2012-2019

# Tree Canopy Assessment

## Louisville, Kentucky

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PREPARED FOR:

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# THE NEED FOR GREEN

Trees provide essential ecosystem services in Louisville, from reducing stormwater runoff to providing wildlife habitat. From the street trees cooling the pavement in the summer to the trees that buffer waterways, trees are a core part of Louisville's landscape.

As with any community,  Louisville faces a host of environmental challenges while seeking to balance new growth. As the most populous county in Kentucky, it has a diverse community and mix of urban, suburban, and commercial lands. A healthy and robust tree canopy is crucial for providing Louisville 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 the effective management of cities. However, that mapping has primarily focused on gray infrastructure, features such as roads and buildings. The USDA Forest Service developed the Tree Canopy Assessment protocols to help communities better understand their green infrastructure through tree canopy mapping and 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 land use or demographic variables, a Tree Canopy Assessment can provide vital information to help governments and residents chart a greener future. Tree Canopy Assessments have been carried out for over 80 communities in North America. This study assessed tree canopy for Louisville over the 2012-2019 time period.

# FINDINGS

Louisville experienced slight tree canopy gain of 1% from 2012 to 2019.

Although tree canopy is increasing, there are also losses throughout Louisville.

Trees planted over a decade ago experienced considerable growth contributing to the increase.

Canopy loss is concentrated in more heavily urbanized areas and on private land.

Street tree canopy increased by 2%, this metric is impressive given that streets are less hospitable to tree survivability.

Tree canopy will likely continue to rise if tree removals do not outpace natural growth and new plantings.

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.

The gains indicate that trees that are left to alone continue to grow and add canopy, paying dividends as they mature.

# 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 and services trees provide will help the county stay green for years to come.

Integrate the data from this study into planning decisions at all levels of government.

Reassess tree canopy at 3-5 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.

# 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.

Remotely sensed data forms the foundation of the tree canopy assessment. High-resolution aerial imagery and LiDAR were used 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.

Tree canopy metrics provide summary statistics and data analytics that provide insights into 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.

# TREE CANOPY BY THE NUMBERS

*The tree canopy assessment reflects change in a seven-year period, from 2012 to 2019.*

**39%**

**Tree canopy coverage as of 2019**

**9,591 acres of canopy gain and 7,365 acres of tree canopy loss**

**1%**

**Absolute change in tree canopy from 38% in 2012 to 39% in 2019**

**There are three ways of tree canopy change**

**2,226 acres of Area Change** - the change in the area of tree canopy between the two time periods 2012 and 2019.

**2.4% Relative % Change** - a calculation used in economics, is the relative gain or loss of tree canopy using 2012 as the base year (95,251 acres-93,025 acres)/(93,025 acres).

**1% of Absolute % Change** - the percentage point change between the two time periods (39%-38%).

**Louisville's tree canopy gain is the equivalent of 1,686 football fields**

## Key Terms

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

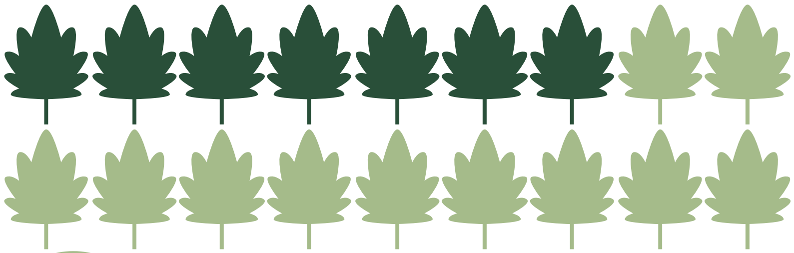
**Possible Tree Canopy - Vegetated:** Grass or shrub area that is theoretically available for the establishment of tree canopy.

**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).

# TREE CANOPY METRICS

**39%** *of Louisville's land is covered by tree canopy*



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

## Existing Tree Canopy

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 an unequal area (e.g., zip codes). Louisville, like many cities, has an uneven distribution of tree canopy. There are some 500-acre hexagons with less than 24% tree canopy and others with 100% tree canopy (Figure 1). This unequal distribution can be traced back decades and reflects everything from land use history to the placement of parks. Those residents living and working in more treed areas benefit disproportionately from the ecosystem services that trees provide. Conversely, the more urbanized areas, mainly Louisville's downtown and the airport, located centrally and into the northeastern portions of the city, have meager amounts of tree canopy and therefore receive fewer ecosystem services from trees.

