A Report on Greater Fairfax County's Existing and Possible Tree Canopy

Why is Tree Canopy Important?

Tree canopy (TC) is the layer of leaves, branches, and stems of trees that cover the ground when viewed from above. Tree canopy provides many benefits to communities, improving water quality, saving energy, lowering summer temperatures, reducing air pollution, enhancing property values, providing wildlife habitat, facilitating social and educational opportunities, and providing aesthetic benefits. Establishing a tree canopy goal is crucial for communities seeking to improve their green infrastructure. A tree canopy assessment is the first step in urban forest planning, providing estimates for the amount of tree canopy currently present in a county as well as the amount of tree canopy that could theoretically be established.

How Much Tree Canopy Does Fairfax Co. Have?

An analysis of Greater Fairfax County based on land cover data derived from high-resolution aerial imagery and LiDAR (Figure 1) found that 150,850 acres of the area were covered by tree canopy (termed Existing TC), representing 53% of all land in the study area. An additional 34% (95,402 acres) of the region's land area could theoretically be modified (termed Possible TC) to accommodate tree canopy (Figure 2). In the Possible TC category, 21% (58,212 acres) of total land area was classified as Vegetated Possible TC and another 13% as Impervious Possible TC (37,190 acres). Vegetated Possible TC, or grass/shrub, is more conducive to establishing new tree canopy, but establishing tree canopy on areas classified as Impervious Possible TC will have a greater impact on water quality and summer temperatures.

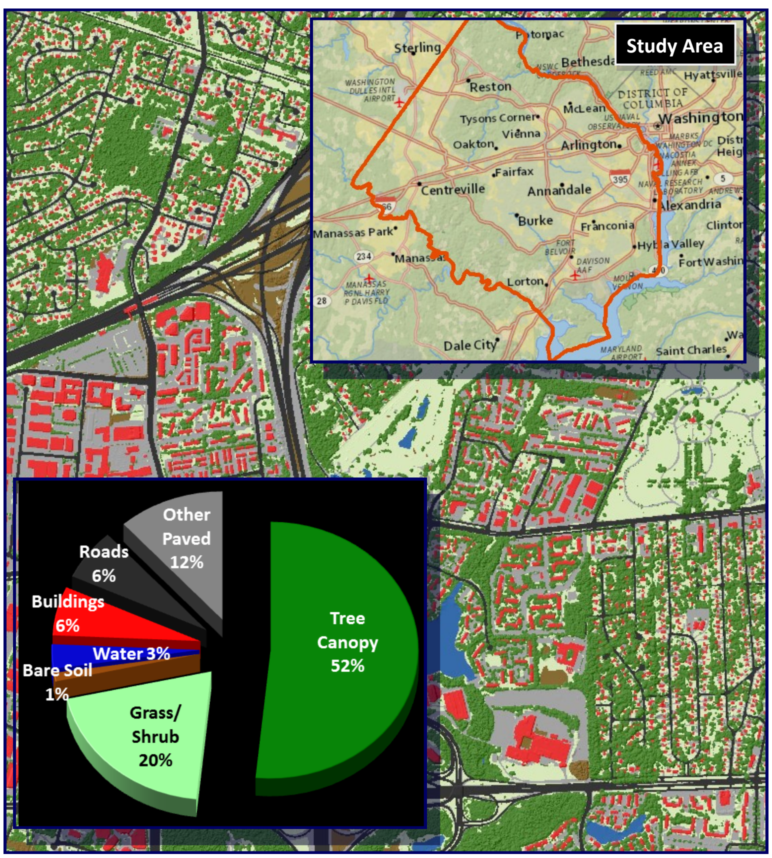


Figure 1: Study area and example of the land cover derived from high-resolution imagery for this project.

Project Background

The goal of the project was to apply the USDA Forest Service's Tree Canopy Assessment protocols to Greater Fairfax County. The analysis was conducted using year 2011 imagery and LiDAR acquired in 2008. This project was made possible through funding from Casey Trees. The Spatial Analysis Laboratory (SAL) at the University of Vermont's Rubenstein School of the Environment and Natural Resources carried out the assessment in collaboration with Fairfax and Arlington Counties, the cities of Alexandria and Falls Church, and the USDA Forest Service's Northern Research Station.

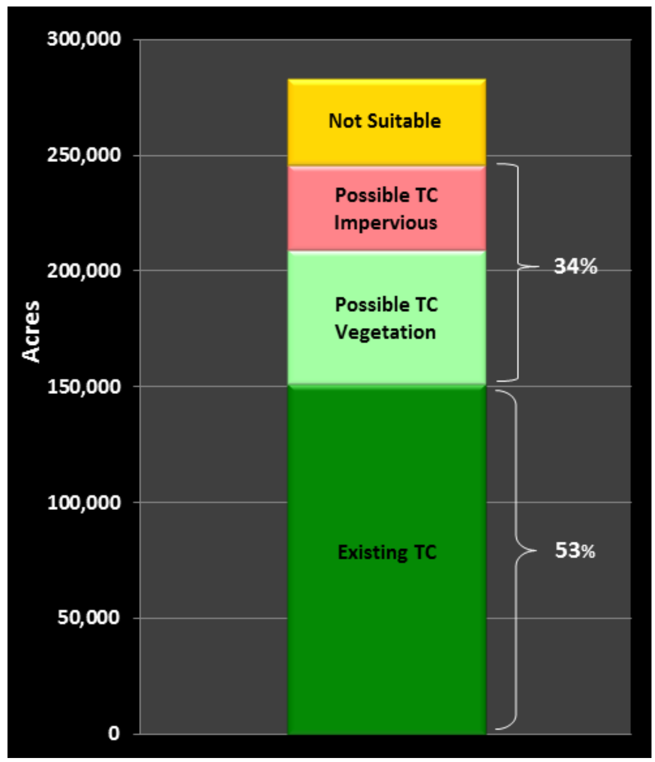


Figure 2: TC metrics for Greater Fairfax County based on % of land area covered by each TC type.

Key Terms

TC: Tree canopy (TC) is the layer of leaves, branches, and stems of trees that cover the ground when viewed from above.

Land Cover: Physical features on the earth mapped from aerial or satellite imagery, such as trees, grass, water, and impervious surfaces.

Existing TC: The amount of urban tree canopy present when viewed from above using aerial or satellite imagery.

Impervious Possible TC: Asphalt or concrete surfaces, excluding roads and buildings, that are theoretically available for the establishment of tree canopy.

Vegetated Possible TC: Grass or shrub area that is theoretically available for the establishment of tree canopy.

Not Suitable: Areas where it is highly unlikely that new tree canopy could be established (primarily buildings and roads).

Mapping Greater Fairfax's Trees

A prior estimate of tree canopy for the entirety of the Greater Fairfax County study area (including water) from the 2001 National Land Cover Database (NLCD 2001) was 34%, far lower than the 52% obtained in this study. The large difference is due to the fact that NLCD 2001 (Figure 3a) only accounted for relatively large patches of tree canopy. Using high-resolution satellite imagery acquired in the summer of 2011 (Figure 3b), in combination with advanced automated processing techniques, land cover for the Greater Fairfax County area was mapped with such detail that trees as short as 8ft tall were detected (Figure 3c).

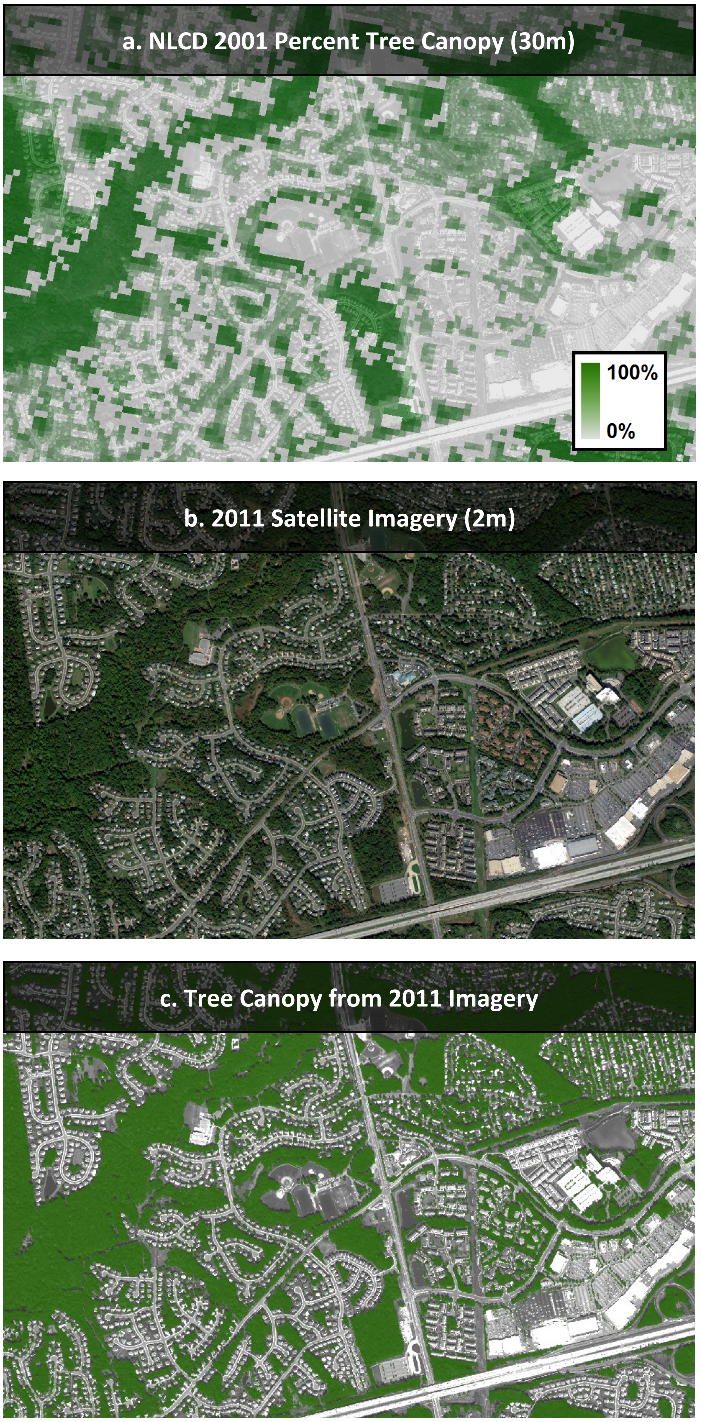


Figure 3: Comparison of NLCD 2001 (a) to high-resolution imagery (b) and tree canopy (c) derived for this study.

