Tree Canopy Assessment

Philadelphia, PA

December 3, 2019

THE NEED FOR GREEN

Philadelphia is facing a host of environmental challenges, from stormwater runoff to the urban heat island effect. At the same time, the City is seeking to become more livable and sustainable to attract companies and residents while ensuring equitable access to environmental amenities.

Trees provide a plethora of ecosystem services. Their canopies provide habitat for wildlife, the transpiration process reduces summer temperatures, and research shows that they can even improve social cohesion and reduce crime. A healthy and robust tree canopy is crucial to the sustainability and livability of our communities.

TREE CANOPY ASSESSMENT

For decades governments have mapped and monitored their infrastructure to support effective management. That mapping has primarily focused on gray infrastructure, features such as roads and buildings. The Tree Canopy Assessment protocols were developed by the USDA Forest Service to help communities develop a better understanding of their green infrastructure through tree canopy mapping and data analytics. Tree canopy is defined as the layer of leaves, branches, and stems that provide tree coverage of the ground when viewed from above. When integrated with other data, such as property land use or demographic variables, a Tree Canopy Assessment can provide vital information to help governments and their citizens chart a greener future. Tree Canopy Assessments have been carried out for over 80 communities in North America. This study assessed tree canopy for the City of Philadelphia over the 2008-2018 time period.

FINDINGS

Philadelphia's tree canopy has declined in 2018 relative to 2008 levels. Although gains were made they were outpaced by losses.

Tree canopy loss is not evenly distributed nor similar. It varies from backyard individual tree removal to the clearing of large patches for new construction.

More tree canopy was lost on residential lands than any other land use type. Residential land also has the most room for establishing new tree canopy.

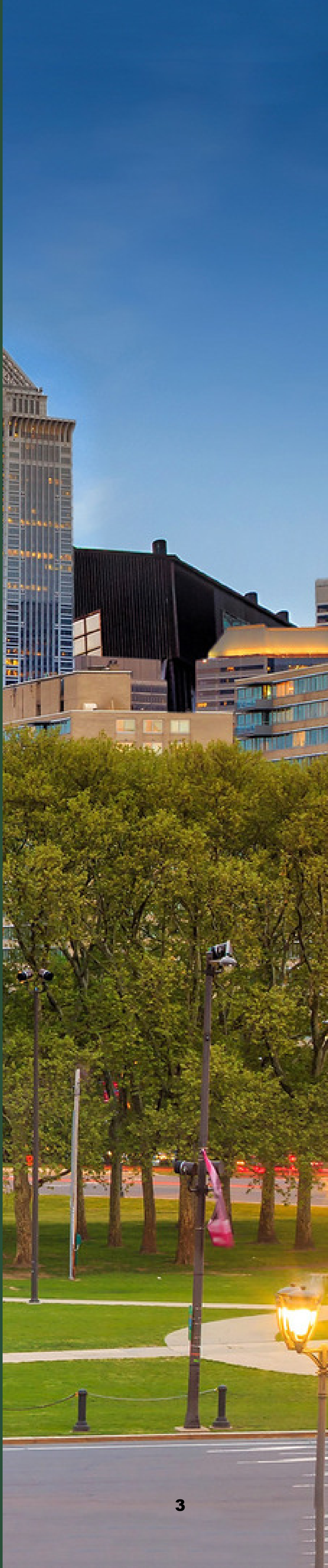
Urbanization, land use, landowner decisions, and construction all play a role in influencing the current state of tree canopy in the city.

Gains were largely limited to individual trees and small patches whereas losses ranged from individual trees to large tracts of forested land.

Street trees provide crucial ecosystems services; the substantial losses of tree canopy within the vicinity of roads is cause for concern.

Tree canopy is declining overall but the story is more nuanced. There were 1,980 acres of tree canopy gained and 3,075 acres of tree canopy lost.

The tree canopy is trending in the wrong direction if the City wishes to achieve its goal of 30% coverage for each neighborhood.



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RECOMMENDATIONS

Preserving existing tree canopy is the most effective means for securing future tree canopy, as loss is an event but gain is a process.

Planting new trees in areas where tree canopy is low or in locations where there has been tree canopy removed will help the City to recover its recent losses.

Having trees with a broad age distribution and a variety of species will ensure that a robust and healthy tree canopy is maintained over time.

The City's residents are crucial if tree canopy is to be maintained over time. Having a populace that is knowledgeable about the value and services trees provide will help the City stay green for years to come.

Integrate the tree canopy change assessment data into planning decisions at all levels of government.

Reassess the tree canopy at 5-10 year intervals to monitor change.

Tree canopy assessments require high-quality, high-resolution data. Continue to invest in LiDAR and imagery to support these assessments and other mapping needs.

Field data collection efforts should be used to compliment this assessment as information on tree species, size, and health can only be obtained through on-the-ground inventories.

TREE CANOPY BY THE NUMBERS

Philadelphia lost 1095 acres of tree canopy
18,450 acres in 2008 to 17,356 in 2018

OVER THE PAST DECADE

6%

LOSS IN TREE CANOPY

The amount of tree canopy lost is the equivalent of over 1,000 football fields worth.

Tree canopy change metrics include two measures:

Area Change - the change in the area of tree canopy between the two time periods. The city lost 1,095 acres of tree canopy over the ten years.

Relative % Change - the relative gain or loss of tree canopy using 2008 as the base year. Relative to the 2008 amount of tree canopy, the city's tree canopy decreased by 6%.

