COLUMBUS URBAN FORESTRY MASTER PLAN

TECHNICAL REPORT

THE CITY OF COLUMBUS RECREATION AND PARKS

Spring 2021

Acknowledgments

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Council President

Elizabeth Brown
Council President Pro Tempore

Mitchell J. Brown

Rob Dorans

Shayla Favor

Emmanuel V. Remy

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President

Terrie TerMeer
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Jennifer Adair, Esq.

Karla Rothan

Bettye Stull

Letha Pugh

Gregg Dodd

Jamie Wilson

Staff Team

Rosalie Hendon
Urban Forestry Master Plan Project Manager, Columbus Recreation and Parks Department

John Bowers
Forestry GIS Analyst, Columbus Recreation and Parks Department

Troy Euton
Assistant Director, Columbus Recreation and Parks Department

Stephanie Garling
Communications and Marketing Manager, Columbus Recreation and Parks Department

Jim Gates
Arborist, Columbus Recreation and Parks Department

Jim Long
City Forester, Columbus Recreation and Parks Department

Craig Seeds
Administrator, Operations and Maintenance Division, Columbus Recreation and Parks Department

Brad Westall
Planning Manager, Columbus Recreation and Parks Department

Project Team

Ann Aubry
Deputy Director, Columbus Department of Public Utilities

Erin Beck
Director of Special Projects, Mayor's Office

Lisa Bowers
Regional Urban Forester, Ohio Department of Natural Resources

Steve Cothrel
Vice-Chair, Columbus Tree Subcommission

Claus Eckert
Executive Director, Green Columbus

Kelsey Ellingsen
Legislative Aide, Council President Pro Tempore Elizabeth Brown

Laura Fay
Board Secretary, Friends of the Lower Olentangy Watershed

Paul Freedman
Planning Manager, Columbus Department of Building and Zoning Services

Emerald Hernandez-Parra
Assistant Director, Columbus Department of Neighborhoods

Brian Kinzelman
Senior Principal, MKSK

Stephen Matthews
Associate Professor, The Ohio State University

Joseph Reidy
Vice President – Development and Director of Environmental Services, Thrive Companies

Karla Rothan
Commissioner - Columbus Recreation and Parks Commission

Rich Simpson
Forestry Regional Supervisor, American Electric Power

Tyler Stevenson
Urban Forestry Program Manager, Ohio Department of Natural Resources

Terrie TerMeer
Vice President - Columbus Recreation and Parks Commission

Scott Ulrich
Healthy Places Program Coordinator and City Bicycle Coordinator, Columbus Department of Public Health

Brandi Whetstone
Sustainability Officer, Mid-Ohio Regional Planning Commission

Andrew Williams
Assistant Director, Columbus Department of Public Service

Acknowledgments

Advisory Group

American Society of Landscape Architects

American Electric Power Ohio

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Building Industry Association of Central Ohio

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Defense Supply Center of Columbus

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Fifth by Northwest Area Commission

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Franklin Soil and Water Conservation District

Franklinton Area Commission

Friends of the Lower Olentangy Watershed

Greater Hilltop Area Commission

Greater South East Area Commission

Greenlawn Cemetery

Livingston Avenue Area Commission

Mideast Area Commission Midwest Biodiversity Institute Milo-Grogan Area Commission Near East Area Commission

North Central Area Commission

North Linden Area Commission

Northeast Area Commission

Ohio Department of Agriculture

Ohio Department of Natural Resources

Ohio Department of Transportation

Ohio Environmental Council

Ohio Environmental Protection Agency

Ohio Railroad Association

OSU Extension

South Linden Area Commission

South Side Area Commission

Southwest Area Commission

The Columbus Foundation

The Ohio State University

University Area Commission

U.S. Department of Agriculture Forest Service

U.S. Green Building Council

West Scioto Area Commission

Westland Area Commission

Consultant Team

DAVEY Resource Group

Kerry Gray
Principal Consultant

Joe Gregory
Regional Manager

Sean Wylie
Arborist

urbancanopy works, LLC

Rachel Comte
Principal, Arborist, Urban Planner

Jenny Gulick
Principal, Arborist

DESIGNING LOCAL

Matt Leasure
Principal, Landscape Architect, Urban Planner

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Introduction

Report Overview

The Columbus Urban Forest Master Plan Technical Report, the first of its kind for the city, provides an overview of urban forestry data, policies and practices to gain an understanding of the current state of Columbus' urban forest. To effectively manage and grow its tree canopy, it is essential that Columbus has the knowledge and insight into what exists today. This report, a companion document to the Columbus Urban Forestry Master Plan (UFMP), laid the groundwork for the UFMP Action Steps, can be used as a reference for policy making and grant writing and serves as the foundation for future plan updates.

The report is organized into the following sections:

Section I: Benefits of Columbus' Urban Forest. Highlights and quantifies the environmental and economic benefits that Columbus' trees provide to the community.

Section II. Columbus' Urban Forest. Examines Columbus' tree canopy by exploring data and information from the City's 2015 urban tree canopy assessment.

Section III. About Columbus' Public Trees. Reviews the compositions, size and diversity of Columbus' publicly managed street tree and park tree population.

Section IV. Columbus' Public Tree Care & Management. Explores the management and care of the City's publicly managed street tree and park tree population.

Section V. Engagement & Outreach. Describes "the players" – the people, organizations and city departments that influence and impact Columbus' urban forest.

Section VI. Indicators of a Sustainable Urban Forest. Explores how Columbus' current urban forest and urban forestry program is rated against the *Indicators of a Sustainable Urban Forest.*

Section VII. Appendices. Provides assessment methodologies, ordinance review and references.

SECTION I.
BENEFITS OF THE URBAN FOREST

Landscape and Climate

Columbus is located where the Scioto and Olentangy rivers meet in Franklin, Delaware and Fairfield counties in central Ohio. The City measures 223 square miles, with 217 square miles of land and six square miles of water. It sits on a limestone bedrock foundation and is within the glacial till plain of Central Ohio. Prior to its development, Columbus' soils were primarily Miami clay loam, with silty loam soils towards the surface and clay subsoils (Smith, 1902). Today, while Miami soils can still be found, soils within the city are classified primarily as urban by the USDA Natural Resource Conservation Service (NRCS, n.d.). These soils are human made having been modified during development and lacking the structure, profile and physical properties of native soils. The lack of a native soil structure can influence the species composition of trees within the city.

Columbus' climate is considered temperate, with seasonal variations and a broad range of temperatures. The average high temperature in July is 85 degrees Fahrenheit and average low in January is 23 degrees Fahrenheit. The city receives an average of 39 inches of precipitation annually (NOAA, n.d.). However, **Columbus' climate is changing;** it is becoming hotter in the summer putting the health and well-being of residents at risk. Climate Central found Columbus to be the **fastest growing heat island** of the 60 major cities studied, currently ranking 8th most intense overall; and **by 2095 Columbus summers could be similar to those in Arkansas today** (Climate Central, 2014 and GLISA, n.d.).

Trees have been proven to be one of the most effective tools for mitigating the effects of climate change by providing essential services and benefits, including (Bastin, et al., 2019; Ulmer, et al., 2019; and CUFR, n.d.):

- Removing ozone from the air which helps reduce atmospheric warming and improves air quality and the public health effects of air pollution.
- Storing carbon and reducing the amount returning to the atmosphere as a greenhouse gas.
- Shading and cooling streets/buildings mitigating the urban heat island effect and reducing the use of air conditioning.
- Intercepting and absorbing stormwater reducing flooding and the amount entering the City's stormwater system.
- Improving water quality by filtering and removing pollutants.
- Providing homes, food and shelter for wildlife.
- Beautifying the community.
- Positively impacting the overall health of urban residents and lessening the negative impacts of urbanization.

Benefits of Columbus' Urban Forest

Annual Value of Columbus' Tree Canopy: $38 Million

Columbus tree canopy cover provides a cumulative, annual value of $38,026,500 or $17.85 per capita by providing the following ecosystem benefits to the community (USDA Forest Service, i-Tree Tools).

Carbon. Columbus trees sequester over 167,860 tons of carbon and store over 4.23 million tons, reducing the amount returning to the atmosphere as a greenhouse gas. Trees can be a tool to help the City reach its goal of being carbon neutral by 2050. The estimated value of the carbon that Columbus' trees have stored over their lifetime is $102 million. **Annual Value: $3.9 million**

Stormwater. Intercepting and absorbing over 33 million gallons of stormwater, reducing the amount entering the storm sewer system. **Annual value: $29.5 million.**

Air Pollution. Removing 1.4 million pounds of ozone, 70,000 pounds of nitrogen dioxide, 206,000 pounds of sulfur dioxide and 31,000 pounds of carbon monoxide from the atmosphere, helping to reduce atmospheric warming, improve air quality and mitigate the public health effects from air pollution. **Annual Value: $2.2 million.**

Air Quality. Columbus' urban forest removes nearly 800,000 pounds of dust, smoke and other particles from the air, directly improving air quality and respiratory health (e.g., asthma). **Annual value: $2.5 million.**

SECTION II.
ABOUT COLUMBUS' URBAN FOREST

Columbus' urban forest is made up of all of the trees growing on public and private property. Although the City of Columbus manages a large number of trees, including those growing along streets, in parks and on other City properties, they constitute a minority of the overall urban forest.

TREE CANOPY COVER

Columbus Baseline: 22% Tree Canopy Cover (2013)

The amount, location and distribution of tree canopy is the driving force behind an urban forest's ability to produce benefits to the community; as tree canopy increases, so do the benefits (Clark, et al., 1997). In 2015, the City of Columbus completed an urban tree canopy assessment using aerial imagery from 2013 to measure the amount of tree canopy and other land cover across the city. **Tree canopy is measured as the layer of leaves, branches and stems of trees that cover the ground when viewed from above.**

Tree canopy and land cover in Columbus (Figures 1 & 2).

- **217 square miles of land area** (excluding water)
- **22% tree canopy cover**
- **2.05 million trees** estimated in Columbus
- **39% of land covered by impervious surfaces** (hard surfaces), like roads, parking lots and buildings
- **33% pervious surfaces,** like grass, vegetation, open space and bare soil that water can move through

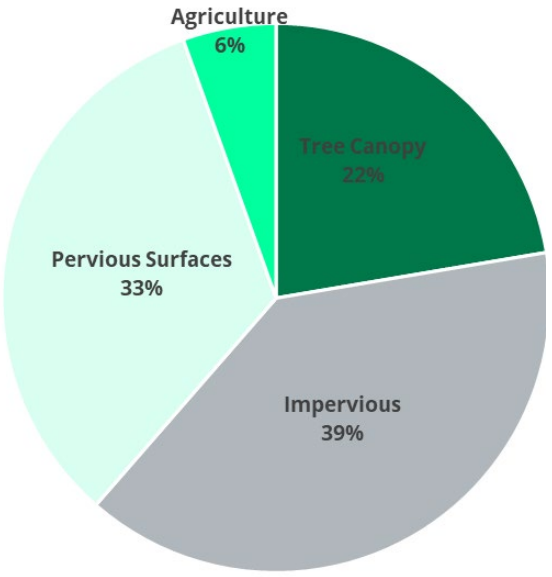


Figure 1. Columbus Land Cover Summary

- **63% tree canopy cover is possible in Columbus** if *all* open areas on public and private property were planted with trees (57,665 acres).
- **70% of tree canopy is on private property.**
- **$38 million in environmental benefits** are provided to the Columbus' community by the city's tree canopy - equivalent to $17.85 per resident.

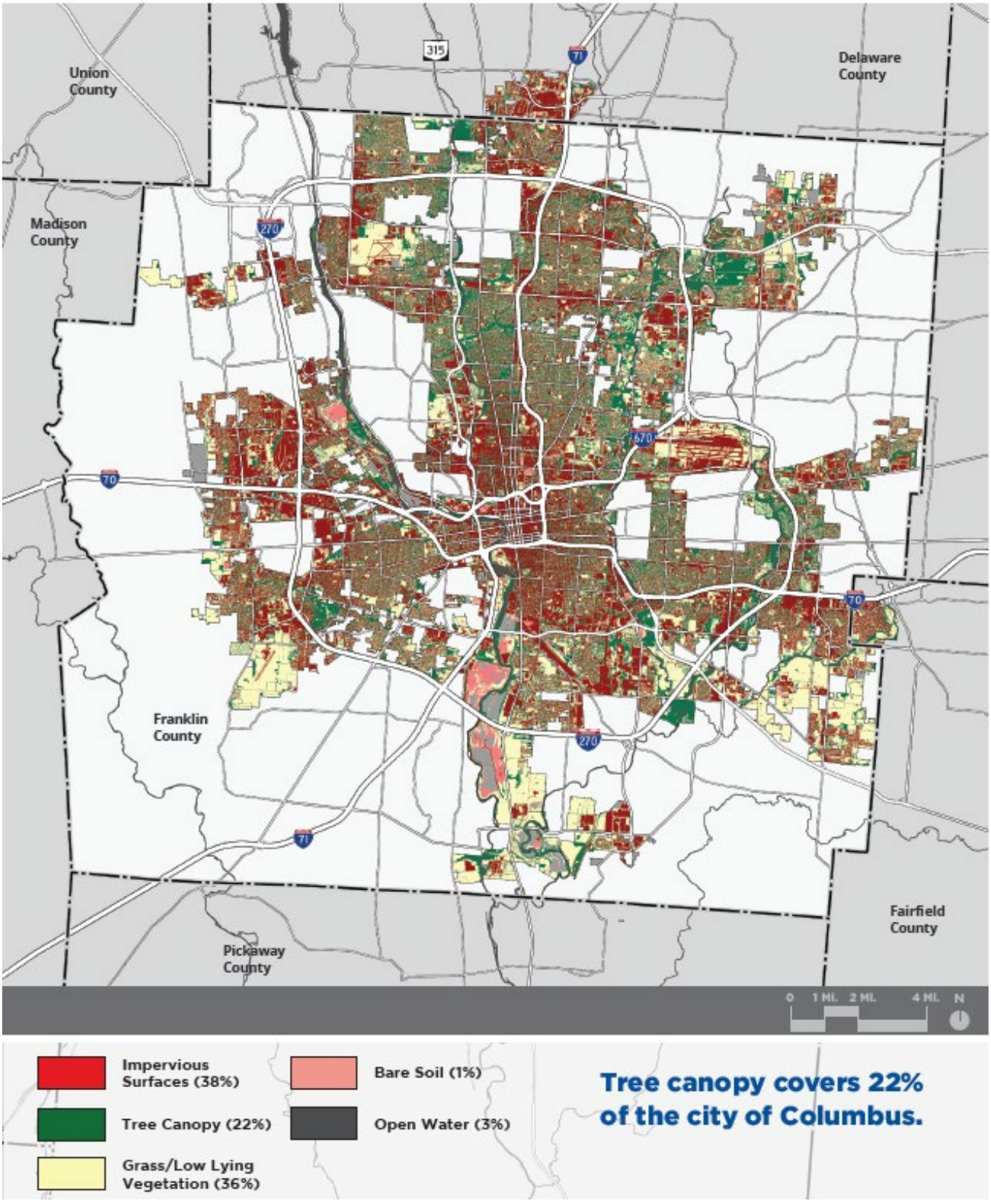


Figure 2. Existing Land Cover in Columbus

HOW DOES THE TREE CANOPY IN COLUMBUS COMPARE TO OTHER CITIES?

Columbus' tree canopy cover is lower than many regional peer cities.

