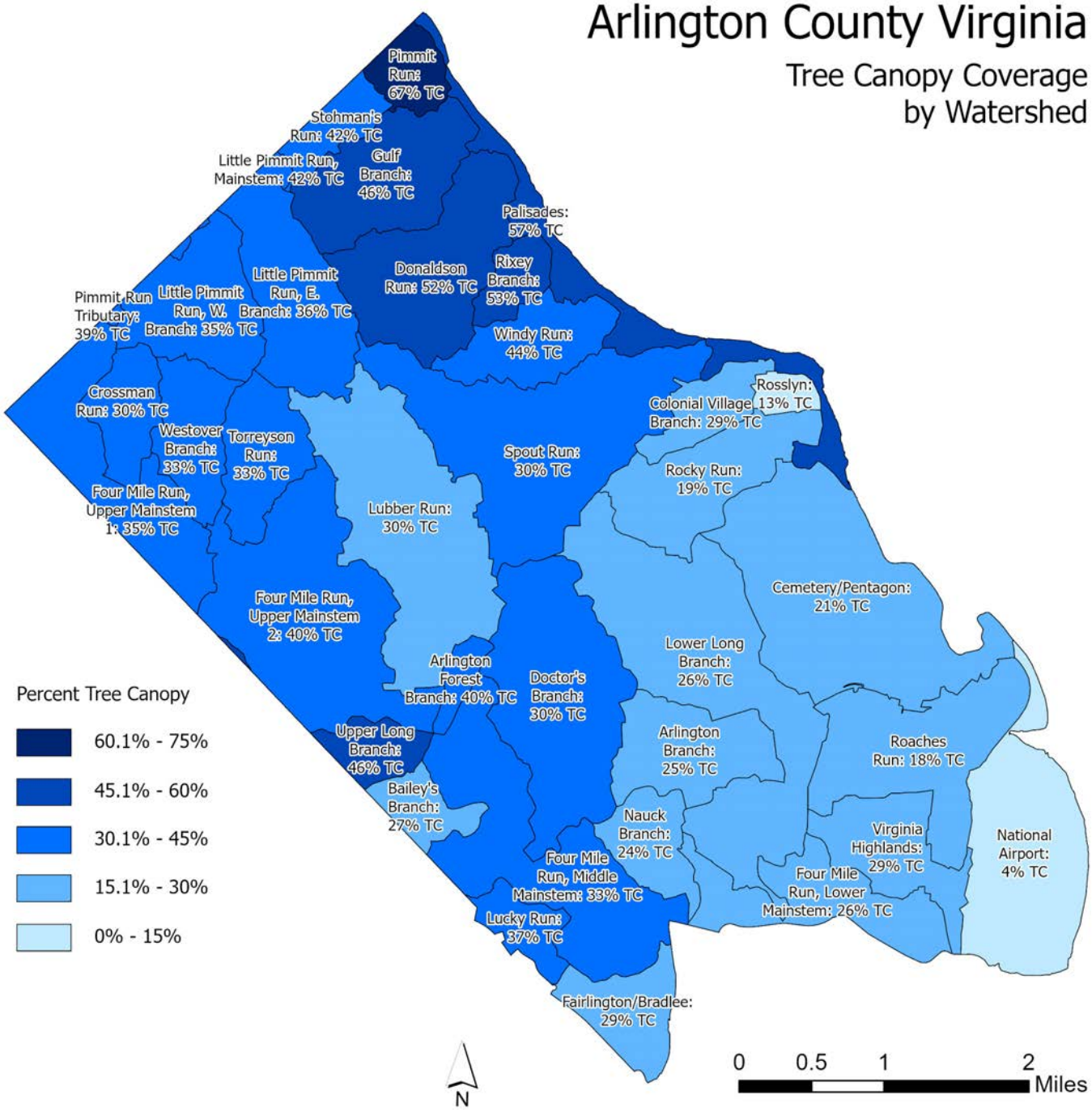
The GIC's **Trees and Stormwater Calculator** (TSC) tool applied to this project can be used to model stormwater uptake by trees for various storms that occur throughout the year. Engineers use storm events as standard for stormwater capture. So, a 10-year storm is the amount of rain that would fall in Arlington over 24 hours for an event with a likelihood of 10% chance of occurrence per year. Most stormwater systems are engineered to capture a 10-year storm. For example, the TSC tool shows that, during a larger 10 year/24hr storm, Arlington's trees currently soak up 33.7 million gallons of water = about 51 Olympic swimming pools of water! During that same storm event, the County's trees would capture 22,338 lbs. of nitrogen, 1,766 pounds of phosphorus, and 2,320 tons of sediment, all of which are prevented from running off and harming local streams. Thus, trees perform an important "ecosystem service" by taking up stormwater, cleansing the water, and reducing flooding. To understand how the tool was created, see Appendix A: Methods.

Name: Arlington, Virginia, USA* — **Urban Tree Canopy Stormwater Model** — version May 4, 2022

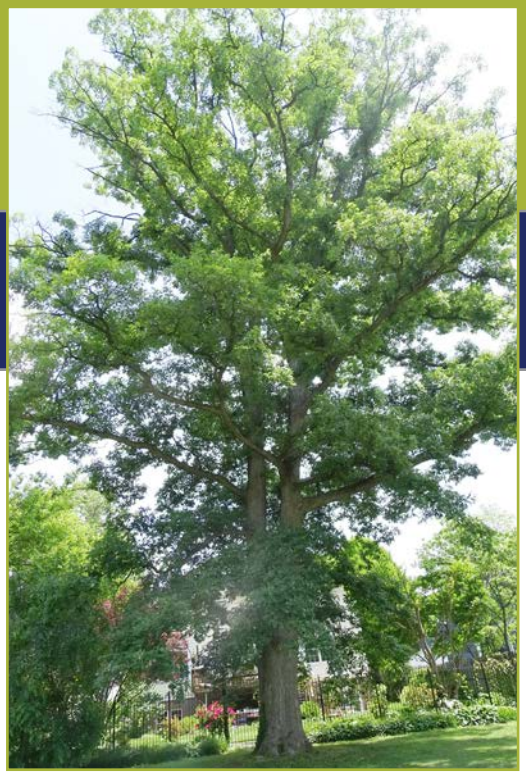
The Green Infrastructure Urban Tree Canopy Stormwater Model estimates stormwater runoff yields for current and potential land cover. The methodology is based upon the NRCS TR-55 method for small urban watersheds. It is used to provide better estimates using GIC's high-resolution land cover and modeling of potential canopy area.

Green Infrastructure Center

				million gallons												
	TOTALS	30.8%	40.9%	32.3	-	-	30.8%									
	Statistics by Drainage Basin (current settings)							Variable								Variable
	Area	Current Tree Cover	Current Impervious Cover	Tree H20 Capture	Increased H2O w/xx% tree loss	Added H2O Capture w/xx% PCA	Adjusted Tree Cover from loss and gain scenarios	Pick an Event	Pick a loss scenario		Converted Land				Canopy Added	Enter % canopy to add
		%		million gallons			%	Event	% UTC loss	% FOS Loss	% Imperv	Max TC Possible	Maximum Potential Added Canopy Area	% Canopy Added	% of PCA achieved	
1	Arlington Branch	24.6%	45.1%	0.7	-	-	24.6%	10 yr / 24	0%	0%	0%	31.0%	6.5%	0.0%	0%	
2	Arlington Forest Branch	39.9%	38.3%	0.2	-	-	39.9%	10 yr / 24	0%	0%	0%	48.0%	8.1%	0.0%	0%	
3	Bailey's Branch	27.0%	49.6%	0.3	-	-	27.0%	10 yr / 24	0%	0%	0%	36.3%	9.3%	0.0%	0%	
4	Cemetery/Pentagon	21.0%	29.9%	1.4	-	-	21.0%	10 yr / 24	0%	0%	0%	26.8%	5.7%	0.0%	0%	
5	Colonial Village Branch	28.6%	54.4%	0.4	-	-	28.6%	10 yr / 24	0%	0%	0%	33.7%	5.1%	0.0%	0%	
6	Crossman Run	30.4%	43.2%	0.4	-	-	30.4%	10 yr / 24	0%	0%	0%	40.1%	9.7%	0.0%	0%	
7	Doctor's Branch	30.5%	40.5%	1.7	-	-	30.5%	10 yr / 24	0%	0%	0%	40.7%	10.2%	0.0%	0%	
8	Donaldson Run	51.6%	20.9%	2.7	-	-	51.6%	10 yr / 24	0%	0%	0%	58.0%	6.4%	0.0%	0%	
9	Fairlington/Bradlee	29.5%	44.9%	0.5	-	-	29.5%	10 yr / 24	0%	0%	0%	39.5%	10.0%	0.0%	0%	
10	Four Mile Run, Lower Mainstem	25.7%	49.0%	0.8	-	-	25.7%	10 yr / 24	0%	0%	0%	35.9%	10.2%	0.0%	0%	
11	Four Mile Run, Middle Mainstem	33.3%	42.6%	1.9	-	-	33.3%	10 yr / 24	0%	0%	0%	41.1%	7.8%	0.0%	0%	
12	Four Mile Run, Upper Mainstem 1	35.4%	38.4%	1.2	-	-	35.4%	10 yr / 24	0%	0%	0%	44.9%	9.5%	0.0%	0%	
13	Four Mile Run, Upper Mainstem 2	40.0%	32.3%	2.7	-	-	40%	10 yr / 24	0%	0%	0%	49.2%	9.2%	0.0%	0%	
14	Gulf Branch	45.7%	27.3%	1.6	-	-	46%	10 yr / 24	0%	0%	0%	55.4%	9.7%	0.0%	0%	



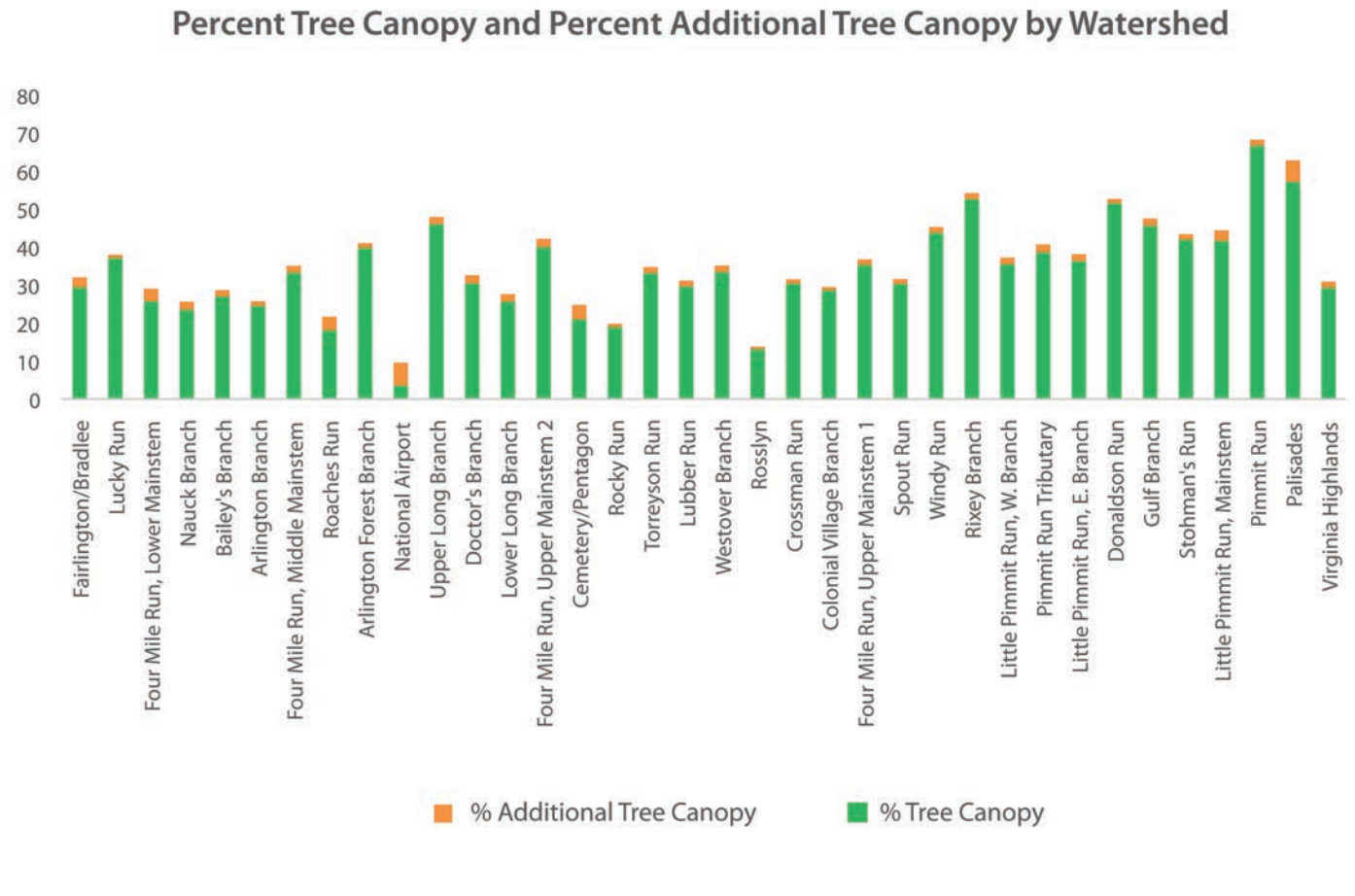
Tree cover varies across County watersheds.
Well-treed watersheds have less runoff and cleaner stormwater.



