# A Report on the City of New York'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 by improving water quality, saving energy, lowering city 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 and environmental quality. A tree canopy assessment is the first step in this goal-setting process, 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 New York Have?

An analysis of New York City's tree canopy based on land-cover data derived from high-resolution remotely-sensed data (Figure 1) found that 39,284 acres of the city were covered by tree canopy (termed Existing TC), representing 21% of the total land area. An additional 43% (81,982 acres) of the city could theoretically be modified (termed Possible TC) to accommodate tree canopy (Figure 2). In the Possible TC category, 25% (45,531 acres) of the city was classified as Impervious Possible TC and another 18% was Vegetated Possible TC (33,976 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.

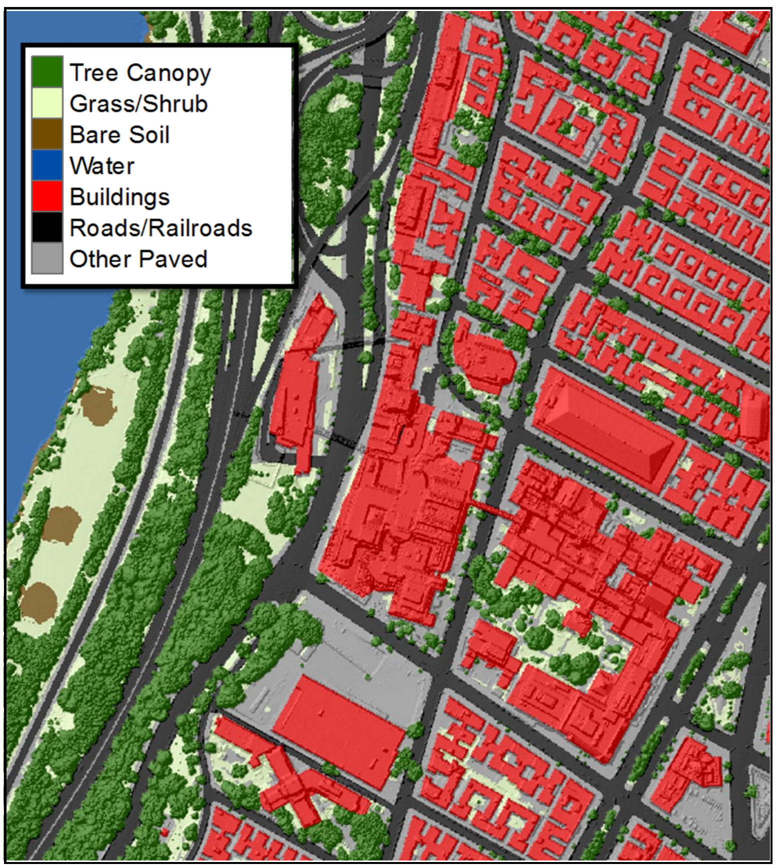



*Figure 1: Land cover derived from high-resolution remotely sensed data for New York City (Columbia University Medical Center and adjacent areas).*

## Project Background

The goal of the project was to apply the USDA Forest Service's Tree Canopy (TC) Assessment Protocols to the City of New York. The primary source of data for this assessment was Light Detection and Ranging (LiDAR) data acquired from April 14th to May 1st, 2010. The City of New York funded LiDAR acquisition, and the National Urban and Community Forestry Advisory Council (NUCFAC) and the National Science Foundation (NSF) funded subsequent tree canopy analyses. The assessment was performed by the Spatial Analysis Laboratory (SAL) at the University of Vermont's Rubenstein School of the Environment and Natural Resources. The analysis was conducted in collaboration with the New York City Department of Parks & Recreation, the New York City Urban Field Station, the USDA Forest Service's Northern Research Station, and Columbia University.

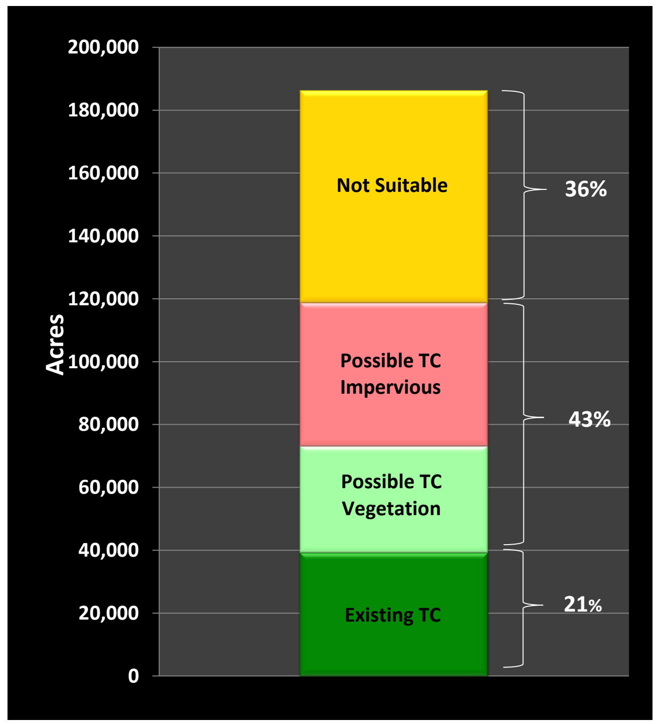



*Figure 2: TC metrics for New York City based on % of land area covered by each type.*

## 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 tree canopy present when viewed from above using aerial or satellite remote-sensing data.
**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.

# Mapping New York City's Tree Canopy

The first high-resolution assessment of New York City's tree canopy was conducted using 3-foot resolution imagery acquired in 2001 (Figure 3a). This study estimated the city's tree canopy to be 24% of its land area. One limitation of the 2001 study was that it relied entirely on aerial imagery (Figure 3a) containing deep shadows created by tall structures (e.g., buildings). The 2010 study relied primarily on LiDAR (Figure 3b). LiDAR sensors emit their own energy in the form of a laser. As such, LiDAR can effectively "see through" shadows, a key advantage in a city such as New York. Differences between the 2001 and 2010 tree-canopy estimates can be traced to three factors: 1) missed tree canopy in the 2001 dataset; 2) tree-canopy loss over the 9-year period; and 3) establishment of new tree canopy. Tree canopy missed by the 2001 dataset is attributable to the shadowing effect combined with limitations in the accuracy of the processing methods used at the time. These errors are evident when Figure 3d is compared to Figures 3e and 3f. The 2001 tree-canopy dataset failed to detect some tall trees (Figures 3d, e, f). The height of the trees (>50ft based in the 2010 LiDAR) suggests that these trees were well established in 2001 but were missed due to limitations in the source data and/or processing methods. It is important to note that the 2001 dataset did overestimate tree canopy in other areas, mistaking either grass or shrubs for tree canopy. Tree-canopy loss, due to a combination of invasive species, storm damage, and other factors, was quite extensive in various locations; the highlighted areas in Figures 3a, 3b, and 3c had extensive tree canopy in 2001 and 2008, but none in 2010. Canopy growth in existing trees combined with new tree plantings likely increased tree canopy in some areas. The fundamental differences between the 2001 and 2010 datasets make it difficult to definitively quantify the difference in canopy between the two periods, but based on a detailed analysis for a small area it appears that New York City has experienced a loss of tree canopy from 2001 to 2010.


