Proposal

City of Burlington Urban Tree Canopy Assessment

Submitted by:
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February 8, 2024

Overview

Communities are struggling with a host of environmental issues, from climate change to stormwater to environmental equity. With traditional gray infrastructure solutions stretched to capacity, communities seek green solutions to address their current challenges and chart a sustainable and equitable future. Trees are one of the most valuable green infrastructures within communities by providing vital ecosystem services and health benefits, including mitigating environmental stressors such as heat exposure and air pollution while conserving wildlife habitats and biodiversity. Understanding current canopy coverage and past patterns of canopy change is critical if communities are to chart a greener future. Having the technological foundations to track tree improvement initiatives is imperative if communities are to assess their success. A tree canopy assessment provides detailed and actionable information communities need to manage their urban forest (Figure 1). They have become the gold standard by which communities integrate information on their tree canopy into planning processes. The tree canopy assessment protocols, developed jointly by the US Forest Service and the University of Vermont, have been employed by hundreds of communities throughout the United States. They have helped to prioritize tree planting initiatives, justify the need for new tree ordinances, and have brought urban forestry into the 21st century. In today's data-centric world, where analytics drive everything from road maintenance to policing, the need for more data on tree canopy puts the urban forestry component of community government at a disadvantage. If you don't know what you have, how can you manage it, set goals, and prioritize budgets?

Our team understands tree canopy's critical role in Burlington. The University of Vermont Spatial Analysis Lab has already conducted two tree canopy assessments for the City of Burlington, first using imagery and LiDAR data from 2004, then again using data collected in 2014 and 2016. The most recent assessment consisted of a detailed tree canopy change analysis in which changes (gain, loss, and no change) was mapped at multiple different geographies (wards, land use types, ownership, etc.). Tree canopy height and tree patch size were also mapped. New high-resolution imagery data were acquired in 2023 that provides a unique opportunity to track the changes in Burlington's tree canopy and provide insight into the driving factors resulting in tree loss, gain, or preservation. While a Tree Canopy Assessment is fundamentally an exercise in geospatial analysis, we recognize that this project is much more than that. This project is about the future of Burlington, its green infrastructure, the health of its residents, and an equitable future for all who call Burlington home.

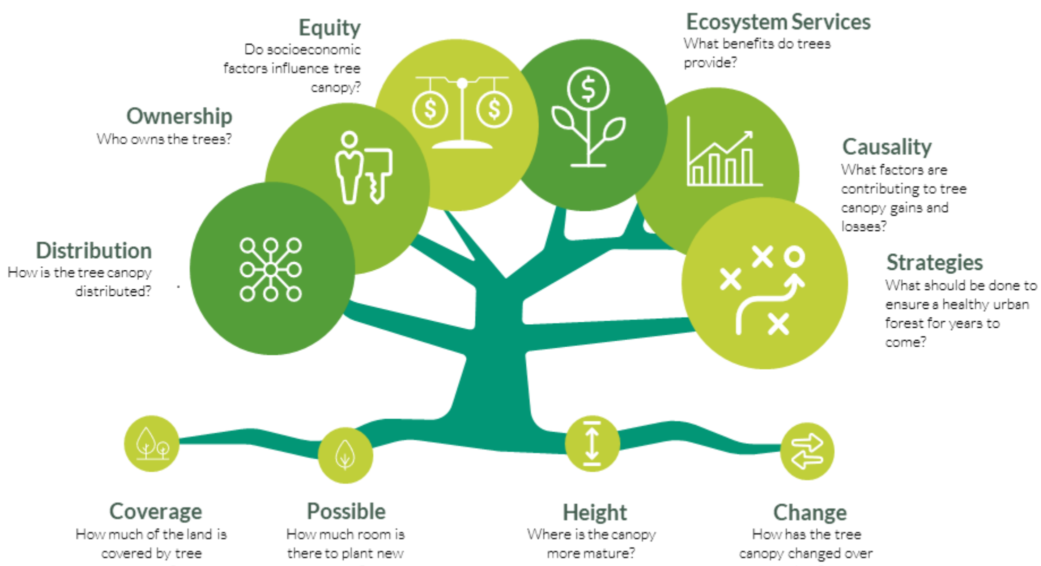

Figure 1. The information this assessment will provide.

Methodology

This project will employ land cover mapping and tree canopy assessment techniques developed in collaboration with the USDA Forest Service. The workflow is illustrated in Figure 2.