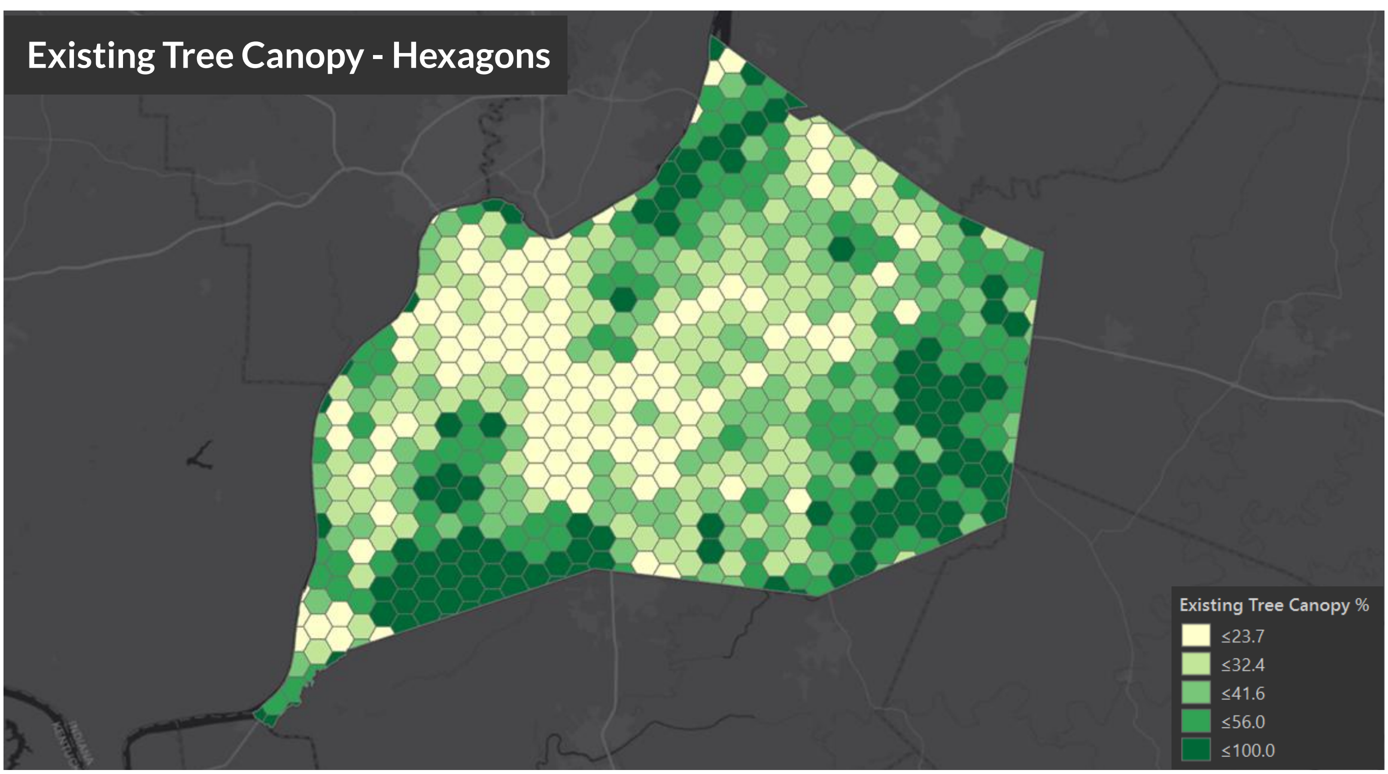



Figure 1. Existing tree canopy percentage for 2019 conditions summarized using 500-acre hexagons. For each of the hexagons, the percent tree canopy was calculated by dividing the amount of tree canopy by the land area, which excludes water.

## Possible New Tree Canopy

Louisville has 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. It should be noted that many other factors go into deciding where a tree can be planted and flourish, including land use, social, and financial considerations. Examples include golf courses and recreational fields. Thus, the Possible-Vegetation category should serve as a guide for further analysis, not a prescription of where to plant trees. With just over 81,500 acres of land (comprising 33.5% of the county's land base) falling into the Possible-Vegetation category, there remain opportunities for planting trees and preserving canopy that will improve the city's total tree canopy in the long term.

In the most densely urbanized areas of Louisville, such as the downtown area, 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. In the city's residential neighborhoods, attention must be paid to ensure healthy natural regeneration of the existing tree canopy and planting new trees. Young trees that were planted in newly developed areas will likely contribute more canopy for decades if preserved but will eventually decline if new trees are not planted to achieve a healthy age distribution.

