Tree Canopy Report: Frederick County, MD

Why is Tree Canopy Important?

Trees provide many benefits to communities, such as improving water quality, reducing stormwater runoff, lowering summer temperatures, reducing energy use in buildings, reducing air pollution, enhancing property values, improving human health, and providing wildlife habitat and aesthetic benefits[1]. Many of the benefits that trees provide are correlated with the size and structure of the tree canopy (TC) which is the layer of branches, stems, and leaves of trees that cover the ground when viewed from above. Therefore, understanding tree canopy is an important step in urban forest planning. A tree canopy assessment provides an estimate of the amount of tree canopy currently present as well as the amount of tree canopy that could theoretically be established. The tree canopy products can be used by a broad range of stakeholders to help communities plan a greener future.

[1]National Research Council. *Urban Forestry: Toward an Ecosystem Services Research Agenda: A Workshop Summary*. Washington, DC: The National Academies Press, 2013.

How Much Tree Canopy Does Frederick County Have?

An analysis of Frederick County based on land cover data (Figure 1), derived from high-resolution aerial imagery and LiDAR, found that 180,968 acres of the study area were covered by tree canopy (termed Existing Tree Canopy). This represents 43% of all land in the study area (Figure 2). An additional 54% (230,009 acres) of the county's land area could theoretically be modified to accommodate tree canopy (termed Possible Tree Canopy). Within the Possible Tree Canopy category, 52% (220,227 acres) of total land area was classified as Vegetated Possible Tree Canopy and another 2% as Impervious Possible Tree Canopy (9,732 acres). Establishing tree canopy on areas classified as Impervious Possible Tree Canopy will have a greater impact on water quality and summer temperatures while Vegetated Possible Tree Canopy, grass or shrub are more readily conducive to establishing new tree canopy (where such lands are not prairie and grassland habitat).

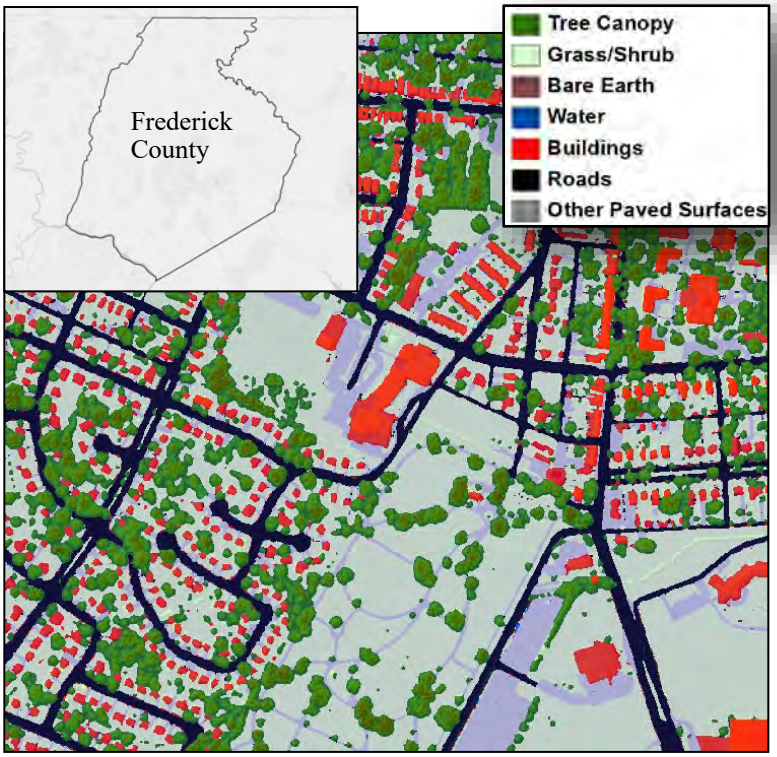

Figure 1: Study area and example of the land cover derived from high-resolution imagery for this project.

Project Partners

This project applied the USDA Forest Service's Tree Canopy Assessment protocols to Frederick County, Maryland. The analysis was conducted using imagery that was acquired in 2014 and LiDAR data that was acquired in 2012. 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 Frederick County, NASA, the University of Maryland, and the USDA Forest Service.

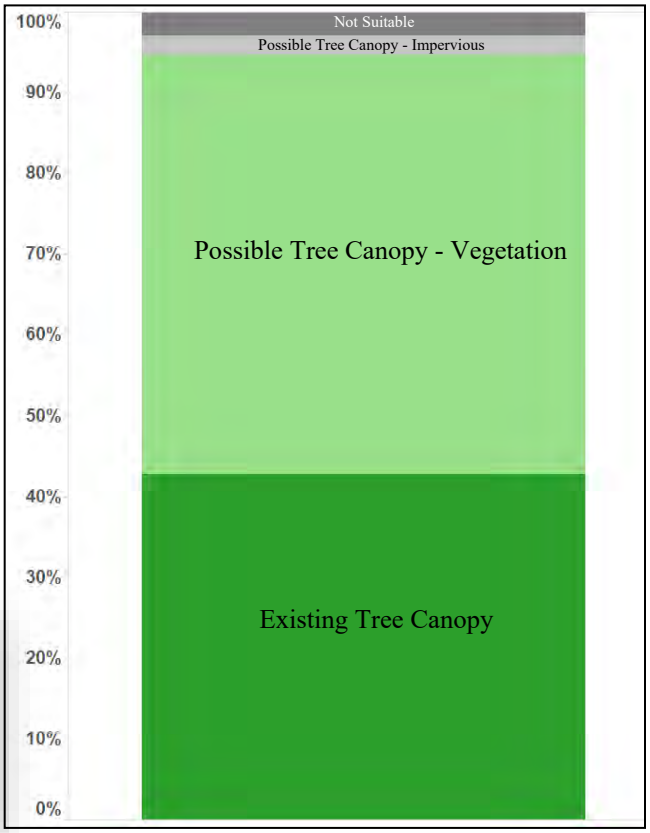

Figure 2: Tree Canopy metrics for Frederick County, MD on percent of land area covered by each tree canopy type.

Key Terms

Land Cover: Physical features on the earth mapped from aerial or satellite imagery, such as trees, grass, water, and impervious surfaces.
Existing Tree Canopy: The amount of urban tree canopy present when viewed from above using aerial or satellite imagery.
Impervious Possible Tree Canopy: Asphalt or concrete surfaces, excluding roads and buildings, that are theoretically available for the establishment of tree canopy if improvements were made.
Vegetated Possible Tree Canopy: 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 Frederick County's Trees

A previous estimate of tree canopy for Frederick County, derived from the 2011 National Land Cover Database (NLCD 2011), was 32%, notably lower than the 43% obtained in this study (these estimates are for the entire study area, including water). This difference is attributed to the lower resolution of the NLCD 2011 dataset (Figure 3a), which only accounts for relatively large extents of tree canopy. Using high-resolution imagery (Figure 3b) from 2014 and LiDAR acquired in 2012, land cover for Frederick County was mapped with such detail that individual trees were detected (Figure 3c). This new tree canopy dataset represents the most accurate accounting of tree canopy ever done for Frederick County, with trees as small as 8ft in height being mapped.

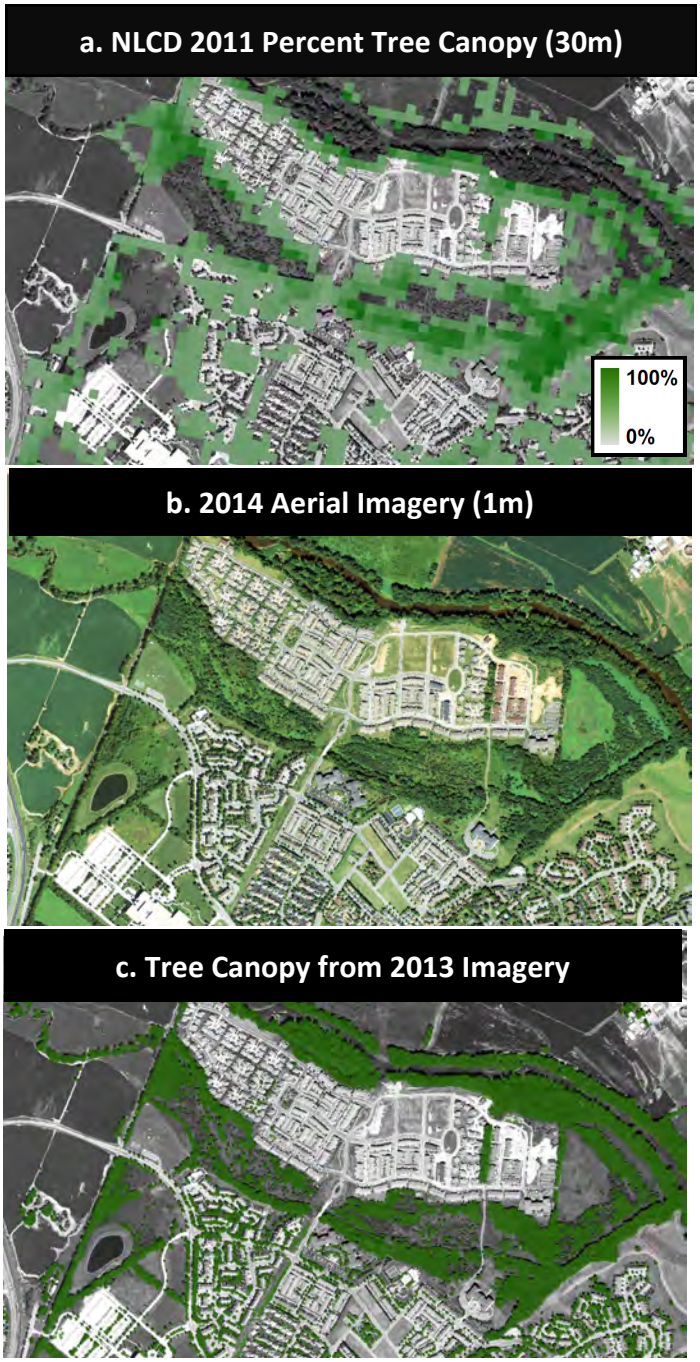

Figure 3: Comparison of NLCD 2011 (a) to high-resolution imagery (b) and tree canopy (c) derived for this study.

Parcel Summary

Tree Canopy (TC) metrics, produced from the land cover data, provide insight into the Existing and Possible tree canopy at units of analysis at various scales. 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 (Tree Canopy area divided by land area of the parcel) (Figure 4). These data can be used to understand the current tree canopy and tree planting opportunities for every property in Frederick County.

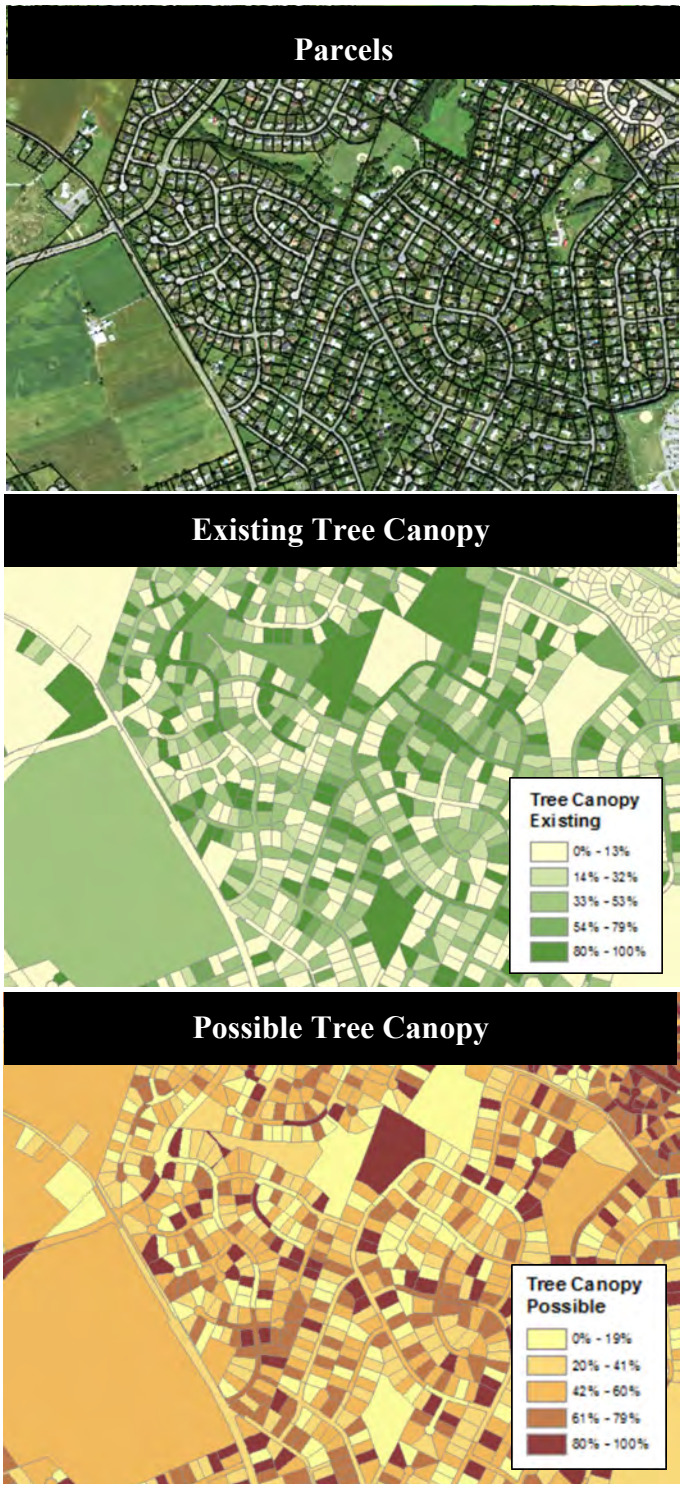

Figure 4: Parcel-based tree canopy metrics. Tree canopy metrics are generated at the parcel level, allowing each property to be evaluated according to its Existing TC and Possible TC.

Land Use & Land Cover

To examine the relationship between land use and land cover, the total area for each land use class was summarized and then the percent of vegetated cover (trees, grass, and shrubs) in each land use category was computed (Figure 5). The strategy for greening will likely differ by land use class. For example, in residential areas tree give-away programs for residents could increase canopy. While in commercial areas, zoning regulations that limit the amount of impervious surfaces may be more appropriate. This analysis of land use and land cover provides an understanding of how "green" each land use class is. The largest single land use category is Agriculture followed by Resource Conservation. Unsurprisingly, Resource Conservation is the most green land use class, with 99% of its land area covered by vegetation. At the low end, 62% of the land in the Right of Way (roads and the surrounding government owned land) land use category is covered by vegetation.

