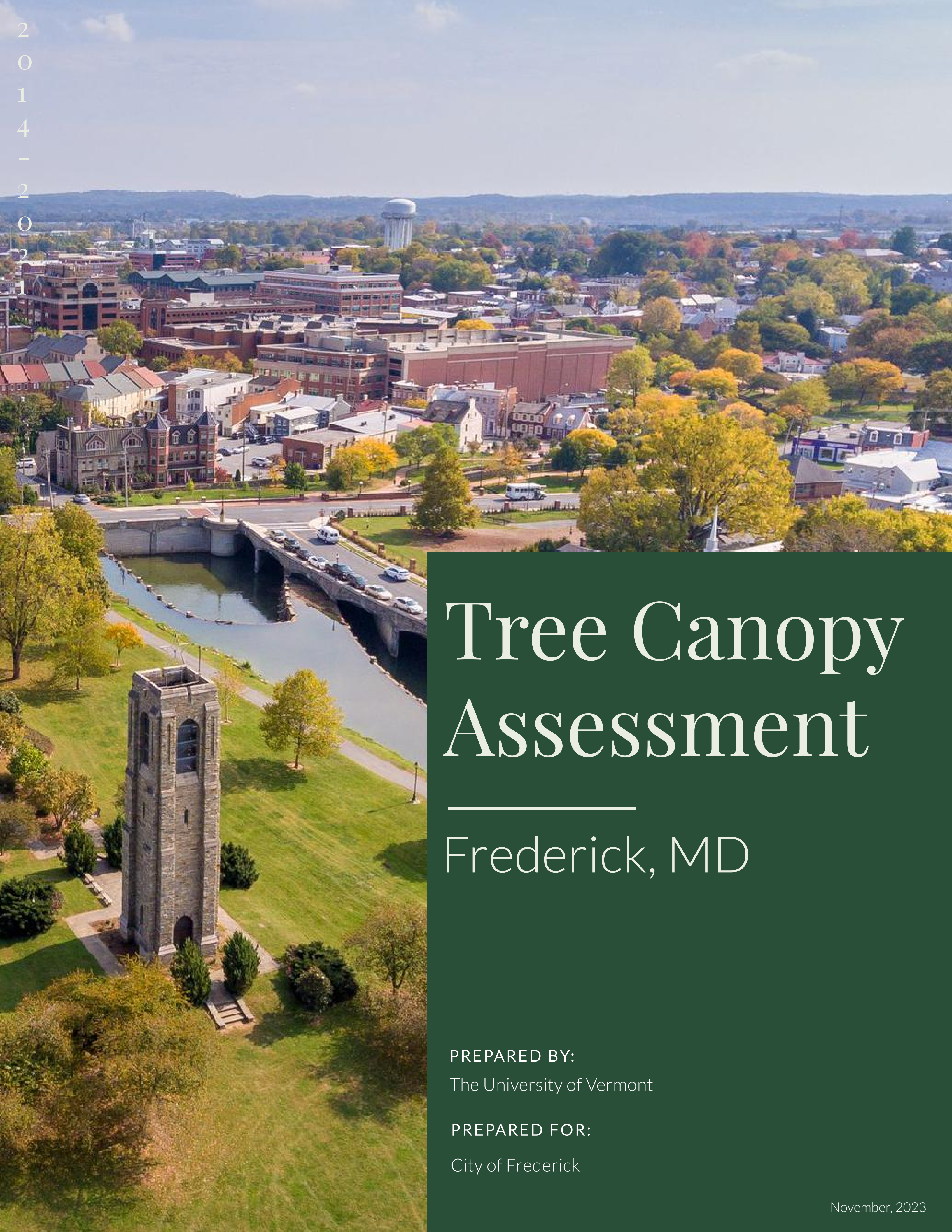
2014 – 2021



Tree Canopy Assessment

Frederick, MD

PREPARED BY:

The University of Vermont

PREPARED FOR:

City of Frederick

November, 2023

THE NEED FOR GREEN

Trees provide essential ecosystem services in the City of Frederick, like reducing stormwater runoff, cooling the pavement in the summer and providing wildlife habitat. Trees are an indispensable part of the region's infrastructure. Research shows that these green assets can improve social cohesion, reduce crime, and raise property values. A healthy and robust tree canopy is crucial to building a more livable and prosperous city.

As with any community, Frederick 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 Frederick'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. Left out of this mapping has been an accounting of the green infrastructure.

The Tree Canopy Assessment protocols were developed by the USDA Forest Service 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 can provide vital information to help governments and residents chart a greener future by helping them understand 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 the City of Frederick over the 2014-2021 period.

TREE CANOPY BY THE NUMBERS

Tree canopy in Frederick was stable. Tree canopy change was computed by mapping the no change, gains, and losses in tree canopy from 2014-2021.

Frederick

+26

Acres

Area change in tree canopy

from new plantings and incremental growth.
(863 acres of gain - 837 acres of loss)

+0.1%

Absolute change in tree canopy coverage

18.6% 2014 Existing Tree Canopy %

18.7% 2021 Existing Tree Canopy %

298,300

Estimated total trees in 2021

Frederick*
(Excluding Fort and Airport)

+8

Acres

Area change in tree canopy

from new plantings and incremental growth.
(806 acres of gain - 798 acres of loss)

0%

Absolute change in tree canopy coverage

20% 2014 Existing Tree Canopy %

20% 2021 Existing Tree Canopy %

278,800

Estimated total trees in 2021

All other metrics in this report include the airport and fort.

TREE CANOPY IS STABLE

FOREST PATCHES ARE BEING BROKEN UP

GAINS ARE INCREMENTAL

RESIDENTS ARE KEY

FINDINGS

The city of Frederick had 2,864 acres of existing tree canopy in 2021, compared to 2,838 acres in 2014.

Gains in tree canopy are offsetting losses, resulting in a slight net increase of 26 acres. Growth of existing tree canopy was the biggest driver of Frederick's canopy gains.

To enhance urban resilience, Frederick can improve access to trees and the benefits that they provide.

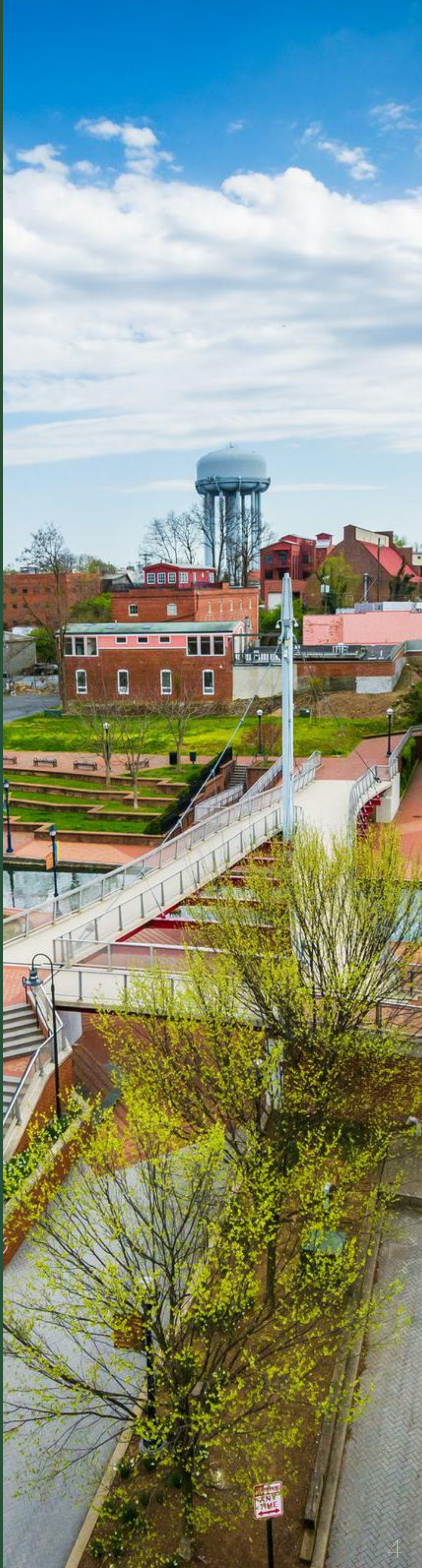
Tree canopy loss is neither evenly distributed nor similar. It varies from removal of individual trees in backyards to clearing of patches of trees for new construction.

Frederick can improve environmental equity by prioritizing tree plantings in neighborhoods most susceptible to environmental risk.

There were 192 acres of tree canopy in the rights-of-way (ROW) in 2021. This represents a loss of about 42 acres since 2013.

Land use history, urban forestry initiatives, natural processes, and landowner decisions, all play a role in influencing the current state of tree canopy in the city.

Tree canopy will likely decline if removals of trees that are reaching maturity continue at the same pace and new trees are not planted to maintain the age diversity of trees.



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 also help the city grow canopy.

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.

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 Frederick's investment in high-quality geospatial data, particularly LiDAR. These investments pay dividends for a variety of uses, from stormwater management to solar potential mapping. This LiDAR will help the Frederick advance their risk management plan by creating the tree centroids needed to run a risk analysis. 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 city'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

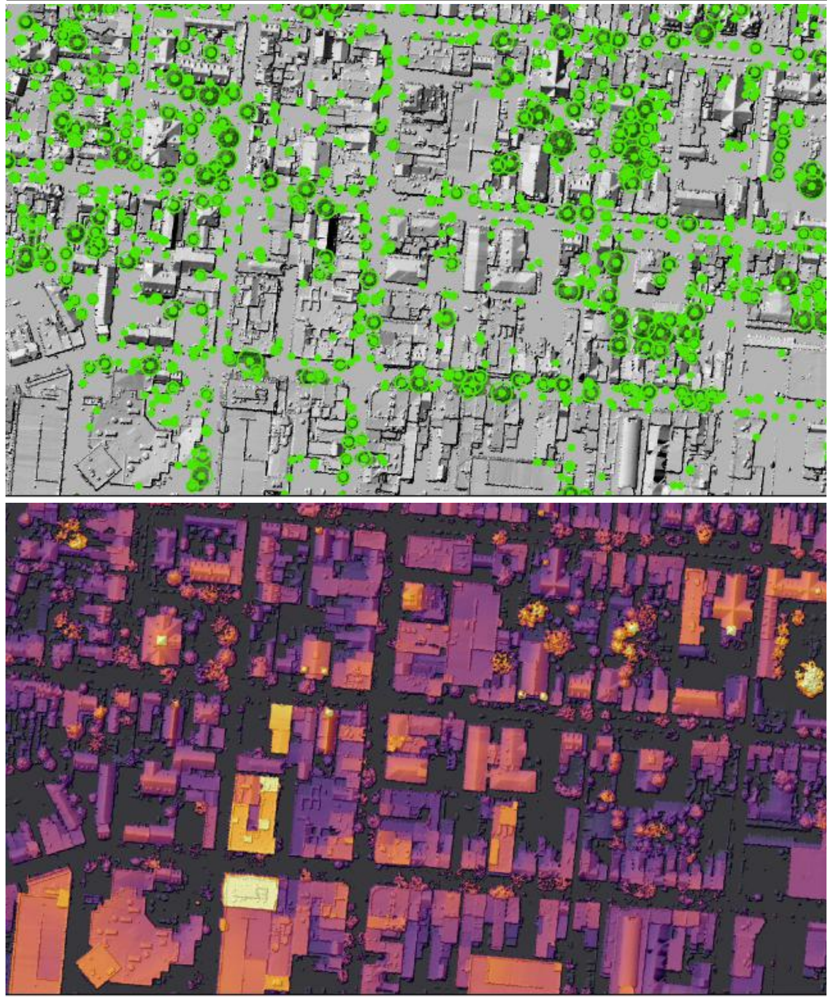


Figure 1. Locations of individual trees and their crowns (top) that were derived from the 2021 LiDAR (bottom).