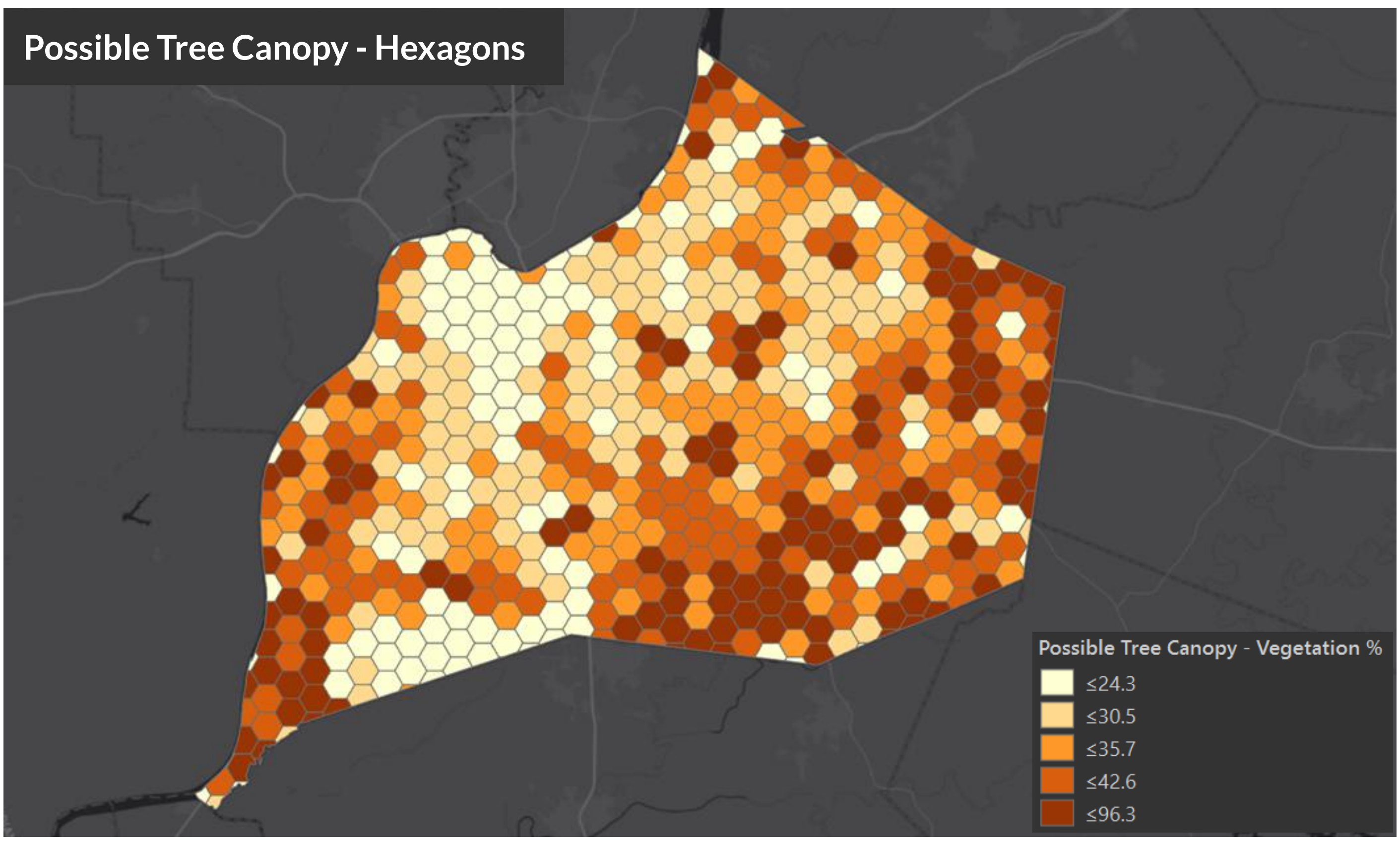



Figure 2. Possible Tree Canopy consisting of non-treed vegetated surfaces summarized by 500-acre hexagons. These vegetated surfaces that are not currently covered by tree canopy represent areas where it is biophysically feasible to establish new tree canopy. It may be financially challenging or socially 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 planting.

## Canopy Change Distribution

The relative tree canopy change percentage shows the magnitude of change throughout the city over the 2012-2019 time period. The relative change is calculated by taking the tree canopy area in 2012, subtracting the tree canopy area in 2019, then dividing this number by the 2012 tree canopy area. Areas with the greatest change indicate that the canopy is remarkably different in 2019 as compared to 2012. For example, In some commercial areas with little tree canopy in 2012, the growth of a few street trees resulted in a sizeable relative gain. Conversely, removals of trees as a result of construction in sparsely treed areas resulted in substantial relative reductions in tree canopy.

Over time tree canopy will likely continue to grow for Jefferson County if the existing canopy is preserved and new trees are planted. There are both environmental and anthropogenic risks facing canopy cover. Invasive species could pose a severe threat if not identified and controlled early. In developed areas, natural events such as storms can have a negative impact on the canopy and will need to be replaced. Climate change may cause trees to grow more quickly but could also result in inhospitable conditions for native species. Other anthropogenic factors include preservation and conservation efforts, the strength of tree ordinances, and the impacts of new development. Managing these risks will be vital to maintaining canopy growth.

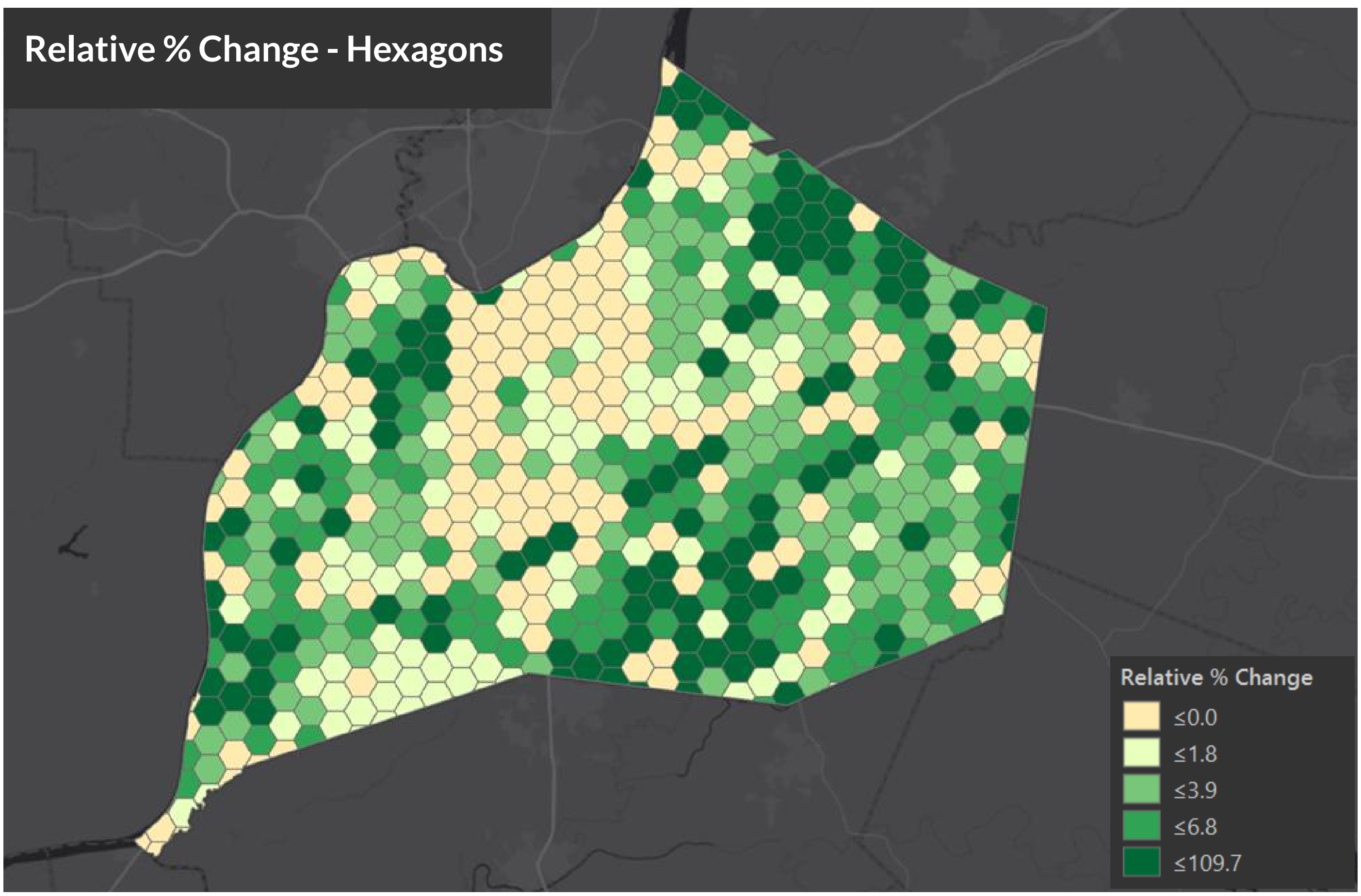



Figure 3: Tree canopy change metrics summarized by 500-acre hexagons. Relative tree canopy is calculated by using the formula (2012-2019)/2012. Colors are categorized by data quantiles. Darker greens indicate greater relative gain, while darker oranges reflect greater relative loss.