*Figure 3: Comparison of 2001 and 2010 imagery and tree-canopy data, Duke Ellington Circle and adjacent areas. Figure 3a shows the imagery used to derive the first tree-canopy dataset, which is shown in Figure 3d. Figure 3b shows a normalized digital surface model (nDSM) derived from LiDAR, which represents the height of features relative to the ground. LiDAR served as the basis for the 2010 tree canopy shown in Figure 3e. Figure 3c shows the most recent aerial imagery available at the time of analysis. Figure 3f shows the 2001 tree canopy overlaid on the 2010 tree canopy. Differences are due to a combination of tree-canopy loss between the two time periods, missed tree canopy in 2001, and new tree canopy resulting from either growth or tree plantings.*

## Boroughs Analysis

The Existing and Possible TC estimates were summarized for all five boroughs of New York City (Figures 4,5). Not surprisingly, Staten Island has the highest percentage of its land area covered by tree canopy, at 30%. Despite its status as one of the most densely-populated urban areas in the United States, Manhattan does not have the lowest Existing TC; its estimate of 20% is higher than the estimates for both Queens (18%) and Brooklyn (16%). This difference is perhaps attributable to the presence of Central Park and other well-forested parklands (e.g., Inwood Hill Park). The lower Existing TC estimates for Queens and Brooklyn are partly to islands and salt marshes in Jamaica Bay that support little or no tree canopy. With a lower urban density than the other boroughs, Staten Island has the largest area of Possible TC, but this estimate is only marginally greater than the estimates for the Bronx, Brooklyn, and Queens. Manhattan, with its extensive matrix of buildings and roads, predictably has the lowest Possible TC. This borough analysis provides a useful strategic perspective on the city, but it obscures unique neighborhood- and parcel-level patterns.

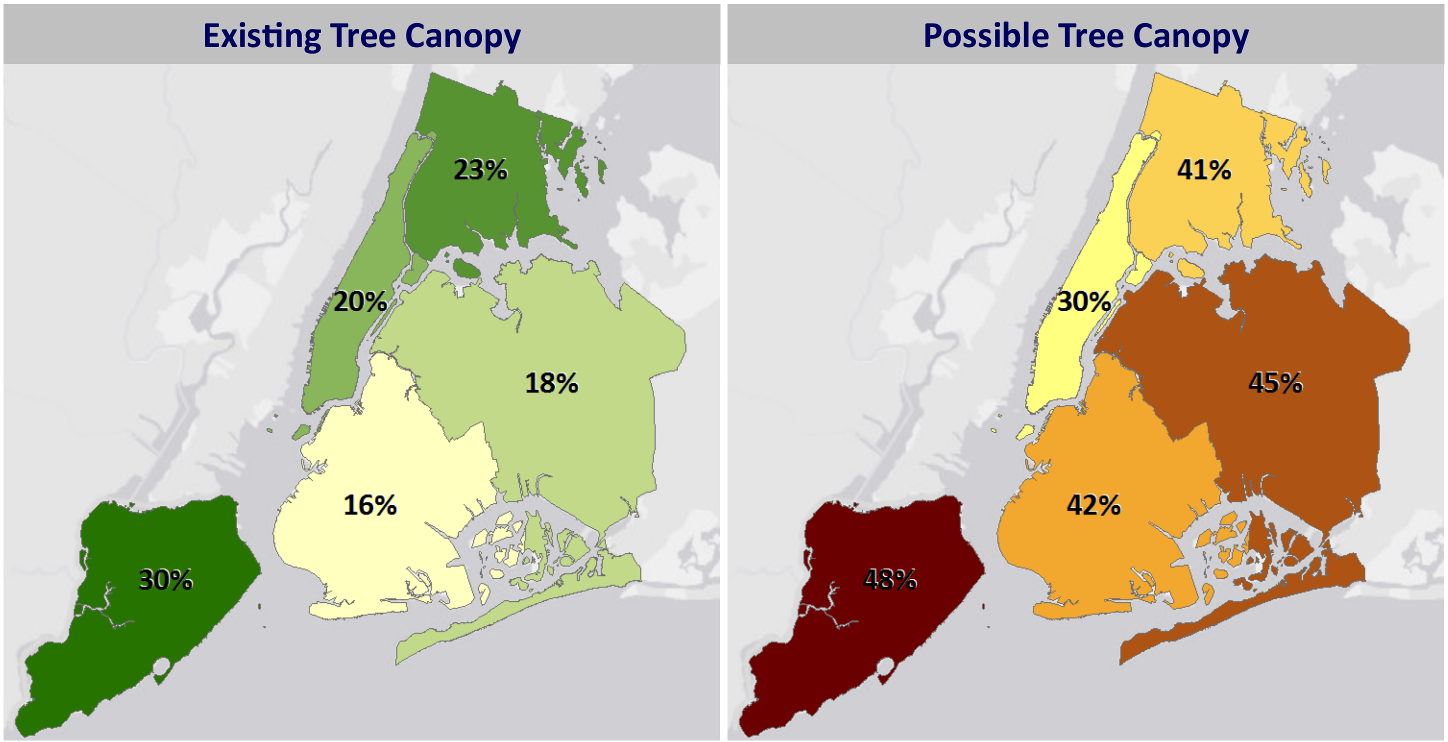



*Figure 4. Existing TC (left) and Possible TC (right) as a percentage of land for each New York City borough.*

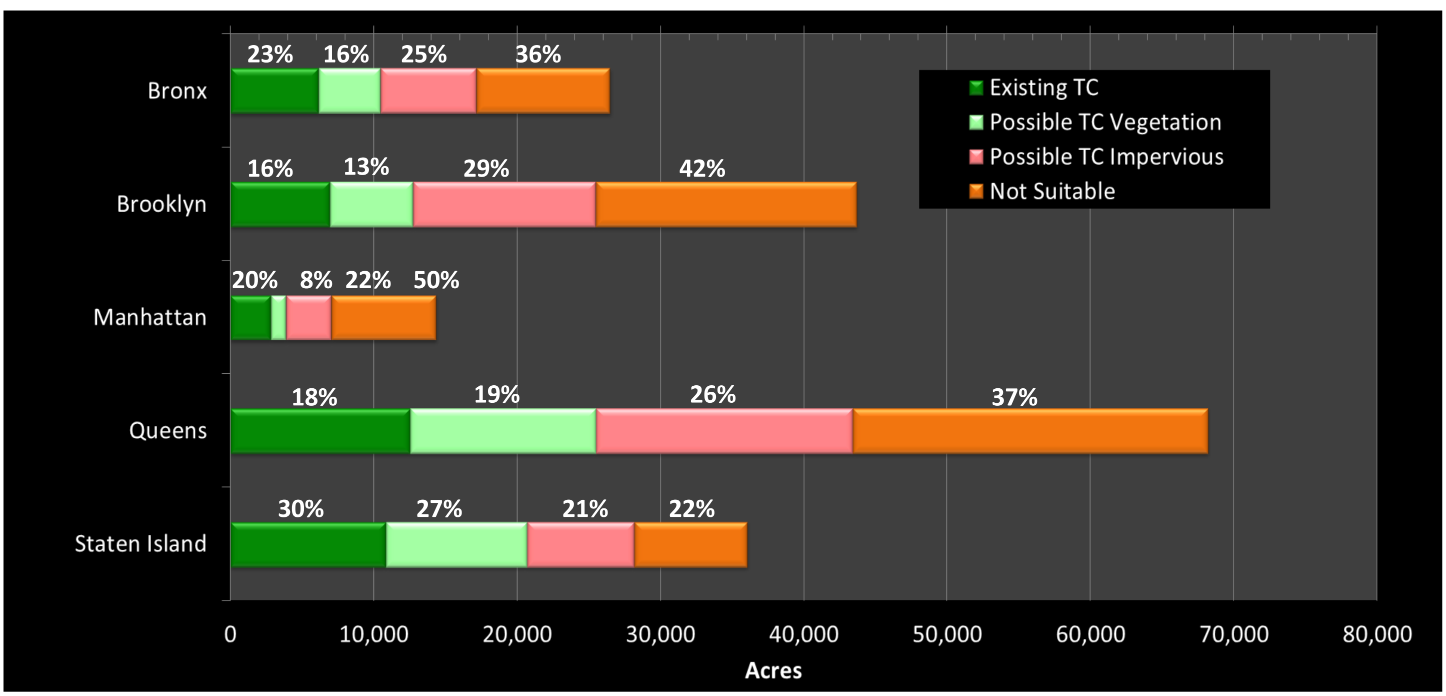



*Figure 5: Tree-canopy assessment acreages by borough. The "not suitable" category includes buildings and roads, where establishment of new tree canopy is unlikely.*