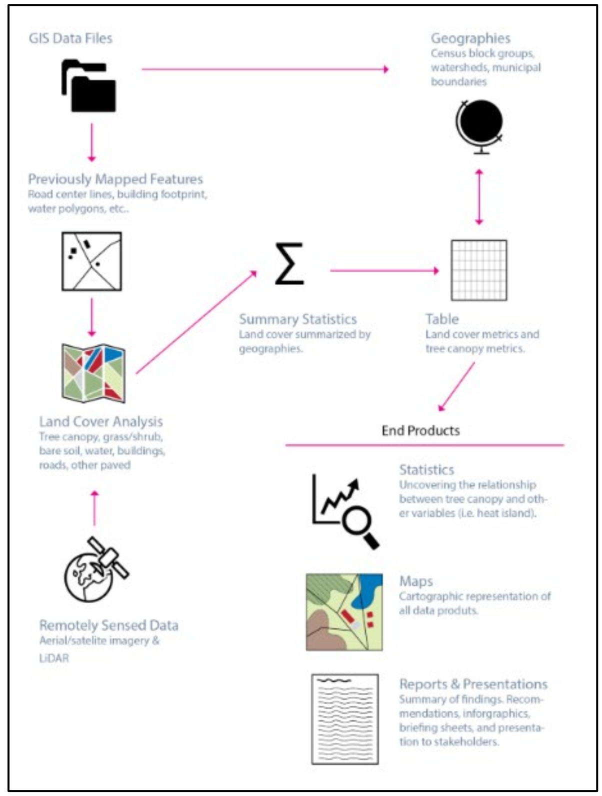

Figure 3. Tree canopy assessment methodology

Our approach to the tree canopy assessment will consist of five phases (Figure 3). Stakeholder feedback and engagement are crucial parts of each stage of our methodology. Therefore, each step has opportunities for engagement, discussion, and review. Our process has equity and trust foundations to ensure that each community's unique needs are incorporated. The assessment begins with the initial kick-off meeting with stakeholders and community leaders to understand their needs, develop relationships between community staff and our team, establish roles and responsibilities, and finalize a schedule and work plan. In the second phase, we acquire the data necessary to conduct the assessments. The third phase centers on mapping, in which tree canopy land cover, canopy change, tree crowns, natural area, and heat islands are extracted from LiDAR and imagery. In the fourth phase, metrics are computed for the geographic units of interest. The metrics we calculate will incorporate spatial analysis of the natural environment (land use, watersheds, etc.) in conjunction with human health and environmental stressors. Engagement with a broad range of stakeholders is essential in this phase to ensure that the metrics support a wide range of resource management goals. Equally important is our commitment to open data. By adhering to standards and including rigorous documentation, we will bring the data and metrics to life through easily understandable maps, charts, and graphics with input from stakeholders that can be used by community leaders while maintaining the scientific integrity of the data itself. In the final phase, we will work closely with the community to incorporate the data derived from the assessment into decision-making workflows to support long-term planning and future assessments.

Figure 2. Tree canopy assessment phases.

Project Team & Experience

Organizational Profile

The University of Vermont (UVM) Spatial Analysis Laboratory (SAL) has garnered a national reputation for employing geospatial technology to help decision-makers answer pressing natural resource issues. The SAL is where GIS started in Vermont. As one of the first organizations in the country to employ GIS software, the SAL was at the forefront of the geospatial revolution. That innovative approach has continued over the past four decades, with SAL faculty, staff, and students driven by the impactful work they perform. The SAL has won numerous awards and accolades for its tree canopy assessment and land cover mapping work. The SAL is also home to UVM's Unoccupied Aircraft Systems (UAS) Team, which has nearly a decade of experience using drone technology for disaster response, agricultural assessment, archeological site mapping, aquatic resource mapping, transportation decision support, and urban planning. Throughout its history, the SAL has worked with numerous federal agencies, state agencies, regional planning commissions, cities, towns, private companies, and non-profit entities.

Figure 4. Qualifications.

Cost

A breakdown of the costs, by task, is presented in Table 1. The total project cost is $26,681.00, with $9,373.00 offset (~35%) with funds from a federal grant the SAL received to support this work, bringing the billable cost to $17,308.00.

Table 1. Project costs.

	Rate	Phase 1		Phase 2		Phase 3		Phase 4		Phase 5	
		Hours	Cost	Hours	Cost	Hours	Cost	Hours	Cost	Hours	Cost
Director	$ 158.00	3	$ 474.00	3	$ 474.00	2	$ 316.00	3	$ 474.00	5	$ 790.00
Manager	$ 87.00	10	$ 870.00	15	$ 1,305.00	8	$ 696.00	16	$ 1,392.00	23	$ 2,001.00
Analyst	$ 95.00	0	$ -	0	$ -	51	$ 4,845.00	0	$ -	0	$ -
Engineer	$ 95.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Specialist III	$ 89.00	0	$ -	6	$ 534.00	12	$ 1,068.00	12	$ 1,068.00	8	$ 712.00
Specialist II	$ 75.00	0	$ -	0	$ -	20	$ 1,500.00	0	$ -	0	$ -
Specialist I	$ 53.00	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -
Technician II	$ 28.00	0	$ -	29	$ 812.00	65	$ 1,820.00	25	$ 700.00	15	$ 420.00
Technician I	$ 21.00	0	$ -	0	$ -	210	$ 4,410.00	0	$ -	0	$ -
Subtotal		13	**$ 1,344.00**	53	**$ 3,125.00**	368	**$ 14,655.00**	56	**$ 3,634.00**	51	**$ 3,923.00**
Project Cost	$ 26,681.00										
Grant Offset	$ 9,373.00										
Cost	**$ 17,308.00**										