A large tree such as this one captures thousands of gallons of rainfall annually, preventing polluted runoff and lessening street and creek flooding.

A typical street tree can intercept between 760 and 3,000 gallons of water per year.

Since trees filter stormwater and reduce overall flows, planting or conserving trees is a natural way to mitigate stormwater. Each tree plays an important role in stormwater management. Based on GIC's review of canopy rainfall interception studies, a typical street tree can intercept between 760 and 3,000 gallons of water per year, depending on species and age. This could be a significant benefit in reducing stormwater flows into storm sewers. A way to calculate the benefits of a tree in a backyard is to use a tape measure to determine diameter (measure the tree's circumference at a height of about 4.5 feet above the ground and divide the result by 3.14). Then, use this on-line app to get a value for an individual tree's stormwater and air quality benefits https://mytree.itreetools.org/#/

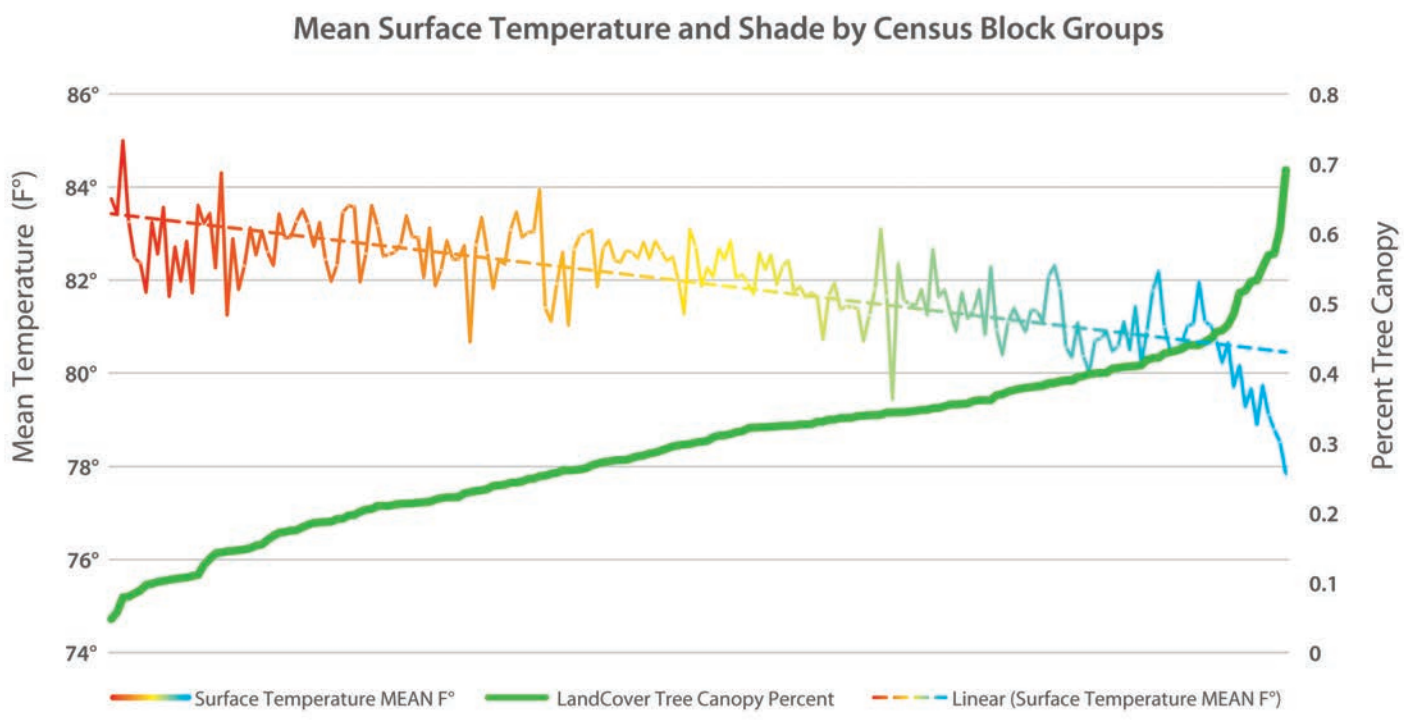


Trees Cool the County

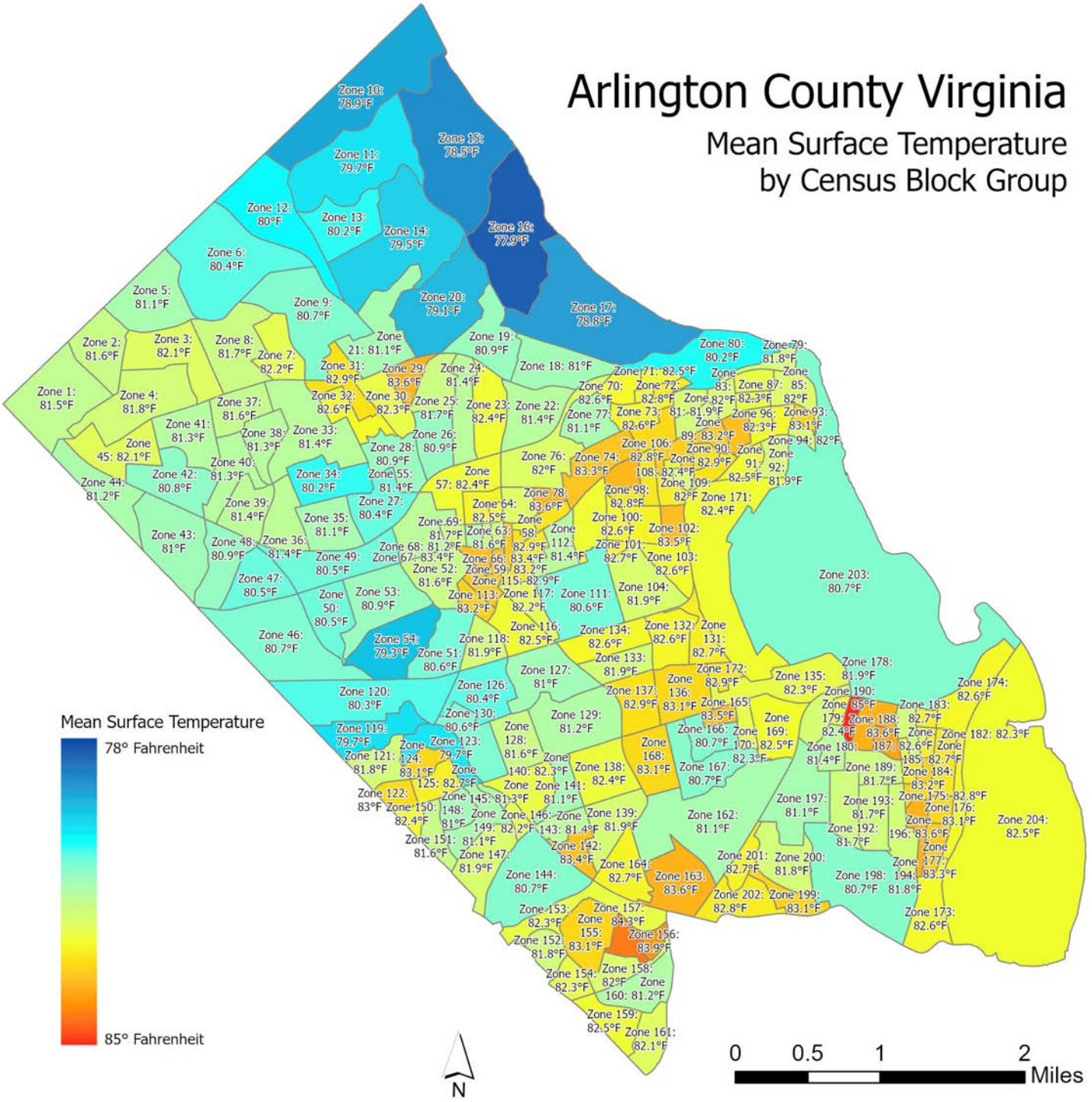
Increasing shade provides many benefits, especially during Virginia's hot summers. Excessive heat can lead to heat stress, which especially affects infants and children up to four years of age, those 65 years and older, those with obesity issues, and those on certain medications (CDC 2020). A single mature tree can transpire hundreds of liters of water per day, which represents a cooling power equivalent to the energy needed to power two average household central air-conditioning units per day (Ellison et al, 2017). In some cases, lower income neighborhoods are less tree covered and hotter. Due to the relative affluence of Arlington County, on average this difference is less pronounced, but recent research has shown significantly higher areas of heat in some neighborhoods. To learn more visit https://www.vfic.org/wp-content/uploads/2022/03/Heat-Watch-VFIC_Report_110321.pdf

Multiple studies have found significant cooling (2–7° F) and energy savings from shade trees in urban areas (McPherson et al 1997, Hashed et al 2001). Shaded pavement also has a longer lifespan, so maintenance costs associated with roadways and sidewalks are less (McPherson and Muchnick 2005). These benefits are particularly important in the southeastern United States, where average temperatures are generally higher than in northern states.

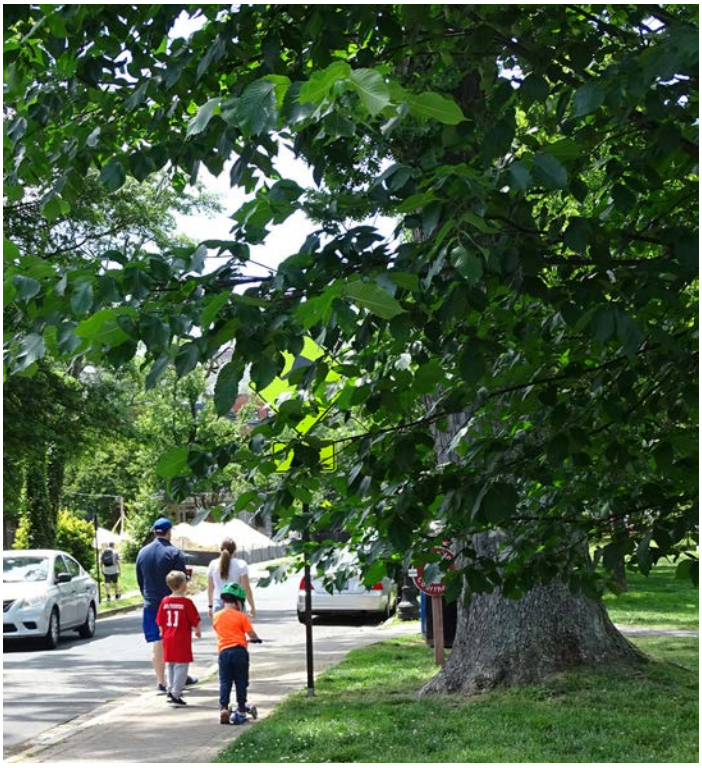
Large paved areas without shade are much hotter and less pedestrian friendly.



Areas in Arlington lacking good tree cover are significantly hotter than areas with a high percentage of tree canopy.



Areas with little or no trees are significantly hotter. In this map, blue-colored areas are cooler, while orange and red areas are hotter. Electricity demand for air conditioning increases approximately 1-9% for each 2°F increase in temperature (U.S. EPA).

