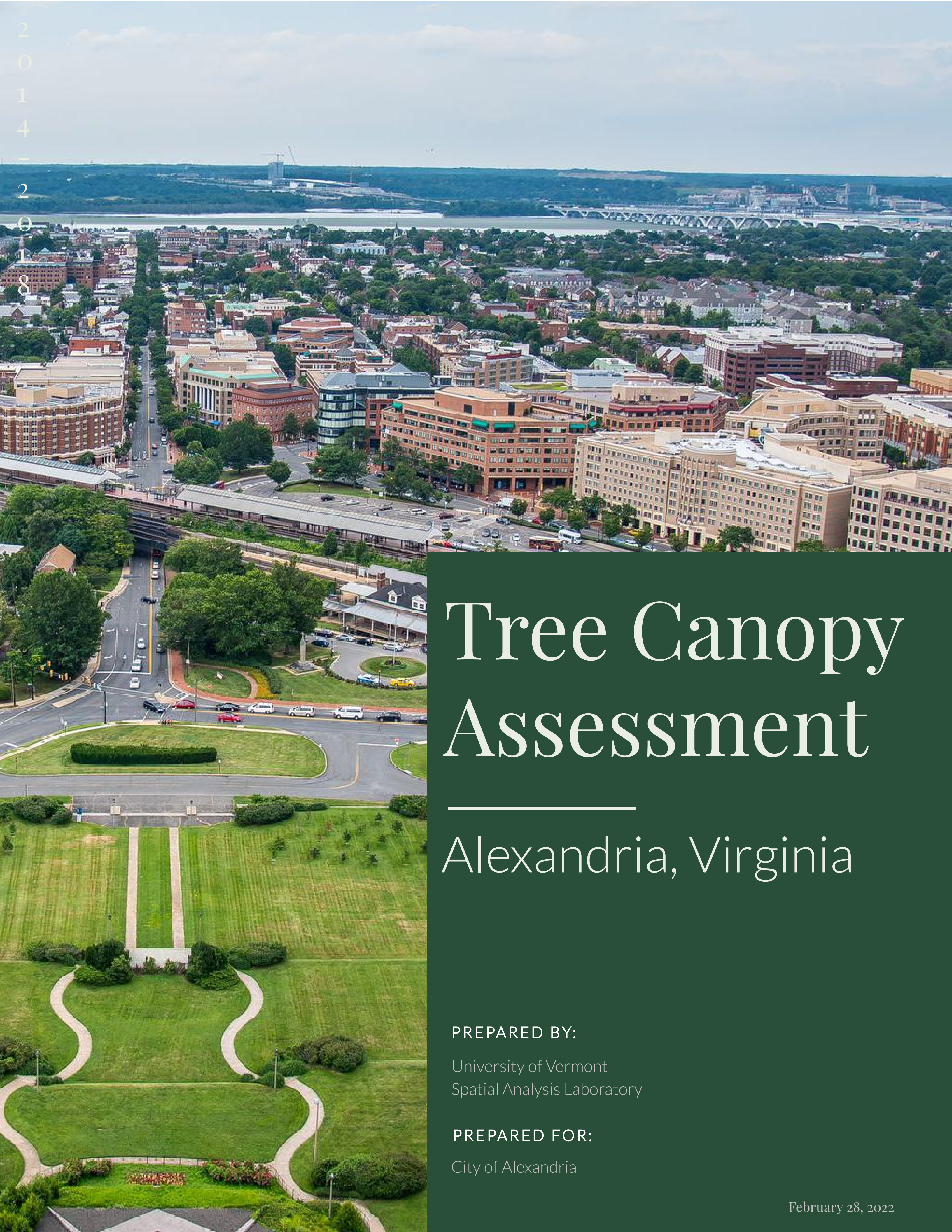


2014–2018

Tree Canopy Assessment

Alexandria, Virginia

PREPARED BY:

University of Vermont
Spatial Analysis Laboratory

PREPARED FOR:

City of Alexandria

February 28, 2022

THE NEED FOR GREEN

Trees provide essential ecosystem services in Alexandria, including reducing stormwater runoff, cooling the pavement in the summer, and providing wildlife habitat. In addition, trees are an indispensable part of the city's infrastructure. Research shows that these green assets can improve social cohesion, reduce crime, and raise property values. A robust urban forest is crucial to building a more livable and prosperous city while contributing to the health of the Chesapeake Bay Watershed

As with any community, Alexandria faces a host of environmental challenges while seeking to balance development and conservation. A healthy and robust tree canopy is crucial for maintaining this balance, providing Alexandria's residents with a resource that will impact the health and well-being of generations to come.

TREE CANOPY ASSESSMENT

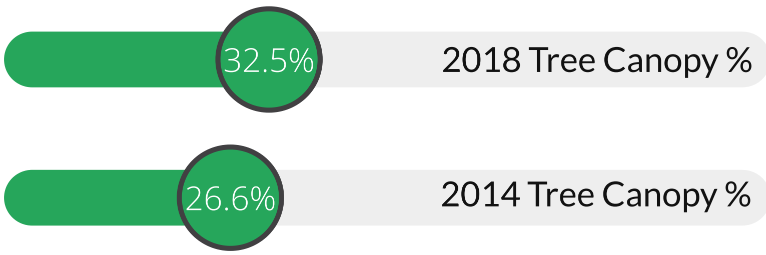
For decades governments have mapped and monitored their infrastructure to support effective management practices. Traditionally, that mapping has primarily focused on gray infrastructure, including features such as roads and buildings. An accounting of the green infrastructure has been left out.

The USDA Forest Service developed Tree Canopy Assessment protocols to help communities better understand their green infrastructure through tree canopy mapping and analytics. Tree canopy is the layer of leaves, branches, and stems that provide tree coverage of the ground when viewed from above.

A Tree Canopy Assessment offers vital information that helps governments and residents chart a greener future by providing them with information on the tree canopy they have, how it has changed, and where there is room to plant trees. Tree Canopy Assessments have been carried out for over 90 communities in North America. This study assessed tree canopy for Alexandria over the 2014-2018 time period.

TREE CANOPY BY THE NUMBERS

Alexandria is gaining tree canopy. Tree canopy change was computed by mapping the no change, gains, and losses in tree canopy from 2014-2018.



756.5

Acres of Gain

196.3

Acres of Loss

5.9%

Absolute change in tree canopy

22.4%

Relative change in tree canopy

569.2 acres of net gain in tree canopy coverage.

Gains in tree canopy are offsetting losses, resulting in a net increase in tree canopy.

Key Terms

Existing Tree Canopy: The amount of tree canopy present when viewed from above using aerial or satellite imagery.

Possible Tree Canopy - Vegetated: Grass or shrub area that is theoretically available for the establishment of tree canopy.

Possible Tree Canopy - Impervious: Asphalt, concrete or bare soil surfaces, excluding roads and buildings, that are 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).

Measuring Tree Canopy Change

Area Change - the change in the area of tree canopy between the two time periods.