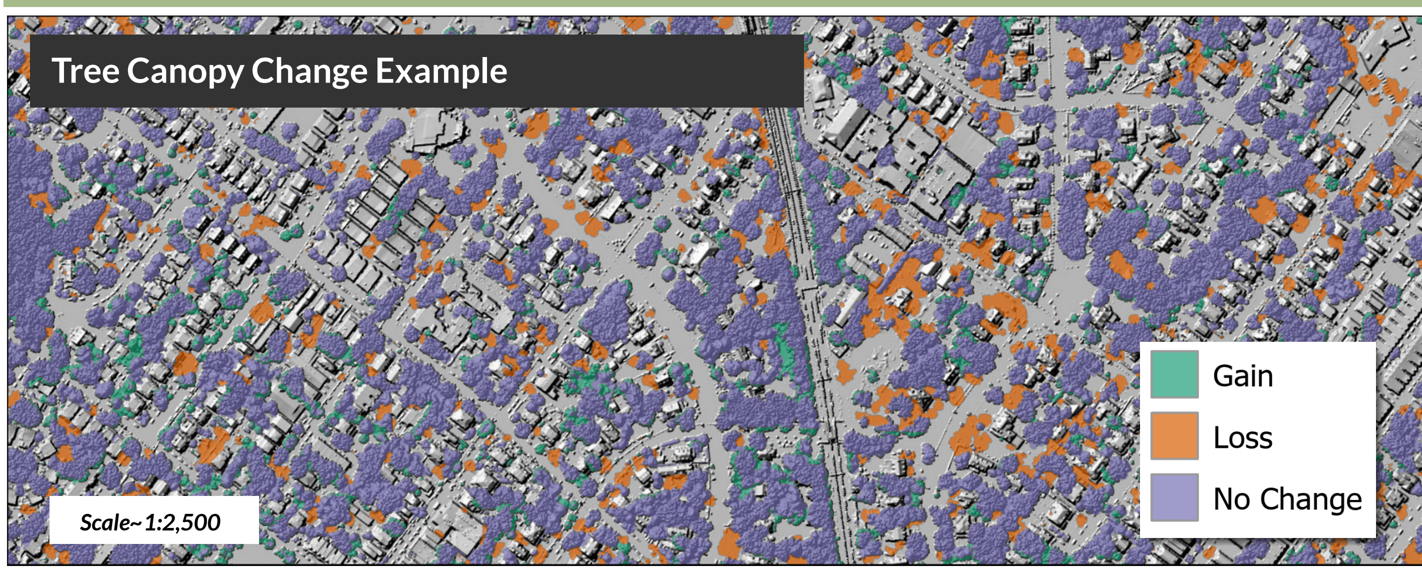
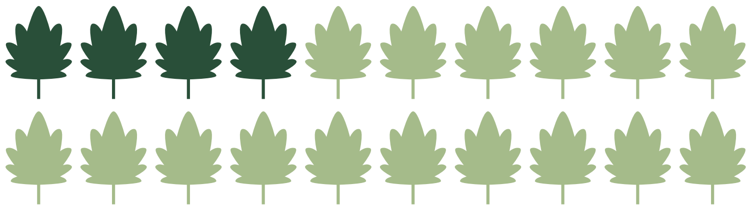


Figure 1. Tree canopy change in the vicinity of the intersection of Lincoln Drive and Carpenter Lane. As with many areas in the City there is a mix of loss and gains. The tree canopy change map is overlaid on the 2018 LiDAR.

TREE CANOPY METRICS

20% *Tree canopy covers 20% of all land within the City of Philadelphia*



Using Geographic Information Sytems (GIS) tree canopy was summarized at various geographical units of analysis, ranging from the property parcel to the ward. These tree canopy metrics provide information on the area of Existing and Possible Tree Canopy for each geographical unit.

Existing Tree Canopy

Philadelphia, like virtually all major cities, has an uneven distribution of tree canopy. There are some 100-acre hexagons with less than 1% tree canopy and others with more than 97% tree canopy. This uneven distribution can be traced back decades and reflect everything from land use history to decisions made on where to locate parks. This distribution also has consequences, with those residents living and working in more treed areas benefitting disproportionately from the services that trees provide. The densely urbanized and industrialized areas, particularly those in Center City and along the Delaware River, have strikingly low amounts of tree canopy and therefore experience the negative impacts, such as increased heat. The northern and western parts of the City contain more park land and lower density residential areas. These areas have correspondingly higher amounts of tree canopy.

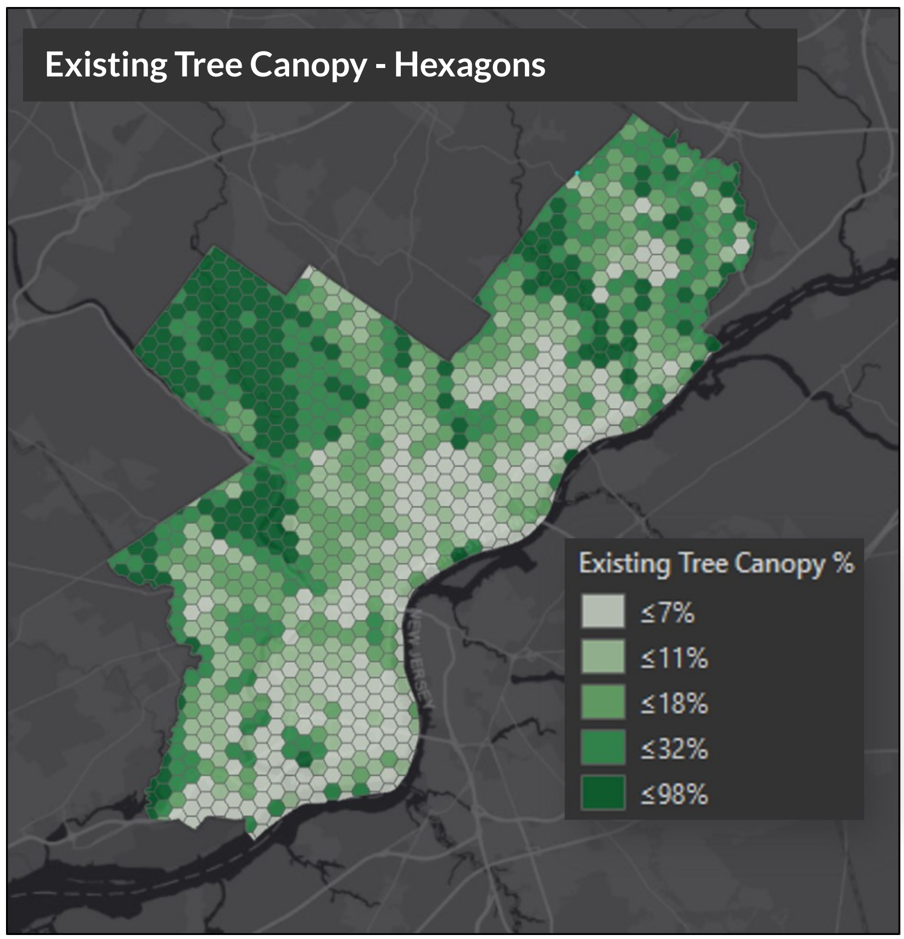


Figure 2. Existing tree canopy percentage for 2018 conditions summarized using 100-acre hexagons. For each of the hexagons, the percent tree canopy was calculated by dividing the amount of tree canopy by the land area, which excludes water. Using 100-acre hexagons as the unit of analysis provides a useful mechanism for visualizing the distribution of tree canopy without the constraints of any existing geography (e.g., zip codes).

Possible New Tree Canopy

Philadelphia does have room to plant more trees. In this assessment, any areas with no trees, buildings, roads, or bodies of water are considered Possible-Vegetation, and represent locations in which trees could theoretically be established without having to remove paved surfaces. But many other factors go into deciding where a tree can be planted and flourish, including land use, social, and financial considerations. Thus, the Possible-Vegetation category should serve as a guide for further analysis, not a prescription of where to plant trees.

