# A Report on Harford 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 Harford Co. Have?

An analysis of Harford County based on land cover data derived from high-resolution aerial imagery and LiDAR (Figure 1) found that 115,598 acres of the area were covered by tree canopy (termed Existing TC), representing 48% of all land in the county (excluding APG, which was not included in the study area). An additional 48% (116,386 acres) of the county's land area could theoretically be modified (termed Possible TC) to accommodate tree canopy (Figure 2). In the Possible TC category, 44% (107,640 acres) of total land area was classified as Vegetated Possible TC and another 4% as Impervious Possible TC (8,746 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.

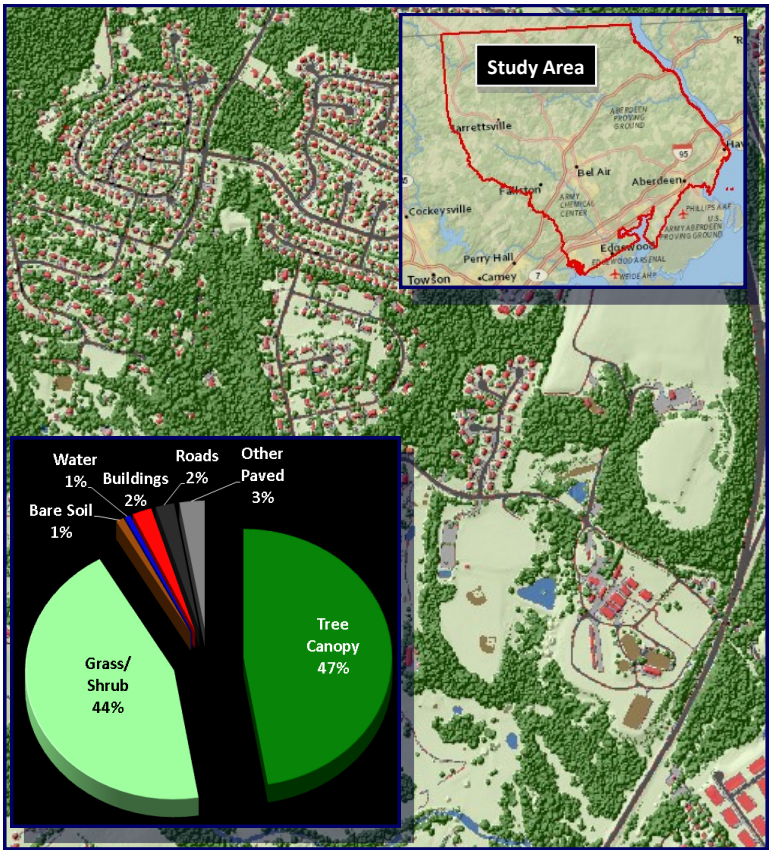



*Figure 1: Study area and example of the land cover derived from high-resolution imagery for this project.*

## Project Background

The goal of the project was to apply the USDA Forest Service's Tree Canopy Assessment protocols to Harford County. The analysis was conducted using year 2011 data. The study area boundary was determined based on the availability of LiDAR, a key input dataset. This project was made possible through funding from Harford County and a grant from NASA's Carbon Monitoring System to the University of Maryland (PI: Ralph Dubayah). 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 Harford County, SavATree, the University of Maryland, and the USDA Forest Service's Northern Research Station.

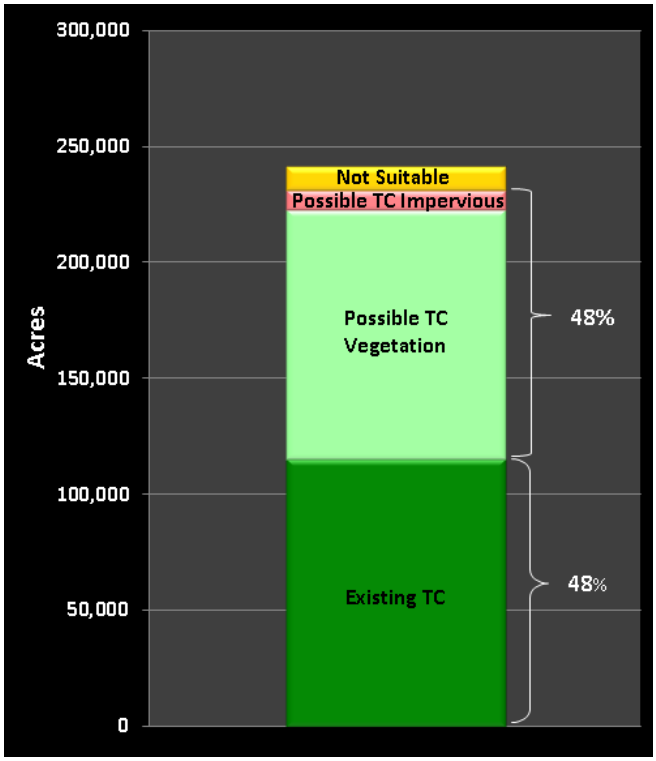



*Figure 2: TC metrics for Harford County based on % of land area covered by each TC type.*

## 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 Harford's Trees

A prior estimate of tree canopy for the entirety of the Harford County study area (including water) from the 2001 National Land Cover Database (NLCD 2001) was 53%, a bit higher than the 47% obtained in this study. The difference may reflect actual forest loss but is more likely due to the relatively coarse, 30-meter resolution of NLCD (Figure 3a). Using high-resolution aerial imagery acquired in the summer of 2011 (Figure 3b), in combination with advanced automated processing techniques, land cover for the Harford County was mapped with such detail that trees as short as 8ft tall were detected (Figure 3c).

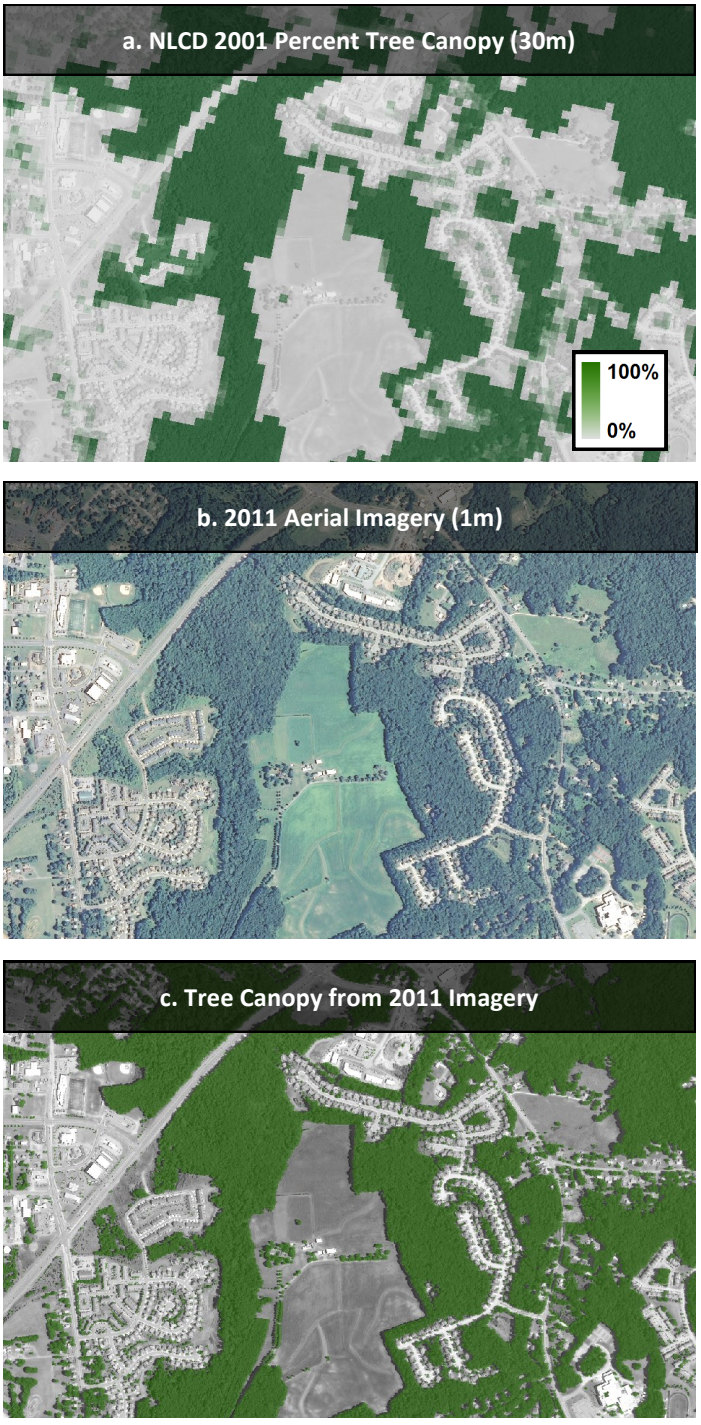



*Figure 3: Comparison of NLCD 2001 (a) to high-resolution imagery (b) and tree canopy (c) derived for this study.*

## Parcel Summary

After land cover was mapped for the study area, Tree Canopy (TC) metrics were summarized for each property in the County'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).