# Neighborhood Projection Areas

At a finer scale, tree-canopy estimates were summarized by the Neighborhood Projection Areas developed for PlaNYC (Figures 6,7). Areas that encompass forested parkland (e.g., Central Park, Todt Hill-Emerson Hill-Heartland Village) predictably contain high volumes of Existing TC and low Possible TC, while dense commercial districts have relatively few trees and few opportunities to expand tree canopy (e.g., Flatiron-Union Square-Chelsea). Other areas exhibit a more complex relationship between Existing and Possible TC. For example, the Marine Park-Floyd Bennett Field and Schuylerville-Throgs Neck-Edgewater areas contain large parks but have only a low-to-moderate level of tree canopy, and both neighborhoods theoretically have high Possible TC estimates. However, it is important to consider that these areas have non-forested open space amenities (e.g., recreational fields, golf courses, managed grasslands) that would have to balanced with any tree-planting programs. The densely-urban area of Hunters Point-Sunnyside-West Maspeth has low Existing TC but moderate Possible TC, suggesting that this area could be a priority for tree planting. The Forest Hills area would likely be a lower priority (i.e., high Existing TC, low Possible TC).

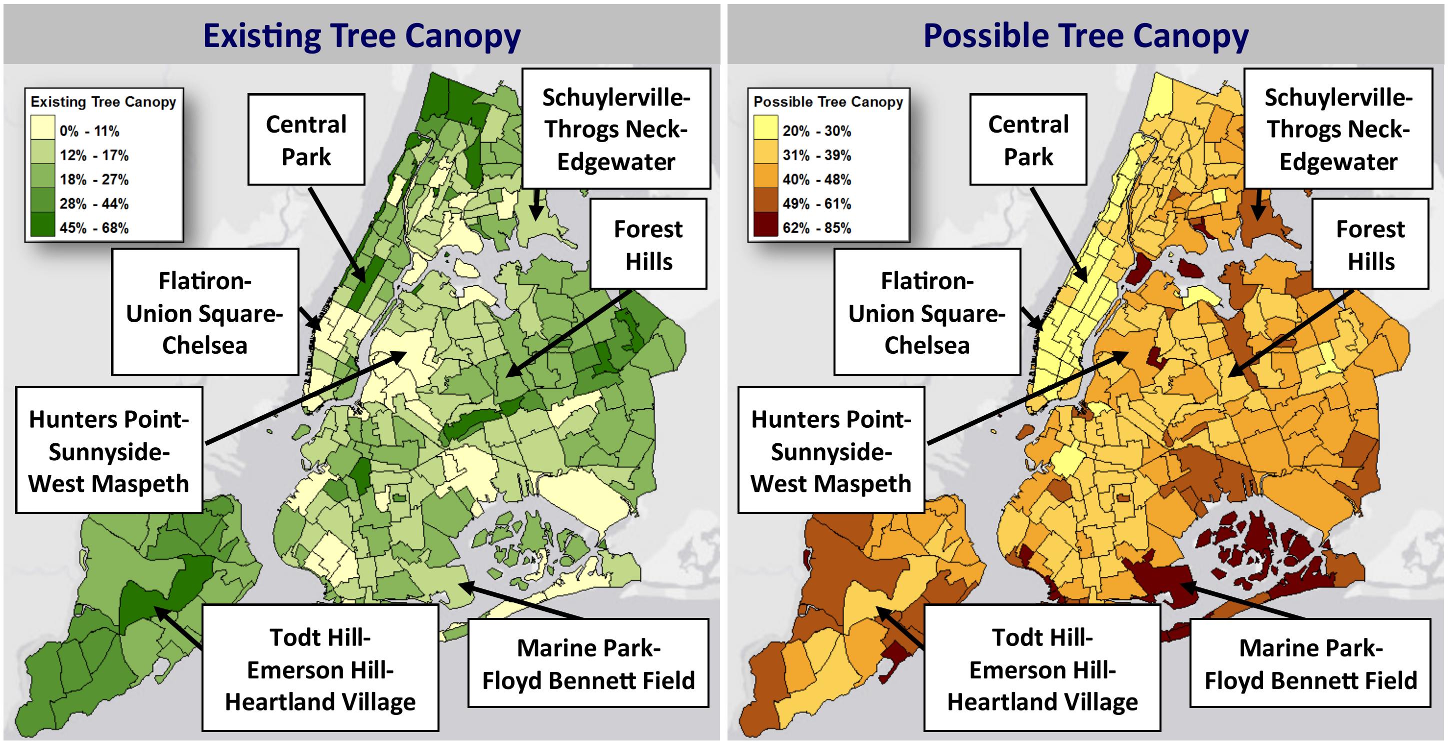



*Figure 6. Existing TC (left) and Possible TC (right) as a percentage of land for the city's Neighborhood Projection Areas.*

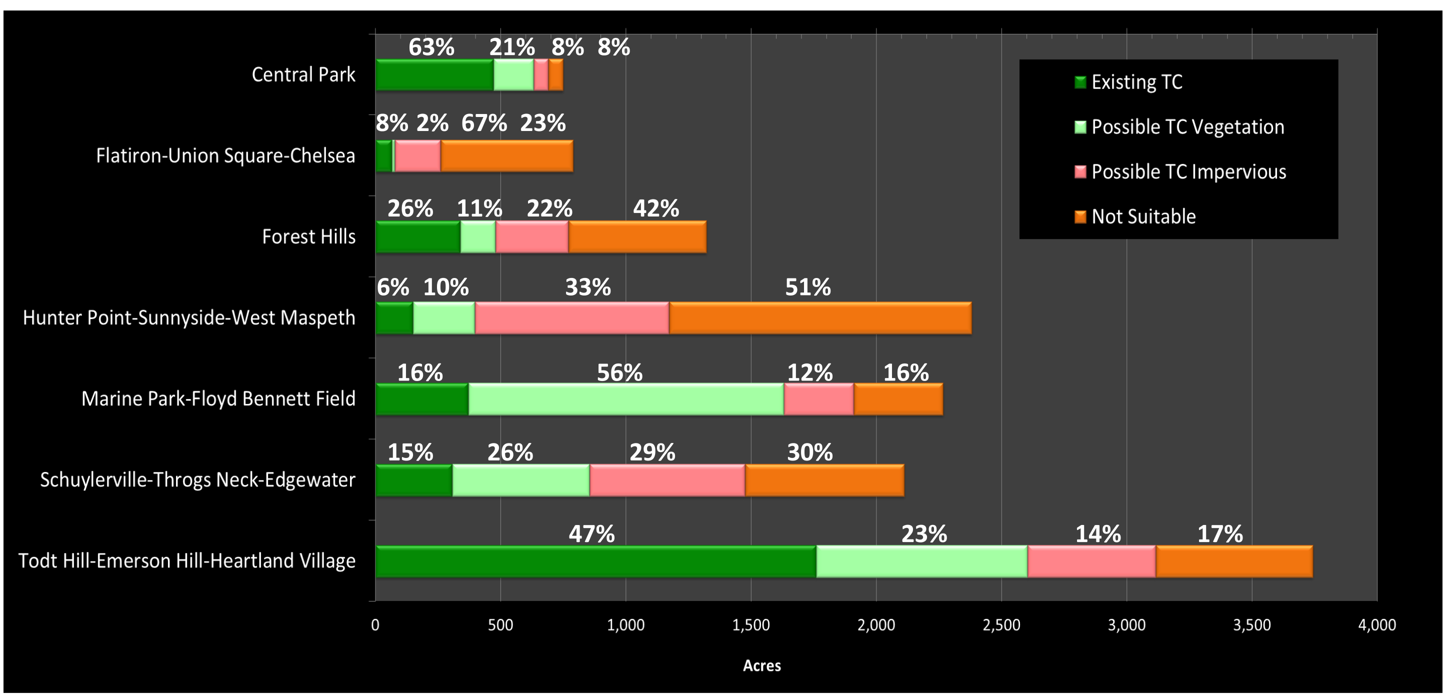



*Figure 7: Tree-canopy assessment acreages for selected city Neighborhood Projection Areas. The "not suitable" category includes buildings and roads, where establishment of new tree canopy is unlikely.*