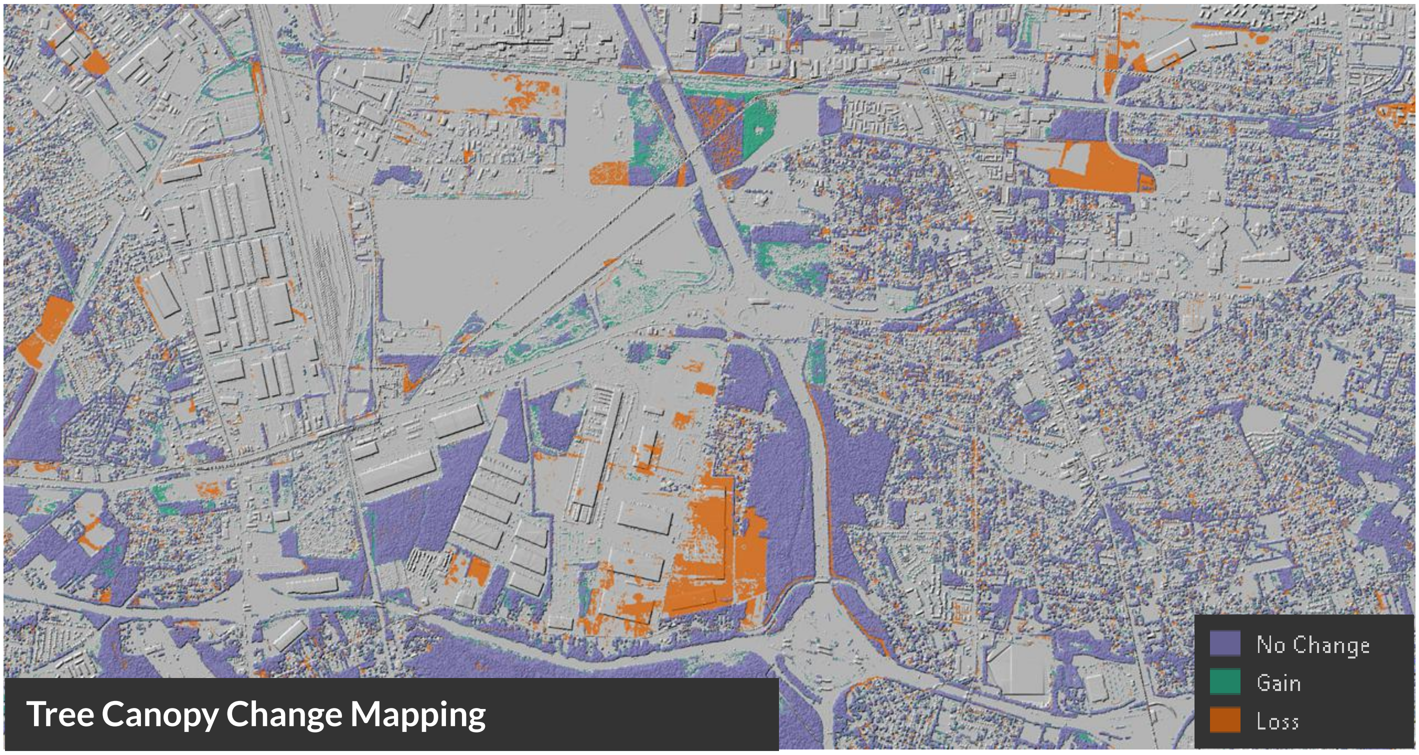



Figure 4: Area North of I-265 & I-65:
Tree Canopy Change Over 2012 LiDAR Hillshade. This area experienced both canopy loss (orange) due to new development and gain (green) due to natural regeneration. Tree canopy change was mapped for the 2012-2019 time period and is overlaid on the 2019 LiDAR hillshade map.