Workplan

Phases and Schedule

The project's five phases and estimated time for completion are shown in Figure 5. This project is expected to take five months from project initiation. We recommend starting the project once the 2023 imagery and LiDAR are made available. Updated Statewide **VT LiDAR is expected to be ready for use: May 2024, therefore this project will start May 2024 with expected delivery of data and deliverables by October/November 2024.**

Phase 1: Kick-off. Project kick-off meeting. Review goals. Establish roles and responsibilities. Set expectations. Finalize schedule and work plan.

Phase 2: Data Preparation. Inventory and collect data. Review data. Prepare data for mapping and analysis.

Phase 3: Mapping. Tree canopy change mapping. Land cover mapping. Urban heat island mapping.

Phase 4: Analysis. Tree canopy metrics, tree canopy change metrics, and land cover metrics.

Phase 5. Reporting. The final report will be written and delivered. A presentation will be given via webinar.

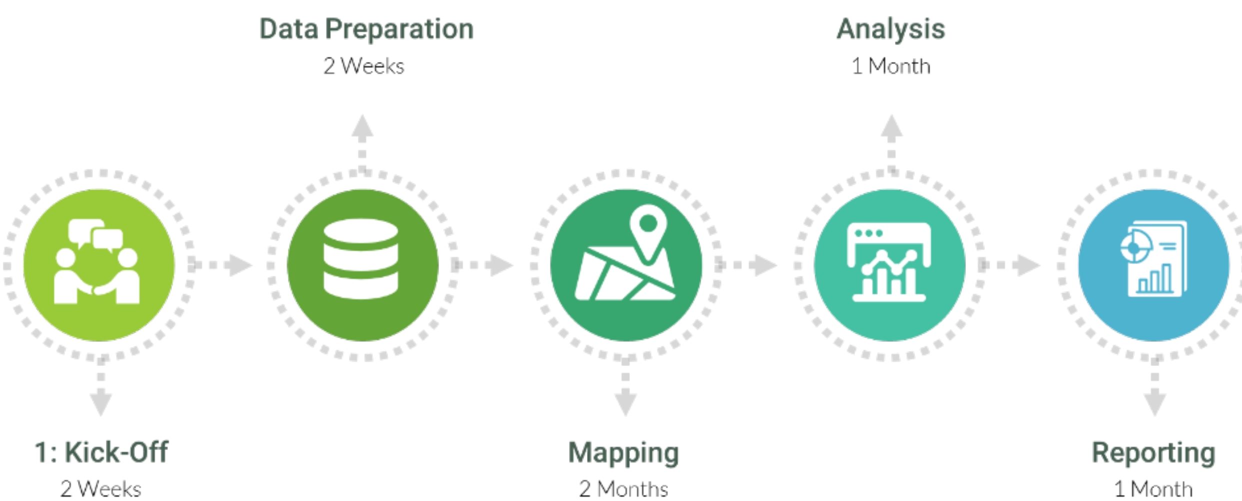

Figure 5. Proposed project timeline.

Source Data

The source datasets required to complete the project are presented in 2. The leaf-on imagery and LiDAR are used to map tree canopy and other land cover features. Available planimetric data will be integrated into the land cover mapping workflow to ensure parity with existing mapping efforts. Geographies, which consists of datasets such as parcels and watersheds, are used for summarizing the tree canopy and land cover data.

Table 2. List of source datasets.

Description	Date	Format	Source
Leaf-On Orthoimagery	2016; 2023	Raster GeoTIFF	USDA
Leaf-Off Othoimagery	2014; 2023	Raster GeoTIFF	VCGI
LiDAR	2014; 2023	Point Cloud	VCGI
Planimetrics	Most recent	Vector	City
Geographies	Most recent	Vector	City

Deliverables

There are eleven deliverables for this project. Sample deliverables from past projects are presented in Appendix A (Figures 1A-8A).

