A Report on the City of Bridgeport'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 city as well as the amount of tree canopy that could theoretically be established.

How Much Tree Canopy Does Bridgeport Have?

An analysis of Bridgeport's tree canopy based on land cover data derived from high-resolution aerial imagery and LiDAR (Figure 1) found that 685 acres of the city were covered by tree canopy (termed Existing TC), representing 27% of all land in the city. An additional 45% (1,447 acres) of the city's land area could theoretically be modified (termed Possible TC) to accommodate tree canopy (Figure 2). In the Possible TC category, 25% (631 acres) of the city was classified as Impervious Possible TC and another 20% was Vegetated Possible TC (514 acres). Vegetated Possible TC, or grass and shrubs, 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.

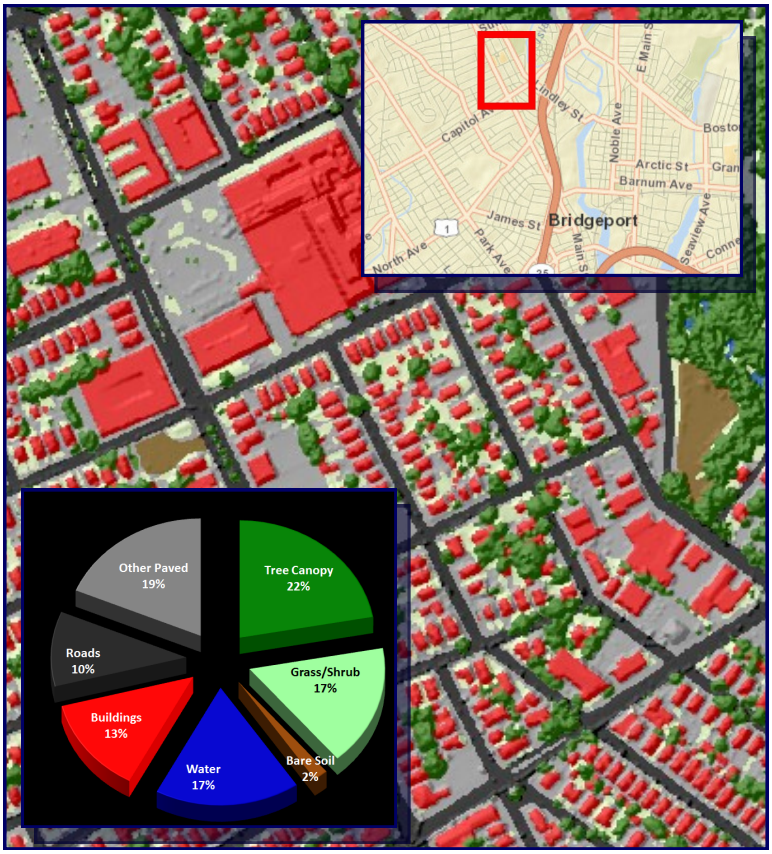


Figure 1: Land cover derived from high-resolution imagery and LiDAR for the City of Bridgeport.

Project Background

The goal of the project was to apply the USDA Forest Service's TC assessment protocols to the City of Bridgeport. The analysis was conducted based on year 2010 data. This project was made possible through funding from the City of Bridgeport. 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 the City of Bridgeport, The Connecticut Department of Energy and Environmental Protection, and the USDA Forest Service's Northern Research Station.

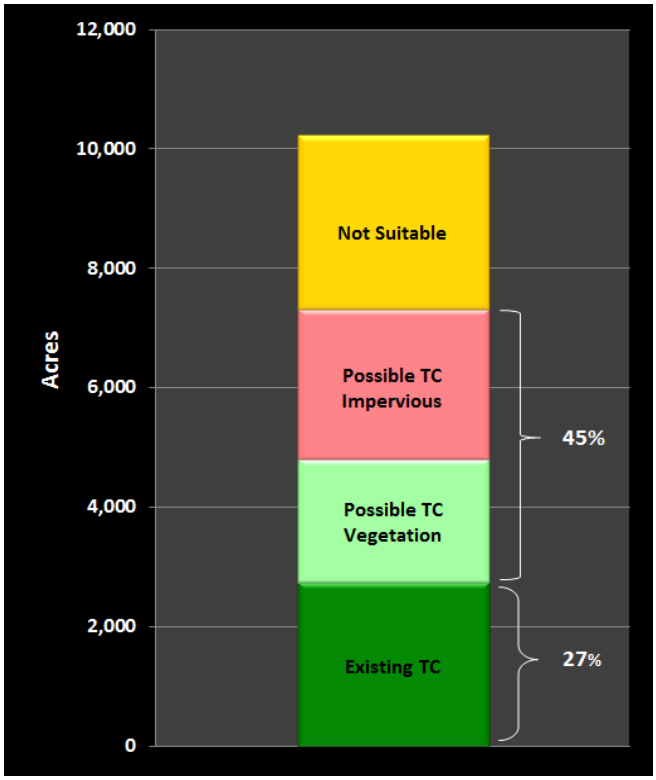


Figure 2: TC metrics for Bridgeport based on % of land area covered by each TC type.

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 Bridgeport's Trees

A prior estimate of tree canopy for the entirety of the City of Bridgeport (including water) from the 2001 National Land Cover Database (NLCD 2001) was 10%, far lower than the 22% obtained in this study (the 27% estimate is a percentage of land area). The large difference is due to the fact that NLCD 2001 (Figure 3a) and the city's vegetation layer only accounted for relatively large patches of tree canopy. Using high-resolution aerial imagery (Figure 3b) and LiDAR, in combination with advanced automated processing techniques, land cover for the city was mapped with such detail that trees as short as 8ft tall were detected (Figure 3c).

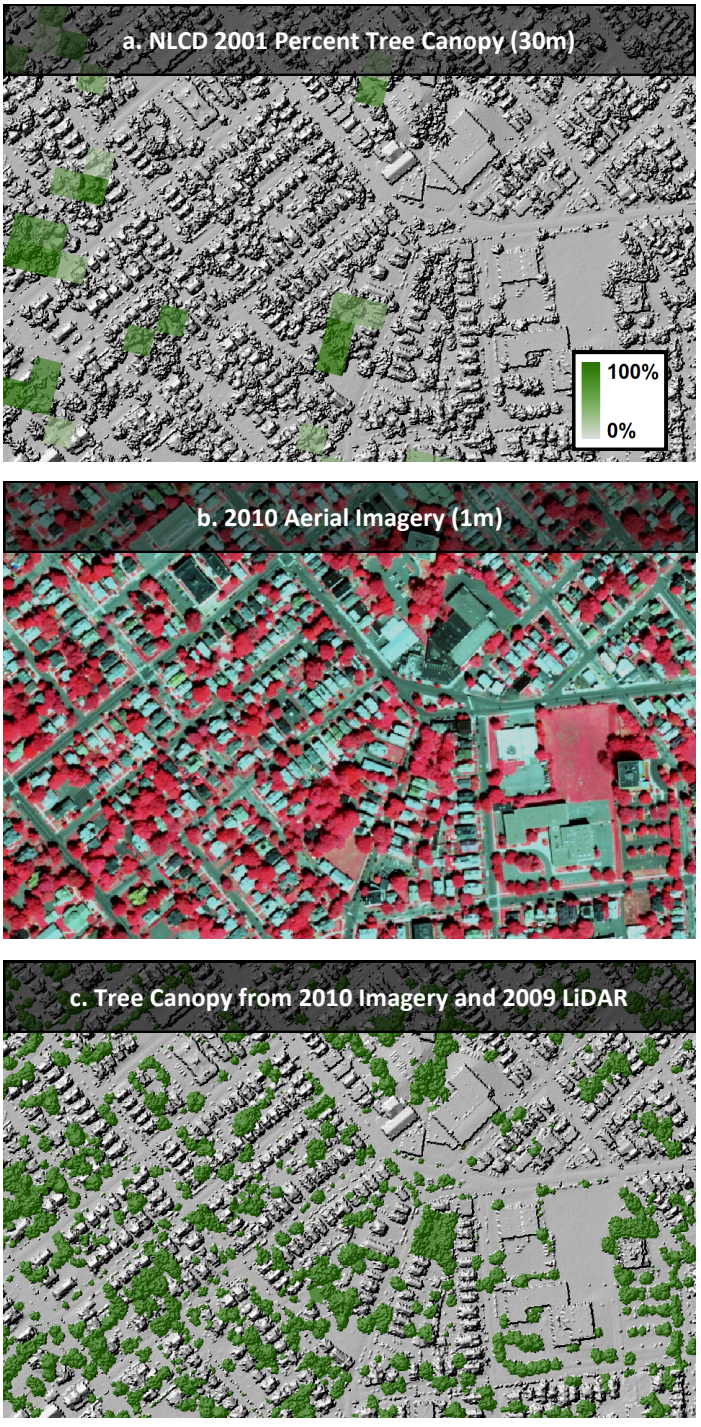


Figure 3: Comparison of NLCD 2001 (a) to high-resolution imagery (b) and tree canopy (c) derived for this study.