At 22%, Columbus' tree canopy cover is lower than many cities in the region (Figure 3). Pittsburgh, Cincinnati and Louisville have nearly twice as much tree canopy cover as Columbus. Understanding tree-related policies, regulations and practices that cities with higher canopy cover have in place, can help Columbus as they evaluate strategies to increase and grow its own tree canopy.

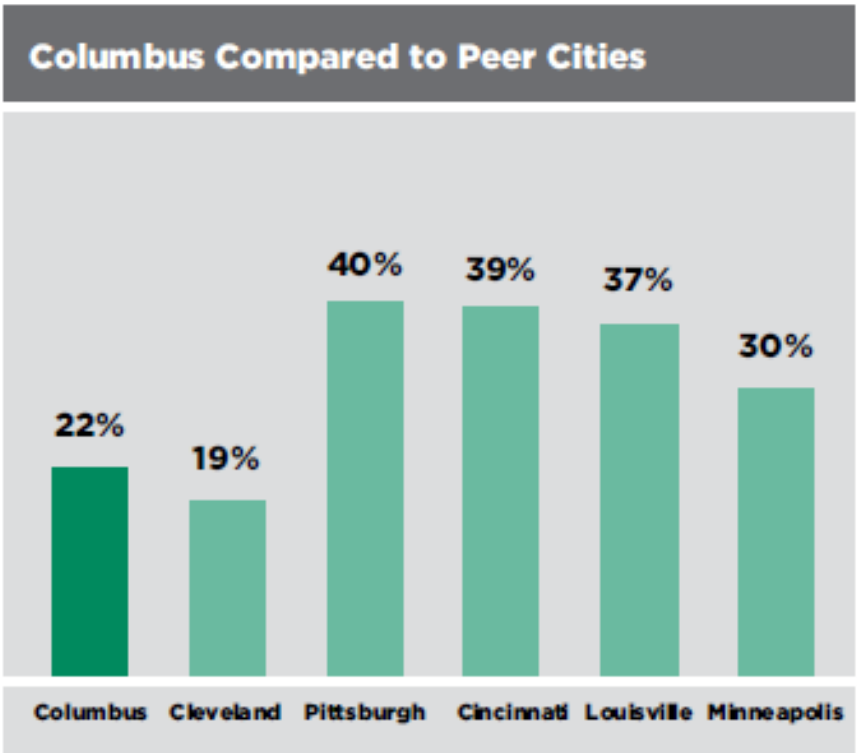


Figure 3. Tree Canopy of Regional Cities

TREE CANOPY ACROSS THE CITY

Tree canopy cover varies across the city - canopy cover in Columbus Communities ranges from 9 to 41%.

Distribution of tree canopy varies across Columbus, changing over decades, sometimes gradually and sometimes abruptly due to weather, climate, disease, disinvestment, economics and development factors. This variability has led to an inequitable distribution of tree canopy cover, meaning areas with lower tree canopy cover receive fewer benefits (see *Equalizing Tree Canopy Across Columbus)*.

Tree Canopy By Land Use

70% of Columbus' Tree Canopy Cover is on Private Property

Tree canopy varies widely between land use types in Columbus - residential properties make up the largest proportion of the city's land area (~50%) and contain the largest amount of the city's tree canopy cover (Figure 4). Figure 5 shows the average tree canopy cover by land use category. Columbus can use this data to **develop policies and initiatives focused on increasing tree canopy cover on land uses that are low** or below the city-wide tree canopy cover of 22%.
(Note: Figure 4 parking is not shown because the amount of land area -- 94 acres -- was too small for it to be displayed in the chart).

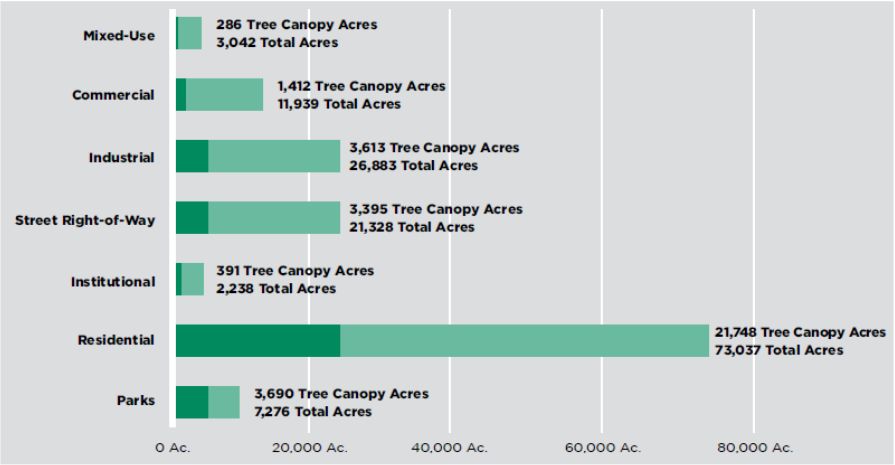


Figure 4. Tree Canopy Coverage by Acre

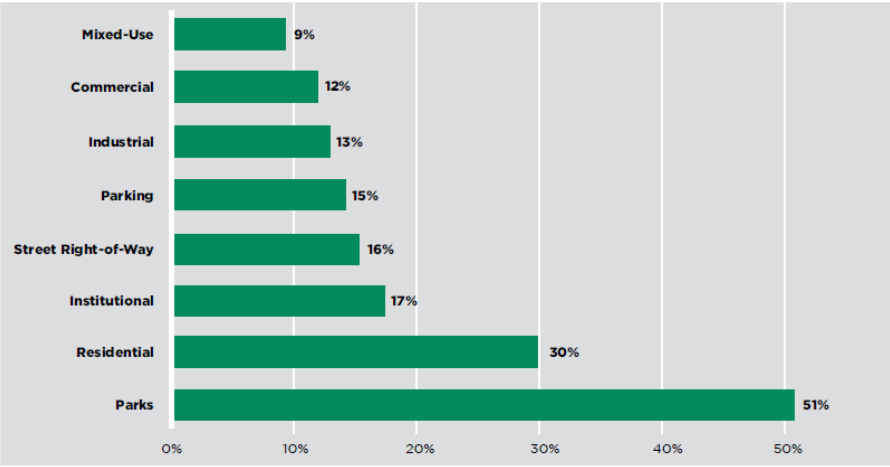


Figure 5. Average Amount of Tree Canopy Cover by Land Use

Tree Canopy by Columbus Community

Columbus Communities Tree Canopy: 9% - 41%

Average Tree Canopy Cover: 22%

Columbus Communities are geographic areas of the city made up of a number of neighborhoods and a variety of land use types. The amount of **tree canopy cover and the benefits it provides is not equitably distributed across Columbus Communities**. Tree canopy cover, excluding the Airport, Dublin Road Corridor, Fort Hayes, Harmon Road Corridor, State of Ohio and Wolfe Park Columbus Communities, **ranges from a low of 9% to a high of 41%** with an average canopy cover of 22% (Figure 6 & 7). See Appendix A for how neighborhoods were determined.

Columbus Communities with higher tree canopy cover not only receive more of the direct benefits trees provide, including removing pollutants from the air, shading and cooling homes and slowing down and absorbing rainwater helping to reduce flooding. These higher canopy Communities also provide important indirect benefits, such as carbon storage and improving air quality, that are important to the overall sustainability of the city.

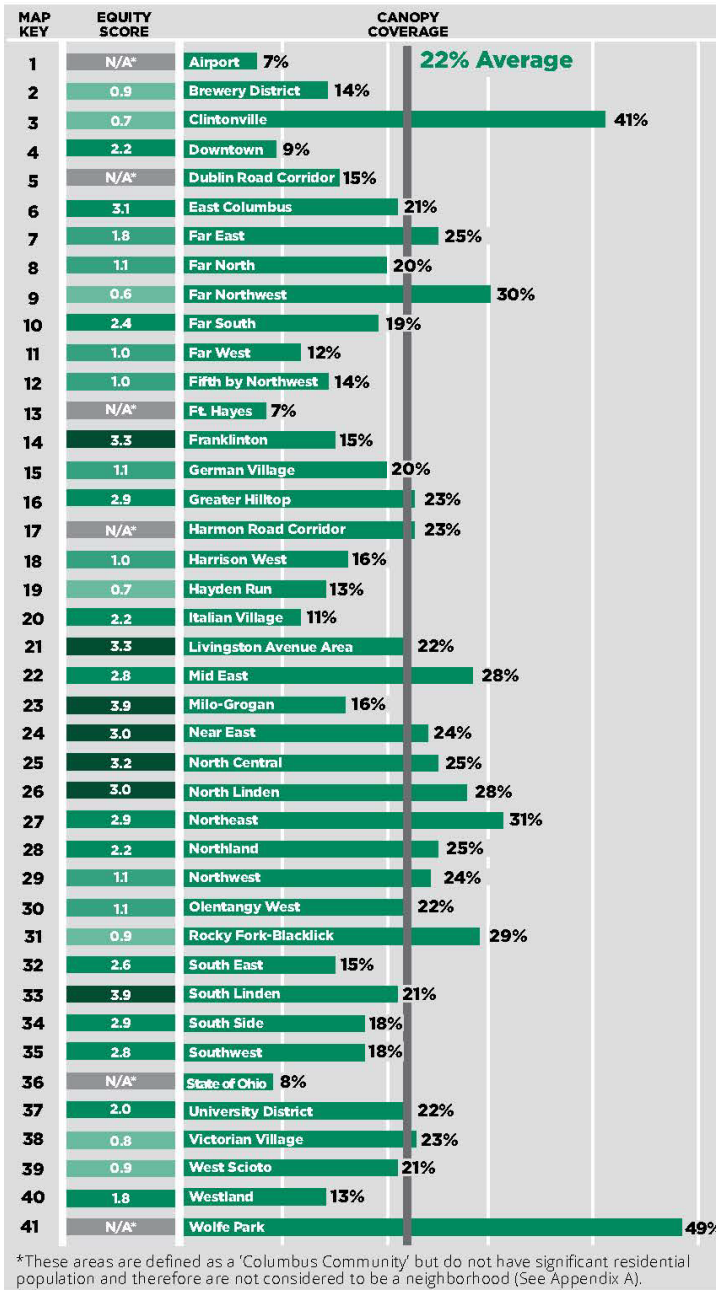


Figure 6. Tree Canopy by Columbus Community (Neighborhood)

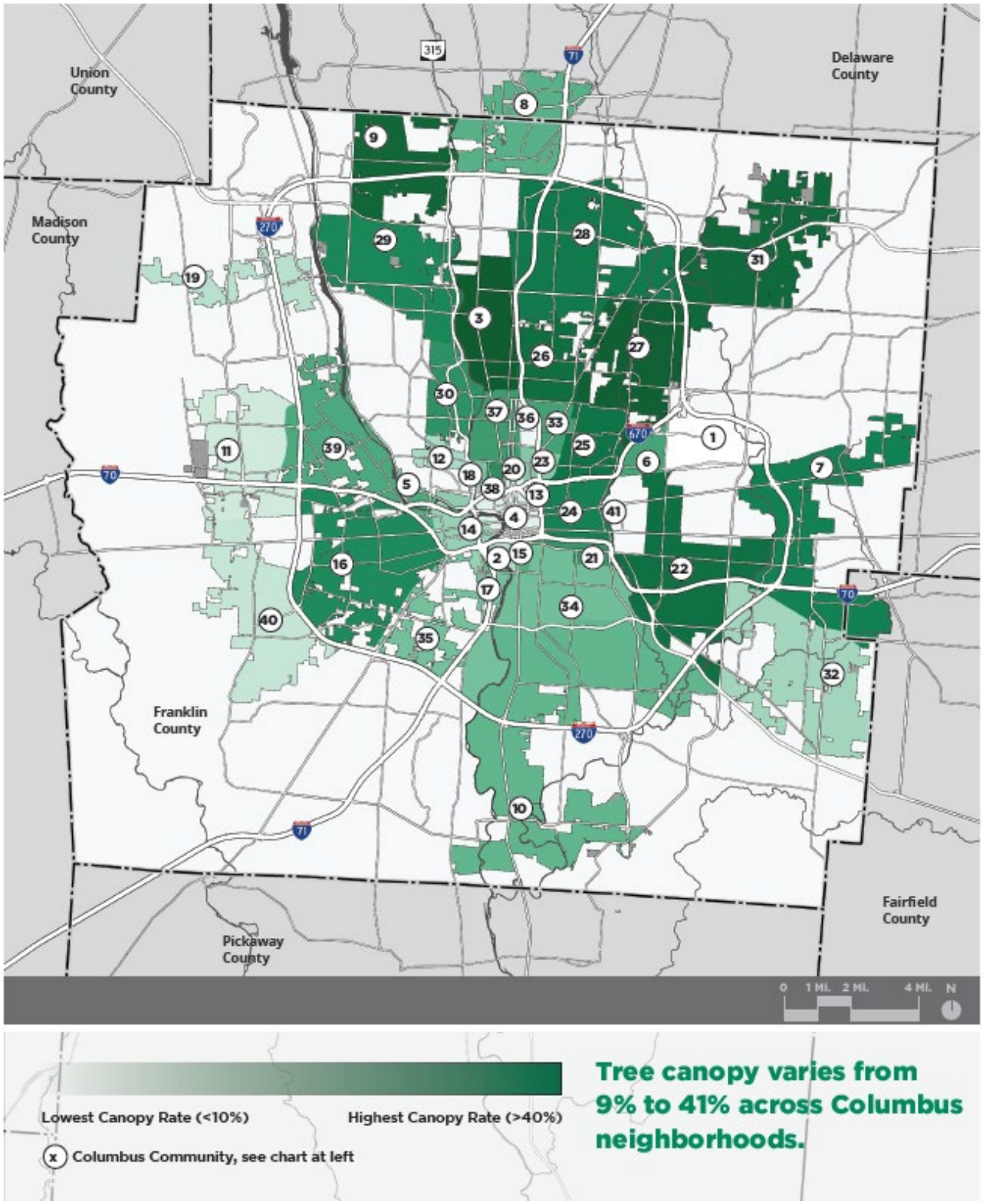


Figure 7. Tree Canopy Cover by Columbus Community (Neighborhood)
Numbers corresponds to Figure 6

RESEARCH: Tree Canopy, Crime & Health

Trees Help Make Neighborhoods Safer

Portland, OR. Street trees planted in neighborhoods with single family homes were associated with lower crime (Donovan, et al, 2012).

Baltimore, MD. A 10% increase in tree canopy was associated with a 12% decrease in crime (robbery, burglary, theft and shooting). Tree canopy on public land provided a greater benefit than private lands (Troy, et al, 2012.)

Philadelphia, PA. Neighborhoods with abundant vegetation had lower rates of crime (assault, robbery and burglary) than areas with sparse or no vegetation (Wolfe, et al, 2012)..

Trees Improve Human Health

New York City. The presence of street trees were associated with a lower prevalence of asthma in early childhood (Lovasi, et al, 2008).

United States. Mortality rates due to cardiovascular and lower respiratory disease increased in counties that lost trees due to the emerald ash borer (Donovan, et al, 2013)..

Pennsylvania. Patients with views of trees outside their hospital room had shorter hospitalizations and required less medication than patients who had a view of a brick wall (Ulrich, 1984).

England. Health inequities and mortality in low-income populations were lower for those living in the greenest areas (Mitchell, et al, 2008).

Equalizing Tree Canopy Across Columbus

Exploring canopy cover through an equity lens

Research has shown that trees provide important benefits to neighborhoods, from cooling the environment to improving physical health and making communities safer (see *Research: Tree Canopy, Crime & Health*). Planting and preserving trees in areas with low to moderate canopy cover is one way a city can increase a city's tree canopy. However, focusing only on these areas to direct planting and preservation efforts does not necessarily ensure that the benefits trees provide are equitably distributed or available to Columbus' most vulnerable populations.