Parcel Summary

After land cover was mapped for the study area, Tree Canopy (TC) metrics were summarized for each property in the study area's parcel database (Figure 4). Existing TC and Possible TC metrics were calculated for each parcel, both in terms of total area (square footage) and as a percentage of the land area within each parcel (TC area divided by land area of the parcel).

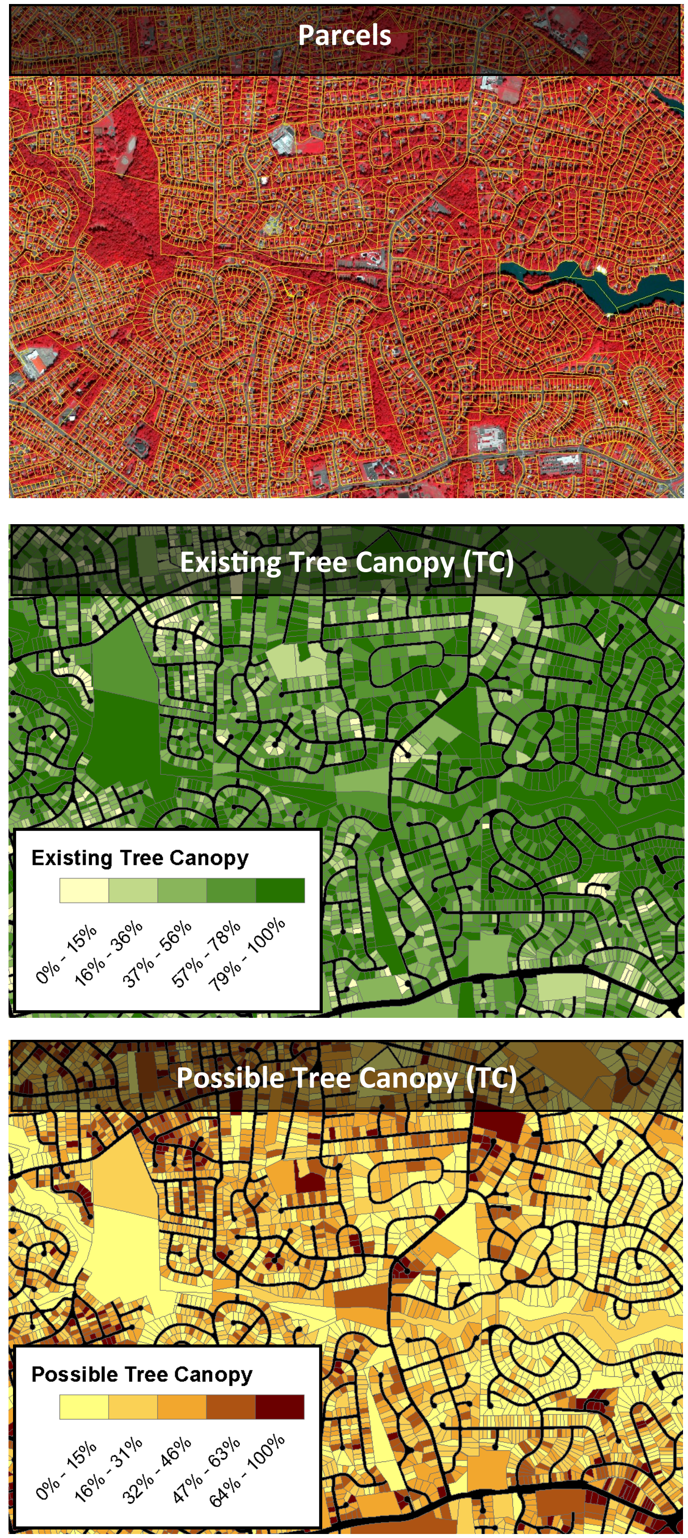


Figure 4: Parcel-based TC metrics. TC metrics are generated at the parcel level, allowing each property to be evaluated according to its Existing TC and Possible TC.

Zoning

An analysis of Existing and Possible Tree Canopy by zoning district was conducted using the study area's parcel data, which can be categorized by Zoning District (Figure 5, Table 1). For each zoning district, tree canopy metrics were calculated as a percentage of all land in the Greater Fairfax County study area (% Land), as a percentage of land area in the specified zoning district (% Category), and as a percentage of total area in the tree canopy type (% TC Type). The majority of Greater Fairfax County is residential land, and thus it comes as no surprise that this category has not only the majority (87%) of the study area's tree canopy, but also the most room to plant new trees. The smaller categories also present opportunities for tree planting. Of all the zoning districts, Residential lands might contain the most area where resources could efficiently be directed to increase tree canopy, although recreation and other open space would be competitive land uses. Residential lands contain 60,997 acres (25%) of land classified as Possible Tree Canopy. This figure accounts for 75% of all the Possible Tree Canopy in the Greater Fairfax County area. Of this 25%, 18% of land area is classified as Possible TC Vegetation. The Planned Units zoning district also has a substantial amount of land in the Possible Tree Canopy Vegetation class (11,600 acres; 5% of all land). Possible TC lands that are already vegetated represent more affordable opportunities for increasing overall tree canopy, although gains in this category generally do not provide as much benefit as increasing tree canopy on land classified as Possible TC Impervious.

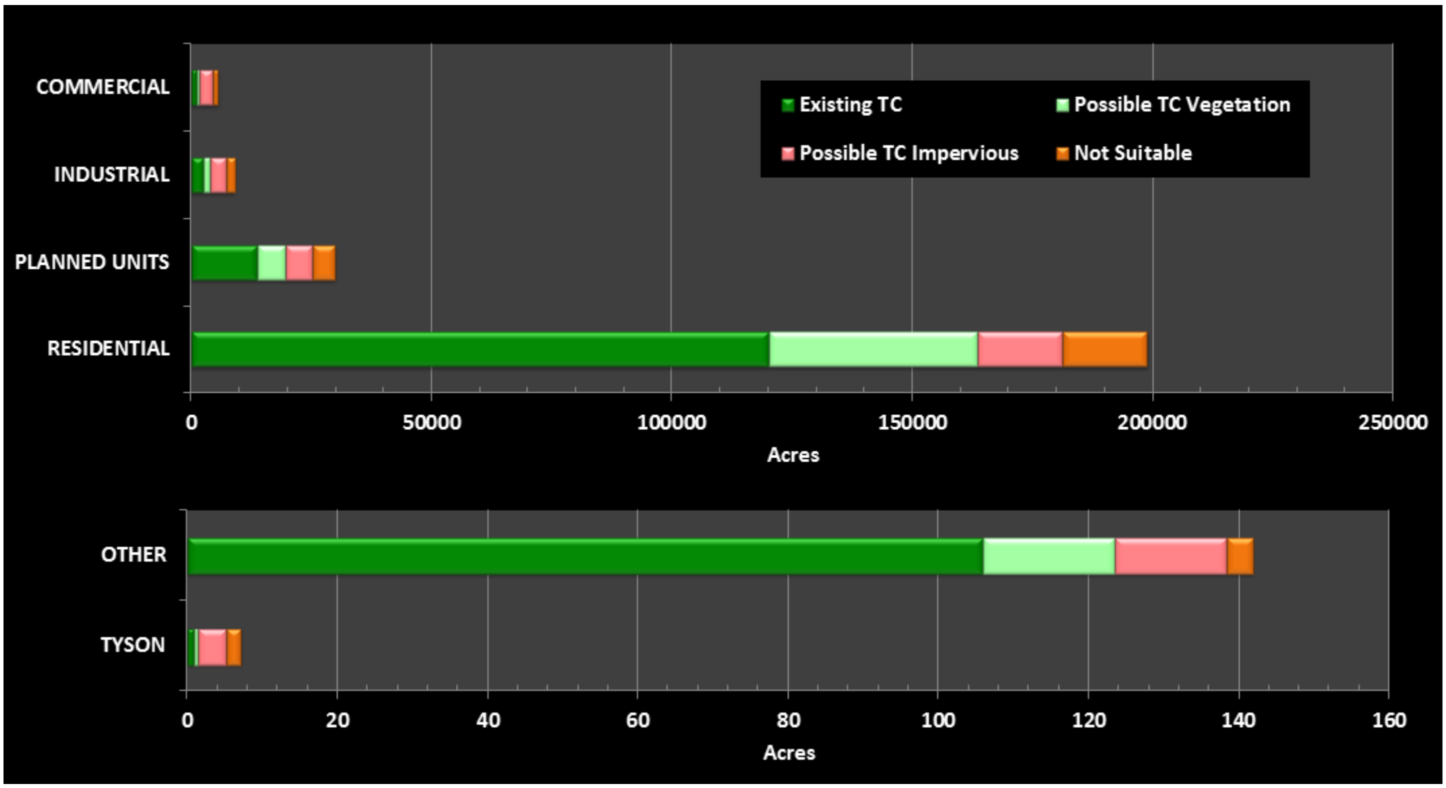


Figure 5: Tree Canopy (TC) metrics summarized for each zoning district.