Parcel Summary

After land cover was mapped city-wide, Tree Canopy (TC) metrics were summarized for each property in the city'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 ÷ land area of the parcel).

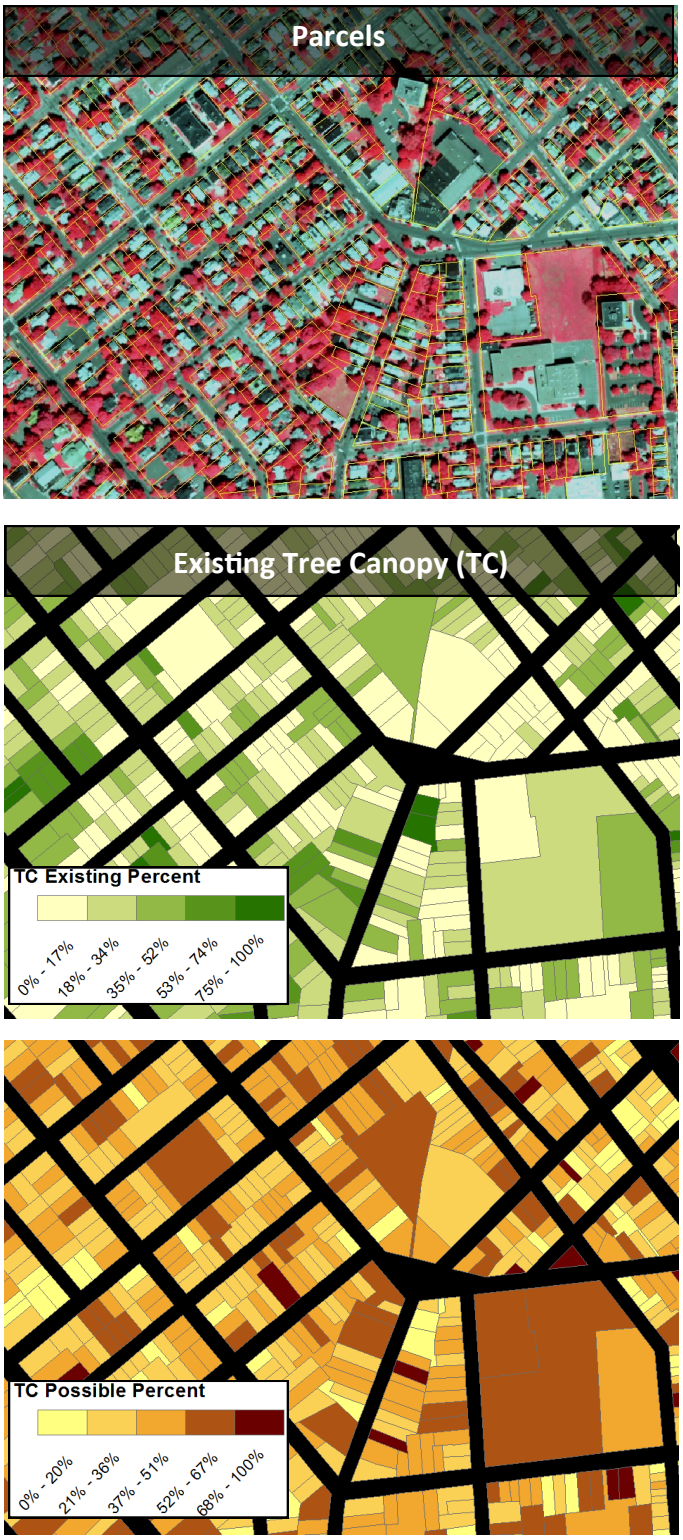


Figure 4a, 4b, 4c: Parcel-based TC metrics. TC metrics are generated at the parcel level, allowing each property to be evaluated according to its Existing TC and Possible TC.

Rights-Of-Way

Land within Bridgeport can be broadly split into two categories (Figure 5), parcel land and rights-of-way. Parcel land refers to all land contained within the city's parcel database. Rights-of-Way (ROW) refers to "non-parcel" land, essentially street rights-of-way and water. The vast majority of the city's land base (79%) exists within parcels, with 21% of the city's land base within the ROW (Figure 6). Within the parcels, 29% of the land is covered by tree canopy. Within the ROW the percent of land covered by tree canopy is somewhat lower (19%). Additional tree canopy (Possible TC) could theoretically be established on 50% of all the parcel land area, but only 26% of the ROW, largely due to the presence of roads. Establishing new tree canopy within the parcel land will likely be easier as much of the Possible TC falls into the Vegetation category whereas in the ROW most of the Possible TC is in the Impervious category.

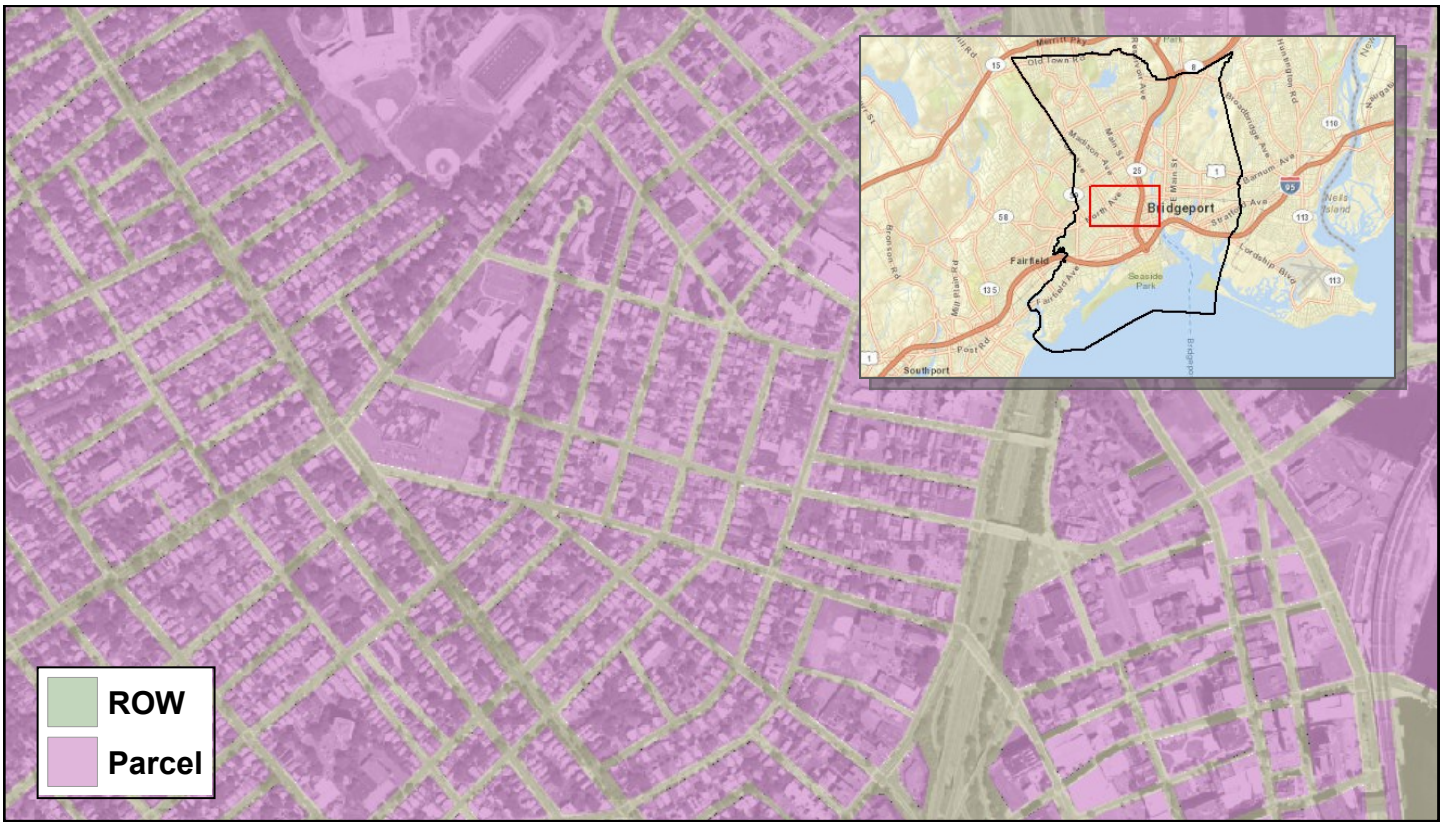


Figure 5: Parcels and ROW land division in Bridgeport.