Relative % Change - the magnitude of change in tree canopy based on the amount of tree canopy in first time period.

Absolute % Change - the percentage point change between the two time periods.

FINDINGS

Alexandria's tree canopy is increasing. If the city can maintain this trend it will continue to move closer to the 40% tree canopy goal.

Gains in tree canopy outpaced losses by a ratio of nearly 4:1.

If current trends continue, Alexandria will continue to gain tree canopy, but only if past planting and preservation efforts can be maintained.

Changes in tree canopy vary throughout the city, from growth in residential trees to the removal of forest patches due to construction.

Most of the canopy gains come from fine-scale growth of existing trees, highlighting the importance of preservation efforts.

The loss of forest patches is of concern as these ecosystem services cannot be made up by the growth of individual trees.

The vast majority of tree canopy and gains in tree canopy are on residential lands. Residents are crucial to the growth of Alexandria's urban forest.

Street trees contribute substantially to the city's overall canopy. Urban forestry funding is key to maintaining the canopy within the rights-of-way.

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 in areas that have high summer temperatures and low tree canopy will enhance ecosystem services and improve equity.

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

Community education is crucial if tree canopy is to be maintained over time. Residents that are knowledgeable about the value of trees 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 from individual park improvements, to comprehensive planning and zoning initiatives, to citywide ordinances.

Reassess the tree canopy at 3-5 year intervals to monitor change and make strategic management decisions.

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.

A CHANGING URBAN FOREST

Alexandria is a thriving city. Its proximity to Washington DC, location on the banks of the Potomac River, and historical significance give it unique characteristics that influence its tree canopy. Alexandria has properties built centuries ago, new commercial developments, and patches of protected urban forest. Not surprisingly, the city's trees experience the everyday challenges of existing in an urban environment in addition to the stressors of invasive species and the complexities of balancing preservation and development. Despite the stark losses of tree canopy that the city has experienced, the slow and steady growth of its existing canopy has resulted in a net increase.

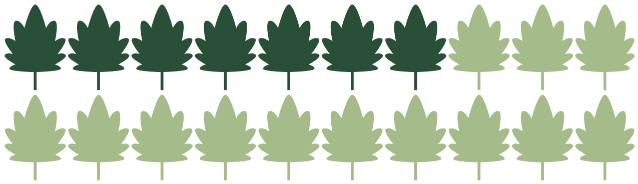
Figure 1: King Street and Melrose Street. The construction of a new building resulted in tree canopy loss, as did the removal of trees in the cemetery, but the remaining trees continued to grow. Of note are the individual, younger trees whose canopies have nearly doubled in size.

Figure 2: Cameron Mills Road and Grand View Drive. In residential areas, tree canopy loss mainly consists of the removal of individual trees, whereas gains come from the growth of existing trees. The tree removals are clearly visible, whereas the growth is more challenging to see as it happens on the edges of the canopy.

Figure 3: North Patrick Street and Wythe Street. The trees planted in the new developments in this area have seen an explosion in the growth of their canopies. If these trees can be retained, the canopy will continue to provide measurable contributions as incremental gains on mature trees often result in higher net canopy gains than the explosive growth that younger trees experience.

TREE CANOPY METRICS

32.5% *of of Alexandria's land is covered by tree canopy*



Tree canopy metrics provide insights into the distribution and factors influencing tree canopy and canopy change. The metrics were computed using GIS and summarized the Existing Tree Canopy, Possible Tree Canopy, and Tree Canopy Change at various geographical units of analysis, ranging from land property parcels to neighborhood boundaries.
**Please refer to page 3 for definitions.*

Existing Tree Canopy

Alexandria is a mosaic of landscapes, including parks, historical districts, dense commercial areas, and suburban residential lands. This patchwork leads to uneven distribution of tree canopy. A grid of 25-acre hexagons was used to visualize the distribution of tree canopy. Across the city, canopy coverage within these hexagons ranges from less than 1% to over 90%. Higher amounts of tree canopy are present in conserved forests and established residential areas—the lowest amounts of tree canopy exist in the commercial districts and along the major transportation corridors.

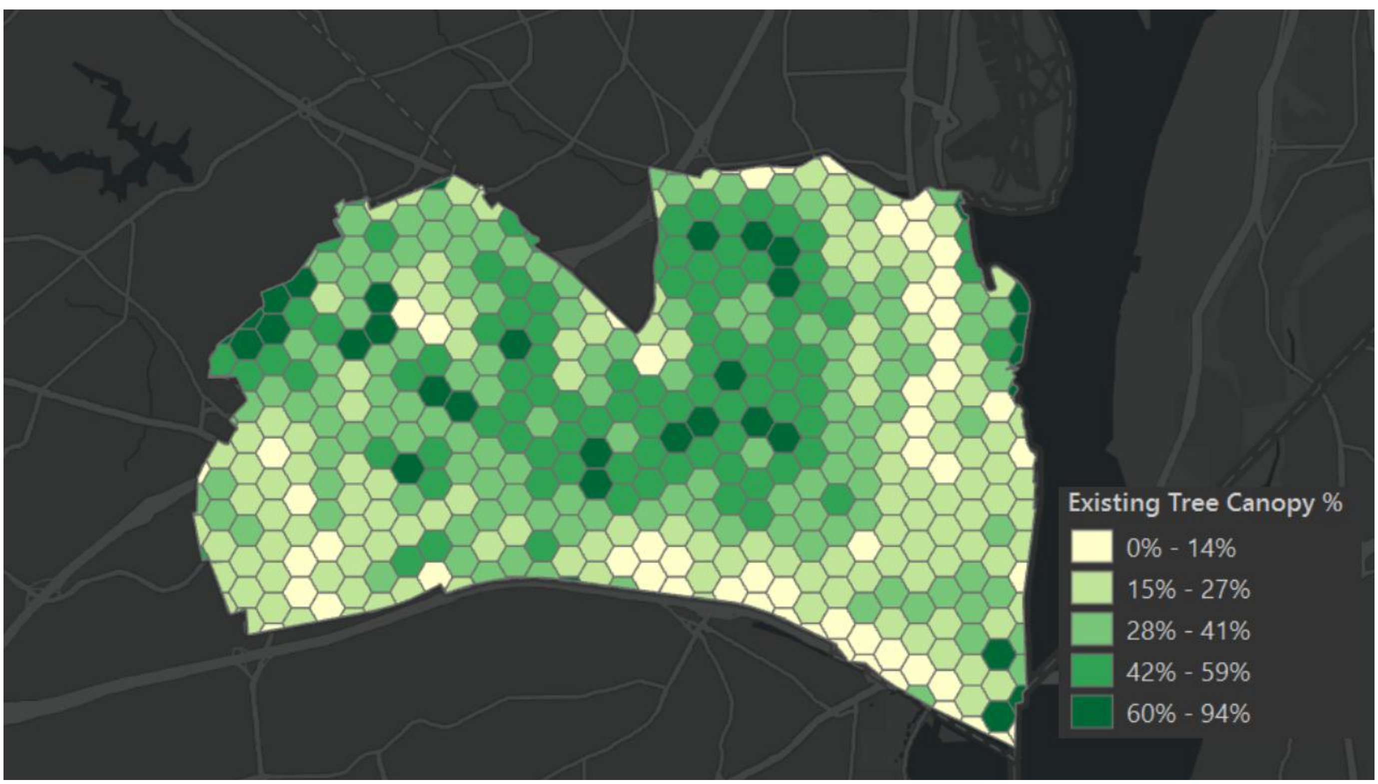


Figure 4. Existing tree canopy percentage as of 2018 summarized using 25-acre hexagons. For each of the hexagons, Existing Tree Canopy was calculated by dividing the amount of tree canopy by the land area, which excludes water. Using hexagons as the unit of analysis provides a standard mechanism for visualizing the distribution of tree canopy without the constraints of other geographies that have unequal area (e.g., neighborhoods).