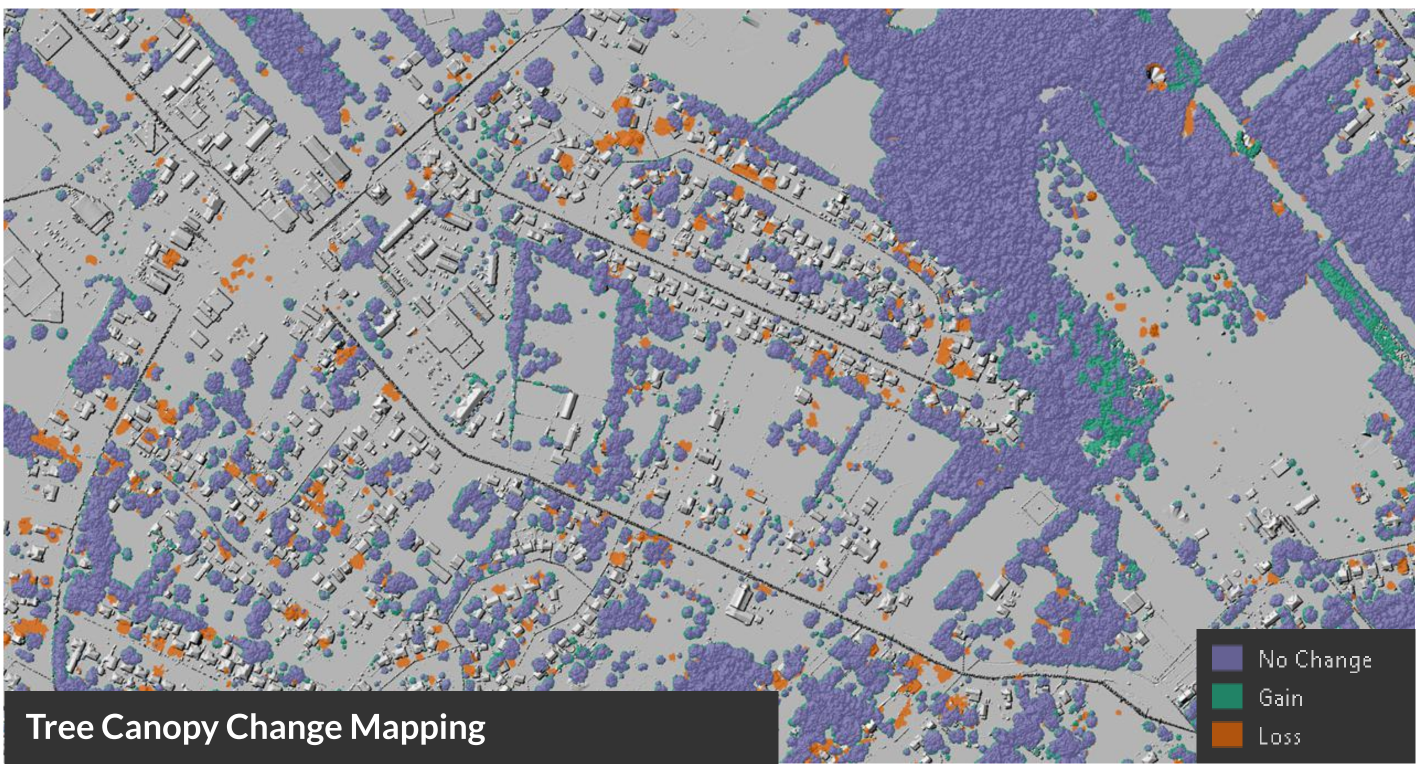



Figure 5: Fairdale- Tree Canopy Change Over 2019 LiDAR Hillshade:
This area experienced significant loss as a result of trees that were removed on private property. There was also canopy gain due to new plantings and natural regeneration. Tree canopy change was mapped for the 2012-2019 time period and is overlaid on the 2019 LiDAR hillshade map.

## Land Use

Land use describes the economic and cultural ways that humans use the land and is composed of categories such as residential, commercial, and recreational. These categories can vary between regions and are defined by the local or regional government. Land use differs from land cover. The latter refers to the features, such as the trees, buildings, and other classes mapped as part of this study. For example, residential land use can contain trees, buildings, 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.

Single Family land use experienced the most tree canopy loss (-3,268 acres) than any other category. Trees planted at the time new residential developments were built have matured and are now being removed due to homeowner preferences and in most cases have not been replaced by new trees. This effect is common in established residential communities when a new generation of trees is not planted to replace tree removals or declining trees. Despite the canopy loss, the overall net change was positive in Single Family land use. There were 4,232 acres of gain, a reflection of the natural canopy growth that occurs if trees are preserved.

The only land use that had a net loss, aside from Vacant, was the Public and Semi-Public lands with 538 acres of loss and 522 acres of gain. Other publicly managed land uses are Parks and Open Space and Right-of-Way (ROW). Parks and Open Space had a net gain of 428 acres and ROW had 541 acres of net gain. Trees in the ROW face inhospitable conditions associated with their close proximity to roads. Regular salting, compaction, limited space, clearance pruning, and plow collisions are some of the challenges that limit canopy establishment and growth in these limiting environments. Street trees not only make roads more aesthetically pleasing, but they also play an important role in reducing stormwater runoff and decreasing the urban heat island effect.

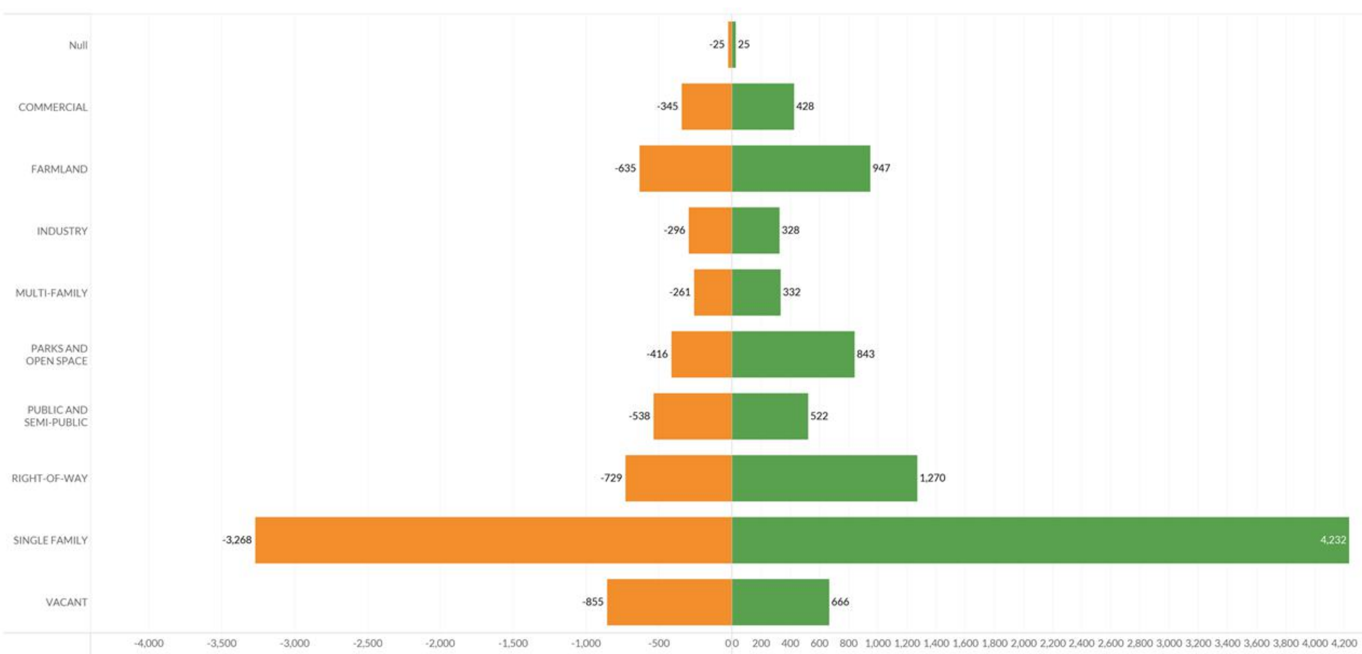



Figure 6: The area, in acres, of tree canopy gain and loss in each of Jefferson County's Land Use categories.