1. **High-resolution 7-class land cover dataset (Figure 1A)**. This dataset will represent land cover based on the most recent source data. The land cover classes include: (1) tree canopy, (2) grass/shrub, (3) bare soil, (4) water, (5) buildings, (6) roads/railroads, (7) other paved. This is a raster geospatial dataset.
2. **High-resolution tree canopy change dataset (Figure 2A)**. This dataset will represent the change in tree canopy. Three change classes will be mapped: (1) no change, (2) gain, and (3) loss. This is a vector geospatial dataset.
3. **Land cover metrics**. The land cover metrics summarize the area and percent area for all seven land cover classes for the various geographies of interest (e.g. land use, parks, watersheds). This is a tabular dataset that can be joined to the appropriate geospatial geography layer.
4. **Tree canopy metrics (Figure 6A)**. The tree canopy metrics compute the existing tree canopy and possible tree canopy area and percent area for the various geographies of interest (e.g. land use, parks, watersheds). This is a tabular dataset that can be joined to the appropriate geospatial geography layer.
5. **Tree canopy change metrics (Figure 3A)**. The tree canopy change metrics summarize total change, percent change, and relative change for tree canopy no change, gain, and loss for the various geographies of interest (e.g. land use, parks, watersheds). This is a tabular dataset that can be joined to the appropriate geospatial geography layer.
6. **Canopy crown mapping (Figure 8A)**. Points and polygons representing the location, height, and crown radius of individual trees. It can be used for 3D visualization.
7. **Forest patch model (Figure 4A)**. The forest patch model divides the tree canopy into small, medium, and large patches to provide insights into the configuration of the urban forest.
8. **Ecosystem services and community metrics (Figure 7A)**. Estimate ecosystem service benefits such as reduction in air pollution or heat, quantify community health benefits, and analyze distribution of tree canopy.
9. **Open Space Inventory**. Create updated layer representing specific land use categories determined by the City of Burlington ((1) agriculture, (2) beach or rock, (3) cemetery, (4) forest, (5) landfille, junkyard or quarry, (6) large mowed lawn, (7) potential green infrastructure, (8) recreation or park, (9) rain garden, (10) small lawn, (11) transitional brush land, (12) water body, (13) wetland, (14) trails, and (15) wildlife corridors).
10. **Report**. The final report contains a summary of the methods and findings.
11. **Presentation**. The final presentation will be delivered via webinar. A copy of the presentation slide deck will be provided.

References

Cincinnati Tree Canopy Assessment

Organization: Cincinnati Park Board

Point of Contact: Matthew DiBona, GIS Computer Systems Analyst, Cincinnati Park Board, 3215 Reading Rd, Cincinnati, OH 513.861.9070 ext 15

Project Summary: In collaboration with AppGeo and SavATree, the University of Vermont Spatial Analysis Laboratory conducted a tree canopy assessment for the city of Cincinnati and Hamilton County. This project revolutionized the city's and county's urban forestry initiatives. Through innovative insights and data products of unprecedented detail, new approaches to tree planting prioritization and risk assessment were incorporated. The City Council unanimously supported the results of the assessment and based on the findings, decided to increase the resources for urban forestry initiatives.

Forest Service Tree Canopy Assessment Protocols

Organization: United States Forest Service

Point of Contact: Dr. Morgan Grove, Research Team Leader, morgangrove@fs.fed.us 240-383-6149

Project Summary: A collaborative effort between the United States Forest Service and the University of Vermont developed the protocols for assessing and prioritizing urban tree canopy. A follow-on initiative extended those protocols for tree canopy change mapping. This work was published in peer-reviewed literature and subsequently applied to over 80 communities within North America. These protocols have become the de facto standard for assessing tree canopy. Additional information can be found on the US Forest Service's web site (https://www.nrs.fs.fed.us/urban/utc/).

Cuyahoga County Tree Canopy Assessment and Change Detection

Organization: Cuyahoga County Planning Commission

Point of Contact: Daniel Meaney, Manager: Information & Research, dmeaney@cuyahogacounty.us 216-443-3709

Project Summary: Using multi-temporal imagery and LiDAR, this project mapped tree canopy and land cover change for Cuyahoga County, Ohio. A geoprocessing workflow was designed, deployed, and developed to enable the Cuyahoga County Planning Commission to explore the relationship between tree canopy and variables stored in other geospatial datasets. More information is on the county's urban tree canopy assessment web site. (https://www.countyplanning.us/projects/urban-tree-canopy-assessment/).

Appendix A:

Sample Products

Products from past assessments are shown below (Figures 1A-8A).

Figure 1A. High-resolution land cover products. Using LiDAR (left) and imagery (center) we derive high-resolution land cover (right), which provides a detailed and accurate accounting of a community's green, gray, brown, and blue infrastructure.