Possible New Tree Canopy

This study found ample space in Alexandria to expand the tree canopy. The term used to describe vegetated areas with no trees, buildings, roads, or bodies of water is Possible-Vegetation. Possible-Vegetation represents the land in which there are is not currently any tree canopy and where new tree canopy could theoretically be established without having to remove hard surfaces. Many factors go into deciding where a tree can be planted with the necessary conditions to flourish, including land use, landscape conditions, social attitudes towards trees, and financial considerations. Examples include golf courses and recreational fields.

The Possible-Vegetation category should serve as a guide for further field analysis, not a prescription of where to plant trees. With over 1853 acres of land, comprising nearly 20% of the city's land base falling into the Possible-Vegetation category, there remain significant opportunities for planting trees and preserving canopy that will improve the city's total tree canopy in the long term. It is also important to note that in Alexandria, Possible-Vegetation space is highly concentrated on residential lawns in areas with decent tree canopy coverage. While it is likely easier to establish tree canopy in these locations, planting trees in areas with higher impervious cover will significantly impact the urban heat island.

Alexandria has enough available land to substantially increase its tree canopy

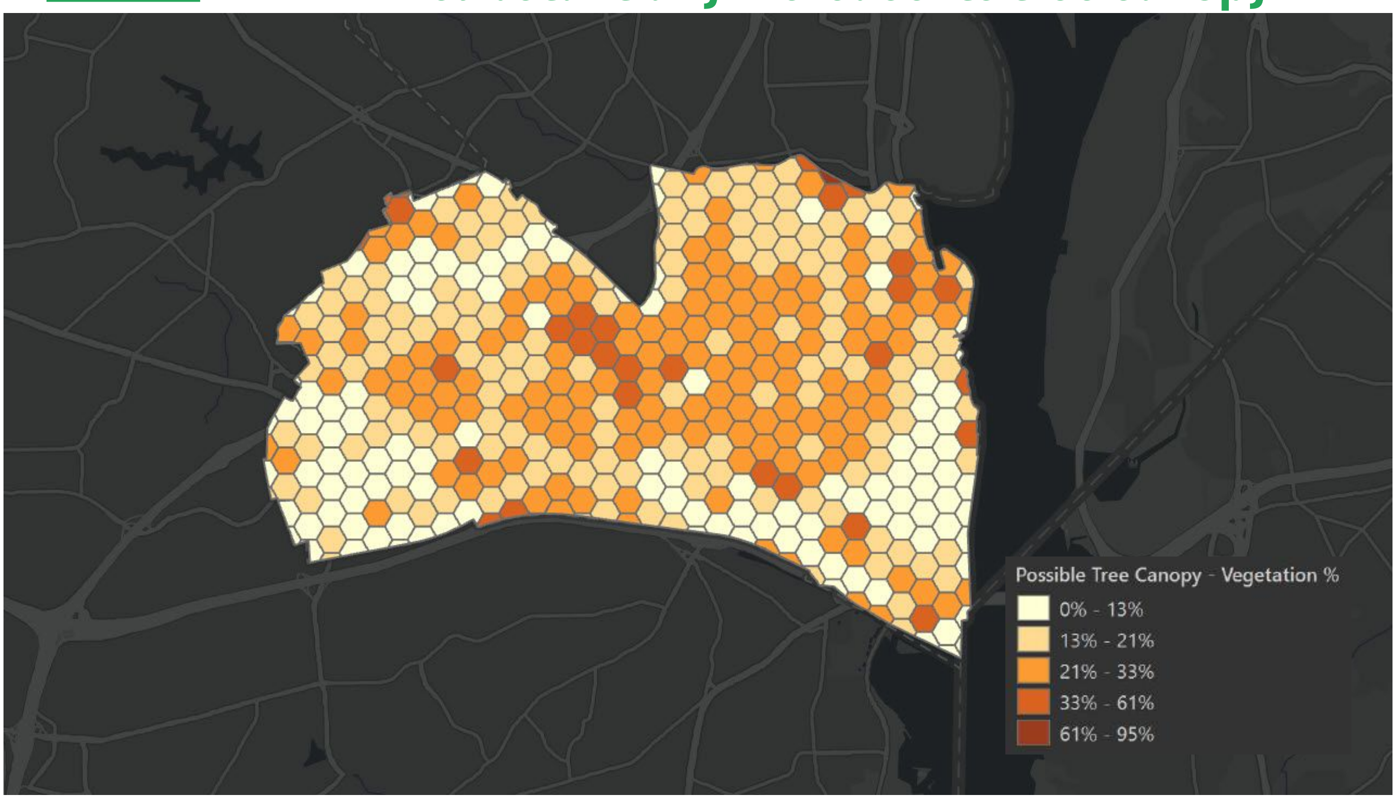


Figure 5. Possible Tree Canopy consisting of non-treed vegetated surfaces summarized by 25-acre hexagons. These vegetated surfaces that are not currently covered by tree canopy represent areas where it is biophysically feasible to establish new tree canopy. It may be financially challenging or socially undesirable to establish new tree canopy on much of this land. Examples include golf courses, recreational and agricultural 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.

Canopy Change Distribution

Alexandria has experienced a net increase in tree canopy, but not all areas have experienced an increase. Removal of large patches of tree canopy due to the construction in the northwest part of the city and wetland restoration in the northeastern part of the city in the southern part of the city resulted in large, localized declines in tree canopy. Loss was also noted in other locations where new commercial properties were built.

Even though there was stark evidence of hundreds of trees being removed throughout the city, this loss was offset by natural growth, some from newly planted trees but most from established canopy. The largest absolute gains were most noticeable in residential areas towards the southern part of the city with a robust tree canopy. Canopy begets canopy as almost all trees gain canopy on an annual basis. The greatest relative gains in tree canopy were in locations where new plantings were carried out on areas with little tree canopy to begin with. Just as forest patches provide valuable ecosystem services, such as wildlife habitat, so do individual trees. In areas with low tree canopy, an individual tree can provide a refuge from the sun while watching a baseball game or help to reduce homeowner air conditioning costs. Natural growth can provide gains in areas with robust canopy, but in areas with low canopy, such as new developments, tree plantings are an important part of a long-term plan to increase tree canopy.