In the most densely urbanized portions of Philadelphia, significantly increasing the tree canopy will be difficult; nevertheless, it remains vitally important to promote the health and number of street trees even in these areas. Similarly, while the heavily forested portions of the City's natural areas have little room for new trees to flourish, attention must be paid to ensure healthy natural regeneration of the tree canopy. The barren industrial lands in South, Southwest, and Northeast Philadelphia, as well as recreational fields across the City, are examples of where existing land use may make establishing tree canopy difficult. Northeast Philadelphia Airport, which has large expanses of grass, and appears clearly in Figure 3, is an area where establishing new tree canopy would violate regulations associated with keeping flight paths clear of obstructions. Nevertheless, with over 20,000 acres of land (comprising 23% of the City's land base) falling into the Possible-Vegetation category, there remain significant opportunities for planting trees and making progress toward the City's tree canopy goal while focusing on areas without the structural barriers of Center City, the City's natural lands, or its airports and industrial areas.

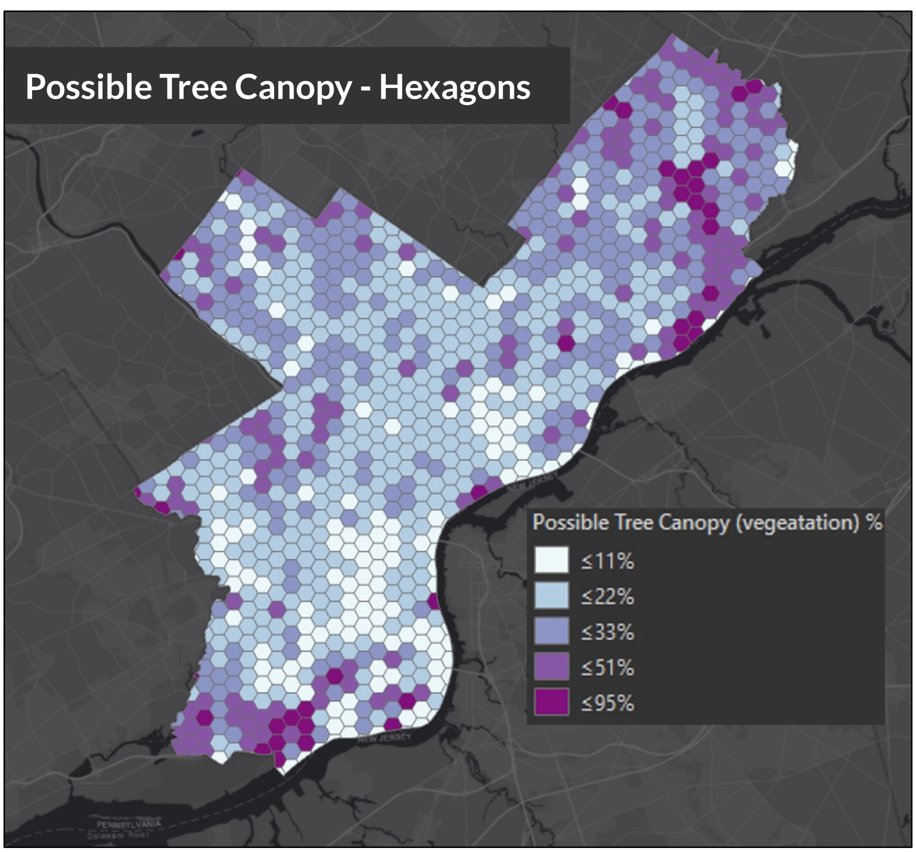


Figure 3. Possible Tree Canopy consisting of non-treed vegetated surfaces summarized by 100-acre polygons. These vegetated surfaces that are not currently covered by tree canopy represent areas where it is biophysically feasible to establish new tree canopy. It may not be financially feasible or socially desirable to establish new tree canopy on much of this land. Examples include golf courses and recreational fields. Maps of the Possible Tree Canopy can assist in strategic planning, but decisions on where to plant trees should be made based on field verification. Surface, underground, and above surface factors ranging from sidewalks to utilities can affect the suitability of a site for tree canopy planting.

City Change Distribution

The relative tree canopy change percentage shows the magnitude of change throughout the City since 2008 (Figure 4). In most cases, those areas with the highest amount of relative loss (negative values) were not large clearings of forested areas, but rather the widespread removal of individual trees and small patches in areas which had below-average tree canopy to begin with. In some cases the removal of even a few dozen trees could result in a stark relative change if there was a low amount of tree canopy in 2008. Because these areas already lacked adequate amounts of tree canopy to provide the City's residents with key ecosystem services, the losses were even more acute. Similarly, the greatest relative gains were in areas with little tree canopy to begin with. In these locations, natural growth or tree-planting initiatives had a massive impact on the relative change in tree canopy.