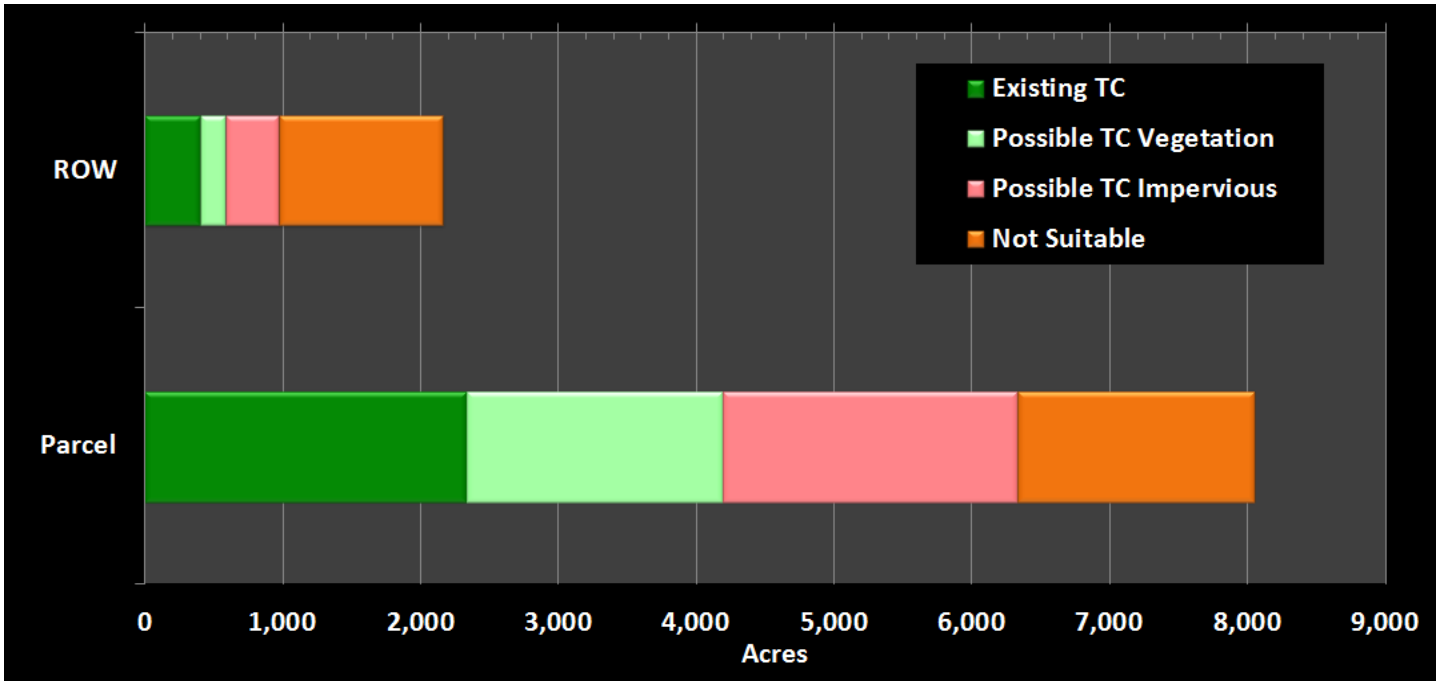


Figure 6: Tree Canopy (TC) metrics were summarized by parcels and ROW.

Zoning

An analysis of Existing and Possible TC by zoning category was conducted using the most recent zoning layer for the city (Figure 7, Table 1). For each zoning district, TC metrics were calculated as a percentage of all land in the city (% Land), as a percentage of land area in the specified zoning district (% Category), and as a percentage of the area for TC type (% TC Type). The majority of Bridgeport is zoned for residential land use, and thus it comes as no surprise that the residential zoned areas have not only the majority of the cities tree canopy, but also the most room to plant new trees. Bridgeport is also characterized by its active industrial base. Industrial areas are not typically associated with tree canopy, but in Bridgeport 12% of the city's tree canopy lies within industrially zoned areas. There remains considerable room for establishing new tree canopy in industrial areas, but this will be challenging due to the amount of impervious surfaces.

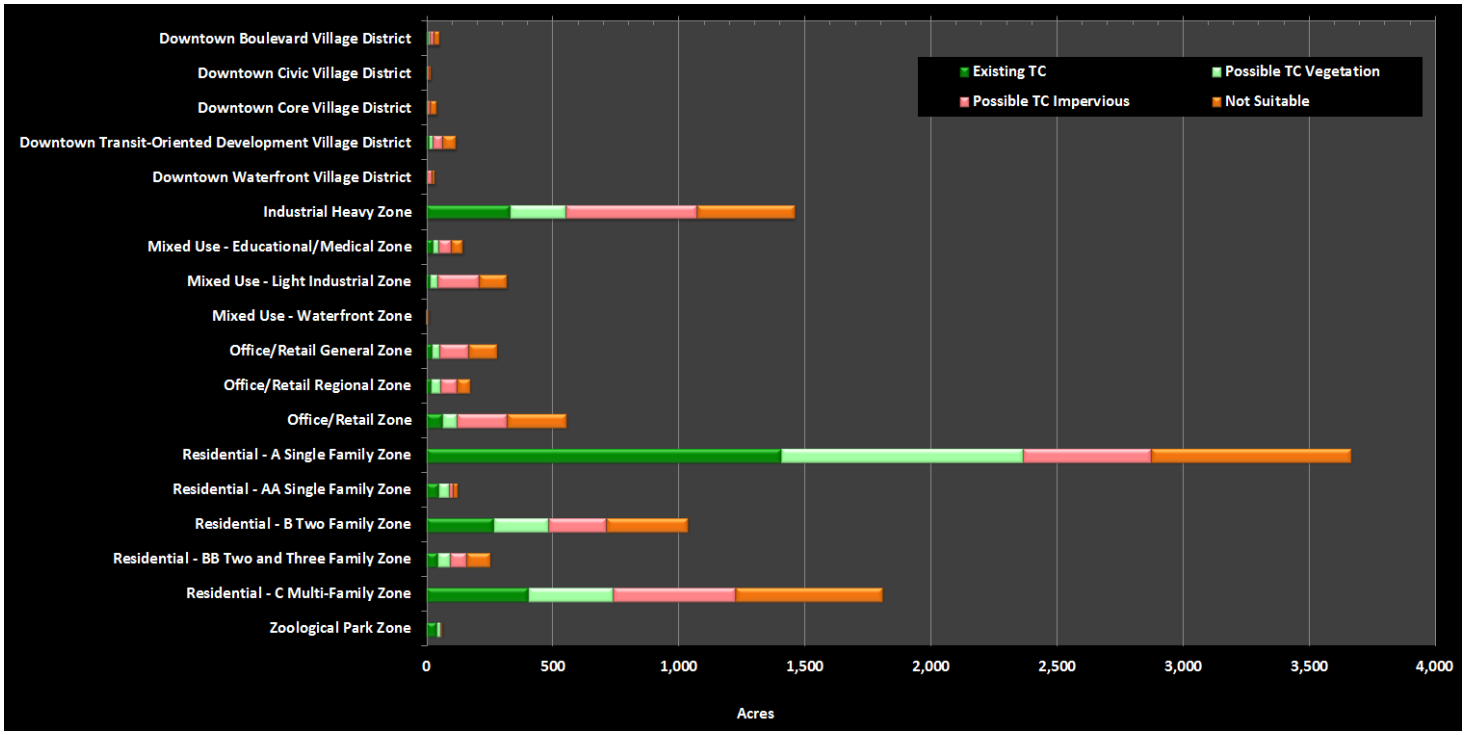


Figure 7: Tree Canopy (TC) metrics summarized for each zoning district.