# Public Right-of-Way Analysis

Analysis of the city's Neighborhood Projection Areas can be refined by considering trees in publicly-owned rights-of-way (PROWs). This distinction is important because the city can play a more direct role in tree-planting efforts on publicly-owned lands or lands with city-held transportation easements. Sidewalks and medians in particular can be important locations for "street" trees, individual trees planted along roads and other transportation corridors. Overall, tree canopy is distributed more broadly in PROWs (Figures 8,9), reflecting the city's commitment to expanding tree canopy with street trees. However, some of the same densely-urban areas identified in the original analysis (e.g., Hunters Point-Sunnyside-West Maspeth) have comparatively little tree canopy in the PROW, suggesting that tree-planting efforts could be beneficial. Possible TC is also more evenly distributed in the city-wide map, indicating that opportunities for expanded tree canopy exist in PROWs throughout the city. Large expanses in park-dominated regions (e.g., Schuylerville-Throgs Neck-Edgewater) again show high Possible TC, suggesting that PROWs could complement other tree-planting opportunities in these areas.

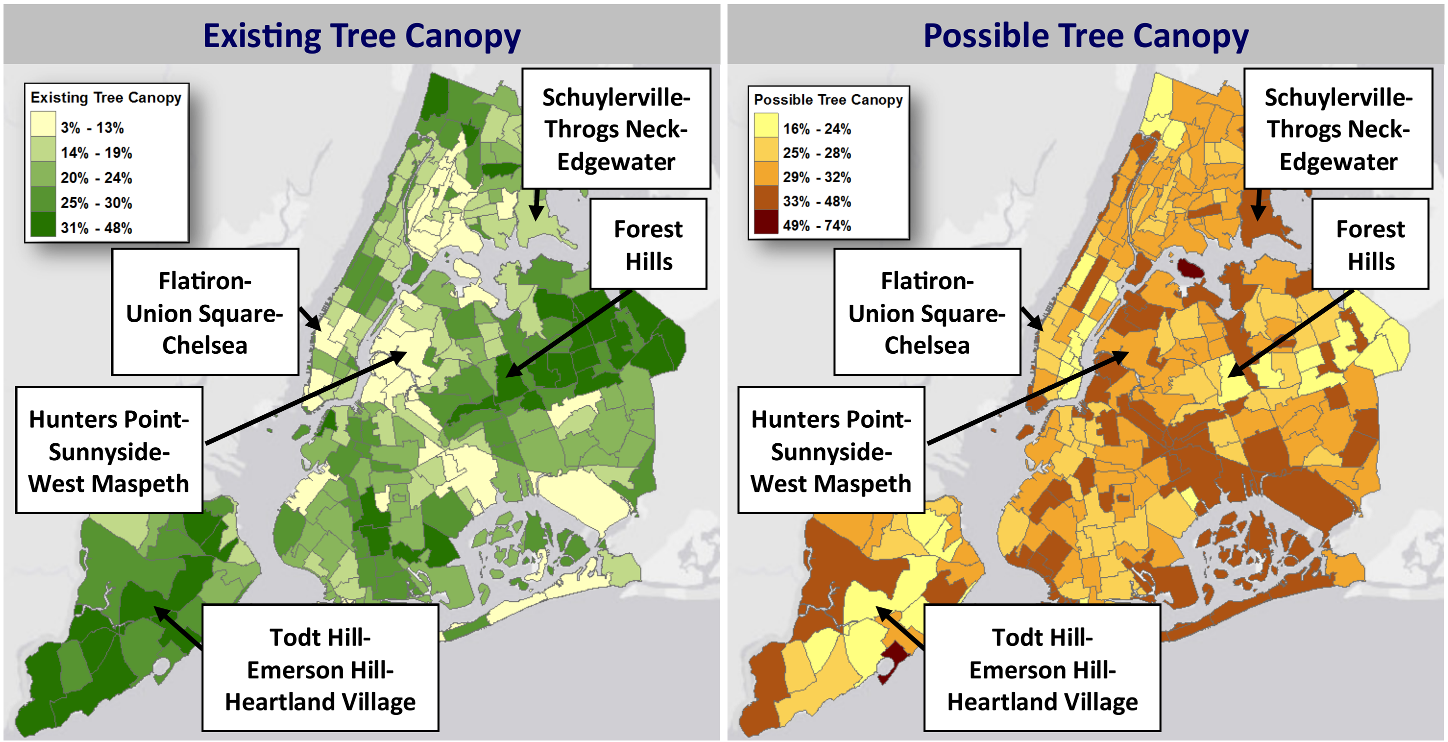



*Figure 8. Existing TC (left) and Possible TC (right) as a percentage of land for public rights-of-way in Neighborhood Projection Areas*

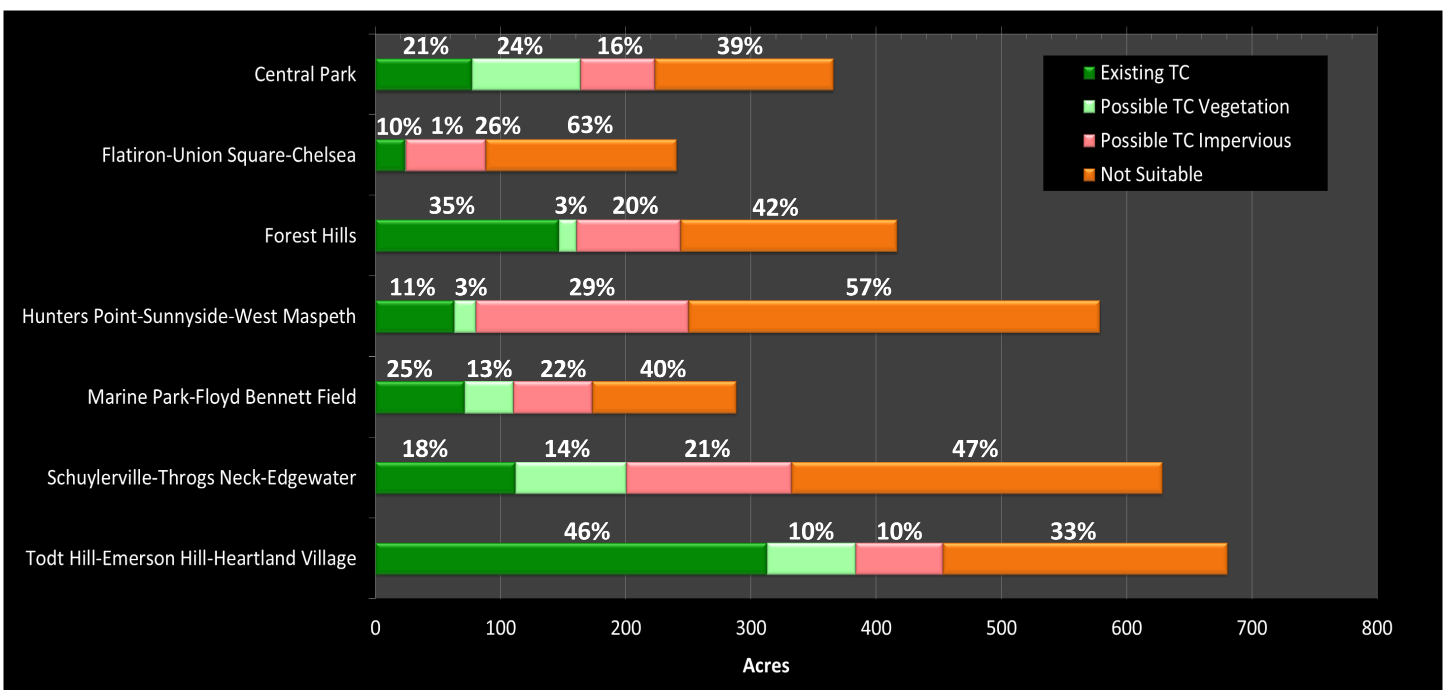



*Figure 9: Tree-canopy assessment acreages for public rights-of-way in selected Neighborhood Projection Areas. The "not suitable" category includes buildings and roads, where establishment of new tree canopy is unlikely.*