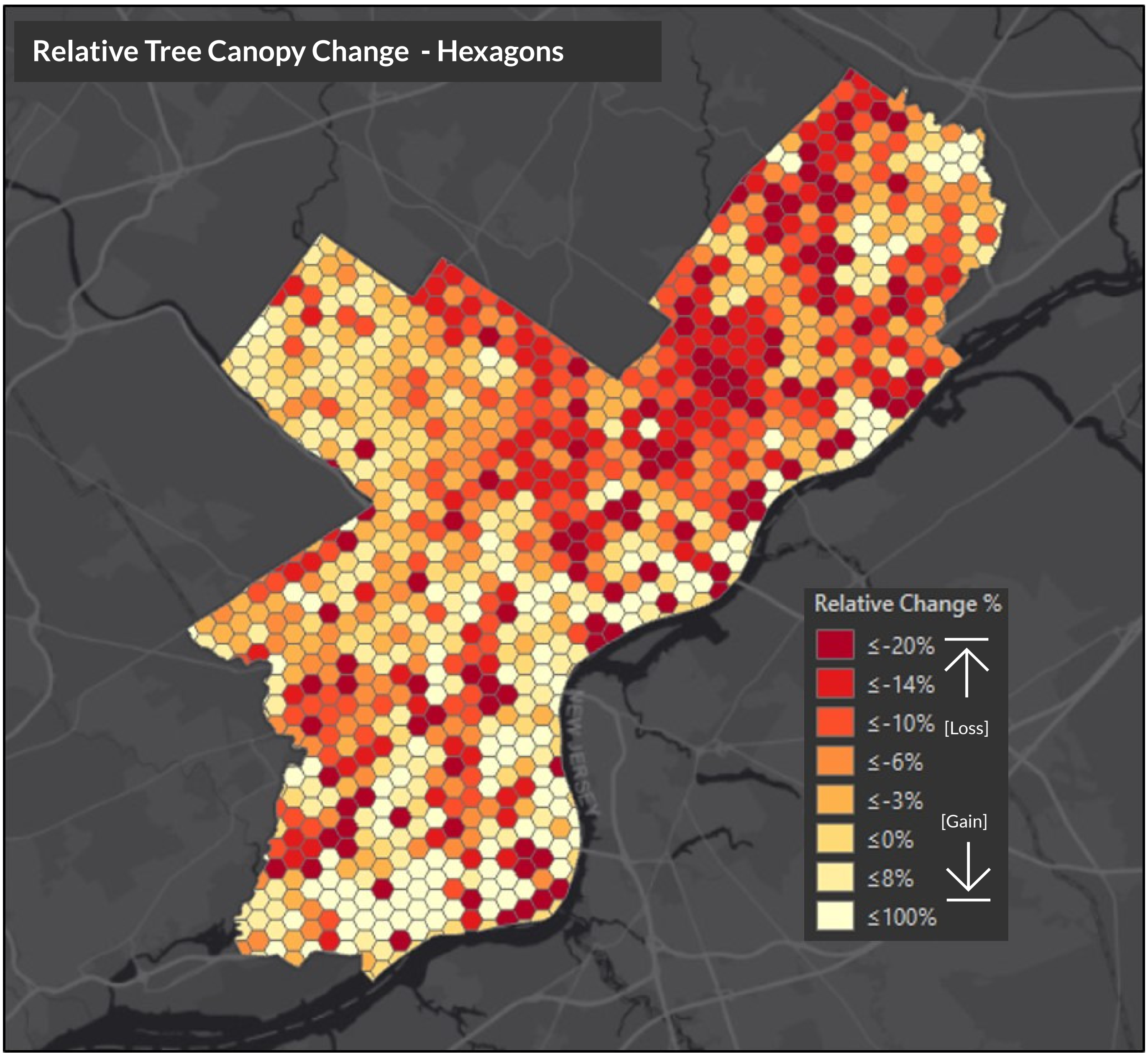


Figure 4: Tree canopy change metrics summarized by 100-acre hexagons. Relative tree canopy is calculated by using the formula (2018-2008)/2008. Negative values (darker colors) indicate loss. Positive values (lighter colors) indicate gain.

Zip Codes

Summarizing the tree canopy change and Existing Tree Canopy by zip codes presents the information in using geographical boundaries that are readily understood. As with the hexagon summaries, patterns emerge. Tree canopy loss as measured by the relative percent change is most concentrated in the northern part of the City. Existing tree canopy is highest in those zip codes that have parks and other natural areas. Not all zip codes experienced decreases in tree canopy. For example, zip code 19145 had just over 13 acres of net tree canopy gain.

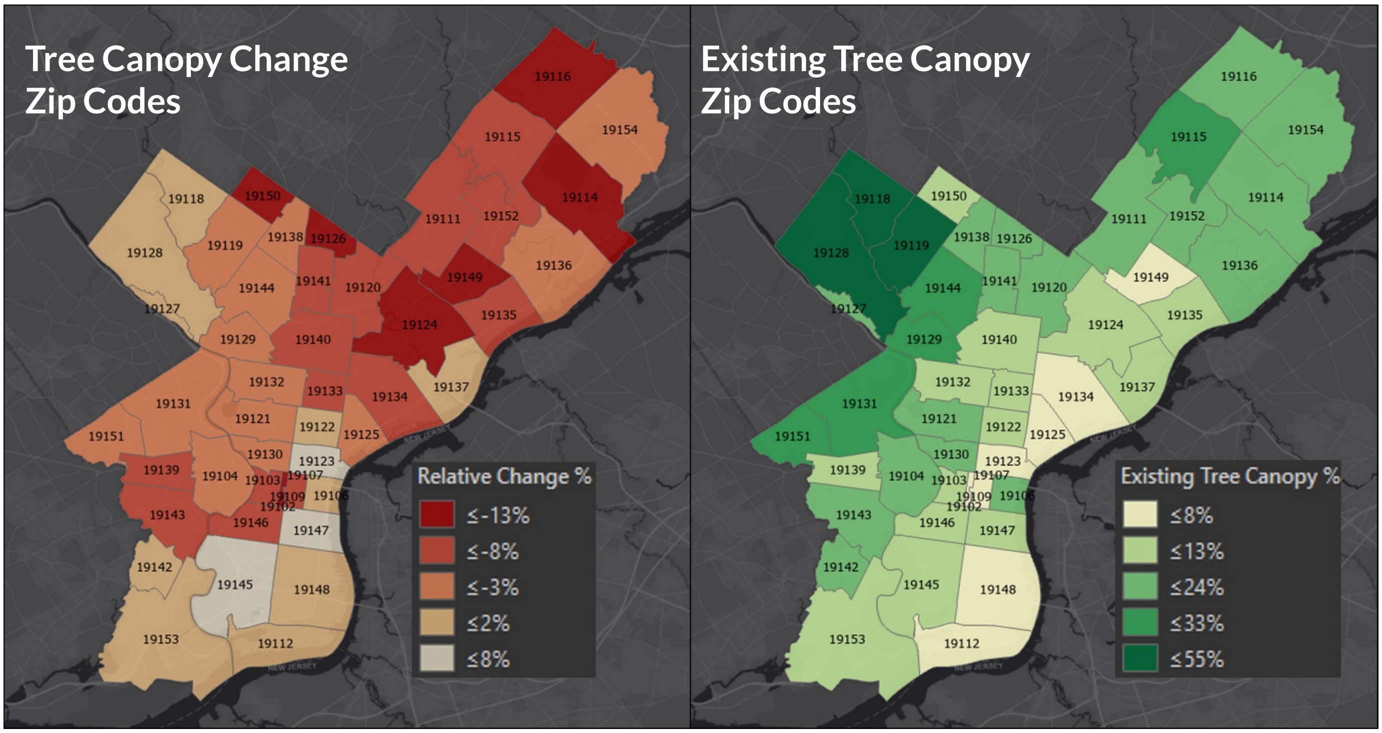


Figure 6: Tree canopy relative change (left) and Existing Tree Canopy (right) summarized by zip code.