Zone	Existing UTC			Possible UTC Vegetation			Possible UTC Impervious		
	% Land	% Category	% UTC Type	% Land	% Category	% UTC Type	% Land	% Category	% UTC Type
Downtown Boulevard Village District	0%	16%	0%	0%	14%	0%	0%	27%	1%
Downtown Civic Village District	0%	17%	0%	0%	10%	0%	0%	39%	0%
Downtown Core Village District	0%	8%	0%	0%	1%	0%	0%	27%	0%
Downtown Transit-Oriented Development Village District	0%	9%	0%	0%	14%	1%	0%	32%	2%
Downtown Waterfront Village District	0%	6%	0%	0%	10%	0%	0%	51%	1%
Industrial Heavy Zone	3%	23%	12%	2%	15%	11%	5%	35%	21%
Mixed Use - Educational/Medical Zone	0%	17%	1%	0%	17%	1%	0%	33%	2%
Mixed Use - Light Industrial Zone	0%	4%	1%	0%	10%	2%	2%	52%	7%
Mixed Use - Waterfront Zone	0%	2%	0%	0%	9%	0%	0%	52%	0%
Office/Retail General Zone	0%	8%	1%	0%	11%	2%	1%	40%	5%
Office/Retail Regional Zone	0%	11%	1%	0%	22%	2%	1%	38%	3%
Office/Retail Zone	1%	12%	2%	1%	10%	3%	2%	36%	8%
Residential - A Single Family Zone	14%	38%	52%	9%	26%	47%	5%	14%	20%
Residential - AA Single Family Zone	1%	41%	2%	0%	32%	2%	0%	11%	1%
Residential - B Two Family Zone	3%	26%	10%	2%	21%	11%	2%	22%	9%
Residential - BB Two and Three Family Zone	0%	18%	2%	0%	20%	2%	1%	25%	3%
Residential - C Multi-Family Zone	4%	22%	15%	3%	19%	16%	5%	27%	19%
Zoological Park Zone	0%	67%	2%	0%	19%	1%	0%	7%	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 Bridgeport's land area is covered by tree canopy in the Residential AA Single Family Zone.

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

The % Land value of 41% indicates that 41% of land in the Residential AA Single Family Zone 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 as Residential AA Single Family.

Table 1: Tree Canopy (TC) metrics were summarized by zoning district. For each zoning category, TC metrics were computed as a percentage of all land in the city (% Land), as a percentage of land in the specified zone (% 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 Bridgeport and their tree canopy. Higher amounts of tree canopy are present in the most northern and western parts of the city (Figure 8a); areas that also tend to have higher median incomes. An inverse relationship between existing tree canopy and renter occupancy rates (Figure 8b). Evidence from other cities shows that tree survival tends to be lower in areas with higher renter occupancies. Tree canopy per capita is lowest in those sections of the city where the population density highest (Figure 8c). 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 8d). Interestingly, the areas with high PPI values also have relatively high amounts of Possible TC.

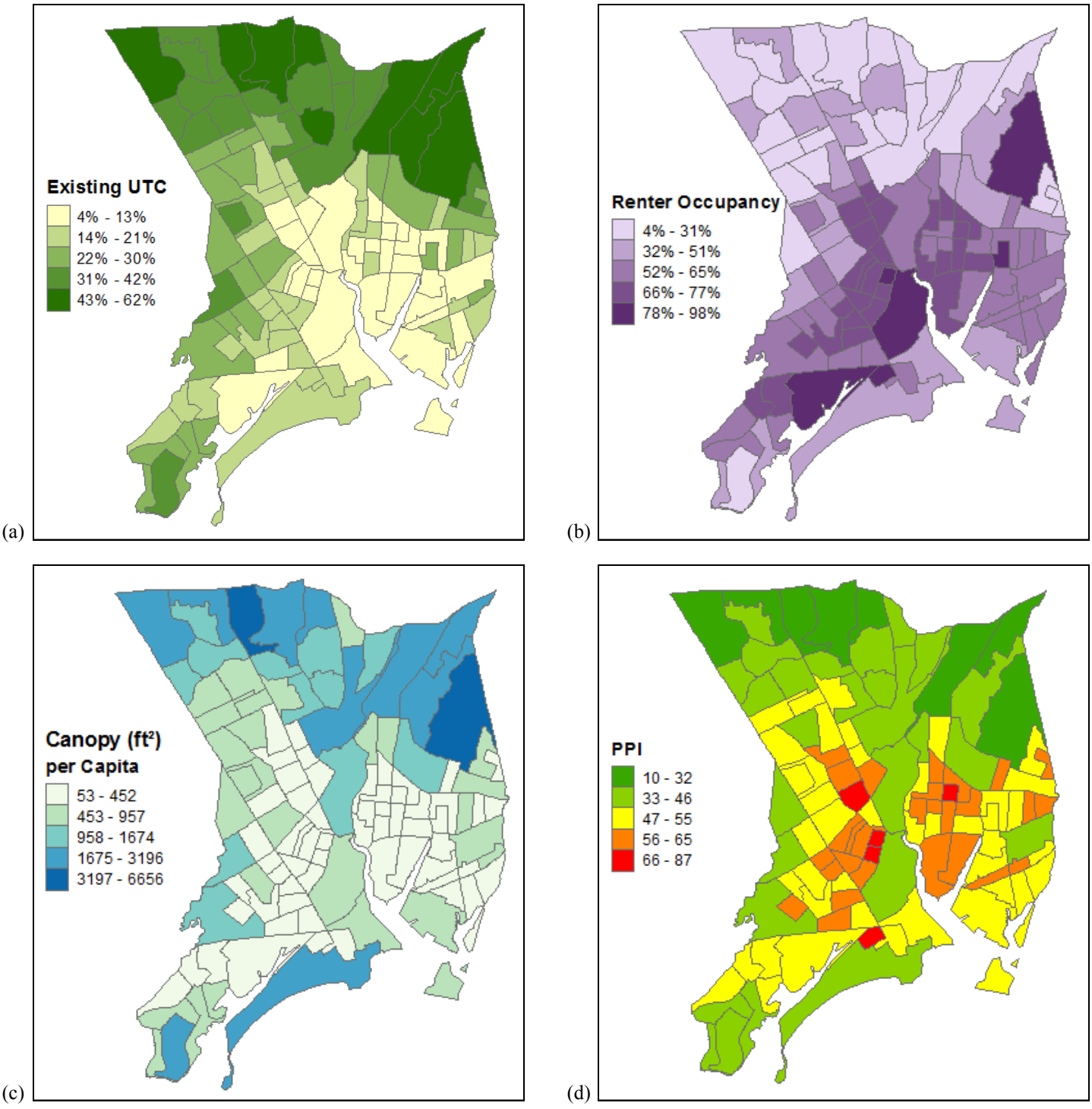


Figure 8: (a) Percent Existing TC; (b) proportion of housing units occupied by renters; (c) tree canopy per capita; and (d) Priority Planting Index.

Land Use

Tree canopy metrics were summarized for each land use category (Figure 9). The TC metrics for the largest twelve land use categories are displayed in Figure 10. Residential-1 Family is the single largest land use category in Bridgeport, with 37% of existing tree canopy. Nearly 60% of the city's total tree canopy is in residential land use categories. The Industrial-Manufacturing category is also important, with 11% of the city's overall tree canopy. In terms of establishing new tree canopy (Possible TC), the Tax Exempt and Condominium categories each have the greatest proportion of their land area available, each having 60%. Substantial proportions of these areas (31% and 40%, respectively) are currently vegetated land, where tree canopy opportunities are generally better than on impervious land. As a percentage of all land in the city it is the residential areas that provide the greatest opportunity for increasing tree canopy (collectively accounting for >40% of Possible TC).