There are both environmental and anthropogenic risks facing canopy cover. Invasive species could pose a serious threat if not identified and controlled early. Natural events such as storms can have a mixed impact on the canopy. Climate change may cause trees to grow more quickly but could also result in inhospitable conditions for native species. Anthropogenic factors include preservation and conservation efforts and the strength of tree ordinances.

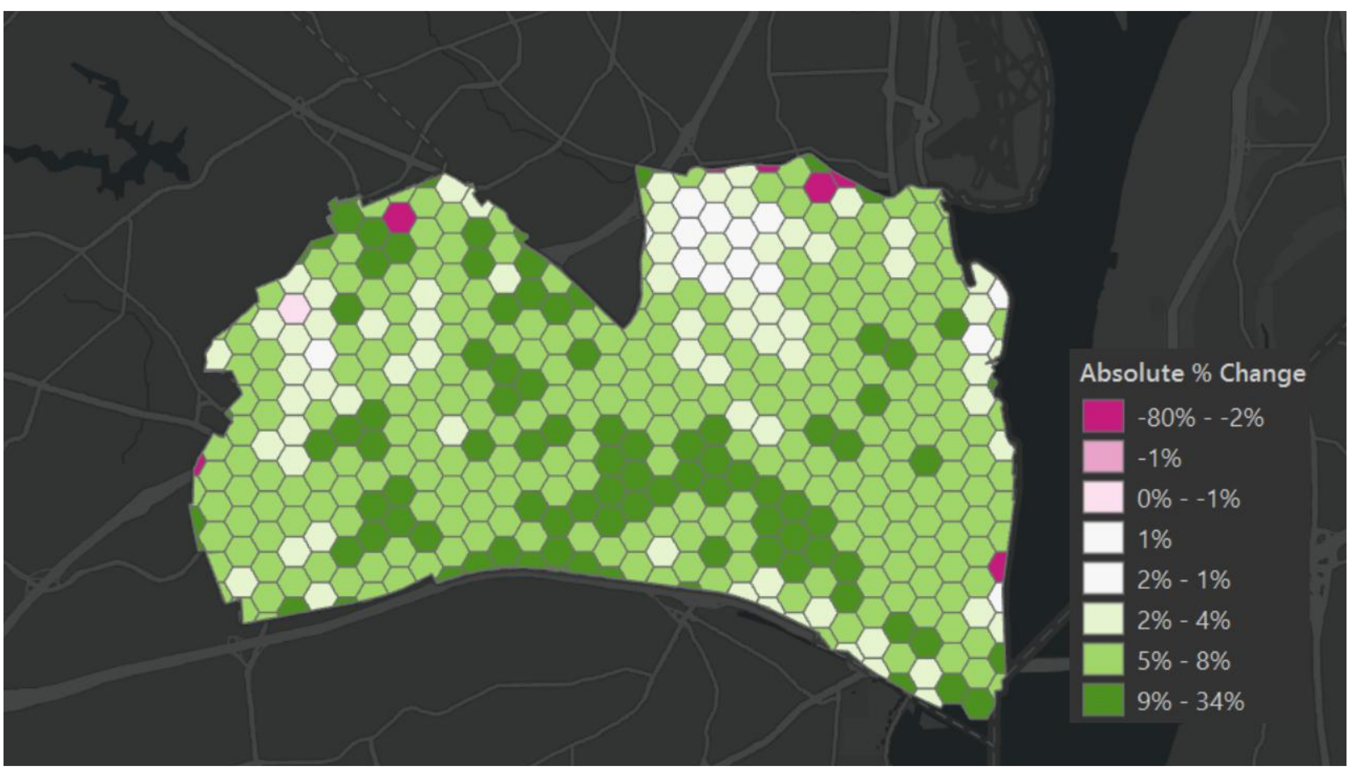


Figure 6: Tree canopy change summarized by 5-acre hexagons. Darker greens indicate greater gain, while darker purple reflects higher amounts of loss.

Tree Canopy Change Mapping

Tree canopy change mapping is an inherently challenging task. Tree canopies in imagery do not appear in the exact location due to image parallax, making it far easier to map losses, which tend to be larger, more apparent events. This study relied on LiDAR, which is more positionally accurate and excels at identifying losses along with the fine-scale gains that occur on the edges of trees. The mapping would have indicated a loss if only imagery had been used for this study. The examples below show the tree canopy change mapping overlaid on the 2014 LiDAR (left panel) and the 2018 LiDAR (right panel). Tree canopy has a textured, rough appearance. Gains appear smooth in the 2014 imagery, and the canopy does not yet exist. Losses appear smooth in the 2018 LiDAR as the canopy is no longer present.