Although 39% of Jefferson County is covered by tree canopy, there is room to plant more trees and establish new canopy. Quantifying Possible-Vegetation by Land Use provides broad insight into available space for more trees. The most Possible-Vegetated space is in the Single Family category. It is encouraging to know that while the canopy is declining in this category, there is an opportunity to plant more with over 30,000 acres of Possible-Vegetated space. Community education is crucial if tree canopy is to be maintained over time. This is particularly important for private property. Residents that are knowledgeable about the value and services trees provide will help the city stay green for years to come.

Increasing the tree canopy will be difficult in the most densely urbanized areas of Jefferson County. Nevertheless, it remains vitally important to promote the health and number of street trees, even in these areas, through ongoing maintenance and new plantings. Possible-Impervious includes asphalt or concrete surfaces, excluding roads and buildings, that are theoretically available for the establishment of tree canopy. Modifications to the hardscape may work to create additional space for trees in the Commercial, Public, and Semi-Public, and ROW categories. The Commercial land use is limited in Possible-Vegetated space (3,219 acres), but there are 6,441 acres of Possible-Impervious space available that can be explored for planting opportunities.


Figure 7: Existing tree canopy and canopy change by Land Use.

## Council Districts

Jefferson County has 26 designated Council Districts, which have been used to map canopy change by district, illustrated in Figure 8. Figure 9 illustrates Existing Canopy and Canopy Change. Existing tree canopy ranged from 15% to 52%. Most districts experienced canopy gain in acreage, with the exception of Districts 2, 4, 9, and 21. The built environment varies by district, and while some districts may have less canopy cover, there may also be less space to plant given urban density and land use.

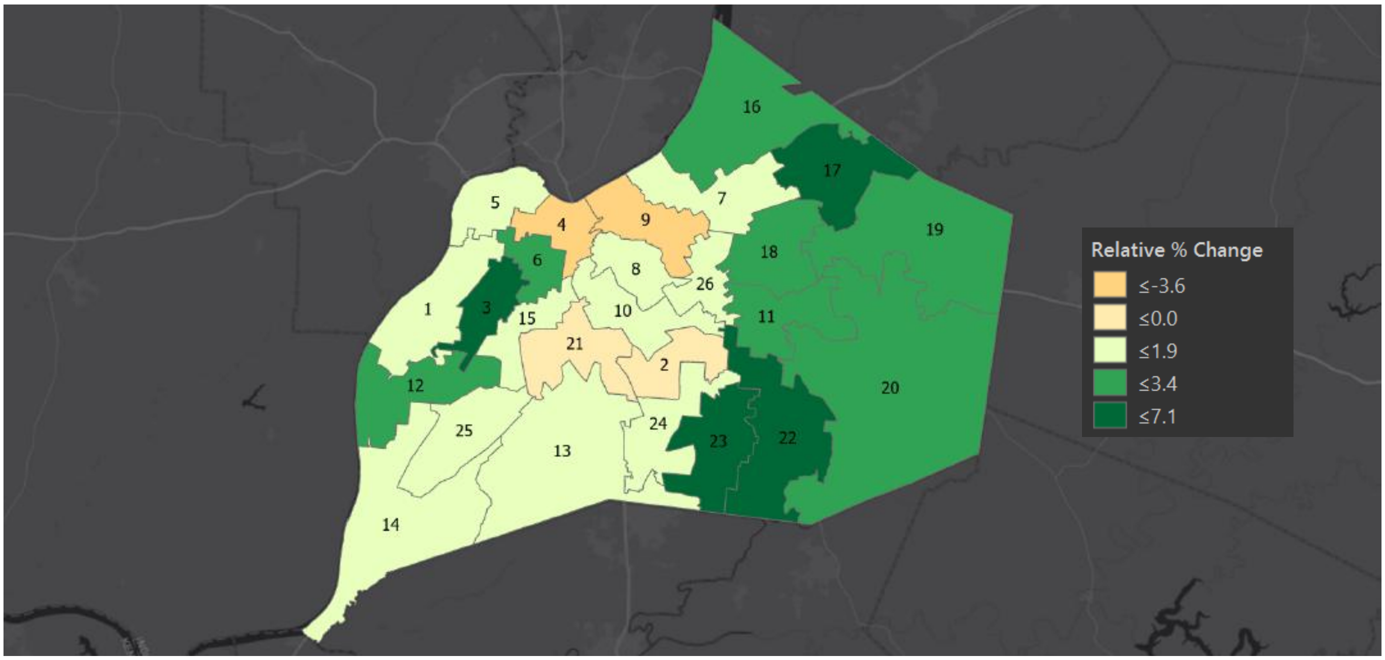



Figure 8: Jefferson County tree canopy change metrics summarized by Council Districts. Relative tree canopy is calculated by using the formula (2012-2019)/2012. Colors are categorized by data quantiles. Darker greens indicate greater relative gain, while orange reflects greater relative loss.


Figure 9: Existing Tree Canopy (% and acres) Tree Canopy Change (Absolute %, Relative % and acres) summarized by Council Districts.

## Tree Canopy Change Height

Canopy height is a useful proxy for tree age and was derived from both years of LiDAR used in this study. The tree canopy was segmented into polygons approximating individual trees. Each of these polygons was then attributed with the height from both the 2012 and 2019 LiDAR data. The height from the 2012 LiDAR was used to understand loss (bottom orange), whereas the height from the 2019 LiDAR was used to understand the gain (top green). Figure 10 (top) shows trees in the 0-60 foot height class experienced gain, while there was minimal gain in the other taller height classes. This reflects the many new trees planted between 2012 and 2019 as well as canopy expanding on existing trees.