When considering equitable distribution of the urban forest, the percent of tree canopy cover is only one factor to consider. Columbus' tree canopy ranges from 7% to 49% across the city, with an average of 22%. Neighborhoods range from a **low of 9% to a high of 41% tree canopy cover** (see Appendix A for how neighborhoods were determined). It is also important to consider the trees themselves: their health, size and species. For example, a neighborhood may have an average amount of tree canopy cover, but if the area has large, aging trees, there is a risk of significant canopy loss in the near term. Additional factors that impact appropriate tree canopy cover may include average area temperatures, stormwater runoff, air pollution, land use, and population information (i.e., economic, demographic and health). A neighborhood with higher temperatures and air pollution will benefit from investments in tree canopy. This means that **equity is not just about canopy cover.** In order to create an equitable tree canopy in Columbus, **both canopy cover and social equity factors were used to prioritize neighborhoods for investment**.

A deeper understanding of the extent and distribution of tree canopy cover related to economic, demographic, environmental and health factors provides a more detailed picture of tree canopy cover, gaps in tree benefits and vulnerable populations.

An analysis of the 2013 Columbus tree canopy cover data was conducted to see how it related to a variety of economic, demographic, health and crime factors in Columbus (see Appendix A for Methodology). The factors were selected by the Urban Forestry Master Plan Project Team, made up of representatives from City departments, outside agencies and local non-profit and environmental groups, based on research that correlated tree canopy with improvements in the factors. While some of these factors are correlated with tree canopy cover, correlation does not necessarily equal causation.

1. Asthma prevalence
2. Chronic obstructive pulmonary disease (COPD)
3. Mental Health
4. Non-White Populations
5. High School Graduation Rate
6. Median Household Income

7. Family Poverty
8. Property Crime
9. Violent Crime

The data from these factors were combined to create a composite social equity index (0=low need, 4 high need) for each Columbus Community. The Community equity index scores were mapped along with tree canopy cover data to identify the Communities with the highest need for tree canopy cover and the benefits it provides based on the social equity index (Table 1). The results of the analysis help Columbus understand how the inequitable distribution in tree canopy cover impacts neighborhoods and provides a tool to help address it.

Figure 8 highlights the neighborhoods that would most benefit from tree planting and care based on the social equity analysis. The map displays both the tree canopy cover (y-axis) and the composite social equity index (x-axis). The areas of interest for Columbus are the pink and purple shaded areas which have medium to high need on the composite social equity index and low to medium tree canopy cover.

Just as canopy cover varies across the city, it also varies within Columbus Communities. There may be high priority and low priority areas within the same neighborhood, as seen on the map in the Hilltop, Franklinton and Northland neighborhoods. Focusing on increasing canopy cover on the high priority areas of a neighborhood, instead of the entire neighborhood, can maximize resources and allow more high priority neighborhood areas across the city to be addressed.

The social equity analysis was part of a larger prioritized planting analysis (see sidebar Prioritized Planting & Tree Placement Analysis) that also included urban heat island and stormwater factors.

Table 1. Columbus Communities (Neighborhoods) by Social Equity Index and Tree Canopy Cover
Excludes Airport, Dublin Road Corridor, Fort Hayes, Harmon Road Corridor, State of Ohio and Wolfe Park Columbus Communities. See Appendix A for how neighborhoods were determined.

Priority		Columbus Community (Neighborhood)	Tree Canopy Cover	Social Equity Index
Social Equity Score > 3.0 (Sorted by Social Equity Score - highest to lowest)	Highest Priority	Milo-Grogan	16%	3.9
		South Linden	21%	3.9
		Franklinton	15%	3.3
		Livingston Avenue Area	22%	3.3
		North Central	25%	3.2
		East Columbus	21%	3.1
		Near East	24%	3.0
		North Linden	28%	3.0
Social Equity Score 2.0 - 2.9 (Sorted by Social Equity Score - highest to lowest)	High Priority	South Side	18%	2.9
		Greater Hilltop	23%	2.9
		Northeast	31%	2.9
		Southwest	18%	2.8
		Mid East	28%	2.8
		South East	15%	2.6
		Far South	19%	2.4
		Downtown	9%	2.2
		Italian Village	11%	2.2
		Northland	25%	2.2
		University District	22%	2.0
Social Equity Score 1.0-1.9 (Sorted by Social Equity Score - highest to lowest)	Moderate Priority	Westland	13%	1.8
		Far East	25%	1.8
		Fifth by Northwest	14%	1.0
		Harrison West	16%	1.0
		Far West	19%	1.0
		Far North	20%	1.1
		German Village	20%	1.1
		Olentangy West	22%	1.1
		Northwest	24%	1.1
Social Equity Score 0.0 - 0.9 (Sorted by Social Equity Score - highest to lowest)	Lower Priority	Brewery District	14%	0.9
		West Scioto	21%	0.9
		Rocky Fork-Blacklick	29%	0.9
		Victorian Village	23%	0.8
		Hayden Run	13%	0.7
		Clintonville	41%	0.7
		Far Northwest	30%	0.6

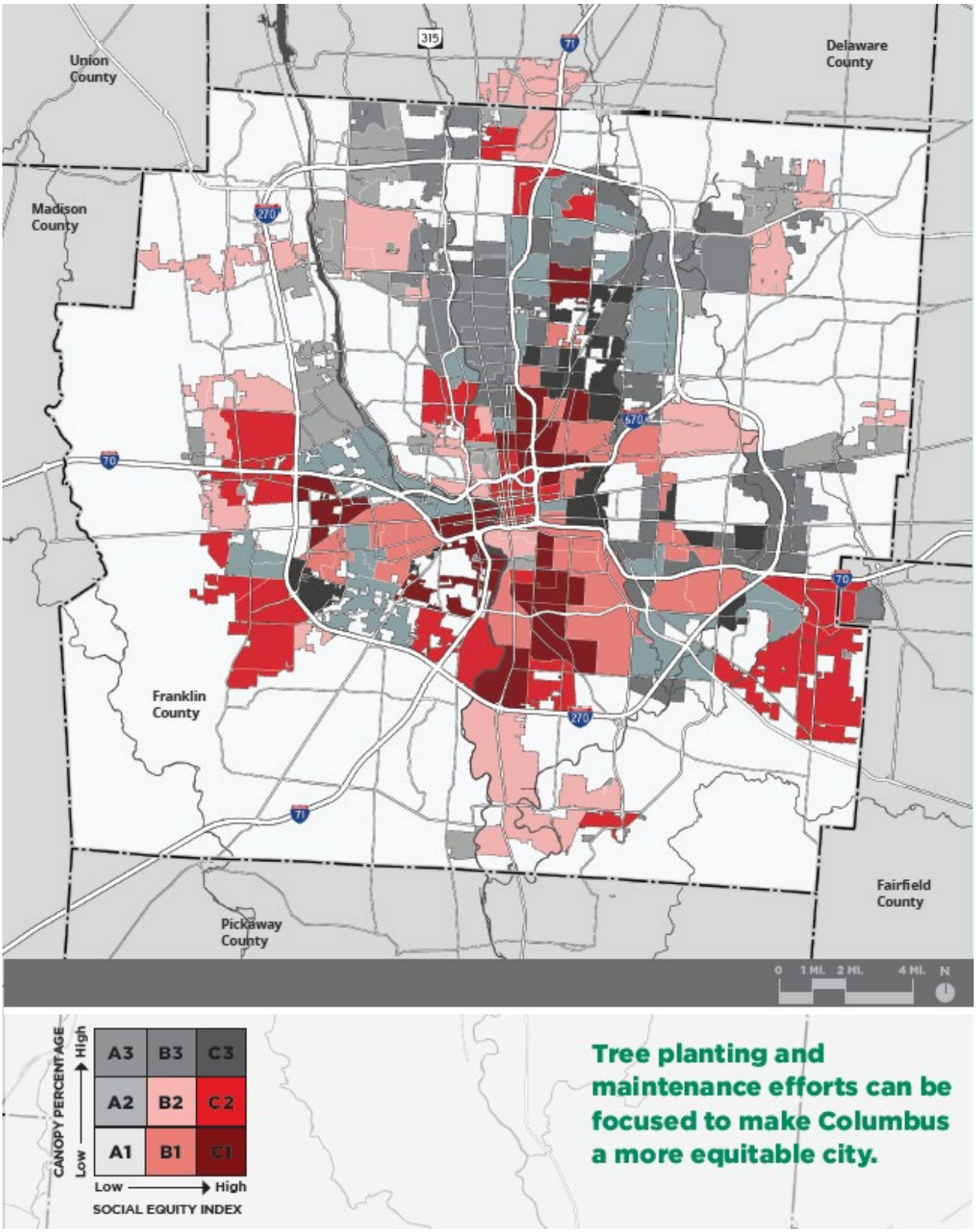


Figure 8. Columbus Communities with Highest Need for Tree Canopy Cover Based on Social Equity Index
Areas of highest need shaded in darker red having low to moderate tree canopy cover **and** rated as moderate to high on the social equity index.

Prioritized Planting & Tree Placement Analysis

Potential Tree Canopy Cover in Columbus: 63%, if ALL Open Spaces Planted (Plan-It Geo, 2015)

Increasing canopy cover to meet canopy targets without a plan can be daunting. Davey Resource Group, Inc., developed a prioritized tree planting and tree placement tool to assist Columbus in targeting tree planting efforts where it is needed most. The layer provides a robust, dynamic tool for the City and community partners to develop planting plans based on specific community priorities.

To develop the prioritized planting and tree placement layer information from the social equity analysis along with urban heat island and stormwater data was used (Figure 10). Potential planting sites were then created in GIS (geographic information system) and assigned the following attributes:

- Tree Size Class (small, medium, or large) based on available growing space.
- Location (Private or Right-of-Way)
- Restriction (non-feasible planting locations)
- Stormwater Priority (Very Low, Low, Moderate, High, Very High)
- Heat Island Priority (Very Low, Low, Moderate, High, Very High)
- Equity Index Priority (Very Low, Low, Moderate, High, Very High)
- Priority for each social equity, health, demographic factor (Very Low, Low, Moderate, High, Very High)
- Composite Priority of all factors (Very Low, Low, Moderate, High, Very High)

Over 600,000 potential tree planting sites were identified in Columbus, with over 65% of those sites on private property (Figure 9)**.** The sites on public property include those along streets, in City parks and other public properties in Columbus. Sites were identified using aerial imagery and the spacing between trees was based on planting in a landscape setting. Not all sites identified will be suitable for tree planting; the City and its partners can use this data as a starting point to identify areas for tree planting and field check the sites for tree planting suitability.

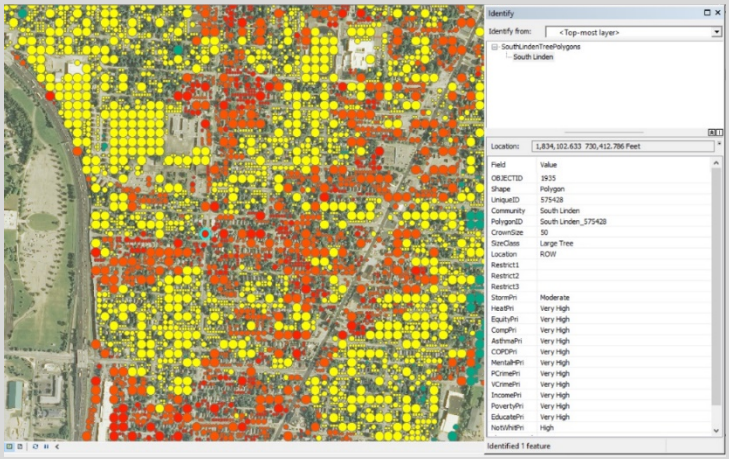


Figure 9. Columbus Prioritized Planting and Tree Placement Geographic Information System (GIS) Layer

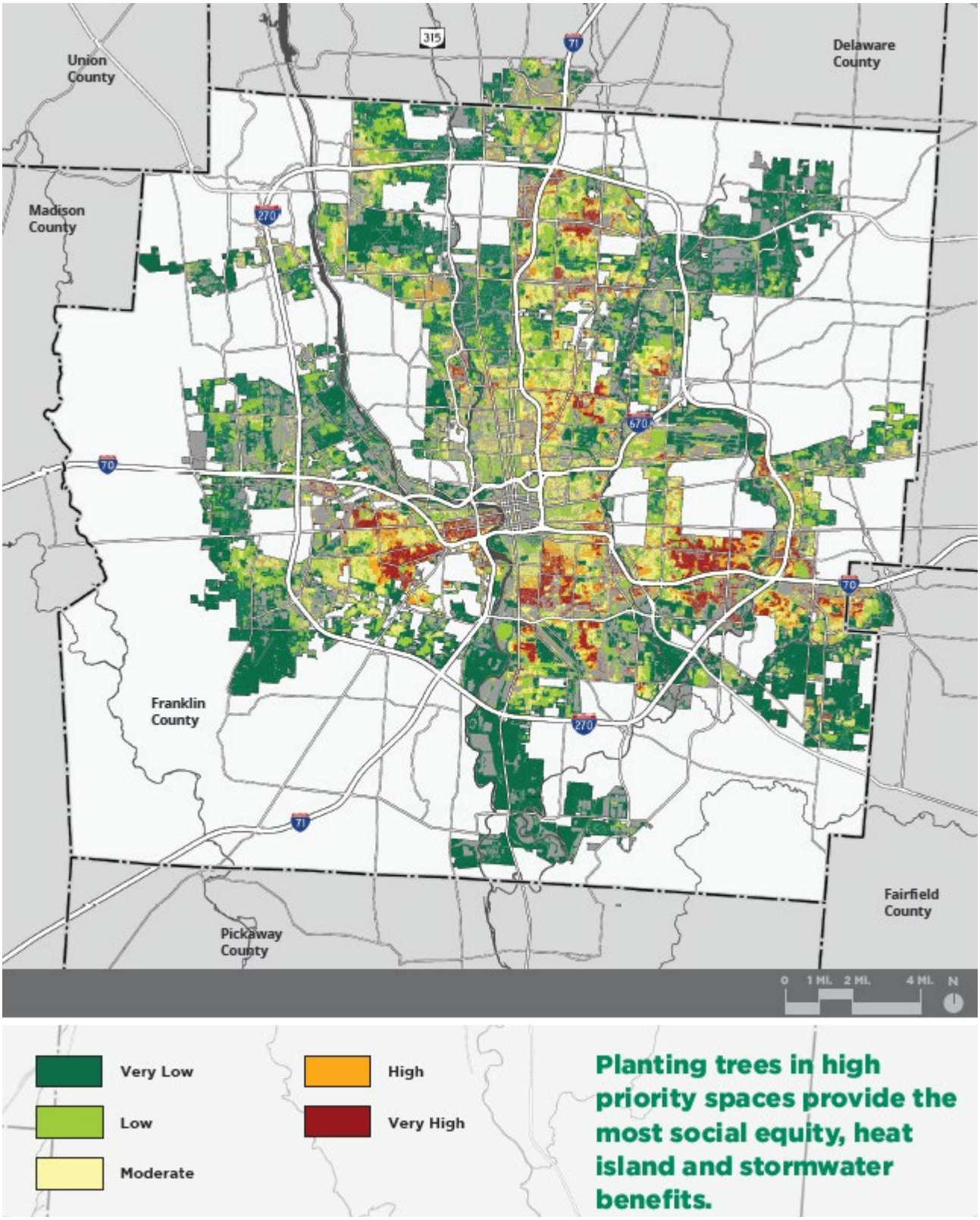


Figure 10. Priority Planting Areas based on Composite Ranking

SECTION III.
COLUMBUS' PUBLIC TREES

The City of Columbus' GIS-based street and park tree inventory provided the basis for the data and information in this section. The street tree inventory conducted in 1997 contains ~106,000 street trees; and the City parks tree inventory completed in 2015 contains ~22,000 trees. Trees planted by other city departments or outside organizations have not been inventoried, therefore staff estimate the inventory is approximately 80% complete. The inventory also does not include trees growing in unmowed areas of parks, natural areas or other city properties. Urban forestry industry standards recommend that municipal tree inventories are updated on a regular basis, as planting, maintenance and removals occur and re-inventoried every 10 years.