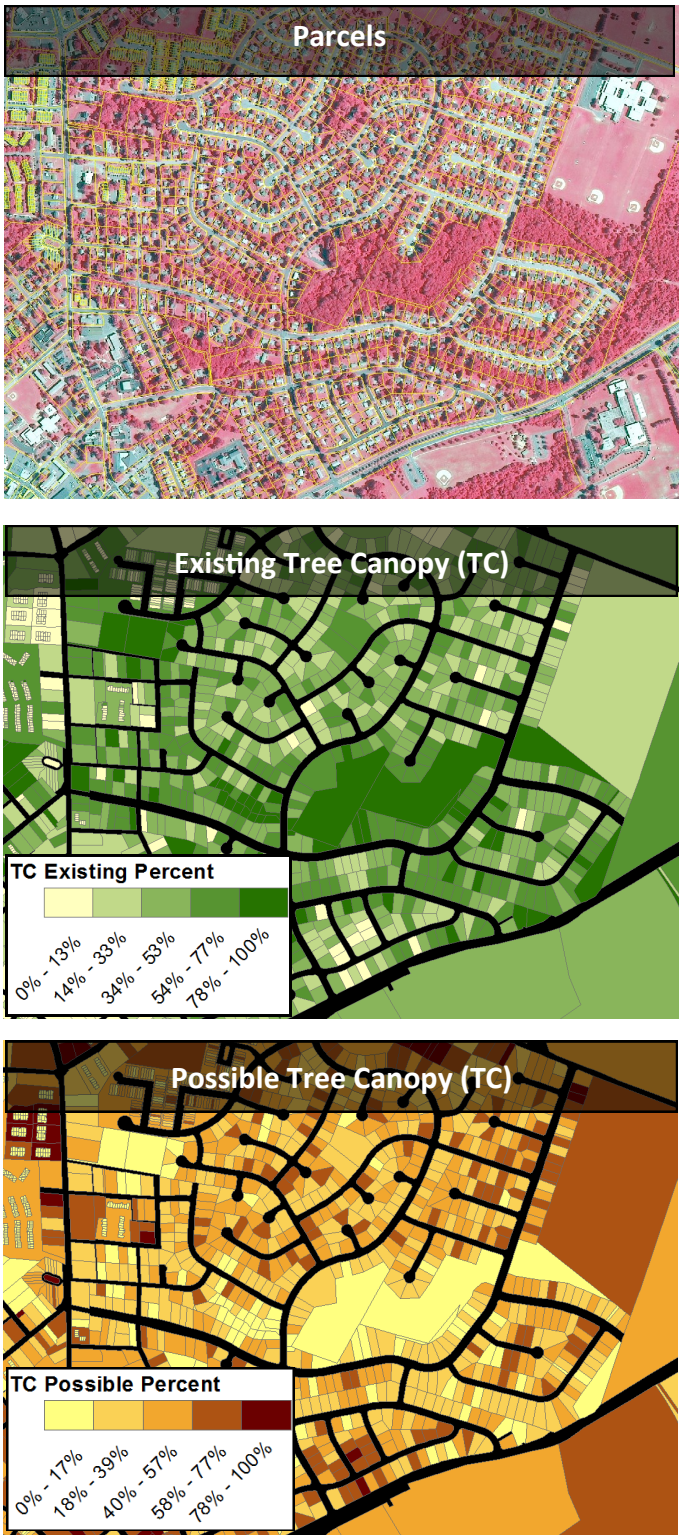



*Figure 4: Parcel-based TC metrics. TC metrics are generated at the parcel level, allowing each property to be evaluated according to its Existing TC and Possible TC.*

# Land Use

An analysis of Existing and Possible TC by land use category was conducted using the County's parcel data, which can be categorized by Land Use Class (Figure 5, Table 1). For each land use category, tree canopy metrics were calculated as a percentage of all land in the Harford County study area (% Land), as a percentage of land area in the specified land use (% Category), and as a percentage of total area in the tree canopy type (% TC Type). The majority of Harford County is residential or agricultural land, and thus it comes as no surprise that these two categories have not only the majority of the area's tree canopy, but also the most room to plant new trees. The Commercial and Exempt categories also present opportunities for tree planting. Of the two predominant land use categories, 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 31,228 acres (28%) of land classified as Possible Tree Canopy. Farm land also has a substantial amount of land in the Possible Tree Canopy Vegetation class, but only 13% of this plantable land lies within a 100 foot buffer zone around streams and other waterways where tree planting would be highly desirable. Outside of these riparian zones, pressure to maintain (or to develop) productive agricultural land might be a challenge for large scale tree planting efforts.

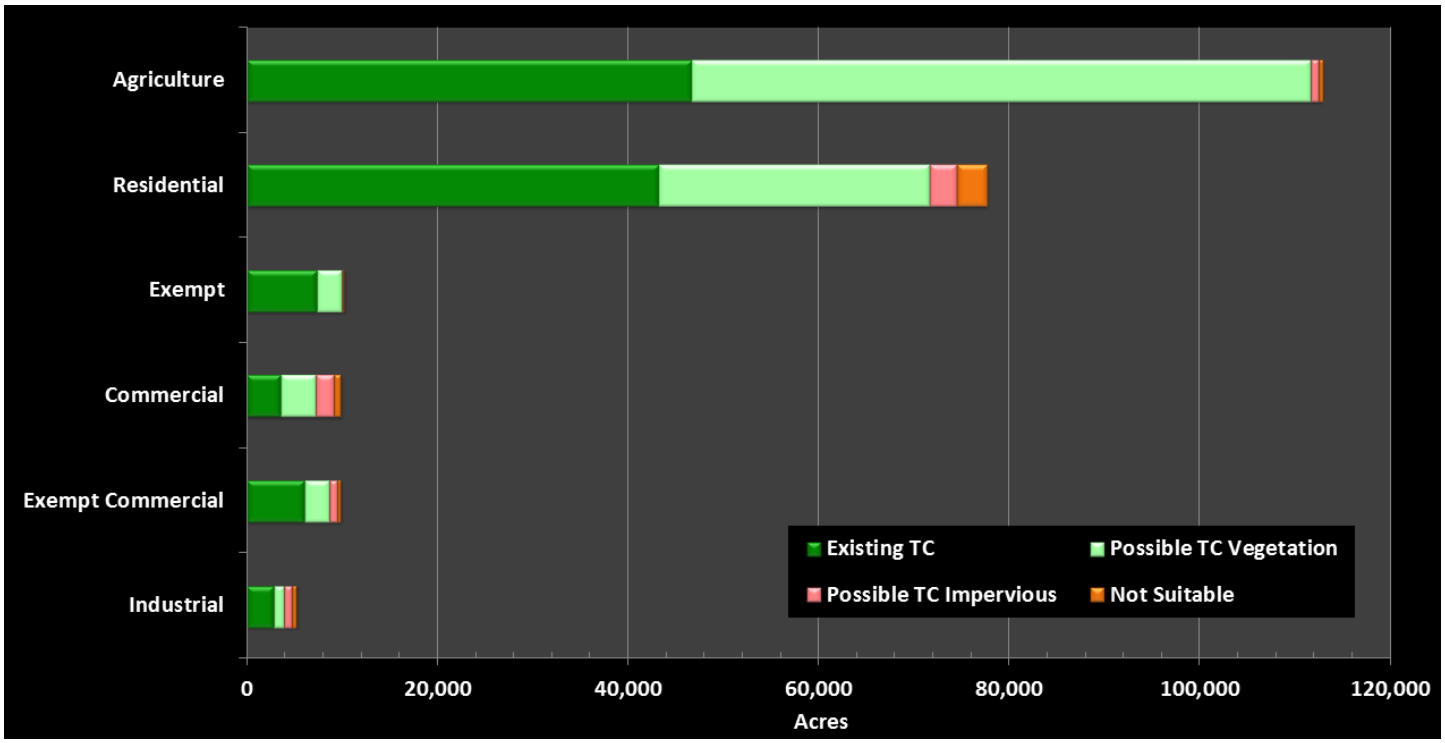



*Figure 5: Tree Canopy (TC) metrics summarized for each zoning district.*

| Land Use | Existing TC | | | Possible TC Vegetation | | | Possible TC Impervious | | |
|---|---|---|---|---|---|---|---|---|---|
| | % Land | % Category | % TC Type | % Land | % Category | % TC Type | % Land | % Category | % TC Type |
| Agriculture | 20% | 41% | 42% | 29% | 58% | 59% | 28% | 58% | 62% |
| Commercial | 2% | 36% | 3% | 2% | 57% | 5% | 2% | 38% | 4% |
| Commercial Condominium | 0% | 64% | 0% | 0% | 21% | 0% | 0% | 10% | 0% |
| Commercial Residential | 0% | 43% | 0% | 0% | 55% | 0% | 0% | 49% | 0% |
| Exempt | 3% | 72% | 7% | 1% | 27% | 2% | 1% | 25% | 2% |
| Exempt Commercial | 3% | 61% | 5% | 2% | 36% | 3% | 1% | 27% | 3% |
| Industrial | 1% | 53% | 3% | 1% | 38% | 2% | 0% | 21% | 1% |
| Apartments | 0% | 35% | 0% | 0% | 49% | 0% | 0% | 28% | 0% |
| Residential Commercial | 0% | 32% | 0% | 0% | 62% | 0% | 0% | 46% | 0% |
| Residential Condominium | 0% | 15% | 0% | 0% | 40% | 0% | 0% | 31% | 0% |

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

The % Land Area value of 3% indicates that 3% of Harford County's land area is covered by tree canopy in the Exempt Commercial land use class.