The high-resolution land cover that forms the foundation of this project was generated from the most recent LiDAR, which was acquired in 2021. Compared to national tree canopy datasets, which map at a resolution of 30-meters, this project generated maps that were over 1,000 times more detailed and better account for all of the city's tree canopy.

Land Cover Mapping

Figure 2. High-resolution land cover developed for this project.

TREE COUNT

298,300+ Individual Trees

Frederick has over 298,300 individual trees, an estimate that was derived from the 2021 LiDAR data.

Tree Crowns & Centroids

Trees, particularly individual ones located in parks, on streets, on college greens, and on residential lands, require attention, care, and maintenance to thrive. In addition to quantifying the city's tree canopy acreage and percent coverage, this study produced an estimate of the number of individual trees in Frederick. This analysis was performed using the 2021 LiDAR data. While not a replacement for field-based inventories, LiDAR provides a unique advantage in that all of Frederick's trees can be counted. With Frederick having an estimated over 298,300 trees, it is important that tree maintenance remains a high priority for land managers. Tree maintenance and care activities will ensure that these critical green infrastructure assets thrive in a challenging urban environment.

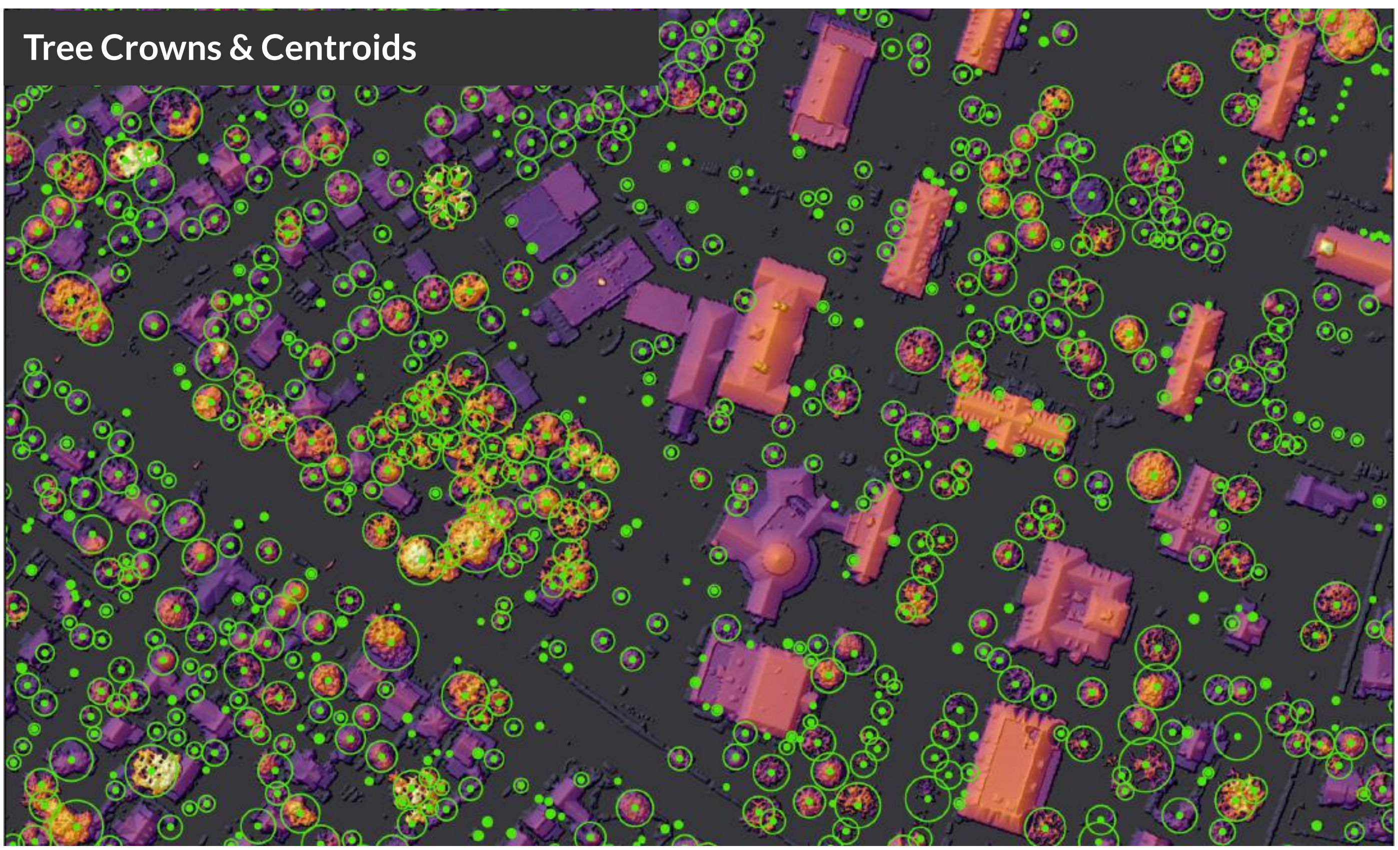


Figure 3. Tree centroids (dots) and tree crowns (circles) mapped from the 2021 LiDAR. Tree mapping from LiDAR involves finding relative high points for each tree, then tracing down until a height inflection point is reached, marking the edge of the crown. This approach to individual tree mapping is most accurate where there is a clear differentiation in tree crowns and is less accurate in forested stands where crowns may overlap.

LANDCOVER

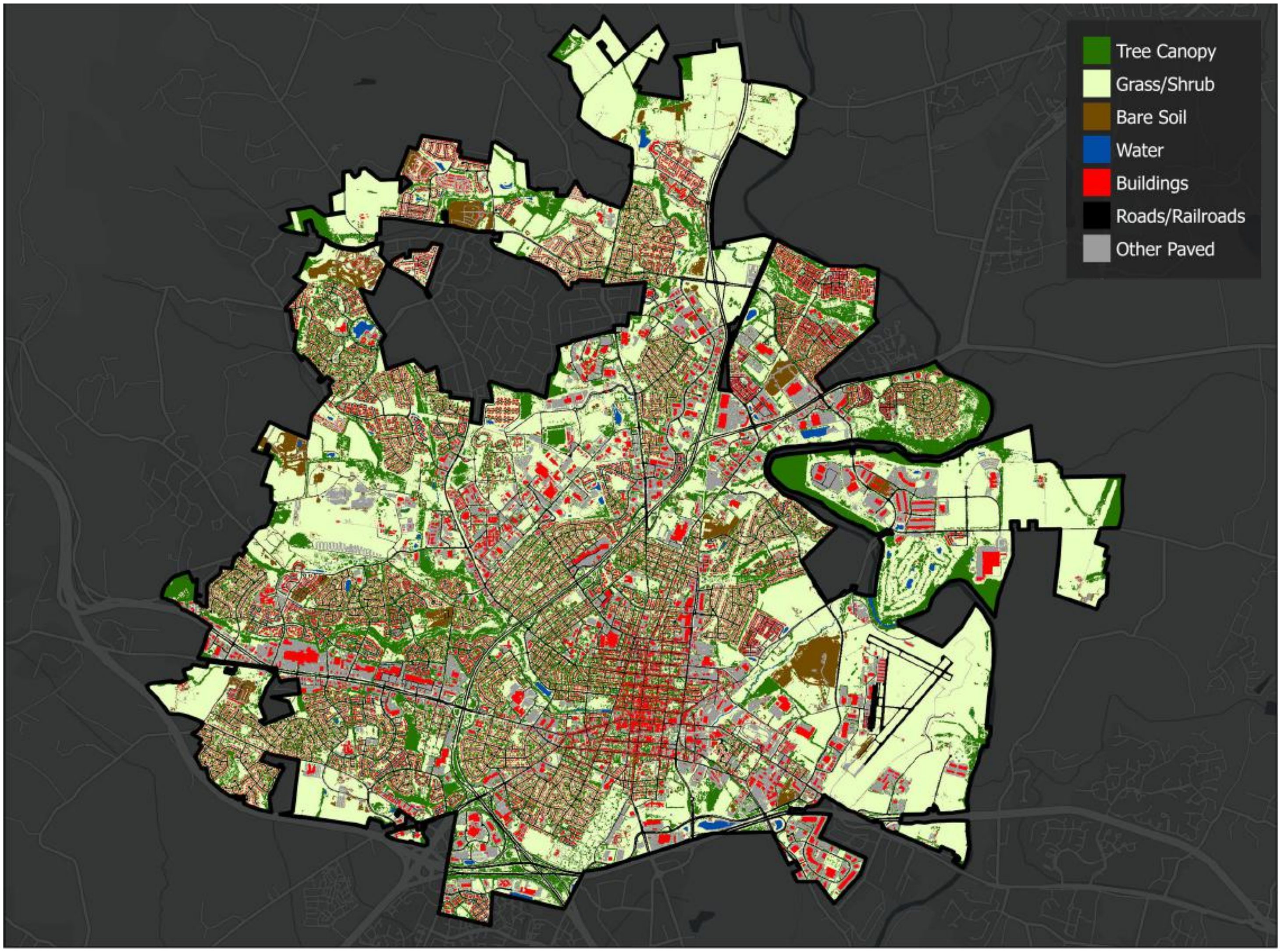


Figure 4. The new 2021 landcover for Frederick was used in this assessment to quantify existing tree canopy, possible tree canopy - vegetated, possible tree canopy - impervious, and not suitable.

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

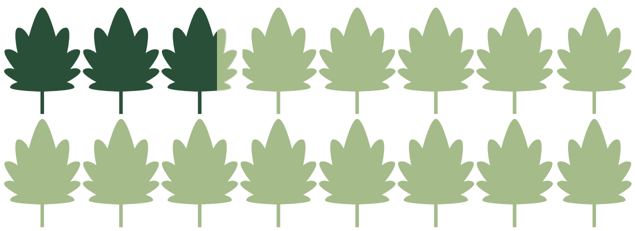
Area Change - the change in the **area of** tree canopy between the two time **periods.**

Relative % Change -the magnitude of change in tree canopy based on the amount of tree canopy in 2011.

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

TREE CANOPY METRICS

18.7% *of Frederick's land is covered by tree canopy*



Tree canopy and tree canopy change were summarized at various geographical units of analysis, ranging from land use and property parcels to council district boundaries. These tree canopy metrics provide information on the area of Existing and Possible Tree Canopy for each geographical unit.

Existing Tree Canopy

Cities commonly have uneven distribution of tree canopy, a pattern that applies to Frederick. There are some 35-hectare hexagons with less than 10% tree canopy and others with nearly 100% tree canopy (Figure 5). This unequal distribution can be traced back to the city's history of development patterns and open space planning. Those residents who live and work in more treed areas (darker green hexagons) benefit disproportionately from the ecosystem services that trees provide. Conversely, the more urbanized regions of Frederick have lower amounts of tree canopy and therefore receive fewer ecosystem services from trees.