While much of Columbus' inventory data are out of date and the analysis of the data may not reflect actual current conditions, **the information provided in this section establishes a baseline which can be updated when new inventory data become available.** This assessment together with the Action Steps, provides tools and strategies to grow and improve Columbus' urban forest.

Size and Age Composition

Public tree population trends heavily towards young trees (0-8" diameter)

The size of trees (trunk diameter) can serve as a general predictor of their relative age. Over **60% of Columbus' street and park trees are young or small trees** (Figure 11). With the potential that most of the trees could reach maturity at the same time, there is a risk that canopy cover will be impacted as these trees die and are removed. Additional resources will also be needed to care for and manage these large, mature trees.

To maintain a sustainable urban forest, it is important for Columbus to have a mix of size/age classes to prevent a significant loss in tree canopy cover. To ensure there is an adequate mix of size/age classes:

- the preservation and care of mature trees should be prioritized to prevent loss of current tree canopy.
- new trees, especially those with large canopies at maturity, should be planted to replace old, dying, dead trees.

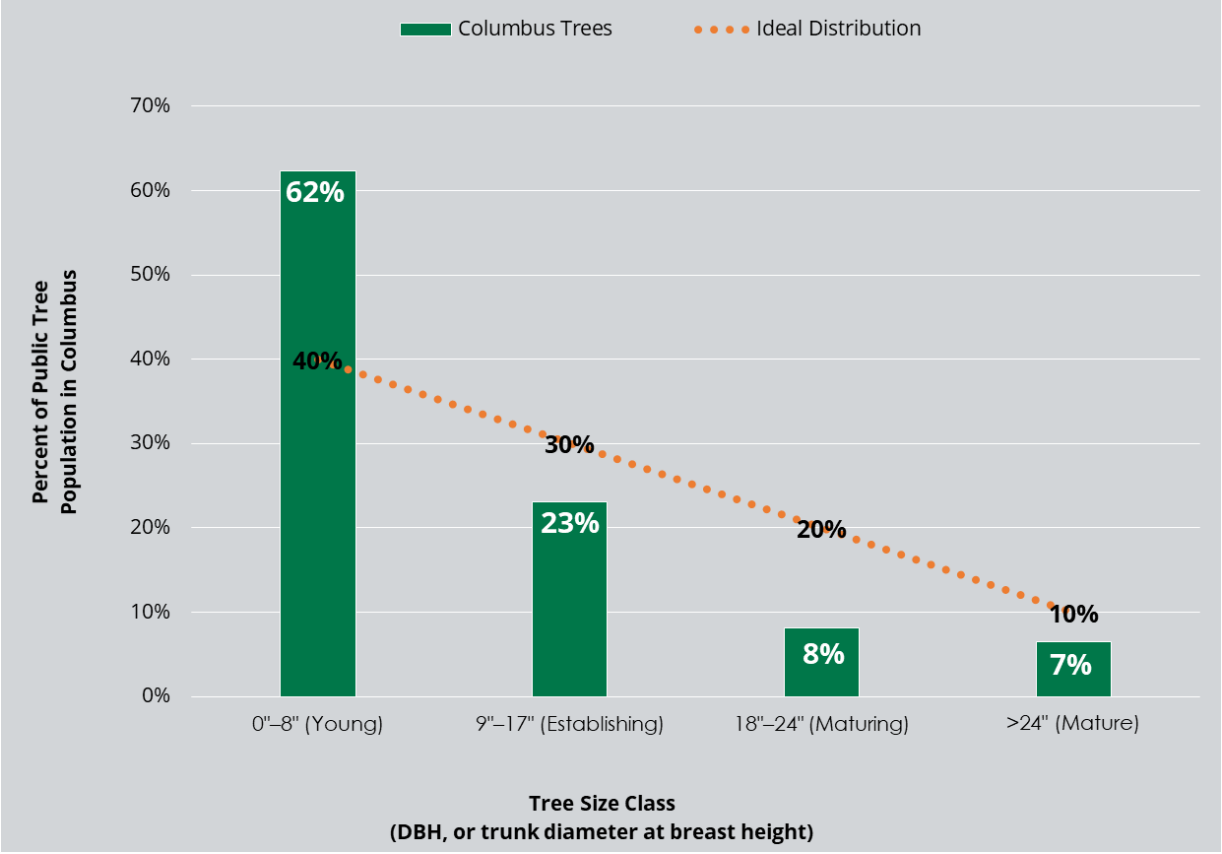


Figure 11. Tree Size Distribution in Columbus Compared to the Industry Recognized Ideal Species Distribution

Tree Condition, Risk and Maintenance Needs

Tree inventory data is out of date and the accuracy of data is unknown.

Columbus' current **tree inventory does not include risk rating** and with less than 10% of the inventory updated over the last 5 years, the **data on condition and maintenance needs is outdated** and may not be accurate. Understanding the condition, risk and maintenance needs of the city's public tree population is important in managing the resource. It is critical for the development of plans, programs and policies to sustainably manage the urban forest to **maximize its benefits and minimize its risk.**

This information is essential to manage and reduce risk, prioritize tree care activities and ensure there are adequate resources, including funding, staff and equipment to sustainably manage and care for the urban forest. It should be collected when the tree inventory is updated.

Species Diversity

No species makes up more than 10% of the City's street & park tree population.

Species diversity is the variety of tree species in the urban forest. **Having more tree species (higher diversity) safeguards the urban forest from pests, diseases and extreme weather events, like ice storms and drought.** Species information in Columbus' tree inventory data is relatively accurate, as that information does not change over time like size or condition.

There are **222 different species and cultivars in Columbus' street and park tree population**. However, they are not evenly distributed across the population. In fact, **14 species represent 55% of population** (Figure 12). To be more resilient to insects, diseases and pests, the City and its partners should evaluate site conditions and existing tree species in the area when planning for new tree planting and select from the 208 tree species and cultivars that are underrepresented in the population.

Species diversity should also be considered at the neighborhood level to ensure that a particular species does not dominate a neighborhood and put the areas canopy cover at risk. The urban tree canopy assessment data provides general information on the location of trees on private property, but tree species are not known. **With the majority of the urban forest in Columbus on private property, having knowledge about the most common tree species can help manage pest and disease outbreaks.** An i-Tree Eco assessment, where trees on both public and private property are assessed can provide that information.

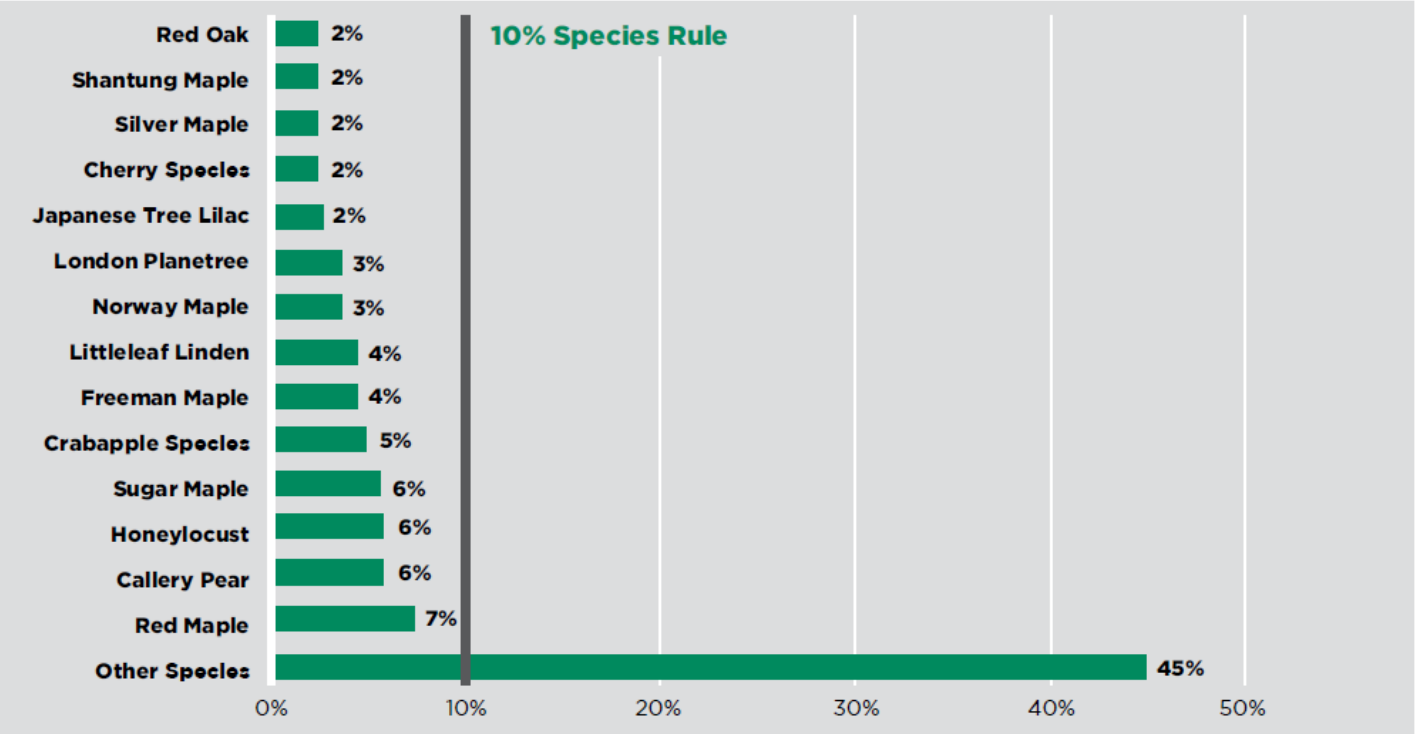


Figure 12. Species Composition of Columbus' Inventoried Trees

Invasive Tree Species

Columbus' inventoried tree population has a variety of native and non-native species. This composition is typical for cities, based on DRGs experience conducting tree inventories for hundreds of US cities, since the harsh urban environment requires species that are tolerant of these conditions. **What cities need to be aware of are non-native tree species that can seed and grow prolifically, impacting native forests**. In Columbus' inventoried tree population, 6% is callery pear (*Pyrus calleryana),* which was recently listed as invasive by the Ohio Department of Agriculture (ODA 2018). Columbus and the Tree Sub-commission should periodically review its tree inventory and approved street tree list against the latest invasive tree species research and information to ensure they are not planting invasive species. Natural areas, parks, vacant lots and yards near plantings of new, unproven, non-native tree species should be monitored to ensure new species do not start sprouting up on their own and become invasive.

Species Vulnerability

Tree Pests and Diseases

Insects and diseases can cause considerable damage and even death to trees, negatively impacting the health, resilience and benefits the urban forest provides to the community. Columbus is all too aware of these impacts, having recently dealt with the emerald ash borer infestation, which killed over 18,000 public ash trees.

Columbus should stay alert to the following pests and diseases that are of most concern to the City's trees (Figure 13). **Proactive tree care and maintenance is critical in detecting pest and disease early and managing outbreaks.**

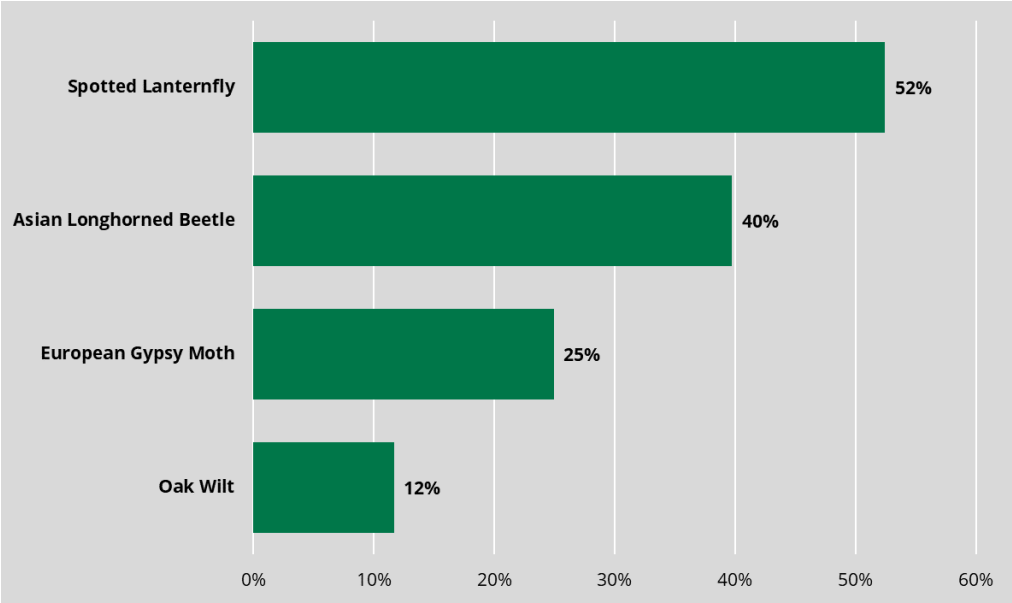


Figure 13. Susceptibility of Columbus' Inventoried Public Trees to Regional Insect & Disease Pests

Asian Longhorned Beetle

At Risk: 40% of Columbus' inventoried tree population

Among the pests of greatest concern for Columbus' urban forest is the Asian longhorned beetle (ALB, *Anoplophora glabripennis*). This invasive insect **feeds, damages and kills many species of hardwood trees,** including maple (Acer), buckeye (Aesculus), birch (Betula), planetree (Platanus), willow (Salix) and elm (Ulmus). The feeding and tunneling damage caused by immature beetles blocks the flow of water and nutrients throughout the tree leading to death. Symptoms of infestations include flagging, or leaf yellowing, branch dieback and weeping wounds.

ALB was discovered in the United States in 1996 and currently present in Ohio. It has been found in Tate Township, East Fork State Park and the East Fork Wildlife Area, but it has been successfully eradicated from several townships including Batavia, Monroe and Stonelick (ODA 2018).

Oak Wilt

At Risk: 12% of Columbus' inventoried tree population

Oak wilt is a vascular disease of oaks (*Quercus*) caused by the fungus *Bretziella fagacerarum*. **It is considered a serious disease in Ohio and has been reported in most of the state's 88 counties** (OSUE, 2019). Oak wilt is spread both overland by a small beetle that carries the oak wilt fungus from infected trees to healthy trees during feeding and underground through interconnected root systems of healthy and infected trees. Trees in the red oak family, including red oak (Quercus rubra), are highly susceptible to this disease and typically die within weeks of infection. In contrast, trees in the white oak family, including swamp white oak (Quercus bicolor), are less susceptible and may survive an infection.