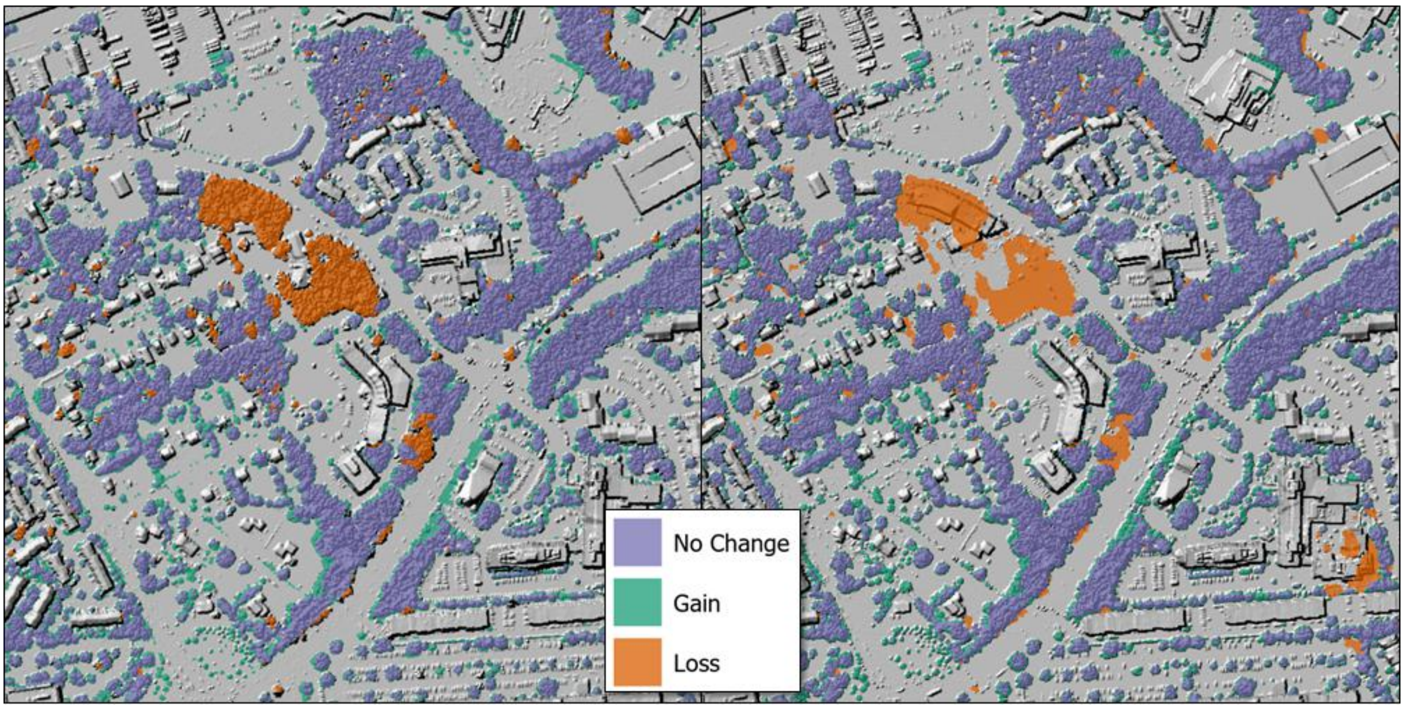


Figure 7. Washington Forest area near North Beauregard Street and Fillmore Ave. Two forest patches were removed for new construction. Forest patches provide important ecosystem services. Even though the city gained tree canopy the loss of patches like these is of concern.

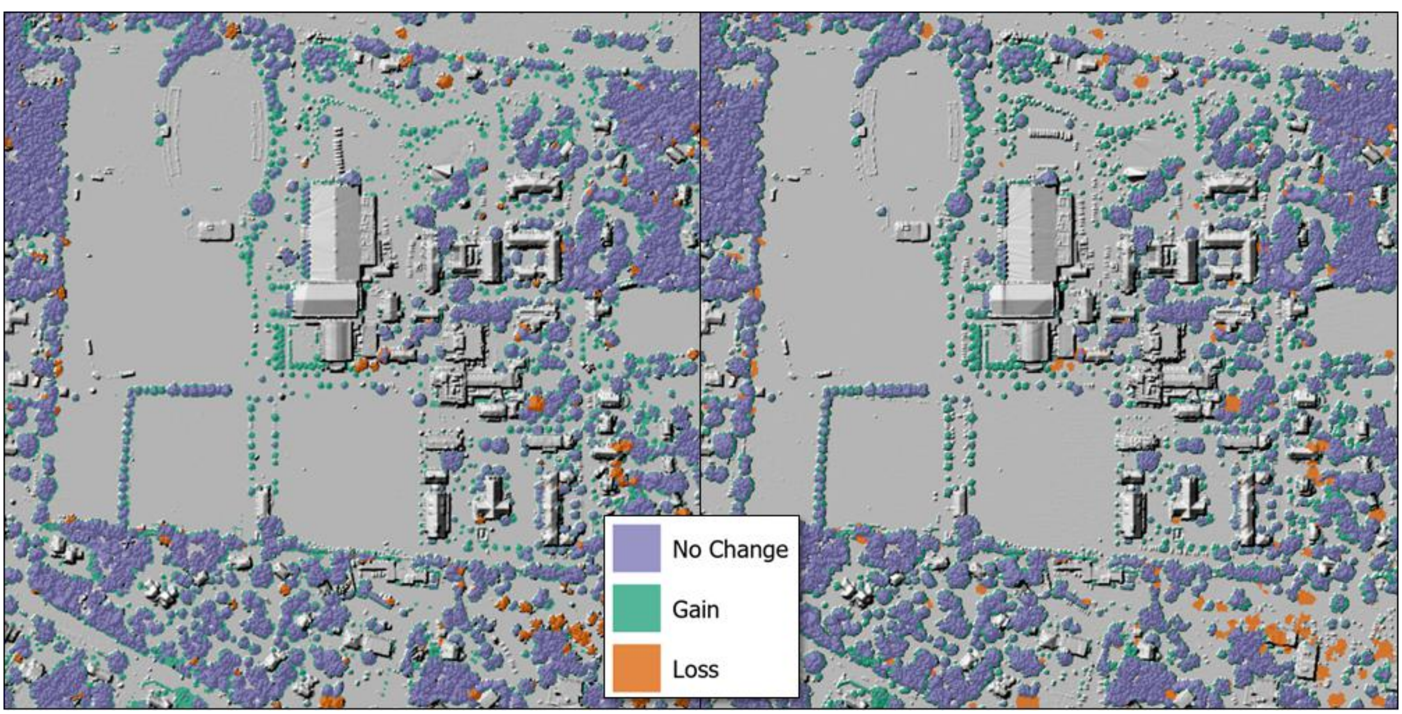


Figure 8: Episcopal High School. The growth surrounding young trees in clearly evident and offset the nearby losses.

The major limitation of LiDAR is that it is acquired under leaf-off conditions during the late fall or early spring. Thus, although it has improved positional accuracy, it tends to underestimate tree canopy slightly. This issue is more apparent in 2014 LiDAR, which is less detailed, and less of a factor in the higher-resolution 2018 LiDAR. This study employed techniques to address these issues. Still, it is likely that at least a portion of the canopy gain mapped, particularly the canopy associated with smaller trees, was present in 2014. Thus, the gains result from growth out beyond a four-year period.