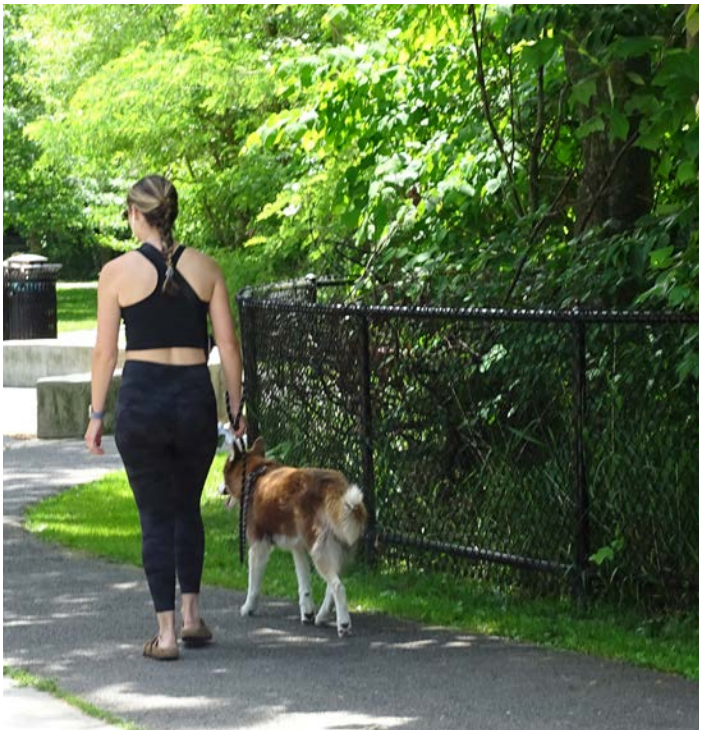


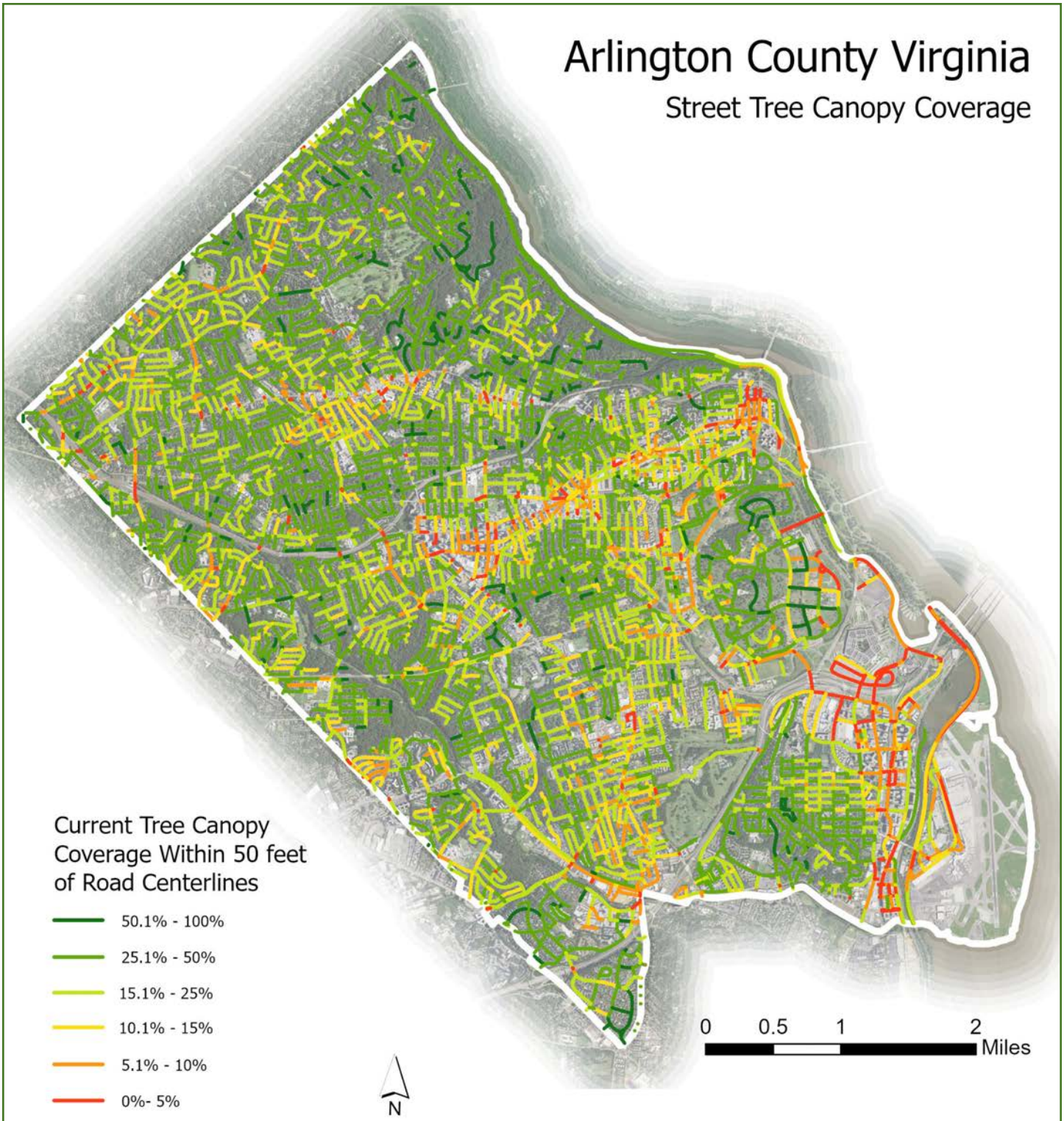
Well-treed areas encourage people to walk and cycle.

Trees cover shades streets, sidewalks, parking lots, and homes, making urban locations cooler and more pleasant for walking, biking, and using public transit. Trees result in people walking more and farther. When trees are not present, people perceive distances to be longer, hotter, and less pleasant, making pedestrians less inclined to walk than if streets are well treed (*Tilt, Unfried, and Roca* 2007).

Shaded streets encourage people (and pets!) to walk father and longer, increasing community fitness.

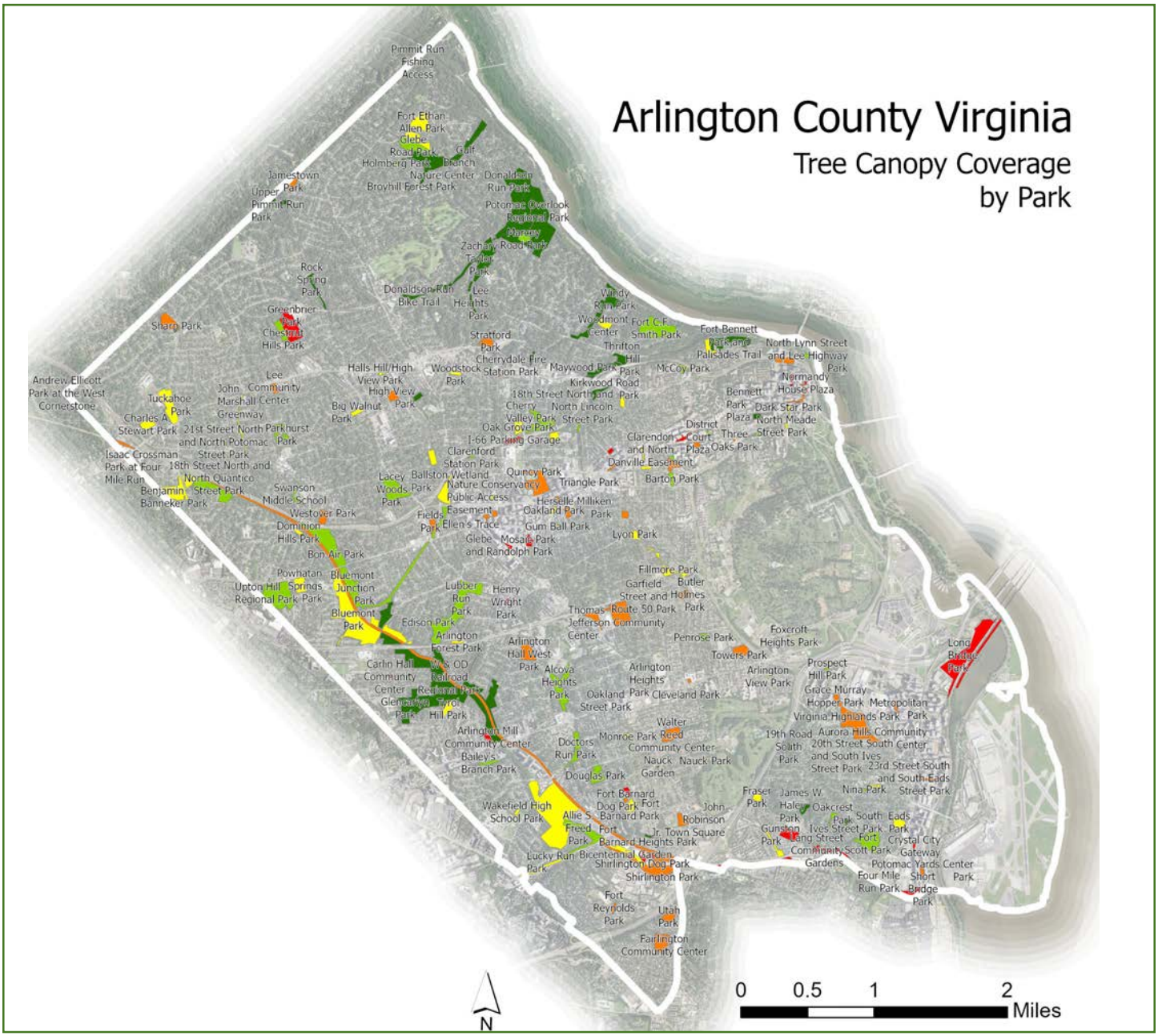
Shaded streets can be up to 7°F cooler than streets with full sun.





While Arlington's neighborhoods are relatively well-shaded, there are streets, especially in commercial areas, that are much hotter (see orange and red streets).

57% of home buyers were more likely to purchase a home near green space, while 50% of home buyers were willing to pay 10% more for a home located near a park or other protected area.



Percent Tree Canopy of Arlington County Parks

PARK NAME	%
Ellen's Trace	0%
Crystal City Gateway	1%
Rosslyn Central Place	1%
Rosslyn Plaza	2%
I-66 Parking Garage	2%
Rosslyn Highlands Park	3%
District Court Plaza	3%
Bennett Park Plaza	3%
Normandy House Plaza	7%
Glebe and Randolph Park	7%
James Hunter Park	8%
Short Bridge Park	8%
Arlington Mill Community Center	9%
4MRV Area Plan Area	9%
Henry Wright Park	10%
Triangle Park	11%
Long Bridge Park	11%
Gunston Park	14%
Fort Barnard Community Garden	14%
Courthouse Plaza	15%
Lang Street Community Gardens	16%
Four Mile Run Park	17%
Carlin Hall Community Center	17%
Mosaic Park	17%
Belvedere Park	18%
Greenbrier Park	19%
Pimmit Run Fishing Access	20%
Jennie Dean Park	22%
Potomac Yards Center Park	22%
John Robinson Jr. Town Square	22%
Penrose Square	22%
Aurora Hills Community Center	23%
Verizon Plaza	23%
Clarendon Central Park	23%
Quincy Park	23%
Three Oaks Park	25%
Thomas Jefferson Community Center	25%
Clarendon-Barton Interim Open Space (Korean Embassy)	25%
Maury Park	25%
Freedom Park	26%
Drew Park	27%
High View Park	27%
W & OD Railroad Regional Park	28%
Arlington Hall West Park	28%
Fields Park	28%
Lee Community Center	29%
Westover Park	29%
Utah Park	29%
21st Street North and North Stafford Street Park	29%

PARK NAME	%
Zitkala-Ša	30%
Welburn Square	30%
Virginia Square Metro Plaza	31%
Gateway Park	31%
Metropolitan Park	32%
Rocky Run Park	32%
Fort Barnard Dog Park	32%
Walter Reed Community Center	32%
23rd Street South and South Eads Street Park	33%
Ellipse Arts Center	33%
Cheerios Park	33%
Fort Reynolds Park	35%
20th Street South and South Ives Street Park	35%
Butler Holmes Park	35%
Minor Hill Park	35%
Stratford Park	36%
Rhodeside Green Park	36%
Fairlington Community Center	36%
Towers Park	37%
Jamestown Park	37%
Virginia Highlands Park	37%
Grace Murray Hopper Park	39%
Shirlington Park	39%
Halls Hill/High View Park	41%
Fort Barnard Park	41%
Eads Park	42%
Oakland Park	43%
Woodlawn Park	45%
Wakefield High School Park	45%
Fort Ethan Allen Park	45%
Garfield Street and Route 50 Park	46%
North Meade Street Park	46%
Nature Conservancy Public Access Easement	47%
Nauck Park	47%
Fillmore Park	48%
East Falls Church Park	48%
Arlington Forest Park	49%
Gum Ball Park	49%
Troy Park	49%
Dominion Hills Park	50%
11th Street Park	50%
Charles A. Stewart Park	50%
Lyon Village Park	50%
Woodmont Center	50%
Arlington View Park	51%

PARK NAME	%
Dark Star Park	51%
Clarendon Market Commons Easement	52%
John Marshall Greenway	52%
Powhatan Springs Park	53%
Big Walnut Park	53%
Monroe Park	53%
Shirlington Dog Park	54%
Edison Park	54%
Lyon Park	55%
Lucky Run Park	55%
Ballston Wetland Park	56%
Hayes Park	56%
Fraser Park	56%
Tuckahoe Park	56%
Dawson Terrace Community Center	57%
Oak Grove Park	57%
Tyrol Hill Park	57%
Bicentennial Garden	58%
Barcroft Park	58%
Nelly Custis Park	58%
Bluemont Park	59%
Herselle Milliken Park	59%
Woodstock Park	60%
Benjamin Banneker Park	60%
Barton Park	61%
Marcey Road Park	62%
Bon Air Park	64%
Parkhurst Park	65%
Courthouse Hill Public Access Easement	65%
Penrose Park	65%
Allie S. Freed Park	67%
Oakland Street Park	67%
Fort C.F. Smith Park	68%
Chestnut Hills Park	68%
Fort Myer Heights Park	68%
Prospect Hill Park	68%
Bluemont Junction Park	68%
McCoy Park	69%
Kirkwood Road Neighborhood Park	69%
Arlington Heights Park	70%
Swanson Middle School	70%
Oakcrest Park	71%
Fort Scott Park	71%
Madison Manor Park	71%
Nina Park	72%
Alcova Heights Park	73%
Cleveland Park	73%
Foxcroft Heights Park	74%

PARK NAME	%
Holmberg Park	74%
Douglas Park	74%
Cherrydale Fire Station Park	74%
Doctors Run Park	75%
Lacey Woods Park	75%
Cherry Valley Park	75%
Clarenford Station Park	76%
Lubber Run Park	77%
18th Street North and North Lincoln Street Park	77%
Maywood Park	78%
Bailey's Branch Park	78%
Arlington Plaza	79%
Upton Hill Regional Park	79%
21st Street North and North Potomac Street Park	79%
North Lynn Street and Lee Highway Park	80%
Glebe Road Park	80%
18th Street North and North Quantico Street Park	80%
Upper Pimmit Run Park	80%
Slater Park	81%
Rock Spring Park	82%
Thrifton Hill Park	82%
Nauck Garden	83%
James W. Haley Park	83%
Cherrydale Park	84%
Hillside Park	84%
Clarendon and North Danville Easement	84%
Glencarlyn Park	85%
Broyhill Forest Park	85%
Fort Bennett Park and Palisades Trail	87%
Windy Run Park	87%
Fort Barnard Heights Park	88%
Gulf Branch Nature Center	89%
Mary Carlin Woods at Bluemont Park	90%
Lee Heights Park	90%
Zachary Taylor Park	90%
South Ives Street Park	90%
Sharp Park	91%
Donaldson Run Bike Trail	93%
Potomac Overlook Regional Park	93%
Kirkwood Road Park	94%
Isaac Crossman Park at Four Mile Run	94%
19th Road South Park	94%
Donaldson Run Park	95%
Andrew Ellicott Park at the West Cornerstone	98%

Trees Clean the Air

In addition to cooling surfaces, trees absorb volatile organic compounds and particulate matter from the air, improving air quality. Higher tree canopies are correlated with better air quality. For example, trees clean the air of ground level ozone (O_3) and filter out fine particulate matter, which can damage lungs and lead to respiratory distress, such as asthma, and can exacerbate various illnesses and diseases. Well-treed neighborhoods have been found to have lower rates of respiratory illness (Rao *et al*, 2014).