## Green Infrastructure Priority Combined Sewersheds

When summarized by combined sewer drainage areas, the TC estimates can be used to identify the sewersheds with the greatest potential for greening. The Flushing Creek and Alley Creek sewersheds have the largest proportion of Existing TC, followed by Bergen Thurston and Bronx River (Figures 10,11). The largest sewershed, East River\Open Water, falls into an intermediate category while the Newtown Creek sewershed has the lowest Existing TC. Because Newtown Creek also contains a large proportion of Possible TC, this sewershed would theoretically rank as one of the highest priorities for green-infrastructure expansion. Other important sites would likely be Westchester Creek and Jamaica Bay Tributaries (i.e., low Existing TC, high Possible TC). Encompassing most of Manhattan and Brooklyn and part of the Bronx, the East River\Open Water sewershed contains the largest total area of developed features not suited to tree-canopy expansion, but it too has ample opportunities for tree planting, particularly its Possible TC-Impervious component. These features include sidewalks, medians, and parking lots that could theoretically be modified to support individual trees and bioswales without impairing their essential transportation-related functions.

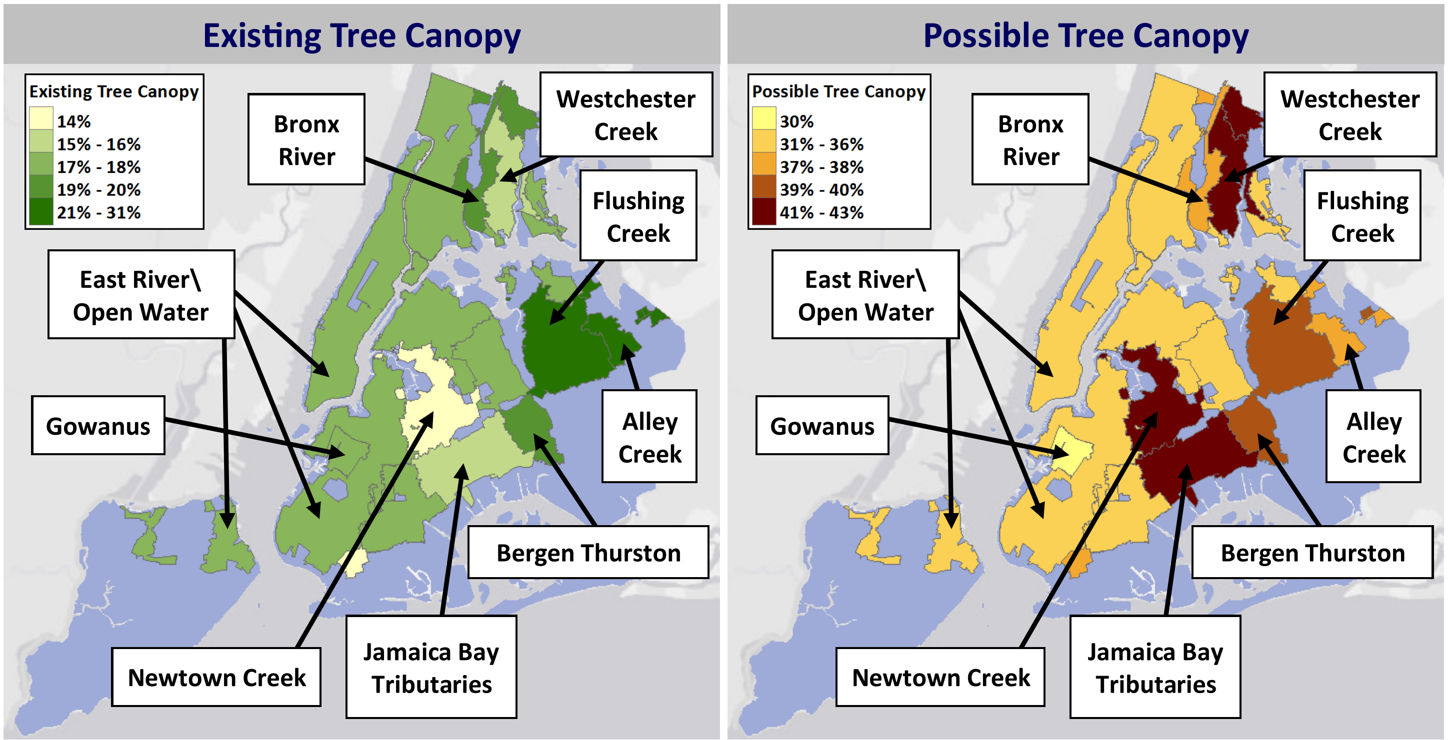



*Figure 10. Existing TC (left) and Possible TC (right) as a percentage of land for green infrastructure priority combined sewer drainage areas.*

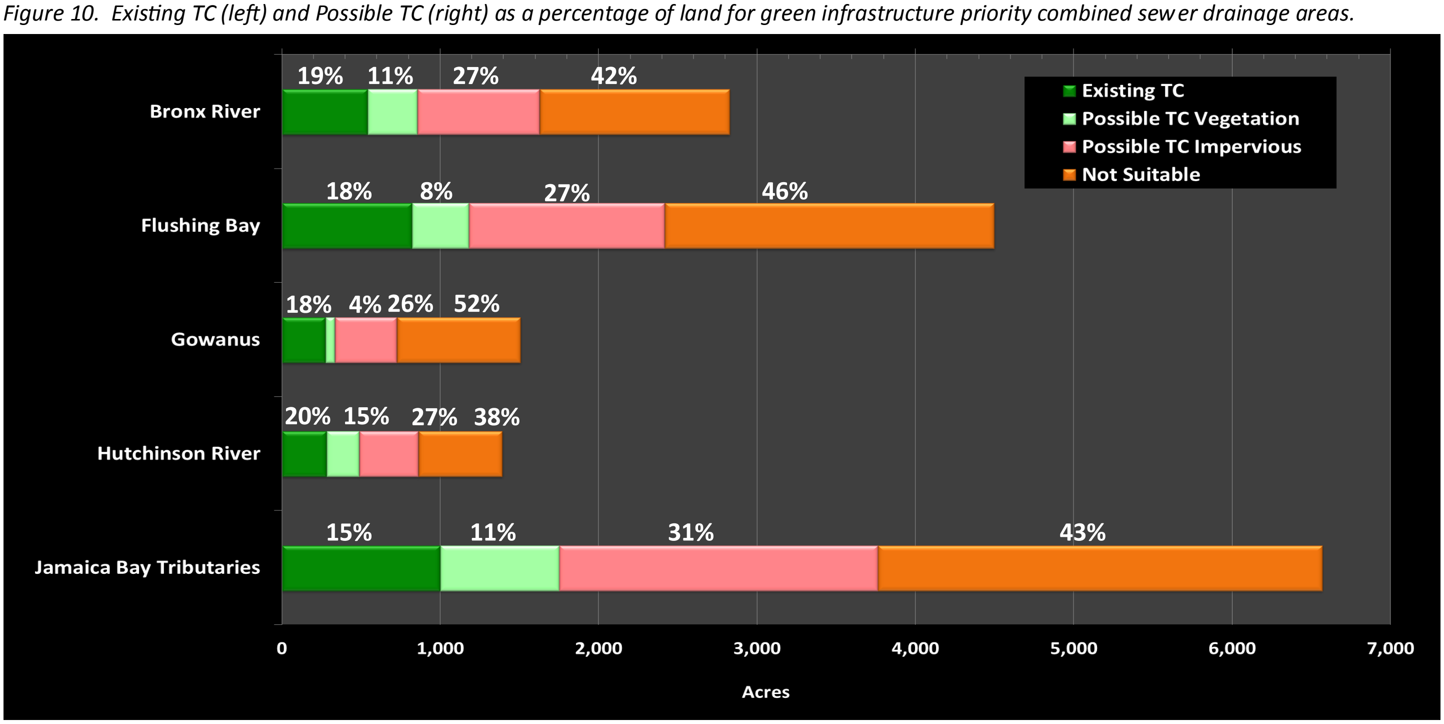



*Figure 11: Tree-canopy assessment acreages for selected green infrastructure priority combined sewer drainage areas. The "not suitable" category includes buildings and roads, where establishment of new tree canopy is unlikely.*