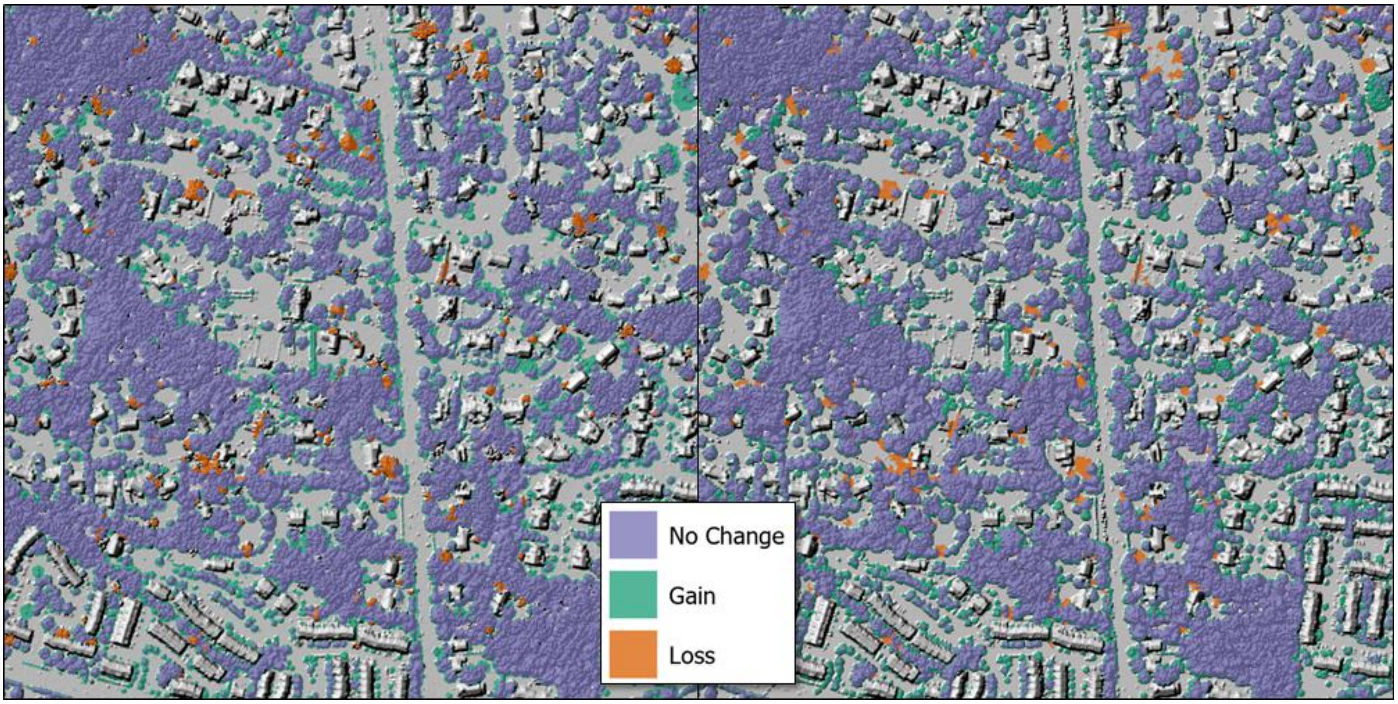


Figure 9. North Quaker Lane and Trinity Drive. This established residential area shows a mix of loss and gains. The losses are more stark as they come from the removals of entire trees. The gains, which are most often along the edges of trees, are fine scale and more than compensate for the losses, resulting in a net canopy increase.

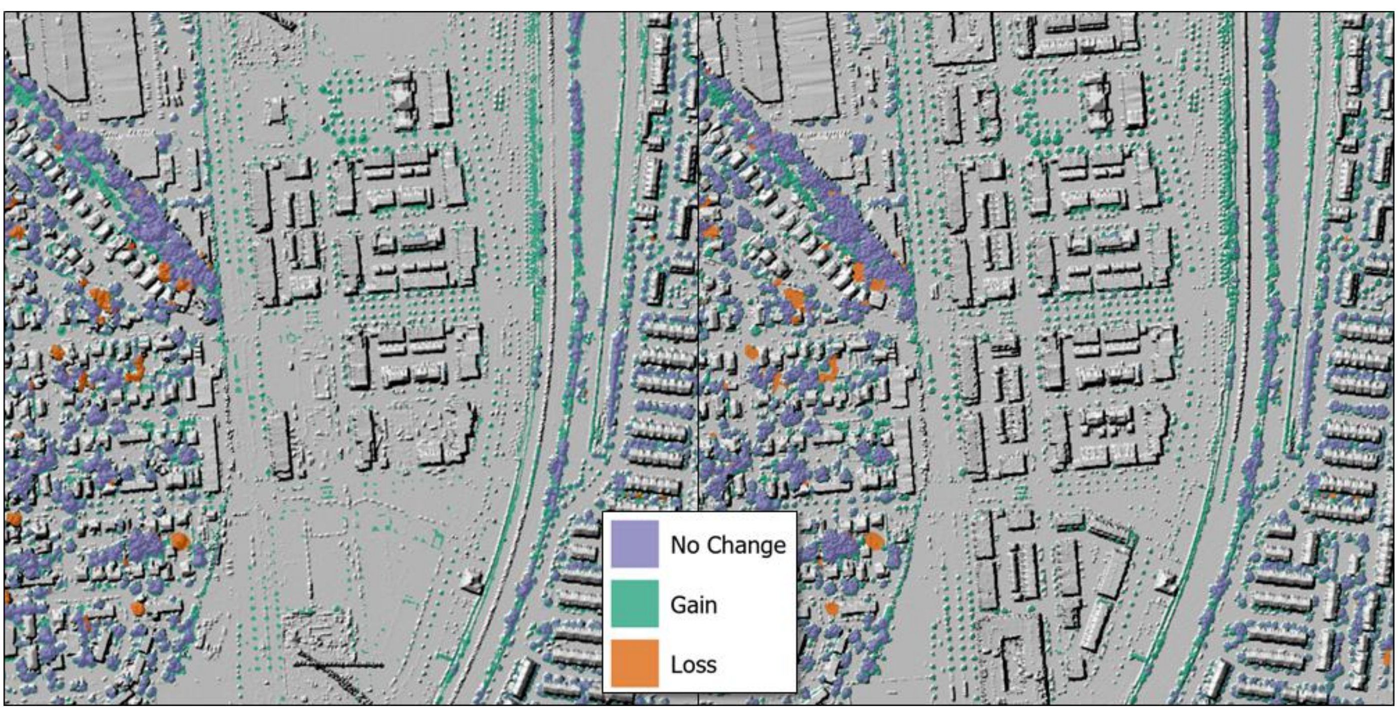


Figure 10: Station 650 Apartments to the east of Route 1. Newly planted trees result in large relative gains in canopy for this area. Although the trees were present in 2014, their canopies only became detectable in 2018.

49% of the city's tree canopy is on residential land, totaling 1,501 acres. Residental land also has the most room to establish new tree canopy, with 920 acres of vegetated land (Possible-Vegetation) not covered by tree canopy. These facts are not surprising given that residential is the most prominent land use in the city. These numbers indicate the crucial role that residents play in the city's tree canopy efforts. Residents must be on board with planting and preservation efforts if the city wishes to maintain or increase its tree canopy. There is clear evidence that robust plantings occur at the time of development. Planting must be coupled with preservation initiatives to create an uneven-aged urban forest and offset the anticipated removals.

Over 20% of the city's tree canopy exists in the rights-of-way (ROW). However, the growing environment near roads is generally inhospitable. Therefore, a well-funded and robust urban forest team is needed to carry out the appropriate routine maintenance and planting actions to maintain the city's robust street tree canopy into the future. While there is less room to plant trees in the ROW, individual trees can have an outsized impact on urban cooling, stormwater runoff, and aesthetics. The larger forest patches primarily reside on government lands. The tree canopy in these patches is critically important as it includes natural understories that provide unique ecosystem services, such as wildlife habitat.

City Government	9%
Commercial	4%
Institutional	11%
Other Government & Utilities	2%
Residential	49%
Rights-of-Way	21%
Vacant Land	5%

Figure 9. Percent of total tree canopy by land use class.

Figure 11: Tree canopy metrics providing information on the Existing and Possible Tree Canopy summarize by land use. Please consult page 3 for the definitions.

Residential land also contributed the largest amount of new tree canopy to the city; it is also where the greatest amount of tree canopy was lost. The right-of-way (ROW) yielded more than half as much new tree canopy, a sign that the city's investments in street tree planting and maintenance over the past decades are paying off. Vacant land had the largest absolute change in tree canopy, a trend that could be reversed if this land is developed. Commercial land, which had low tree canopy coverage to begin with, showed the greatest relative gain in tree canopy. City government land has the highest percent tree canopy coverage, followed by residential and institutional.