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

The % Land value of 61% indicates that 61% of land in the Exempt Commercial land use class is covered by tree canopy.

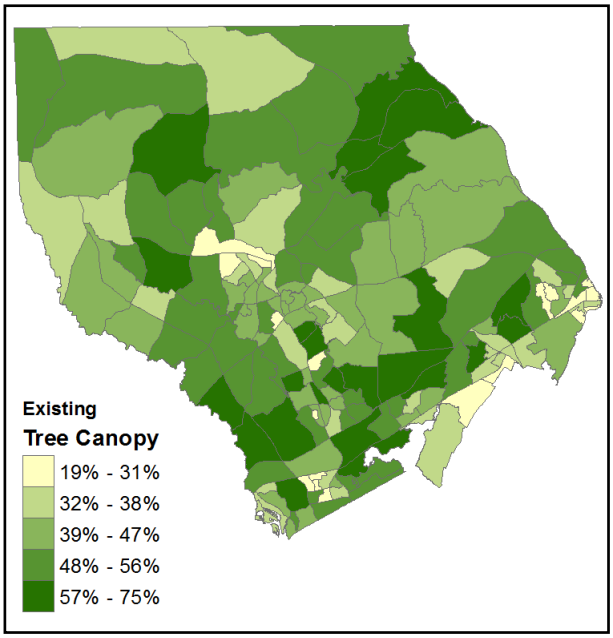
$$\%\ \text{TC Type} = \frac{\text{Area of TC type for land use category}}{\text{Area of all TC type}}$$

The % TC Type value of 5% indicates that 5% of all tree canopy is in land classified in the Exempt Commercial land use class.

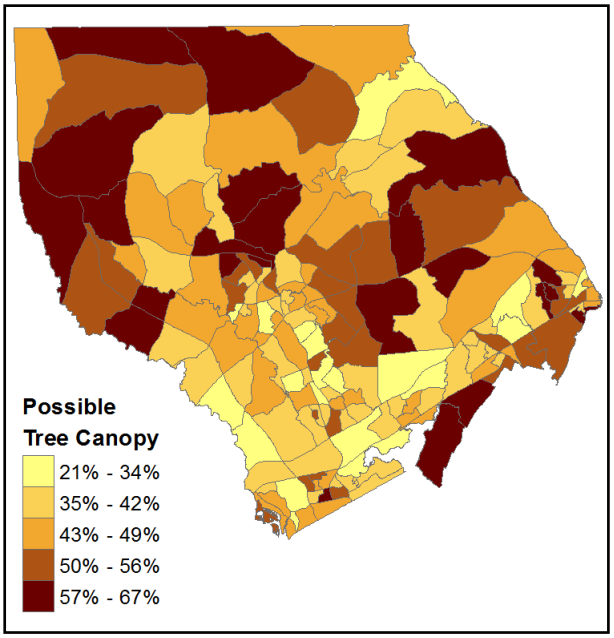
*Table 1: Tree Canopy (TC) metrics were summarized by land use. For each land use category, TC metrics were computed as a percentage of all land in the county(% Land), as a percentage of land in the specified category (% Category), and as a percentage of the area for TC type (% TC Type).*

## 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 Harford County 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). These maps can be used to help direct resources for tree planting. Many of the block groups in the lowest median income bracket have a relatively low amount of tree canopy — a relationship that does not appear to be as strong in Harford County as in some other localities that have had similar tree canopy assessments (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).




(a)

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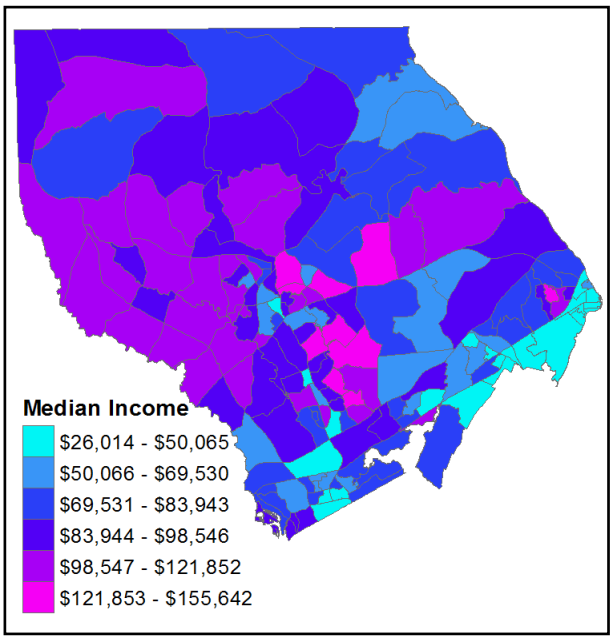


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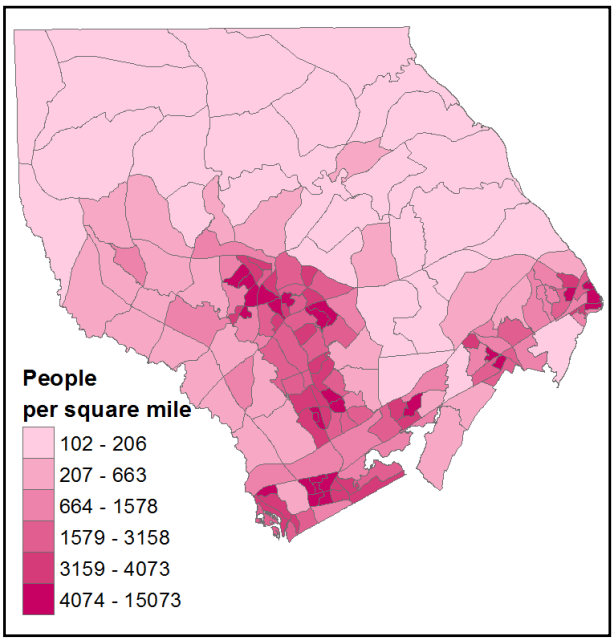



(d)

*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 Harford County.*

## Socio-Demographic Analysis

The Priority Planting Index (PPI) 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 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.

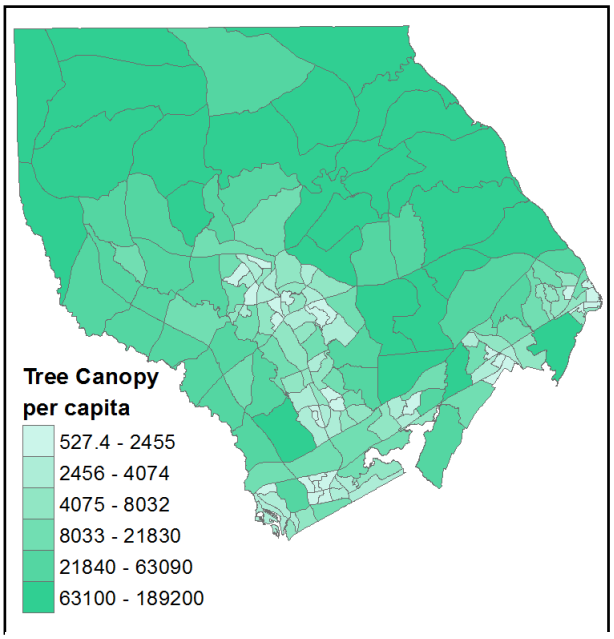



*Figure 7: Tree canopy per capita by census block group in feet squared.*

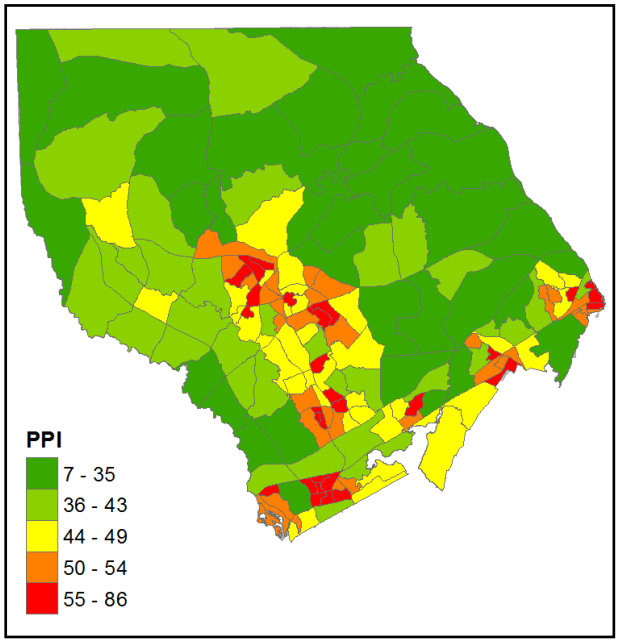



*Figure 8: Priority Planting Index by census block group.*

## 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 study area we used a Landsat satellite image acquired on June 21, 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.