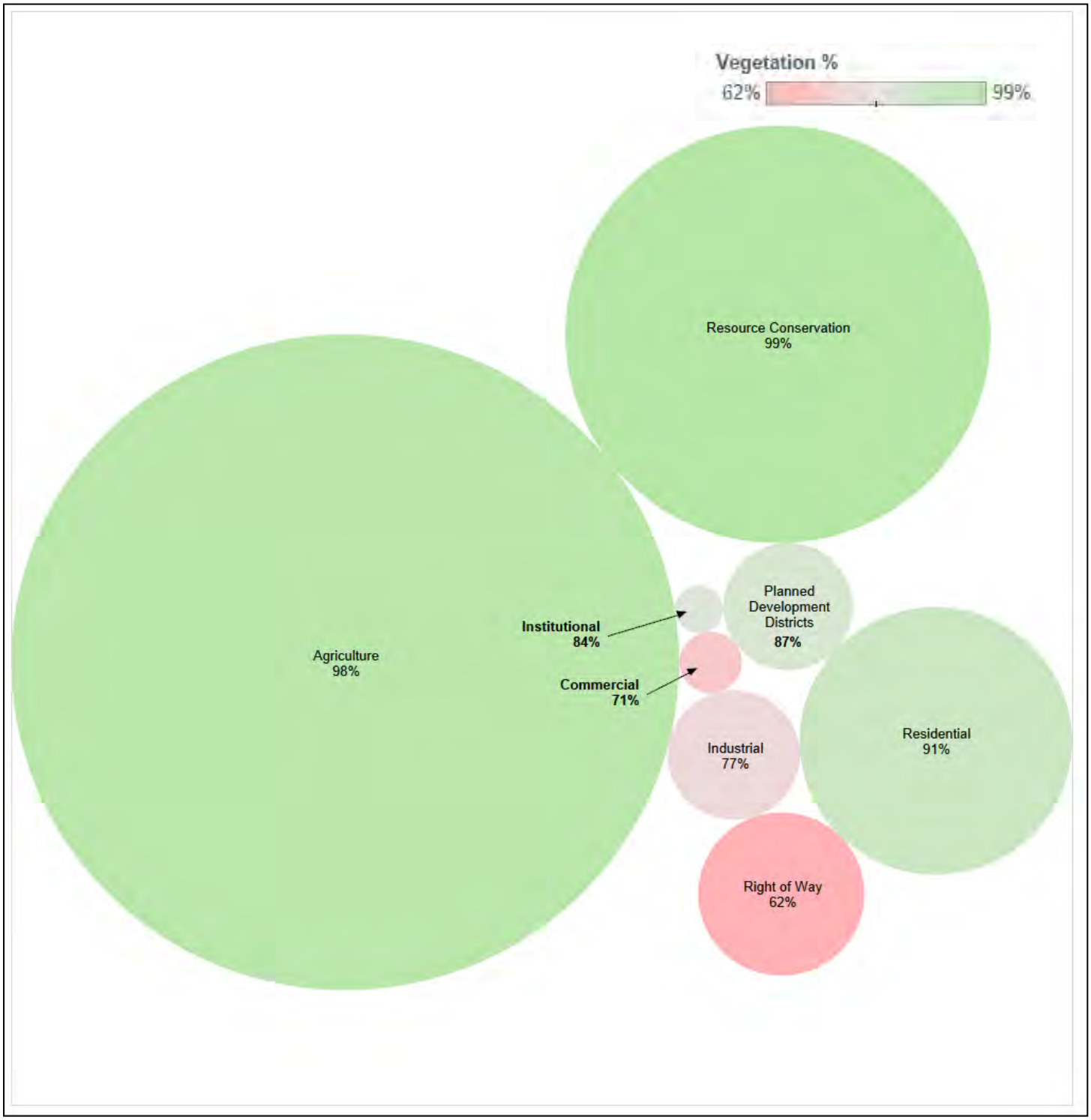

Figure 5: Percent of vegetated cover for each land use class in relation to total land area. The size of the circle represents the total land area, the color gradient represents the percentage of vegetation. Percentages are calculated based on the amount of vegetation relative to land area (i.e. water is excluded).

Land Use

Tree Canopy metrics were grouped according to land use categories. Agriculture is the dominant land use in Frederick County and also most Possible Tree Canopy by total area and has the highest percentage of Possible Tree Canopy (84%) (Figure 6). The Forest land use class has the most Existing Tree Canopy by total area and has the highest percentage of Existing Tree Canopy (87%). For all land uses there is an inverse relationship between Existing Tree Canopy and Possible Tree Canopy (Figure 7). This indicates that land uses with large amounts of tree canopy generally have less open space to plant new trees, but this relationship does not always hold true in more urbanized areas where select parcels with low Existing Tree Canopy also have low Possible Tree Canopy. An approach that considers all land use types is crucial for Frederick County to maintain and increase its tree canopy, with governments, residents, non-profits, and the private sector all playing a role. Establishing new tree canopy will be constrained by land use practices. For example, new trees in agricultural areas will likely be limited to riparian buffer zones.

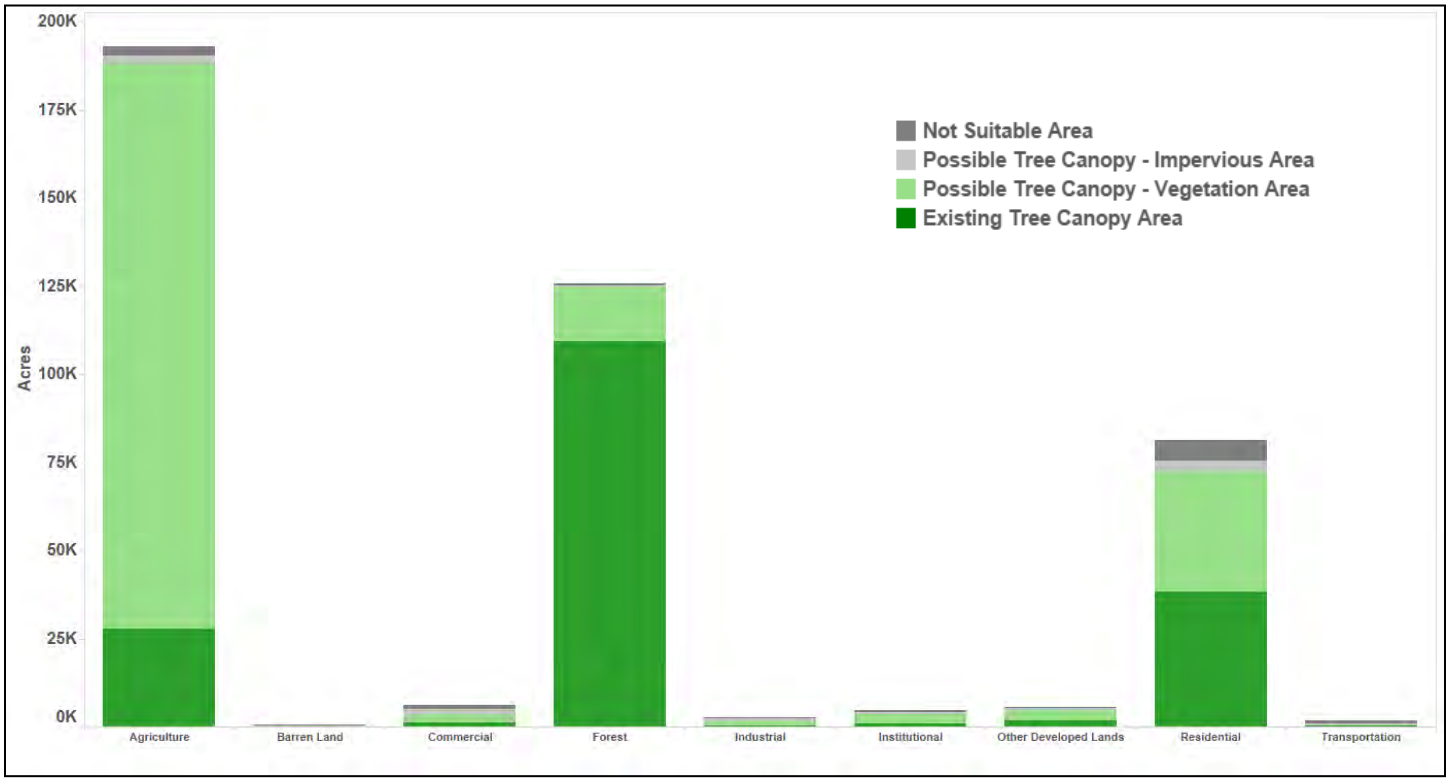

Figure 6: Tree canopy metrics derived from the parcel dataset summarized by land use.

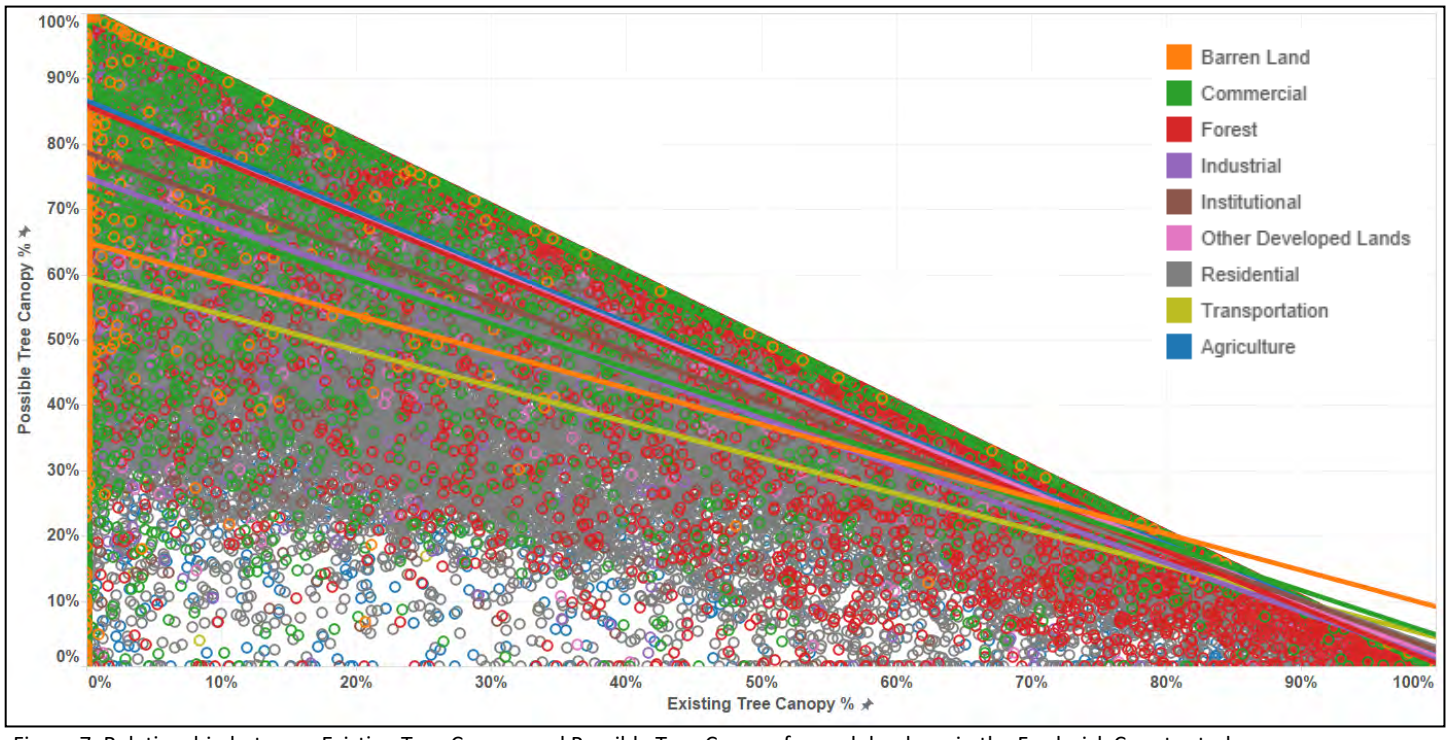

Figure 7: Relationship between Existing Tree Canopy and Possible Tree Canopy for each land use in the Frederick County study area.

Urban Heat Island

Urbanized areas are typically substantially warmer than surrounding rural locations. This effect, known as the urban heat island has multiple negative impacts such as increased energy expenditure and higher mortality in vulnerable populations. Trees reduce ground surface temperatures, through shading and transpiration. Impervious surfaces further contribute to the urban heat island effect because they absorb and hold thermal radiation from the sun. Analysis of recent thermal data (Landsat, September 18, 2015) illustrated the urban heat island effect in Frederick County (Figure 8). For example, the large continuous strip of forest to the West, provides for substantially lower temperatures. By plotting surface temperature versus Existing Tree Canopy (Figure 9) it was determined that a statistically significant inverse relationship between tree canopy and surface temperature provides clear evidence that trees help reduce the urban heat island effect.