Zoning	Existing TC			Possible TC Vegetation			Possible TC Impervious		
	% Land	% Category	% TC Type	% Land	% Category	% TC Type	% Land	% Category	% TC Type
COMMERCIAL	0%	19%	1%	0%	8%	1%	1%	50%	10%
INDUSTRIAL	1%	27%	2%	1%	17%	3%	1%	37%	11%
OTHER	0%	75%	0%	0%	12%	0%	0%	10%	0%
PLANNED UNITS	6%	46%	10%	2%	20%	12%	2%	19%	19%
RESIDENTIAL	49%	60%	87%	18%	22%	84%	7%	9%	60%
TYSON	0%	13%	0%	0%	8%	0%	0%	52%	0%

$$\% \text{ Land} = \frac{\text{Area of TC type for zoning district}}{\text{Area of all land}}$$

The % Land Area value of 1% indicates that 1% of Greater Fairfax County's land area is covered by tree canopy in the Industrial zoning district.

$$\% \text{ Category} = \frac{\text{Area of TC type for zoning district}}{\text{Area of all land for specified land use}}$$

The % Land value of 27% indicates that 627% of land in the Industrial zoning district is covered by tree canopy.

$$\% \text{ TC Type} = \frac{\text{Area of TC type for zoning district}}{\text{Area of all TC type}}$$

The % TC Type value of 2% indicates that 2% of all tree canopy is in land classified in the Industrial zoning district.

Table 1: Tree Canopy (TC) metrics were summarized by zoning district. For each district, TC metrics were computed as a percentage of all land in the county(% Land), as a percentage of land in the specified category (% Category), and as a percentage of the area for TC type (% TC Type).

Socio-Demographic Analysis

US Census Block Groups contain a wealth of socio-demographic information that, when combined with TC metrics, provide new insights into the relationship between the citizens of the region and their tree canopy. Percent Existing and Percent Possible Tree Canopy maps indicate socio-demographic units where tree canopy is sparse and where planting opportunities exist (Figure 6a & 6b). Higher amounts of tree canopy are present in areas around Clifton and Reston and along the Potomac River (figure 6a); these areas also tend to have higher median incomes (Figure 6c). Population density is relatively high in some of these block groups with low amounts of Existing Tree Canopy and would thus be places to look at enhancing tree canopy for the benefit of these population centers (Figure 6d).

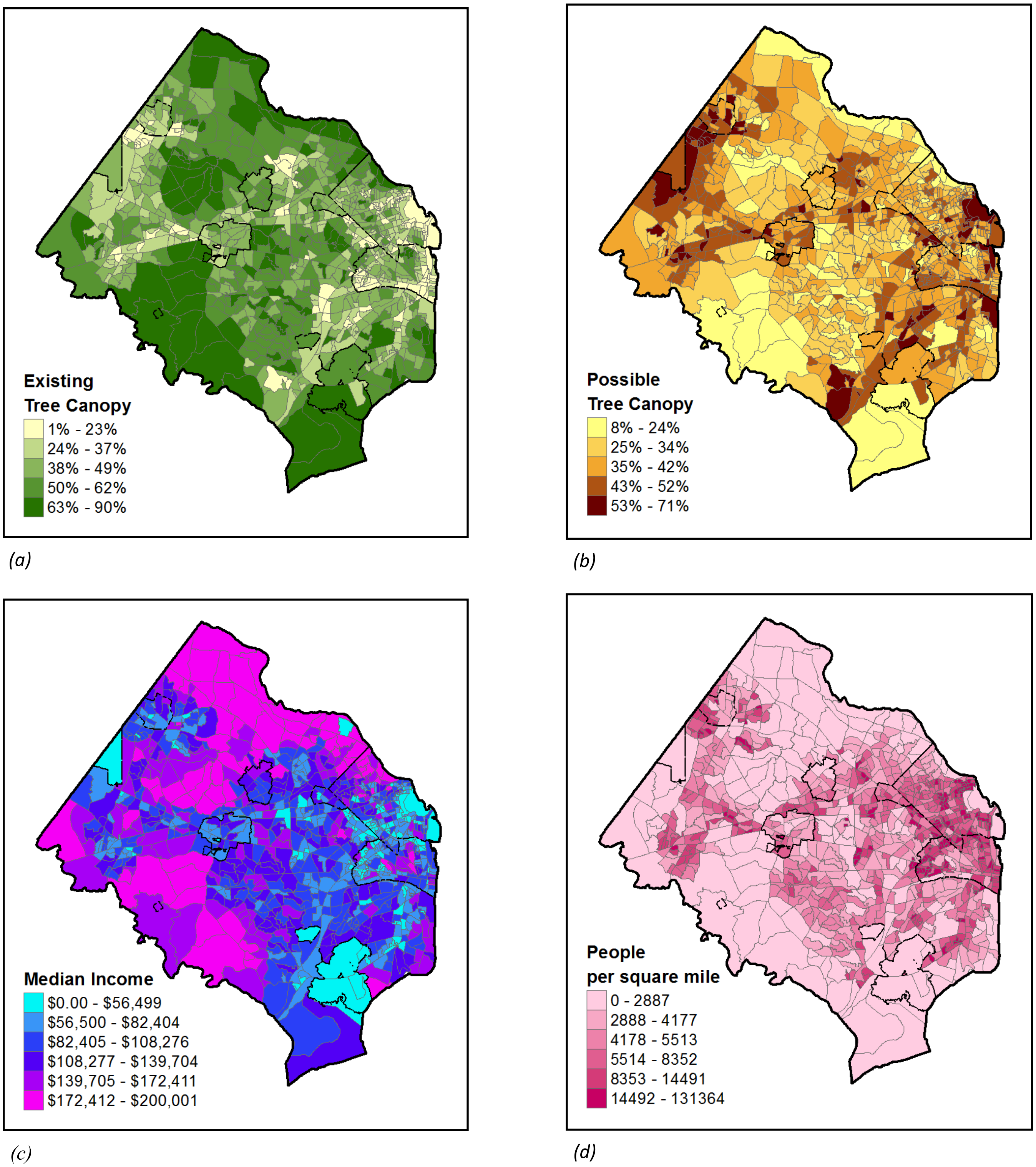


Figure 6: (a) Percent Existing TC; (b) Percent Possible TC; (c) 2011 median income per capita; and (d) people per square mile for census block groups in Greater Fairfax County.

Priority Planting Areas

The Priority Planting Index (PPI), developed by Dr. David Nowak of the USDA Forest Service, incorporates census data and TC metrics to score block groups based on the need for tree plantings. The Priority Planting Index, which factors in population density, tree stocking levels, and per capita tree cover (Figure 7) helps to identify areas where tree planting efforts can be targeted to address issues of environmental justice (Figure 8). Interestingly, the areas with high PPI values also have relatively high amounts of Possible TC.

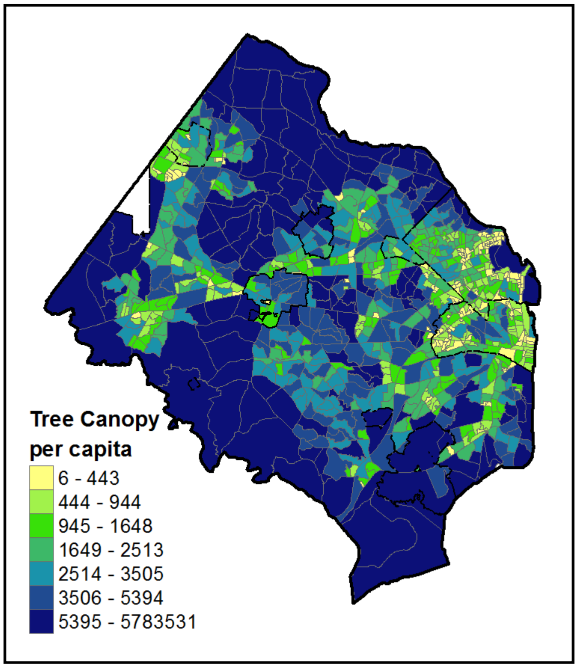


Figure 7: Tree canopy per capita by Census block group in feet squared.

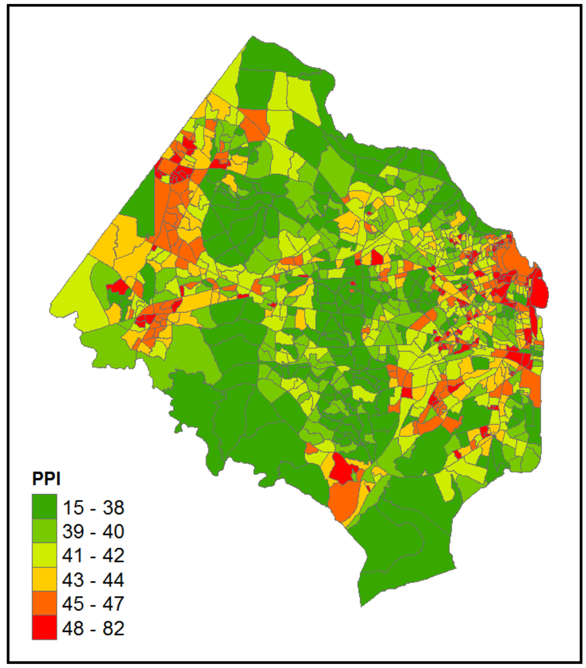


Figure 8: Priority Planting Index by Census block group.

Surface Temperature

One of the chief benefits of tree canopy is the ability to reduce summer temperatures in urbanized areas, ameliorating the urban heat island effect. The urban heat island effect is largely a result of impervious surfaces, which unlike vegetation, retain and emit heat. To examine the urban heat island effect in the study area we used a Landsat satellite image acquired on July 5, 2011. Landsat has the ability to measure surface temperature at a relatively detailed scale. Landsat surface temperatures were summarized at the Census block group level and compared to both tree canopy and impervious surfaces (Figures 9 & 10). It was found that block groups with lower amounts of tree canopy and higher amounts of impervious surfaces tend to have higher temperatures. Higher summer temperatures are associated with increased energy use, which in turn, drives up the cost of living along with operational costs for commercial and industrial operations.