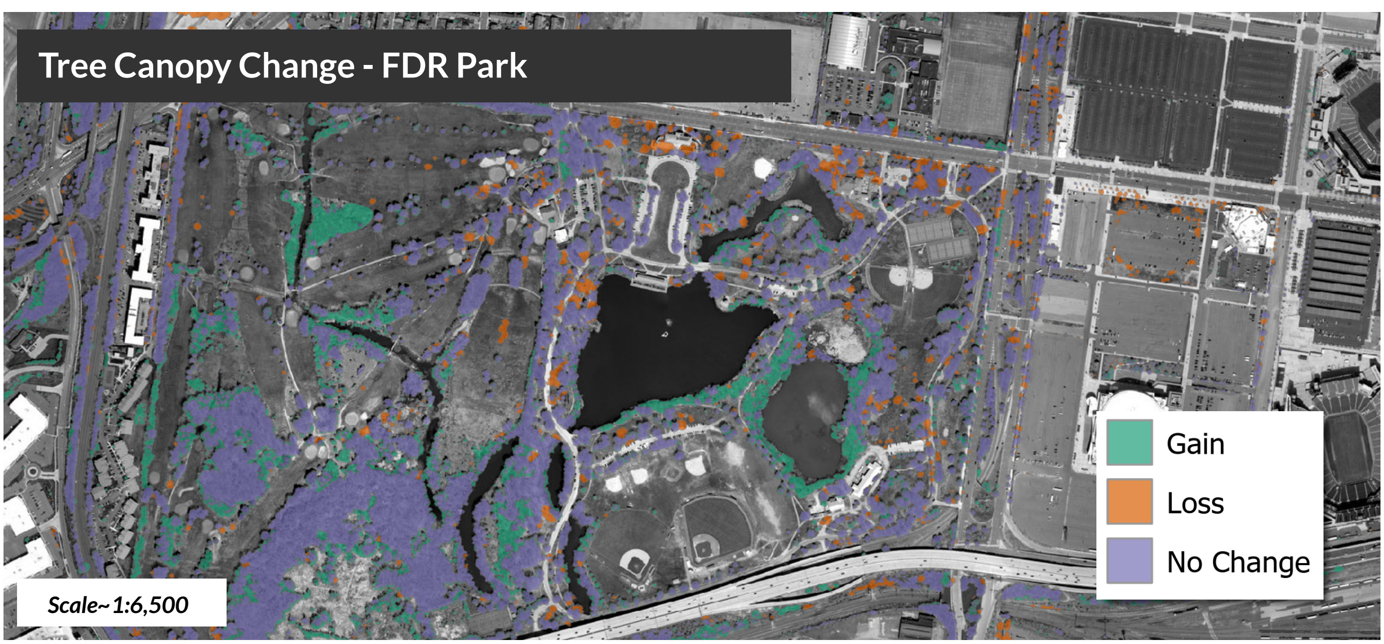


Figure 7: Tree canopy change for FDR Park located in zip code 19145. Although there were losses, these were outpaced by the gains, resulting in a net increase in tree canopy.

Land Use

Land use is different from land cover. Land cover refers to the features, such as the trees, buildings, and other classes mapped as part of this study. Land use is how we, as humans, make use of the land. Residential land use can contain tree, building, impervious, grass, and other land cover features. Land use can significantly influence the amount of tree canopy and the room available to establish new tree canopy. This study made use of DVRPC land use data to summarize tree canopy metrics and change metrics. Wooded land use has the largest amount of total tree canopy, followed closely by residential. Most of the room for planting new trees is on residential land. Residential land also saw the most substantial aggregate loss of tree canopy and the most significant absolute decrease in tree canopy. Wooded land use, despite having a large amount of tree canopy, showed a minimal decline. This difference between the loss in residential and wooded land uses points to factors other than natural causes for the decline in tree canopy. While some trees on residential land use likely have reach maximum life expectancy, factors such as construction and landowner removal are more likely to play a role. The losses on recreation and institutional land uses are also cause for concern as these land uses have relatively high total amounts of tree canopy.

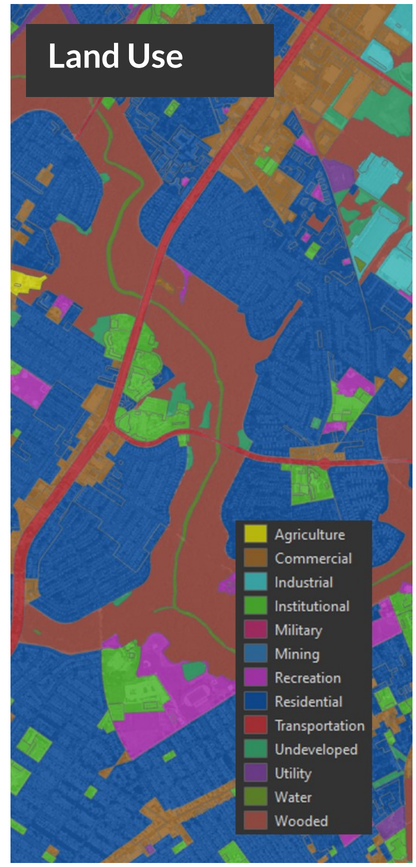


Figure 8: Philadelphia's land use categories.

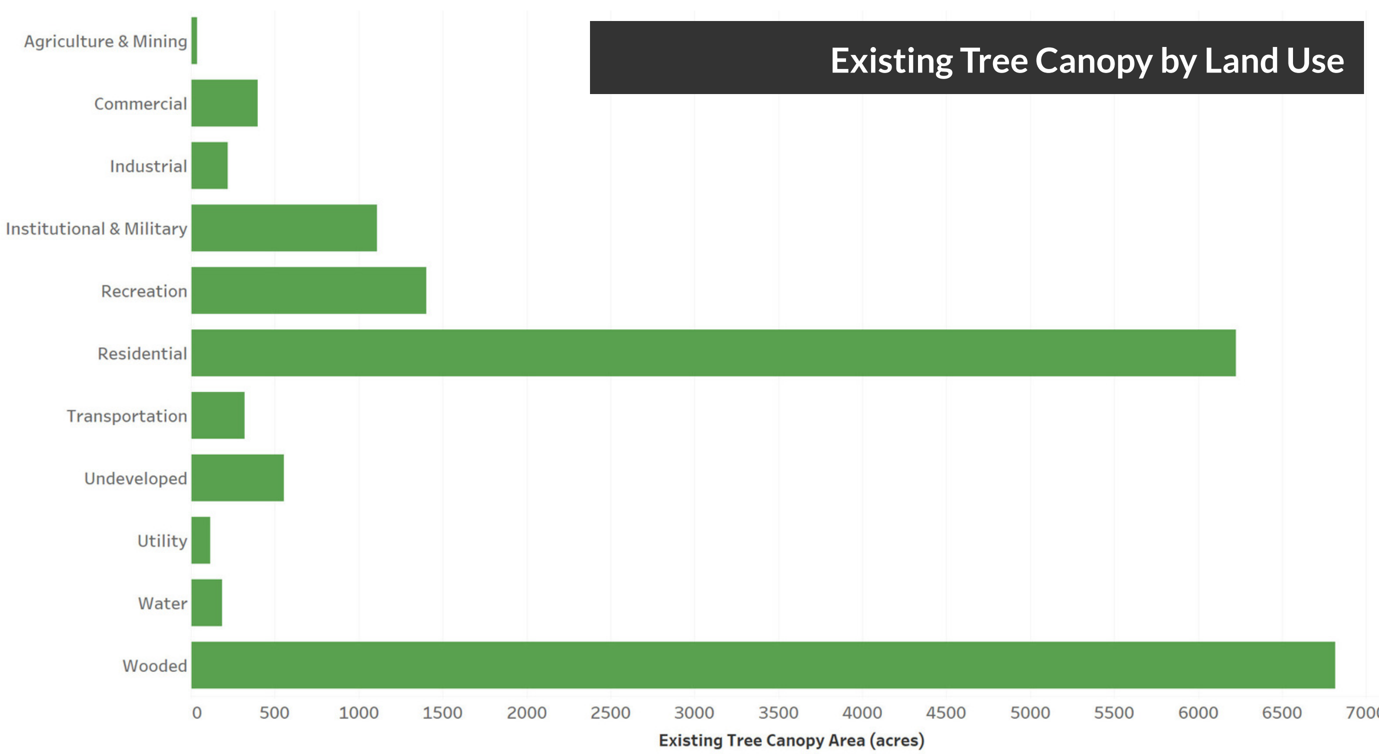


Figure 9: Existing tree canopy metrics summarized by land use.