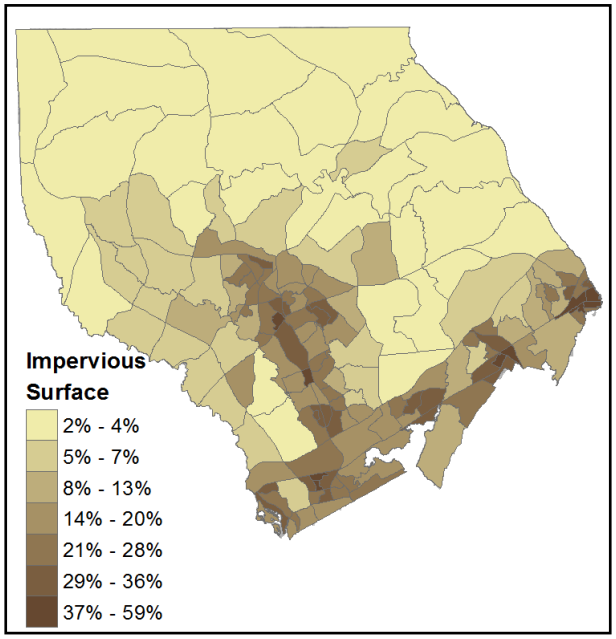



*Figure 9: Amount of impervious surface by census block group.*

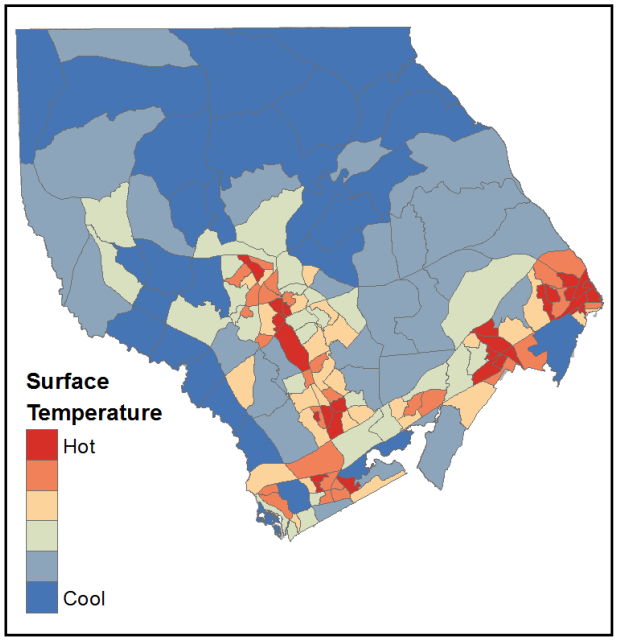



*Figure 10: Surface temperature by census block group.*

## Development Envelope & Green Infrastructure

Existing and Possible Tree Canopy were also summarized by components of Green Infrastructure (hubs and corridors) and for the Harford County development envelope. Green Infrastructure is indeed green with 99% of land in this designation classified as vegetation (figure 11). Existing tree canopy accounts for 85% of this vegetated land in the "hub" component and 67% of "corridors". Efforts to enhance connectivity could possibly pay dividends by focusing on planting opportunities in the Vegetated Possible Tree Canopy category, which accounts for 8,731 acres (31%) of "corridor" land. Harford County's development envelope, at 46% Existing Tree Canopy, has nearly the same percentage as the land outside of the development envelope, which matches the county-wide figure of 48% (Figure 12). Ample opportunities exist to increase tree canopy on already vegetated lands both in and outside of the development envelope. Impervious Possible Tree Canopy accounts for 5,416 (10%) of land in the development envelope, and this category represents the most effective areas to target for tree plantings that would be most effective in mitigating such urban issues as stormwater runoff and heat loading during summer months.

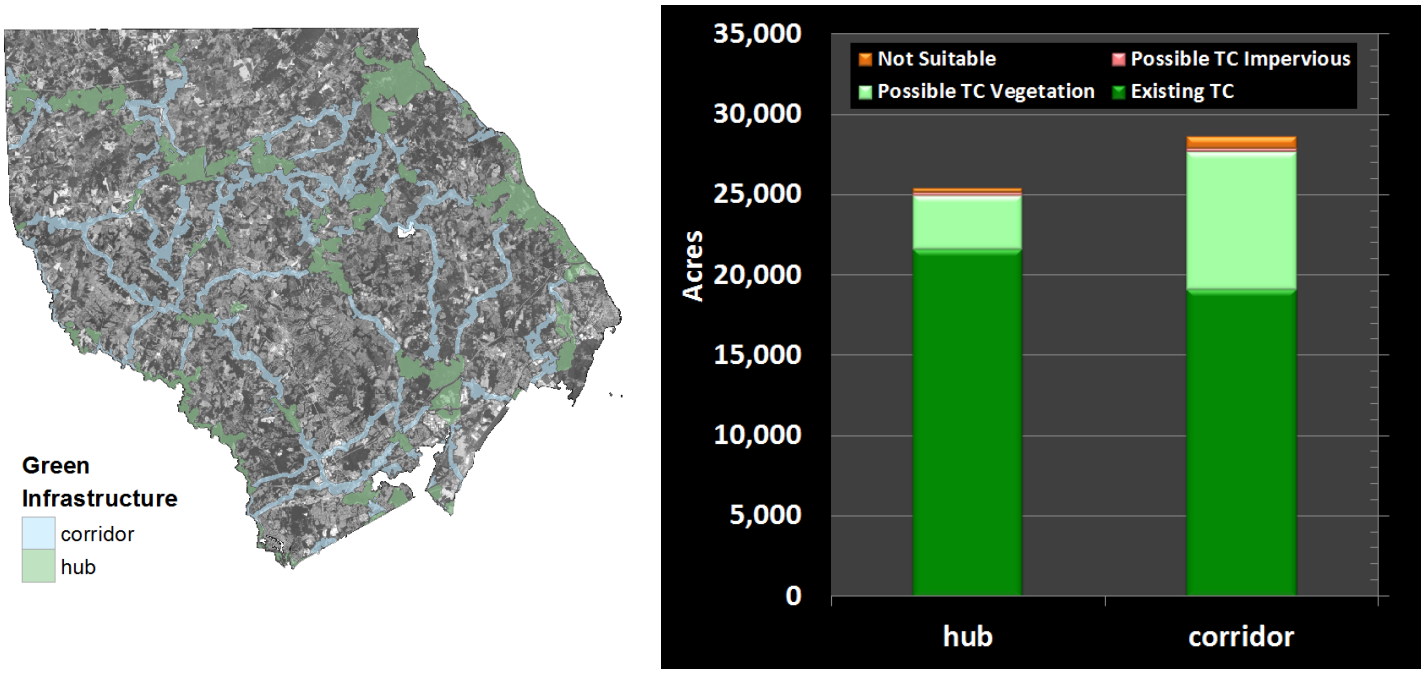



*Figure 11: Green Infrastructure (hubs and corridors) and Tree Canopy metrics for these components.*

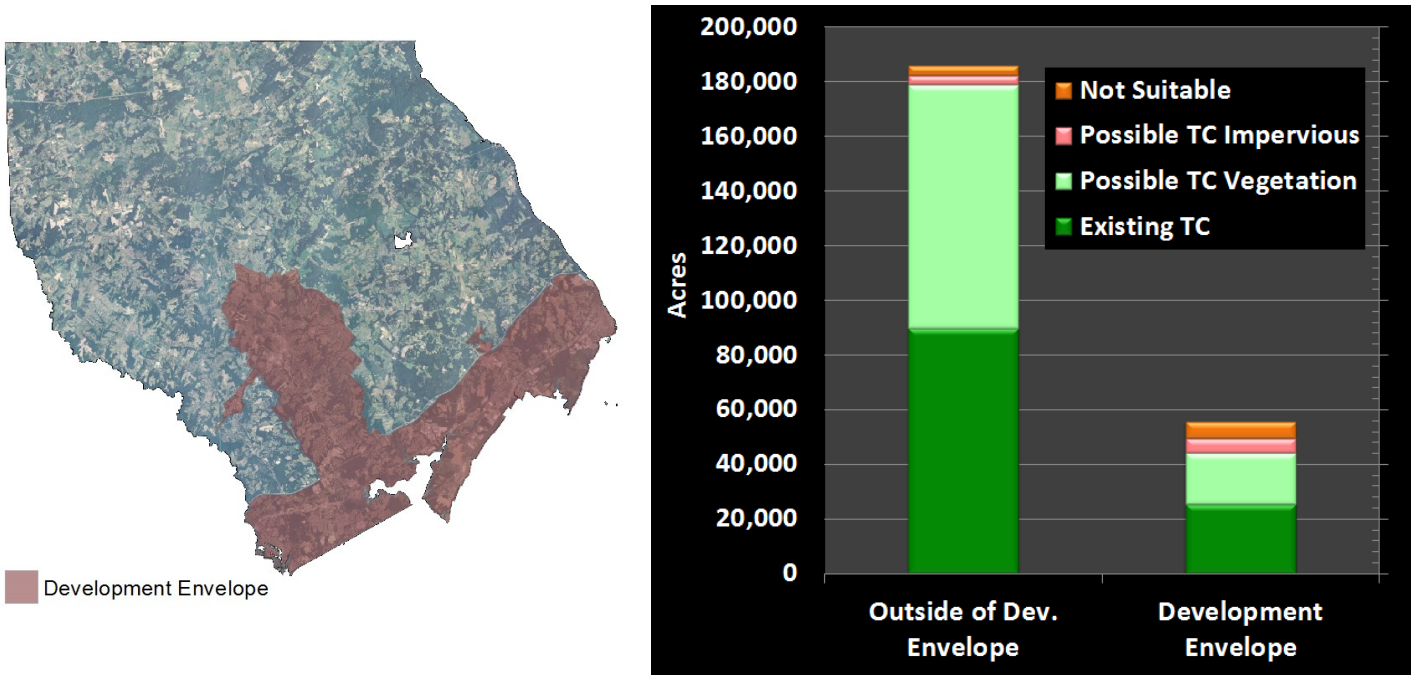
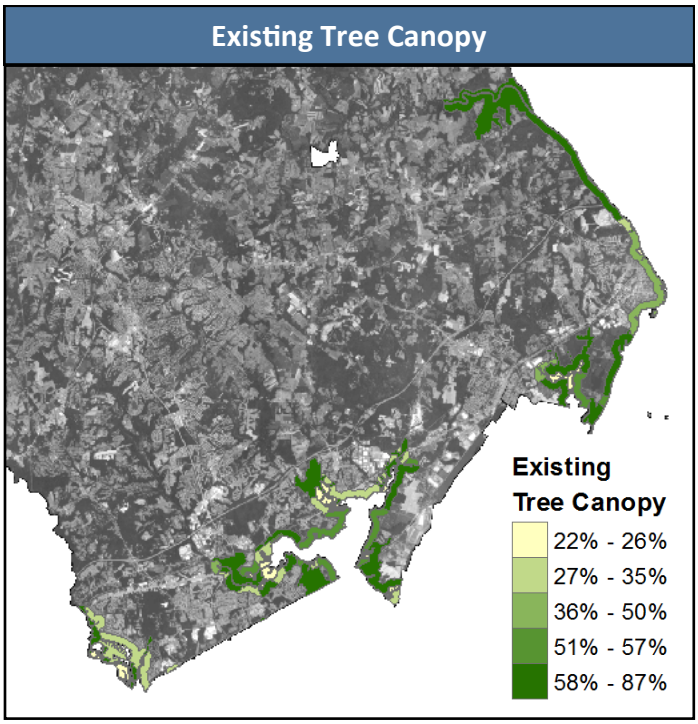