Spotted Lanternfly

At Risk: 52% of Columbus' inventoried tree population

The spotted lanternfly (*Lycorma deilcatula*) is an invasive insect discovered in 2014 that has established populations in Pennsylvania, Delaware, New York and Virginia. **It is a nuisance pest due to its astounding population booms and negative impacts on landscape and agricultural crops.** Spotted lanternfly stresses and weakens a tree by feeding on its sap -- causing significant damage and even death (Penn State Extension, n.d.). It feeds on over 70 different plants and although not present in Ohio, it is a potential threat to many species growing in Columbus including maple (Acer), walnut (Juglans), birch (Betula), willow (Salix) and apple (Malus). Tree of heaven (Ailanthus) is used as a trap tree to monitor pest presence and control populations (Dara et al, 2015)

Gypsy Moth

At Risk: 25% of Columbus' inventoried tree population

The gypsy moth (*Lymantria dispar*) is an invasive insect that has been in the United States for over 150 years. Its caterpillars feed on and defoliate hundreds of species of trees and shrubs, but **oaks** (Quercus), **maples** (Acer), **apples** (Malus) and **cherry** (Prunus) are some of their **preferred hosts** -- species that are widely planted in Columbus.

Currently, gypsy moth is established in 51 counties in Ohio and management efforts are underway in Columbus (ODA, 2019). **During outbreaks, caterpillars chew on leaves in incredible numbers, resulting in defoliation of the entire tree canopy** (Collins, 1996). Their feeding damages and weakens

the tree making it more vulnerable to other pests and diseases and droughts, especially if defoliation occurs several years in a row**. Gypsy moth will not kill a tree the first year, however, repeated heavy feeding can cause trees to die.**

Climate Change

Columbus' urban forest is facing challenges from changes in climate. According to Great Lakes Integrated Sciences + Assessments (GLISA) between 1951 and 2012 in Columbus (GLISA, n.d.):

- Annual average temperature increased by 2.3 degrees F
- Total precipitation increased by 19.8%
- The number of "very heavy precipitation days" increased by nearly 32%

Based on GLISA's future climate projections, **by 2095 Columbus summers could be similar to those in Arkansas today.** These challenges can impact the species of trees growing in Columbus because not all species currently growing in the city will be able to adapt to the changing climate.

The USDA Forest Service has developed the **Climate Change Tree Atlas** (Prasad, et al., n.d.) which uses climate change models to measure the current and future habitat of 134 native tree species in the eastern United States. Table 2 shows species growing in Columbus and their predicted vulnerability to climate change. The City may want to increase the planting of species like, hackberry (*Celtis occidentalis),* river birch (*Betula nigra)* and sycamore (*Platanus occidentalis)* whose habitat is predicted to increase; and reduce the planting of red maple (*Acer rubrum),* northern red oak (*Quercus rubra) and* American basswood (*Tilia americana)* whose habitat is predicted to decrease.

While the Atlas does not currently include all of the tree species growing in Columbus, it provides useful information on impacts that climate change may have on tree species growing in Columbus. It is recommended that the City of Columbus and the Tree Sub-commission reference the Tree Atlas and tree selection resources when revising the city's approved street tree list.

Table 2. Predicted Climate Change Vulnerability of Select Tree Species Found in Columbus
Source: USDA Forest Service Climate Change Tree Atlas

Anticipated Changes to Species in Columbus as Climate Warms			
Habitat Suitability	**Proportion of Public Tree Inventory**	**Common Name**	**Expected Change In Species Importance***
Species whose habitat is expected to improve by 2100 (thus likely to thrive)	6.0%	Honeylocust	79%
	2.2%	Silver Maple	45%
	1.5%	Hackberry	29%
	1.2%	Sweetgum	Begin to Emerge
	0.9%	Pin Oak	45%
	0.9%	Eastern Redbud	54%
	0.5%	River Birch	Begin to Emerge
	0.4%	Sycamore	11%
	0.3%	Eastern Cottonwood	38%
No Change	0.7%	Eastern White Pine	0
Species whose habitat is expected to worsen by 2100 (thus likely to decline)	6.9%	Red Maple	-31%
	5.6%	Sugar Maple	-67%
	2.1%	Northern Red Oak	-25%
	1.6%	American Basswood	-72%
	1.5%	Swamp White Oak	-40%
	0.7%	Black Walnut	-4%
	0.4%	Black Cherry	-73%
	0.4%	White Oak	-25%

*Expected change in importance of species in forested landscapes

Space for Trees

Understanding the location of overhead and underground utilities along with soil conditions **aids species selection and ensures the right tree species is planted in the right location**. The tree inventory lacks data on overhead and underground utilities, as well as soil conditions which can lead to the wrong species being planted or a tree being planted in a location that will cause future conflicts with utilities. This data may be available through other city departments, organizations and agencies. When the tree inventory is updated, the City should look at the feasibility of acquiring or collecting this data.

SECTION IV.
PUBLIC TREE CARE & MANAGEMENT

Trees Managed by the City of Columbus

Public trees growing in the street right-of-way (including tree lawns), in parks and on other City-owned properties are managed by the City of Columbus.

Columbus' Urban Forestry Program

The City of Columbus is **responsible for managing over 127,000 trees growing along public streets and in City parks**. The City Forester and a team of 26 staff in the Forestry Section of the Recreation and Parks Department are responsible for managing this resource, including:

- tree pruning
- tree removal
- tree planting
- managing the city tree nursery
- performing tree inspections in response to resident requests and utility/infrastructure projects
- interdepartmental cooperation, including pruning for public safety
- plan review
- tree grate maintenance
- storm response
- tree data management
- customer service support

The Recreation and Parks Forestry section is solely and legally responsible for managing and maintaining public trees; and they must provide prompt, efficient and safe delivery of arboricultural services to residents. To do this, they must set goals and plan work by balancing the ever-changing needs and conditions of the urban forest with the demands of the residents and do so with limited staff, equipment and funding.

Funding

Budget is not adequate to address all urban forestry needs.

Stable and predictable funding is critical to effectively manage and grow Columbus' urban forest. Columbus' urban forestry program is funded through the Recreation and Parks Operations Extension Fund (General Fund) for street tree maintenance and the Recreation and Parks Capital Improvement budget for street tree planting. From 2011-2020, additional funding was provided to Forestry to address the emerald ash borer (EAB) crisis. **EAB funding source is shown in past forestry expenditures.** However, since its use is limited to ash trees and **will not be available in the future, it is not included in the budget and funding analysis.**

Figure 14 displays Forestry's Operations and Maintenance, Tree Planting and Emerald Ash Borer (EAB) program budgets from 2017-2020. During that time, Forestry's budget has remained relatively stable, however, the amount of work Forestry has to perform did not -- resulting in a 6–12-month backlog of tree removal and pruning work orders.

Benchmarking is an important tool to help a community understand how its urban forestry activities and budget align with other communities. Columbus' urban forestry operation and maintenance and planting budget was benchmarked against other communities in the United States that completed the 2014 Municipal Tree Census survey. **Columbus' per-tree spending was 38% lower than the average of all surveyed cities** and 20% lower than Midwest cities surveyed (Figure 15). The per-tree spending in Columbus is likely even lower since the City's tree inventory data is out-of-date and does not include all of the street trees in Columbus. It should also be noted that 36% of the communities surveyed stated their current budget was inadequate to meet the needs of their urban forestry program and on average were 45% below their identified needs. This information further highlights the degree to which **Columbus' urban forestry program is underfunded**.

Forestry's **limited budget resources have led it to operate a reactive program**. Tree maintenance activities are primarily driven by resident requests, hazards identified by City staff and emergencies. A reactive urban forestry program leads to inefficient service delivery, low customer satisfaction and negatively impacts the overall condition, value and sustainability of the Columbus' urban forest.

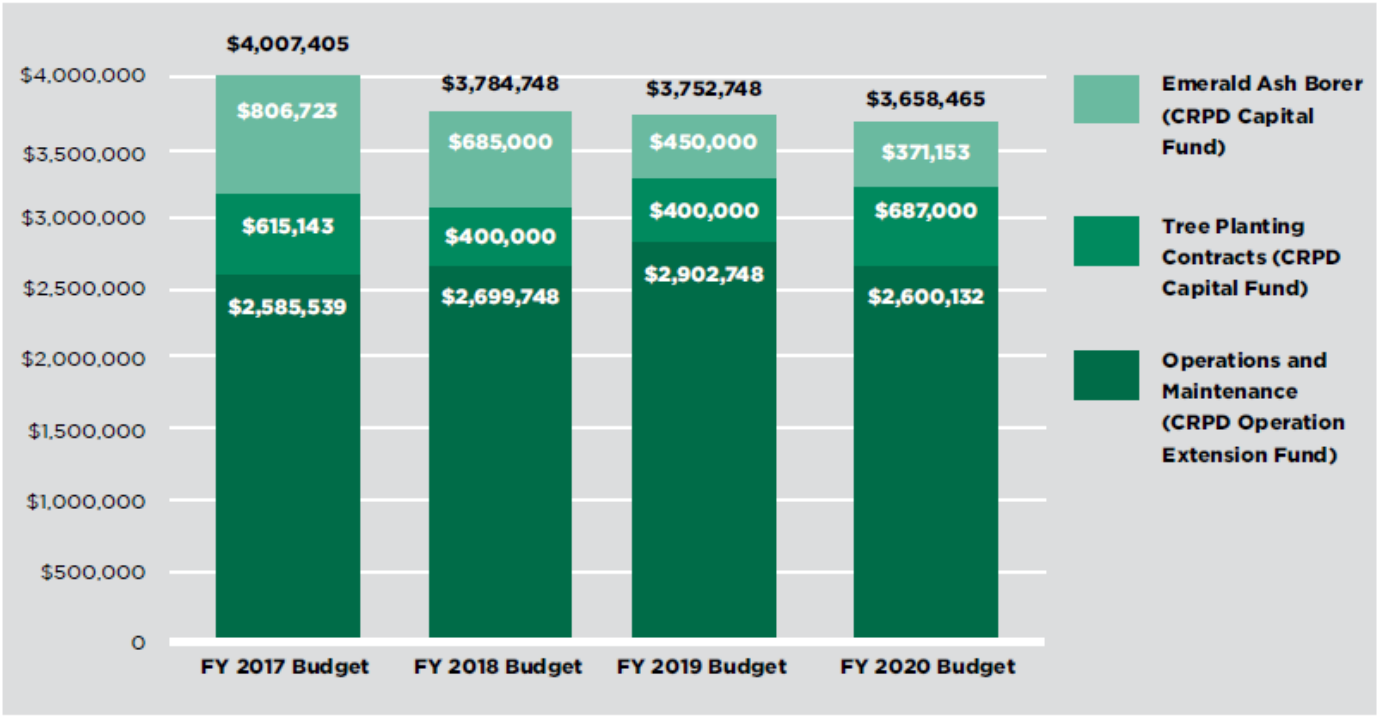


Figure 14. Columbus Forestry Budget 2017-2020

Figure 15. Annual Budget Spent per Street Trees by US Communities (Source: 2014 Municipal Tree Census)

Staff & Equipment

City of Columbus Forestry staff have industry certifications and accreditations; however, there are not enough staff to address all the needs of the City's publicly managed trees.

Caring for the City's trees has a long history in Columbus. As early as the 1940s, the city funded one tree removal and one tree pruning crew according to former City Forester Jack Low. Today, Forestry has a City Forester; 5 Arborists; 4 tree removal and pruning crews; a nursery and tree planting crew; and GIS and office support staff. The full-time Forestry staff are supplemented by 6 limited term/part-time EAB staff.

The 2014 Municipal Forestry Census of Tree Activities (Hauer et al, 2016) found for all cities surveyed, the average number of street trees cared for per Forestry employee was 4,821 (Figure 16). The 14 Tree Trimmers and Supervisors in Columbus care for 7,567 street trees per employee. That is **36% more trees to care for per employee than the national average.** The number of street trees per employee in Columbus is likely even higher since the City's tree inventory data is out-of-date and does not include all of the street trees in Columbus.

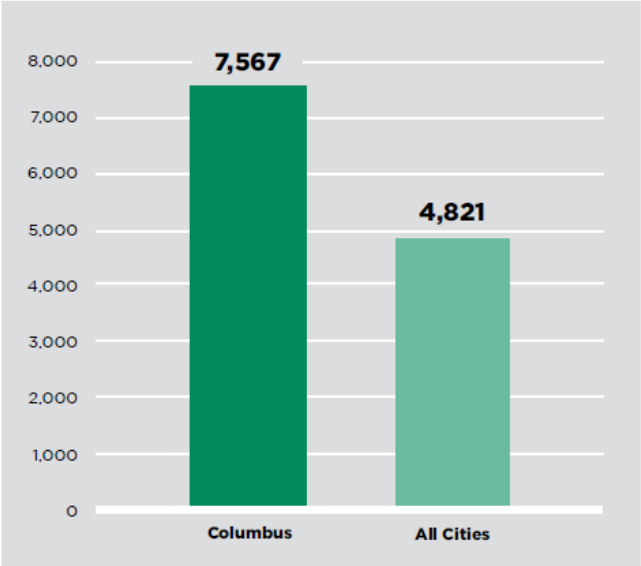


Figure 16. Street Trees Per Employee All Cities and the City of Columbus (Source: Municipal Tree Census)

The Forestry Section has knowledgeable and skilled staff with industry recognized qualifications and certifications, including:

- International Society of Arboriculture (ISA) Certified Arborists (10)
- Tree Risk Assessment Qualified (4)
- ISA Certified Tree Workers (4)

However, there are **not enough staff to address Columbus' public tree care, planning and management program needs.** Current resources only **allow Forestry to be reactive** and even at that, there is a backlog of uninspected service requests and in progress work orders.

The reliance on limited and part-time Emerald Ash Borer (EAB) program staff to assist with tree care, planting and maintenance activities is also a concern. The EAB program is ending and the funding for these positions is uncertain. EAB staff play a critical role in assisting the program and their absence will impact the work Forestry can accomplish. Additional skilled staff, in-house and/or contractors are essential to address current needs and move Forestry to a proactive maintenance program.

Staffing Needs

Operations & Maintenance

Without an updated street tree inventory and an Urban Forest Management Plan, the number of full-time operational staff (or contractors) needed to move to a proactive program cannot be precisely determined. However, if Columbus focused just on **achieving the national average of 4,821 street trees per forestry employee, Forestry would need to add 8 new Tree Trimmer/Tree Trimmer Supervisor positions.** The number of staff needed to achieve this national standard may actually be higher once the street tree inventory is updated and an accurate count of street trees has been determined. Adding additional operations and maintenance staff will also require investments in equipment and tools to outfit the crews to conduct tree care operations.

Forestry operations staff are also involved in **plan review and inspections**. Their volume far exceeds the capacity of the staff, resulting in unreviewed plans and a backlog in inspections. This has reportedly led to tree removals and damage that could have been avoided.

Planning and Management

For Columbus to maintain a sustainable and resilient urban forest, the City must not only focus on daily tree care and management operations but also on planning and coordination. The responsibilities of management positions within Columbus Recreation and Parks Department's Urban Forestry program do not include planning, implementation, policy development, or coordination at a high level. Currently, Forestry managers administer the internal operations to plant and maintain public trees, consuming their full attention and capacity.

With current capacity devoted to managing internal operations, leadership is unable to coordinate with other departments and guide the City's planning process as a whole, from an urban forestry perspective. Creating capacity for citywide planning and coordination is critical to the implementation of the UFMP and future plans.

Columbus Urban Forestry leadership needs a broader role in planning and implementation citywide. Forestry management positions must be available to coordinate with other organizations and City departments in order to successfully implement long-term plans such as the UFMP. Additional managers are needed to perform these assignments while operational administration continues.

City Nursery

The City of Columbus Recreation and Parks Division operates a 45-acre tree nursery in the city. The nursery was established in 1962 on 50 acres adjacent to the City's wastewater treatment plant. In the 1970s the wastewater treatment plant used 5 acres of the nursery for an expansion, which brought it to its present size of 45 acres. When the nursery was established, ground irrigation and a 5-acre pond were installed to irrigate the trees.