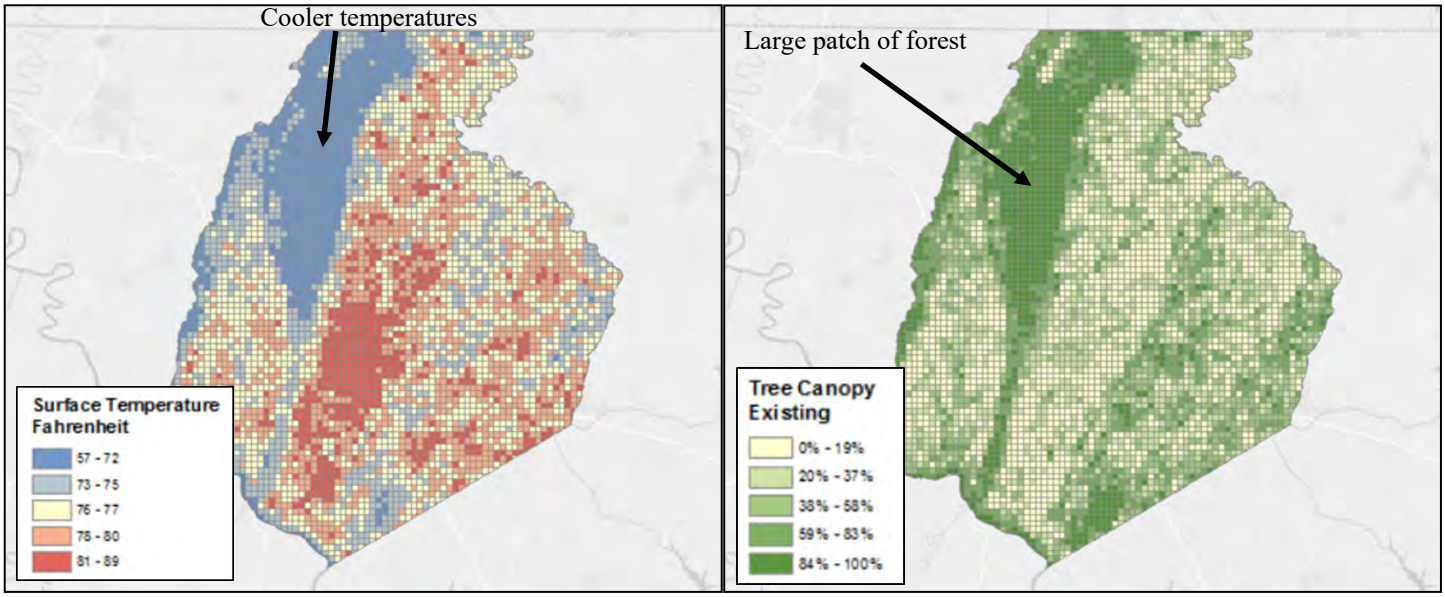

Figure 8: Surface temperature, degrees Fahrenheit on September 18, 2015 (left) in comparison with Existing Tree Canopy (right).

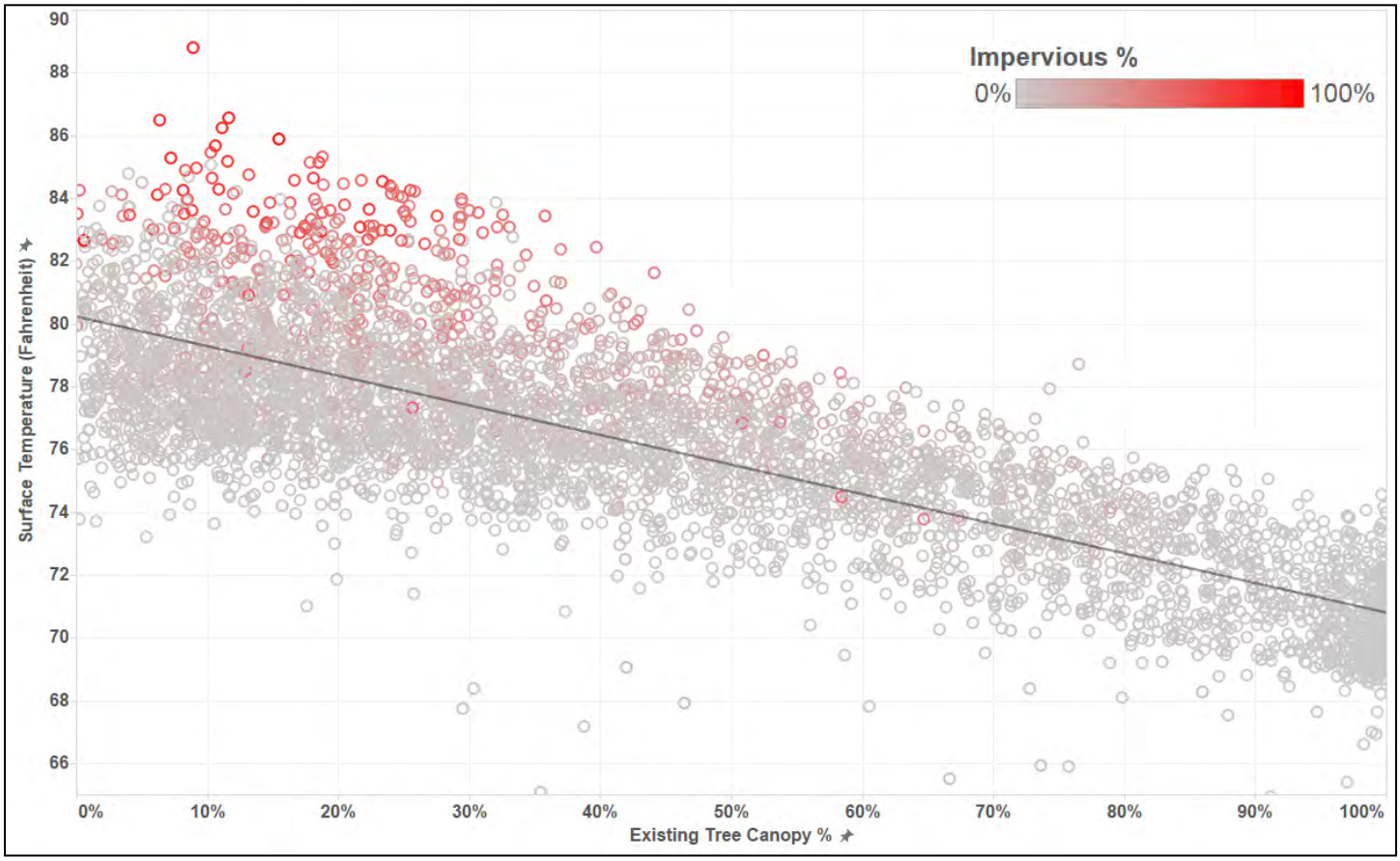

Figure 9: Surface temperature in relation to percent tree canopy. Each circle represents a 4,000,000sq ft grid cell. A 2000ft x 2000ft grid was overlaid on the region and for each grid cell the percent tree canopy, percent impervious, and average surface temperature were summarized. Surface temperature was derived from Landsat satellite imagery acquired on September 18, 2015.

Watersheds

Analyzing the Existing and Possible TC by land use for each watershed allows for tree canopy planting plans to be tailored to addressing water quality and stream health. Existing and Possible Tree Canopy were summarized for each watershed within Frederick County (Figure 10). Upper Monocacy Watershed has the highest percentage of Existing Tree Canopy (48%). This watershed, located in northern half of Frederick County, has large patches of forest and has little urban development. Double Pipe Creek Watershed has the highest percentage of Possible Tree Canopy (76%) and the lowest Existing Tree Canopy percentage (23%). Double Pipe Creek Watershed is located in the north east of Frederick County and is comprised of large agricultural fields and new housing developments with little tree canopy.

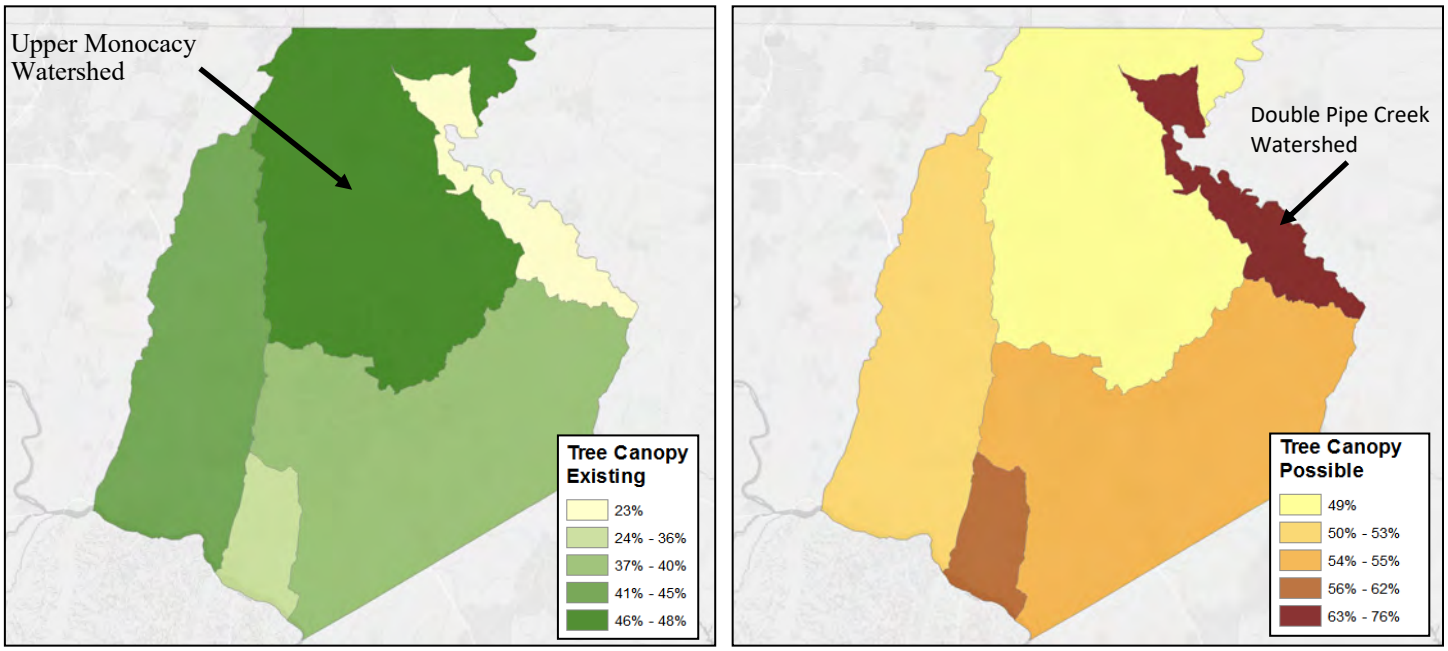

Figure 10: Percent Existing Tree Canopy by watershed in comparison to Percent Possible Tree Canopy by watersheds.

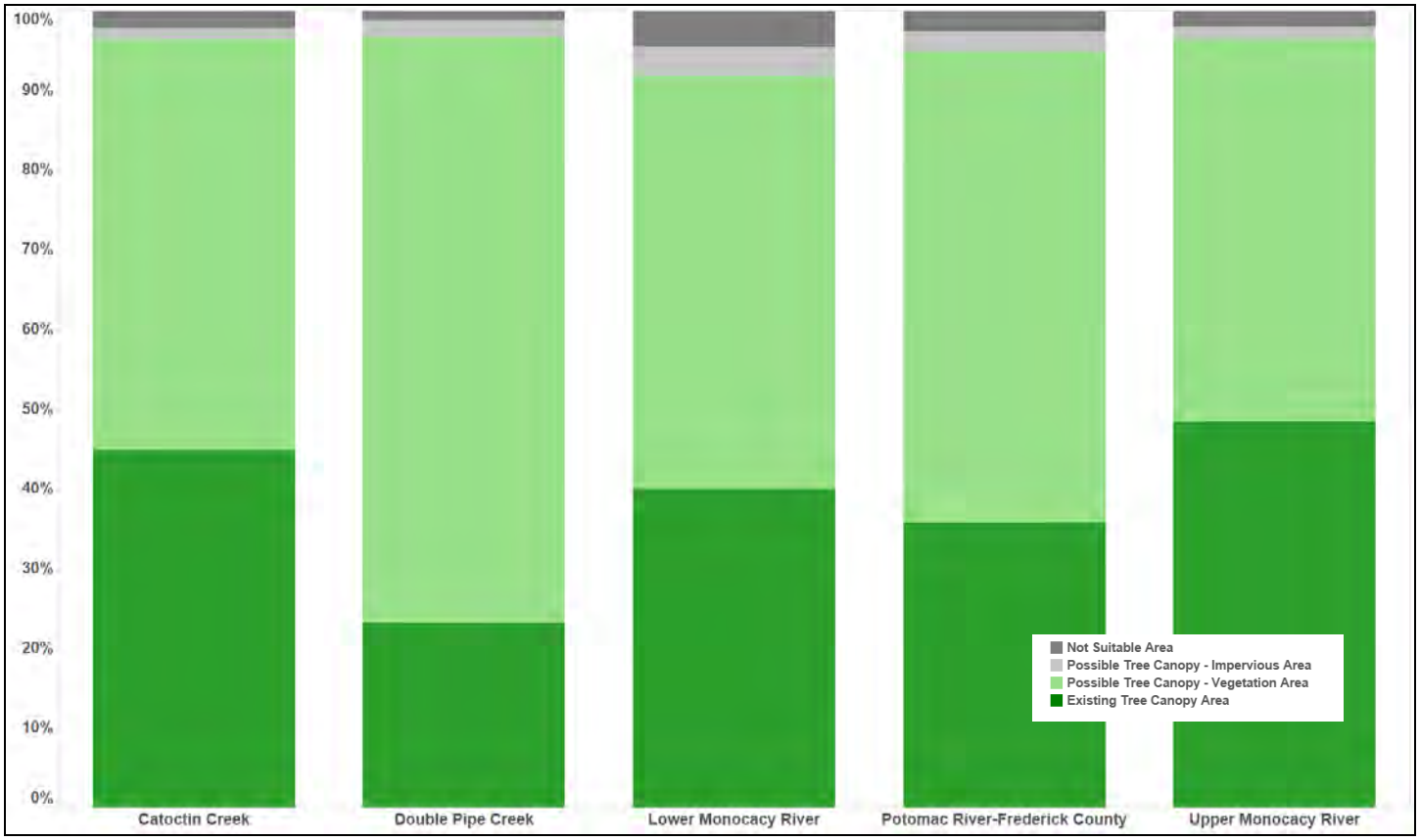

Figure 11: Tree Canopy Metrics by percentage for each watershed in Frederick County.

Zoning

An analysis was performed on the County's zoning classes. In contrast to land use, which indicates the nature and extent of actual landscape features, zoning is a planning tool that indicates where specific land uses are encouraged and/or anticipated to occur. Most of Frederick County's Existing Tree canopy occurs in the Resource Conservation and Agriculture classes (Figure 12 & 13). Agriculture encompasses the largest area of Possible Tree Canopy (169,838 acres), with Residential containing the second largest area of Possible Tree Canopy (12,591 acres). Agricultural fields and lawns account for many of the vegetated sites where expanded tree canopy is theoretically possible. The distribution emphasized the vital role that individual citizens play in maintain and expanding tree canopy; any program to maintain or increase tree canopy must include the active support and cooperation of residential landowners. While constituting a smaller portion of the study area's land area, other zoning classes also provide opportunities for expanding tree canopy, including various commercial, industrial, and Planned Development District areas. These urbanized areas are especially important for facilitating runoff retention and other tree canopy benefits.