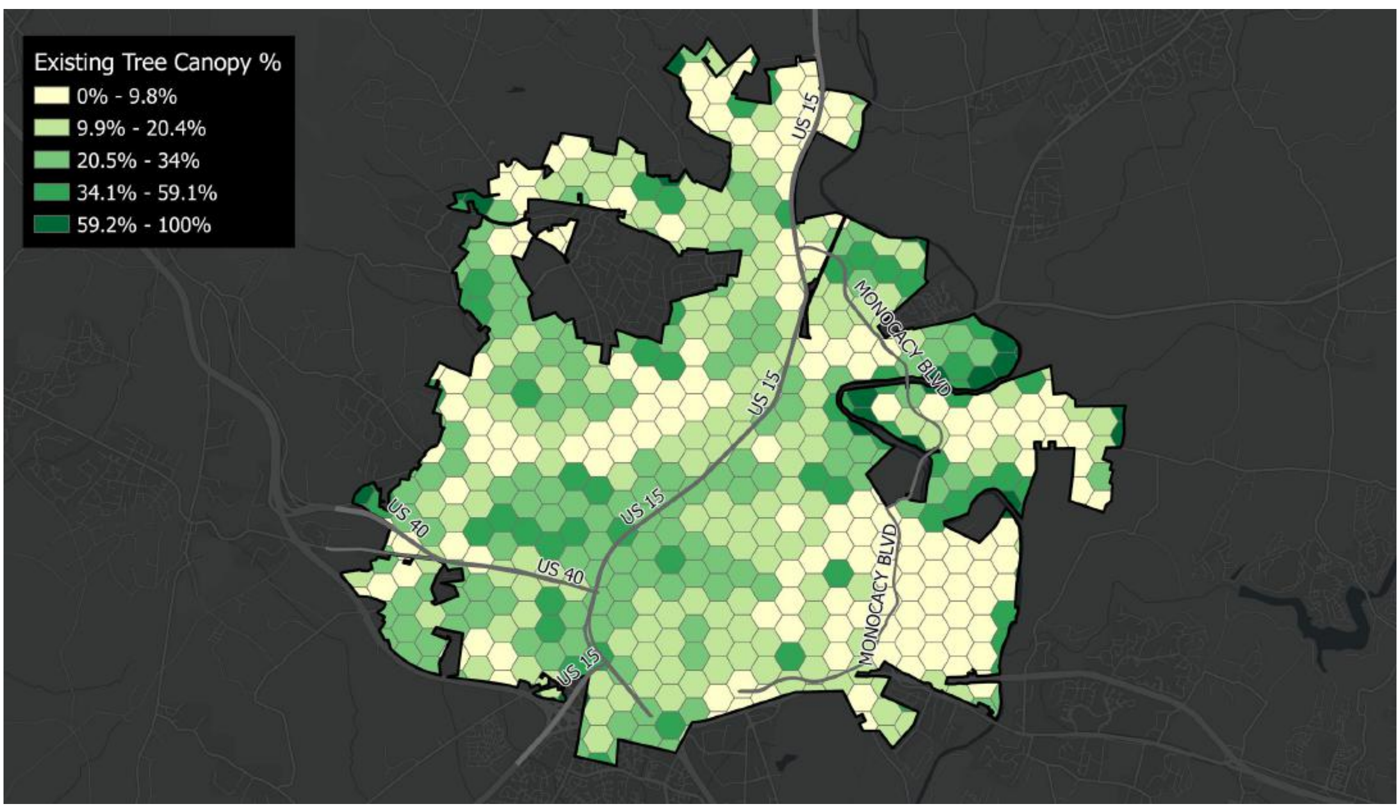


Figure 5. Existing tree canopy percentage for 2021 conditions summarized using 35-hectare hexagons. For each of the hexagons, the percent tree canopy was calculated by dividing the amount of tree canopy by the land area, which excludes water. Using hexagons as the unit of analysis provides a standard mechanism for visualizing the distribution of tree canopy without the constraints of other geographies that have unequal area (e.g., zip codes).

Possible New Tree Canopy

There is available space in Frederick 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 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. While there is open space to plant trees, there is a direct conflict in use; thus, the Possible-Vegetation category should serve as a guide for further field analysis, not a prescription of where to plant trees. With 6,954 acres of land (comprising 45.5% 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 Frederick's total tree canopy in the long term.

In the city's most densely urbanized areas, significantly increasing the tree canopy will be difficult; nevertheless, it remains vitally important to strive for canopy gains. In Frederick's residential areas, healthy natural regeneration of the existing tree canopy and planting new trees will be important. There is often a "plant and forget" cycle in residential areas, where trees are generally planted when homes are built, without the follow-up to replace trees as they decline to establish the next generation of canopy.

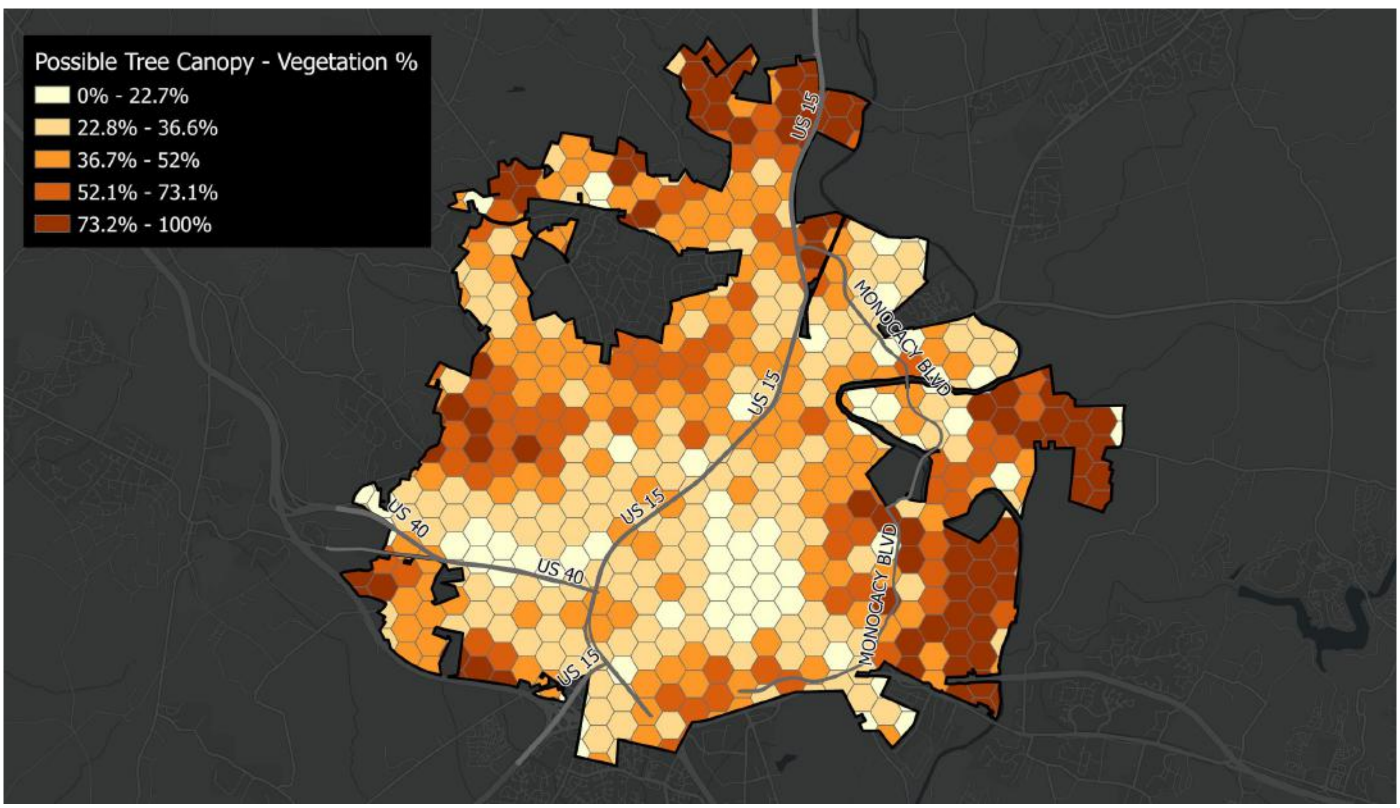


Figure 6. Possible Tree Canopy consisting of non-treed vegetated surfaces summarized by 35-hectare hexagons. These vegetated surfaces that are not currently covered by tree canopy represent areas where it is biophysically feasible to establish new tree canopy. It may be financially challenging or socially 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 — Absolute % Change

The city of Frederick has experienced a slight net increase in overall tree canopy over the 2014 to 2021 time period, but gains and losses were not distributed uniformly. All areas of the city experienced both gains and losses though some areas saw a net increase and others a net decrease in tree canopy. Removal and die off of mature trees resulted in the loss of large patches of tree canopy. Mature trees with large crowns contribute substantially to tree canopy and take decades to grow, so their loss creates large, localized declines in tree canopy. Even though there was evidence of tree loss throughout the city, planting efforts, preservation programs, and natural growth helped offset losses and stem decline. Canopy begets canopy as almost all trees gain canopy on an annual basis.

The trajectory of Frederick's tree canopy in the future is uncertain. 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. In conserved areas, tree canopy will return through natural growth, but in urbanized areas, trees lost to storms will need to be replanted. 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. Managing these risks will be key to achieving canopy growth.

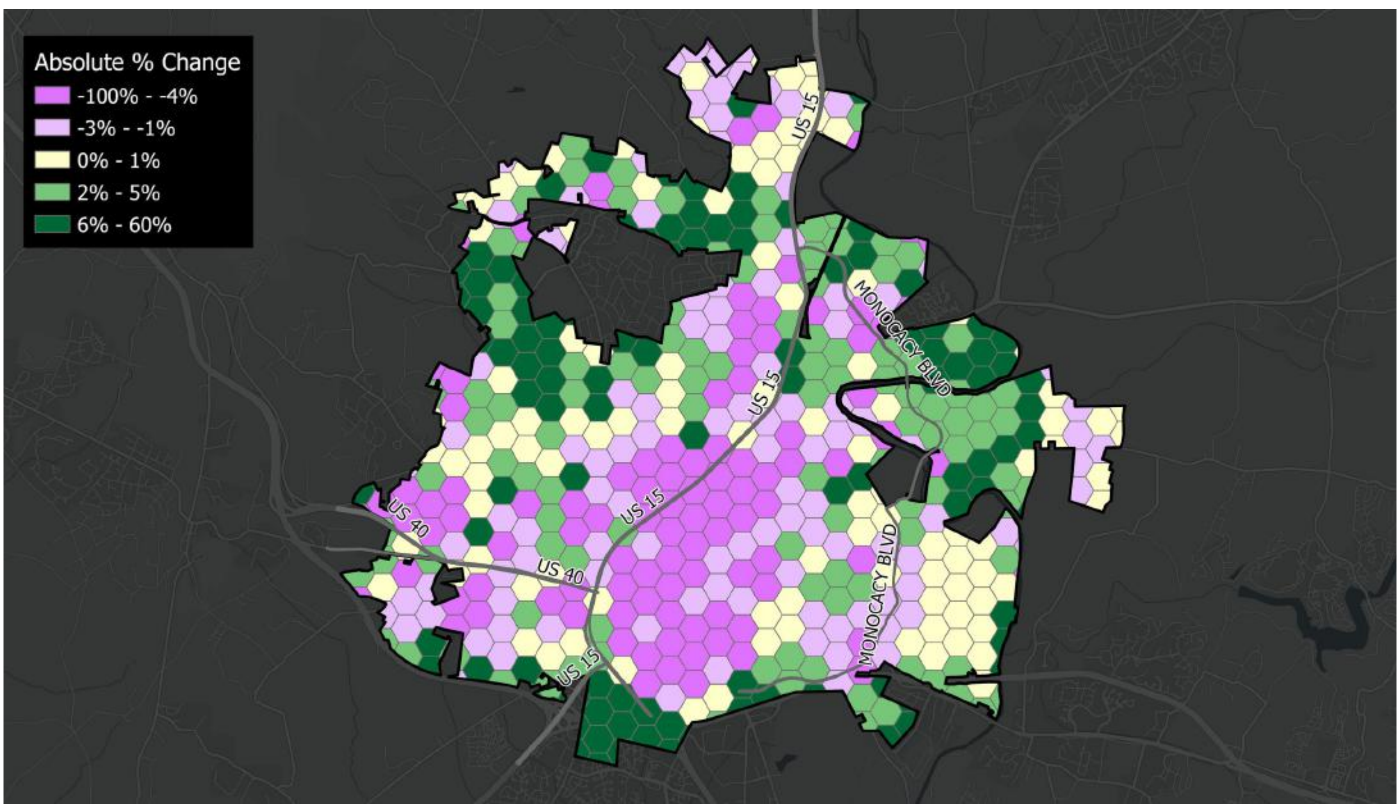


Figure 7: Tree canopy change summarized by 35-hectare hexagons. Darker greens indicate greater gain, while darker purple reflects higher amounts of loss.