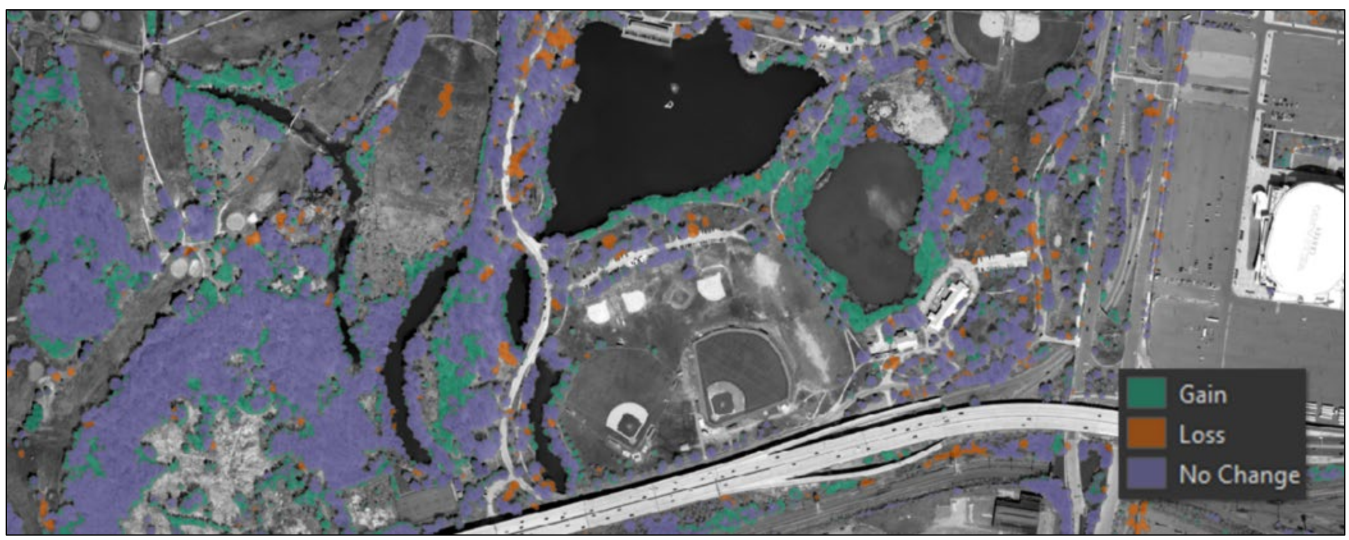

Figure 2A. Tree canopy change mapping. Using two time periods of data the change to individual trees is accounted for enabling change metrics to be computed down to the individual property parcel.

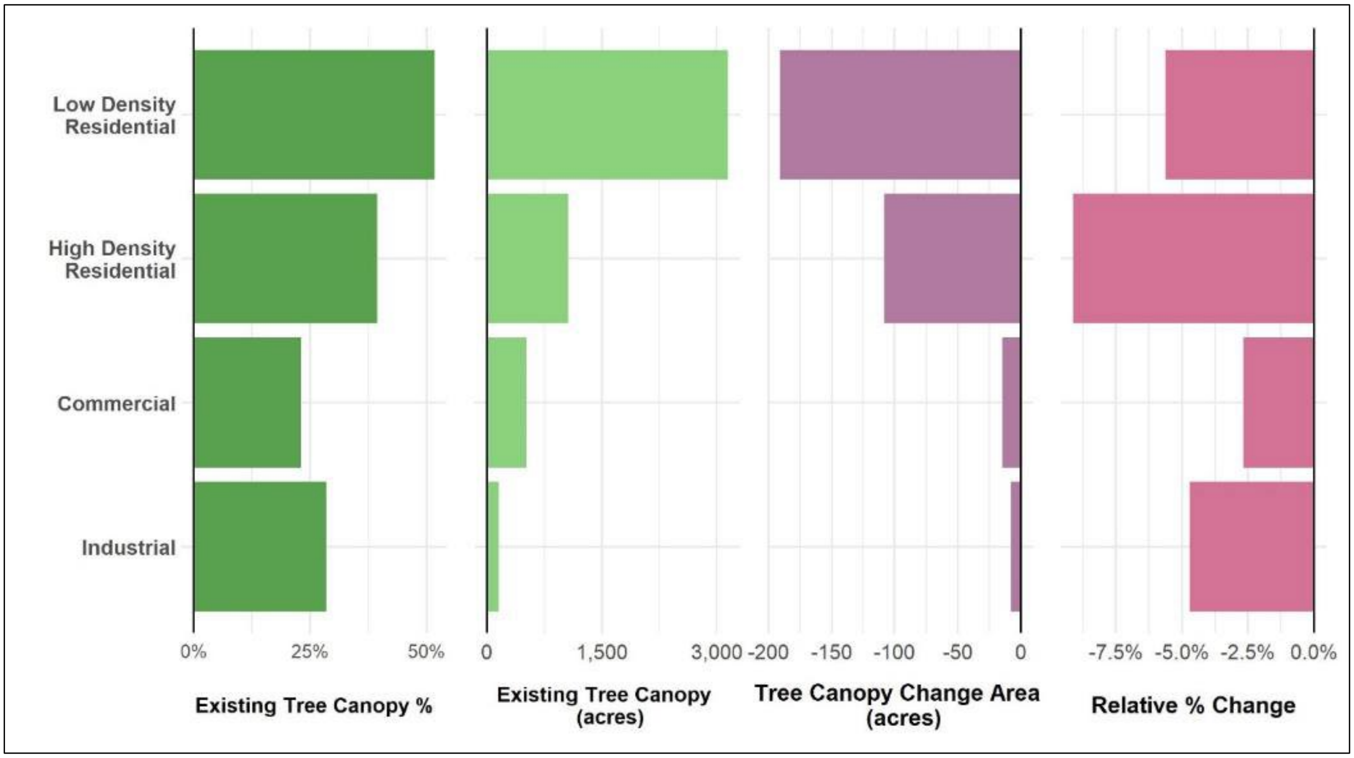

Figure 3A. Tree canopy change metrics. Change metrics provide insights into the drivers of change. In this example the tree canopy change data was integrated with land use zoning data to help understand how tree canopy is changing on different land use types.