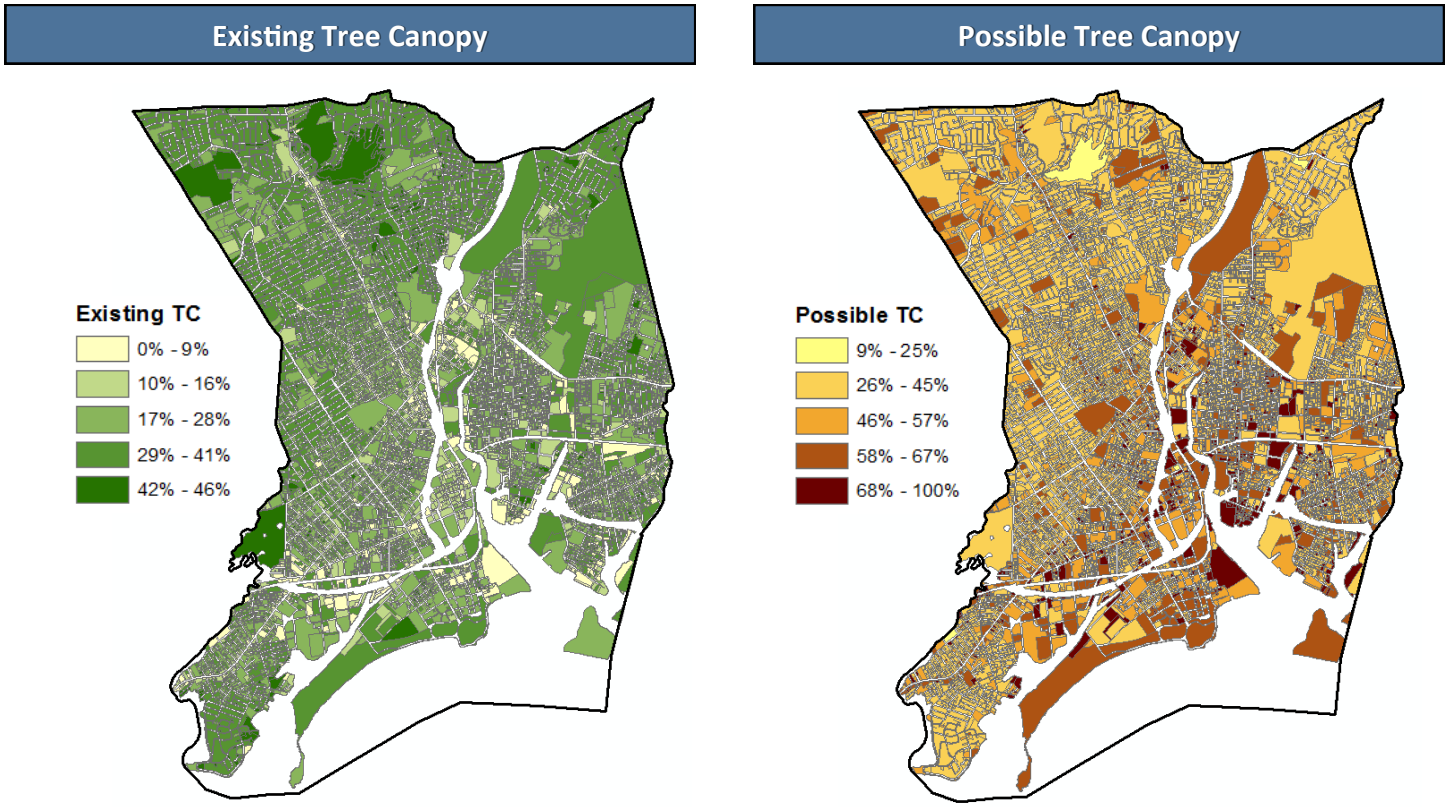


Figure 9. Existing TC (left) and Possible TC (right) as a percentage of land area.

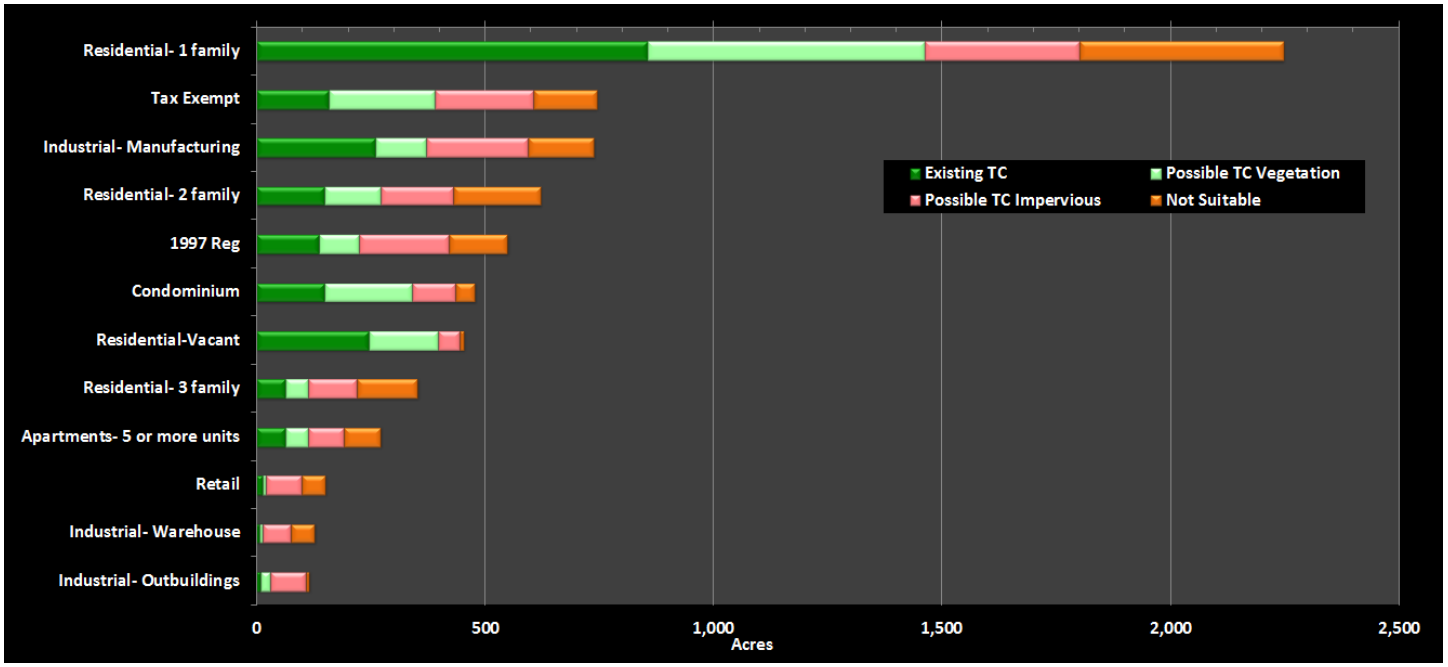
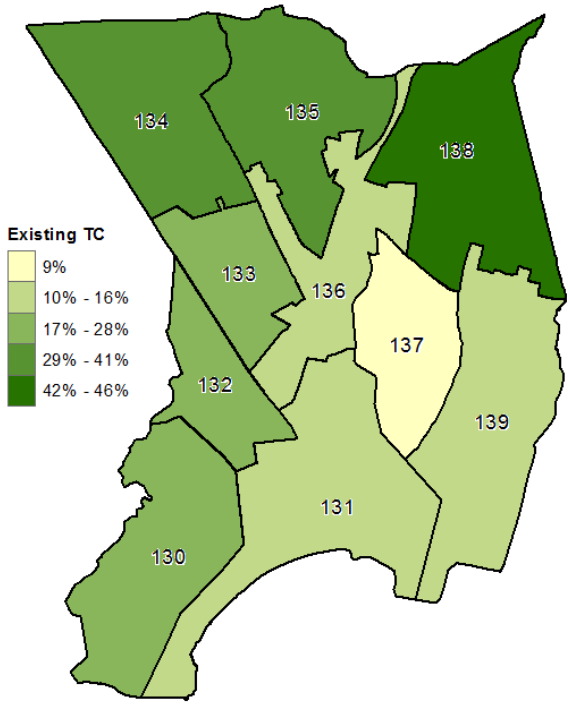


Figure 10: TC metrics summarized by Land Use (largest 12 categories are shown).