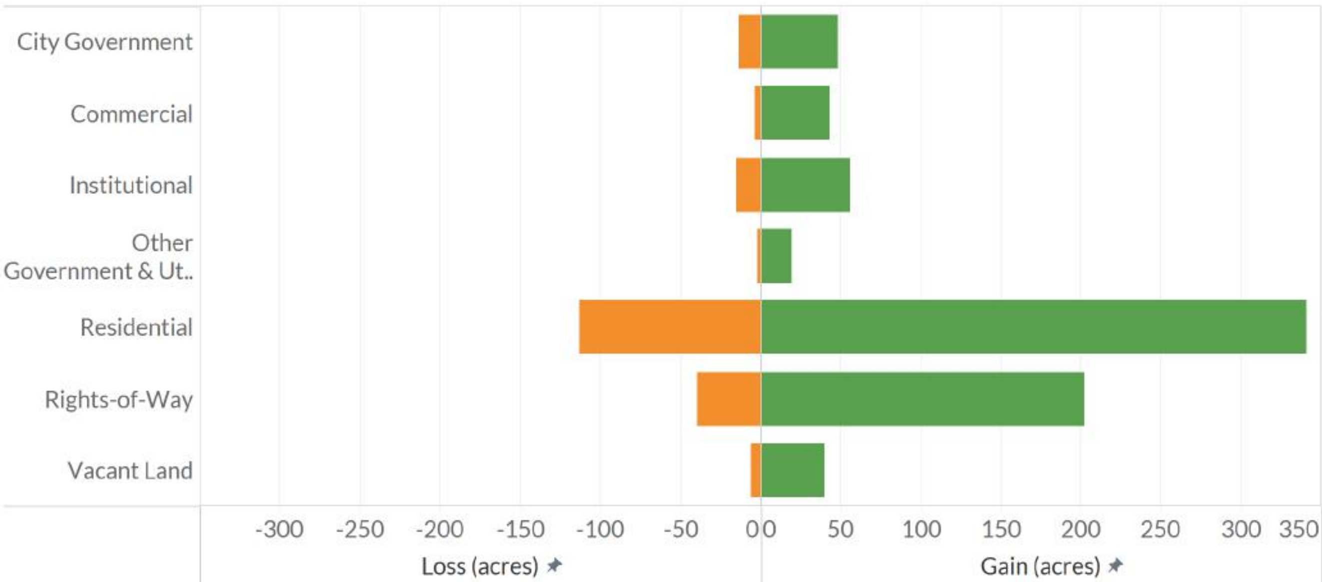


Figure 12: Tree canopy gains and losses by generalized land use categories

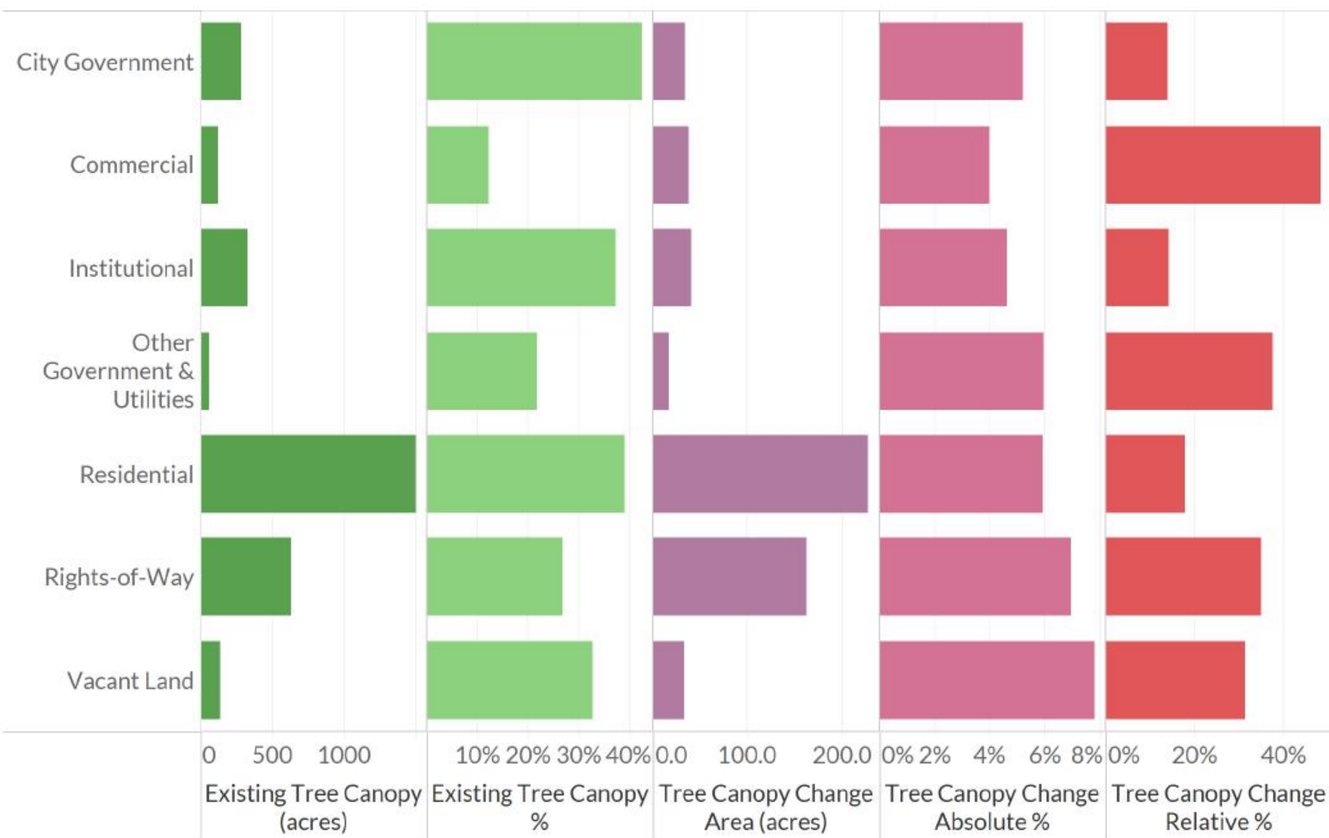


Figure 13: Tree canopy and change metrics for generalized land use categories.

The ecosystem services trees provide make them an essential part of Alexandria's infrastructure. Current and past practices impact the distribution of tree canopy. These factors include zoning decisions, the ability of residents to request and advocate for new street trees in their neighborhood, and racist practices of the past, such as redlining. In order to ensure a just and equitable future in which all of Alexandria's residents are afforded the advantages that the trees provide, the city should strategically target its planting efforts. Climate change is anticipated to exacerbate the urban heat island, resulting in tens of thousands of excess deaths in the coming decades. A way to address past equities, enhance ecosystem services, and make Alexandria a more sustainable city is to focus on areas that are routinely warmer in the summertime. This study found a clear, statistically significant, inverse relationship between tree canopy and the urban heat island, with heavily treed areas over 5 degrees (F) cooler than areas with lesser amounts of tree canopy.