# Department of Parks & Recreation Properties

The New York City Department of Parks & Recreation (DPR) owns thousands of properties in the city, including world-renowned urban parks (e.g., Central Park, Prospect Park), small neighborhood parks, playgrounds, recreational fields and courts, gardens, natural areas, beaches, and parkways. Accordingly, DPR owns and manages a large proportion of the city's trees. The largest properties, encompassing large expanses of trees intermixed with recreational facilities, generally have the largest Existing TC totals (Figure 12). In contrast, many of the smallest properties tend to be developed playgrounds or fields where tree cover is sparse. This pattern is reversed for Possible TC, with many of the largest properties having fewer opportunities for tree-canopy expansion. Exceptions include beaches, golf courses, and extensive playing fields. It is important to reiterate that Possible TC only indicates where, under the right social, political, environmental, and economic conditions, existing land uses could theoretically be modified to support additional trees. Tree-planting programs would thus work to complement rather than replace non-forested recreational amenities.

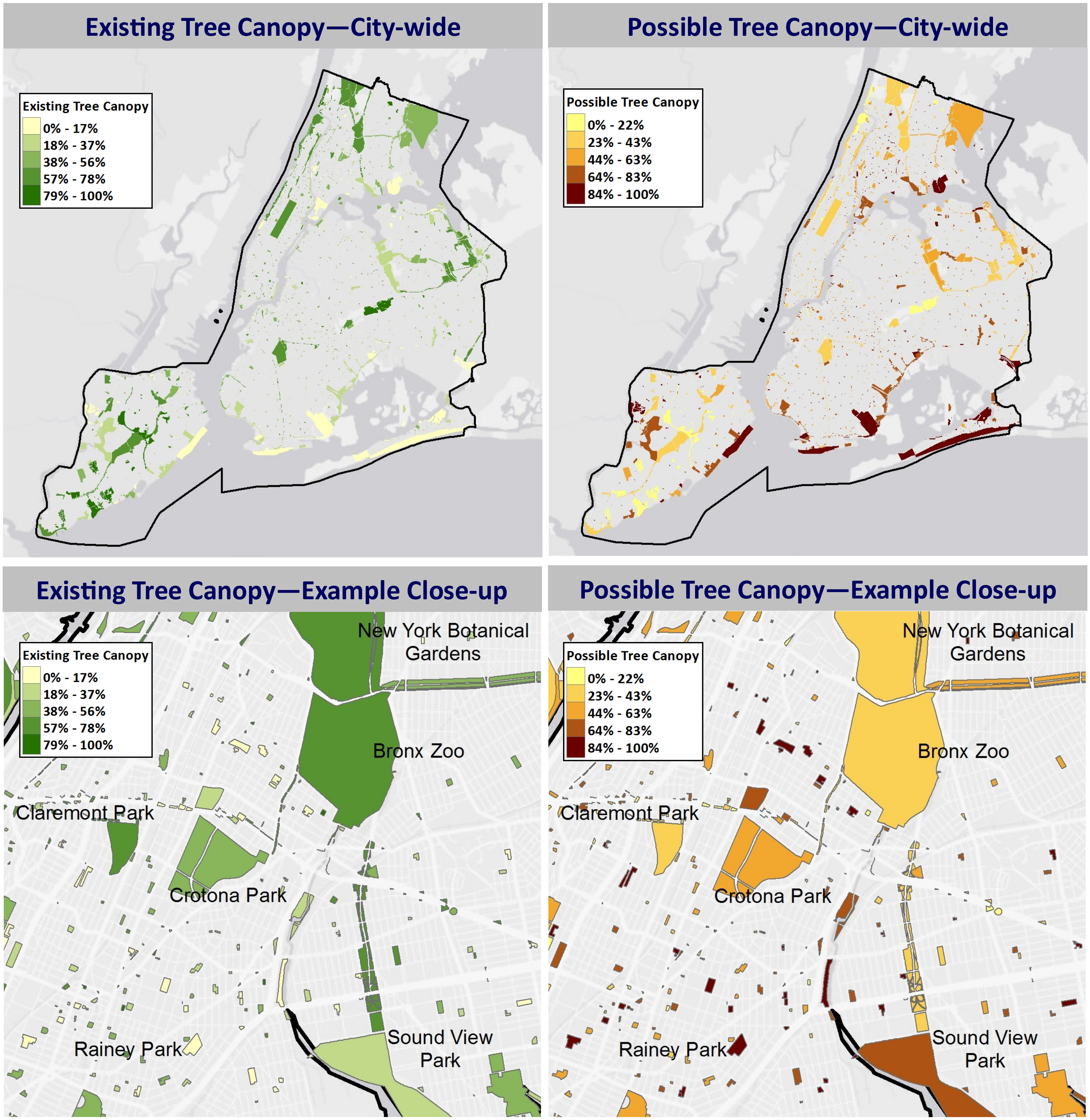



*Figure 12: Tree-canopy assessment for New York City Department of Parks & Recreation (DPR) lands: Existing TC (left) and Possible TC (right) as a percentage of land for DPR-owned properties.*

## Ownership—Primary Land Use Tax Lot Output (PLUTO)

The New York City Department of City Planning (DCP) maintains a database called the Primary Land Use Tax Output (PLUTO) system. This database stores the boundaries for each property parcel in the city, along with accompanying attribute information describing land use, physical address, and assessed value, and thus can serve as a fine-scale geography for examining local patterns in tree canopy (Figure 13). It enables evaluation of Existing and Possible TC between individual ownership parcels, providing site-specific information that is essential to the planning and management of tree-planting programs. It can also be used to show how tree-canopy patterns are clustered across neighborhoods and, when aggregated to broader scales, the city at large (Figure 15, Table 1). Such information is essential not only for prioritizing sites where tree planting is feasible but also where additional trees are most likely to provide tangible environmental and social benefits.