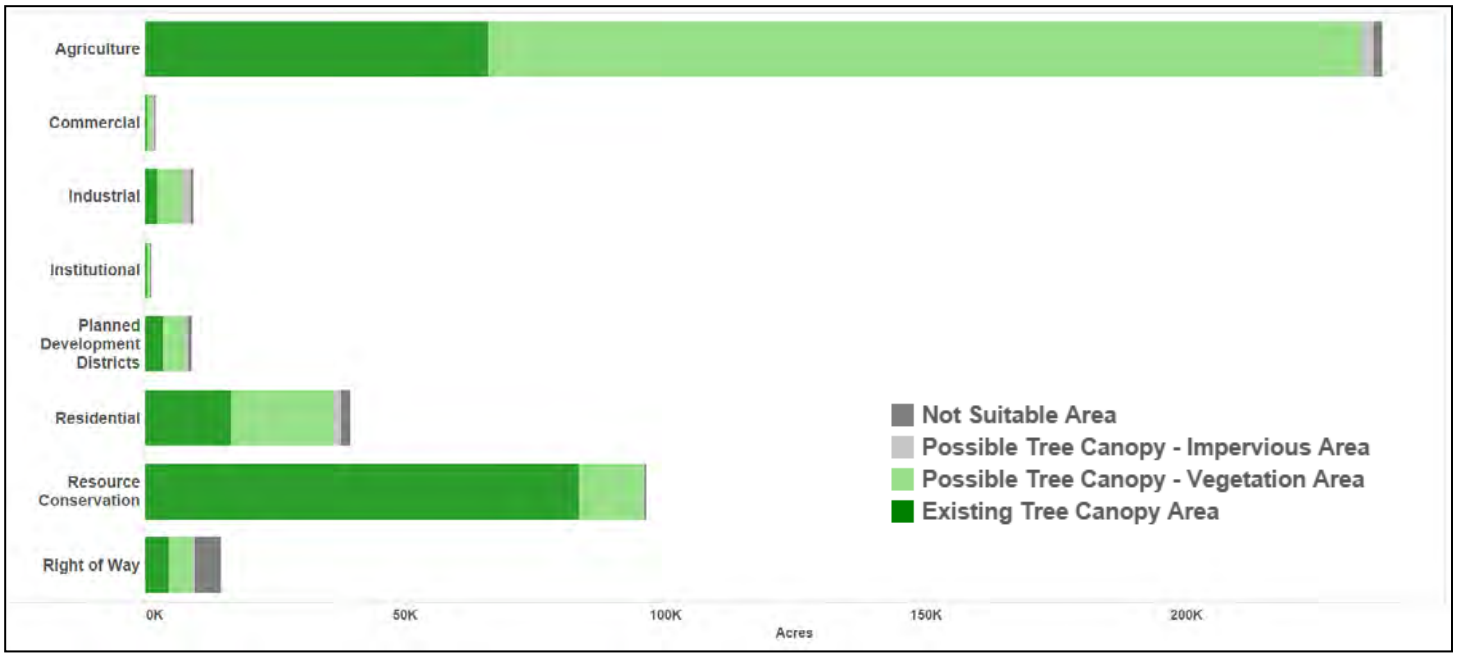

Figure 12: Total area (acres) of Possible Tree Canopy Vegetation for each zoning class in Frederick County.

Figure 13: Percent Existing Tree Canopy (left) in comparison to Percent Possible Tree Canopy (right) by zoning class.

Community Growth Areas

Tree Canopy metrics were computed using the Community Growth Areas layer for Frederick County. Fountaindale had the highest percentage of existing tree canopy with 71% (Figure 14). Fountaindale, which is located to the West of the City of Frederick, is primarily residential and contains large patches of continuous forest (Figure 15). Walkersville contains the highest percentage of Possible Tree Canopy with 75%, this high percentage can be explained by examining the land Walkersville encompasses,. It is comprised of large agricultural fields and newly developed land with very little tree canopy.

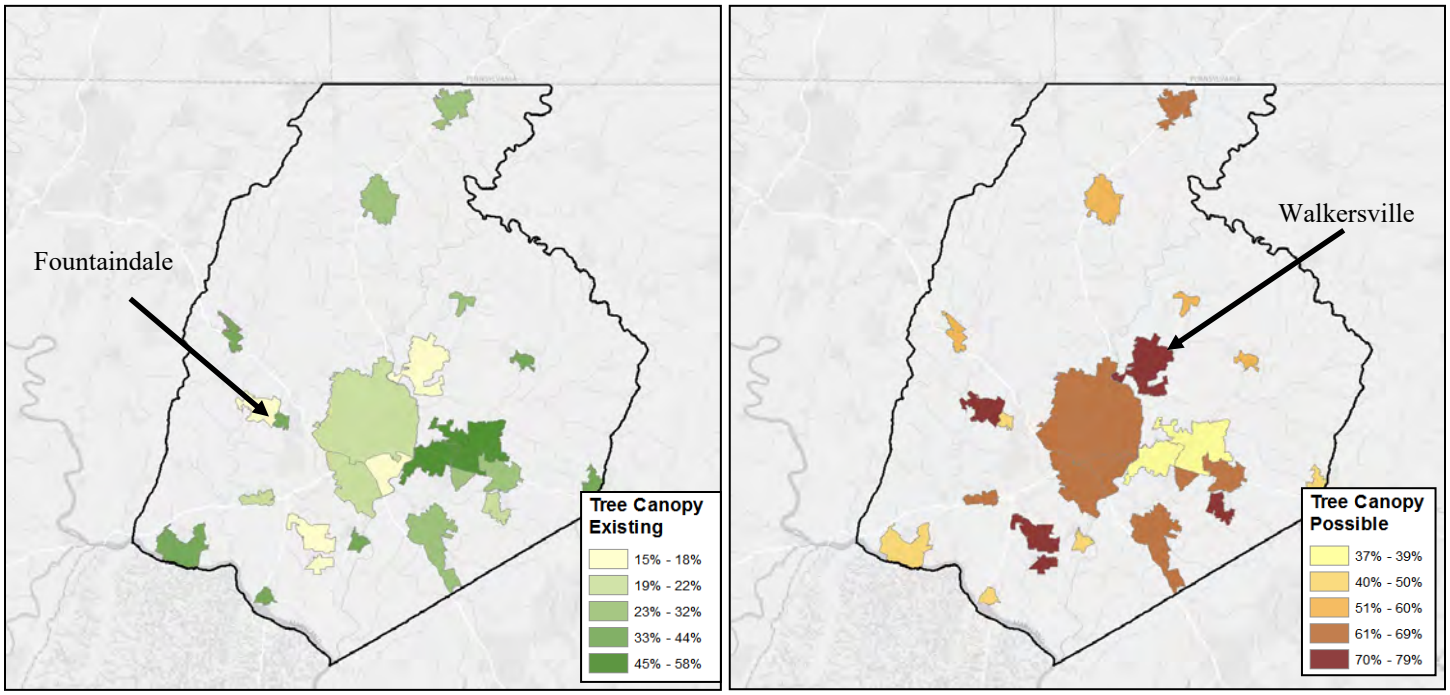

Figure 14: Percent Existing Tree Canopy by Community Growth Areas in comparison to Percent Possible Tree Canopy by watersheds.

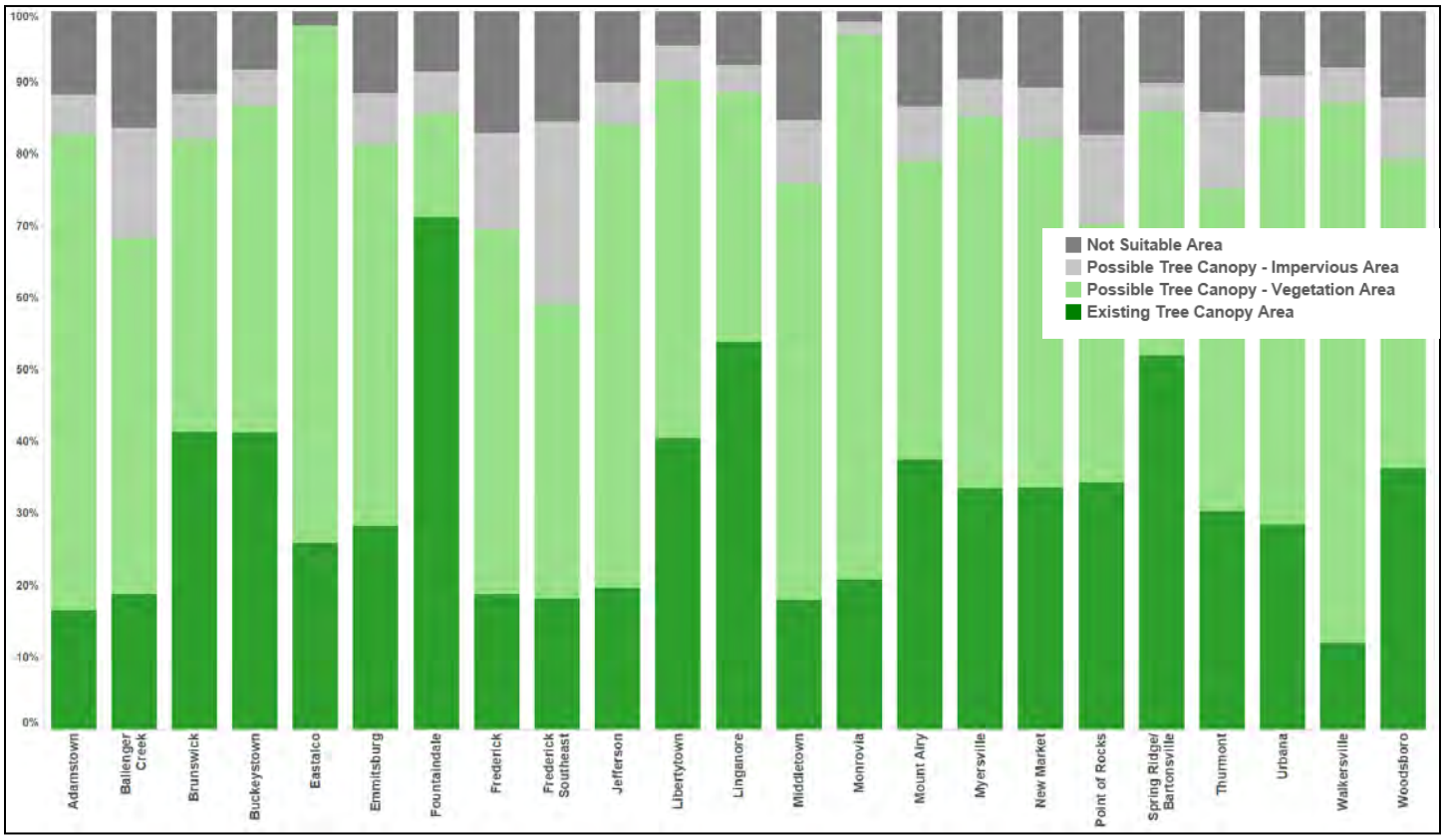

Figure 15: Tree canopy Metrics percentage by Community Growth Areas

Municipal Separate Storm Sewer System (MS4)

Metrics were also computed for the MS4 layer, which is very important to the community in regards to storm water runoff. It was found that 34% of the MS4 layer contains Existing Tree Canopy (Figure 16 &17). For Possible Tree Canopy, 53% of the MS4 layer has room for establishing more tree canopy. A large area of the MS4 layer encompasses newly developed residential neighborhoods with little tree canopy and agricultural fields.

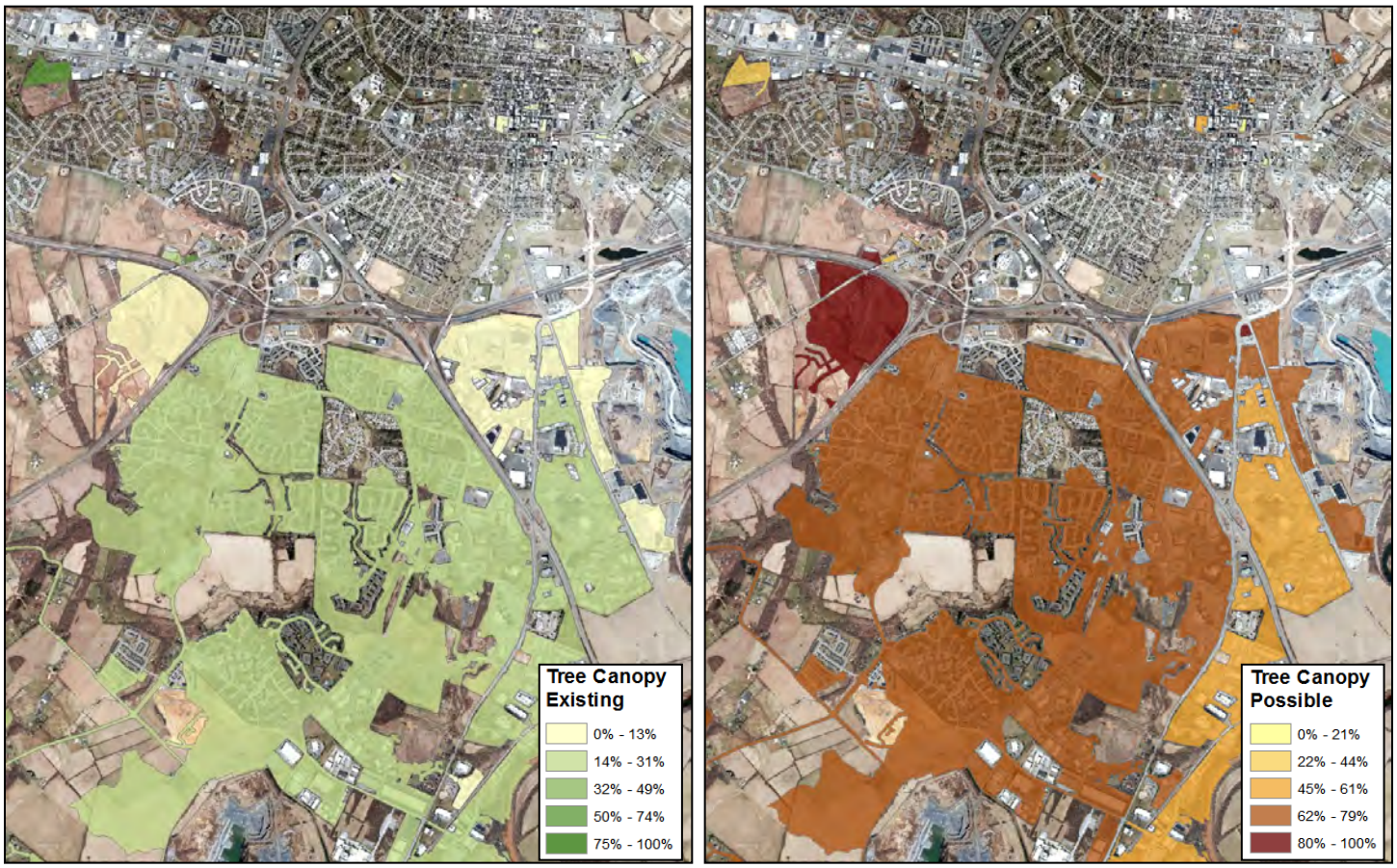

Figure 16: Percent Existing Tree Canopy (left) by MS4 boundary in comparison to Percent Possible Tree Canopy (right).