*Figure 12: Development Envelope and Tree Canopy metrics inside and outside of this zone.*

## Critical Areas

Existing and Possible Tree Canopy were summarized by Critical Area type (Figure 13). Resource Conservation Areas are 77% forested and account for 45% of the all Tree Canopy in Critical Areas (Figure 14). Tree Canopy also covers 50% or more of Federal/Municipal and Limited Development Areas. In terms of establishing new tree canopy, Resource Conservation Areas also have the largest fraction of the Vegetated Possible Tree Canopy category (46%). Intensely Developed Critical Areas also present opportunities in this category. Tidal Wetlands show a high percentage of Vegetated Possible Tree Canopy as well, but most of this appears to be emergent wetland, which does not represent real opportunities for tree planting. As with the development envelope, the Intensely Developed Critical Areas have the largest area available to increase tree canopy on impervious surfaces. Eighteen percent of this developed type is in the Impervious Possible Tree Canopy category. 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. Relative to more heavily developed urban areas, the Intensely Developed Areas have a moderate fraction of land in impervious surfaces.



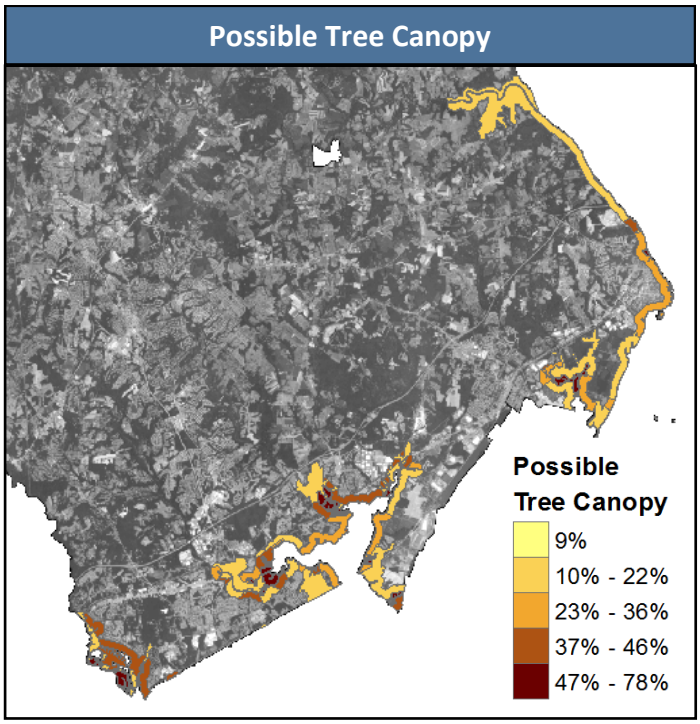




*Figure 13: Existing and Possible Tree Canopy for Critical Area Types.*

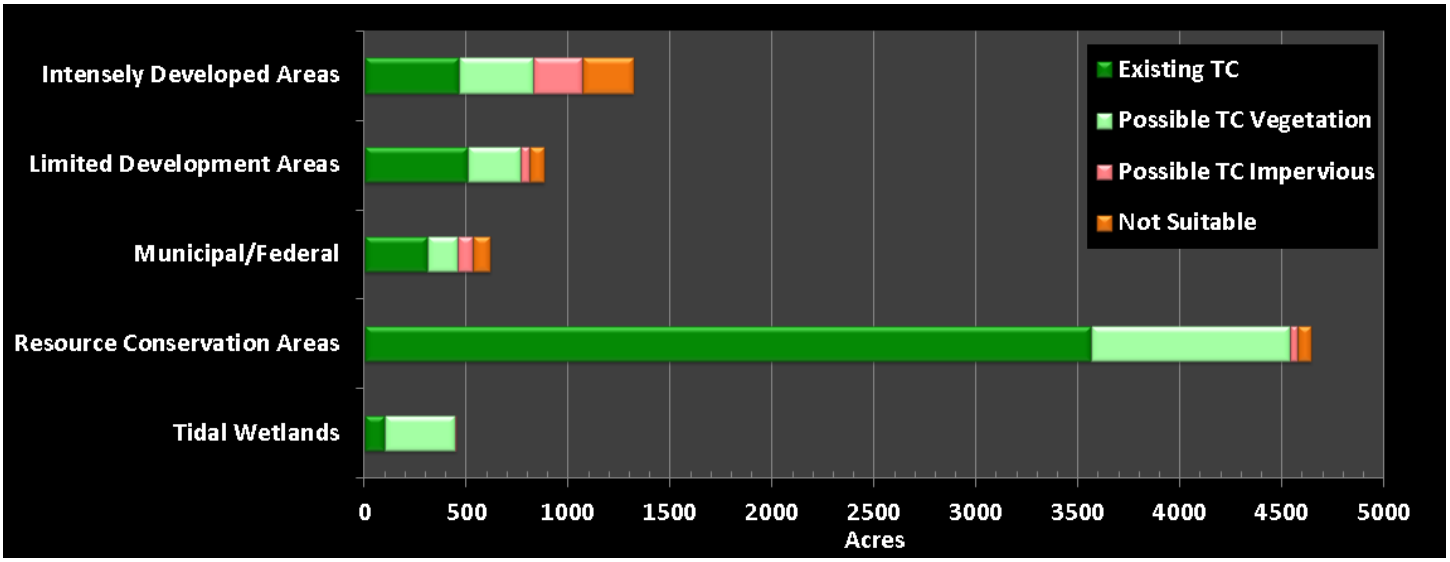



*Figure 14: Tree Canopy metrics summarized by Type for Critical Areas.*

## Watersheds

Existing and Possible Tree Canopy were also summarized by watersheds in Harford County (Figure 15). Existing Tree Canopy percentages for all watersheds except for the tiny section of APG are all very close to the county-wide average of 48% — another indication that Harford County's tree canopy is distributed relatively evenly across the county (Figure 16). Deer Creek is the largest watershed, over twice the size of the next largest watershed, and contains 38% of the county's tree canopy. Church Creek watershed has the greatest amount of tree canopy on a percentage basis. Bynum Run has the lowest percentage of Existing Tree Canopy (43%) among the non-APG watersheds, but this proportion is not substantially less than the average. As the largest watershed, Deer Creek contains the largest amount of Possible Tree Canopy but has a large percentage of agricultural land that may be less tenable for tree planting. Broad Creek, Little Gunpowder and Winter's Run have relatively large percentages of Vegetated Possible Tree Canopy (4-7%). Winters Run could be the watershed to focus on for tree canopy improvements on developed land with 2,350 acres (6%) of this watersheds land in the Impervious Possible Tree Canopy category.