Tree Canopy Gains and Loss by Land Use

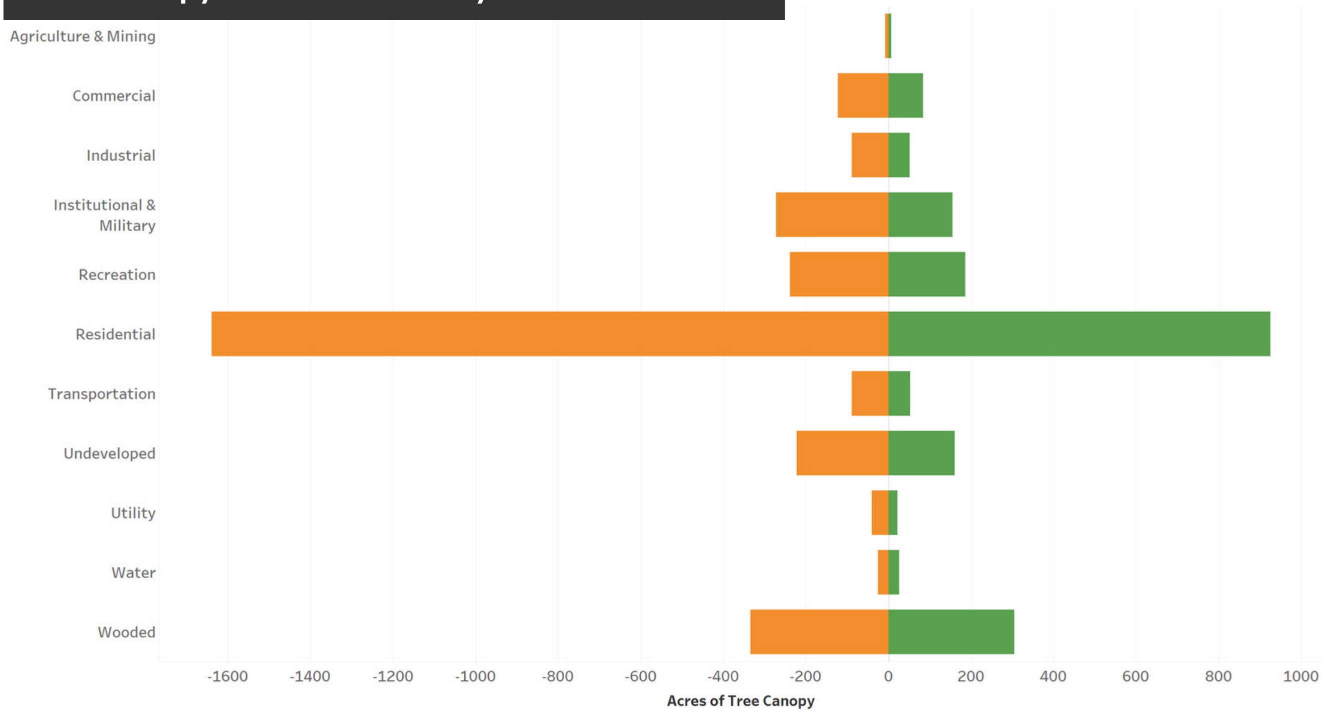


Figure 11: Tree canopy change, in acres, from 2008 to 2018 by land use class. Gains are shown in green and losses are shown in orange. Residential tree canopy had the greatest losses and the greatest gains.