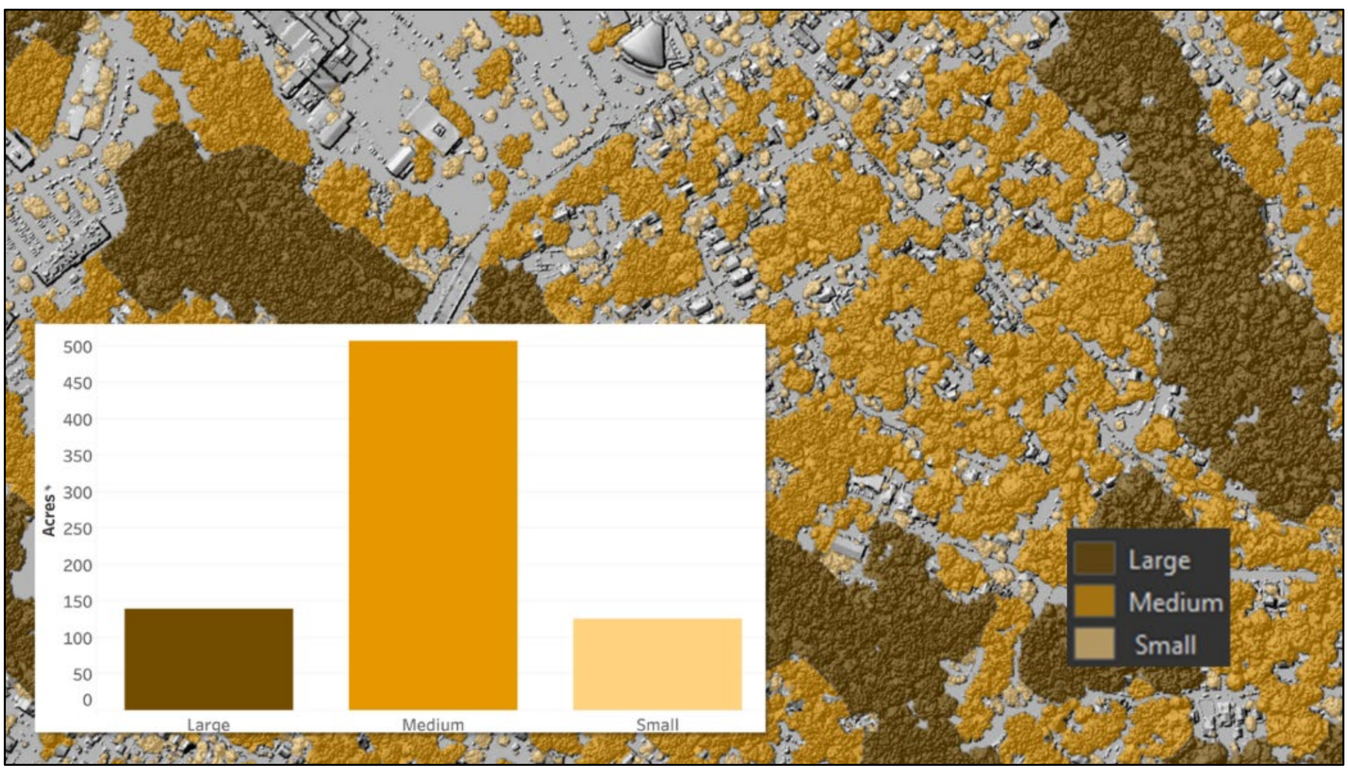

Figure 4A. Forest patch analysis. Land cover mapping quantifies the amount of tree canopy, but the configuration of that tree canopy is also important to understand as larger forest patches are associated with greater ecosystem services.