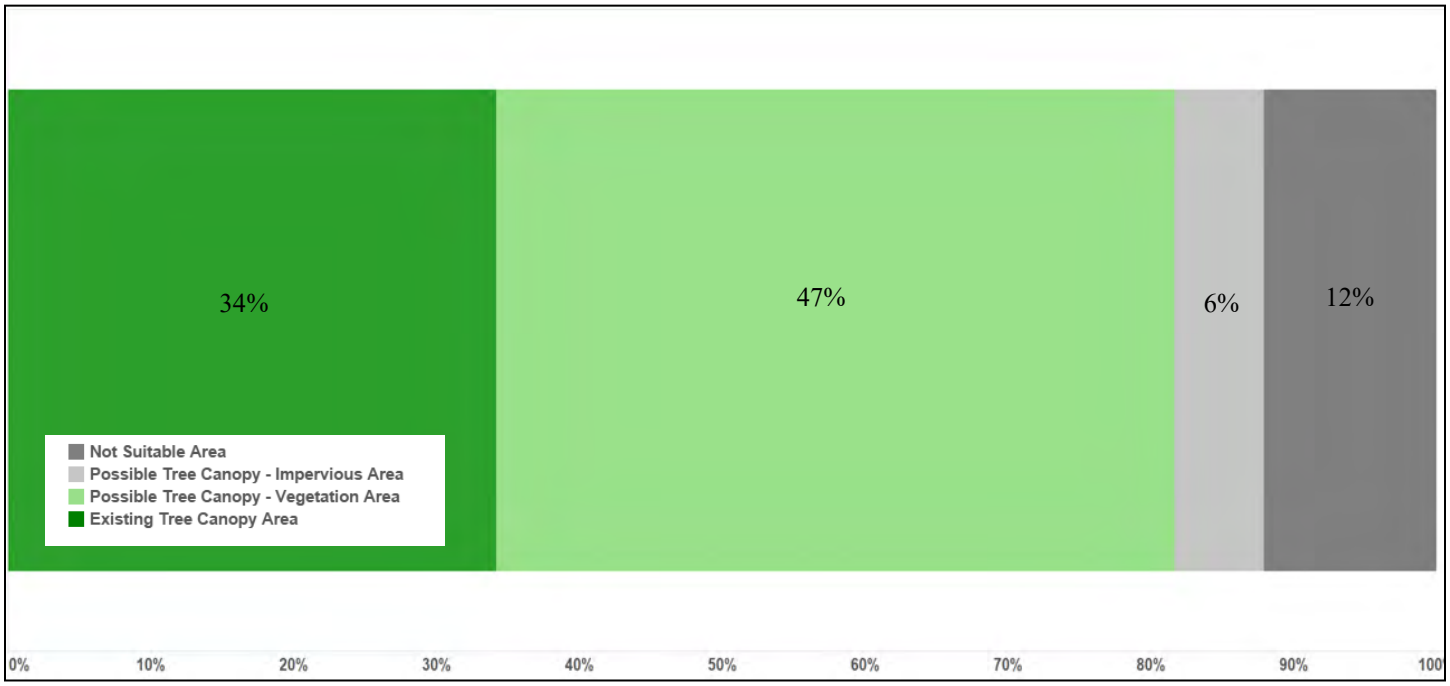

Figure 17: Tree canopy Metrics percentage by Community Growth Areas

Floodplains

Trees are important in flood plains as they to not only reduce flooding but serve as important habitat. Two stream buffer layers were used to summarized tree canopy metrics within the floodplain, the 35 foot stream buffer and the 300 foot stream buffer. The 35 foot stream buffer has 72% Existing Tree Canopy compared to the study area average of 43% (Figure 18 & 19). In comparison, the Existing Tree Canopy is much lower at 52% for the 300ft stream buffer. There is room to plant trees within both stream buffer areas, with 27% Possible Tree Canopy in the 35 foot stream buffer and 46% in the 300 foot stream buffer.

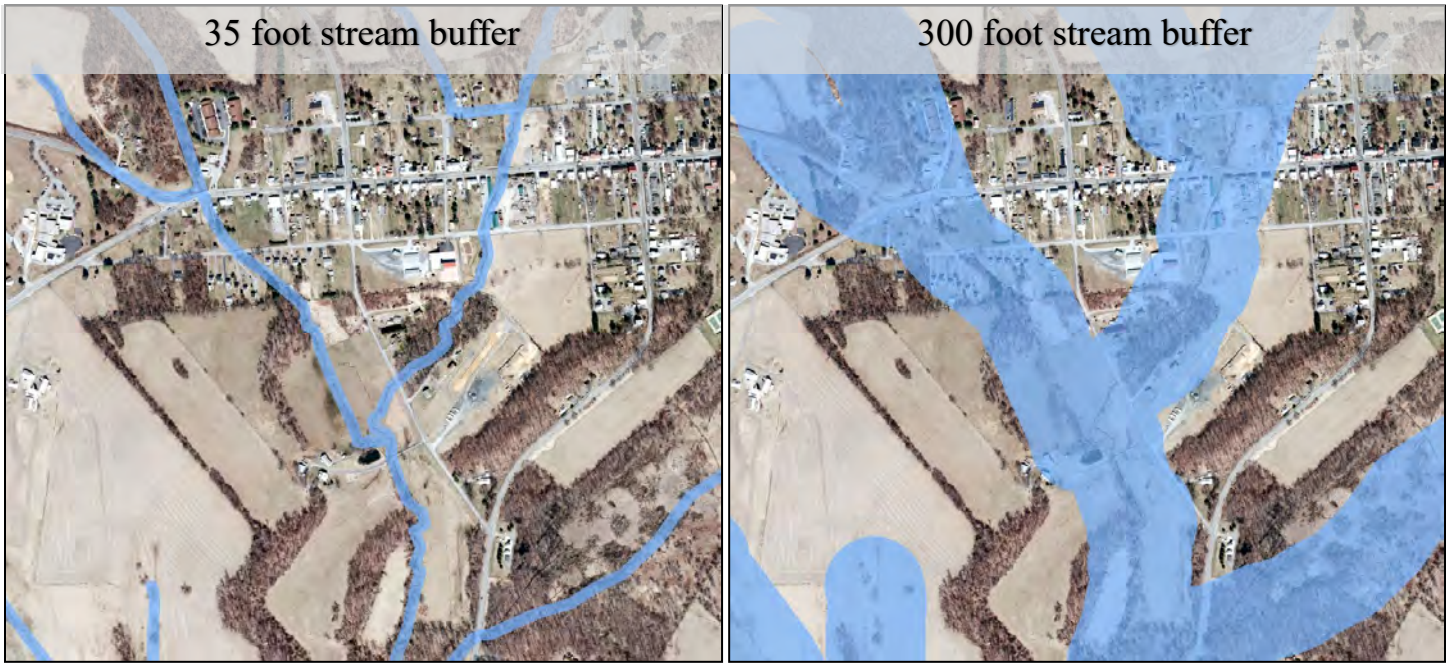

Figure 18: Stream Buffers of 35 feet (left) and 300 feet (right)

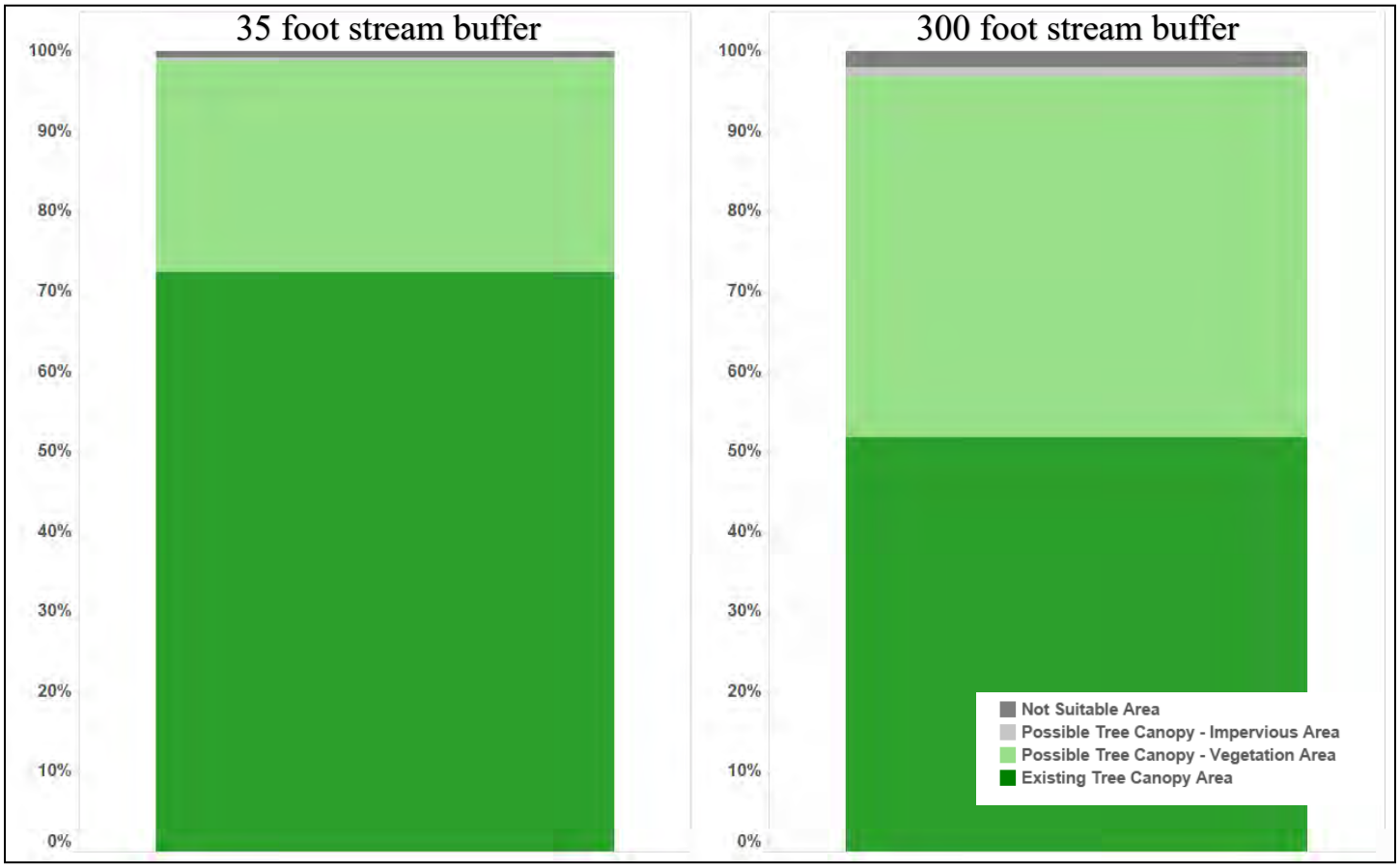

Figure 19: Tree canopy Metrics percentage by stream buffer distance.

Monocacy River Corridor

A similar analysis to the stream buffers was conducted on the Monocacy River Corridor (Figure 20). Just like floodplains, the river corridor is important to mitigate flooding risks and provide a healthy environment for habitat. It was found that 49% of the Monocacy River Corridor is Existing Tree Canopy (Figure 21). The remainder of the land within the corridor is 50% Possible Tree Canopy with only 1% being Not Suitable land for establishing Tree Canopy.