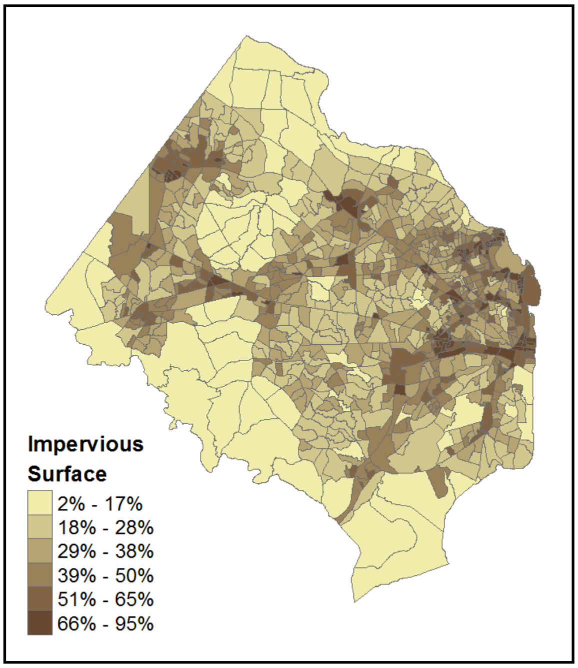


Figure 9: Amount of impervious surface by Census block group.

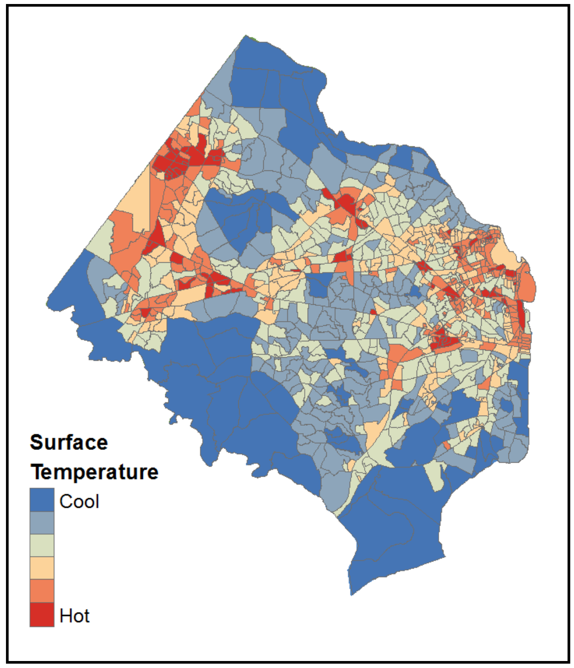


Figure 10: Average surface temperature by Census block group.

LifeMode Groups

To understand how the region's land and tree canopy in relation to the characteristics of the region's population, tree canopy was summarized using the Esri Tapestry[tm] LifeMode groupings. LifeMode groups represent people who are similar based on income and age. Most of the land within the region is in the "High Society" group, the wealthiest of all the groups, consisting primarily of married couples in affluent neighborhoods that are not ethnically diverse. This group also lives in areas with a relatively high proportion of the land covered by tree canopy (49%). "Scholars & Patriots," a group that includes both college students and patriots, live in areas with a slightly higher amount of land covered by tree canopy (50%), despite the fact that they are considerably less well off than "High Society."

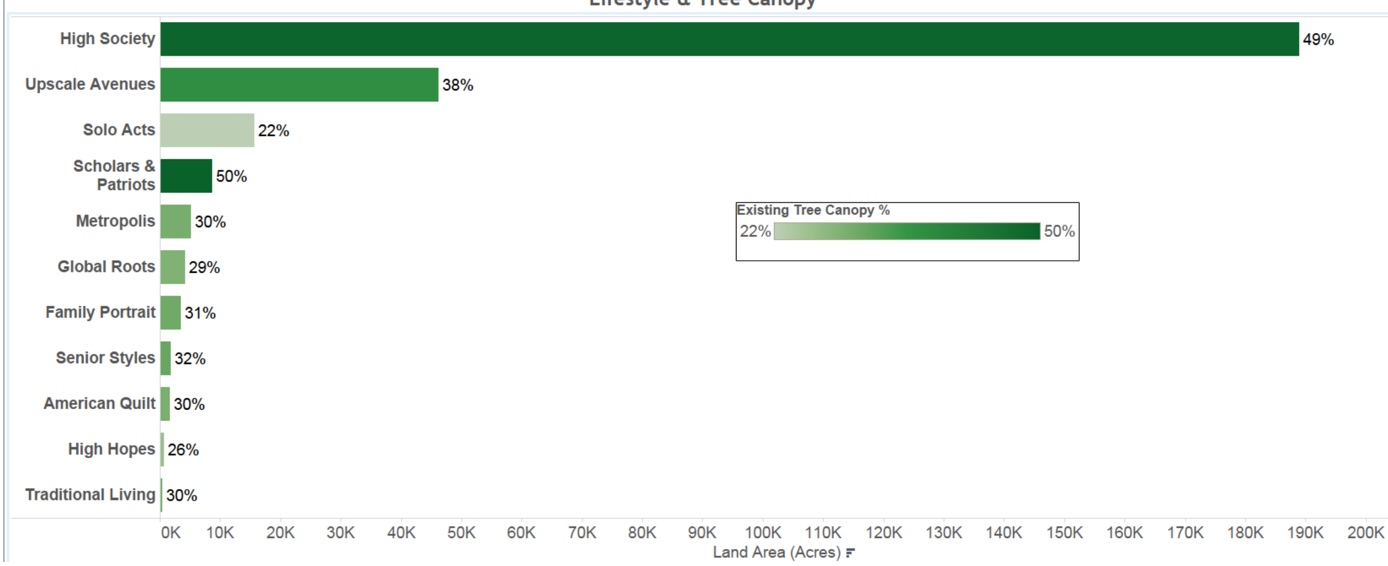


Figure 11: Land area and Existing Tree Canopy by LifeMode Group. The length of the bar represents the total amount of land in each LifeMode group, the color gradient and numbers at the end of each bar indicate the % Existing Tree Canopy.

Population and Income

There is always interest in examining the relationship between socio-demographic data and tree canopy to examine issues of environmental justice. Figure 12 shows how Existing Tree Canopy relates to both population density and median household income for all of the block groups in the region. The analysis indicates that population density is inversely related to tree canopy, and that income is positively correlated with tree canopy. It should be noted that drawing broad conclusions from these data should be done with great care as these relationships are complex and may also be reflective of land use history as much as of the socio-demographic makeup of the region. In addition, these relationships don't hold true for all communities. For example there is no relationship between population density and tree canopy in Alexandria, nor is tree canopy increase with income in the City of Fairfax.

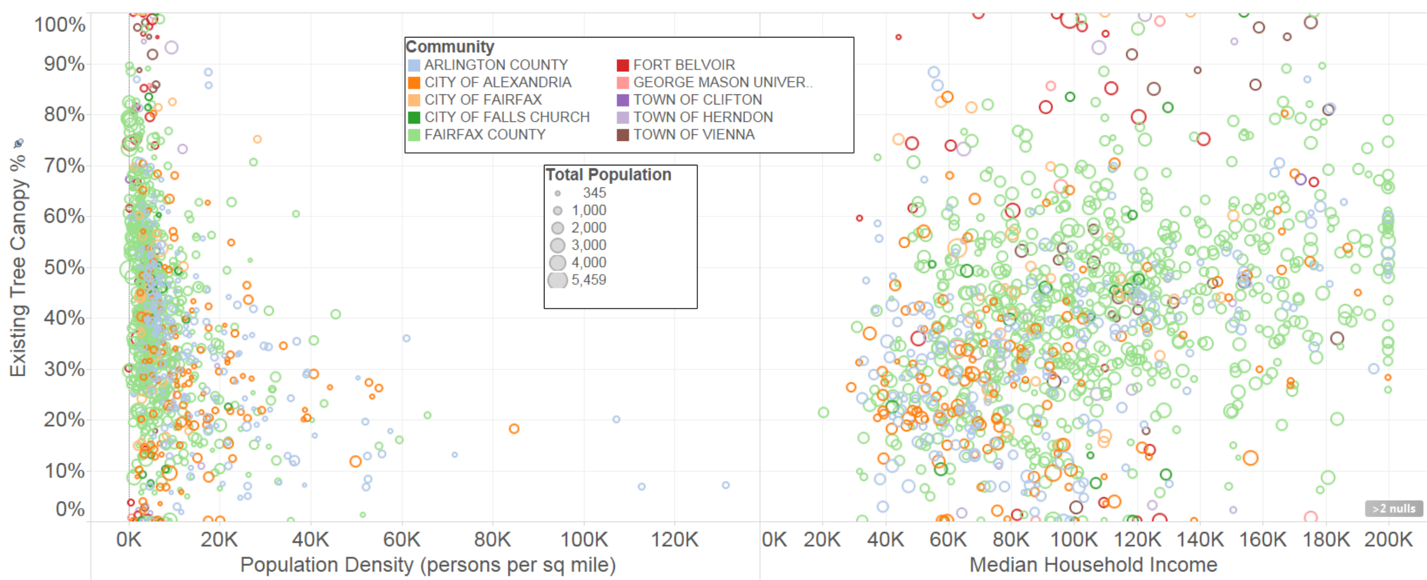


Figure 12: Existing Tree Canopy in relation to population density and household income for Census block groups in the region. Each circle represents a Census block group color coded according to the community it is in and sized based on the total population within the block group.

Communities

Existing and Possible Tree Canopy were summarized by the study areas large communities, including Arlington County (Figure 13). Fairfax County land outside of the communities considered here is 56% forested and accounts for 86% of the study area's Tree Canopy. Tree Canopy covers at least 50% of Clifton, Vienna and Fort Belvoir (Figure 14). In terms of establishing new tree canopy, Herndon, Dulles and George Mason University have approximately half of their land area classified as Possible TC. Many of Herndon's vegetated TC opportunity areas are in conflicting uses (e.g., recreation fields and golf courses). Airports typically do not represent real opportunities for tree planting, but the Dulles polygon appears to have a large area of idle vegetated land that might be plantable. Excluding the bulk of Fairfax County, Alexandria, Arlington County, and Fort Belvoir have the greatest acreage available to increase tree canopy on vegetated land. Herndon and George Mason University have the largest percentage of impervious land where tree canopy increases are possible. New tree planting in impervious areas can provide many benefits but typically comes at greater expense compared to planting in areas of existing vegetative cover.