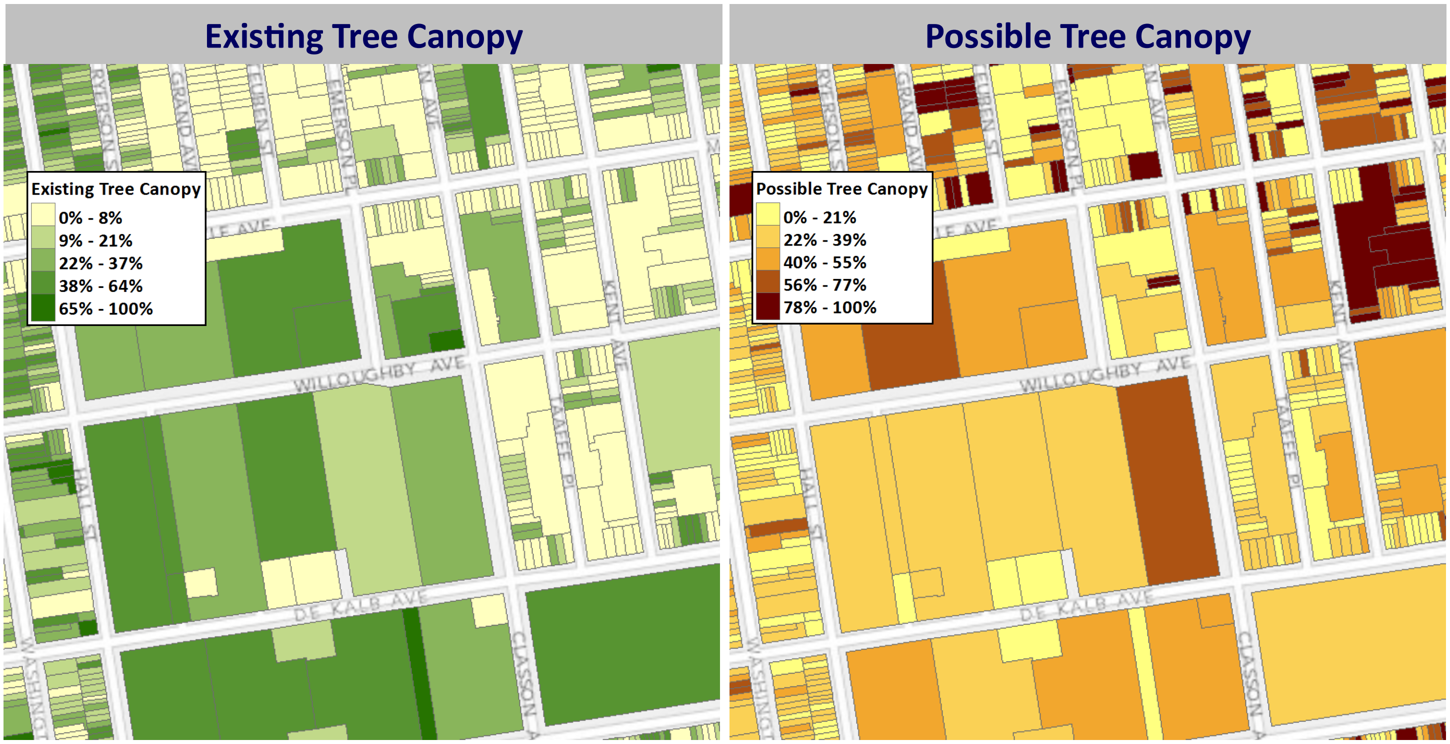
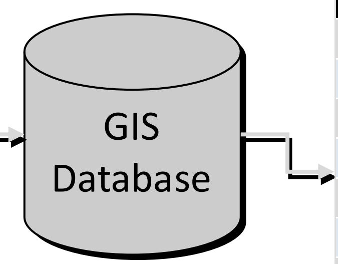



*Figure 13: Tree-canopy assessment for New York City Department of City Planning (DCP) tax-lot database (PLUTO): Existing TC (left) and Possible TC (right) as a percentage of land within individual parcels.*

## Decision Support


Parcel-based tree-canopy metrics were integrated into the city's PLUTO database (Figure 14). Decision makers can use GIS to query specific tree-canopy 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 tree canopy improvement goals for an individual property.




| Attribute | Value |
|---|---|
| Owner | NYC DPR |
| Land Use | Park |
| Address | 3036 Johnson Ave. |
| Tax Status | Exempt |
| Assessed Value | $3,798,000 |
| Existing Tree Canopy | 75% |
| Pervious Surfaces | 23% |
| Impervious Surfaces | 2% |
| Possible Tree Canopy | 25% |

*Figure 14: GIS 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.*

# Land Use

The land-use designations in PLUTO include various residential, commercial, industrial, public facilities, and open space classes (Figure 15, Table 1). The One & Two Family Buildings residential class constitutes the single largest class by land area, followed by the Open Space and Outdoor Recreation class. Not surprisingly, these classes contain the largest total areas of Existing TC, but they also contain the largest areas of Possible TC. Other residential classes similarly have high proportions of Possible TC, emphasizing the importance of residential, privately-owned lands to successful protection and expansion of tree canopy in the city. Additional opportunities for expanding tree canopy occur on publicly-owned, institutional, and transportation-related lands, where coordinated tree-planting programs are perhaps more feasible and effective. The Vacant Land class also provides opportunities for tree planting, especially as part of re-development plans that seek to augment the built environment with elements of the green infrastructure. These city-wide trends can help guide changes in zoning and development policies that increase tree cover.