Trees also sequester carbon, which forms greenhouse gases such as sulfur dioxide and carbon dioxide. These gases contribute to a warming planet and are associated with health problems due to excessive heat. By storing carbon and preventing its release, trees mitigate the impacts of climate change. The table below shows statistics for air pollution removal by trees in Arlington.*

Trees clean the air and reduce the chemicals that cause greenhouse gases. Even at the neighborhood scale, trees significantly reduce particulate pollutants, resulting in less respiratory illnesses. According to the American Lung Association (ALA), Arlington does very well in combating particulate matter, likely due to its leafy green neighborhoods.[1] However, canopy levels do vary between County neighborhoods, so it's important to ensure that all neighborhoods are well-treed to reap these benefits. Overall, the County does not do as well for other air pollutants, such as ozone, for which it received a failing grade from the ALA.

[1] https://www.lung.org/research/sota/city-rankings/states/virginia/arlington

Trees reduce fine particulate matter and clean the air of many other pollutants.

Air Pollution Removal by Trees in Arlington

Pollutant (Abbrev.)	Benefit Description	Removal rate (lbs/acres/year)	Acres Canopy	Removal rate (lbs/year)
CO	Carbon monoxide removed annually	0.15	5,181	751.58
NO_2	Nitrogen dioxide removed annually	2.64	5,181	13,682.24
O_3	Ozone removed annually	15.36	5,181	79,597.38
PM_{10}	Particulate matter greater than 2.5 microns and less than 10 microns removed annually	4.09	5,181	21,170.50
$PM_{2.5}$	Particulate matter less than 2.5 microns removed annually	0.49	5,181	2,542.31
SO_2	Sulfur dioxide removed annually	0.95	5,181	4,899.72
C	Carbon dioxide sequestered annually in trees	4.43	5,181	22,951.83
C	Carbon dioxide stored in trees (note: this benefit is not an annual rate)	NA	5,181	633,546,840

* based on iTree multipliers and USFS calculations for carbon rates for Northern Va.

Methods to Determine Current and Potential Tree Canopy Cover Value

This assessment determined the current and potential future tree canopy and quantified the ecosystem services that tree canopy provides. First, a highly detailed land cover analysis was conducted to determine current and potential tree cover. (See Appendix A for details on the methods used.) In addition to urban forest planning now underway, this new land cover data can be used for other purposes, such as to analyze public policy on stormwater management, urban cooling, walkability, and street tree plantings. The detailed land cover maps can also inform area or neighborhood plans and planting campaigns.

Civic associations can use the data and educational materials to motivate residents to plant more trees and encourage the County to do the same for public lands. They can also learn about important trees in their communities by using the County's viewer, which shows existing inventoried trees, as well as the locations for champion (large and significant) trees: https://www.arcgis.com/apps/dashboards/f2529535681e4fb6a8bb3107191687f7

Mapping Tree Cover

Satellite imagery from the National Agricultural Imagery Program (NAIP) distributed by the USDA Farm Service Agency was classified based on four infrared bands to determine the types and extent of different land covers in the County. Additional data sets from the County, the National Wetlands Inventory, and the National Hydrography Dataset were used to classify the following:

1) **Tree canopy**, defined as woody vegetation over 8' in height.
2) **Wetlands** that are indistinguishable using other spectral/feature-based image classification tools.

LiDAR (light detection and ranging) data from 2018 were used as a further check of the data by determining the height of vegetation, in order to distinguish between large shrubs and trees.[2] This allowed the GIS analyst to separate bushes from trees and other vegetation. This distinction of tree/non-tree vegetation is very important when modeling tree benefits, since the modeled pollution-removal benefits are based on trees, and do not necessarily translate to smaller, non-woody vegetation.

Arlington County's tree canopy in 2021 was 33% compared to 41% in 2017— an 8% loss.

Taking the entire County into account, **Arlington's Tree Canopy is 31%.** This is based on imagery that was flown in 2021 and processed by GIC in the fall of 2022. Excluding land in the airport and land on Department of Defense properties, which are not managed by the County, Arlington's tree canopy is 33%. This is also based on 2021 imagery from the National Agricultural Imagery Project (NAIP) that was processed in the fall of 2022.

The most recent County commissioned study, carried out in 2017, estimated a 41% canopy coverage, or 8% more canopy than shown by the 2021 data. When reviewing such percentages, it is important to note that all studies have a margin of error of several percentage points. However, this difference of 8% is greater than such a margin. GIC's errata testing shows that the data accuracy for the 2021 canopy cover data processed by GIC in 2022 has an accuracy rate of 97%.

[2] LiDAR is a remote sensing method that uses light in the form of a pulsed laser to measure ranges (variable distances) to the top of the vegetation, compared to the underlying surface of the earth. The farther the laser beam travels, the shorter the vegetation. 2018 is the most recent date for LiDAR data.

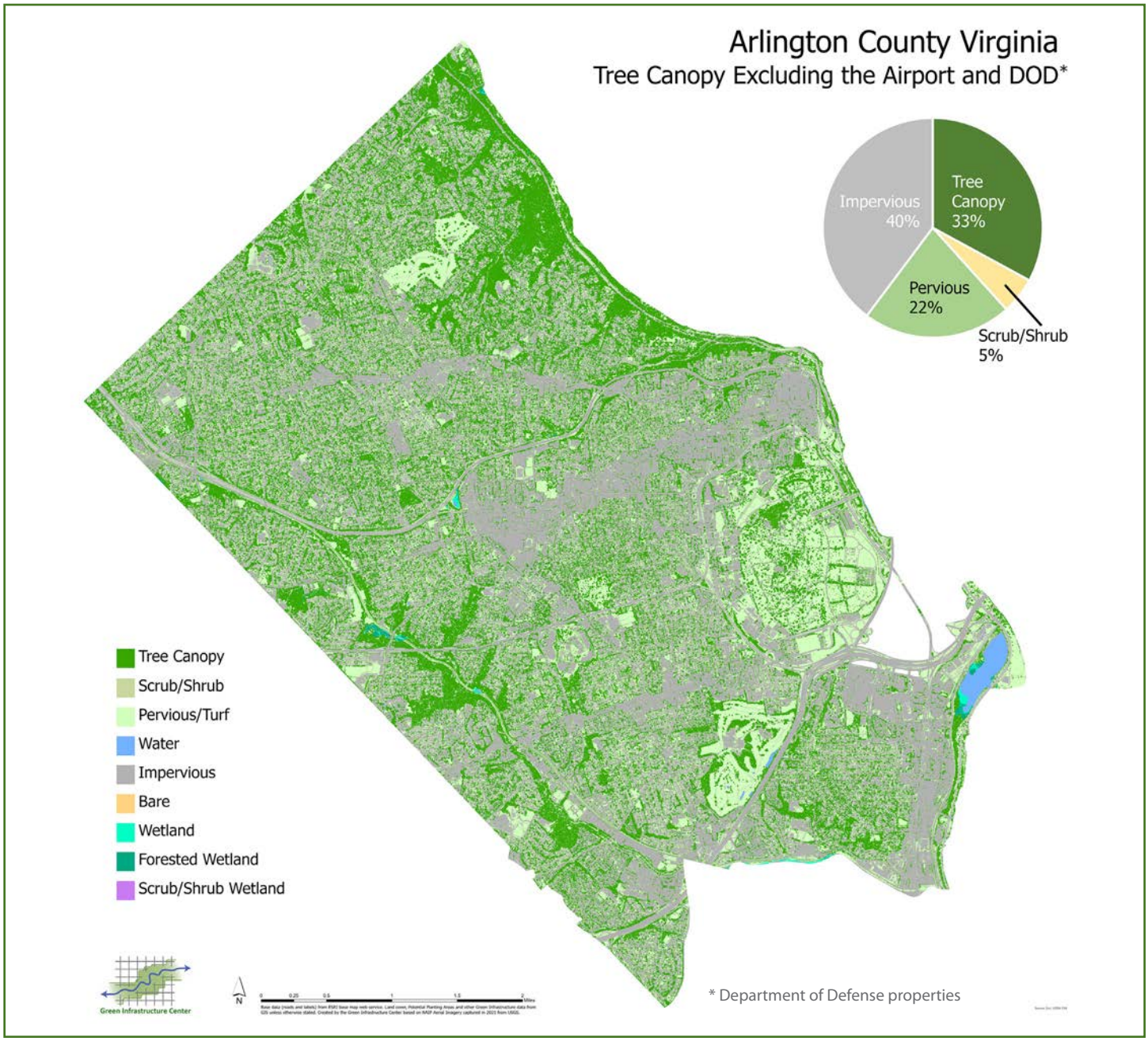
There could be several reasons for the change in canopy percentage between 2017 and 2021. For example, the 2017 study does not appear to have used LiDAR to separate out shrubs and so may have overestimated tree cover, mistaking bushes for trees. Thus, the County's tree cover may have been less than was reported in 2017. In addition, trees have likely been lost to storms, development, re-development, disease, and old age over the intervening four years.

One small caveat to the canopy percentage recorded as 33% is that newly planted trees may not show up as trees because they could be quite small (e.g., only 8 feet tall) and could be misclassified as shrubs. However, there are not enough newly planted trees in the county to change the canopy percentage significantly.

Determining Plantable Acreage

Potential Planting Areas

In urban areas, realistic goals for expanding tree canopy depend on an accurate assessment of plantable open acreage. A Potential Planting Area (PPA) map estimates areas where it may be feasible to plant trees. The PPA is estimated by selecting those land cover features that have space available for planting trees and accounts for the overlap of canopy (canopy that is intermingled, or a large canopy tree that partially covers an understory tree). This study found 714 acres of open space where 132,660 trees could be planted. Of those trees: 10,030 could be planted in parks and 5,315 at schools, with 44,202 as street trees (within 50 feet of a road centerline), while the remainder could be planted on private property.



Possible Planting Spots

Potential Planting Spots (PPS) are created from the PPA. A GIS modeling process is applied to select spots where a tree can be planted, depending on the desired mature size. For this analysis, expected sizes of 20ft. and 40ft. diameter for individual mature canopy trees were used, with priority given to 40ft diameter trees, since larger trees provide more benefits.

Potential Canopy Area

The Potential Canopy Area (PCA) was created from the PPS. Once possible planting spots are selected, a buffer around each point is created to represent the mature canopy spread. For this analysis, that buffer radius is either 10' or 20' which represents the canopy spread. These individual tree canopies are then merged to form a Potential Canopy Area.

The PPA map does not include playing fields, cemeteries, and other land uses that are unsuitable for new tree plantings. Even so, it is not practical to plant all the remaining open spaces, as this would result in a mostly shaded County with no vegetable gardens or sunny spots. Usually, about half the available open space can actually be planted.