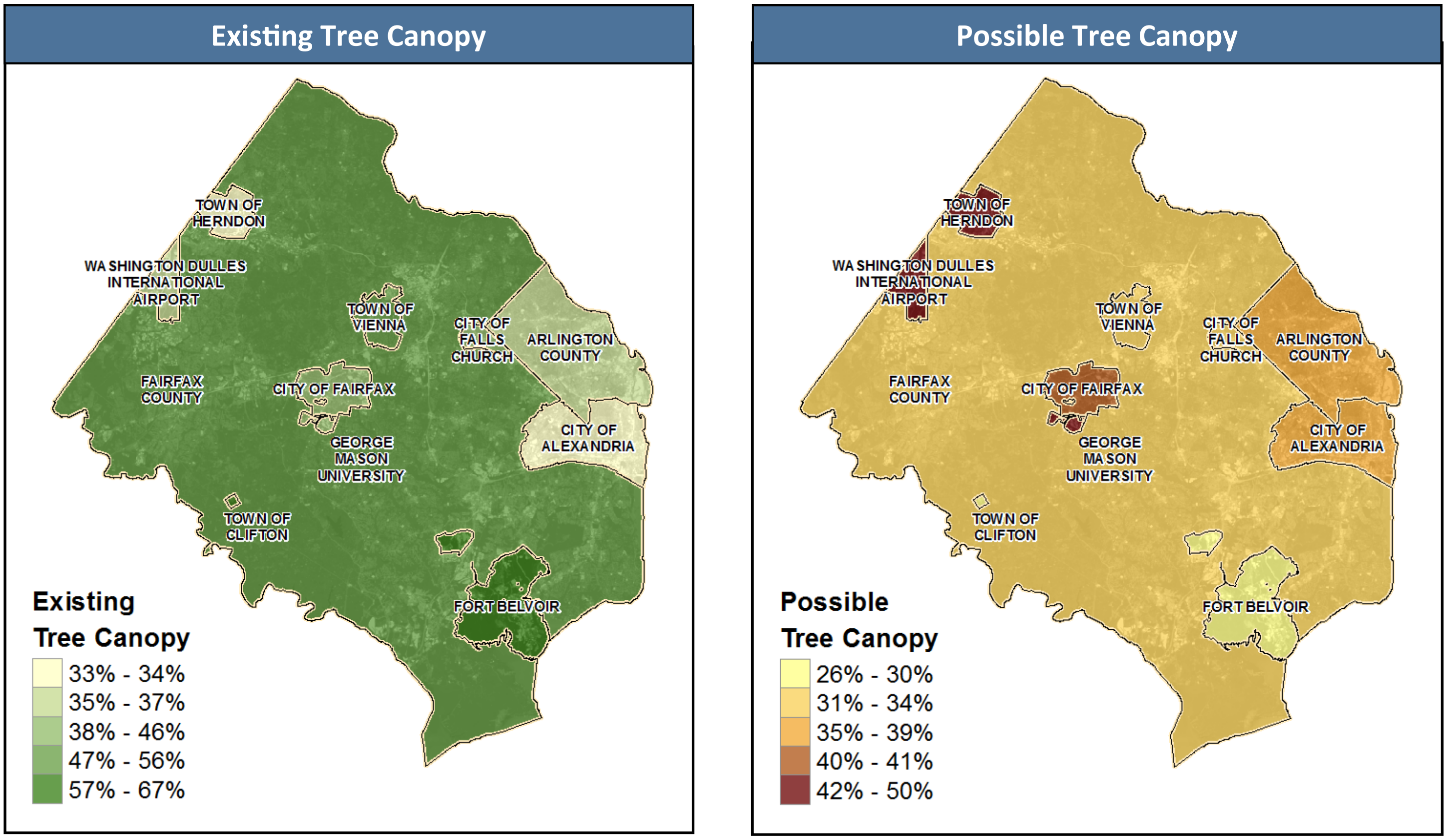


Figure 13: Existing and Possible Tree Canopy for Greater Fairfax County Communities.

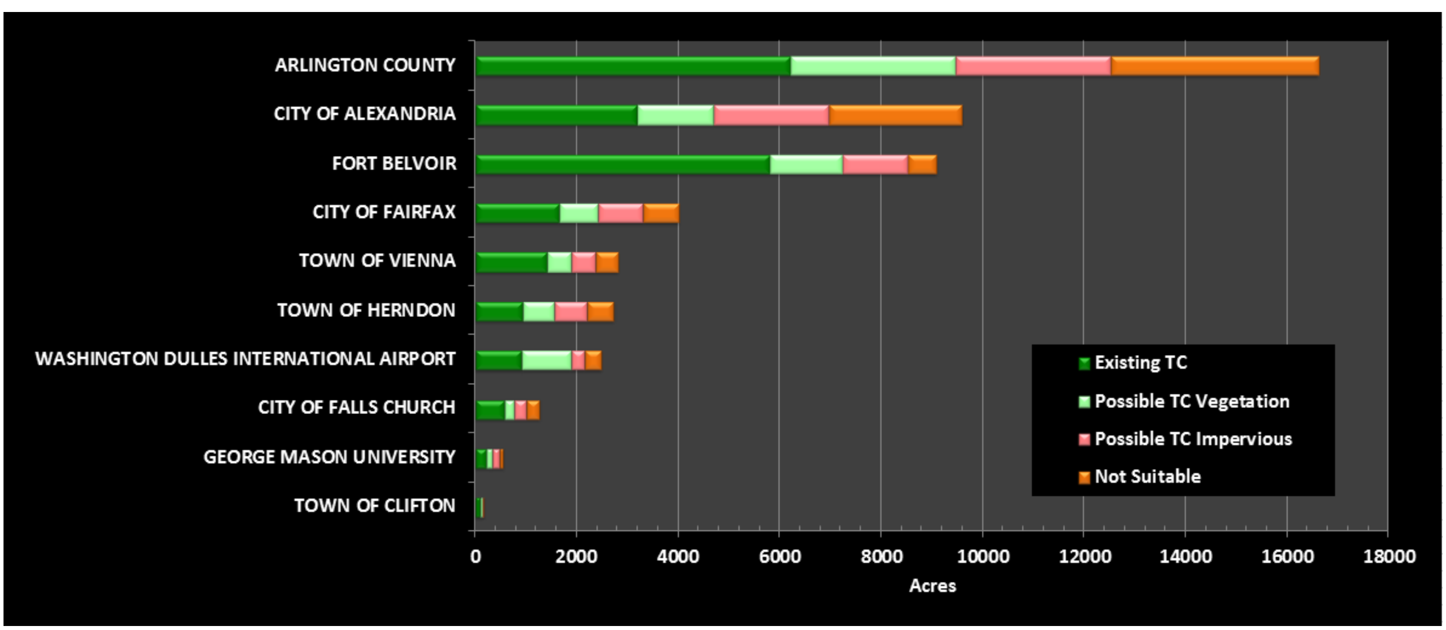


Figure 14: Tree Canopy metrics summarized by Community.

Parks

Existing and Possible Tree Canopy were summarized for Greater Fairfax County's parks (Figure 15). Considering parks by class, Parks with Resource-based Values are nearly 90% forested (Figure 16). Tree Canopy also covers 50% or more of the other park classes. In terms of establishing new tree canopy, District Parks have the largest fraction of the Vegetated Possible Tree Canopy category (36%), although Resource-based Parks have the largest acreage in this category (13,58 acres). Among individual parks with a high percentage of land classified as Possible Tree Canopy, many are occupied by golf courses and recreation fields.