Canopy Change Distribution

The magnitude of tree canopy change across Frederick can be measured by the relative tree canopy change over the 2014 - 2021 period. The relative change is calculated by taking the tree canopy area in 2014, subtracting the tree canopy area in 2021, then dividing this number by the area of tree canopy in 2014. Areas with the greatest change indicate that the canopy is markedly different in 2021 as compared to 2014. In some of the commercial and urbanized areas with little tree canopy in 2014, the growth of street trees resulted in a sizeable relative gain. Conversely, the removal of trees as a result of construction in sparsely treed areas resulted in substantial relative reductions in tree canopy.

Trees, when properly cared for, can mitigate environmental risks and challenges relating to the urban environment such as flooding, air quality, and urban heat island. This makes tree canopy an important part of a the city's infrastructure. 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, shade cars in a parking lot or help to reduce homeowner air conditioning costs. Though growing conditions in rights-of-way (ROW) areas can be tough, they are a tool to increase canopy in low coverage areas. Natural growth can provide gains in areas with robust canopy, but in areas with low canopy, such as commercial spaces, tree plantings are an important part of a long-term plan to increase tree canopy.

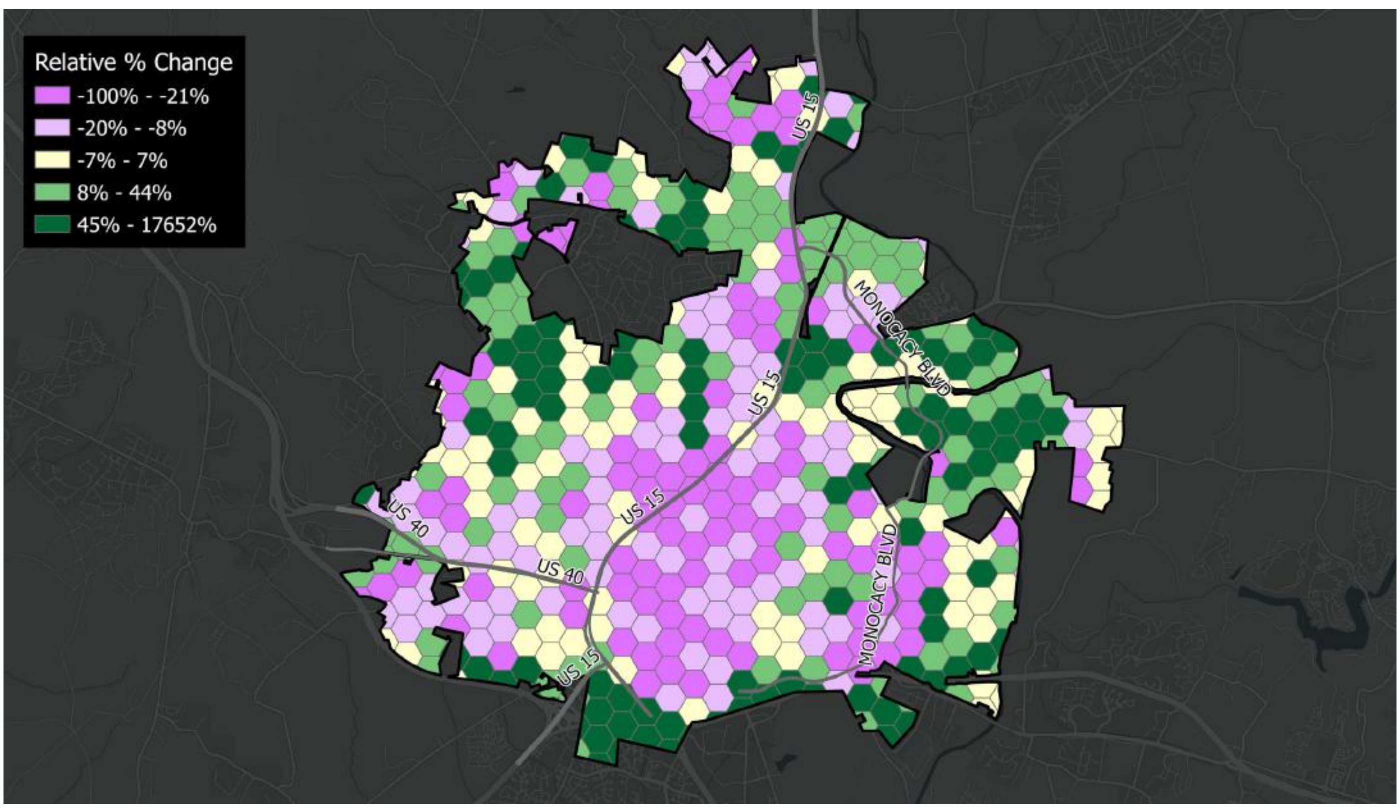


Figure 8: Tree canopy change metrics summarized by 35-hectare hexagons. Relative tree canopy is calculated by using the formula (2014-2021)/2021. Colors are categorized by data quantiles. Darker greens indicate greater relative gain, while darker purple reflects a higher magnitude of loss.

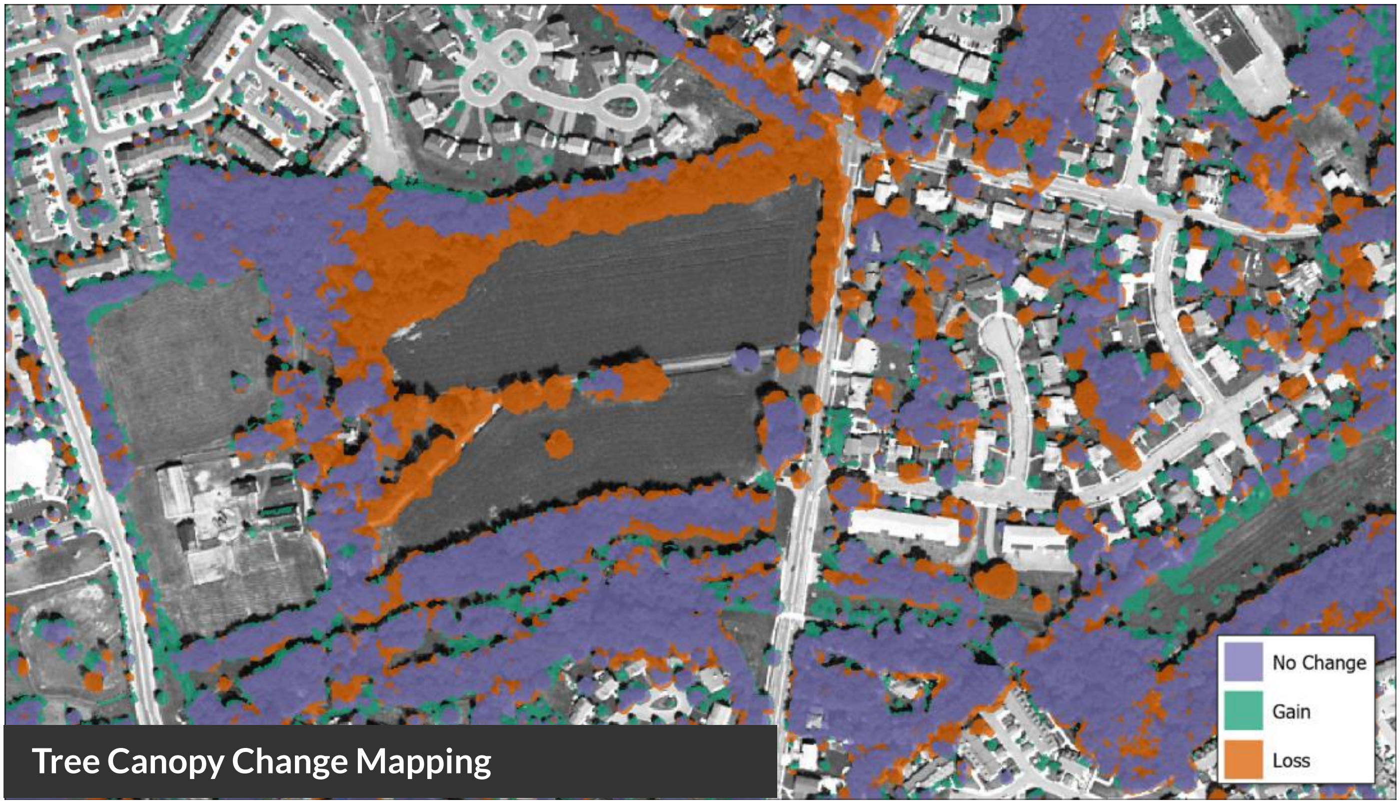


Figure 9: Tree canopy change mapping for the area surrounding Baughmans Ln. and Shookstown Rd. overlaid on 2013 imagery. This area experienced a mix of gain and loss.