Potential Planting Area Data

NAIP Image

Potential Planting Area (PPA)

Potential Planting Spots (PPS)*

Potential Canopy Area (PCA)

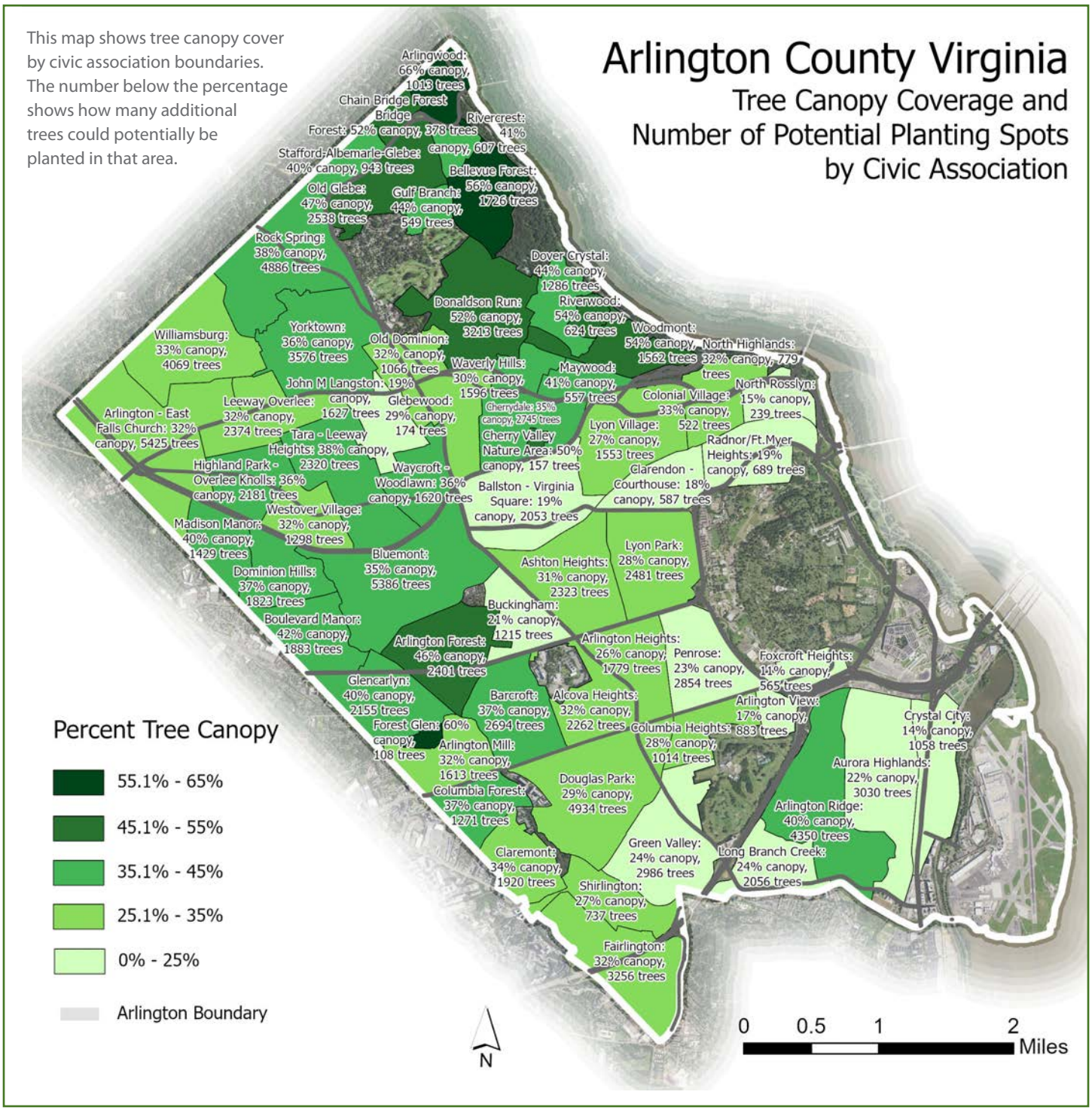
After mapping the landcover, we examine open spaces that could be available for planting = lawn, or bare earth as PPA.
We can see whether we can fit trees in the open spaces (PPS) and then digitally grow out those trees to determine future canopy (PCA).
This helps us know just how many trees could be planted in Arlington.

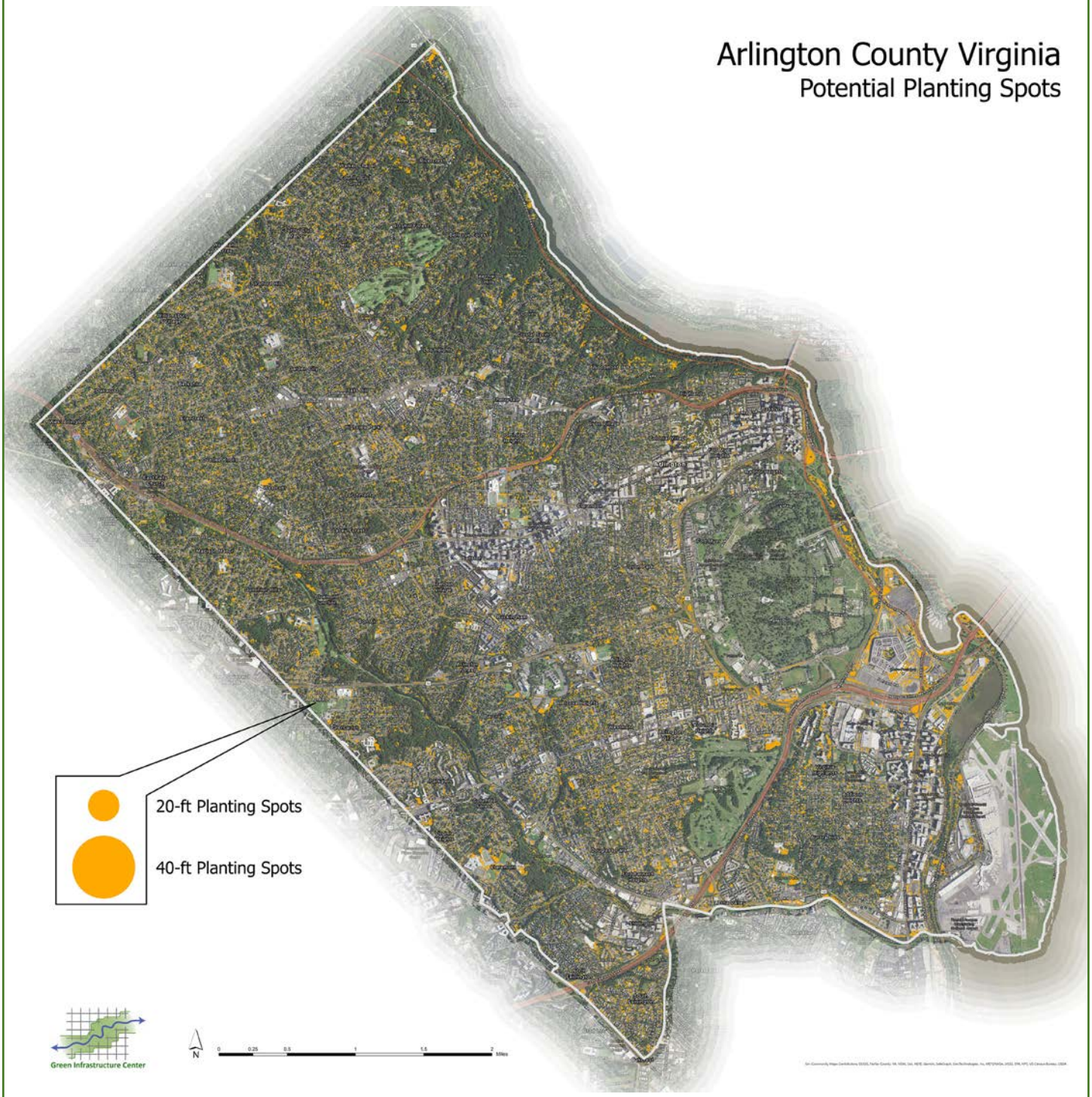
Since the current canopy is 33% and the maximum potential canopy is 39%, only 6% of plantable open space remains. As it is not possible to plant all open areas, **planting about half yields a canopy coverage of 36%, or about 66,300 trees** that could be fitted into the open area. Note that these estimates include setbacks from such structures as buildings, roads, and other paved areas. Past estimates of plantable open space may not have fitted the canopy into the actual landscape and probably overestimated the plantable open space. Also note that, since trees are removed each year, because of storms, disease, development, etc. additional **trees will need to be planted every year, just to maintain the existing 33% canopy**.

Of the land cover types mapped, only pervious (bare earth) and turf land covers were considered for the PPA. However, some paved areas could be removed or reduced, soils conditioned, and then used to plant new canopy. For example, a parking lot could be redesigned in order to accommodate more tree canopy to absorb and clean stormwater runoff. Some cities have lowered their parking minimums (number of required spaces) and others have adopted a parking maximum (a cap on the number of spaces, to avoid over paving). If fewer spaces are required, more space is available to plant trees.

Another way to examine the data is by civic association. Both existing tree cover and plantable open space vary by neighborhood. And some areas are seeing more redevelopment – tear downs of existing bungalows and post-WWII properties that are rebuilt, with larger homes taking up far more of the lot coverage.

The map below shows the canopy by civic association and the number of trees that could be planted in each neighborhood. The Potential Planting Spots map is available here: https://www.arltreeconsort.net/arlington-tree-canopy-report-and-maps to see tree planting locations. Note that planting plans will still require some field checking to avoid overhead powerlines and conflicts with underground utilities. (Call Miss Utility by dialing 811 at least 72 hours prior to excavating, and do not plant on public land without prior permission.)

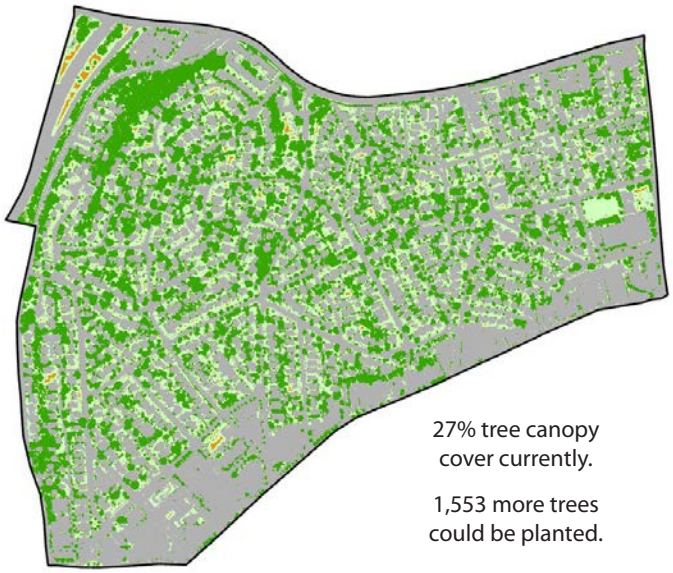



Arlington County Virginia
Potential Planting Spots
20-ft Planting Spots
40-ft Planting Spots
Green Infrastructure Center
N

Trees are lost through residential removal, new development, poor maintenance and old age.

The key is to understand that the County is losing canopy and that a concerted effort is needed now to stem the loss.

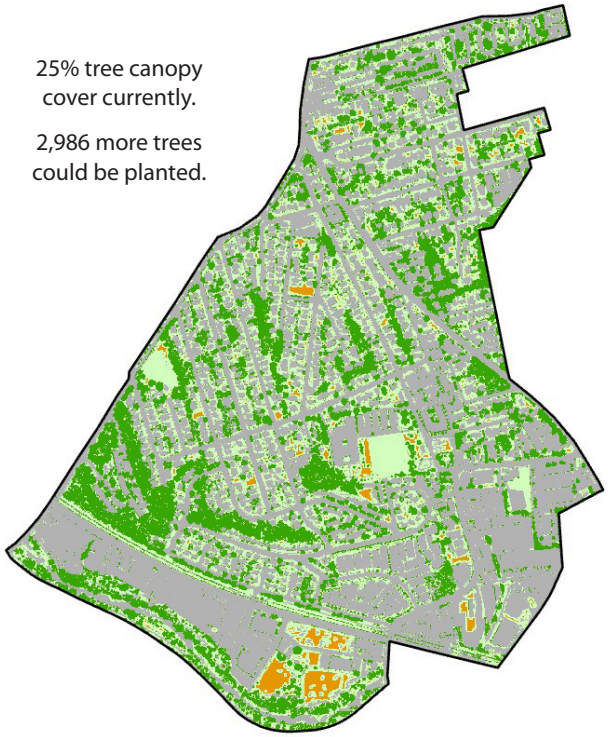
It is important to remember that these data are a snapshot in time from data gathered during a particular flyover (fall 2021). Trees may have been removed since then, damaged by a recent storm, or new ones may have been planted and not yet show up in the imagery. So, all planting sites should be field checked before finalizing plans. The key is to understand that the County is losing canopy and that a concerted effort is needed now to stem the loss.



27% tree canopy cover currently.

1,553 more trees could be planted.

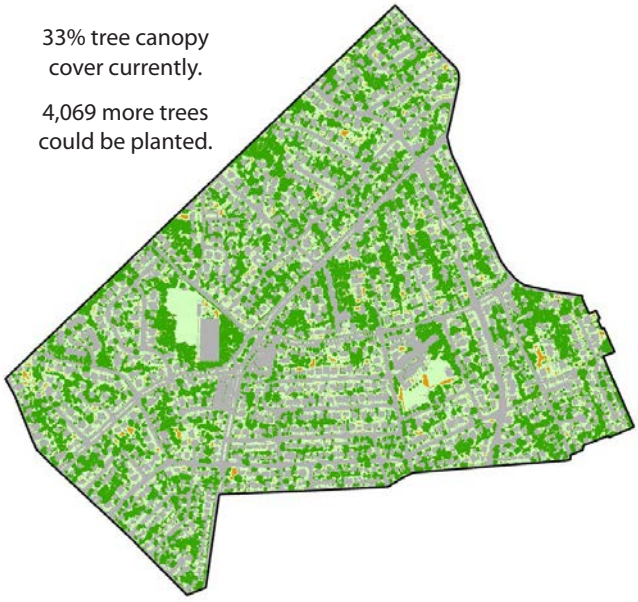
Lyon Village Civic Association



25% tree canopy cover currently.

2,986 more trees could be planted.

Green Valley Civic Association



33% tree canopy cover currently.