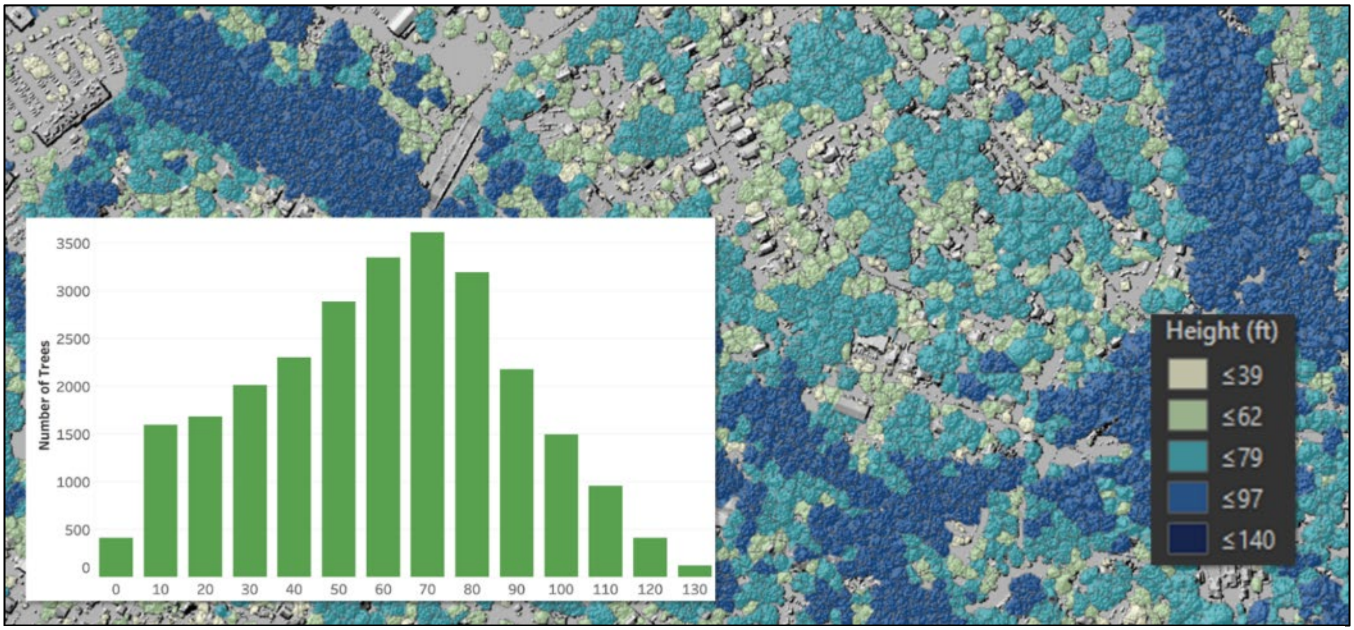

Figure 5A. Tree canopy height model and height distribution histogram. Tree canopy height derived from LiDAR provides an understanding of the vertical structure of the tree canopy and can be used to as a proxy for age in some cases.