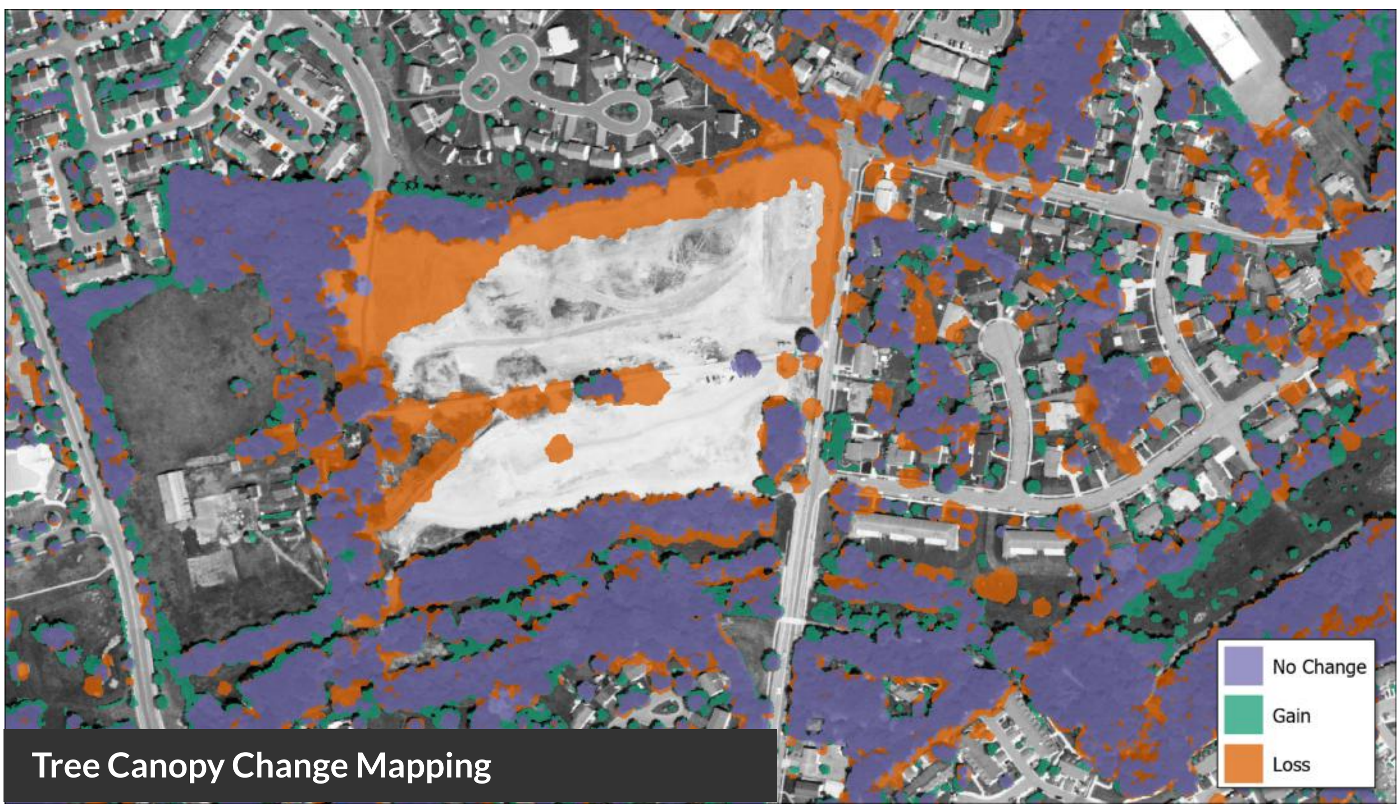


Figure 10: Tree canopy change for the same area above but overlaid on the 2021 imagery. The areas of gain appear rough now that tree canopy is present, and the areas of loss appear smooth due to the absence of tree canopy.

PATTERNS OF CHANGE

Numerous factors contribute to the wide range of tree canopy change patterns in Frederick, including zoning, land use history, urban density, and landowner decisions. The following examples illustrate how these factors influence canopy change. Examining patterns and processes over the past decade can provide insights into how the canopy may change in the future.

Forest Natural Succession

Growth of already existing canopy was the largest driver of the city's tree canopy gains.

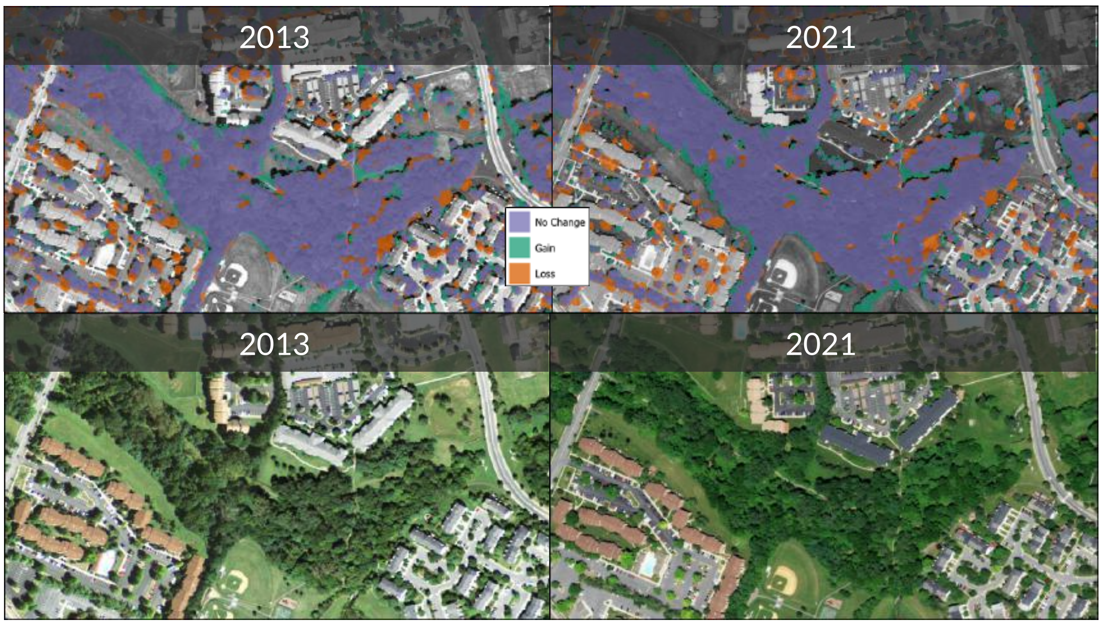


Figure 11. Natural growth in Willowdale Park helped offset losses in the surrounding area. Maintaining large forest patches is important because they provide essential ecosystem services and habitat for wildlife.

Mix of Loss and Gains

Park

Natural Sucession

Urban Forest Patch Development

Urban forest patches provide wildlife habitat, filter pollution, and reduce stormwater runoff. Development needs should balance the essential ecosystem services. Forest patches can be removed in a matter of days and take decades to rebuild.

Figure 12. Forest patch removal around Thomas Johnson Dr resulted in an overall decrease in canopy coverage for the vicinity.

Forest Patch Loss

Commercial Area

New Construction

New Residential Development

Tree planting and loss can coincide with new developments. Trees are often removed to provide space for new construction. Tree plantings with the completion of new residential developments can help offset losses from construction, but newly planted trees tend to be the same age and type. The more diverse tree canopy is in age distribution and species type, the healthier it will be. The trees in this development were likely present in 2013, but were so small they were below detectable levels. Their rapid growth is evident in the 2021 LiDAR data.

Figure 13. Growth of recently planted trees around Christophers Xing and Oppossumtown Pike resulted in a high relative percent gain for the area.

Tree canopy gain

Residential Area

Tree Planting

Established Residential Developments

Trees continue to grow and contribute canopy in more established neighborhoods, but age, disease, invasive species, storms, and changing landowner preferences all contribute to removals. As a result, losses may outpace gains over time if replacement trees are not planted. Tree planting and natural succession are slow but important processes for increasing urban tree canopy.

Figure 14. Mix of tree canopy gains and loss in the residential area around Rollinghouse Dr.

Mix of Loss and Gains

Residential Area

Widespread Tree Removal

Neighborhood Advisory Councils

Frederick's Neighborhood Advisory Councils (NACs) ranged in existing tree canopy percent coverage from 14.2% (NACs 2 and 12) to 26% (NAC 5). The differences in canopy is the result of land use history and changes to the built environment. Areas with large parks and open space tend to have more canopy, while neighborhoods that are more dense with commercial or industrial use tend to have less tree canopy.

Each of the NACs experienced both gains and losses in tree canopy. Gains outpaced losses in NACs 1, 2, 4, 10 , and 12 resulting in a net gain in tree canopy while the other NACs saw overall losses from 2014 to 2021. NAC 6 had the largest loss of tree canopy over the 7-year time period both in terms of area of net loss (42 acres) and magnitude of change (2.7% relative decrease). NAC 4 on the other hand had the largest net increase of 55 acres and highest relative percent increase at 1.9%. The severity of losses were buffered by gains through replanting efforts and natural succession.

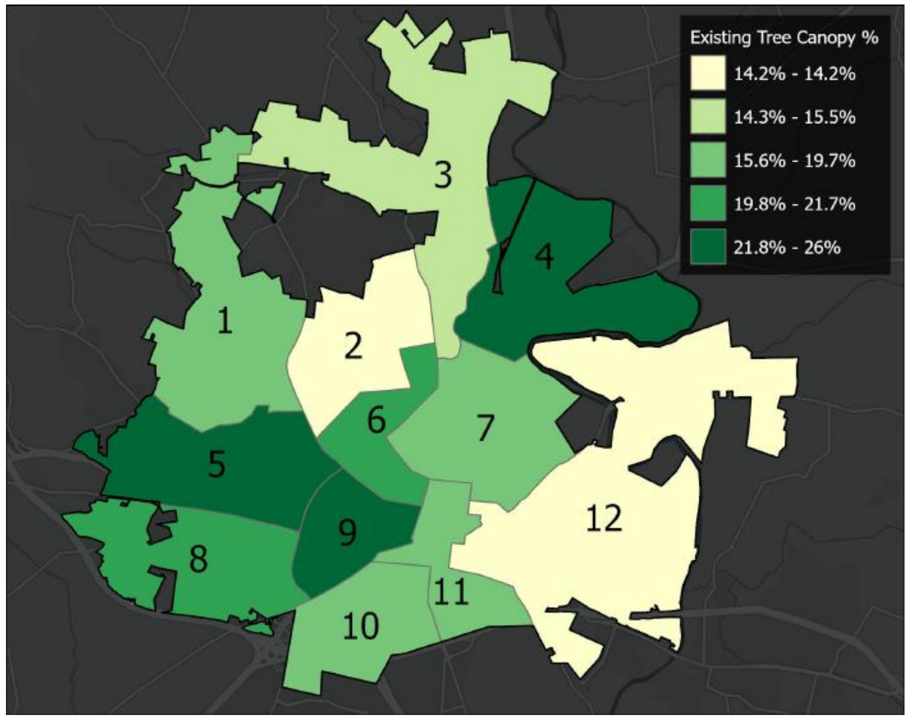


Figure 15: Existing tree canopy percentage for 2021 conditions summarized by NAC.

Figure 16: Tree canopy and change metrics summarized by NAC.

Land Use

Land use is how humans make use of the land including the economic and cultural activities practiced there. Land use is not to be mistaken by land cover which refers to landscape features, such as trees, buildings, water and other classes mapped as part of this study. Land use can significantly influence the amount of tree canopy and the room available to establish new tree canopy. Tree canopy cover was calculated in terms of percent of the land area within each land use type (Figure 18) to understand the proportion of each of each unit with canopy coverage, and as a percent of city-wide total tree canopy area (Figure 17) to determine contribution to Frederick's overall tree canopy.

Residential lands contain the largest portion of Fredericks tree canopy with 45% of the city's tree canopy area falling under this land use type. These findings underscore the importance of engaging with private land owners to preserve tree canopy. This land use also experienced the greatest net losses in tree canopy of any of the land uses. Since residential land is such a large contributor to total tree canopy, this will be an important trend to reverse to maintain the city's urban forest. Commercial and Mixed Use areas also saw net losses in tree canopy over the 2014-2021 time period while Industrial, Institutional, and Park areas all achieved net gains.