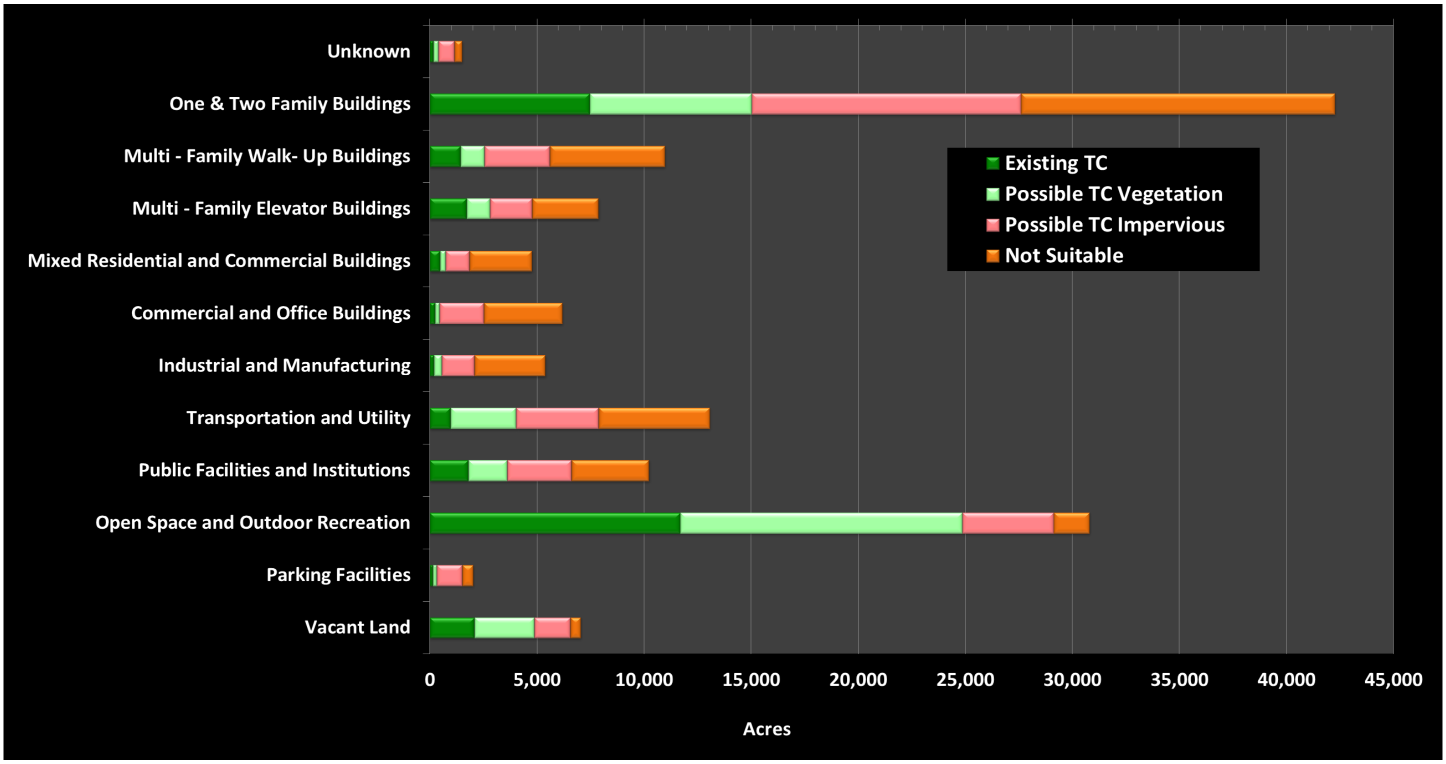



*Figure 15: Tree Canopy (TC) metrics summarized by land use.*

| Land Use | Existing TC | | | Possible TC Vegetation | | | Possible TC Impervious | | |
|---|---|---|---|---|---|---|---|---|---|
| | % Land | % Category | % TC Type | % Land | % Category | % TC Type | % Land | % Category | % TC Type |
| **Unknown** | 0% | 12% | 1% | 1% | 64% | 1% | 0% | 16% | 1% |
| **One & Two Family Buildings** | 5% | 18% | 26% | 14% | 48% | 29% | 5% | 18% | 24% |
| **Multi - Family Walk- Up Buildings** | 1% | 13% | 5% | 3% | 38% | 6% | 1% | 10% | 4% |
| **Multi - Family Elevator Buildings** | 1% | 22% | 6% | 2% | 39% | 4% | 1% | 14% | 3% |
| **Mixed Residential and Commercial Buildings** | 0% | 10% | 2% | 1% | 28% | 2% | 0% | 5% | 1% |
| **Commercial and Office Buildings** | 0% | 4% | 1% | 2% | 37% | 3% | 0% | 3% | 1% |
| **Industrial and Manufacturing** | 0% | 4% | 1% | 1% | 35% | 3% | 0% | 7% | 1% |
| **Transportation and Utility** | 1% | 8% | 3% | 5% | 53% | 10% | 2% | 23% | 10% |
| **Public Facilities and Institutions** | 1% | 18% | 6% | 3% | 47% | 7% | 1% | 18% | 6% |
| **Open Space and Outdoor Recreation** | 8% | 38% | 41% | 12% | 57% | 25% | 9% | 43% | 41% |
| **Parking Facilities** | 0% | 8% | 1% | 1% | 67% | 2% | 0% | 8% | 1% |
| **Vacant Land** | 1% | 30% | 7% | 3% | 64% | 7% | 2% | 40% | 9% |

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

The % Land Area value of 1% indicates that 1% of New York City's land area is covered by tree canopy in the Multi-Family Elevator Buildings land-use class.

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

The % Land value of 22% indicates that 22% of land in the Multi-Family Elevator Buildings land-use class 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 6% indicates that 6% of all tree canopy is in the Multi-Family Elevator Buildings land-use class.

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

# Conclusions

- Despite its size and dense urban environment, more than 21% of New York City's land area is occupied by tree canopy. These trees help moderate stormwater runoff, ambient air temperatures, and air pollution while also providing aesthetic, economic, and recreational benefits.
- With an extensive built environment devoted to residential, commercial, and developed land uses, 36% of the city's land area includes developed features that are unsuited for additional trees, including buildings and the transportation infrastructure. Although green rooftops with trees are an important and expanding urban feature, they are unlikely to constitute a significant proportion of the city's tree canopy in the near term.
- Other landscape features nonetheless provide many opportunities for expanding tree cover, including lawns, the margins of fields, sidewalks, street medians, and parking lots. Together, these features constitute 43% of the city.
- A primary advantage of this assessment protocol is that it can summarize tree canopy according to many different landscape geographies, which helps elucidate current TC patterns and to prioritize tree-planting efforts. These geographies range from fine-scale descriptors such as individual ownership parcels to coarse-scale political boundaries such as boroughs.
- At an intermediate scale, neighborhoods provide an effective overview of both the city's tree-canopy distribution and its opportunities for additional planting. Further analysis of public rights-of-way within neighborhoods is also informative, identifying concentrations of Possible TC that are directly controlled by the city. While expansion of tree canopy on privately-owned lands is an important goal in its own right, coordinated tree-planting programs will likely be most efficient and effective on publicly-controlled lands.
- NYC DPR is an important land manager in New York City, owning a variety of woodland, open field, and recreational features. Opportunities for expanding tree canopy likely exist on these lands but must be balanced with maintenance of socially-desirable recreational amenities and ecologically-significant non-forested features such as grasslands and wetlands.

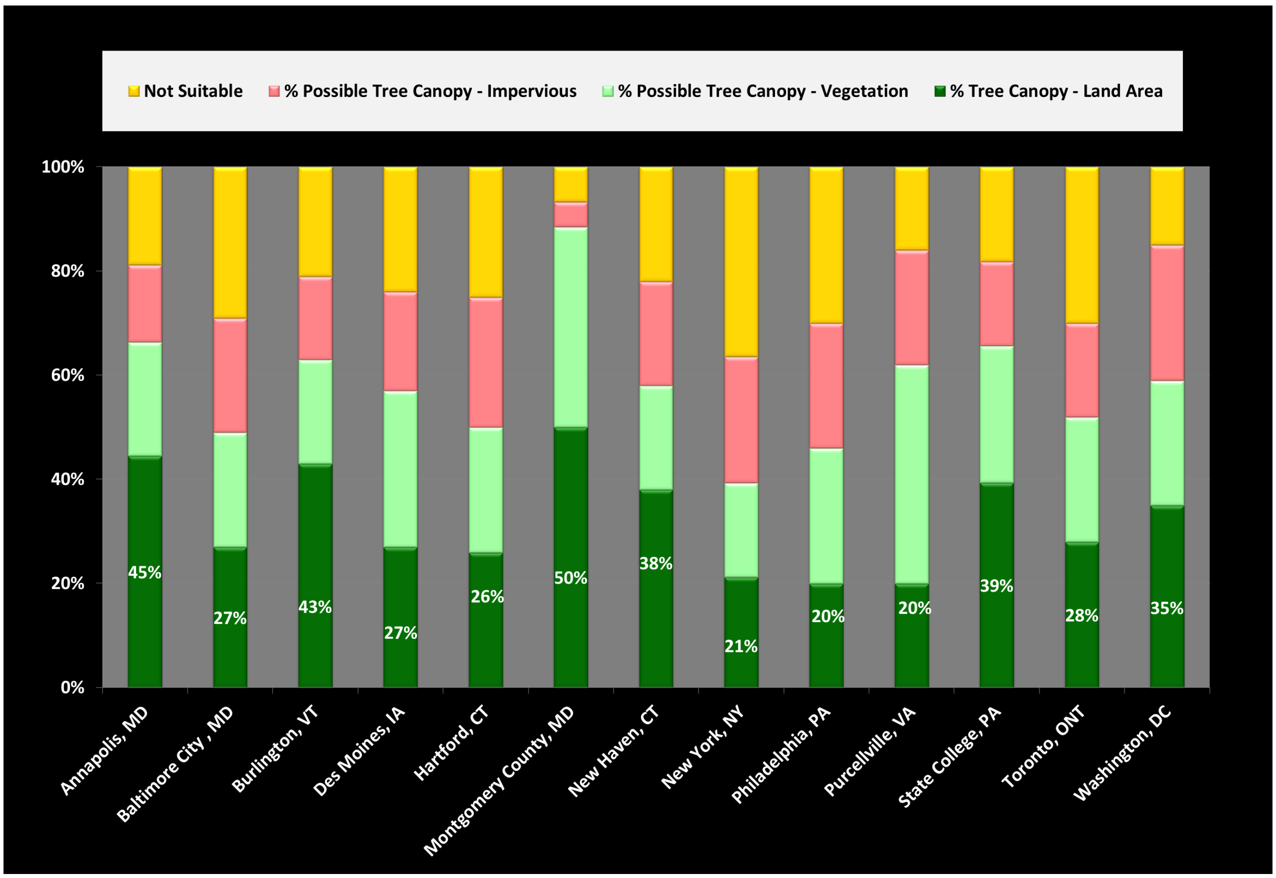



*Figure 16: Comparison of Existing and Possible TC with other selected cities that have completed tree-canopy assessments.*

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## Additional Information


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**http://nrs.fs.fed.us/urban/utc/**



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