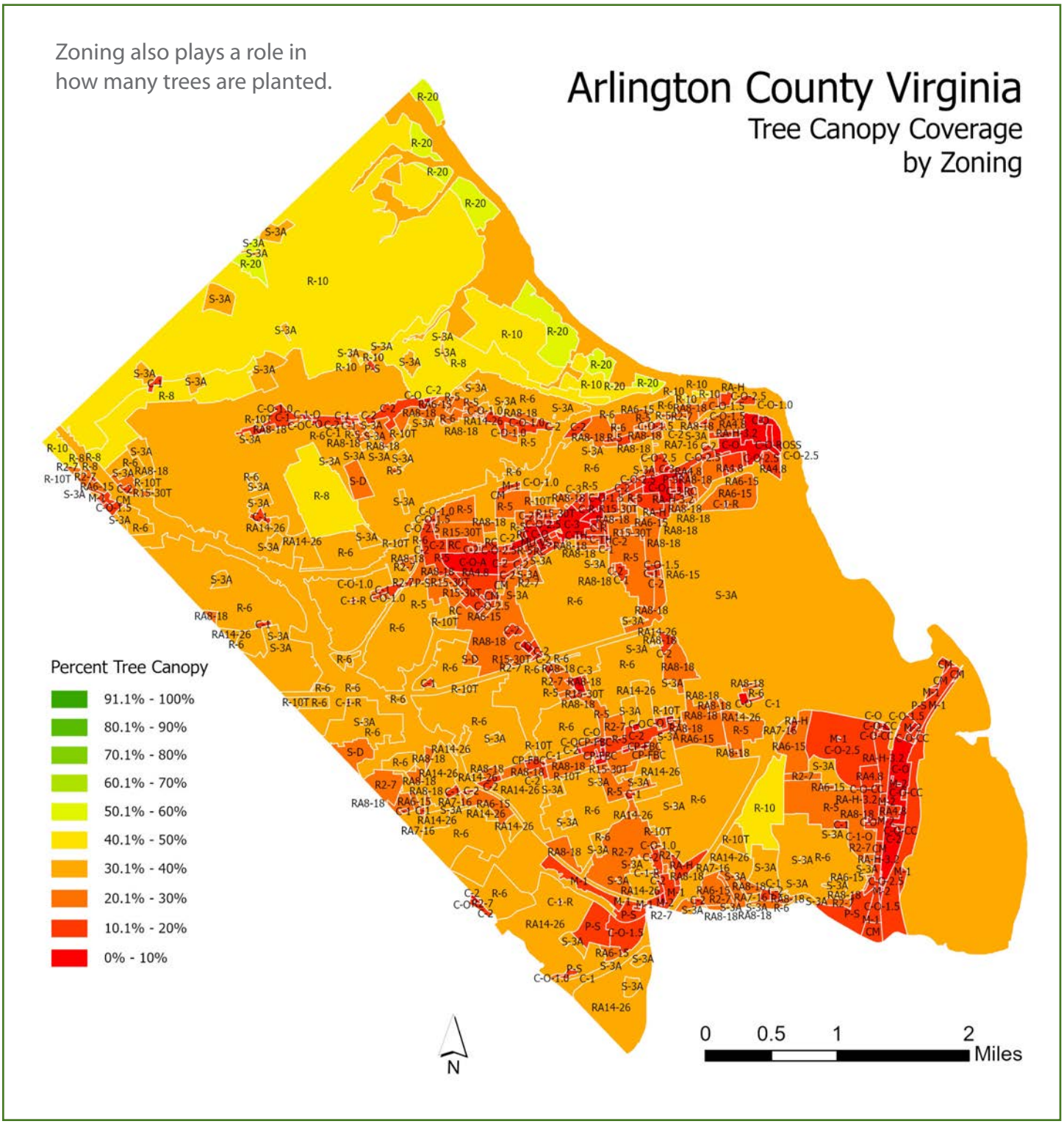
4,069 more trees could be planted.

Williamsburg Civic Association

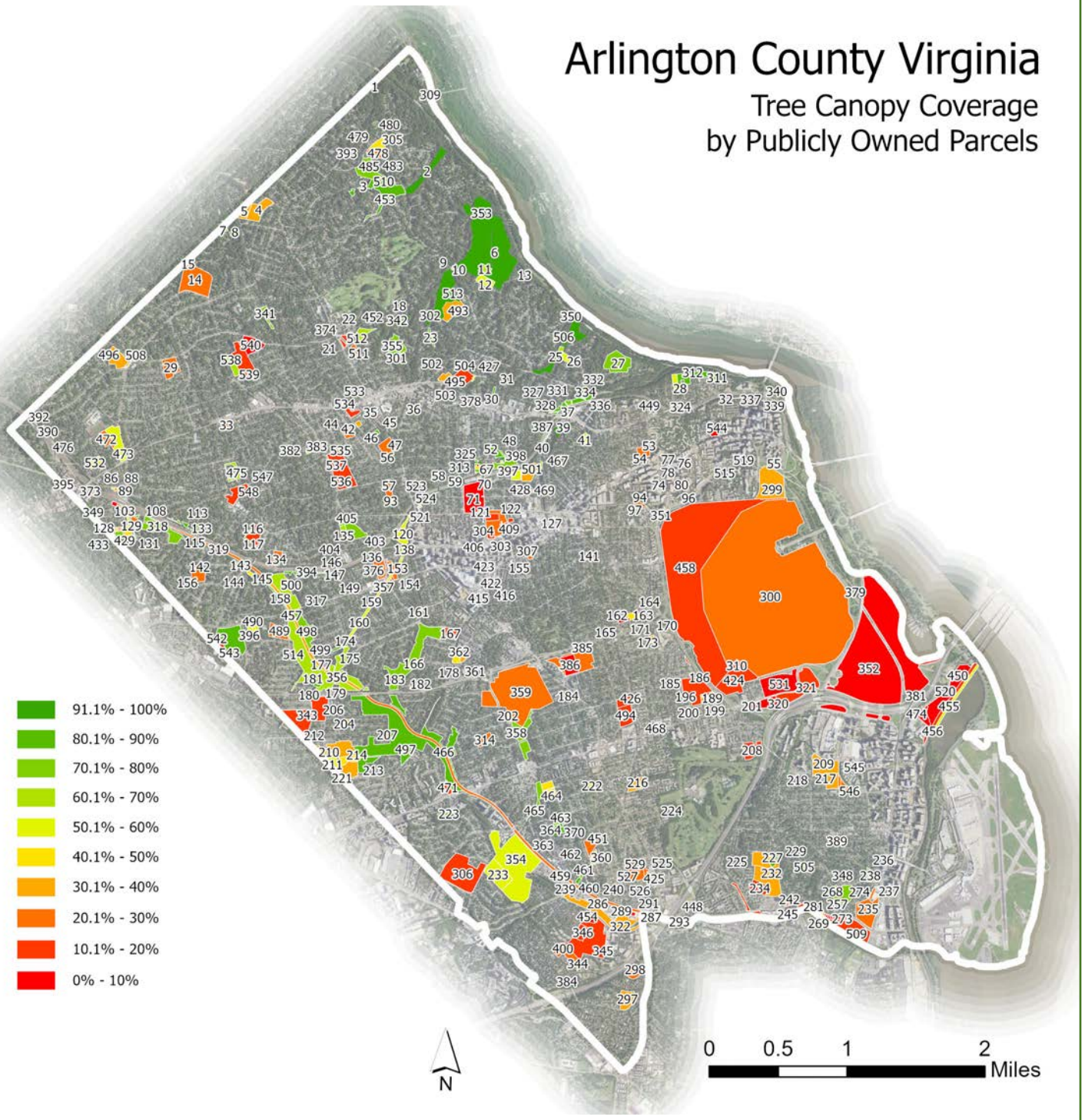
Zoning

Zoning also plays a role in how many trees remain (see map). While the Virginia state code caps the planting coverage that localities can require by zoning class (20% residential, 15% planned development and 10% commercial), the amount of impervious area by lot could be better regulated (for example, patios less than 8 inches tall could be included as part of the impervious area calculation). Lot coverage is currently limited in Arlington County for several zoning districts.

Recent changes in the zoning ordinances that allow increased density may put additional pressure on the existing tree canopy and reduce the number of replacement trees it is possible to plant. To see the new "missing middle" density code changes visit https://www.arlingtonva.us/Government/Programs/Housing/Housing-Arlington/Tools/Missing-Middle. To see the county code for lot coverage visit: https://www.arlingtonva.us/Government/Programs/Building/Codes-Ordinances/Zoning/Lot-Coverage.



The County controls how many trees are planted on County-owned public land, while the federal government controls planting on federal properties such as Arlington Cemetery.



Recommendations for Arlington Communities

A community meeting sponsored by the Arlington County Civic Federation was held on March 25, 2023 in order to engage community members in learning about tree canopy and to chart a course for action. (See Appendix B for all comments received at the meeting.) The following recommendations incorporate community comments as well as professional suggestions from the natural resources staff of GIC.

1 Update the Forestry and Natural Resources Plan Using More Accurate Canopy Data and Analysis

As of this report's writing, the County is currently updating its Forestry and Natural Resources Plan (FNRP). The most recent update of the draft plan acknowledges that the trend in canopy cover is likely downward and that "this trend of tree canopy loss likely continues." That plan should be updated to reflect the findings from this report to accurately reflect the County's actual canopy cover (as of 2021). Based on previously reported canopy coverage, the County appears to have lost a significant number of its trees. Canopy loss will occur in most communities unless existing mature trees are retained and new trees are planted. Mowing in urban areas prevents regeneration of new trees from seeds (as would happen in a forest), so active tree planting is needed to ensure that next generation trees will grow.

Arlington should continue to plant new street trees to replace its aging canopy, simply to maintain the existing canopy level as old trees die.

Damaged trees in parks should be removed to protect public safety – and replaced with healthy new ones. A closer look at the damage to the tree shown above, is shown in the photo below.

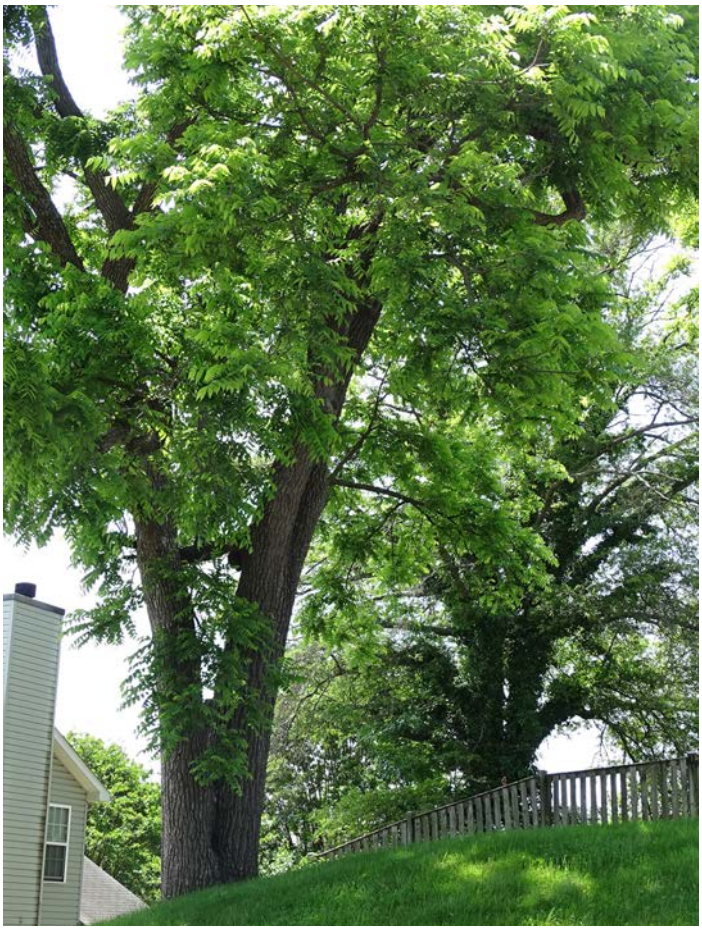
2 Retain Mature Trees

Whenever possible, large, mature healthy trees should be retained. A large tree provides many more benefits in carbon capture, cleaning the air, taking up stormwater, and providing shade, food, and habitat. This can be facilitated through such tools as density bonuses that encourage building taller rather than wider, and thereby saving more trees along the sides of new buildings.

A tree planting campaign can educate residents on why older trees should be maintained. EcoAction Arlington offers information and some assistance with tree care. See https://www.ecoactionarlington.org/ to learn more.

A public relations campaign could be initiated to share the benefits of tree retention more widely with new residents. Consider working with local realtor firms to share information with them.

Older trees may need more care. A limb that is failing may be torn away during a windstorm and inflict more damage to the tree than if it had been carefully removed prior to failure. Residents and business owners should consult with a certified arborist to advise them on any limbs at risk of falling, if a tree needs to be removed because of rot, or if it needs to be treated for pests or disease. For a list of professionals who can help, see: https://goodtreecare.com/find-an-arborist/va/arlington.



Larger trees add value to residential lots and save on cooling bills. They also provide mental health benefits for people.

A homeowner removed this large Dawn Redwood tree. While not illegal, education may have dissuaded this resident from removing a tree that cleans the air, reduces stormwater runoff, provides habitat, cools their property, and improves their property's value.