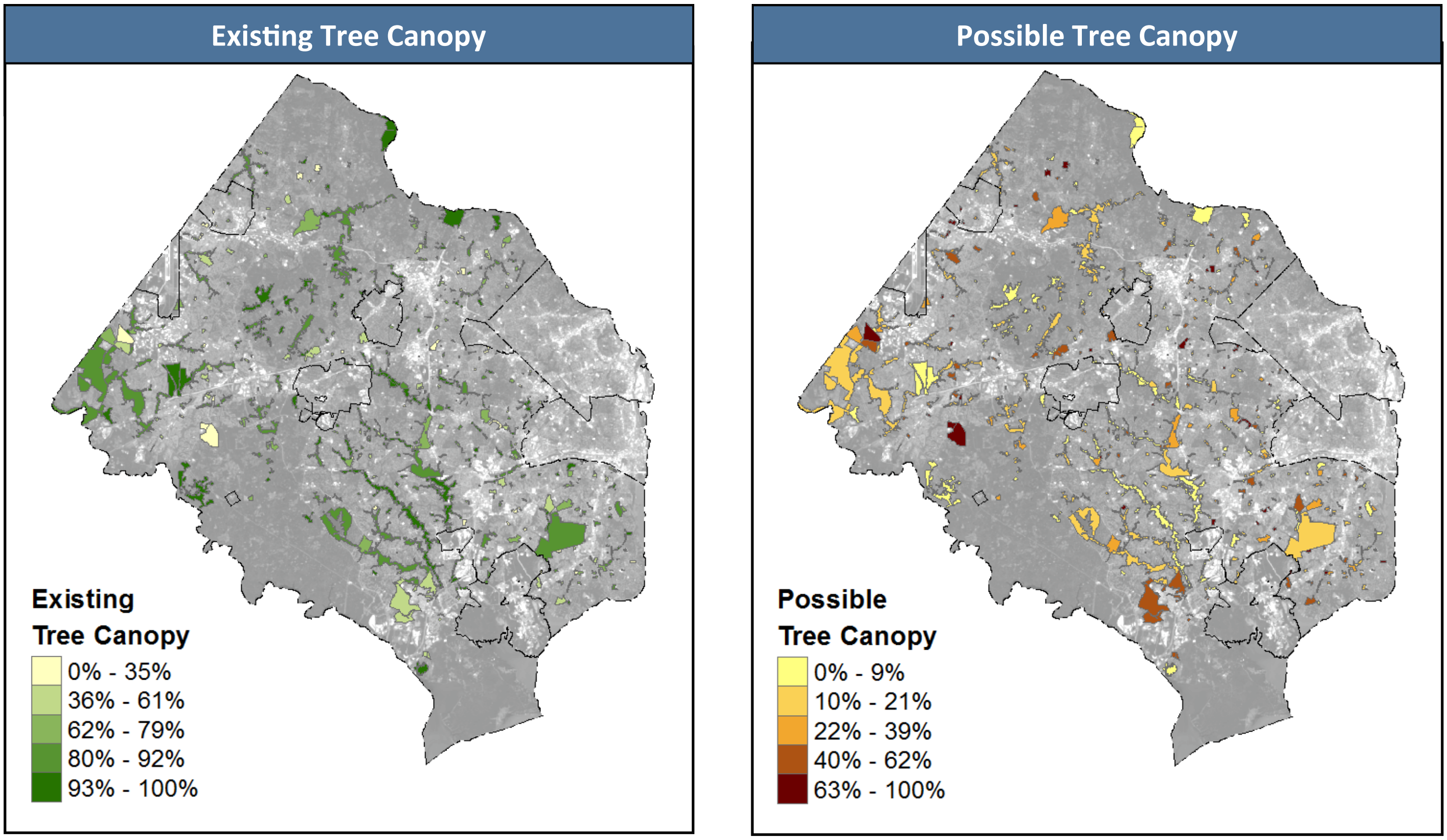


Figure 15: Existing and Possible Tree Canopy for Parks.

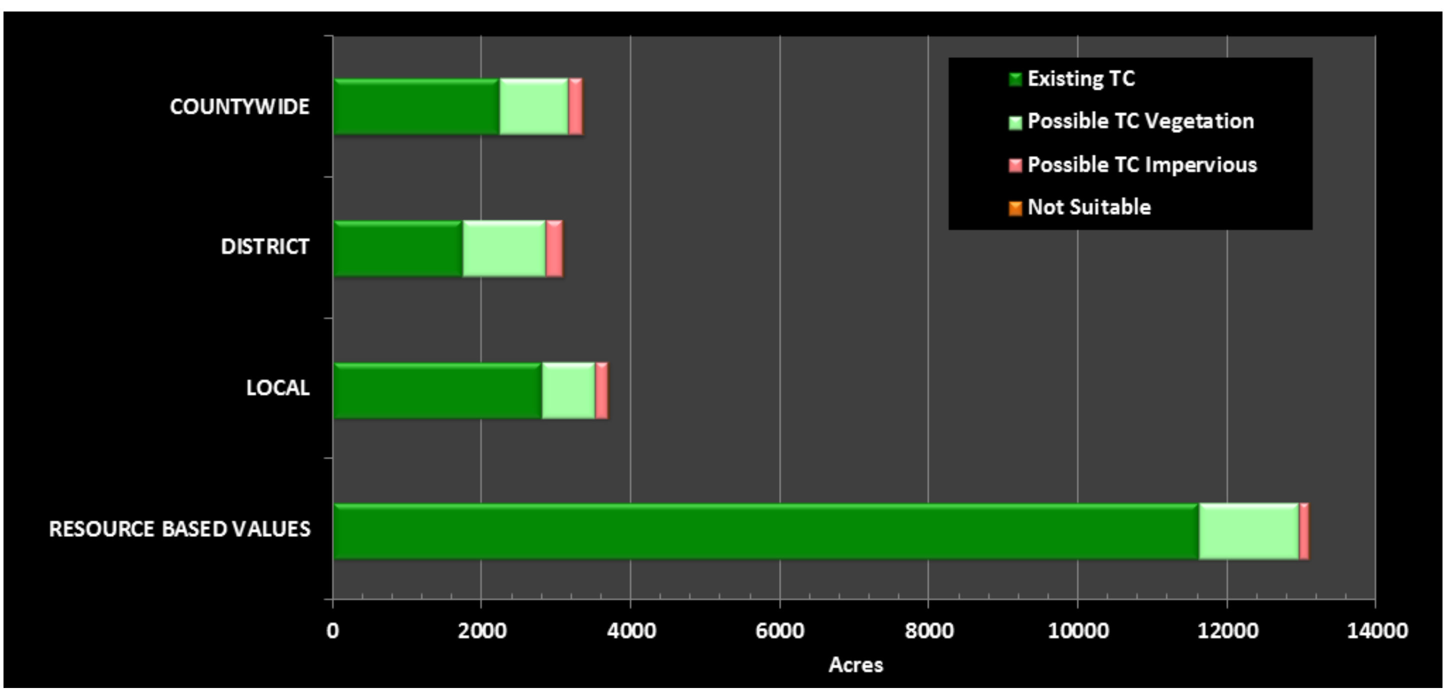


Figure 16: Tree Canopy metrics summarized by Park Class.

Watersheds

Existing and Possible Tree Canopy were also summarized by watersheds in Greater Fairfax County (Figure 17). Nearly three-quarters of Existing Tree Canopy is in the 6 largest watersheds (Figure 18). Of these, Pope's Head Creek has the largest fraction of forested land (69%). The most heavily forested watersheds in the study area are small, peripheral watersheds in the North and South corners along the Potomac River and near the confluence of Bull Run and the Occoquan River. Ryan's Dam, Old Mill Branch, High Point and Kane Creek are all more than 80% forested. Tree Canopy covers only about one-third of the Four Mile Run and Horsepen Creek watersheds. The four largest watersheds — Difficult Run, Accotink Creek, Cameron Run and Cub Run have the largest acreage of Possible Tree Canopy (together accounting for 72% of this category). In terms of tree planting opportunities, Bull Run and Mill Branch have relatively large percentages of Vegetated Possible Tree Canopy (>30%). Accotink Creek, Cameron Run, Four Mile Run and Cub Run have the largest amount of land for tree canopy improvements on developed land, each with at least 4,000 acres of land in the Impervious Possible Tree Canopy category.

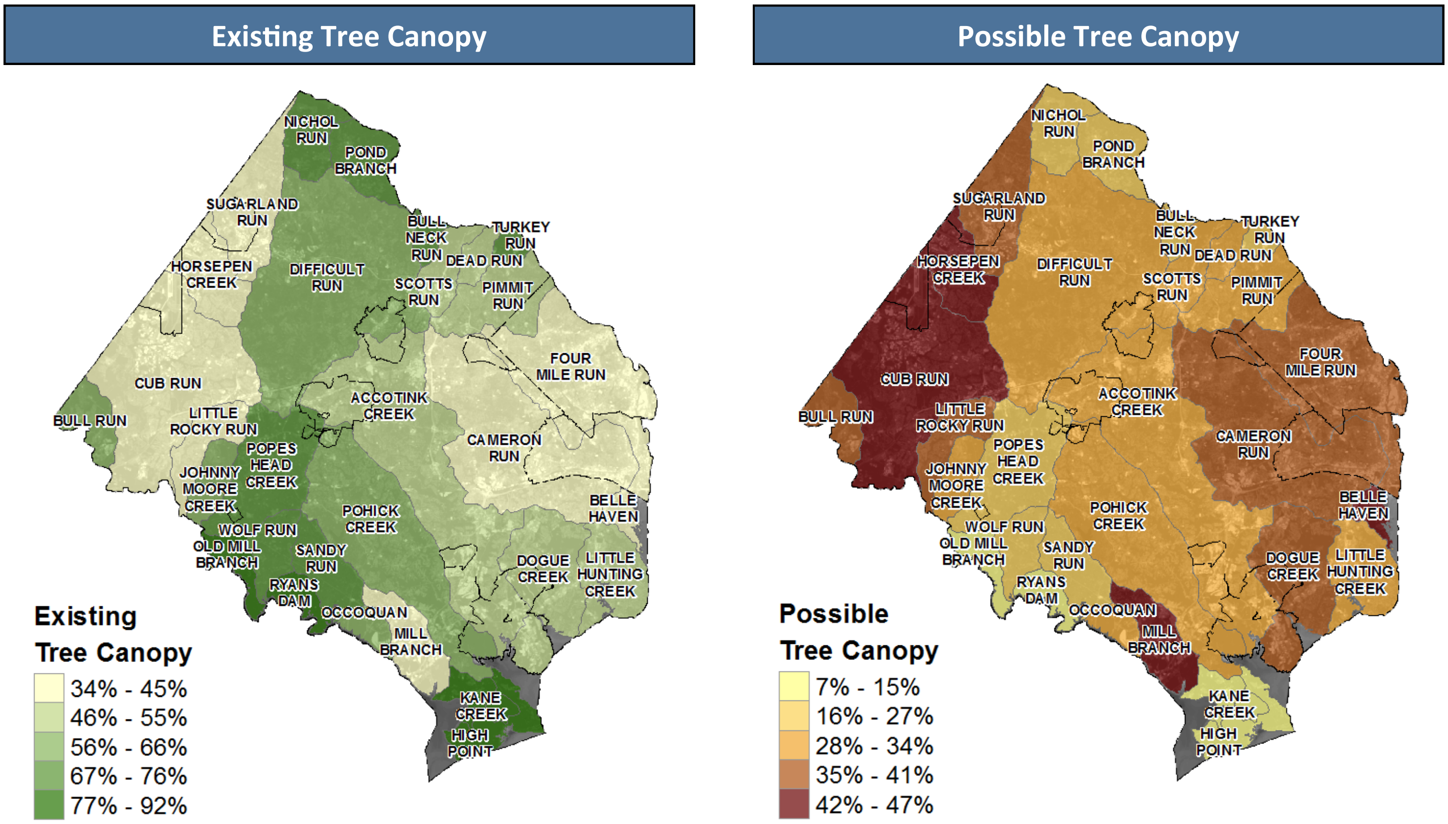


Figure 17: Percent Existing and Possible Tree Canopy by watershed.