Diverse height structure corresponds to a healthy and diverse tree age distribution across the city. Louisville has the fewest trees in both ends of the height curve, the shorter 0-20 foot range and the taller 80-130 foot range. It will be important to preserve trees in this 10-50 foot height range, so they can grow into the 60+ foot range while planting a variety of new trees to continue the lifecycle. This will help to develop the next generation of trees that reach maturity and balance the distribution,

A concern is that large amounts of tree canopy is being lost in the 0-50 foot height classes (Figure 10 bottom). These height classes are the ones contributing the majority of the gain in tree canopy. The loss of trees in the 0-50 foot height range reduces full canopy potential and results in the city losing out on the benefits from these trees. It is impressive that there are some very mature trees in the 130 height class, which points to the height potential for certain tree species in Louisville provided the right conditions.

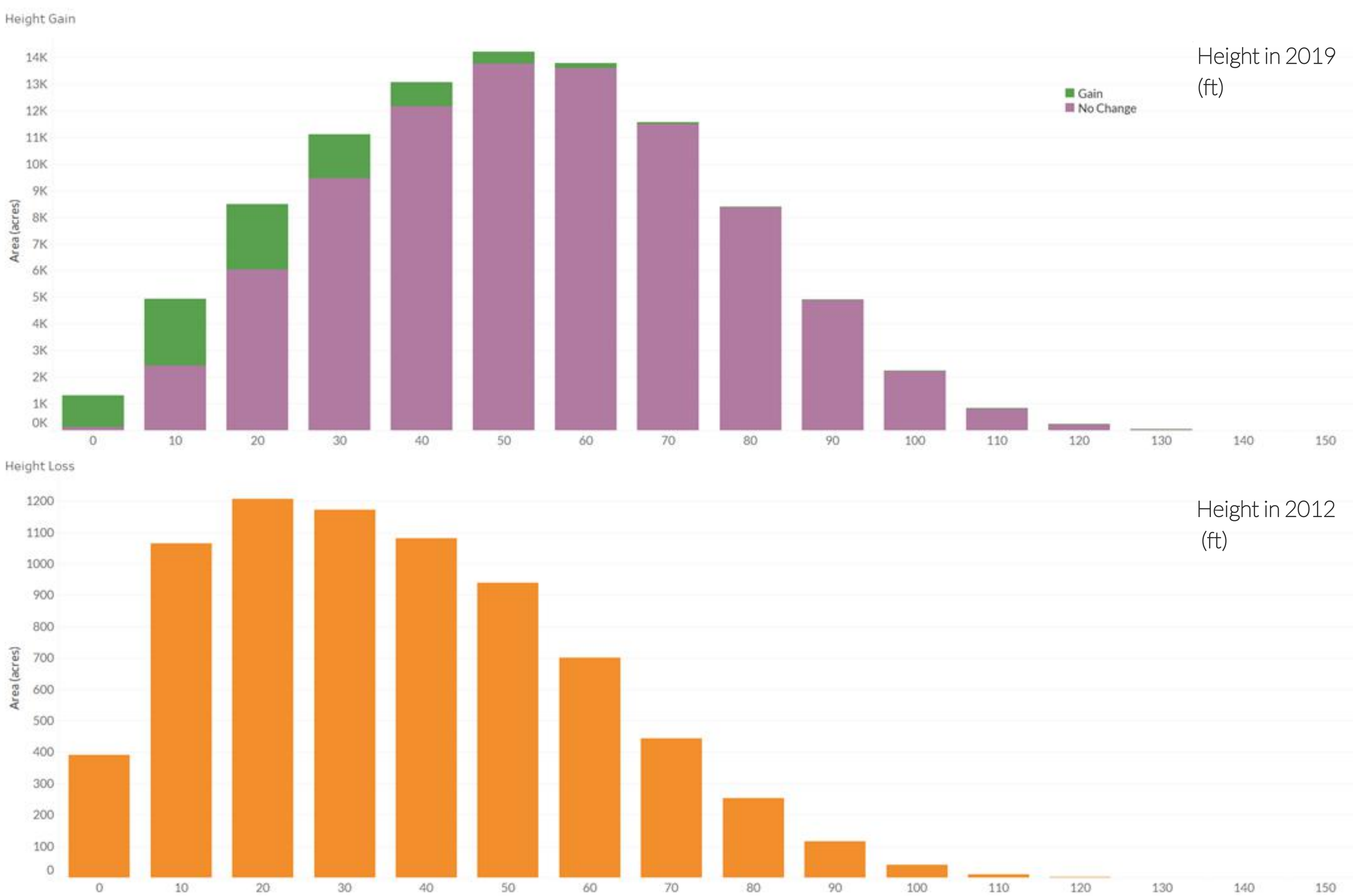



Figure 10: The tree canopy was segmented into polygons approximating individual trees. Each of these polygons was then attributed with the height from both the 2012 and 2019 LiDAR data. The height from the 2012 LiDAR was used to understand loss (bottom orange), whereas the height from the 2019 LiDAR was used to understand the gains (top green).

# 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 canopy tree along the Ohio River in Waterfront Park to a stand of trees in the Jefferson Memorial Forest, every tree in Louisville was mapped.