Council Districts

Council District 137 has the lowest Existing TC (Figures 9, 10). All of the other districts in the southern and central areas of the city have similarly low Existing TC, although three districts in the southeast (131, 137, 139) all have relatively high Possible TC — greater than 48% (although Council District 131 includes a substantial, undeveloped coastal area). Council District 138 has the highest Existing TC (46%). Much of this tree canopy, however, appears to be within a heavy industrial zone that remains largely undeveloped. All Council Districts present opportunities as each has over one-third of its area identified as Possible TC.

Existing Tree Canopy



Possible Tree Canopy

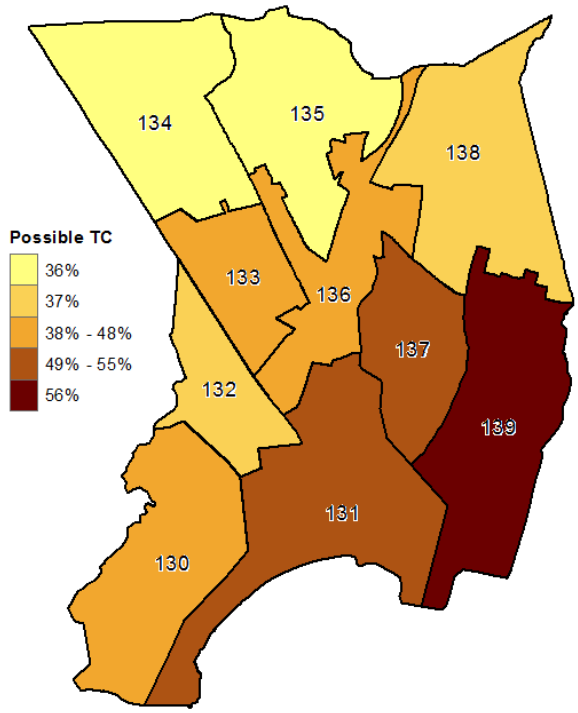


Figure 11. Existing TC (left) and Possible TC (right) as a percentage of Council District land area.

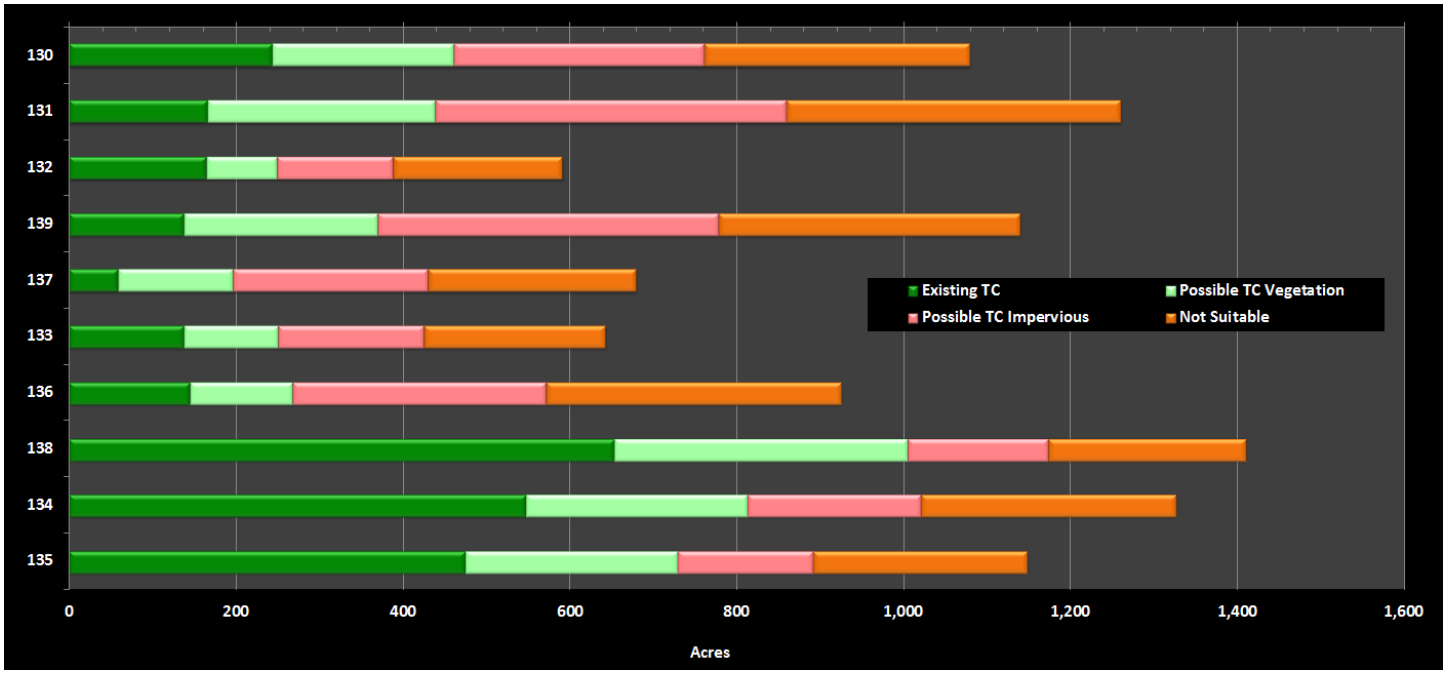


Figure 12: TC metrics summarized by Council District.

Watersheds

Existing and Possible Tree Canopy (TC) was analyzed for the portions of the 3 subwatersheds of the Pequonnock River with the city limits (Figure 13). Tree canopy in these watersheds varies widely, with the Middle Pequonnock subwatershed having 40% of its land area covered by tree canopy and the Lower Pequonnock River having 14%. Tree canopy distribution in the subwatersheds is largely a factor of land use. Middle Pequonnock and Island Brook are mostly residential and open spaces, whereas Lower Pequonnock has a high proportion of commercial and industrial uses. Possible TC is highest in this heavily-developed subwatershed. Nearly half of its land area is in non-building, non-road impervious surfaces and vegetation that, if modified, could potentially support tree canopy. However, establishing tree canopy on many of these areas will be challenging due to their current use (e.g. parking lots and recreational fields). Overall, Existing TC is higher and Possible TC lower, in residential neighborhoods.