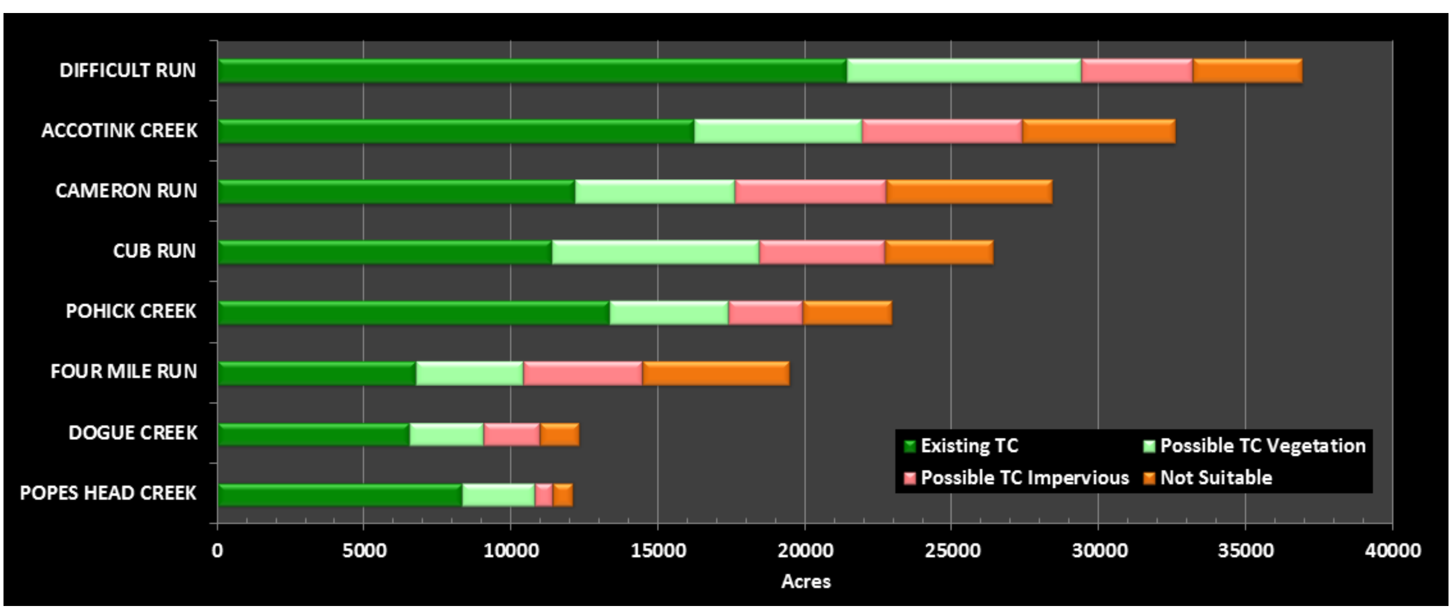


Figure 18: Tree Canopy metrics summarized by watershed (for watersheds larger than 10,000 acres).

Opportunities for Greening Urbanized Watersheds

Opportunities for greening were explored for watersheds that have 10,000 or more acres within the Fairfax County region. This analysis was carried out using Esri Tapestry[tm] urbanization data, which assigns Census block groups urbanization codes based on how developed an area is. "Principal Urban Centers" are the most urbanized areas in the region and "Small Towns" the least. Most of the land in Fairfax is characterized at "Metro Cities," areas that are dominated by single family homes in a metropolitan areas. Watersheds in more urbanized areas tend to suffer from increased runoff and poorer stream health. Figure 19 summarizes the relative land area of each watershed by urbanization group (color gradient) along with amount of non-treed vegetated land (Possible Tree Canopy-Vegetation) in each of the watersheds by urbanization group (numbers). To a large extent the amount of vegetated land available for new tree plantings mirrors that of the region as a whole, with the largest acreage in "Metro Cities," however, not all watersheds are the same. Cub Run for example is one of the regions less urbanized watersheds, with "Suburban Periphery," being the dominant urbanization group. The Four Mile Run watershed represents a much more urbanized watershed, but despite the relatively high amount of land in the "Principal Urban Centers" group, there is still considerable room for establishing more tree canopy.

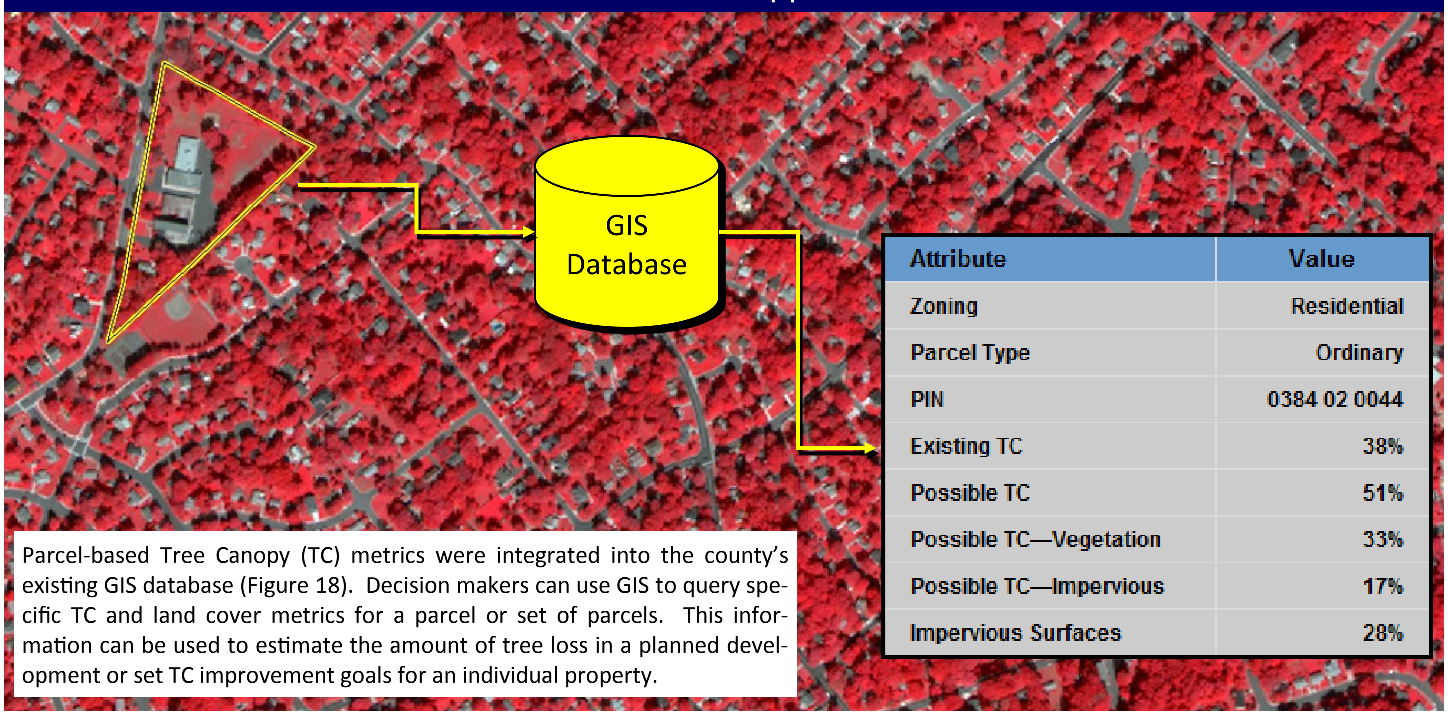
	Urbanization Group				
Watershed	Principal Urban Centers	Metro Cities	Urban Outskirts	Suburban Periphery	Small Towns
ACCOTINK CREEK	335	3,522	351	1,357	
CAMERON RUN	869	4,243	76	268	
CUB RUN	61	1,483	1,868	2,356	443
DIFFICULT RUN	116	7,472	165	243	
DOGUE CREEK	161	1,332	387	643	
FOUR MILE RUN	1,199	1,567	11	132	
POHICK CREEK	55	1,532	84	2,366	
POPES HEAD CREEK	38	2,386	6	33	

% of Watershed Land Area by Urbanization Group

0.19% — 97.29%

Figure 19. Opportunities for tree plantings, by urbanization group, for watersheds with greater than 10,000 acres in the region. Numbers represent the area of Possible Tree Canopy-Vegetation (land with vegetative cover that does not have tree canopy) in acres. The color gradient represents the proportion of the watershed in each one of the urbanization groups. Urbanization decreases from left to right, with "Principal Urban Centers" representing the most developed areas and "Small Towns" indicative of most rural areas in the region.

Decision Support



Attribute	Value
Zoning	Residential
Parcel Type	Ordinary
PIN	0384 02 0044
Existing TC	38%
Possible TC	51%
Possible TC—Vegetation	33%
Possible TC—Impervious	17%
Impervious Surfaces	28%

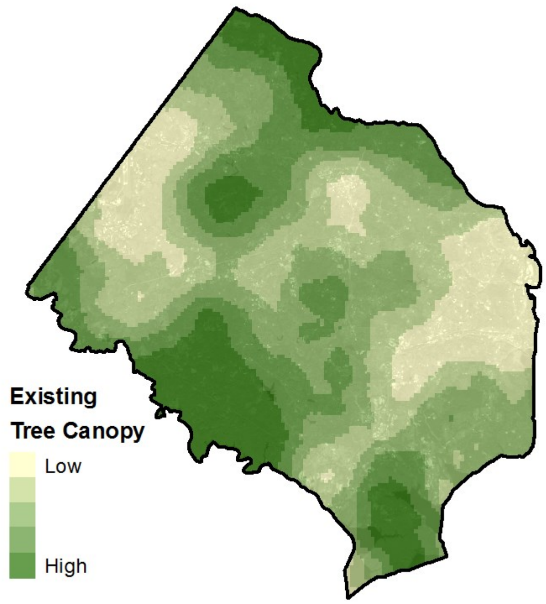
Figure 20: GIS-based analysis of parcel-based TC metrics for decision support. In this example, GIS is used to select an individual parcel. The attributes for that parcel, including the parcel-based TC and land cover metrics, are displayed in tabular form providing instant access to relevant information.