## Tree Canopy Mapping

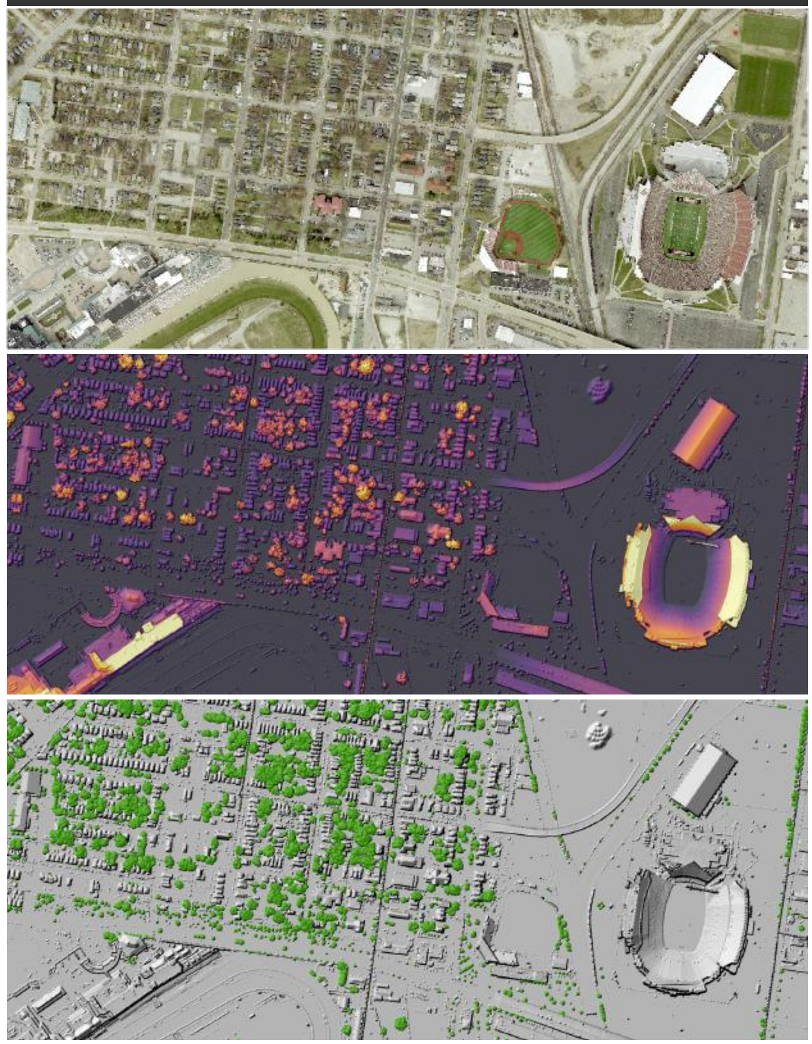


Figure 11: Imagery (top), LiDAR surface model (middle), and high-resolution tree canopy (bottom). By combining these datasets the land cover mapping process capitalizes on their strengths and minimizes their weaknesses. The land cover dataset is the most detailed, accurate, and current for Jefferson County.

The high-resolution land cover that forms the foundation of this project was generated from the most recent LiDAR, which was acquired in 2019 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 county's tree canopy.

## Land Cover Mapping


Figure 12: High-resolution land cover developed for this project.

# MAPPING TREE CANOPY CHANGE

This study made use of aerial imagery and LiDAR data acquired in 2012 and 2019. 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.

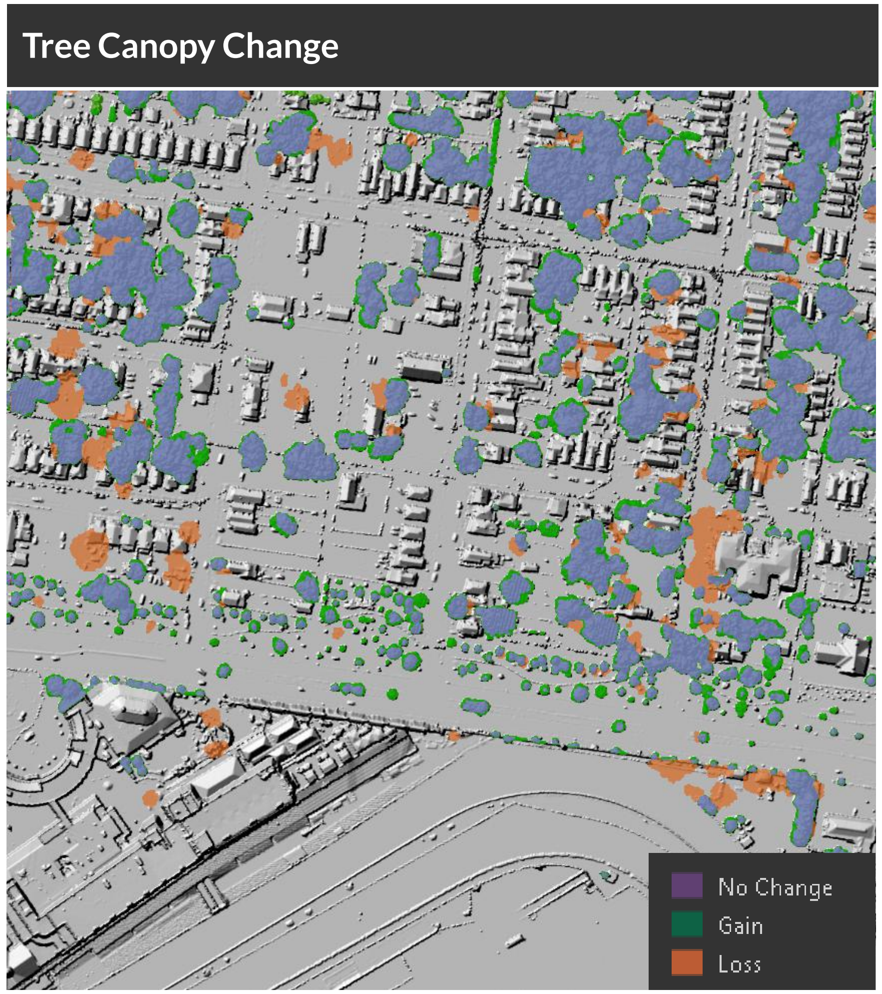



Figure 13: Tree canopy change mapping in the vicinity of the Churchill Downs. Tree canopy change was mapped for the 2012-2019 time period and is overlaid on the 2019 LiDAR hillshade map.

## 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 2012 and 2019 datasets were acquired with different specifications. This assessment was completed independently of prior tree canopy assessments for Jefferson County, and methodologies are not directly comparable. Great care was put into resolving the differences in the data to ensure that tree canopy change between 2012 and 2019 reflected an actual change in the canopy as opposed to differences in the source data.

This assessment was carried out by the University of Vermont Spatial Analysis Lab in collaboration with TreesLouisville. 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 Louisville/Jefferson County Information Consortium (LOJIC) and the USDA. 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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