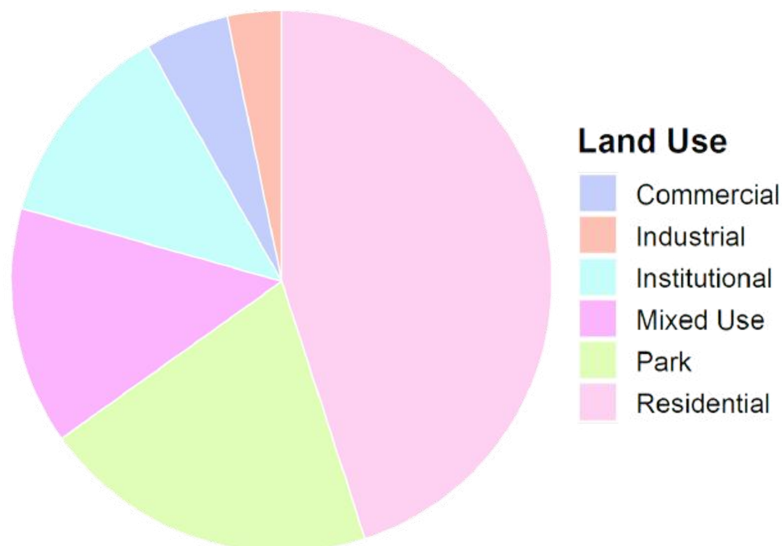


Figure 17: Frederick Tree Canopy Distribution by Land Use.

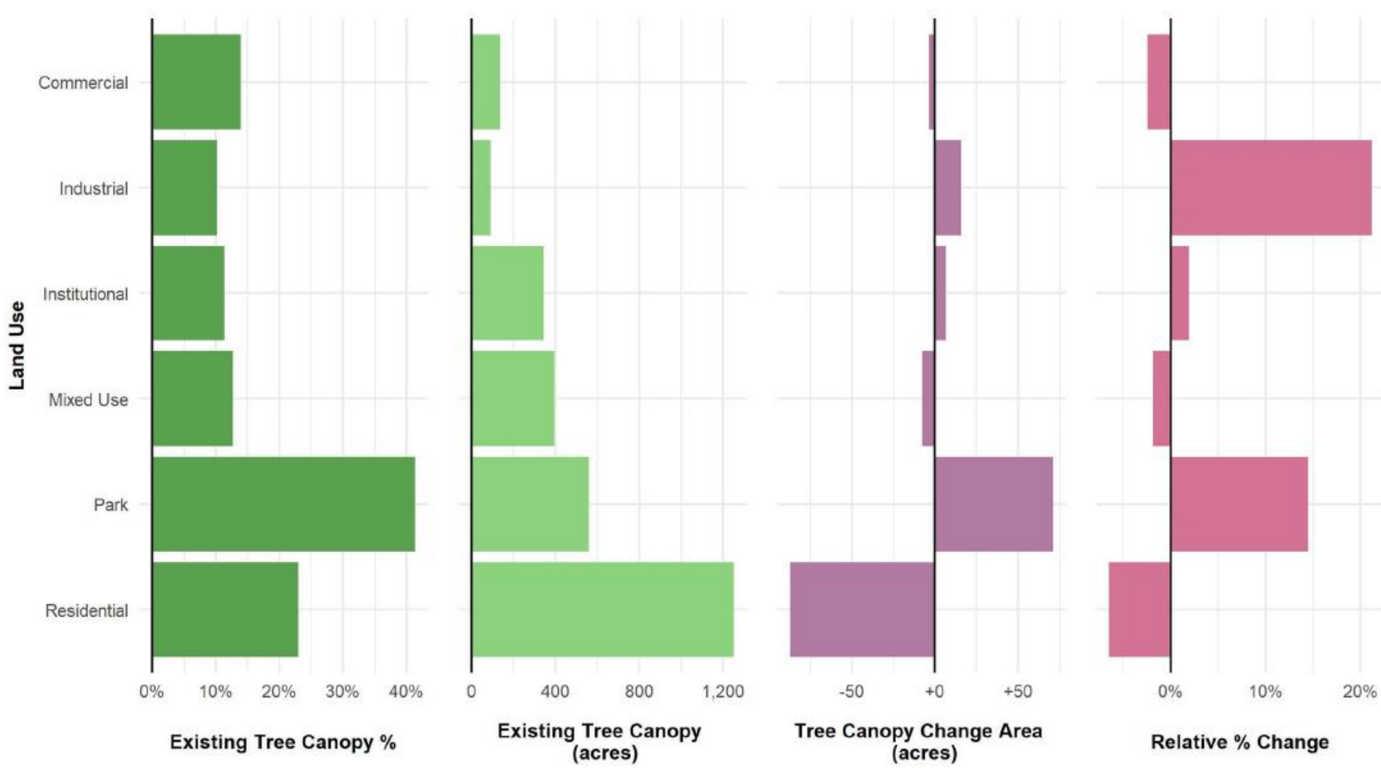


Figure 18: Tree canopy and change metrics by Land Use.

Sub-Watersheds

Frederick's tree canopy is an important factor in managing the health of the city's waterbodies. The land use within a watershed or sub-watershed can have large impacts on its health, including water quality and flood risk. Maintaining robust tree canopy can mitigate problems associated with the impervious surfaces by managing stormwater runoff, filtering pollution, and stabilizing the banks of streams and rivers. Land use and land cover within a drainage area, and especially the proportion of impervious surfaces covering the land key drivers of the amounts of pollution entering waterways. The Monocacy Direct sub-watershed had the highest tree canopy percent coverage at 27.7% of its land area. It also had the largest net gains in area with an increase of 44.4 acres between 2014 and 2021. It's neighboring sub-watershed, Monocacy Direct - South, had the lowest percent canopy cover at 5.7%. The Ballenger Creek - Lower Mainstream sub-watershed had the largest magnitude gain in tree canopy with a 142.7% increase. The Carroll Creek - Lower Mainstream sub-watershed had the largest area of tree canopy net loss (73 acres) of the sub-watersheds in Frederick.

Figure 21: Existing tree canopy percentage for 2021 conditions summarized by sub-watershed.

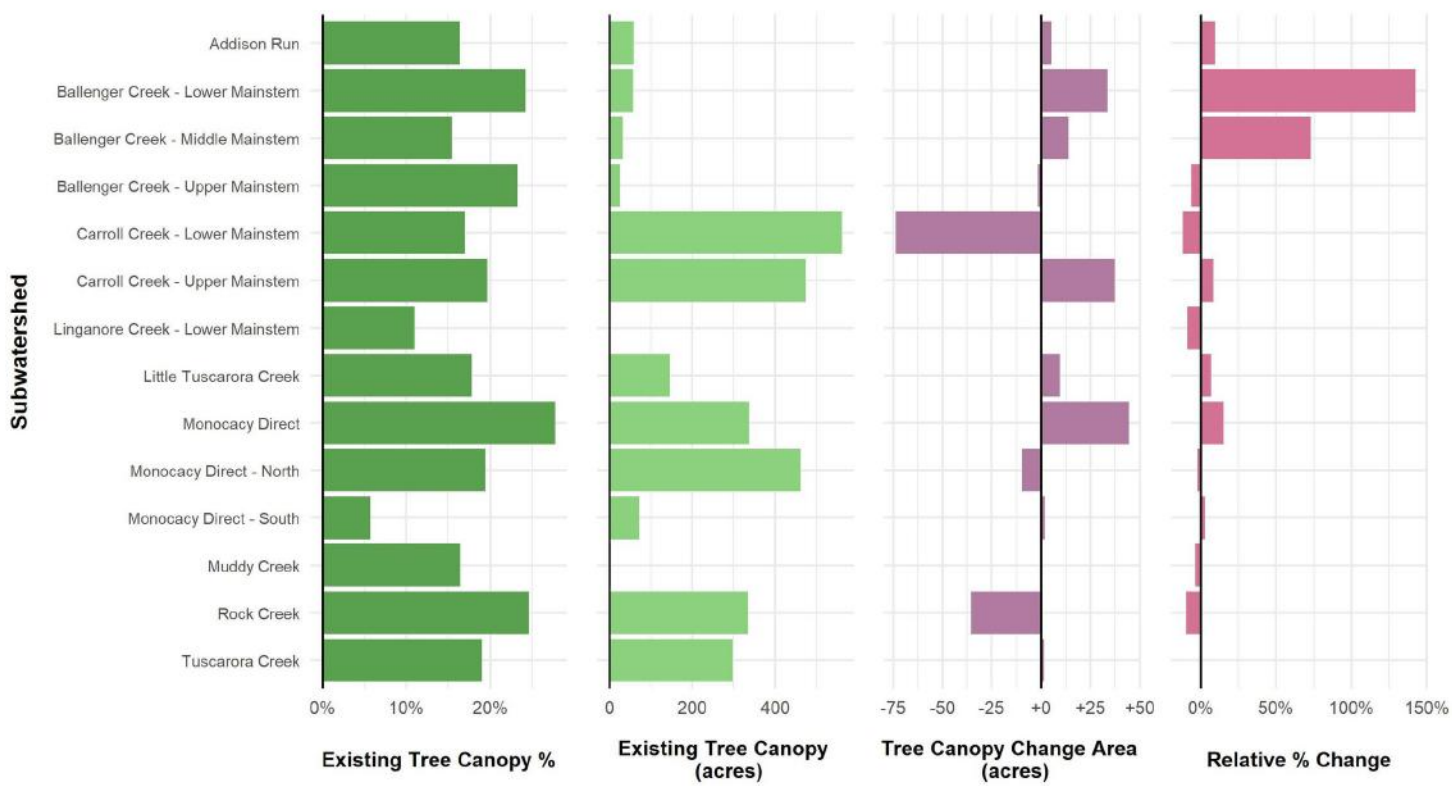


Figure 22: Tree canopy and change metrics summarized by sub-watershed.

Census Block Groups — 2020

Census block groups represent administrative boundaries established by the US Census every 10 years based on population. Generally, block groups have a population between 600 to 3,000. Block group data includes sociodemographic information such as income, education attainment, marital status, and race. Existing tree canopy percent (**Figure 23**) ranges from 0% to 44% within the block groups. Block groups within Frederick City have a high potential for possible tree canopy (**Figure 24**) ranging from 0% to 77%, with an average of 34.5%. Overall, block groups within Frederick City saw an average relative decrease in tree canopy from 2014 to 2021 of 1% in percent tree canopy (**Figure 25**). Absolute canopy change (canopy percent of 2021 subtracted by canopy percent of 2014), ranged from a 12% decrease to a 15% increase (**Figure 26**).

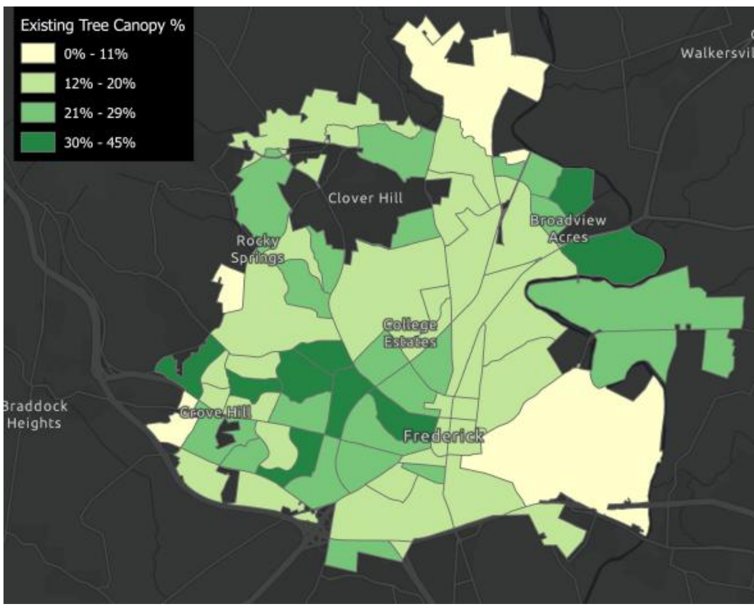


Figure 23: Existing tree canopy percentage for 2021 conditions summarized by 2020 census block groups.