Tree Canopy Opportunity Index

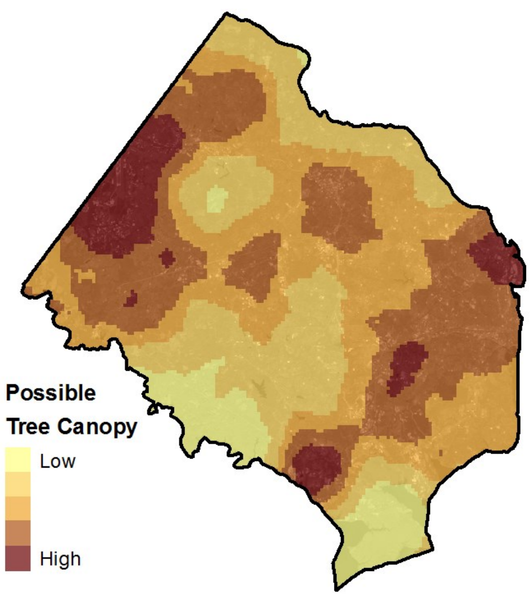
In addition to simple descriptive statistics, more sophisticated techniques can help identify areas of the city where tree-planting and stewardship programs would be most effective. One approach is to focus on spatial clusters of Existing and Possible TC. When a 1000-foot grid network is superimposed on the land-cover map (Figure 21a), it is possible to map regions of the study area where high values of Existing TC are tightly clustered (Figure 21b). A similar map was constructed for Possible TC (Figure 21c). A single index was created by subtracting the percentage of Existing TC per grid cell from Possible TC, which produced a range of values from –1 to 1. When clustered, this tree canopy opportunity (TCO) index highlights areas with high Possible TC and low Existing TC (Figure 21d); these areas theoretically offer the best places to strategically expand tree canopy and to increase its many attendant benefits. Unlike PPI (Figure 8), TCO does not take into account population information. As such, the areas with the highest TCO are open areas such as parks and cemeteries and the airport that have low Existing and high Possible TC. As with all such analyses, however, landscape context must be evaluated before setting priorities.

a. 1000ft Grid

b. Existing Tree Canopy Hotspots



c. Possible Tree Canopy Hotspots



d. Tree Canopy Opportunity Index

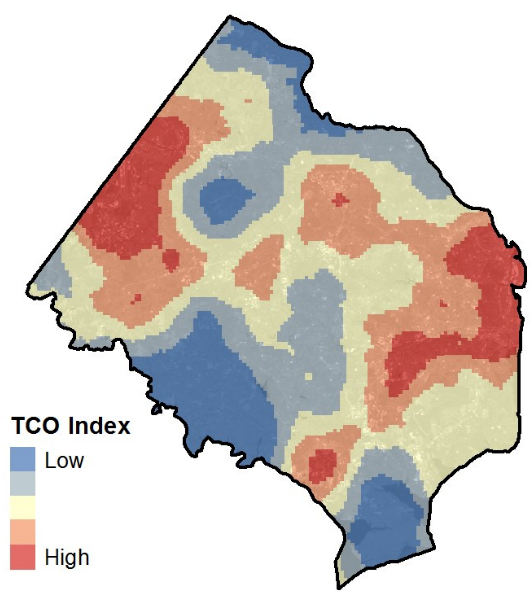


Figure 21: (a) Grid network (1000-foot cells) superimposed on land-cover map for Greater Fairfax County and then used in spatial cluster analyses; (b) Spatial clustering of Existing TC in Greater Fairfax; dark green areas are highly clustered and have high Existing TC values; (c) Spatial clustering of Possible TC in Greater Fairfax; dark red areas are highly clustered and have high Possible TC values.; and (d) Spatial clustering of a combined index of Existing and Possible TC; red areas theoretically provide the best opportunities for expanding tree canopy.

Conclusions

- Greater Fairfax County's tree canopy is a vital county asset that reduces stormwater runoff, improves air quality, reduces the county's carbon footprint, enhances quality of life, contributes to savings on energy bills, and serves as habitat for wildlife.
- Greater Fairfax County should consider setting tree canopy goals, not only for increasing the county's overall tree canopy but to focus on increasing tree canopy in urban and residential areas that have the least Existing Tree Canopy and high Possible Tree Canopy.
- Residential zones dominate the two-county area, and thus these zones have both the greatest net amount of Existing Tree Canopy and Possible Tree Canopy. Residential land contains 87% of the study area's tree canopy and the Planned Units Zone contains another 10% of the study area's tree canopy. The pattern is similar for Possible Tree Canopy, indicating that an "all lands, all owners" approach will be needed in order to preserve and increase Greater Fairfax County's Tree Canopy.
- Strategies for increasing tree canopy will likely differ by land use type. For example, tree planting initiatives on park lands will likely target riparian buffers in order to support existing recreational uses, yet at the same time reduce surface runoff.
- Within low Tree Canopy communities, existing land uses will preclude tree planting in some areas where much of the vegetated land is occupied by cemeteries, golf courses, wetlands and airfields. Efforts to increase Tree Canopy in these highly-developed communities might best be focused on large parking lots, where Tree Canopy must be limited yet will offer great benefit.
- Despite the dominance of residential land within the study area all land use types have vegetated or impervious surfaces, that if improved, could yield additional tree canopy. For example, 17% of the land in the industrial zoning district contains non-tree canopy vegetated cover that could support tree canopy.
- The presence of impervious surfaces and the lack of tree canopy in the county's more urbanized areas causes higher summer surface temperatures, which has an adverse economic impact.
- Efforts to preserve Greater Fairfax County's current tree canopy and establish new tree canopy will likely take many forms. Tree canopy prioritization analyses can help managers make strategic decisions to match their objectives from the property parcel to the watershed scale.

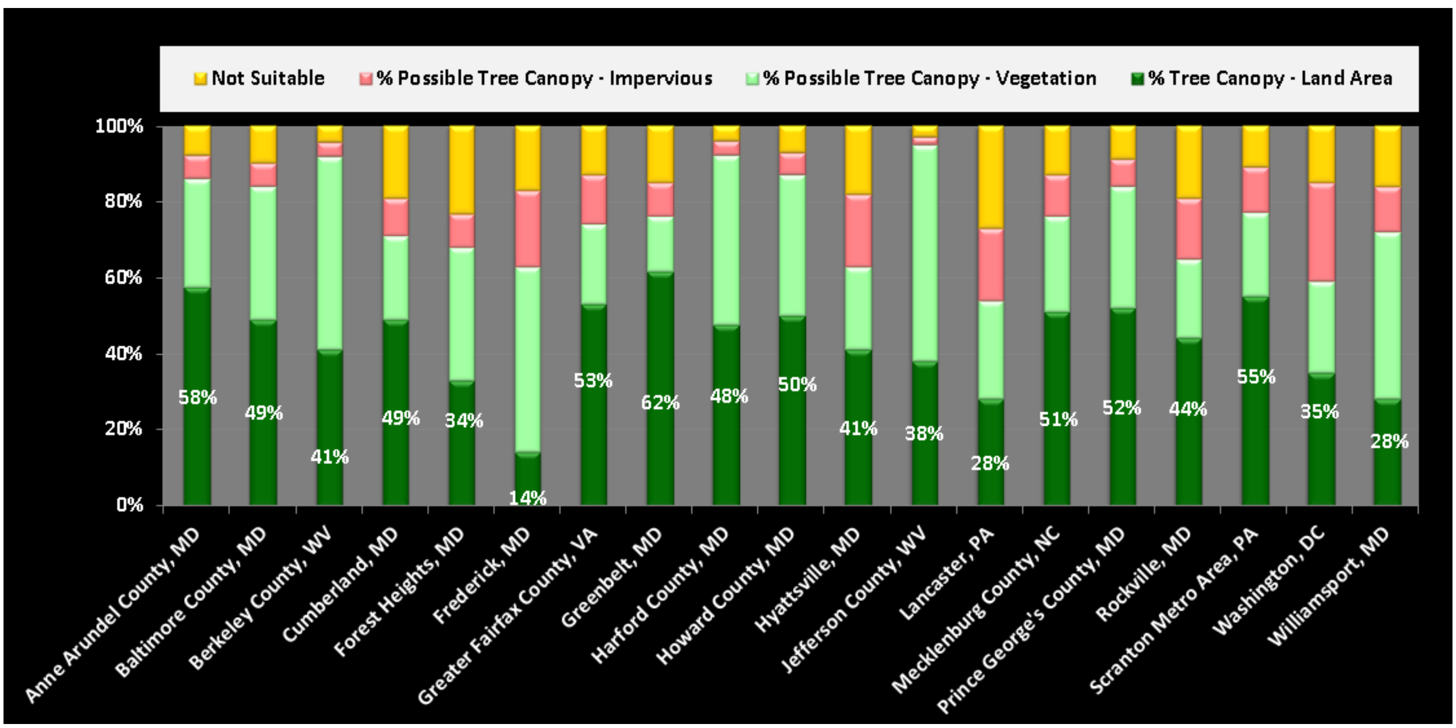


Figure 22: Comparison of Existing and Possible Tree Canopy with other similar communities that have completed Tree Canopy Assessments.

Prepared by:

Jarlath O'Neil-Dunne
University of Vermont
Spatial Analysis Laboratory
joneildu@uvm.edu
802.656.3324

Additional Information

For more info on the Urban Tree Canopy Assessment please visit **http://nrs.fs.fed.us/urban/UTC/**

Spatial Analysis Lab Tree Canopy Assessment Team: Ernie Buford, Jon Cusick, Christoph Griesshammer, Sean MacFaden, Michelle Marasco, Jarlath O'Neil-Dunne, Will Seegers, Brad Stewart and Rebecca Zeyzus.