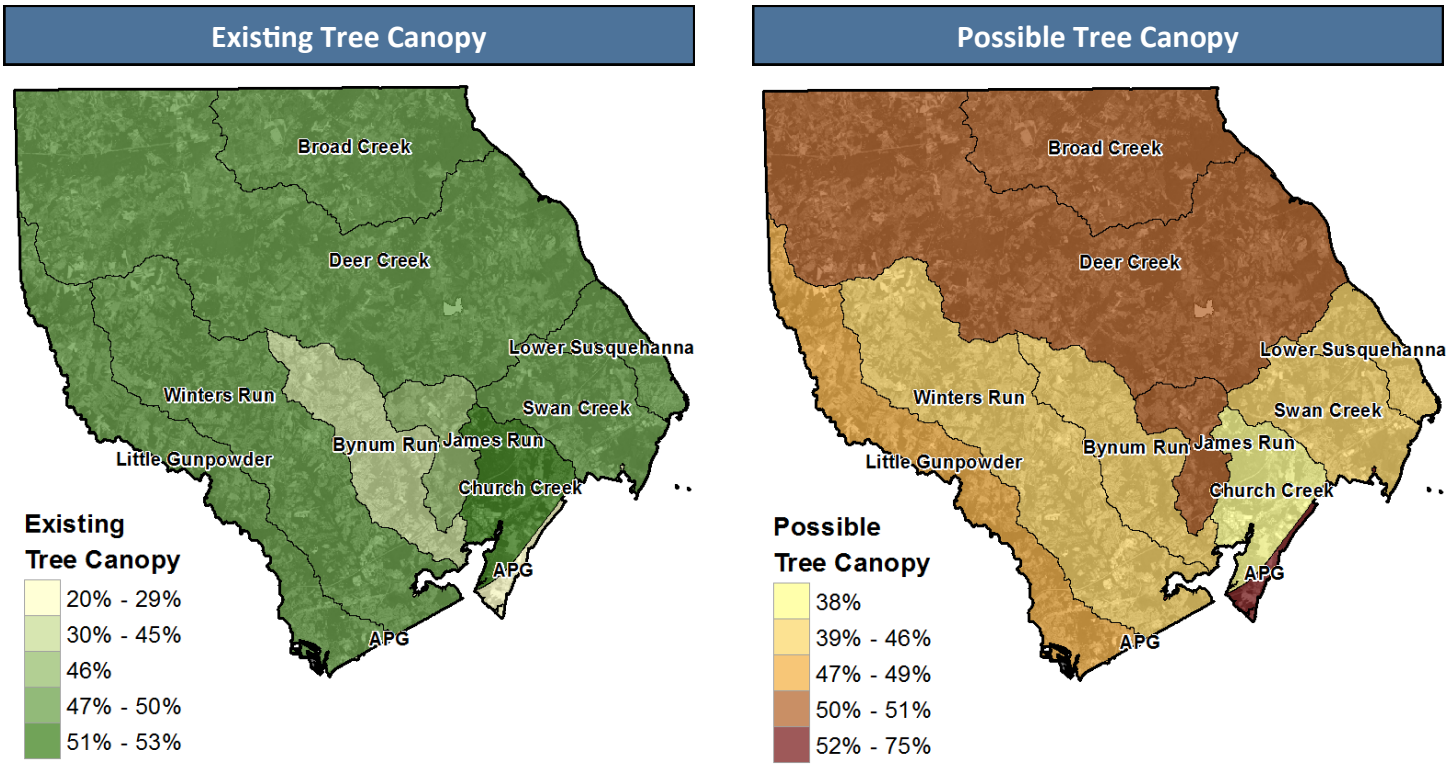



*Figure 15: Percent Existing and Possible Tree Canopy by watershed.*

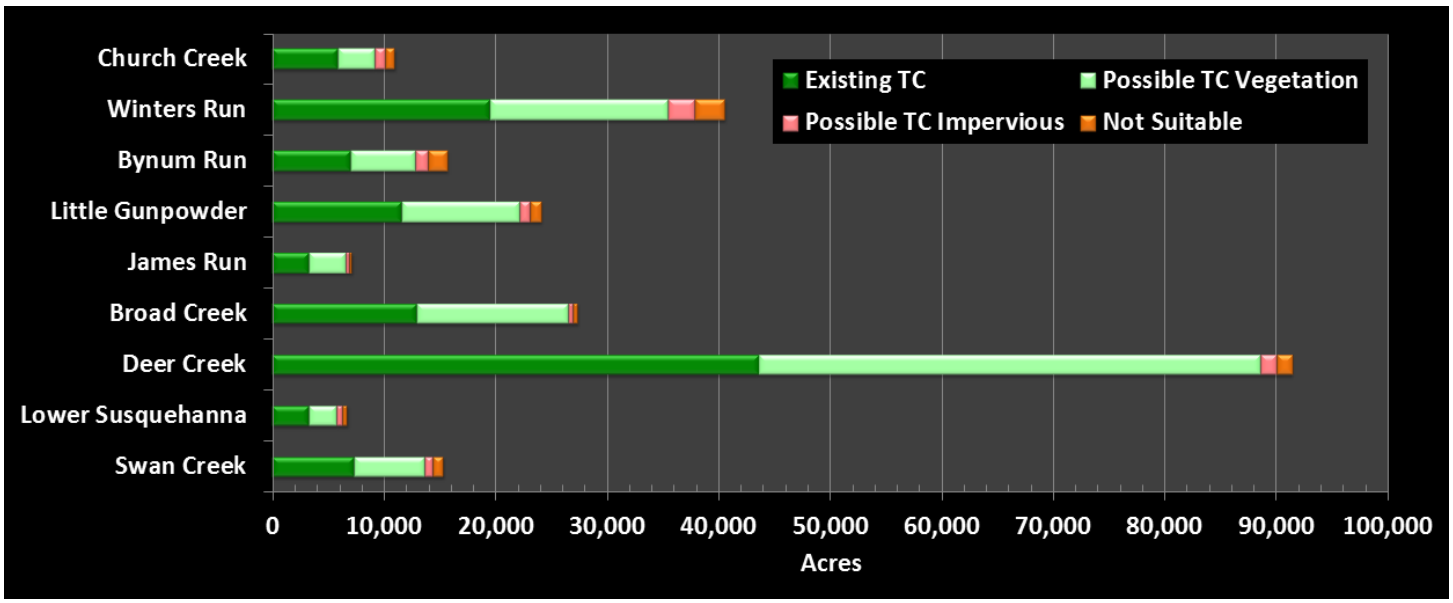



*Figure 16: Tree Canopy metrics summarized by watershed.*

## Riparian Areas

Riparian zones in the Harford County focus area have been modeled using a 100 foot buffer around streams and other hydrologic features. Existing and Possible Tree Canopy were tabulated for these riparian areas and for Special Flood Hazard Areas (SFHA; Figure 17). Within the riparian areas, which total 49,747 acres (land area), 69% of land is Existing Tree Canopy and 29% is categorized as Possible Tree Canopy. Of the 29% available land, only 1% is impervious surface, so ample opportunities exist to stabilize stream banks and protect water quality by increasing the amount of tree canopy in these environmentally important zones. As one would expect, floodplain results are similar with 66% Existing Tree Canopy and 32% Possible.