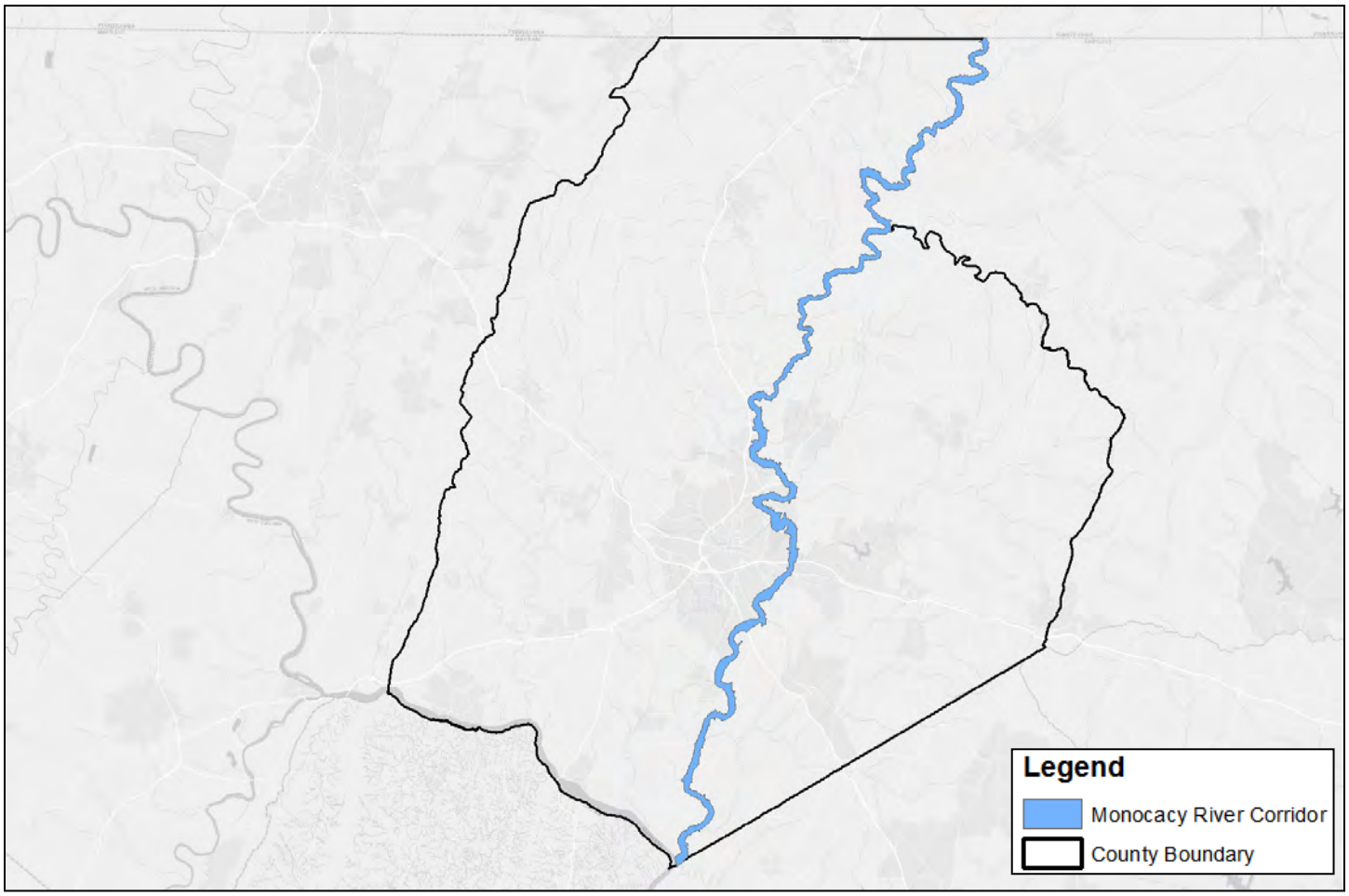

Figure 20: Map of the Moncacy River Corridor

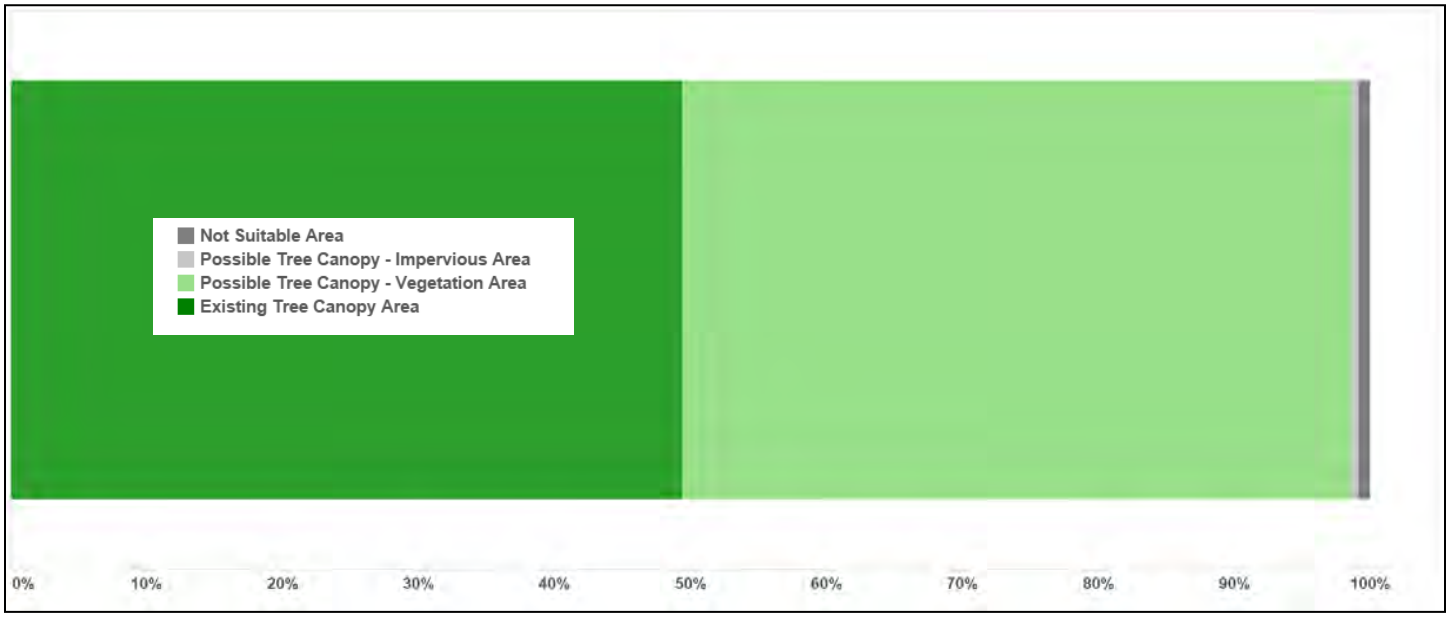

Figure 21: Tree canopy Metrics percentages of the Monocacy River Corridor.

Urbanization

Tree Canopy metrics were computed using the Esri Urbanization Gradient, which is a measure of the level of development in each Census block group. There are only two Principal Urban Centers groups, these being the most urbanized block groups encompassing a small area of City of Frederick's downtown (Figure 22). Suburban is the largest of the Urbanization categories and contains 41% Existing TC (Figure 23, Figure 24). Rural areas have the highest Existing TC percentage with 52% . The fact that the most urbanized areas have the lowest tree canopy is not surprising, but it is interesting that Metro Cities, which are urbanized suburbs have more land covered by trees than the less urbanized Urban Outskirts and Suburban Periphery areas is surprising. This is likely due to development patterns in which more established suburban developments have greater tree canopy. Large gains in tree canopy are unlikely to come in agricultural areas due to land use requirements. As agricultural areas convert to suburban development tree canopy will increase, but the corresponding impervious surfaces will cause additional issues to arise.

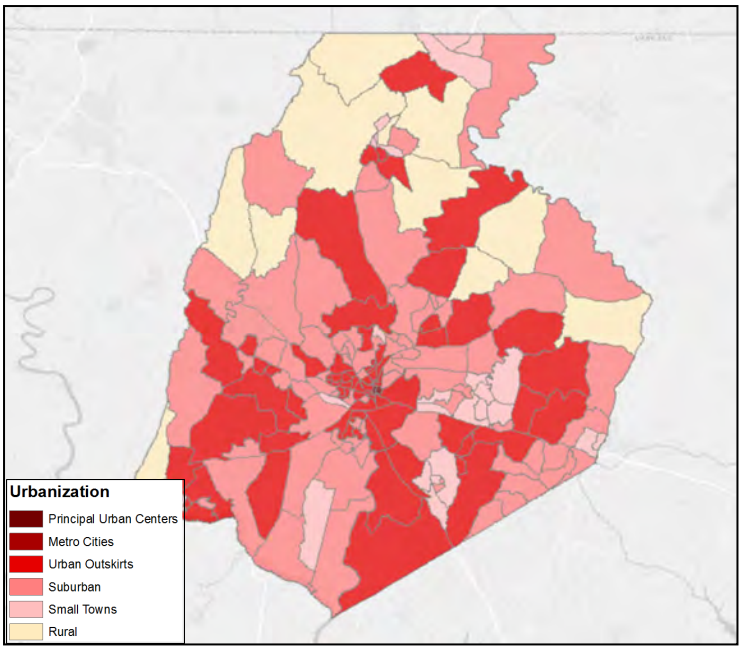

Figure 22: Urbanization Gradient displayed by Census block group.

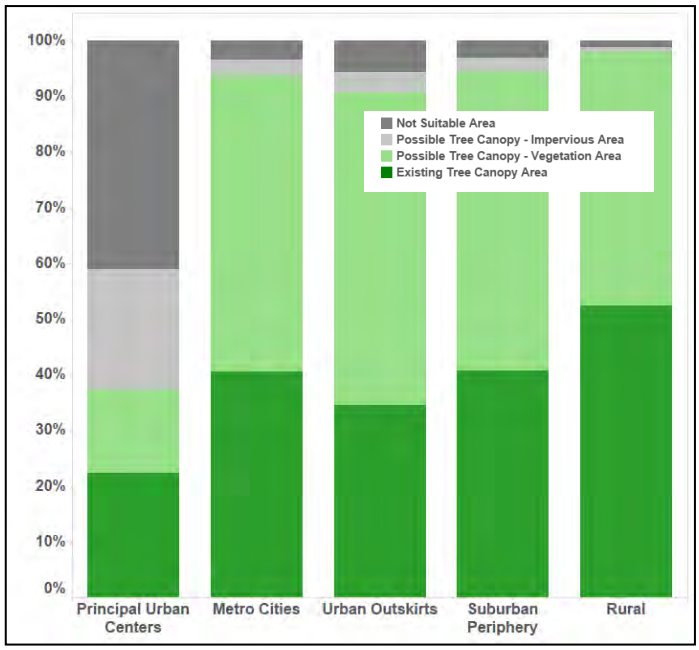

Figure 23: Tree Canopy Metrics percentages by urbanization group.

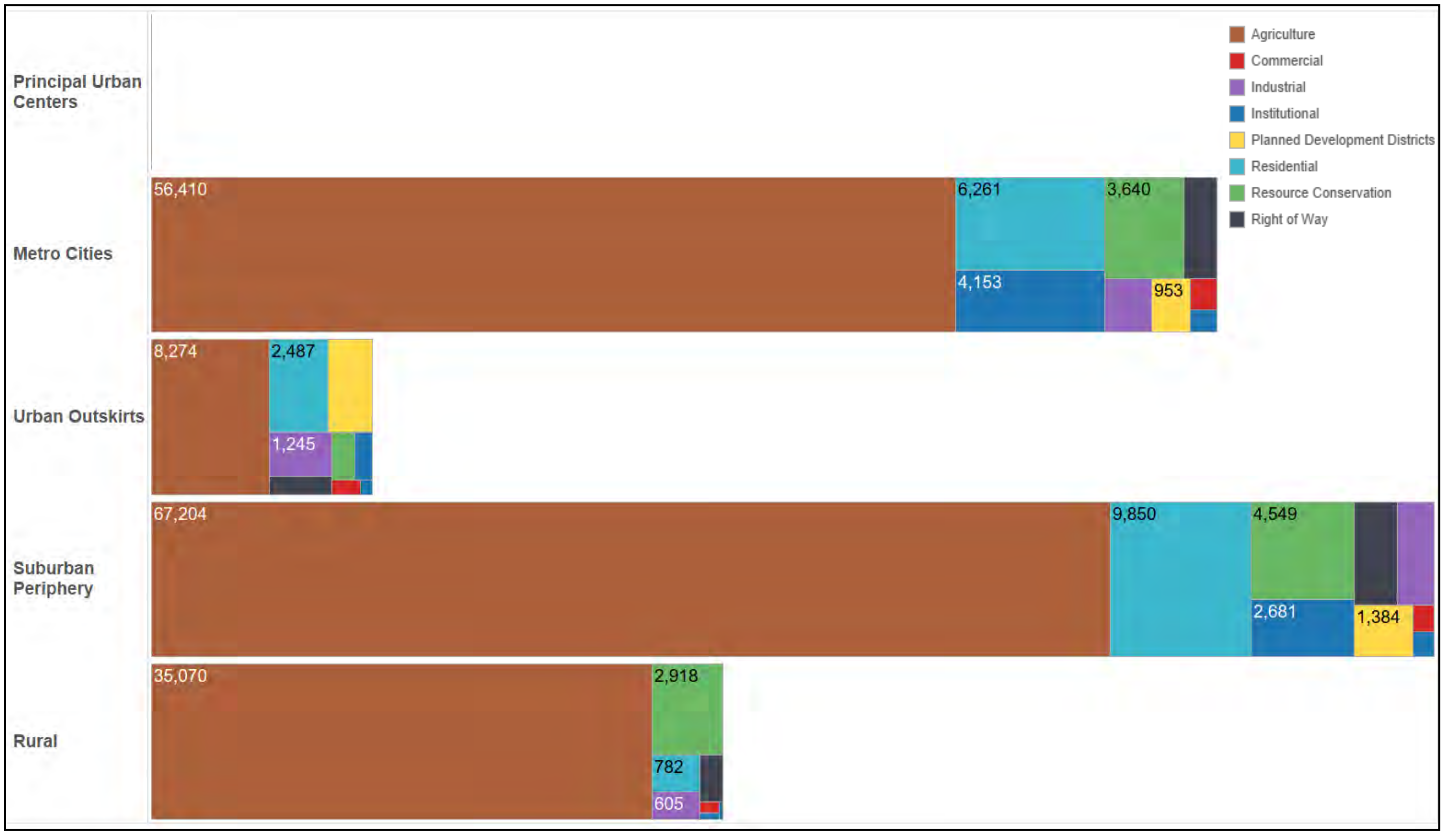

Figure 24: Total area (acres) of Possible Tree Canopy Vegetation for each Urbanization Group and summarized by zoning type.

Socio-Demographic Market Analysis

Efforts to increase tree canopy can be more successful if they are tailored to specific social groups. Esri's LifeMode groups can be used to do just that (Figure 25). LifeMode groups were designed using data from the US Census, with each group sharing an experience such as being born in the same time period, or a trait ,such as affluence. For example, Upscale Avenues are characterized as prosperous married couples who generally live in older suburbs, frequently exercise and subscribe to premium movie channels. Variances in land cover by LifeMode groups can offer insights into optimizing marketing messages that can convince residents to maintain their current tree canopy or plant new trees (Figure 26). High Society encompasses the largest area (218,707 acres) and has the second highest percent of its land covered by Existing Tree Canopy percentage(43%). High Hopes, has the highest percentage of land available for the establishment of new tree canopy. (74%).