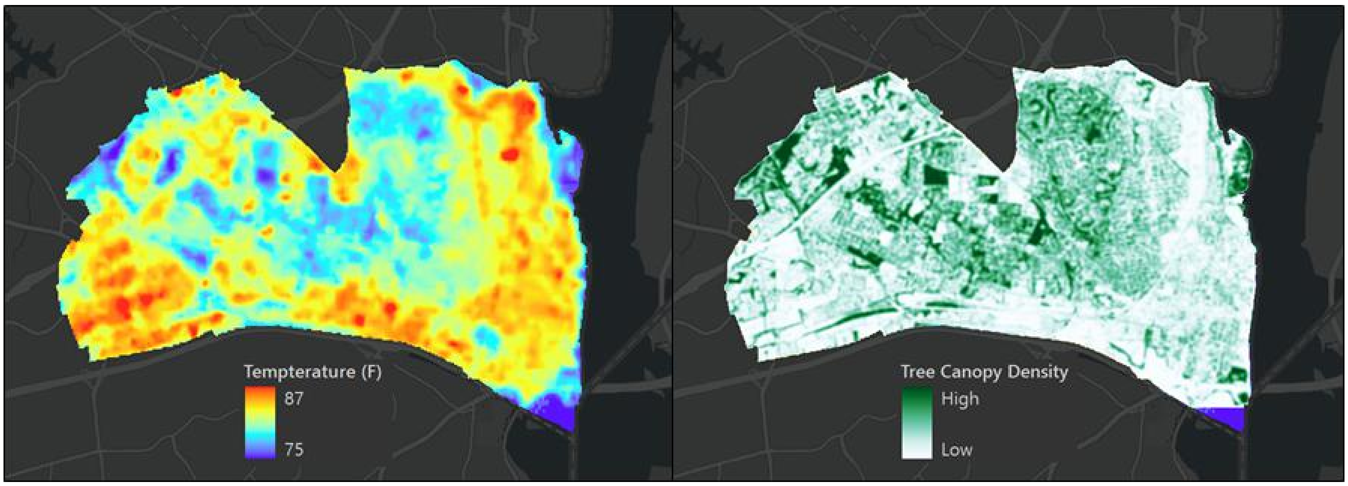


Figure 14: Surface temperature derived from Landsat satellite thermal imagery acquired in July of 2018 (left) and 2018 tree canopy density (right). Areas with high amounts of tree canopy are associated with lower temperatures.

Figure 15: The relationship between tree canopy and surface temperature. Each dot represents a 25-acre hexagon (see page 7). The dots are colored based on the percent of land covered by impervious surfaces. There is an inverse relationship between tree canopy and surface temperature that is statistically significant.

THE TREE CANOPY ASSESSMENT PROCESS

This project employed the USDA Forest Service's Urban Tree Canopy assessment protocols and made use of federal, state, and local investments in geospatial data. Tree canopy assessments should be completed at regular intervals, every 3-5 years.

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.

The Importance of Good Data

This assessment would not have been possible without investments in high-quality geospatial data, particularly LiDAR. These investments pay dividends for a variety of uses, from stormwater management to solar potential mapping. Good data supports good governance.

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 township's tree canopy to be mapped in greater detail and with better accuracy than ever before. From a single street tree along a roadside to a patch of trees in a park, every tree in the city was accounted for.

Tree Canopy Mapping

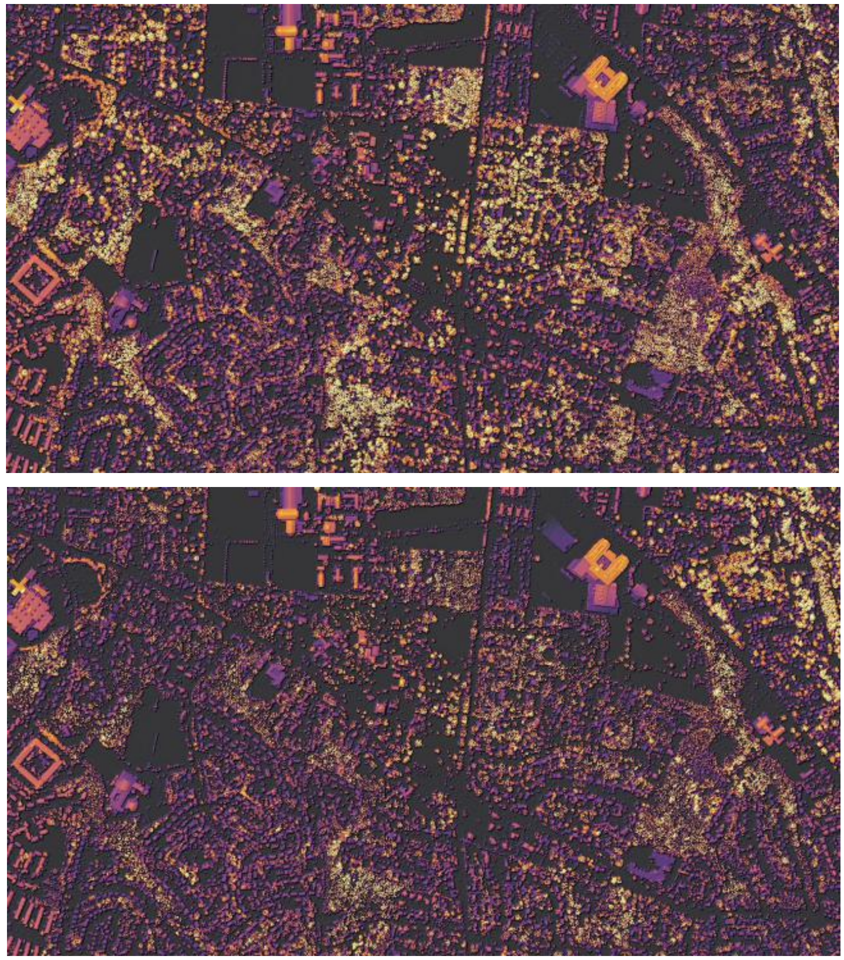


Figure 16: The LiDAR used in this study. 2018 (top) and 2014 (bottom) displayed as color infrared composites.

The high-resolution land cover that forms the foundation of this project was generated from the most recent LiDAR data, which was acquired in 2018. Compared to national tree canopy datasets, which map at a resolution of 30-meters, this project generated maps that were over 900 times more detailed and better account for all of the city's tree canopy.

Land Cover Mapping

Figure 17: High-resolution land cover developed for this project.

This assessment was carried out by This assessment was carried out by SavATree and the University of Vermont Spatial Analysis Lab. 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 Alexandria, Fairfax County, the USDA, and the USGS. The project was funded by the City of Alexandria. Additional support for data analytics came from a Catalyst Award from the Gund Institute for Environment at the University of Vermont. Computations were performed on the Vermont Advanced Computing Core supported in part by NSF award No. OAC-1827314.

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