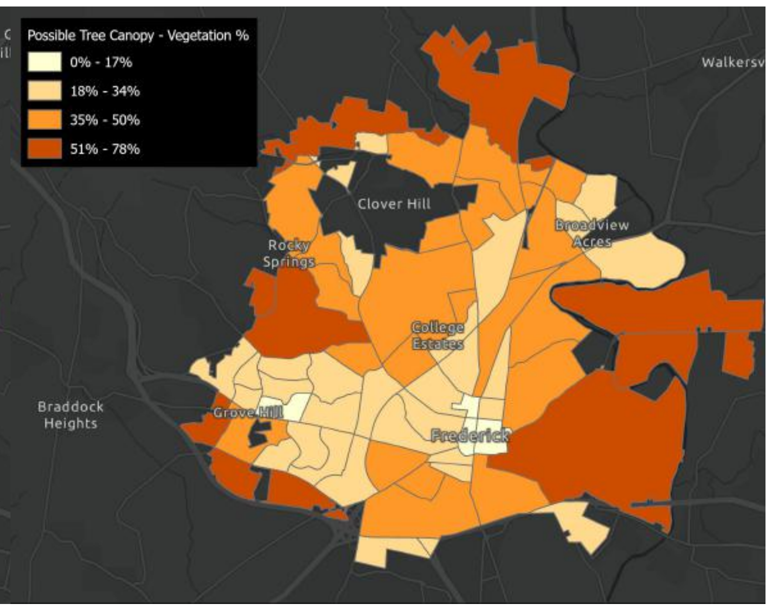


Figure 24: Possible tree canopy percentage (vegetation) for 2021 conditions summarized by 2020 census block groups.

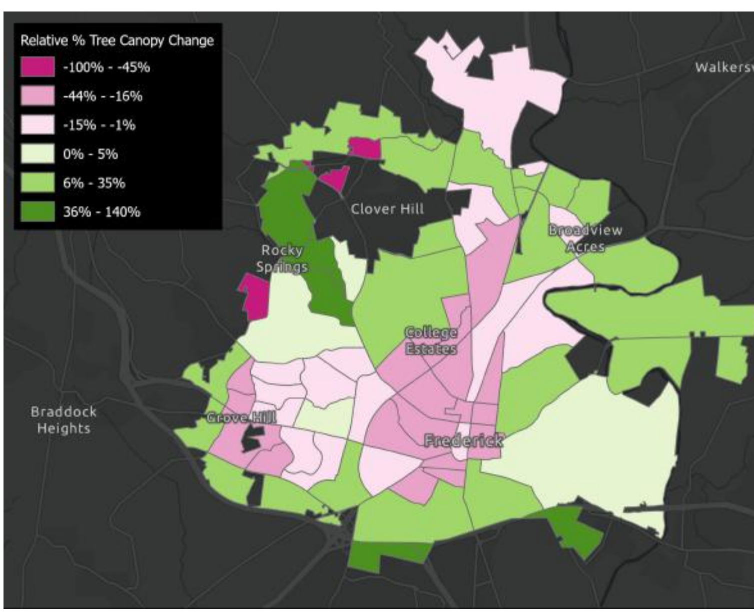


Figure 25: Relative tree canopy change for 2021 conditions summarized by 2020 census block groups.

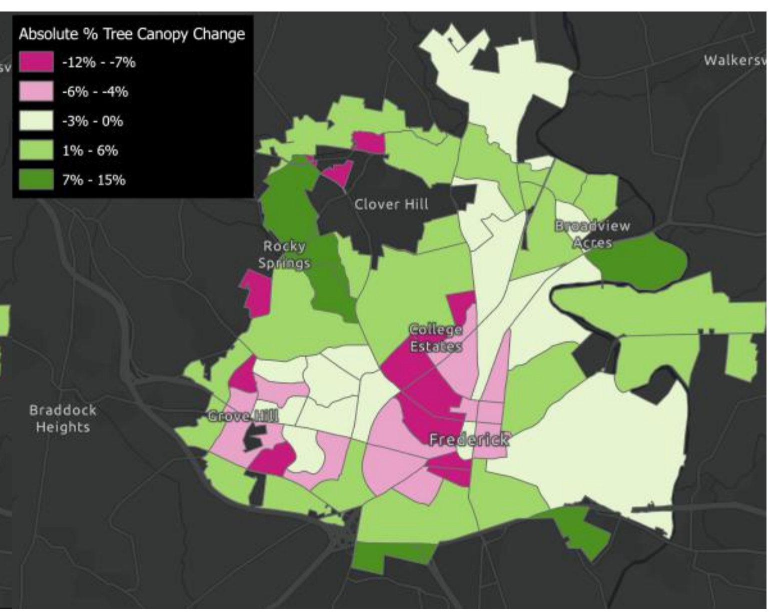


Figure 26: Absolute tree canopy change for 2021 conditions summarized by 2020 census block groups.

Market Analysis

2021 Esri's Tapestry Census Block Groups

Efforts to increase tree canopy can be more successful if they are tailored to specific social groups. Esri Tapestry Segmentation provides a detailed description of census block groups grouped together by similar sociodemographic characteristics. Life Mode groups represent markets that share a common experience (i.e. born in the same generation or a significant demographic trait). Variances in land cover by Life Mode groups can offer insights into optimizing marketing messages that can convince residents to preserve their current tree canopy or plant new trees. Family Landscapes have the most existing tree canopy, 22.7%, followed closely by Midtown Singles (21.4%) and Middle Ground (21.4%) (**Figure 27b**). Scholars and Patriots and Senior Styles saw the largest absolute increase in tree canopy from 2014 to 2021 (**Figure 28**).

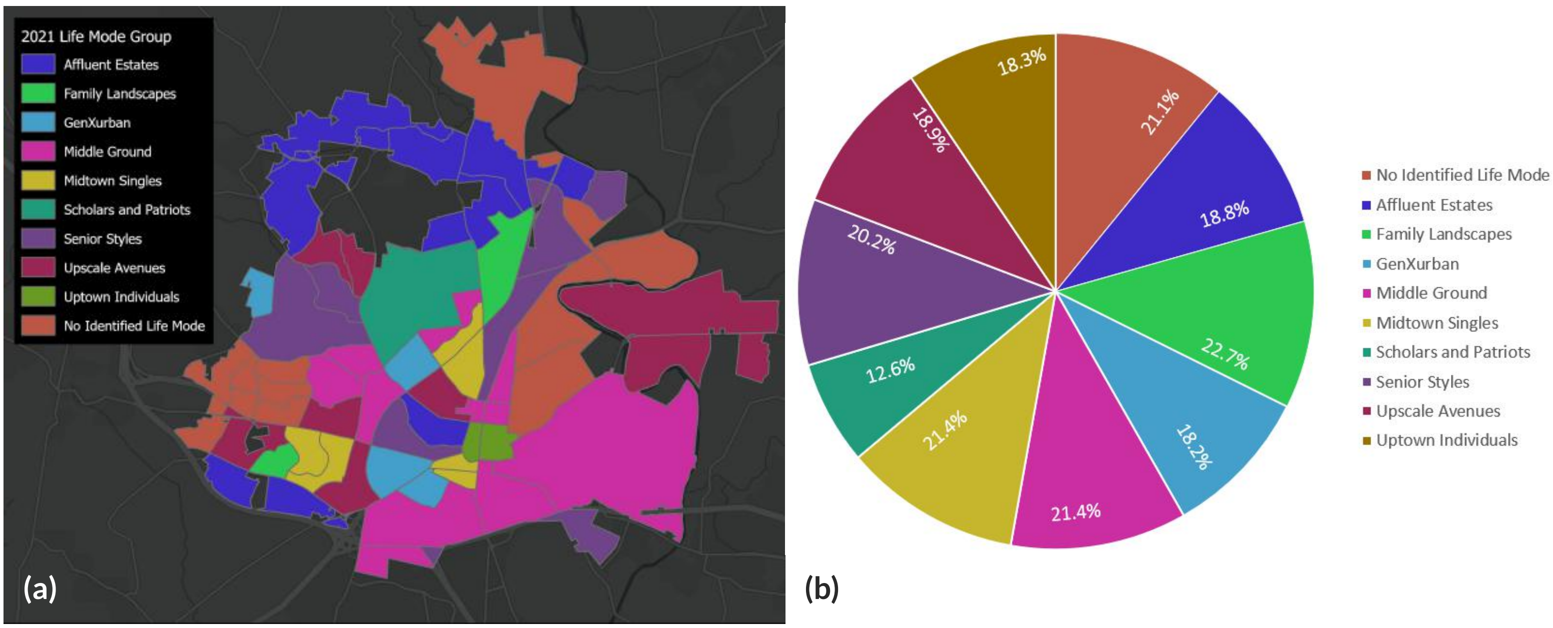


Figure 27: (a) This map displays the distribution of Esri tapestry Segmentation Life Mode Groups across Frederick City. The map colors align with those in (b) and ***Figure 28*** *below. (b) Distribution of existing tree canopy within each LifeMode Group.*

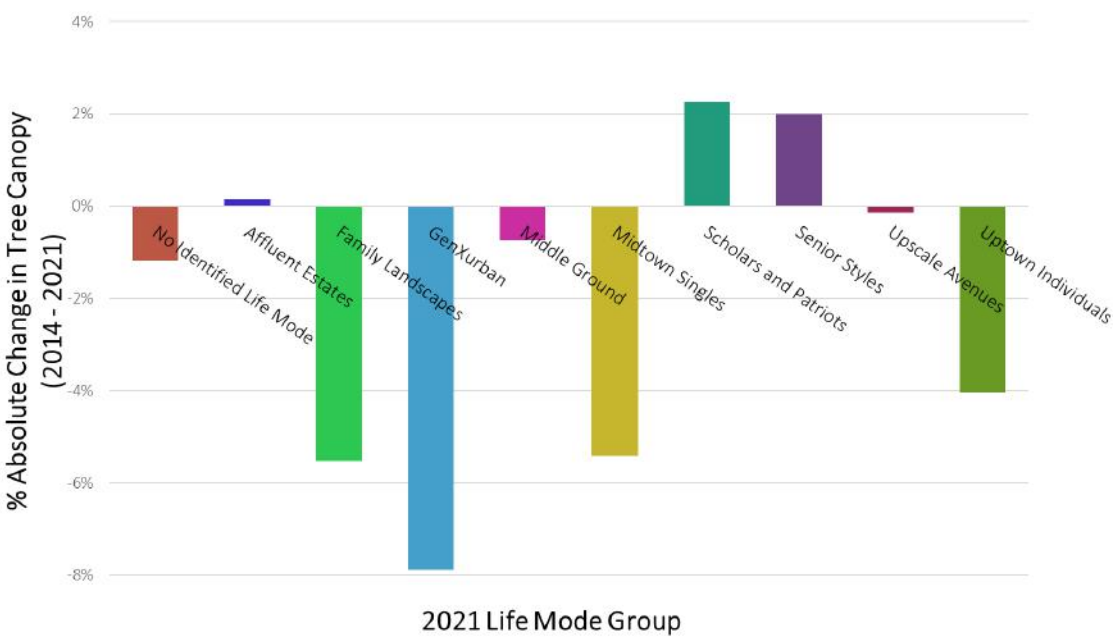


Figure 28: Absolute change in canopy between 2014 to 2021 by 2021 Esri Life Mode Group. See below for Life Mode Descriptions.