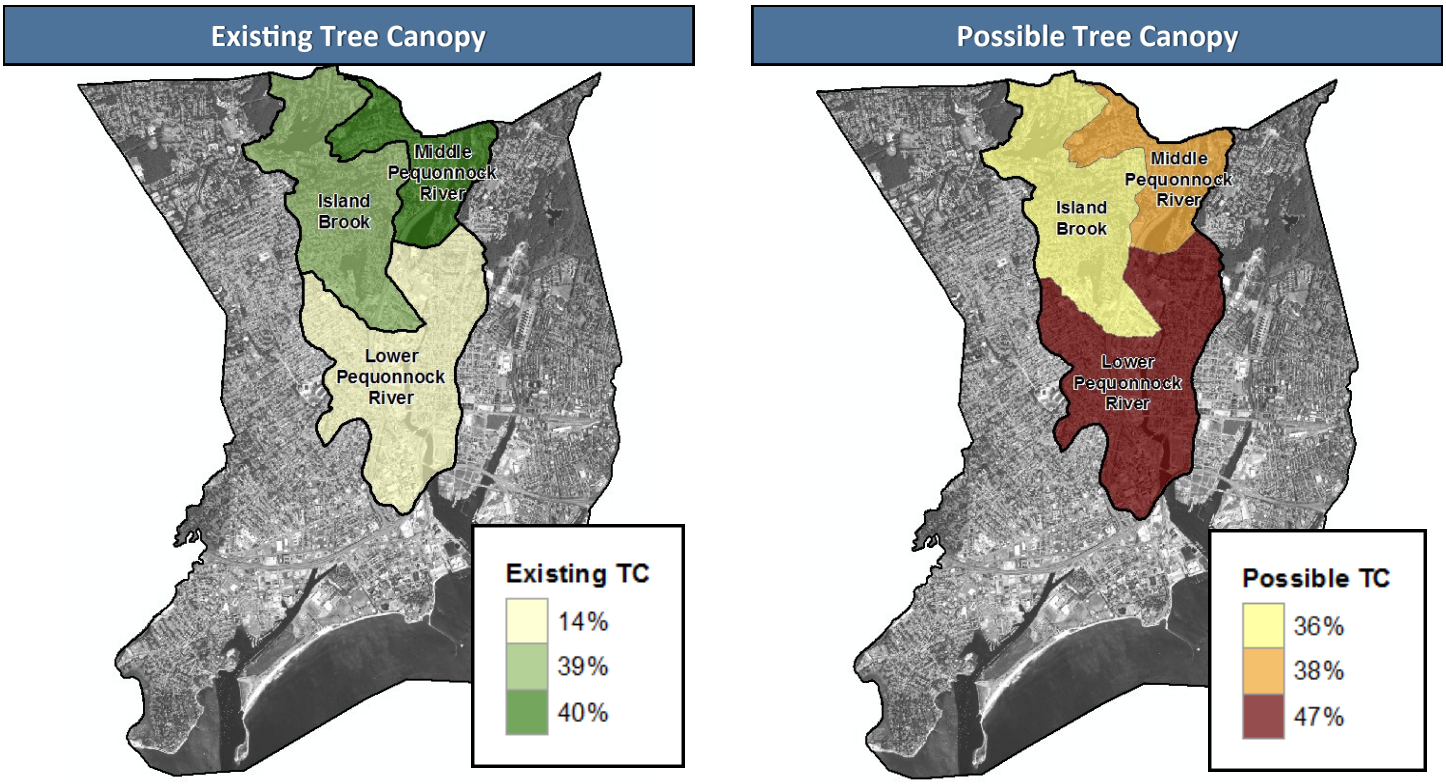
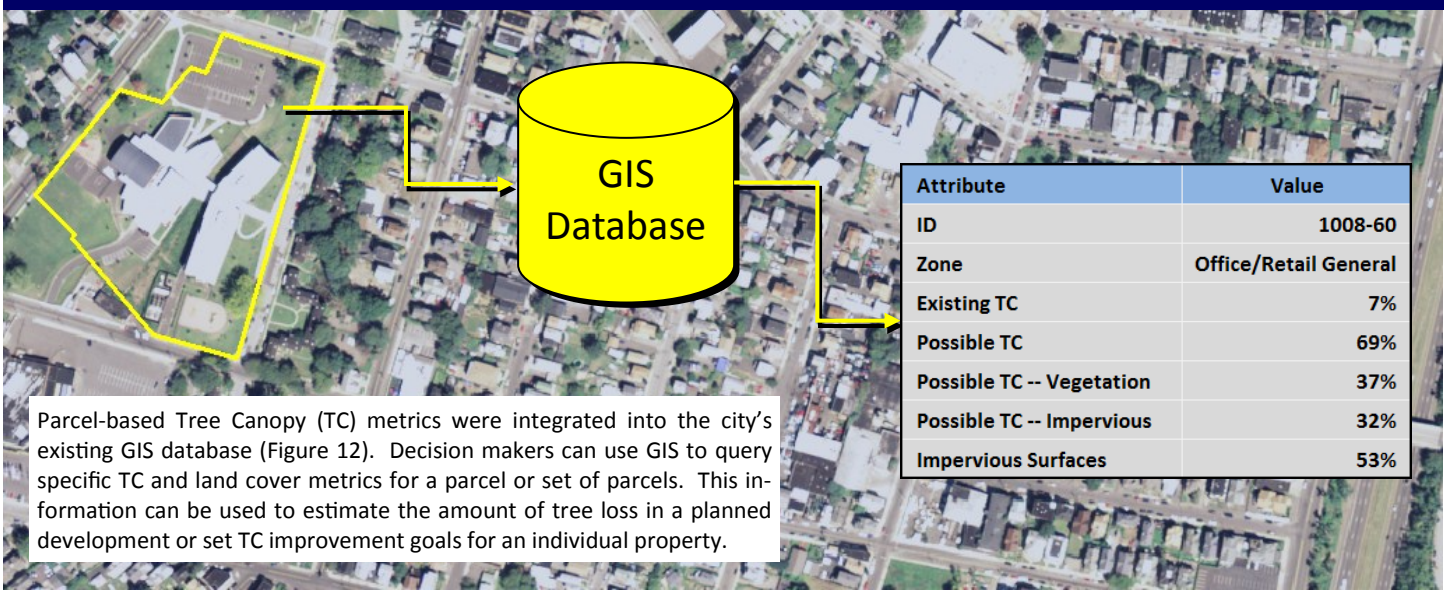


Figure 13. Existing TC (left) and Possible TC (right) as a percentage of neighborhood land area.

Decision Support



Parcel-based Tree Canopy (TC) metrics were integrated into the city's existing GIS database (Figure 12). 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 14: 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 200-foot grid network is superimposed on the land-cover map (Figure 15a), it is possible to map regions of the study area where high values of Existing TC are tightly clustered (Figure 15b). A similar map was constructed for Possible TC (Figure 15c). 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 15d); these areas theoretically offer the best places to strategically expand Bridgeport's tree canopy and to increase its many attendant benefits. Unlike PPI (Figure 8d), TCO does not take into account population information. As such, the areas with the highest TCO are the largely industrial and commercial sections of the city that have low Existing and high Possible TC. As with all such analyses, however, landscape context must be evaluated before setting priorities.