Photo Credit: Arlington Connection

Trees also need to be maintained to remain healthy. Invasive vines, such as this English Ivy, should be removed.

3 Initiate Or Expand A Robust Tree Planting Campaign

A tree planting campaign should be initiated by public and private entities to encourage greater tree planting by the public. This can include tree giveaways, training in proper planting methods and tree care, support for planting at rental properties (with owner agreement), and such fun events as competitions to see which neighborhood can plant the most trees.

Note that smaller trees, such as saplings, often survive better because their roots have not been compromised by extended time in pots, where they may become rootbound resulting in circular roots that are hard to unwind and may cause the tree to live a shorter lifespan.

To learn more about planting campaigns see GIC's guide at: http://www.gicinc.org/PDFs/TreePlantingCampaignGuide_GIC_June2022.pdf. The County and EcoAction Arlington both provide support for neighborhood tree plantings. Applications are accepted twice a year by EcoAction at: https://www.ecoactionarlington.org/community-programs/trees/. Residents can also adopt and help care for a public tree or become tree stewards to help with tree care. For more information, see: https://www.arlingtonva.us/Government/Programs/Sustainability-and-Environment/Trees/Support-Trees.

A well-treed neighborhood of today may not have good coverage in the future unless young trees — the next generation — are planted.

New trees should be planted in residential areas.

Fun events such as competitions to see which neighborhood can plant the most trees can help boost tree planting in residential areas.

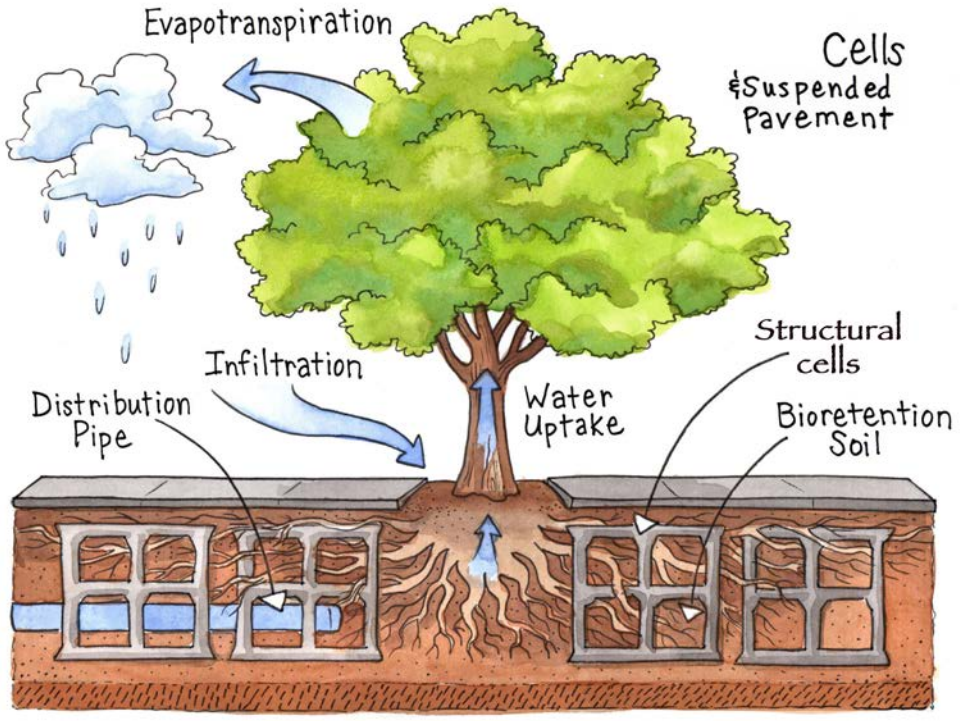
4 Retrofit Older Street Tree Pits to Expand Soil Volume

Trees need adequate soil volume in order to grow (root space) and obtain nutrients from the soil. Arlington County has fairly progressive standards for soil volume and quality for trees (small trees: 600 ft^3, medium trees: 900 ft^3; and large shade trees: 1,200 ft^3), along with requirements to amend soil when its quality is insufficient – as is common when extensive site grading has occurred. For more, see: https://www.arlingtonva.us/files/sharedassets/public/forestry/soil-volume-calculations-guide.pdf.

Arlington County could encourage the use of modern tree pit designs along streets and in new developments where planting space is limited or root control is needed. For those areas where street trees have died, the County should reconstruct soil pits with larger underground volume to ensure replacement trees can thrive. The County should also remove dead trees from schools and parks.

As an older County, there are likely many tree planting pits for street trees that would not meet the County's current tree pit standards. Arlington could enlarge some of these tree pits using structural cells and structural soils, in order to provide expanded underground space. This can be done as part of a street redesign or when repairing underground utilities as part of other maintenance projects.

Such work would benefit from funding, such as the millions of dollars presently available from an initial allocation in the Inflation Reduction Act of $1.5 billion dollars for tree planting, care and maintenance. Arlington County and other local planting initiatives could apply to the Virginia Department of Forestry to fund demonstration projects. This cost could be built into County procurements for new street designs. To see examples of these technologies, visit: https://greenblue.com/na/product-category/soil-cells/.



Underground structural cells can be used to support tree roots and to protect underground utilities.

Image credit: GreenBlue Urban Demonstration Project

These two rows of trees were planted at the same time. The trees on the left were planted with more open space than the trees on the right, but the ones on the left are smaller and dying, while the ones on the right are larger and thriving. The difference is their underground support, with large structural cells supporting the root structure of trees planted on the right.

The County should remove dead street trees to protect public safety.

The County should remove dead and dying trees from public parking lots and consider whether the underground pit area is large enough to support new trees, whether soil volume needs to be increased, or if structural root supports are needed.

Avoid planting trees under power lines, where they may interfere with power supplies.

5 Promote the New Stormwater Credit for Tree Planting

Stormwater fees are currently assessed on properties to fund County costs to manage stormwater runoff. The county recently adopted new planted trees as an allowed credit to offset the amount of a lot's stormwater fee. Actions taken during Calendar Year 2023 will be eligible for credit on the first bill in May 2024. The more treed the land is, the less runoff will occur. To learn more about the Stormwater Utility and Stormwater Credit Program, see: https://www.arlingtonva.us/Government/Programs/Sustainability-and-Environment/Stormwater/Stormwater-Utility-Implementation.

6 Fully Fund Staffing for Violation Inspection and Enforcement

At the community meeting held to inform this report, several residents complained about the lack of enforcement of existing codes and site plans required to protect existing trees. An example of a developer cutting roots and thus compromising survivability of trees to be retained was provided by a community member.

If bad actors know that violations will probably not be inspected or punished, they will be more likely to repeat such behavior. Virginia currently caps fines for civil penalties at a few thousand dollars. However, requiring replacement of large trees lost by 1:1 or 2:1 by basal area can cost far more than a financial fine and is a tool for ensuring better compliance with tree protection requirements. In addition, requiring urban forest staff to review site plans or rezonings for treed lots can ensure that opportunities for saving trees are not missed.

The current urban forest staff for Arlington County does an excellent job, but they seem to be understaffed. Arlington is a large, densely developed County and more staff are probably needed to ensure that staff time for both education and enforcement are supported. The new Arlington County Forestry And Natural Resources Plan (in draft form as of this printing) should include a recommendation for hiring additional urban foresters to supplement the existing team. This would also ensure better maintenance of trees on public lands, some of which are choking under vines and other invasive species. For additional comments and recommendations from the public, see Appendix B: Community Meeting Comments.

Next Steps

In addition to implementing the ideas mentioned above, caring for existing trees and planting new ones, Arlington's residents, civic groups, and environmental organizations can work together to coordinate actions and activism County-wide to ensure that Arlington's urban forestry program is focused and well-funded. The county's draft forestry and natural resources plan makes the case that 87% of the county's land area is under private ownership. This means that actions by the private sector are critically important to ensuring robust canopy coverage of the future.

To get involved in on-going efforts to support Arlington's trees, citizens can comment on the current master plan (https://www.arlingtonva.us/Government/Projects/FNRP) and consider joining other like-minded residents and organizations listed in Appendix C. The information from this study and meetings will be available at Arlington Consortium for Tree Sustainability (ACTS) https://www.arltreeconsort.net/, an emerging network of organizations and individuals sharing information and support for current and planned activities in support of Arlington's trees. For questions, use the Contact form at the ACTS website or download copies of maps.

Links to maps: https://www.arltreeconsort.net/arlington-tree-canopy-report-and-maps or contact ACTS by email: info@arltreeconsort.net

Everyone should get engaged in conserving and planting trees.

In short, let's have less of this…

…and more of this.

Appendix A: Methods

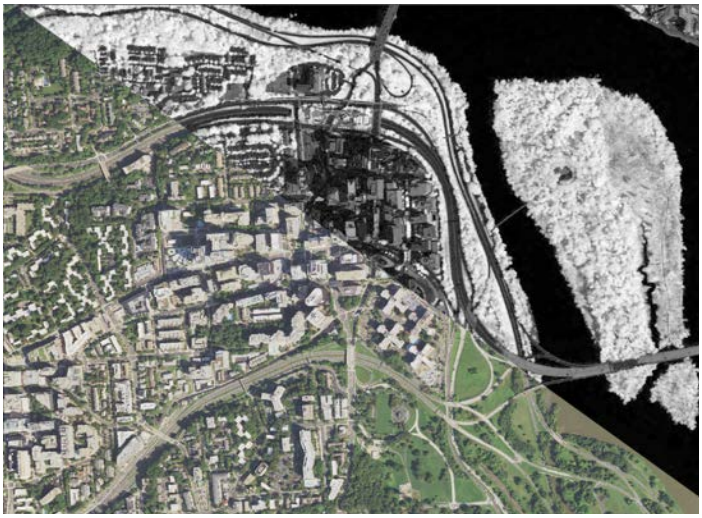
Summary of GIC'S Land Cover Classification:

The canopy data represent Arlington's land cover at a pixel resolution of 1 meter. The primary source or this land cover is NAIP aerial imagery (National Agricultural and Imagery Program) 4 band/0.6-meter resolution aerial imagery captured in 2021. Additionally, LiDAR data from 2018 was used to determine height of features in order to distinguish trees from bushes.

- Imagery was obtained from the National Agricultural Imagery Project (NAIP). It is flown every 2 years. We analyze the image as a series of "rasters." Rasters are used to create a Normalized Difference Vegetation Index or "NDVI"
- The NDVI is a standardized index allowing a GIS analyst to generate an image displaying greenness (relative biomass) based on imagery captured from above the Earth. This index imagery can pick out vegetation by using the contrast in the characteristics of two bands from a multispectral raster dataset. Vegetation can be identified through the chlorophyll pigment absorptions in the red (R) band and the high reflectivity of plant materials in the near-infrared (NIR) band.
- The NDVI image, along with the provide 4 spectral bands (red, blue, green and infrared) are used to identify various features where they visually match the imagery most accurately; for example, the green reflected from the leaves of a tree. A tree canopy class is verified and refined using a LiDAR Normalized Digital Surface Model (NDSM) to differentiate trees from smaller green vegetation. See text box for more on what is LiDAR.
- Note: High NDVI= grass, trees, or shrubs, low NDVI= water or an impervious surface such as asphalt.

GIC created an NDVI raster from the NAIP imagery, and created class breaks to differentiate "green" land cover from "not green". The "green" land cover was further split into three classes: tree canopy, scrub/shrub, and pervious surfaces (e.g., turf grass). LiDAR data were used to classify these areas. Anything green and shorter than 2-3 feet was grass, anything above 8 feet and green was tree canopy, and anything at a height between these two classes was scrub/shrub.

Existing data sources were used for impervious surfaces, wetlands, and water. During the classification, priority was placed on the accuracy of Tree Canopy and pervious surfaces (where trees can be planted), however classification accuracy is above 97% for all classes.



Notice how bright the canopy appears in the black and white NDVI image compared to roads, buildings, and water.

Potential Planting Areas:

Potential planting areas were derived from the pervious surfaces captured during the process of Arlington's land cover classification. These areas were edited to ensure sufficient area for plantings to grow. Then, exclusions were applied. Areas such as sports fields, cemeteries, airports, golf courses, and a water treatment facility were used to produce exclusion areas, and then local stakeholders were consulted to supply any additional PPA exclusions.

Potential Planting Spots

Potential planting spots were points created within the potential planting areas, with enough space between them to allow sufficient space for growth. Where there was space, planting spots were afforded canopy space representing a 40-foot diameter canopy spread. Where larger trees could not be planted, spots were created for smaller trees to allow for a 20-foot canopy diameter canopy spread. To determine if a tree could be fitted into a space and not conflict with surrounding structures such as buildings, tree planting points were offset from buildings by three meters to allow for trees to spread out. All other impervious surfaces are offset by one meter. Trees are allowed to overlap (about 20%) since, in natural settings, trees do intermingle and are not completely separated. A minimum planting area of 1 square meter was used.

These are potential planting spots (not actual). Data have limitations and all sites should be ground truthed before developing a planting plan. Limitations to planting spots include:

1) Power lines overhead. The consultants do not have access to overhead power-line data as Dominion Virginia Power does not share power lines or facility data due to concerns for terrorism (foreign or domestic.)

2) Underground utilities such as water lines, cables, power lines. The city has access to such data and could use those line locations to exclude some streetside planting spots. Note that trees can be co-located with utilities when using other underground structural cells to separate roots from utility lines.