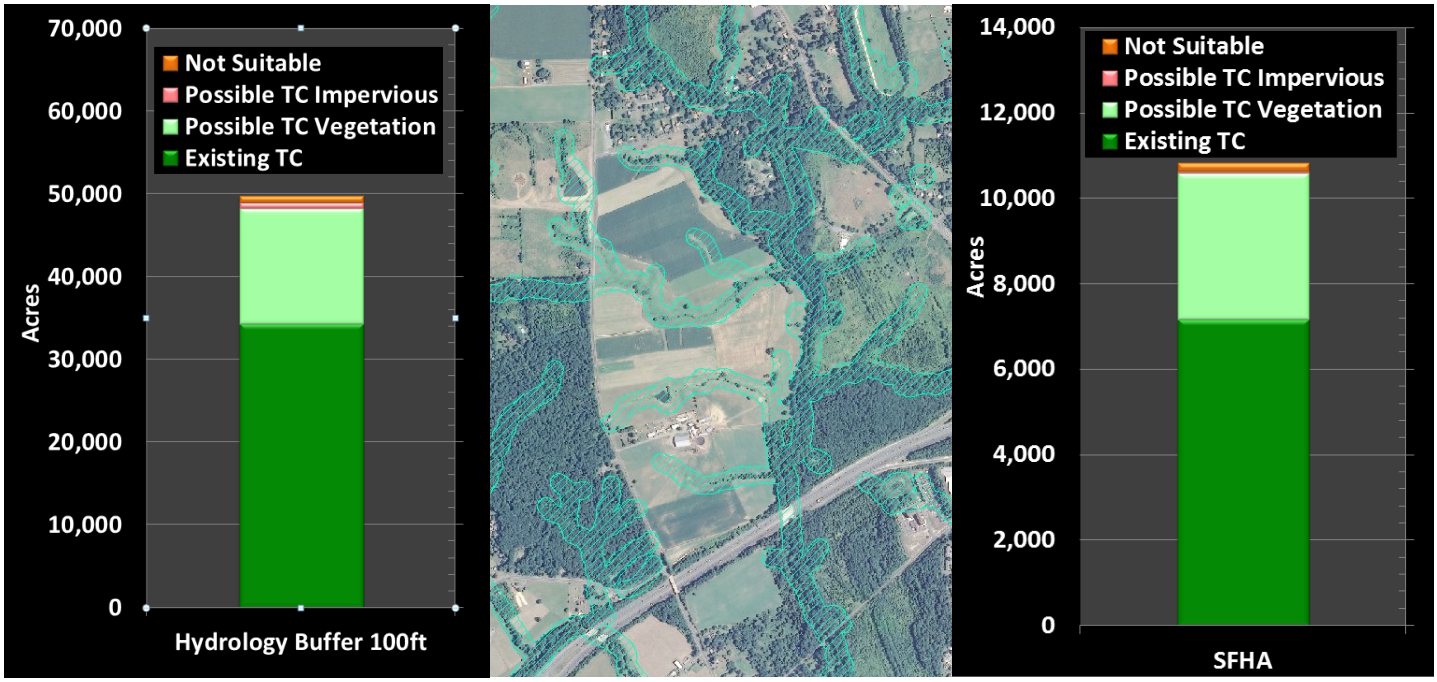
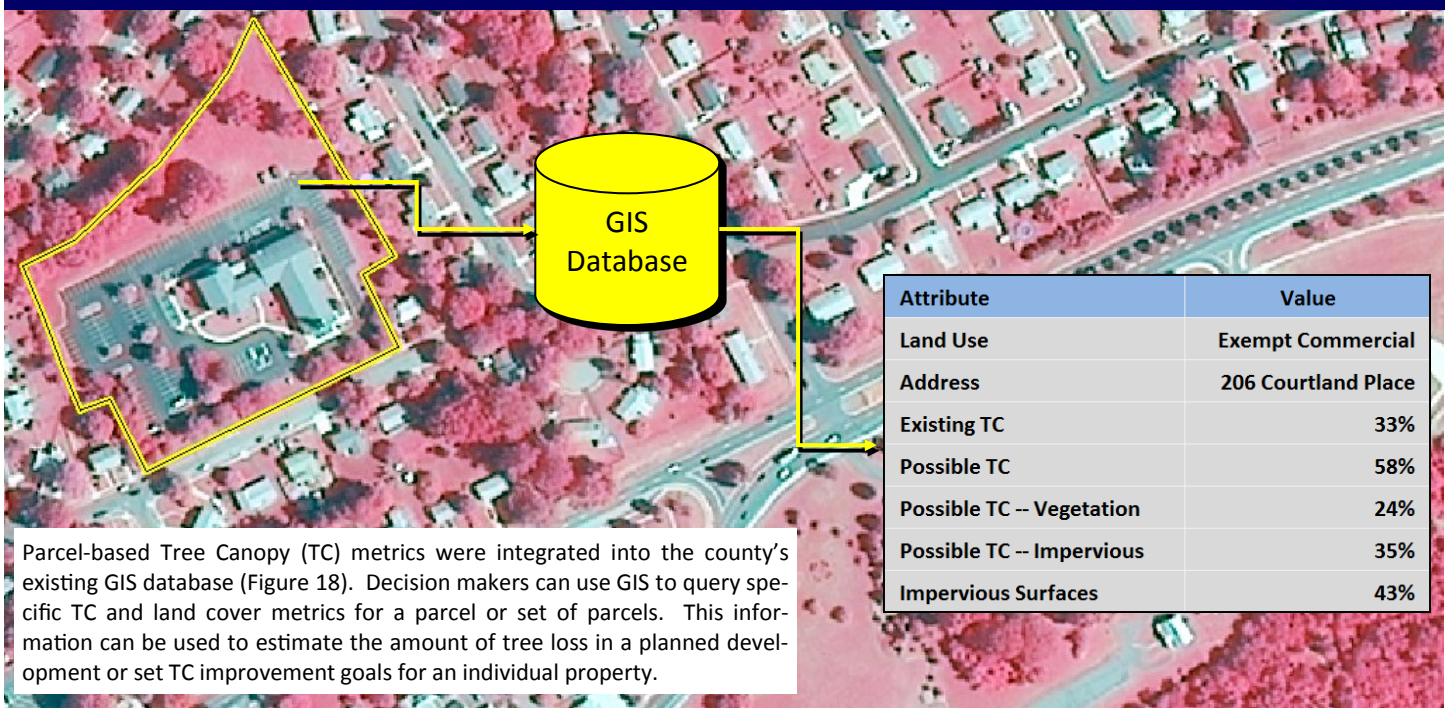



*Figure 17. Tree Canopy metrics summarized by 100 foot hydrology buffer (shown in center) and by Special Flood Hazard Area (SFHA).*

## Decision Support




Parcel-based Tree Canopy (TC) metrics were integrated into the county's existing GIS database (Figure 18). Decision makers can use GIS to query specific TC and land cover metrics for a parcel or set of parcels. This information can be used to estimate the amount of tree loss in a planned development or set TC improvement goals for an individual property.

*Figure 18: 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 19a), it is possible to map regions of the study area where high values of Existing TC are tightly clustered (Figure 19b). A similar map was constructed for Possible TC (Figure 19c). 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 19d); these areas theoretically offer the best places to strategically expand Harford County's 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 rural and agricultural areas that have low Existing and high Possible TC. As with all such analyses, however, landscape context must be evaluated before setting priorities.

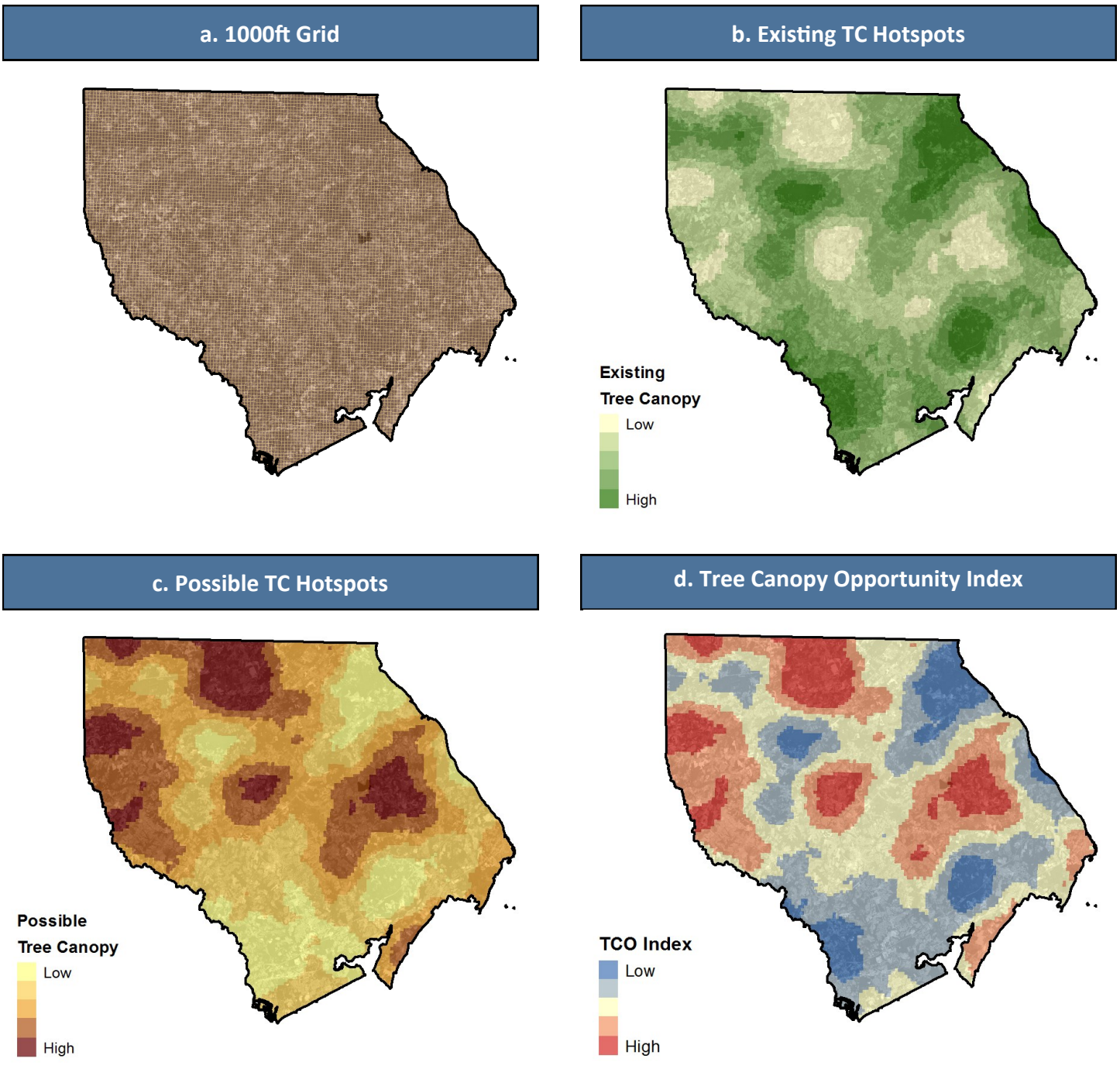



*Figure 19: (a) Grid network (1000-foot cells) superimposed on land-cover map for Harford and then used in spatial cluster analyses; (b) Spatial clustering of Existing TC in Harford; dark green areas are highly clustered and have high Existing TC values; (c) Spatial clustering of Possible TC in Harford; 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.*

# Prioritization

Prioritization is the act of identifying areas to focus tree planting efforts based on management objectives and available planting space. Prioritization helps identify opportunities and effectively target resources. For a given area there may be many different prioritization analyses conducted in order to help meet the needs of various organizations and stakeholders. A sample prioritization matrix was created as part of this study, taking into account land use, watersheds, and Green Infrastructure. The prioritization matrix depicted in Figure 20 characterizes planting opportunities for the green infrastructure categories (hub and corridor) for each of the watersheds by land use types. The color indicates the relative amount of Possible Tree Canopy within each Green Infrastructure class by watershed. The chart is designed to help determine, for each watershed, and each Green Infrastructure class within that watershed, on what land use type land available to plant trees is concentrated in.

Some examples of how to interpret this chart:

•Establishing new tree canopy in the Bynum Run watershed should focus on Residential and Commercial land uses for the Corridor and Exempt and Industrial land uses for the Hub as these two land use types have the highest Possible Tree Canopy.

•Establishing new tree canopy in the Church Creek watershed should focus on Agricultural, Residential, and Industrial land uses for both the Corridor and Hub.