The nursery initially started as a ball-and-burlap (B&B) tree nursery but due to poor root ball quality, Forestry switched to growing bare root tree stock which they have been successfully growing since the 1990s. **The Nursery meets the needs of the City's street tree planting program** by providing bare root trees, not available at local commercial nurseries, for Forestry to plant along city streets. **The Nursery provides 2,000 bare root trees per year towards City street tree planting efforts**.

Nursery tree stock is grown from seeds of local native trees that are propagated by Forestry nursery staff and purchased tree whips/liners. The nursery grows over 20 different species.

The City Nursery provides many partnership opportunities between city and volunteer partner organizations including utilizing the nursery to grow trees for community tree giveaways; acting as an outdoor classroom for young tree training education program; and providing volunteer opportunities to learn about nursery operations.

Management Tools

Tree Inventory

A comprehensive, up-to-date GIS-based public tree inventory is the foundation of a municipal urban forestry program. **It provides crucial information on the composition, condition, risk and maintenance needs of a city's publicly managed trees. The public tree inventory is the basis for prioritizing tree care activities and delivering urban forestry services cost effectively.** Data from the tree inventory is critical to:

- Develop sustainable urban forestry plans that maximize trees' benefits and minimize risks to residents.
- Identify work priorities.
- Ensure there are adequate resources (funding, staff and equipment) to sustainably manage and care for the urban forest.

Columbus tree inventory contains data from the **1997 inventory of street trees** (~106,000 trees) and a 2015 inventory of trees in mowed areas of city parks (~22,000) (Figure 15). The tree inventory receives basic updates to reflect trees that have been planted or removed by Forestry. Trees planted by other city departments or outside organizations have not been inventoried, therefore staff estimate the inventory is approximately 80% complete. The inventory does not include trees growing in unmowed areas of parks, natural areas or other city properties.

Urban forestry industry standards recommend that municipal tree inventories are updated on a regular basis, as planting, maintenance and removals occur and re-inventoried **every 10 years**. **Columbus' tree inventory is out of date.**

Canopy Assessment

In 2015, the City of Columbus had an urban tree canopy assessment completed. The assessment used 2013 aerial imagery and found that the city **had 22% tree canopy cover**.

Over the last 7 years, Columbus has experienced significant growth and development, as well as the loss of thousands of ash trees due to the emerald ash borer. This has led to **questions about the accuracy of the 2013 tree canopy data**. Industry standards recommend conducting a canopy assessment every 5-10 years, with more frequent assessments recommended if development activities, insect/disease pests or natural causes could have impacted tree canopy cover.

It is recommended that Columbus conducts a new tree canopy assessment to measure current canopy cover and analyze changes in canopy cover since 2013. The canopy change analysis can identify areas of canopy loss and growth within the city and help identify where tree planting and preservation activities should be targeted.

Plans and Programs

While a lack of resources is a major reason the Columbus forestry program is reactive, an equally important issue is a lack of planning and programming. Forestry has not developed fundamental urban forestry plans or programs. The following plans and programs are currently not in place in Columbus:

- **Urban Forest Management Plan: A three to five year work plan for the city's publicly managed tree** population based on updated data from the city's tree inventory. It provides an assessment of the current city-managed tree population based on inventory data, identifies risk and maintenance needs, the resources needed to address them and a schedule to complete.

- **Risk Management Program:** A risk management program focuses on ensuring the urban forest is proactively managed to **eliminate hazards and risk with a focus on public safety**. This program is outlined in an urban forest management plan.

- **Disaster Management:** A disaster preparedness and response plan **addresses and responds to disasters in the community**. The plan includes staff, roles, contracts, response priorities, debris management and communication plan.

- **Street Tree Planting Plan:** Outlines the locations of tree planting for a one to five year time horizon. The plan uses data from the tree inventory and urban tree canopy assessment to target planting in areas of greatest need within the community. The City should develop a tree planting plan for 2021 utilizing data from the priority planting analysis to determine areas of highest need for tree planting.

Developing plans and programs to manage the city's urban forest helps to identify and communicate program needs (see Emerald Ash Borer Strategic Plan sidebar). An Urban Forest Management Plan can fold in many of the other plans and programs that Columbus is missing (Risk Management, Public Tree Maintenance, Disaster Preparedness) to develop a comprehensive plan. **An updated tree inventory is a key component in developing an Urban Forest Management Plan. However, an outdated inventory should not stop Columbus from beginning to plan.**

Emerald Ash Borer Strategic Plan

In 2011, Columbus Recreation and Parks Forestry section developed the Emerald Ash Borer (EAB) Strategic Plan to address the EAB crisis in the city. The plan identified City Forestry staff re-alignments needed to address the EAB infestation; reduction in services caused by re-alignment; equipment needs and costs; temporary staffing needs; contracting staff needs; and a budget. The plan was supported by City leadership, leading to:

- An additional $9 million allocated to implement the plan from 2011-2019
- Over 18,000 ash trees and stumps removed
- Full implementation of the strategy in 2019, 2 years earlier than planned.

Public Tree Maintenance

Columbus' current public tree maintenance program can best be described as **reactionary** with tree care and management activities completed based on resident requests, storm damage and emergencies. A reactive urban forestry program leads to inefficient service delivery, low customer satisfaction and negatively impacts the overall condition, value and sustainability of the trees in Columbus.

Columbus utilizes a 311 system to manage requests, including tree maintenance requests from Columbus residents. Between 2015 and 2019. Forestry received an average of **4,800 service requests per year**, which are investigated by the City's arborists. **Street Tree Maintenance was the top service request** type received, which includes requests for tree pruning and tree removal. The majority of tree-related service requests are received between April and October.

Figure 17 shows the work activities completed by City of Columbus Forestry crews between 2015-2019. **Pruning was the top activity,** followed by tree planting and tree removal. City Forestry Contractors also performed tree work for Forestry, primarily tree planting; those numbers are not reflected in Figure 17.

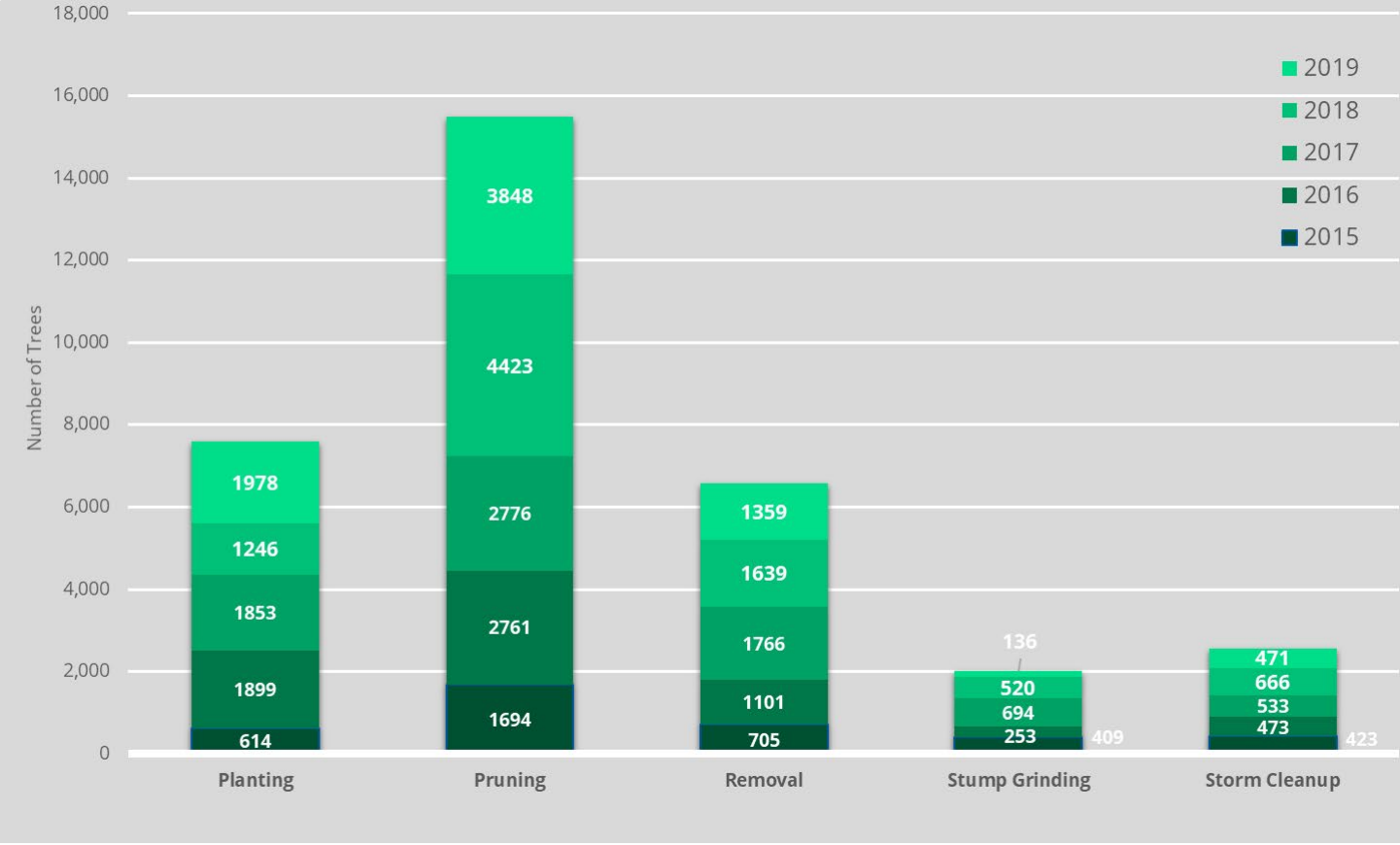


Figure 17. Work Activities Completed by City of Columbus Forestry Crews 2015-2019

Tree Pruning Cycle

Critical for the health of Columbus' street trees.

A routine pruning cycle is not currently in place in Columbus, except for newly planted trees that are pruned three years after planting. For this proactive activity to have the most impact, young trees should continue to be pruned every three years until they have been in the ground for nine years and then can be added to the City's routine pruning cycle, once established.

Routine tree pruning is important to sustainably manage Columbus' urban forest. Trees pruned regularly develop proper form and are healthier, leading to:

- Lower Pruning Costs: Lower per tree pruning costs compared to reactive pruning done in response to storm damage, sight clearance, or immediate hazards
- Frequent inspections: Early identification and correction of insect/disease problems
- Less Damage: Reduction in storm-related tree damage
- Lower future maintenance costs
- Satisfied Residents: Reduction of tree-related service requests and improved customer service
- Development of a healthy and sustainable urban and community forest (Stutz et al, 2004).

All infrastructure requires routine maintenance. Trees require routine maintenance in the form of tree pruning just like roads require occasional resurfacing to maintain optimal condition. For Columbus to initiate a routine pruning cycle will require planning, additional staff and resources. A routine pruning cycle plan, based on geographic management areas, should be developed as part of an urban forest management plan. The plans should consider the species, condition and maintenance needs of each area (see Routine Pruning Cycle Scenarios).

Tree Removal and Tree Planting

From 2015-2019, Forestry planted over 15,200 trees--nearly twice as many trees as were removed -- representing a net gain. **Volunteers also contributed to this gain by planting nearly 11,000 trees and seedlings in City parks and other city properties** (Figure 18). Forestry should continue planting efforts, using the new priority planting analysis, while not losing sight of the maintenance needs required to maintain the nearly 3,100 new trees planted on average per year. As the routine pruning cycle shows, costs increase as new trees are added. Careful planning should ensure that planting continues to outpace removals, while considering future maintenance costs.

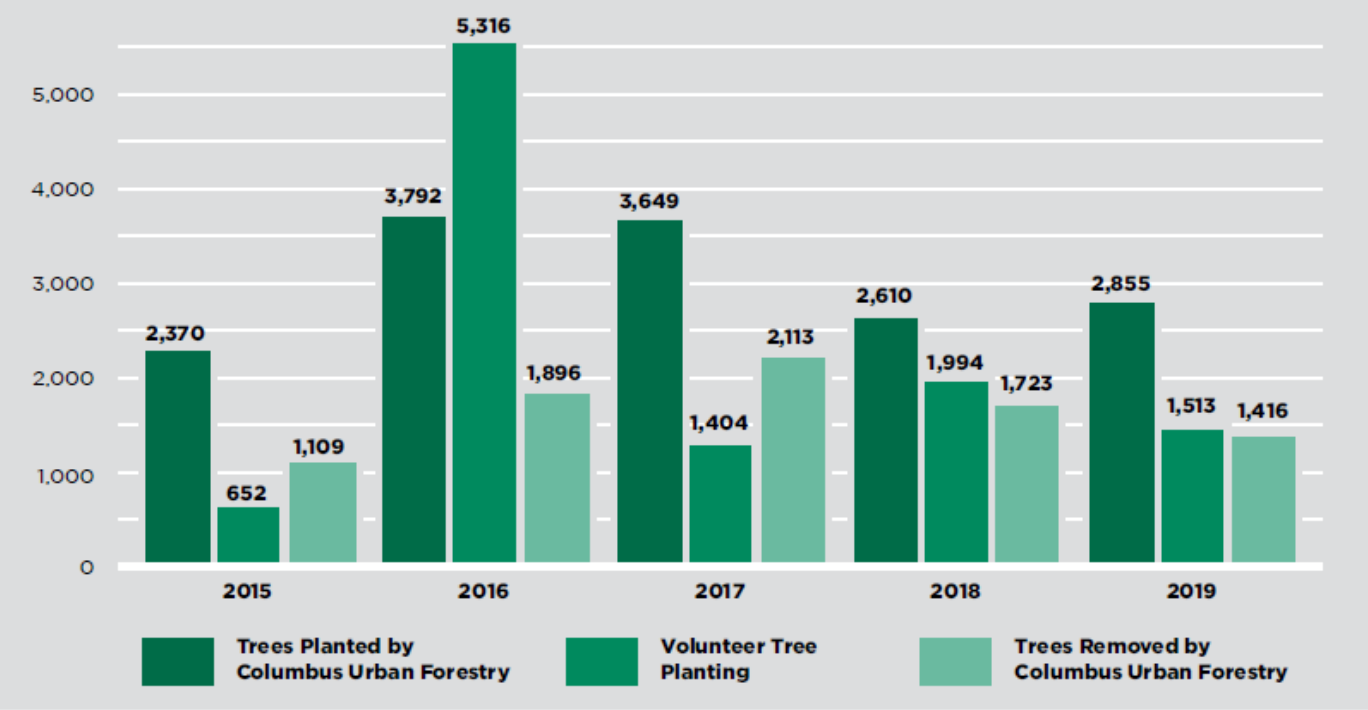


Figure 18. Columbus Tree Planting by City of Columbus Forestry staff, Contractors and Volunteers and Tree Removals completed by Forestry 2015-2019

City Ordinances & Policies

City policies and regulations provide the foundation for the urban forestry program outlining requirements and specifications for the planting and care of Columbus' public trees. They also provide the regulatory framework for the protection and preservation of the urban forest assets as well as the enforcement of activities and issues that impact the community's trees.

The most significant finding of Columbus' ordinance and policy review is that **Columbus does not have adequate tree protection and preservation regulations on private property.** A review of ordinances in two neighboring Ohio communities, Gahanna and Dublin and a peer city of Columbus, Charlotte, North Carolina highlights the deficiencies in the ordinance (Table 3). With over 70% of the city's land area and urban forest, privately owned, tree protection, preservation and planting on private land will have the most widespread impact.