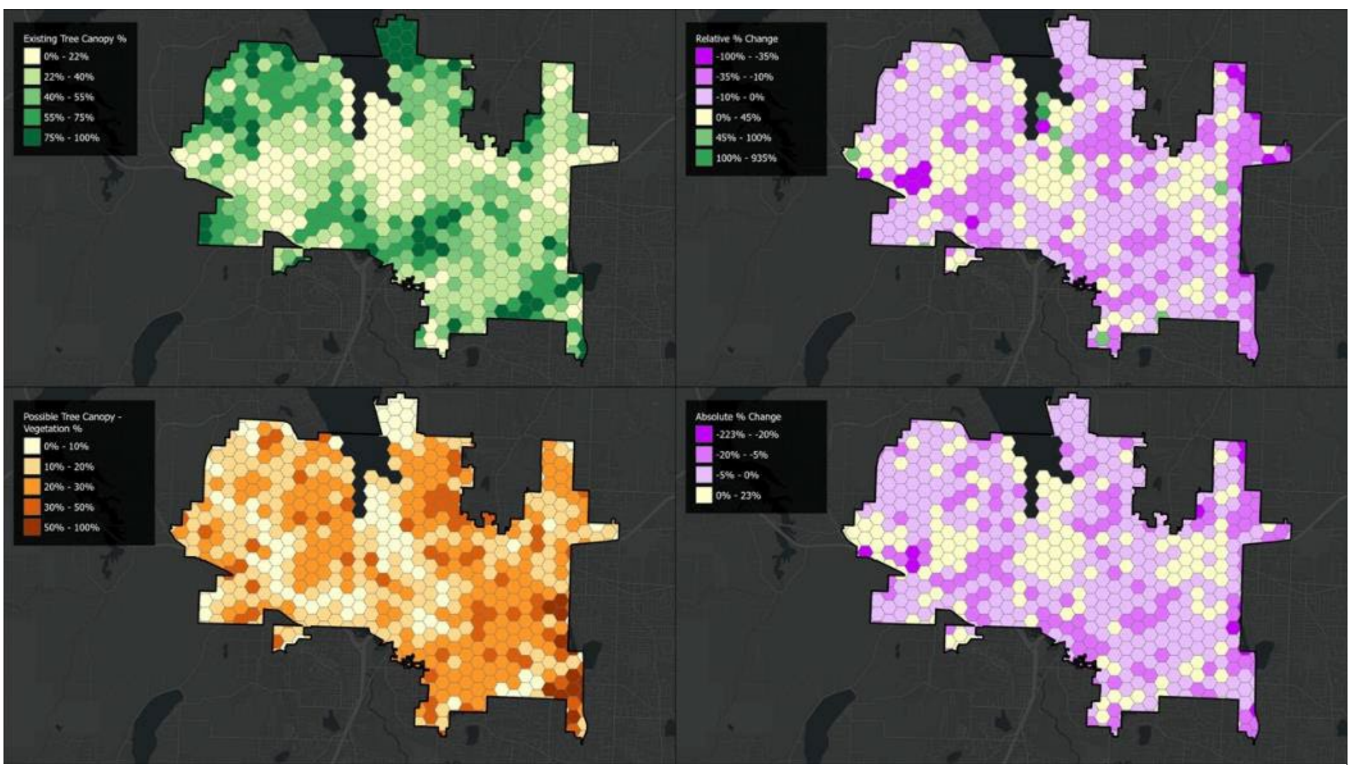

Figure 6A. Tree canopy and change metrics for the City of Olympia's tree canopy assessment. Hexagons provide a consistent unit of analysis to examine the existing tree canopy (upper left), potential tree canopy (lower left), the relative percent change in tree canopy (upper right), and the absolute change in tree canopy (lower right).

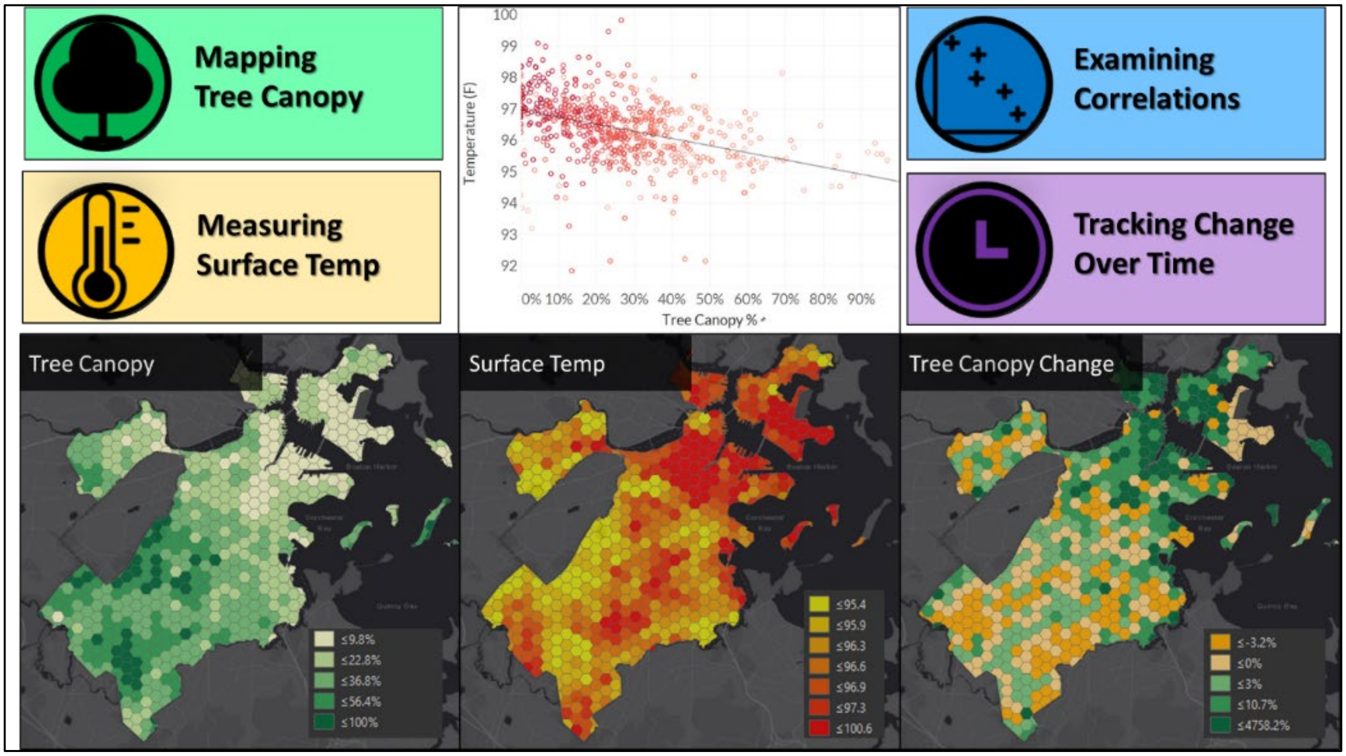

Figure 7A. Tree canopy metrics infographic developed by our team for Boston's tree canopy assessment. This analysis integrated existing (current) tree canopy density measures with tree canopy change and urban heat island analytics to help the city assess the impact of past tree planting and preservation initiatives.

Figure 8A. Example of a tree centroid/crown dataset developed by our team for a past tree canopy assessment. Tree centroids are displayed as points and tree crowns as circles. The tree centroids and crowns are overlaid on the LiDAR (left) and imagery (right) used for the project.