•Outreach activities seeking to convince Commercial land owners to establish new tree canopy in Green Infrastructure Hubs will make the greatest contribution in the primarily in the APG watershed.

•Street tree planting initiatives within the rights-of-way (ROW) in Hubs will likely be most successful in the Bynum Run, Church Creek, and Lower Susquehanna watersheds due to the amount of land available.

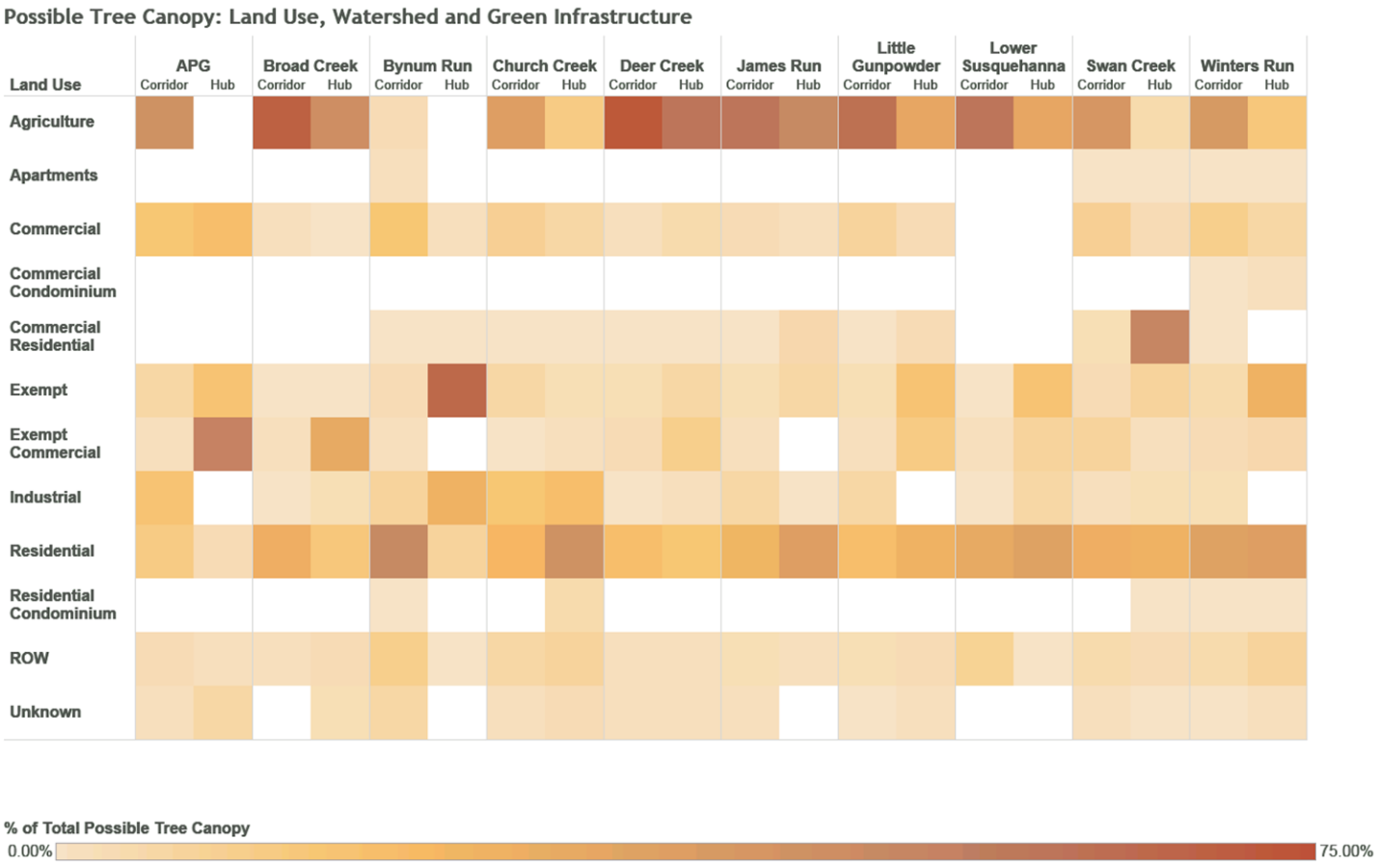



*Figure 20: Prioritization matrix for Harford County that look as planting opportunities (Possible Tree Canopy) for the two Green Infrastructure types (hubs and corridors) by land use within each watershed.*

## Conclusions

- Harford 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.
- Harford 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 riparian zones, urban and rural areas that have the least Existing Tree Canopy and high Possible Tree Canopy.
- Agriculture and residential land uses dominate the county, and thus these two land use types have both the greatest net amount of Existing Tree Canopy and Possible Tree Canopy. Agricultural land contains 42% of the county's tree canopy and residential land contains 39% of the county's tree canopy. The next highest land use category, exempt (primarily government land), contains 7% of the county'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 Harford County's Tree Canopy.
- Strategies for increasing tree canopy will likely differ by land use type. For example, tree planting initiatives on agricultural lands will likely target riparian buffers in order to insure a working agricultural landscape, yet at the same time reduce surface runoff.
- Within the Development Envelope the story is different with residential land owners having a clear majority of the net Existing Tree Canopy and net Possible Tree Canopy.
- Despite the dominance of residential and agricultural land use within the county all land use types have vegetated or impervious surfaces, that if improved, could yield additional tree canopy. For example, 21% of the land in industrial land use 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.
- Although the net amounts are greater outside of the Development Envelope the relative percentages of both Existing and Possible Tree Canopy inside and outside of the Development Envelope are quite similar, reflecting the influence of agriculture in reducing tree canopy in the more rural parts of the county.
- Efforts to preserve the 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.

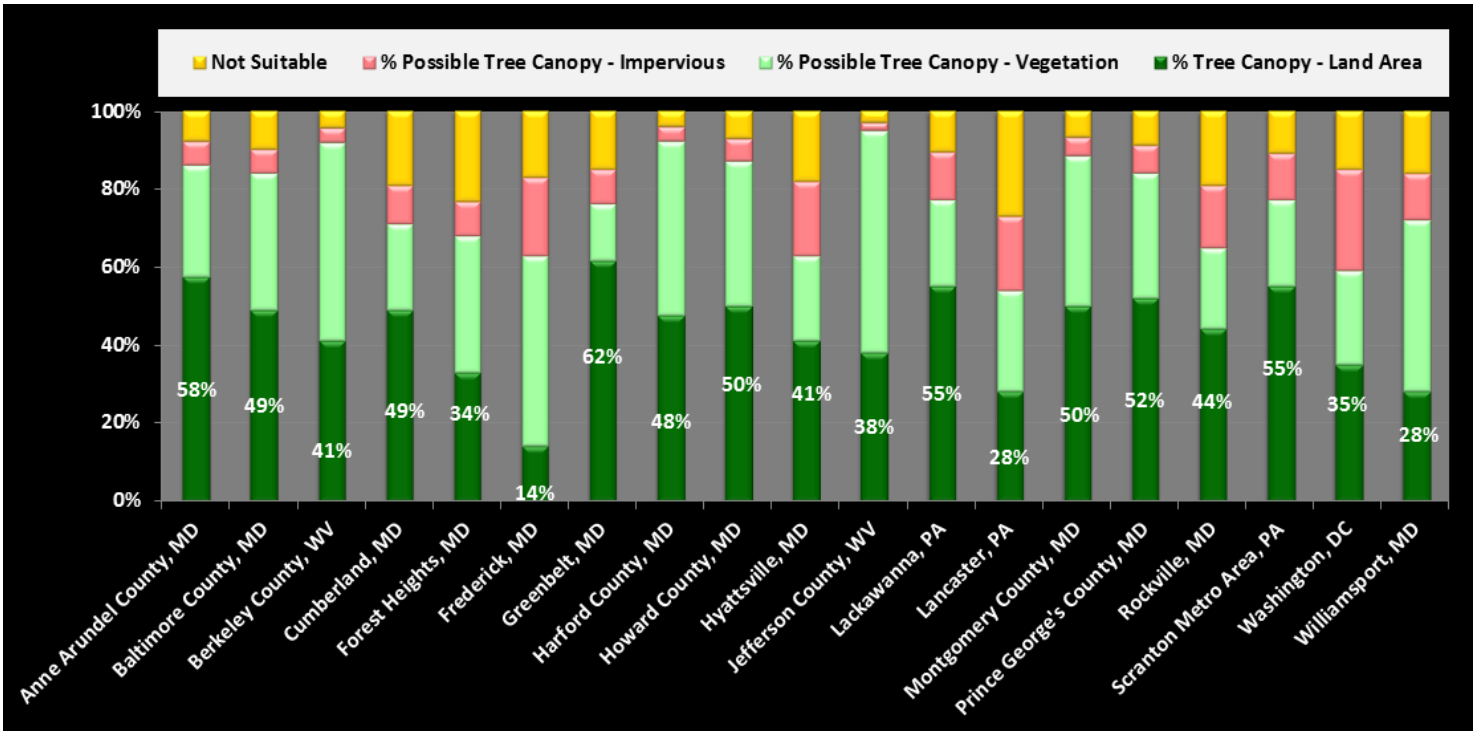



*Figure 21: Comparison of Existing and Possible Tree Canopy with other similar communities that have completed Tree Canopy Assessments.*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## Additional Information

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


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