Tree Canopy Net Loss by Land Use

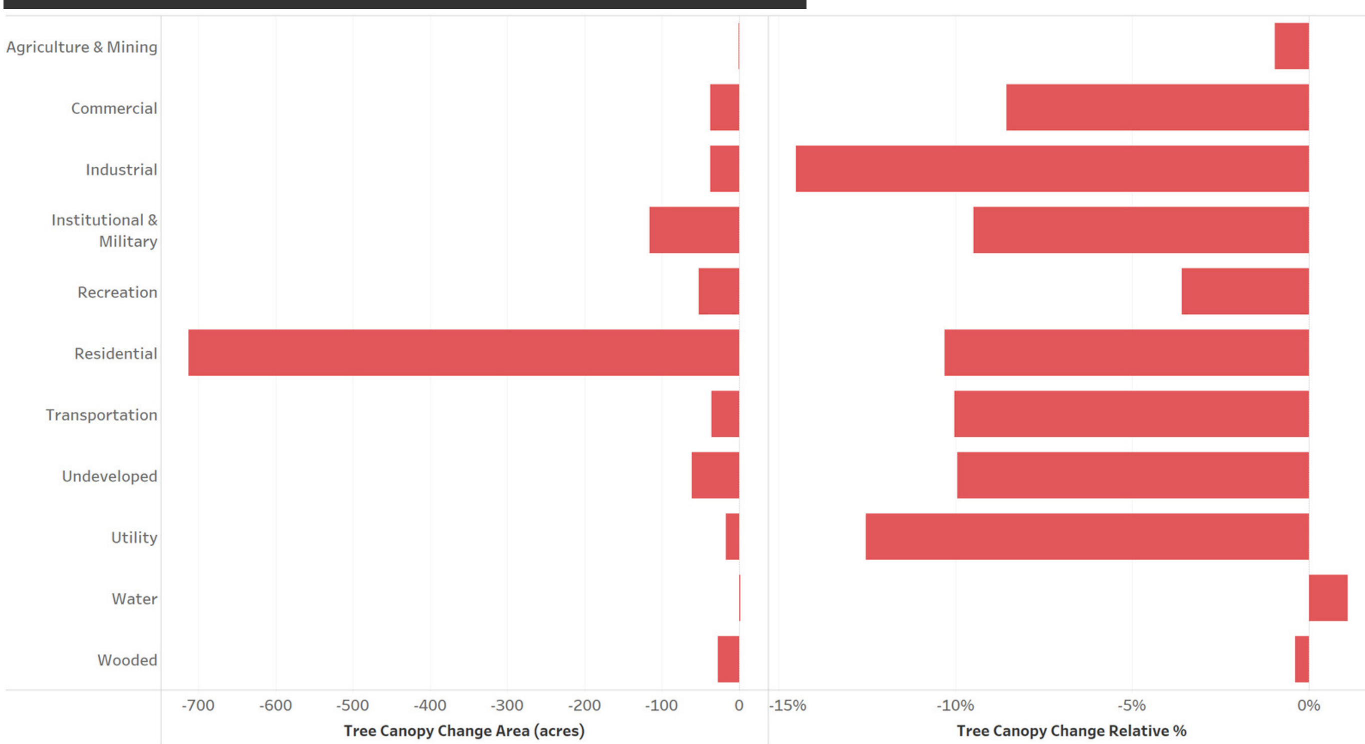


Figure 12: The net area and relative change in tree canopy by land use from 2008 to 2018. The net area losses were highest on residential lands. The relative net loss was highest on industrial lands but as such little tree canopy existed within this land use, this loss had a minimal impact at the city scale.

Parks

Tree canopy within the City's parks is currently 60%. From 2008 to 2018 it declined by 1% in absolute terms and 2% relative to the area of tree canopy present in the parks in 2008. These losses ranged from individual trees to large, ecologically significant patches.

Figure 13. Tree canopy change for the area around McPherson Square. Tree canopy change is overlaid on a LiDAR hillshade for 2018.

Roads

13% of the tree canopy within a 50-foot buffer around the City's street was lost between 2008 and 2018. Canopy in the right-of-way creates green streets that provide important ecosystem services such as cooling, noise reduction, and precipitation interception.

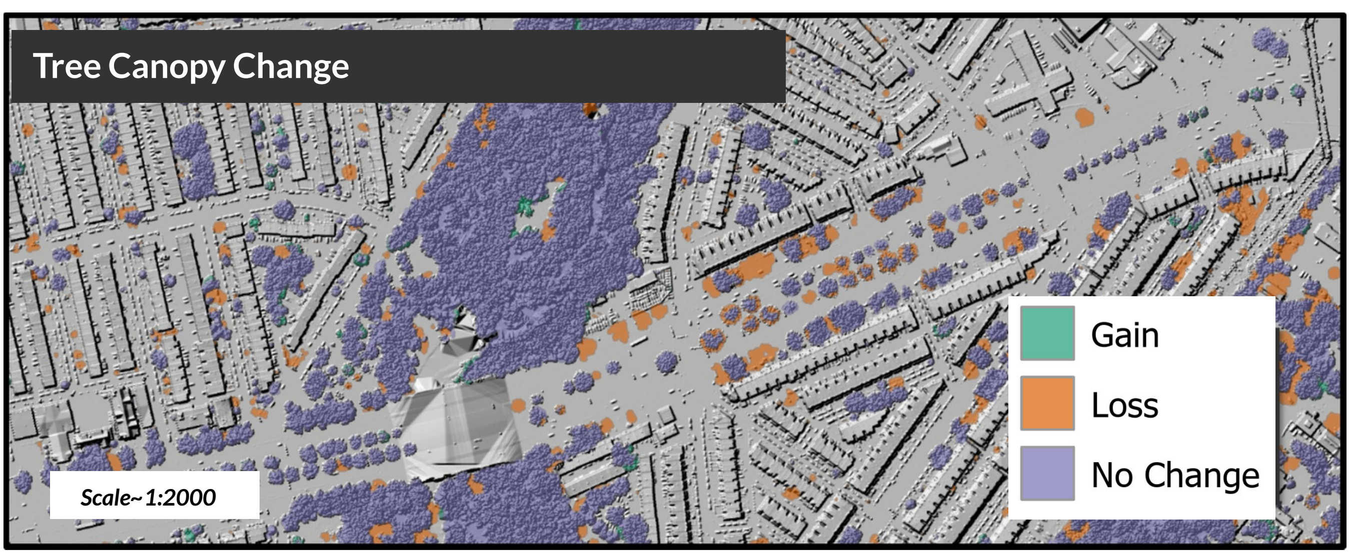


Figure 14: Tree canopy change along Route 1. Tree canopy change is overlaid on a LiDAR hillshade from 2018. Roads were buffered 50-ft from the edge of the pavement.

THE TREE CANOPY ASSESSMENT PROCESS

This project employed the USDA Forest Service's Urban Tree Canopy assessment protocols and made use of hundreds of thousands of dollars of data provided by community partners.

Remotely sensed data forms the foundation of the tree canopy assessment. We use high-resolution aerial imagery and LiDAR to map tree canopy and other land cover features.

The land cover data consist of tree canopy, grass/shrub, bare soil, water, buildings, roads/railroads, and other impervious features.

The land cover data are summarized by various geographical units, ranging from the property parcel to the watershed to the municipal boundary.

These summaries, in the form of tree canopy metrics, are an exhaustive geospatial database that enables the Existing and Possible Tree Canopy to be analyzed.

The tree canopy metrics data analytics provide basic summary statistics in addition to inferences on the relationship between tree canopy and other variables.

The report (this document) summarizes the project methods, results, and findings.

The presentation, given to partners and stakeholders in the region, provides the opportunity to ask questions about the assessment.

Existing Tree Canopy

The tree canopy that you currently have, consisting of the leaves, branches, and stems when viewed from above.

Possible New Tree Canopy

Land where it is biophysically feasible to establish new tree canopy (excludes buildings and roads). It is easier to establish tree canopy on vegetated areas as opposed to impervious surfaces.

MAPPING THE TREE CANOPY FROM ABOVE

Tree canopy assessments rely on remotely sensed data in the form of aerial imagery and light detection and ranging (LiDAR) data. These datasets, which have been acquired by various governmental agencies in the region, are the foundational information for tree canopy mapping. Imagery provides information that enables features to be distinguished by their spectral (color) properties. As trees and shrubs can appear spectrally similar, or obscured by shadow, LiDAR, which consists of 3D height information, enhances the accuracy of the mapping. Tree canopy mapping is performed using a scientifically rigorous process that integrates cutting-edge automated feature extraction technologies with detailed manual reviews and editing. This combination of sensor and mapping technologies enabled the city's tree canopy to be mapped in greater detail and with better accuracy than ever before. From a Church Street shade tree in Franklin Square to a core forest patch in Pennypack park, every tree in the city was accounted for.

Figure 15: Imagery (top), LiDAR surface model (middle), and high-resolution tree canopy (bottom). By combining these datasets the land cover mapping process capitalizes on their strengths and minimizes their weaknesses. The land cover dataset is the most detailed, accurate, and current for the City of Philadelphia.

The high-resolution land cover that forms the foundation of this project was generated from the most recent LiDAR and imagery, which were acquired in 2017 and 2018, respectively. Compared to national tree canopy datasets, which map at a resolution of 30-meters, this project generated maps that were over 1000 times more detailed and better account for all of the city's tree canopy.