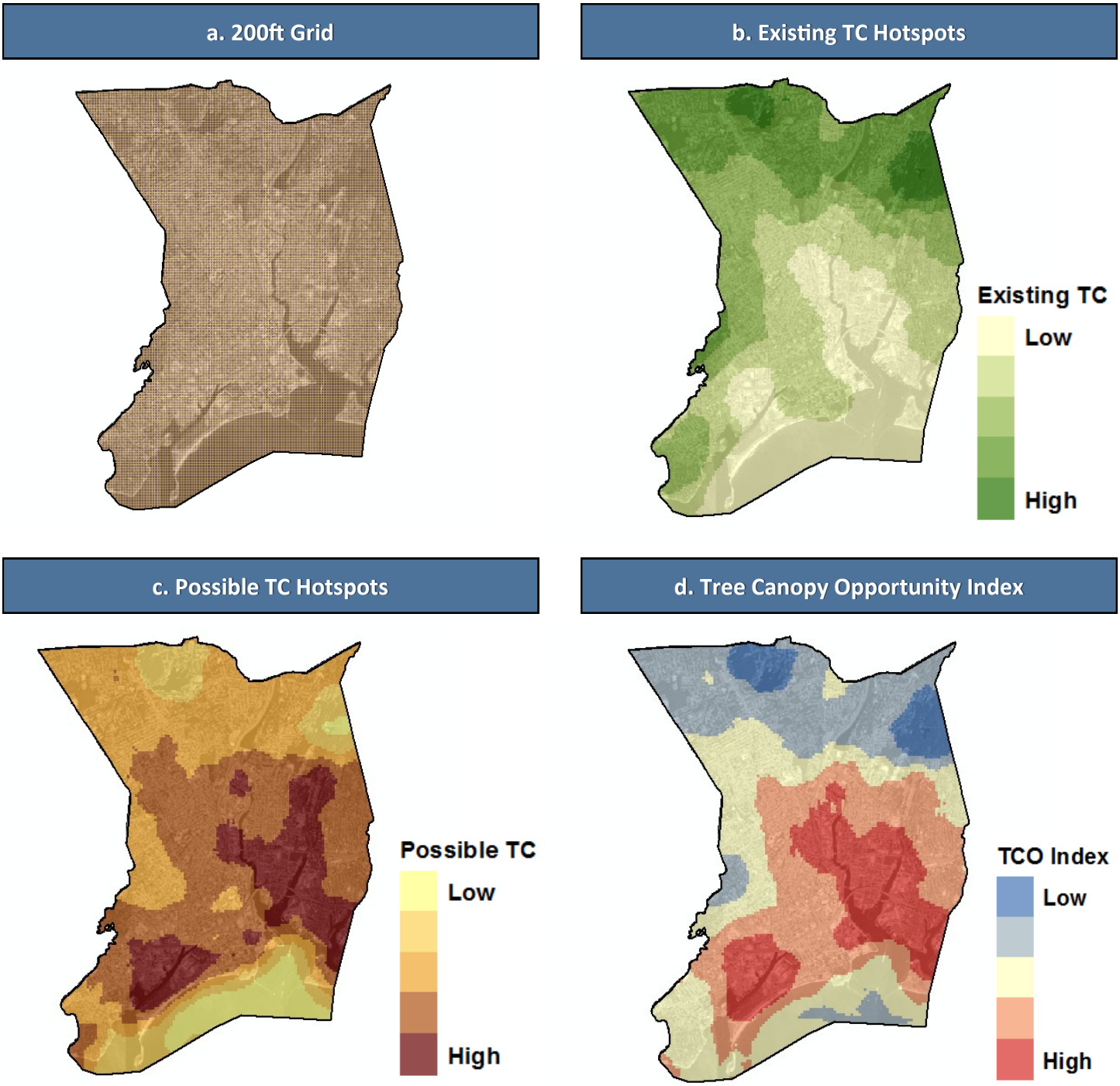


Figure 15: (a) Grid network (250-foot cells) superimposed on land-cover map for Bridgeport and then used in spatial cluster analyses; (b) Spatial clustering of Existing TC in Bridgeport; dark green areas are highly clustered and have high Existing TC values; (c) Spatial clustering of Possible TC in Bridgeport; 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

- Bridgeport's urban tree canopy is a vital city asset that reduces stormwater runoff, improves air quality, reduces the city's carbon footprint, enhances quality of life, contributes to savings on energy bills, and serves as habitat for wildlife.
- Although this assessment indicates that 45% of the land in Bridgeport could theoretically support tree canopy, planting new trees on much of this land may not be socially desirable (e.g. recreation fields) or financially feasible (e.g. parking lots). Setting a realistic goal requires a detailed feasibility assessment using the geospatial datasets generated as part of this assessment.
- With Existing and Possible TC summarized at the parcel level and integrated into the city's GIS database, individual parcels can be examined and targeted for TC improvement. Of particular focus for TC improvement should be parcels in the city that have large, contiguous impervious surfaces. These parcels contribute high amounts of runoff, which degrades water quality. The establishment of tree canopy on these parcels will help reduce runoff during periods of peak overland flow.
- Bridgeport's residents are the largest "owner" of tree canopy by land use type. Programs that educate residents on tree stewardship and provide incentives for tree planting are crucial if Bridgeport is going to sustain its tree canopy in the long term.
- Geographically the greatest opportunities for increasing tree canopy lie in the central, southeast, and southwest sections of the city. The TCO Index, which highlights those portions of the city where the "biggest bang for the buck" can be achieved will help with strategic planning.
- Census Block Group summaries can be used to target the expansion of new tree canopy in areas of the city to meet the needs of underserved populations. The Priority Planting Index (PPI) can help to guide these efforts.
- Efforts to improve the quality of the Pequonnock River should focus on subwatersheds with low amounts of Existing TC.

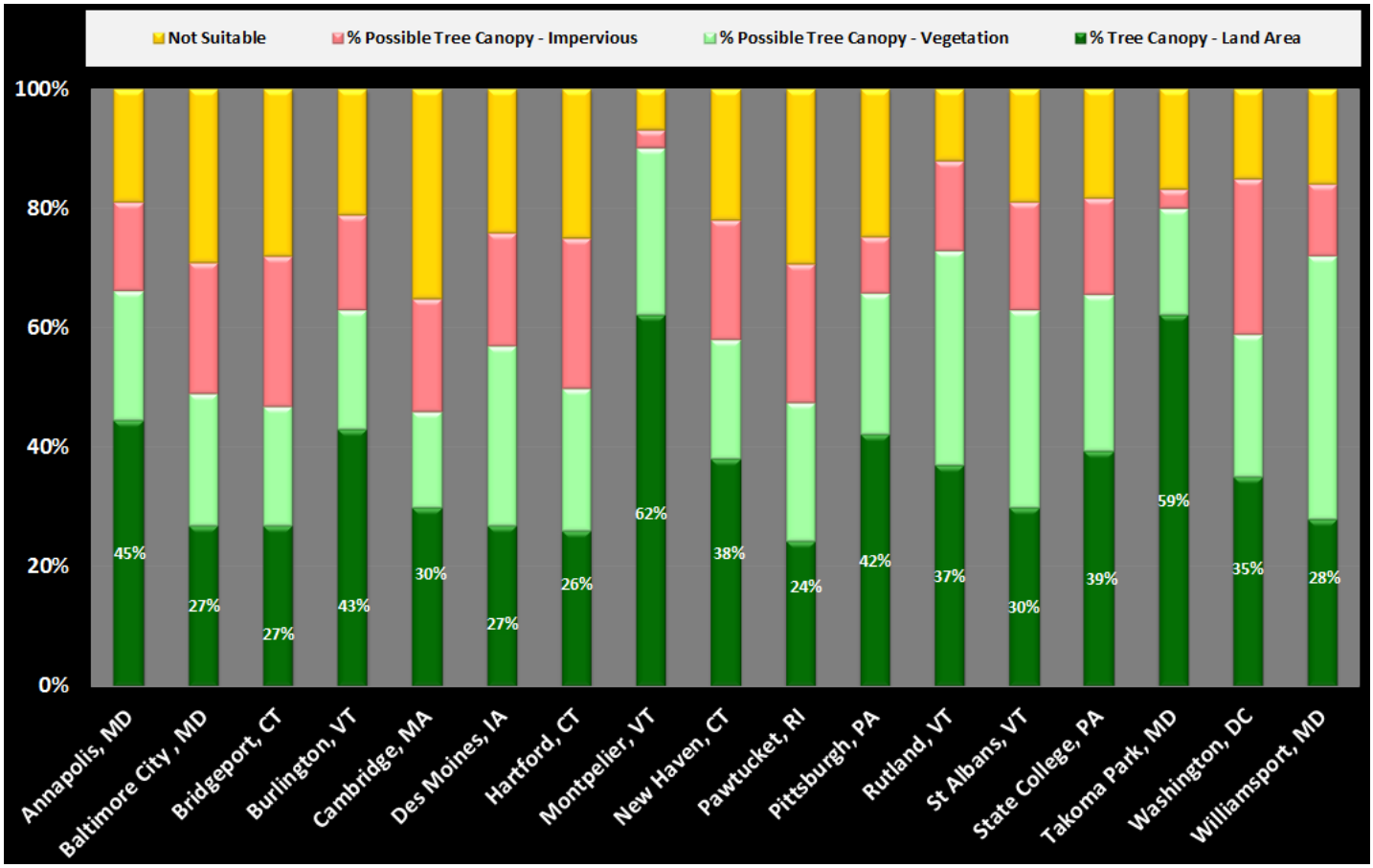


Figure 16: Comparison of Existing and Possible Tree Canopy with other similar cities that have completed Tree Canopy Assessments.

Prepared by:

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

Additional Information

This project was made possible by a grant provided by the Connecticut Department of Energy and Environmental Protection Division of Forestry and funding provided by Northeastern Area State and Private Forestry, U. S. Forest Service. For more info **http://nrs.fs.fed.us/urban/UTC/**

Spatial Analysis Lab Tree Canopy Assessment Team: Maddy Brumberg, Ernie Buford, Jon Cusick, Christoph Griesshammer, Ray Gomez, Sean MacFaden, Michelle Marasco, Alan McCarthy, Jarlath O'Neil-Dunne, Max Reis, Anna Royar, Harry Sandler, Will Seegers, Charles Souchuns, Brad Stewart, D.J. Westley, Rebecca Zeyzus and Adam Zylka.

University of Vermont Spatial Analysis Lab