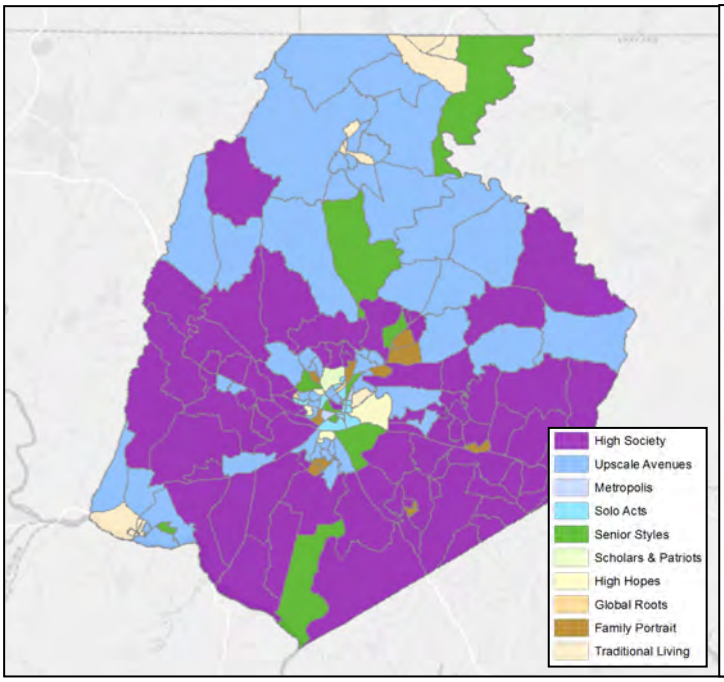

Figure 25: LifeMode groups displayed by Census Block Group.

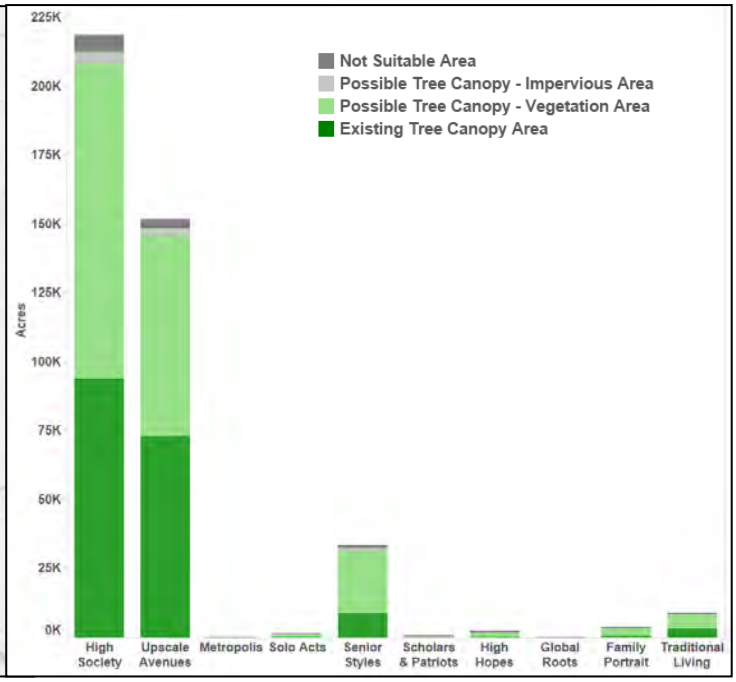

Figure 26: Tree Canopy Metrics by LifeMode group.

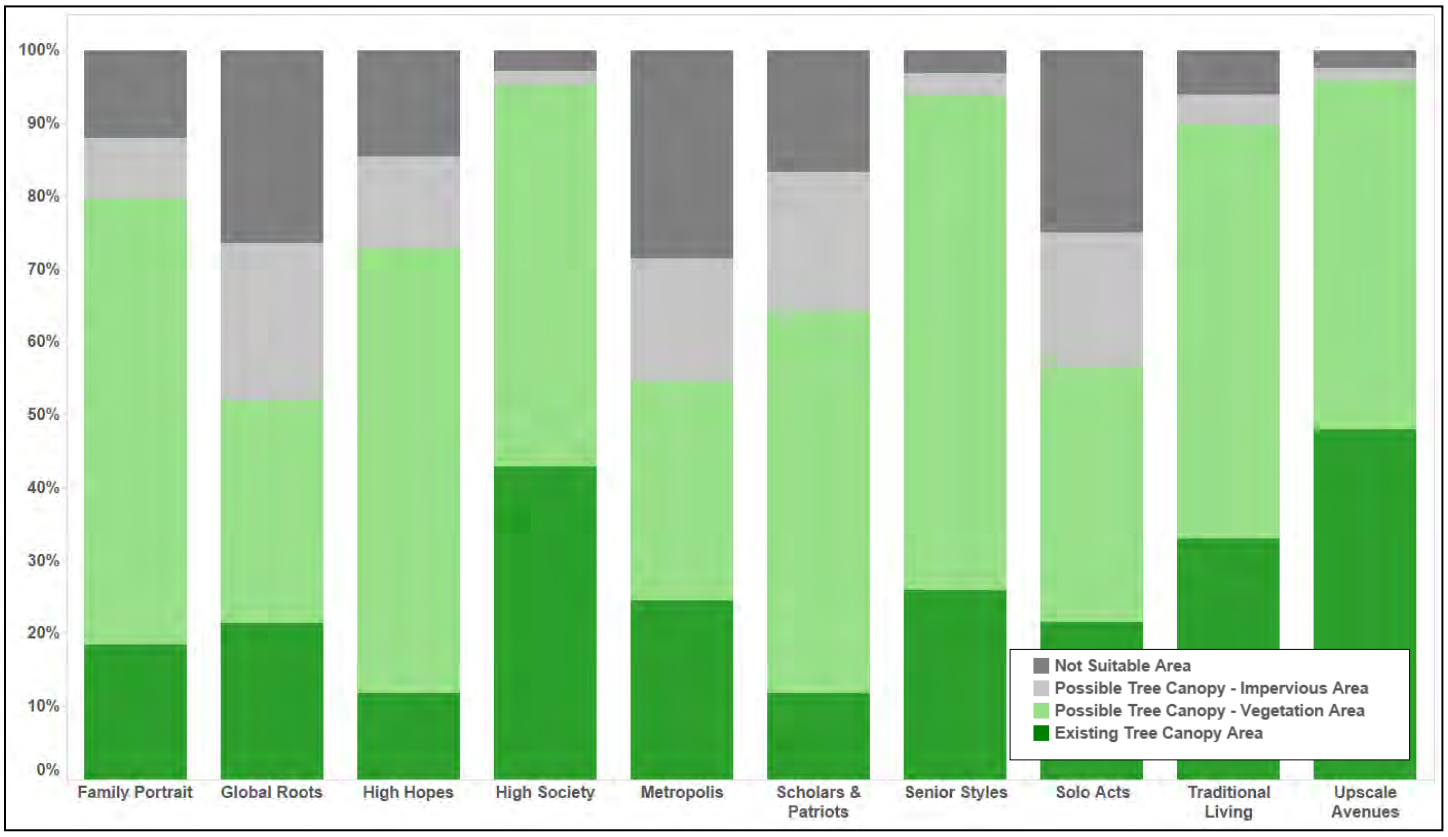

Figure 27: Acreage of Possible Tree Canopy Vegetation for each Lifestyle group in Frederick County and summarized by land use.

Tree Canopy Height

Knowing the height of the tree canopy can be of value for a variety of reasons, ranging from locating large trees for preservation to estimating the age of a forest stand. The tree canopy dataset was divided into polygons that approximate individual trees using a combination of high-resolution imagery and LiDAR. Each one of these polygons was then attributed with average and maximum height information from the 3D LiDAR data that were collected in 2012 (Figure 28). The resulting tree polygon database can be used to visualize the tree canopy in three dimensions or carry out various analyses such as estimating biomass, finding the tallest trees, or computing the number of trees over 100 feet. The vast majority of trees in the county are 70 feet or less in height (Figure 29).

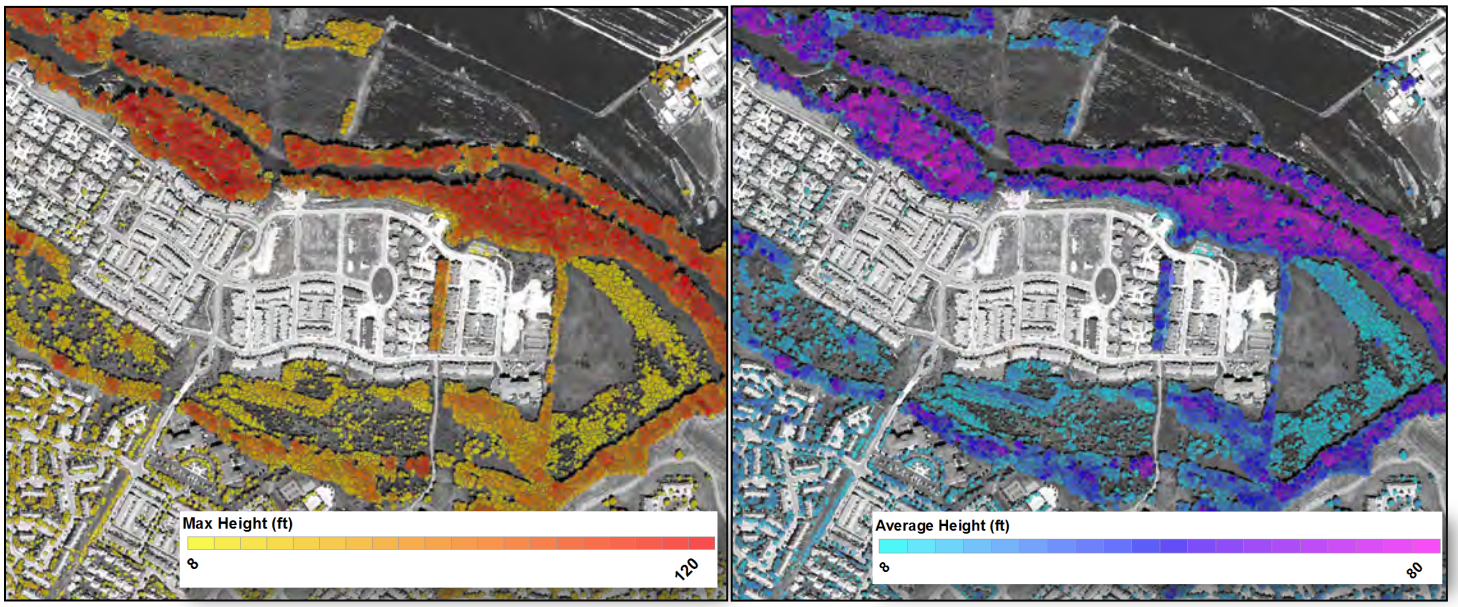

Figure 28: Maximum canopy height (left) computed for Frederick County and average canopy height (right).

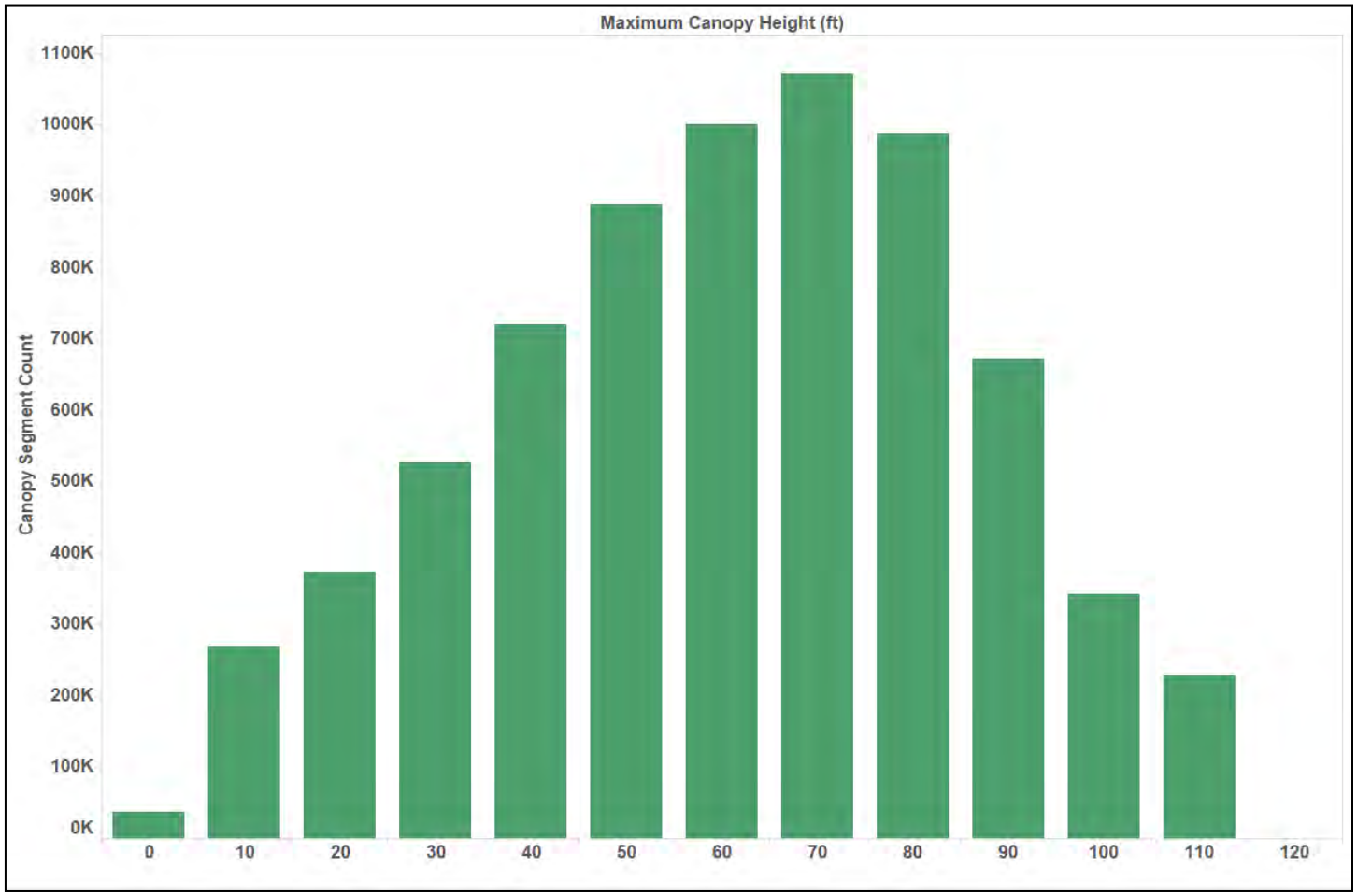

Figure 29: Count of tree canopy segments by max height class. The height of the bar reflects the number of tree canopy segments in each one of the 10ft height classes.