City ordinances should be revised to include private property tree regulations that reflect the values and needs of the urban forest and the Columbus community. **Appendix B** provides the results of the ordinance review and includes a Priority Level to assist Columbus in prioritizing ordinance revisions.

Table 3. Comparison of Tree Protection and Preservation Ordinance by Community

	Columbus, OH	Gahanna, OH	Dublin, OH	Charlotte, NC
Land Use Regulated				
Single/two-family Residential		●	●	●
Multi-family Residential	X	●	●	●
Commercial/industrial		●	●	●
Public Land	●	●	●	●
Public Tree Damage and Removal				
Restricts tree removal on public property	●	●	●	●
City permit or approval required for tree removal, pruning or excavating	●	●	●	●
Prohibits damage to public trees (e.g. ropes, signs, wires, and excavation)	●	●	●	●
Private Tree Damage and Removal				
Restricts tree removal on public property		●	●	●
City permit or approval required for tree removal on private property		●	●	●
Requires preservation of trees during development on private property		●	●	●
Prohibits damage to preserved/protected trees		●	●	●
Regulated Features on Private Property				
Forests/wetlands		●	●	●
Specific species and/or size tree (e.g., heritage/significant trees)	X	●	●	●
Tree critical root zone/dripline			●	●
Amount of canopy cover (minumum amount set)				●
Riparian buffers, natural areas, preservation zones		●		●
Tree Protection Measures				
Tree protection/preservation preservation plan required		●	●	●
Identification of prohibited activities in dripline/critical root zone		●	●	●
Tree protection fencing or other protection measures required		●	●	●
Credits/incentives for tree preservation		●		●
Site Plan/Development Requirements				
Inventory and location of trees/forests/woodlands on site		●	●	●
Tree protection/preservation plan		●	●	●
Tree protection measures (e.g., fencing, soil protection, trunk protection)		●	●	●
Landscape plan with mitigation plantings		●	●	●
Grading and utility plans with trees		●	●	●
Mitigation/Penalties				
Tree planting requirements for removal of regulated trees	●	●	●	●
Fee in lieu of planting mitigation trees	●		●	●
Tree planting establishment, maintenance and survival requirements		●	●	
Penalties established for damage and removal of preserved/saved trees		●	●	●
Tree fund	●	●		●

Note: 'X' Only applies to University District zoning overlay.

Executive Order 2015-01 Tree Protection and Mitigation Policy

Adopted in 2015, the policy establishes tree protection and mitigation requirements for City of Columbus capital improvement projects (CIP). While the policy is an important first step in protecting public trees, after 5 years in use there are areas that require strengthening and clarifying. The following changes are recommended:

- examine how the Executive Order can be incorporated into City Code to strengthen it and expand its application beyond City of Columbus projects
- expand activities the Order covers to include routine maintenance activities conducted by City departments.
- require a tree protection plan for all projects
- increase mitigation planting requirements from a tree-for-tree replacement to diameter of inches removed.
- simplify tree replacement fee calculation.
- Establish process and procedures for Recreation and Parks (Forestry) to collect and track mitigation fees and monitor installed mitigation trees.

City Plans and Program

Across the City, divisions and departments are actively working to improve and enhance the services provided to the Columbus community. To enhance these services, plans, studies and strategies are developed and implemented. Trees are important for improving the quality of life in Columbus - the following plans and programs can be strengthened to support the UFMP and grow the urban forest.

Downtown Streetscape Standards Manual (2015)

The manual can be strengthened to support the UFMP and increase canopy cover in the downtown district. For instance, adding street trees as an element in parking lot screening; incorporating trees in median landscapes; increasing the diversity of street trees that can be planted in the downtown district (currently 15 species are approved and monocultures by block are recommended); and encouraging tree planting to improve the pedestrian experience.

The Columbus Green Community Plan - Green Memo III (2015)

If the Green Memo is revised, the goals, objectives and action steps should be revised to reflect those in the UFMP to support its implementation and the goals of increasing and improving tree canopy in Columbus.

Sustaining Scioto - Investing Today, Preserving Tomorrow (2015)

The climate change adaptation strategies recommend decreasing the amount of hardscape and encouraging green infrastructure. However, they do not explicitly consider street trees as an adaptive strategy for stormwater management. Street trees should be considered as stormwater management strategy.

Columbus Climate Adaptation Plan (2018)

The Columbus Climate Adaptation Plan (CCAP) was developed by the Byrd Polar Climate Research Center at the Ohio State University in collaboration with the City of Columbus and the Mid-Ohio Regional Planning Commission. The CCAP details Columbus' climate vulnerabilities and provides climate adaptation strategies to enhance the community's preparedness and resilience.

The plan recognizes trees as a strategy to mitigate the effects of climate change. However, there are sections of the plan where trees can play an important role in improving the impacts of climate change. For instance, trees can improve air quality and reduce energy demand during summer months; trees can reduce flooding by capturing and slowing down stormwater runoff; and planting trees along sidewalks and bike paths to improve pedestrian/cyclists experience and ultimately encourage their use. The UFMP should be used as a resource when updating the CCAP to identify additional ways that trees can be used to mitigate the effects of climate change.

Sustainable Columbus

Sustainable Columbus is an initiative of the City of Columbus to encourage sustainability and policies that help improve the environment and preserve the city's natural resources. The initiative includes a variety of programs, including:

- **GreenSpot**
- **Smart Columbus**
- **Columbus Blueprint**

The urban forest should be added as a program of Sustainable Columbus (see Action Item 3.5); and as the UFMP actions are implemented, they should be promoted within the Sustainable Columbus platform and programs.

Neighborhood Pride & Celebrate One

Neighborhood Pride is a partnership initiative between the City of Columbus, neighborhoods, residents, businesses, schools and organizations to beautify neighborhoods and improve safety.

Celebrate One is a city-led initiative to reduce the infant mortality rate in Columbus. The program began in 2014 and has seen a reduction in infant mortality in Columbus. The program provides a variety of initiatives to improve the health of mothers and children before, during and after pregnancy.

The Priority Tree Planting analysis, conducted as part of the development of the UFMP, can be coupled with data and information from these programs to identify areas where increases in tree canopy cover can help meet program goals and objectives.

Communication

Improvements to communication and collaboration are needed to grow trust and better understand the needs of the community. For example, the City has tracked resident refusals of street tree planting since 1998. The results (Figure 19) identify that some neighborhoods refuse new street trees more than others. Understanding what leads residents to refuse street trees and addressing those issues can help build trust and support for Columbus' trees, their management and help grow Columbus' tree canopy.

Communication between residents and City staff is limited to responses to service requests and notifications in advance of tree planting. Residents are not notified when requested tree work will be scheduled and must utilize 311 to follow-up on tree maintenance scheduling. This lack of communication leads to low customer satisfaction and frustration as citizens are required to contact 311 for status updates and keep track of their 311 reference numbers (which they rarely do).

The current program also lacks a formal process to coordinate with other city departments and outside entities (ex: utility companies, non-profit organizations, developers) whose activities have an impact on the street tree resource. While these impacts may be positive or negative, **a lack of coordination, collaboration and communication, has led to other city assets (e.g., public utilities, streets, sidewalks) being prioritized over and at times, at the expense of, trees.** It is important that Forestry has a seat at the table when City projects are being designed and implemented, to ensure trees are adequately preserved, protected and mitigated when removals are necessary.

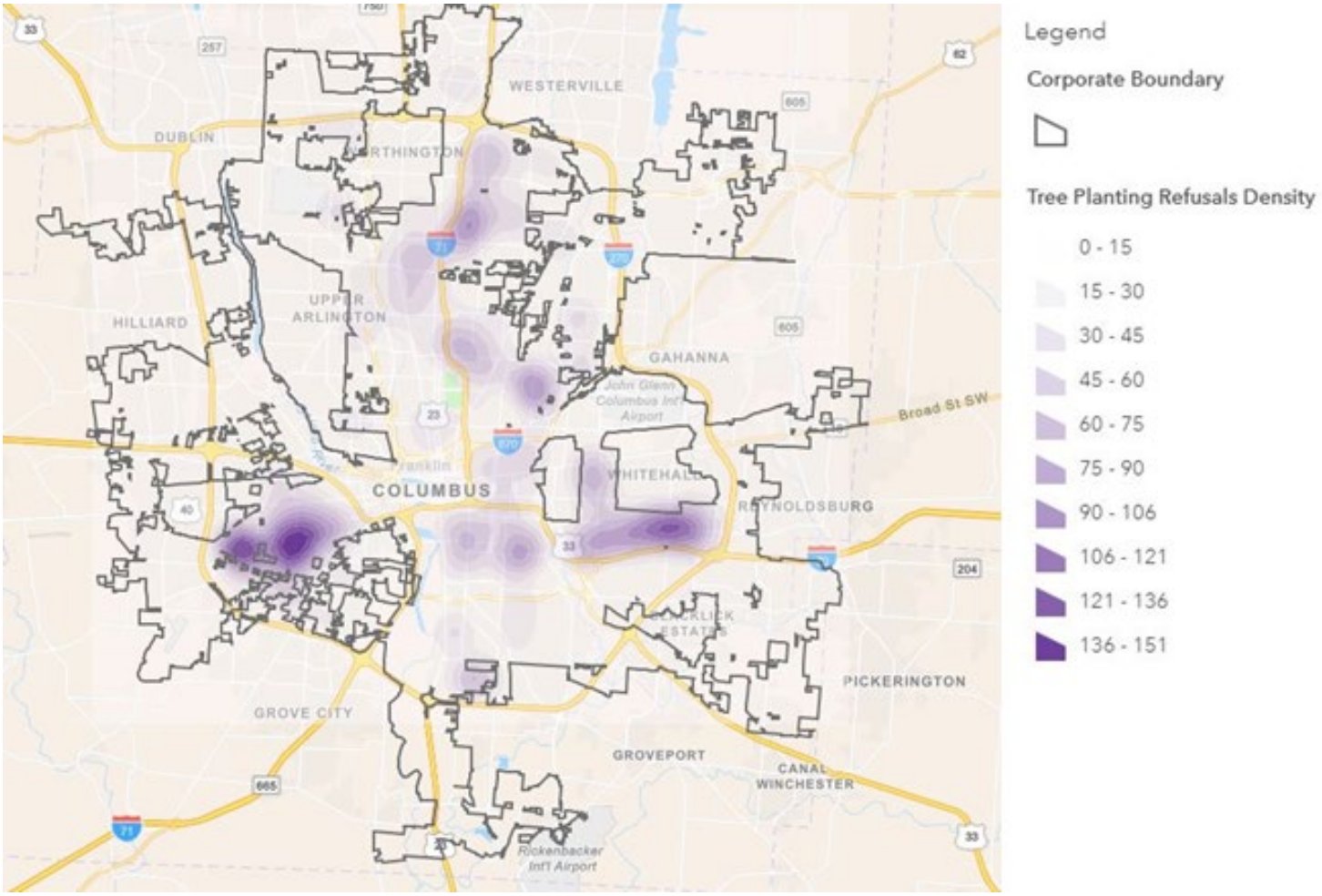


Figure 19. Street Tree Planting Refusals 1999-2019

SECTION V.
ENGAGEMENT & OUTREACH

An assessment of an urban forest must go beyond the data on the trees themselves and examine the human element (The Players). While the City is leading this project, the urban tree canopy assessment revealed that 70% of the tree canopy in Columbus is privately owned, so **true progress will only come from a fully engaged community.**

The level of engagement in a community can be assessed by looking at nine groups:

- Neighborhoods
- Large Landowners
- Green Industry
- City Departments / Other Agencies
- Funders
- Utilities
- Developers
- General Public
- Regional Partners

During the UFMP process, an Advisory Group was created, made up of representatives from neighborhoods, nonprofits, academia, private sector businesses, area commissions from across the city and multiple city and county departments. The Advisory Group assessed the level of engagement for each group, as well as identified ways to improve engagement.

One of the unifying elements around engagement was a **lack of a central or unified goal in urban forestry for all to work towards**. Significant improvements in the level of engagement across all nine groups can be made through development of well-defined, unified goals. The UFMP will provide the roadmap and set goals and targets for the community to work towards. The key will be promoting and communicating them and clearly identifying the actions each group can take to help achieve them.

Prioritization of trees and strong leadership is needed. This can be achieved through allocation of additional resources for the care, planting and management of trees, more effective tree protection regulations and high-level engagement from across the community -- from the Mayor and City Council to industry leaders to non-profit organizations and community members.

The Players

Neighborhoods

Neighborhood action focuses on the level of engagement, participation and cooperation around urban forestry and trees at the neighborhood level in Columbus. The Advisory Group assessed the city as LOW for the following reasons:

- Lack of a coordinated education and outreach program about trees and the urban forest.
- Levels of engagement and participation vary by neighborhood.
- Conflicting city policies and lack of information about the urban forest.
- No central city tree goal or priorities for neighborhoods to work towards.
- Other priorities may be higher for a neighborhood or its residents.

Ways to improve neighborhood level participation in improving tree canopy cover in Columbus included providing more space for trees to grow; offering resources and expertise on trees and tree planting; developing educational materials; engaging with schools and youth; and utilizing and improve networks, including the Area Commission network.

Large Landowners

Large landowners in the city represent public entities, private companies, schools, universities, transportation, health care and golf courses. There are 27 different landowners (excluding the City of Columbus) that own at least 200 acres within the city. Their lands make up **15% of the total city land** area, and the activities they do on their properties can positively or negatively impact canopy cover. The LOW assessment was based on the following:

- variability in sites,
- different priorities; lack of interest in trees,
- minimal regulations/incentives to preserve and protect trees,
- no central city tree goal or priorities for landowners to work towards.

Increased regulations; improved education; increased resources and tools for large landowners; and targeted engagement were all ideas suggested by the Advisory Group to improve large landowner involvement in Columbus' urban forest.

Green Industry Involvement

The green industry is considered organizations and companies that are engaged in growing, installing and caring for trees and plants, including nurseries and tree care and landscaping companies. This Indicator was assessed as MODERATE with Advisory Group members. There is some engagement by private companies on initiatives, however, there is not a central goal for these groups to help work towards.

Ways engagement with the green industry can be improved, include:

- Better regulations and incentives around landscaping and tree planting.
- Identifying key green industry players.

- Holding green industry led community workshops to promote active engagement by the green industry and to develop advocates for the urban forest.
- Developing a central goal/vision for the urban forest that all Players can work towards.

City Department and Agency Cooperation

The City of Columbus is a large city with over 8,000 employees and 16 departments. It geographically falls within three counties: Franklin, Delaware and Fairfield. The City was assessed as LOW for this Indicator in part because of the size and number of departments, organizations and agencies that need to be engaged. Other reasons for the assessment included:

- Lack of resources to adequately coordinate and collaborate.
- Lack of communication between City departments.
- Conflicting and competing priorities among City departments and outside agencies.

Securing the engagement of City leadership in urban forestry initiatives; improving coordination efforts by developing inter-departmental working groups; and improving policy and regulations were suggested to improve coordination, communication and cooperation among different city departments and outside agencies.

Funder Engagement

Columbus' urban forestry program is funded through two funds: the Recreation and Parks Operations Extension Fund (General Fund) for street tree maintenance and the Recreation and Parks Capital Improvement budget for street tree planting. There is no engagement or investment in urban forestry initiatives by local funders outside of the City, leading to the LOW assessment.
One of the major reasons expressed for the low level of engagement by local funders is the lack of a strategic plan, central vision and priorities. The UFMP will provide this roadmap and strategy that can be shared with local funders and aid in securing additional resources.