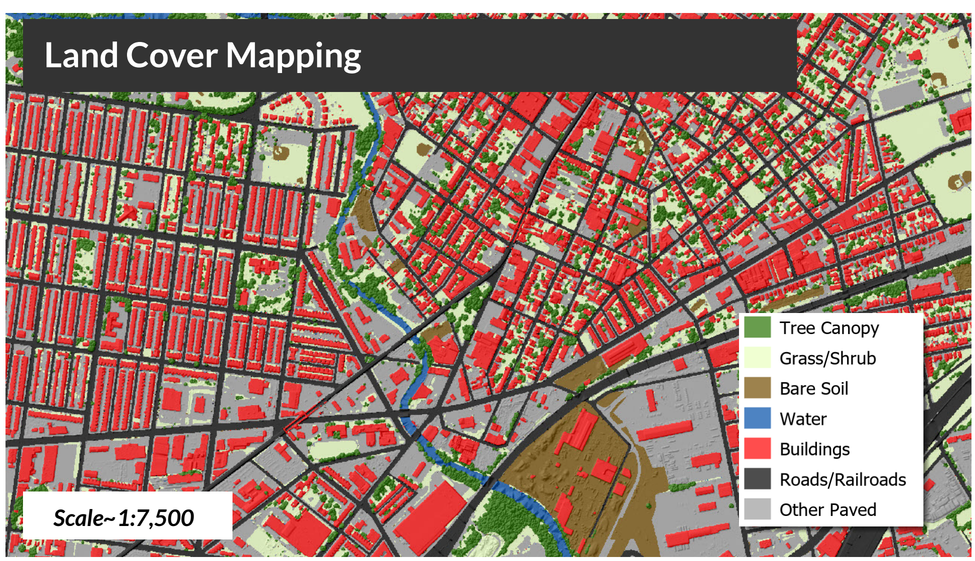


Figure 16: High-resolution land cover developed for this project.

MAPPING TREE CANOPY CHANGE

This study made use of LiDAR data acquired in 2008 and 2018, and aerial imagery acquired in 2010 and 2018. LiDAR is positionally more accurate and thus served as the primary data source for determining change. The imagery was used to confirm the change detected using the LiDAR. Both LiDAR datasets were acquired under leaf-off conditions and thus tend to underestimate tree canopy slightly. The two LiDAR and imagery datasets are not directly comparable due to differences in the sensor, time of acquisition, and processing techniques employed. This study went to great efforts to reduce the errors associated with differences in the datasets to come up with the most accurate estimate of tree canopy change possible. Losses are generally easier to detect than gains as losses tend to be due to a large event, such as tree removal, whereas gains are incremental growth or new tree plantings, both of which are smaller in size.

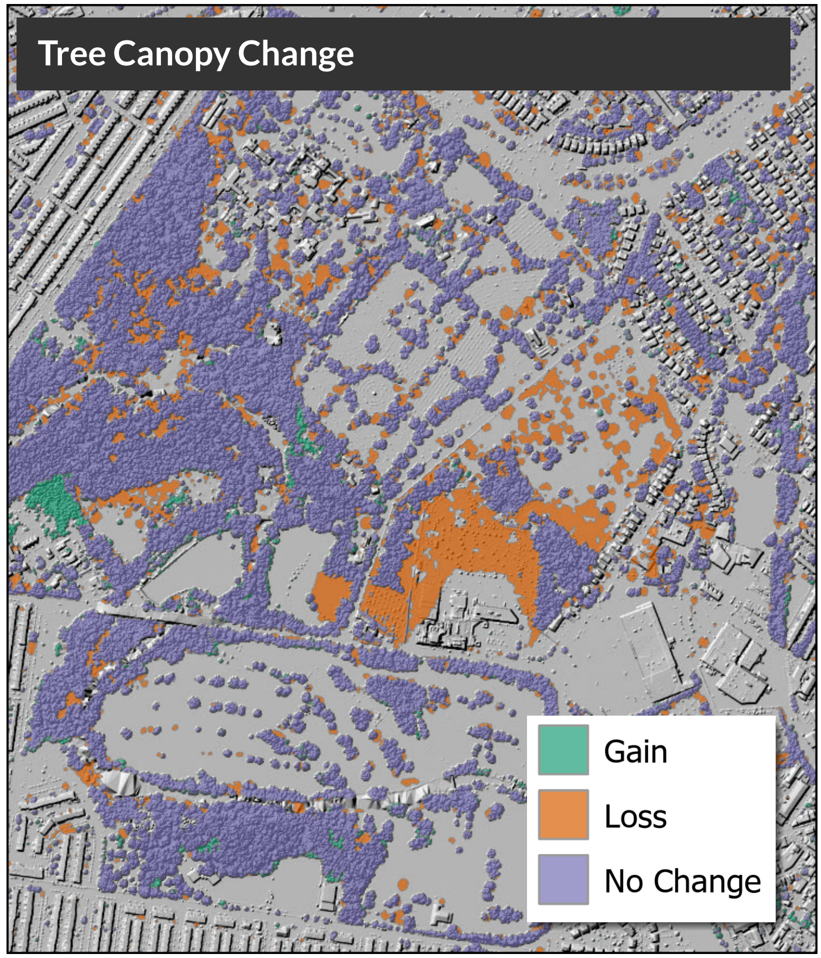


Figure 18. Tree canopy change mapping in the vicinity of Tacony Park and Oakland Cemetary. Tree canopy change is overlaid on a LiDAR hillshade model based on 2018 data. Rough areas generally correspond to areas with tree canopy and smooth areas are those without tree canopy.

Comparisons to Past Studies

A vital component of the Tree Canopy Assessment Protocols is ensuring that changes in tree canopy are attributed to actual gains and losses in tree canopy as opposed to differences in the source data. The first Tree Canopy Assessment was carried out by the same University of Vermont team, using data from 2008. These data were acquired with different specifications and were less accurate than the 2018 data.. Furthermore, recent improvements in the tree canopy mapping methods provided the opportunity to revisit the 2008 mapping. This re-analysis found that the 2008 mapping slightly underestimated the tree canopy, over-estimating gaps in forested closed canopies. The 2008 study reported a city tree canopy percentage of 20%. This reanalysis of the data puts the 2008 estimate at 21%.

This assessment was carried out by the University of Vermont Spatial Analysis Lab in collaboration with the City of Philadelphia. The methods and tools used for this assessment were developed in partnership with the USDA Forest Service. The source data used for the mapping came from the City of Philadelphia and the USDA. The project was funded by TreePennsylvania, the Pennsylvania Urban and Community Forestry Council. Additional support came from a Catalyst Award from the Gund Institute for Environment at the University of Vermont.

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