Forest Patch Analysis

Not all tree canopy provides the same ecosystem services. Larger forested patches are associated with improved wildlife habitat and watershed health, among other benefits. The forest patch analysis partitions the tree canopy into three classes based on their size, shape, and density: 1) small 2) medium, and 3) large. In general, small patches represent individual trees or small rows of trees areas, medium patches represent clumps of trees, often in suburban or agricultural settings, and large forest patches consist of forested stands, which are often associated with a duff layer (Figure 30). The majority of Frederick County's tree canopy is located within the large patch class (Figure 31).

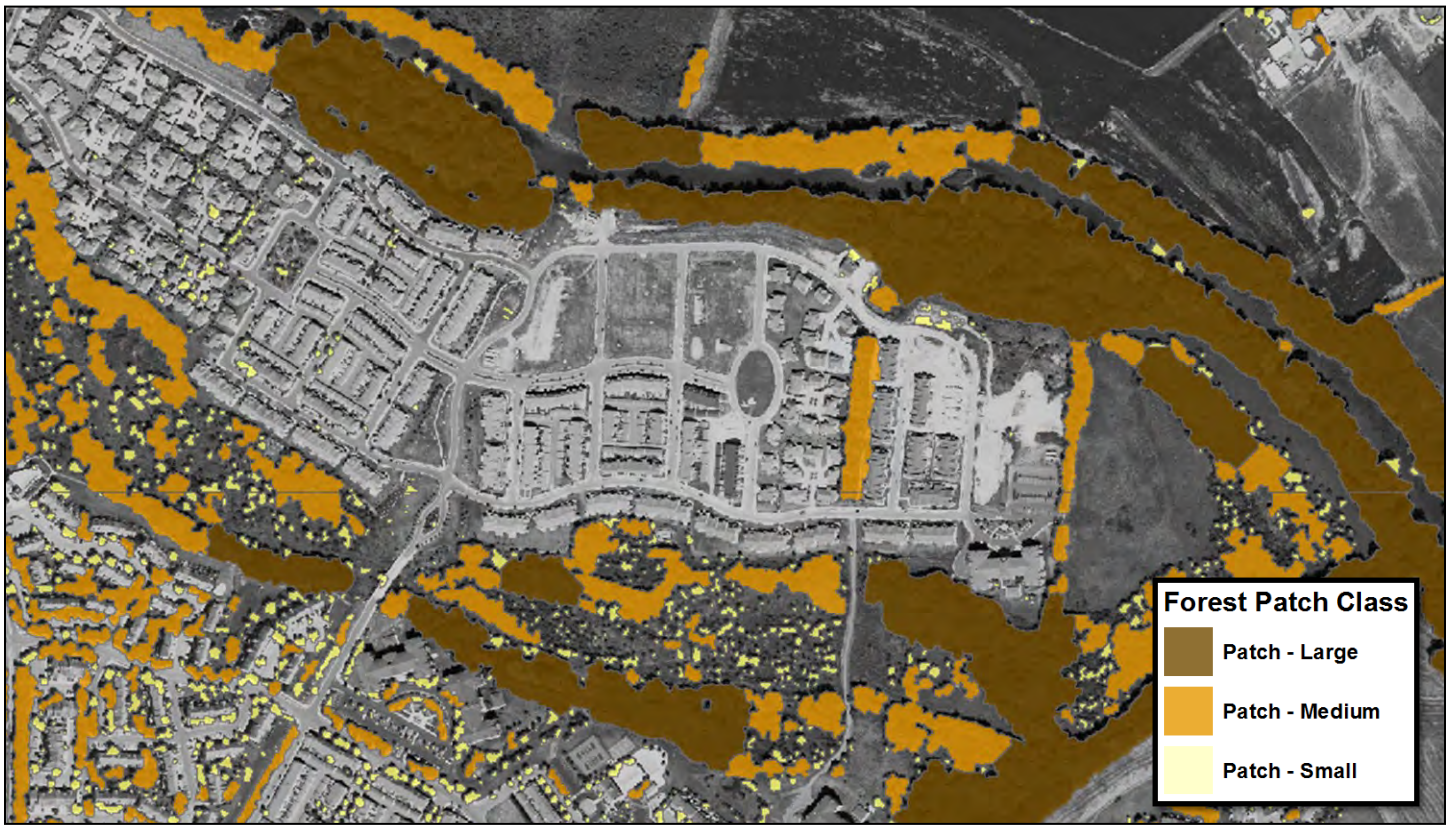

Figure 30: Forest patch classes, in which the tree canopy is subdivided into one of three categories.

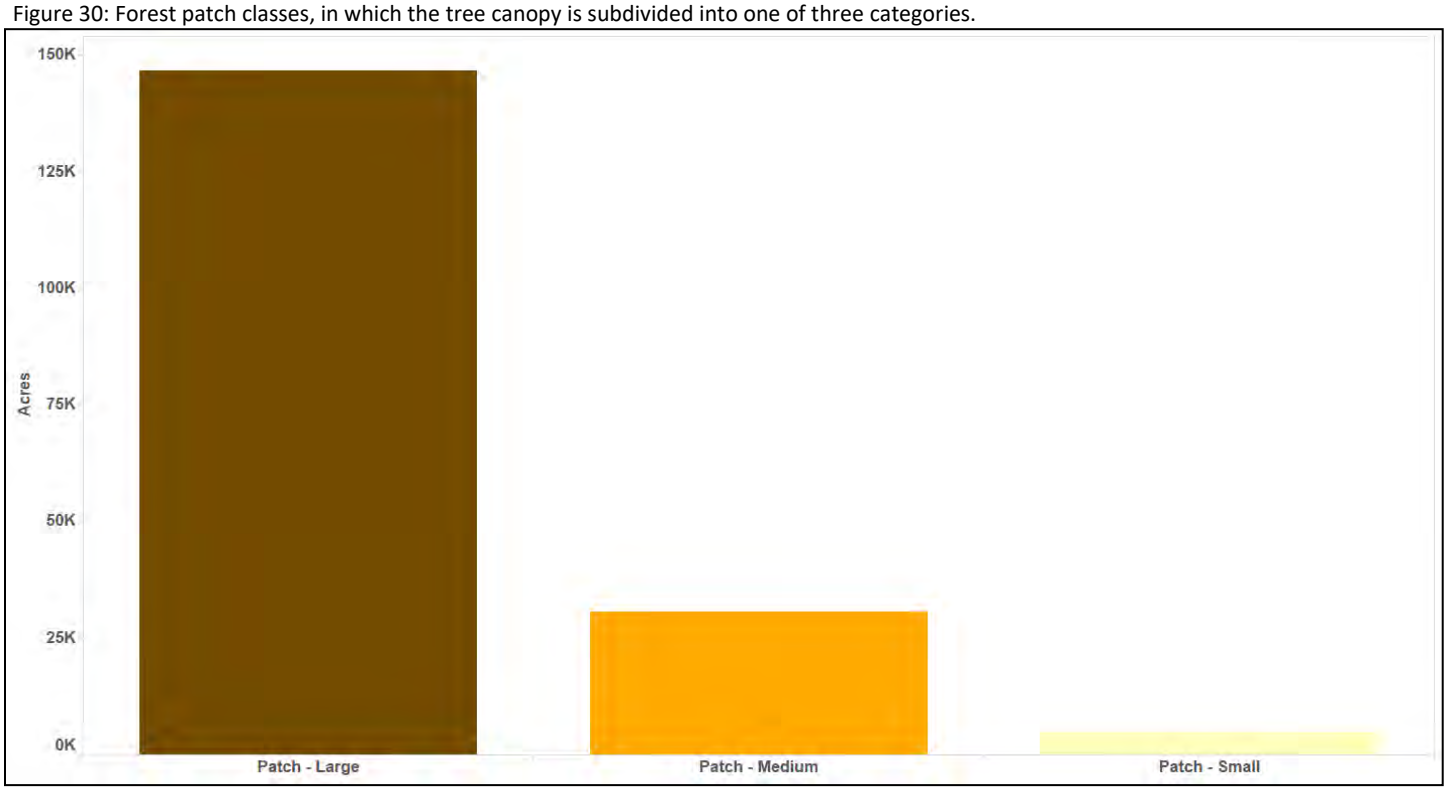

Figure 31: Number of acres each forest patch size contains.

Conclusions

- This study provides the foundation for understanding the quantity, distribution, and configuration of tree canopy within Frederick County. The true value of the study will be realized when the analyses are used to drive and specify goals to conserve existing tree canopy in addition to establishing new tree canopy.
- Tree canopy in Frederick County is a vital asset that provides ecosystem services such as stormwater runoff reduction, improved air quality, decreased carbon footprint, enhanced quality of life, savings on energy bills, and habitat for wildlife.
- The distribution of ecosystem services varies with the trees producing those services. The data from this study can be used to establish localized canopy goals and targeted plantings and conservation efforts to maximize limited resources. Selecting a specific ecosystem benefit to build an engagement campaign can increase the success in tree planting action, particularly when such an audience is already galvanized around a particular issue (e.g. engaging residents concerned about stormwater in a specific neighborhood in tree planting efforts).
- Tree canopy is correlated with lower surface temperatures. Increasing canopy cover in Frederick County will help reduce summer temperatures, thereby reducing energy use, improving health, and saving businesses and homeowners money by lowering energy bills. Targeting tree planting in sites with high surface temperatures would maximize these benefits.
- Frederick County's residents are paramount to preserving existing tree canopy and increasing canopy cover in the future. There is currently more tree canopy on residential land than any other land use type and more room to plant trees on residential property than on any other land use type.
- Preserving tree canopy is just as important as new planting initiatives. Efforts to maintain larger forested areas will facilitate natural regeneration in addition to insuring the preservation of the unique ecosystem services provided by these areas.
- When planning tree planting projects the socio-demographic market analysis data can provide key insights to better inform such efforts. The native language, culture, willingness to volunteer, and other factors are key considerations for any outreach activities.
- Future tree canopy assessments should be planned to assess changes to the tree canopy in Frederick County. Such assessments can provide crucial information on how effective tree planting and preservation efforts are, in addition to understanding how other factors (e.g. development) may be impacting tree canopy. Future assessments will only be made possible if continued investments in high-resolution remotely imagery and LiDAR are made. It is suggested that the future assessments are conducted every 5 to 10 years.

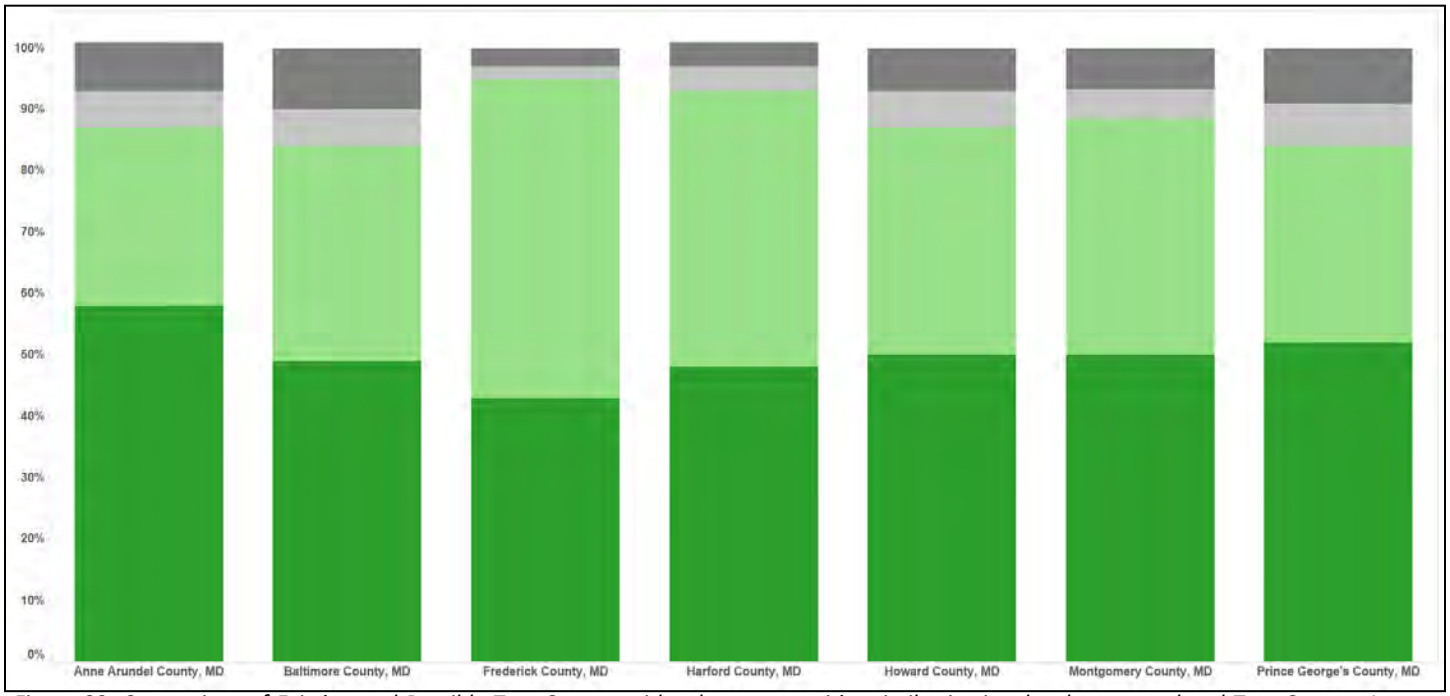

Figure 32: Comparison of Existing and Possible Tree Canopy with other communities similar in size that have completed Tree Canopy Assessments.

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/**

Tree Canopy Assessment Team: Amanda Adams, Noah Ahles, Jason Black, Ernie Buford, James Clark, Maurie Clark, Zoe Davis, Tayler Engel, Emma Estabrook, Walter John Gabrysiak, Samuel Grubinger, Max Hoover, Sarah Leidinger, Sean MacFaden, Jarlath O'Neil-Dunne, Kyle Onofreo, Anna Royar, Matthias Sirch, Mike Sisti, Nathanial Ward, Gavin Zeitz,.

University of Vermont Spatial Analysis Lab