Life Mode Descriptions

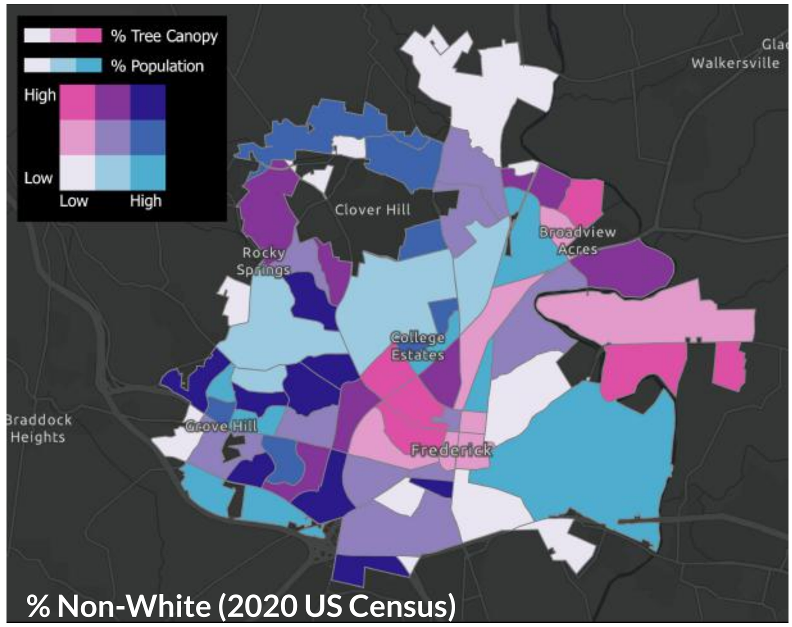
Affluent Estates: established well-educated homeowners
Family Landscapes: successful young families in first home
GenXurban: middle-aged families with a mortgage
Middle Ground: lifestyles of millennials
Midtown Singles: millennials on the move; single and moving
Scholars and Patriots: college and military populations; highly mobile
Senior Styles: seniors in retirement
Upscale Avenues: married couples with older children
Uptown Individuals: young, successful singles in the city
No Identified LifeMode: Block groups with no LifeMode identified.

EQUITY & ENVIRONMENTAL JUSTICE

Environmental Equity & Urban Resilience

Like many communities in the United States, Frederick City faces environmental risks and challenges relating to the urban environment. Trees, when properly cared for, can serve as a solution to create a sustainable and more resilient community. However, resiliency requires preparedness to overcome shocks to Frederick City and a crucial component of its resiliency are its residents. Thus, to enhance urban resilience, we recommend Frederick City targets neighborhoods lacking access to tree canopy cover and for tree planting prioritization to be further informed by the distribution of demographic groups that are typically more susceptible to environmental risks. These include historically marginalized populations like racial and ethnic minorities and residents living with a median annual income less than $25,000. Block group boundaries and demographics are based on 2020 census data from the American Community Survey.

In Frederick City, there are few census block groups that have **both** a high percent of existing tree canopy and where the majority of the population identifies as either Non-White or has a median annual income < $25,000. There is also some overlap between census block groups that have high Non-White population and percent of households with a median annual income of < $25,000. Frederick City could prioritize tree planting initiatives in block groups that have low percent existing tree canopy (light pink and blue) with higher percent of population identified as disadvantaged.



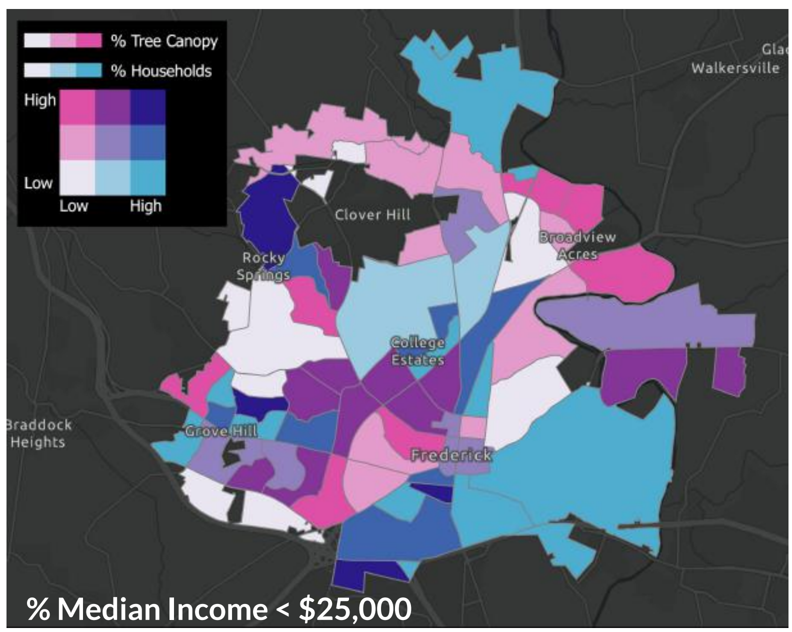


Figure 29: These maps show percent existing tree canopy cover in relation to two demographic variables that are highly interrelated and typically within the most susceptible groups against environmental challenges. Shades of pink indicate tree canopy percentage by block group, with the darkest shade indicating higher percentages. Meanwhile, shades of blue indicate percentage of residents within each of the demographic groups, with the darkest shade indicating higher percentages.

COMMUNITY RESILIENCE

Environmental Stressors & Neighborhood Prioritization

With an increase in severe storms and extreme weather across the country, flooding and rising temperatures are two environmental challenges that impact Frederick City. Using the Urban Cooling and Flood Retention modules from the Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST) tool, we were able to identify areas that have higher potential for reducing flooding (a. Flood Retention Index) and mitigating high summertime temperatures (b. Heat Mitigation Index). The maps below can be used to determine tree planting allocation to strengthen community resilience against flooding and rising temperatures.

Mitigation Capacity by Local Vegetation

Trees can be critical in bank stabilization, water quality protection, and absorbing water during high precipitation events. The capacity for flood retention **(a)** based on the 2021 Landcover produced by the tree canopy assessment and average varies across the landscape. Frederick City's vegetation acts as a riparian buffer filtering runoff and absorbing precipitation into the soil. The heat island effect considerably affects cities, and rising temperatures can result in fatalities (particularly among the elderly and those with cardiovascular diseases). Frederick City's capacity of local vegetation to mitigate rising temperatures **(b)** varies throughout the urban landscape.

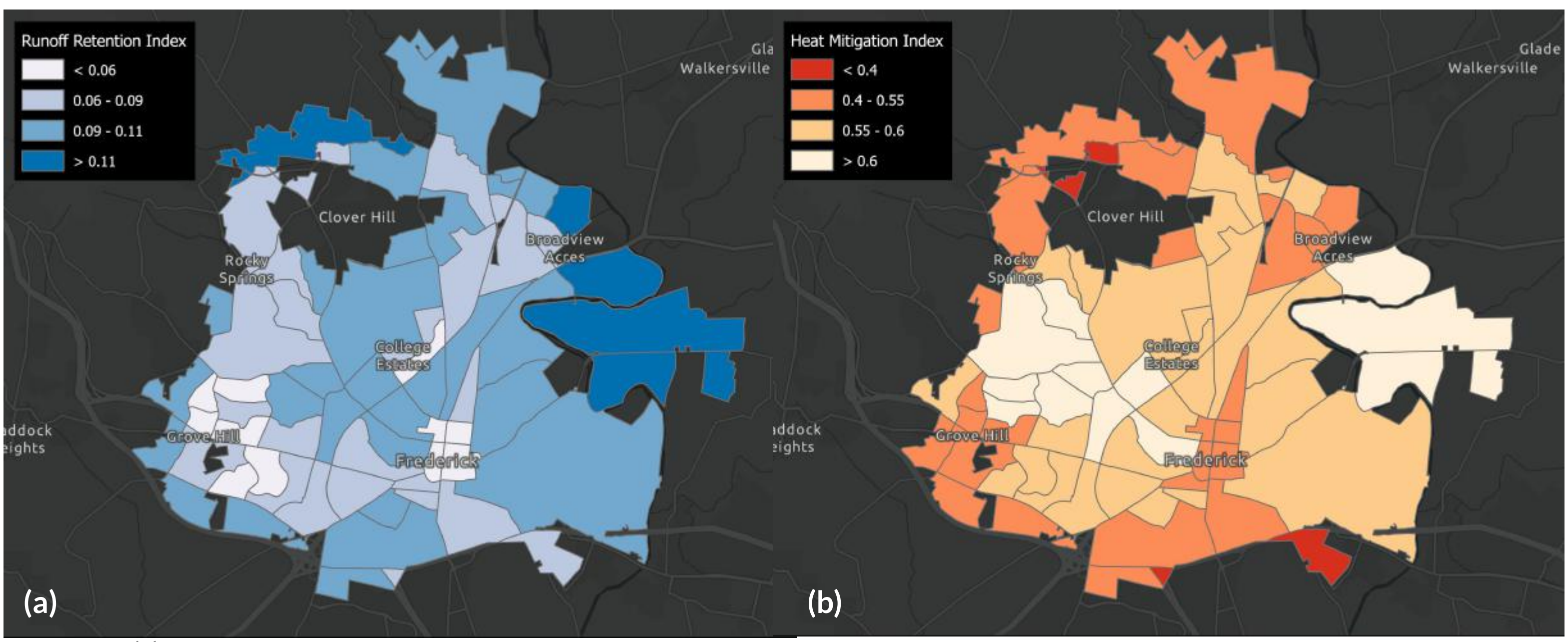


*Figure 30: **(a)** The flood retention index ranges from zero (low retention potential) to one (higher retention potential). Flood retention index estimated annual average rainfall (mm) in Frederick City. **(b)** The heat mitigation index ranges from zero (low mitigation capacity) to one (high mitigation capacity). Summertime average temperature was estimated for Frederick City between June and August of 2021. Both these results were modeled with InVEST.*

This assessment was carried out by the University of Vermont Spatial Analysis Lab in collaboration with the City of Frederick. 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 Frederick, Frederick County, the State of Maryland, and the USDA. The project was funded by the City of Frederick. Additional support for this project was provided by 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.

Report Authors

Jarlath, O'Neil Dunne

Marie Bouffard

Paige Brochu

Tree Canopy Assessment Team

Ernie Buford

Anna Royar

Kelly Schulze

Maeve Naumann

Eli Stein

Jake Gess

City of Frederick Point of Contact:

Jenny Willoughby

Sustainability Manager

Sustainability Department

The City of Frederick

140 West Patrick Street Frederick, MD 21701

(301) 600-2843 | jwilloughby@cityoffrederickmd.gov