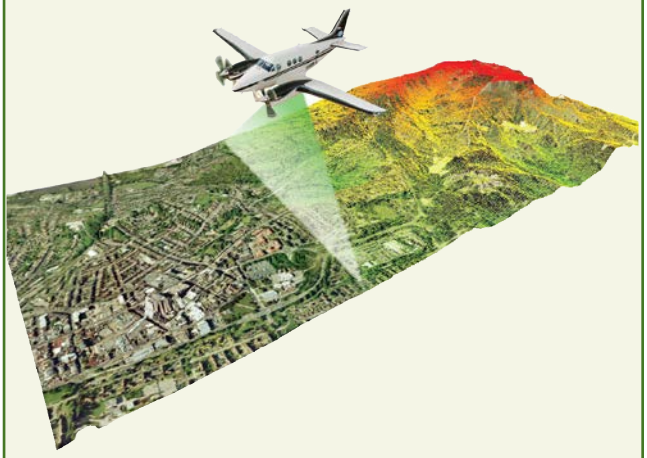
QA/QC

A confusion matrix (*see table below*) was created to test how often the points are correct or incorrect when identified as tree cover. To ensure the highest possible accuracy, 429 randomly selected points were tested. This is done by comparing the classified land cover to the NAIP imagery at the location of each point. Findings are shown in the table at the bottom of this page.

In addition, GIC staff checked canopy in the field with GPS images taken to confirm canopy indicated in the field was correctly identified during the imagery classification process. GIC checked field photos against the imagery-derived canopy and all were found to be correct except for three newly planted trees that were small enough to be mistaken for shrubs. This is a common error when new trees are planted and are too short to be picked up as trees. This error self-corrects in future mapping when these trees mature and are taller. GIC found that, based on field-checks, the classification is largely accurate. Given that the NAIP imagery and LiDAR data were captured in prior years, there were small differences found where trees have since been removed or planted. However, no major discrepancies were found.

A concern was raised during the community workshop that invasive bamboo would be classified as canopy, resulting in a misrepresentation of Arlington's tree coverage. By comparing images captured by the GPS camera of bamboo to the classified canopy, it was determined that this invasive species had a no impact on the classification as GIC correctly identified the bamboo patches as non-tree. Although bamboo is tall, its form is not tree-shaped. The use of LiDAR or object recognition software are commonly used to refine imagery analysis as they can be used to determine shapes. Fore more about LiDAR see the text box (*right*).

LiDAR Mapping



Light detection and ranging (LiDAR) is a remote sensing technology using laser scanning to create detailed 3D models. A plane with a LiDAR unit flies back and forth as the device sends laser pulses downward in a narrow swath to get data for a large area. Each pulse reflects off the ground or an object above the ground (called a "return"). Measuring the time it takes for the laser pulse to return to a sensor, combined with the sensor's position, we can determine the 3D coordinates of each point.

The combination of all spatially resolved returns constitutes a point cloud, or the LiDAR data product. A common product derived from point clouds are tree canopy models. GIC can separate bushes (short objects) from trees (tall objects over 10 feet tall). GIC counted vegetation as trees if greater than 8 feet tall.

A Confusion matrix was run to test the accuracy of the canopy data which resulted in ....

CLASS VALUE	Tree Canopy	Scrub/Shrub	Pervious	Water	Impervious	Wetland	Points Sampled	Accuracy
Tree Canopy	99	0	1	0	2	0	102	97.1%
Scrub/Shrub	0	37	0	0	1	0	38	97.4%
Pervious	0	0	128	0	2	0	130	98.5%
Water	0	0	0	4	0	0	4	100.0%
Impervious	0	0	2	0	152	0	154	98.7%
Wetland	0	0	0	0	0	1	1	100.0%
Points Sampled	99	37	131	4	157	1	429	98.1%

The result of this confusion matrix allowed GIC to determine that the tree canopy classification had an accuracy of 97.1%.

Stormwater Uptake

The Trees and Stormwater Calculator (TSC) tool developed by GIC uses modified TR-55 curve numbers to calculate stormwater uptake for different land covers. The use of curve numbers to estimate runoff volumes is a widely recognized and accepted method utilized by stormwater engineers. The runoff equation has been modified to add a canopy interception factor to account for the role trees play in the interception of rainfall, based on location and planting conditions (e.g., trees over pavement versus trees over a lawn, or in a forest).

Tree canopy reduces the proportion of precipitation that becomes stream and surface flow, also known as water yield. A study by Hynicka and Divers (2016) modified the water yield equation of the NRCS model by adding a canopy interception term (Ci) to account for the role that canopy plays in capturing rainfall, resulting in:

$$R = \frac{(P - C_i - I_a)^2}{(P - C_i - I_a) + S}$$

Where **R** is runoff, **P** is precipitation, $\mathbf{I_a}$ is the initial abstraction (the fraction of the storm depth after which runoff begins), and **S** is the potential maximum retention after runoff begins for the subject land cover **(S = 1000/CN – 10)**.

Major factors determining CN are:

- The hydrologic soil group (defined by surface infiltration rates and transmission rates of water through the soil profile, when thoroughly wetted).
- Land cover types.
- Hydrologic condition – density of vegetative cover, surface texture, seasonal variations.
- Treatment – design or management practices that affect runoff.

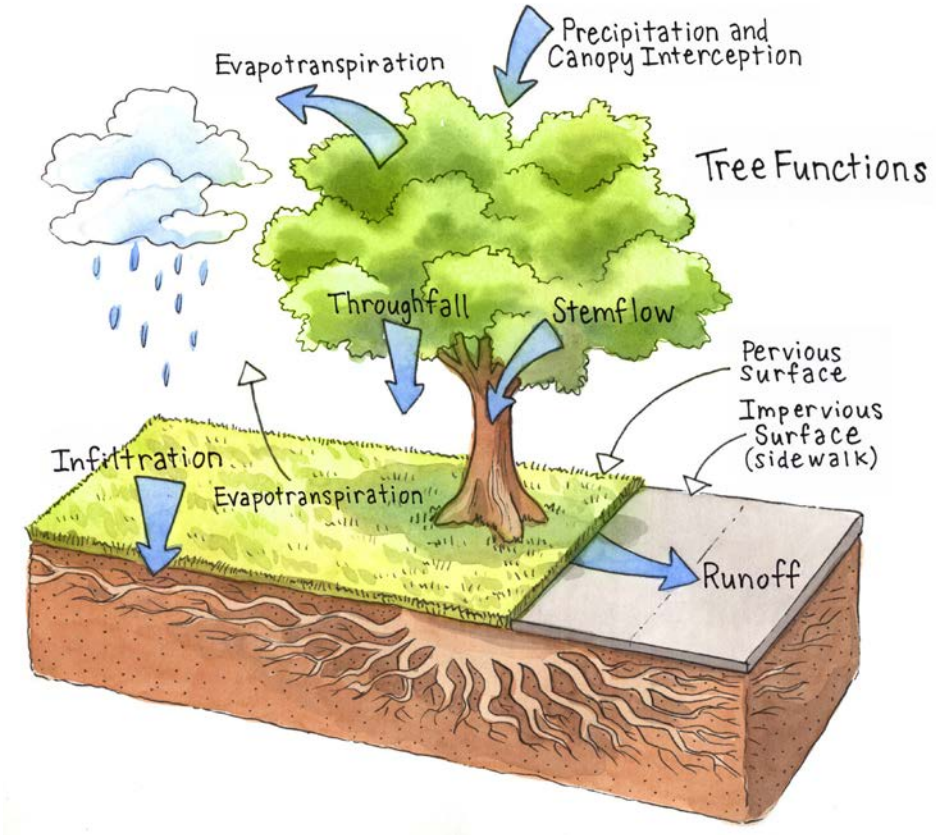
The TSC allows for more detailed assessments of stormwater uptake based on the landscape conditions of the County's forests. It distinguishes whether the trees are within a forest, a lawn setting, a forested wetland or over pavement, such as streets or sidewalks. The amount and type of open space under and around a tree and the condition of its surrounding surface soils affect the infiltration of water. This is because the conditions and the soil in which the tree is living affect the amount of water the tree can intercept. The tool also calculates the amount of nitrogen, phosphorus and sediment the trees and their surrounding soils take up.

Tree over street

Trees over forest

Tree over lawn

Tree over parking lot



Communities can use the stormwater calculator tool for setting goals at the watershed scale for planting trees or for evaluating consequences of tree loss as it pertains to stormwater runoff. Curve numbers produced for this study can be utilized for stormwater plans and for estimating the benefits of tree planting in each of the County's watersheds.

GIC's Trees and Stormwater Calculator (TSC) tool can also be used to run 'what-if' scenarios, specifically losses of tree canopy from development or storms, and increases in tree canopy from tree planting programs. The GIC's TSC tool includes a data field to hypothetically add trees to calculate outcomes for stormwater uptake from new tree plantings. The TSC tool uses PPA data to determine how many more trees could be planted. Contact Mary Glass at info@arltreeconsort.net for a copy of the spreadsheet-based tool. The analysis can be used to create plans for adding trees, or better protecting trees to reduce stormwater runoff impacts and improve water quality. This methodology was developed and tested in 13 communities in the southern US including three in Virginia, under a grant from the Southern Region of the USDA Forest Service. For more about the project, please visit: http://www.gicinc.org/trees_stormwater.htm .

Appendix B: Community Meeting Comments

Community Comments from Tree Forum sponsored by the Arlington Civic Federation, March 25, 2023. Comments are provided verbatim and are not edited.

From Comment Cards:

- We need to find and sponsor a candidate who will run on a tree platform (position).
- Can we write the grant and give it to the County, so the staff does not have to do the legwork? (referring to new federal funds from the USFS).
- I am a fan of treed street raised medians from my experience all of them on West Side Drive in NYC. Many sections of the much older Broadway have achieved a full street canopy building front to front – there are several sections of the much newer Westside Drive that are getting close (together), and it is even wider (of a street).
- I'm wondering about the capacity of LiDAR to differentiate areas infested with bamboo (and unhealthy trees due to competition) vs. a healthy tree forest, specifically for GIC. You might spot check Missionhurst, a religious order-owned property near Vernon St.
- The County needs to quickly focus on the requirements for new construction/redevelopment in single family homes. There must be smaller footprints, set-backs, sq. footage, etc. to allow more room for trees to remain and new trees to be planted. The rate of redevelopment in my neighborhood Glencarlyn has resulted in loss of many mature trees.
- I'd like to see more staff hired by DES to implement plans for more tree cover in Arlington and also to get grant money to plant, maintain and preserve trees, in hard-to-plant areas like street right of ways by using subsurface state-of-the-art designs.
- To the County: hire more staff to meet tree planting/planning/maintenance now that $$ is available (from USFS and VA).

From Flip Charts:

- Maintain landscape trees free of vines (have an active maintenance program). Especially for parks where vines are being allowed to grow up trees and kill them. County arborist must help with this.
- How can we restore our parks and overcome the damage floods and deer have done?
- Include the park table/% canopy as a spreadsheet table in group email.
- 74% of Arlington is privately owned. Everyone should plant a tree in their own yard.
- County should plant trees in front of every property in the Right-of-Way (RoW).
- RoW – Older neighborhoods have narrow (ones). Need to expand; wider sidewalks, trees, bike lanes.
- Get this information – Stormwater in particular (trees uptake of) to DES.
- Way to quantify solar versus trees at a residential scale (carbon saved by a solar panel versus a tree).
- Dealing with invasives (how to)
- County needs to enforce its existing ordinances. Construction damages to trees, and tree roots are not enforced.
- Incorporate more stringent enforcement of/ + increase of RoW previous area and canopy protection. Older neighborhoods may see more development soon.
- Encourage more pervious (area) and trees in parks, reduce and stop putting in impervious features.
- Start incentives to reward homeowners for having higher numbers of trees on private property. (May be in reference to current proposal to give 5% credit on stormwater utility for tree planting).
- Encourage County to incorporate green infrastructure in the strategic plan; set strategic goals.
- Create a changing climate resilient planting list.
- Plant disease resistant dogwoods (see GW Parkway).

Appendix C: Links to Resources

Tree Planting Campaigns Guide: http://www.gicinc.org/PDFs/TreePlantingCampaignGuide_GIC_June2022.pdf

Arlington Consortium for Tree Sustainability (ACTS) - www.arltreeconsort.net

Arlington County Sustainability and Environment Office Forestry information https://www.arlingtonva.us/Government/Programs/Sustainability-and-Environment/Trees

Arlington's Ecosystem Services Report for its trees: https://www.arlingtonva.us/Government/Programs/Sustainability-and-Environment/Trees/Tree-Statistics/i-Tree-Eco

Arlington's Urban Forest Master Plan (update in process): https://www.arlingtonva.us/Government/Projects/FNRP

Arlington's Urban Forestry and Natural Resources Commission (FNRC) provides the County Board with advice and recommendations: https://www.arlingtonva.us/Government/Commissions-and-Advisory-Groups/Forestry-and-Natural-Resources-Commission

Ecoaction Arlington - Apply to plant trees in your Arlington Community! (due in June) https://www.ecoactionarlington.org/community-programs/trees/

Arlington County Civic Federation Environmental Affairs Committee: https://www.civfed.org/about-us/committees/environmental-affairs/

USDA Urban Forest Connections Webinar Series: https://www.fs.usda.gov/research/products/multimedia/webinars/urbanforestconnections

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