Utility Engagement

The right-of-way is limited in size which can create conflicts between trees and utilities (overhead and underground). This Indicator was as LOW due to:

- Conflicting priorities, such as providing safe and reliable utilities vs. having adequate space for trees.
- Lack of coordination and communication.
- Trees are not seen as an asset and are readily removed when utility conflicts arise.

Building relationships; establishing better policies and regulations to prevent damage/loss of public trees; improving communication; and developing formalized processes to coordinate were all recommended actions that Advisory Group members suggested for improving coordination.

Developer Engagement

The Advisory Group assessed the city LOW on developer engagement. The consensus was that the development community was not actively engaged in supporting and advancing urban forest goals and objectives because:

- Differing priorities that set other site elements above trees.

- No clear city goals and priorities around trees.
- Poor existing City code that does not require tree protection or preservation.

Developer engagement is critical to improving tree canopy cover and the urban forest in Columbus. Developing and sharing city tree goals; improving regulations; creating incentives for tree preservation and planting; and developing better land use plans can all help to improve developer engagement.

Public Awareness

Awareness by the general public about the benefits of trees and their role in improving and caring for the urban forest was assessed as LOW. Advisory Group members state the following as the reasons for the low assessment:

- Perception that trees are a nuisance. While residents may recognize the benefits of trees, issues such as maintenance, tree roots lifting sidewalks or getting into pipes overshadow the benefits.
- Lack of awareness, knowledge and resources about the benefits of trees and how to plant and care for them.
- Different neighborhoods require different levels of engagement and messaging to meet the needs of their residents.
- Other priorities may be higher than trees, including providing for basic needs.

Better outreach campaigns with targeted messaging that addresses concerns; and providing technical assistance/knowledge on species selection to improve specific concerns, i.e., tree species and location to plant to reduce air conditioning costs can help improve public awareness and engagement.

Regional Collaboration

Assessed as MODERATE, the Advisory Group found that regional cooperation around urban forestry issues exist. There are existing partnerships at the regional level and among neighboring communities that share a similar vision to improve the Columbus region's tree canopy cover.

Incorporating tree canopy and urban forests into the Regional Sustainability Agenda can help elevate the urban forest in the region; sharing the UFMP with other communities and the county can help develop regional goals to improve and grow the urban forest; and seeking opportunities for partnerships around urban forestry initiatives can improve regional collaboration.

Section VI.
Indicators of a Sustainable Urban Forest

The *Indicators of a Sustainable Urban Fores*t, a comprehensive resource and program assessment tool, was the basis for determining the current state of Columbus' urban forest (Clark et al., 1997; (Kenney et al., 2011). This assessment tool helps to look beyond just tree data and analysis (The Trees component) to also understand how the urban forest is managed (The Management component) and the network of stakeholders that influence and impact it (The Players component). For each component, there is a set of Indicators and metrics for assessing a city's current performance level and determining the sustainability of their urban forest. Columbus' assessment was determined based on data, information and input from the City of Columbus and the UFMP Advisory Group.

The Trees: LOW
The Management: LOW-MODERATE
The Players: LOW

Figure 20 displays the assessment of all 32 Indicators and Figures 21, 22 and 23 show Columbus' current performance level for each of the Indicators -- providing a snapshot of the state of the urban forest. The results of the assessment identified areas where Columbus' urban forestry program can be improved and were used to develop the UFMP Action Steps.

32 Indicators of a Sustainable Urban Forest

COLUMBUS, OHIO		Assessed Performance Level		
		Low	Moderate	Good
The Trees	Tree Canopy Cover	●		
	Equitable Distribution	●		
	Age Distribution	●		
	Condition of Publicly-Owned Trees	●		
	Condition of Publicly-Owned Natural Areas	●		
	Trees on Private Property		●	
	Diversity / Pest Vulnerability		●	
	Suitability - Overhead	●		
	Suitability - Ground Level	●		
	Suitability - Soil Conditions	●		
	Suitability - Invasives		●	
	Suitability - Climate Change Adaptiblity		●	
The Management	Tree Inventory		●	
	Canopy Assessment		●	
	Plans and Programs: Management Plan	●		
	Plans and Programs: Risk Management	●		
	Plans and Programs: Planting		●	
	Plans and Programs: Disaster Management	●		
	Maintenance of Publicly-Owned Trees (Right-of-way)	●		
	City Staffing and Equipment		●	
	Funding	●		
	Tree Protection Policy	●		
	Communication		●	
The Players	Neighborhood Action		●	
	Large Landholder Involvement	●		
	Green Industry Involvement		●	
	City Department/Agency Coordination	●		
	Funder Engagement	●		
	Utility Engagement	●		
	Developer Engagement	●		
	Public Awareness	●		
	Regional Collaboration		●	
	Totals	20	12	0
		63%	37%	0%

Figure 20. Columbus Assessment on the 32 Indicators of a Sustainable Urban Forest

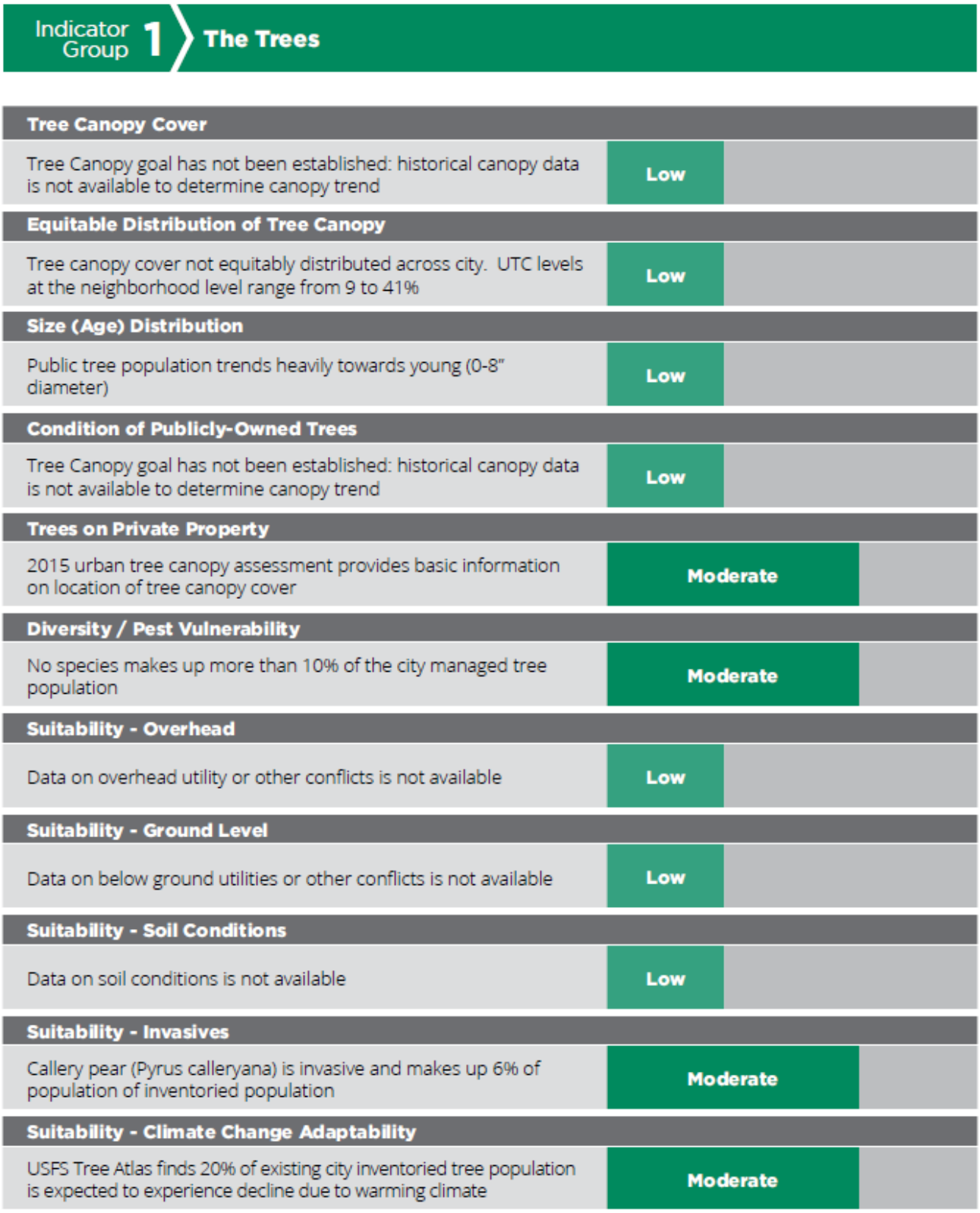


Figure 21. The Trees Indicators

Indicator Group 2 The Management

Tree Inventory	
GIS-based street & park tree inventory completed in 1996; data is outdated and incomplete	**Moderate**
Canopy Assessment	
Urban tree canopy assessment completed in 2015 using 2013 aerial imagery. Assessment becoming outdated	**Moderate**
Plans & Programs: Management Plan	
A comprehensive urban forest management plan has not been developed	**Low**
Plans & Programs: Risk Management	
Tree inventory data lacks risk rating: maintenance activities are not based on risk	**Low**
Plans & Programs: Planting	
Tree planting and establishment program consistently funded	**Moderate**
Plans & Programs: Disaster Management	
Disaster management plan has not been developed	**Low**
Maintenace of Publicly-Owned Trees	
Request based, reactive system; a systemic maintenance program not in place	**Low**
City Staffing and Equipment	
Staff with industry certifications and accrediations; not sufficient number of staff to address all the needs of the urban forest	**Moderate**
Funding	
City urban forestry activities funded solely by the City. Budget is not adequate to address all urban forestry needs	**Low**
Tree Protection Policy	
Tree protection and preservation not required in City Code	**Low**
Communication	
Avenues for communication in place but used sporadically and without coordination or only on a one-way basis	**Moderate**

Figure 22. The Management Indicators

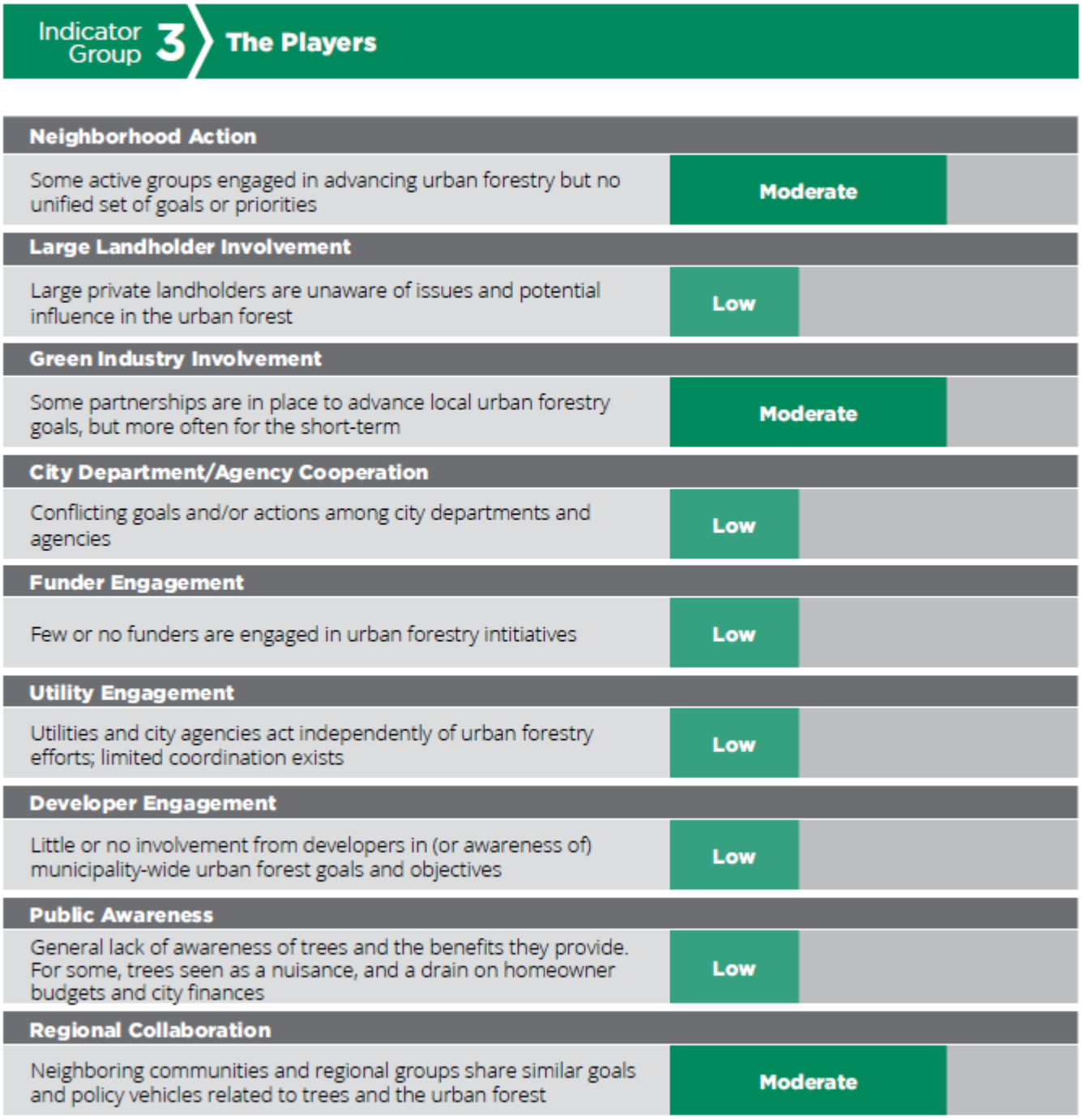


Figure 23. The Players Indicators

Section VII.

Appendices

APPENDIX A. METHODOLOGIES

TREE BENEFITS

To determine the environmental benefits that the urban forest provides to Columbus, i-Tree Canopy and i-Tree Hydro analyses were conducted utilizing the city's 2013 urban tree canopy data. i-Tree is a suite of tools developed by the USDA Forest Service that quantifies the benefits and services trees provide to a community. i-Tree Canopy analyzes tree canopy data to measure the benefits that trees provide; while i-Tree Hydro utilizes land cover data to model the effects that changes in tree canopy and impervious surface (e.g., roads, buildings, etc.) have on local hydrology.

CALCULATING PRIVATE PROPERTY TREE CANOPY

This report and the Columbus Urban Forest Master Plan identified that 70% of the tree canopy in Columbus is privately owned. This was based on data from the 2015 Columbus Urban Tree Canopy Assessment (Plan-It Geo) and was calculated as follows:

Public Parcels = 5,876 acres of tree canopy.

Public Right-of-Way = 3,389 acres of tree canopy.

Total Public Tree Canopy = 9,265 acres

Private land defined by parcels not having the selected exempt land use codes - as defined in Public and Private Exempt Parcels below.

Total Private Tree Canopy: 21,894 acres

Total Public and Private Tree Canopy = 31,159 acres.

21,894 private tree canopy acres / 31,159 total canopy acres = **70% private tree canopy**

Public and Private Exempt Parcels

Using the 2015 UTC GIS parcel layer, parcels were queried by land use code and those with exempt status were identified. **Public exempt parcels** were those owned by:

- State of Ohio
- City of Columbus
- other governmental bodies
- colleges

Private exempt parcels were those owned by:

- churches
- cemeteries
- housing authority

Columbus Communities' Population Analysis and Range in Tree Canopy Cover

A population density analysis was conducted on the 41 Columbus Communities boundaries. The 2019 population was apportioned by block groups to the communities, and then populations were calculated by square mile. Six communities had population density one or more standard deviation less than the mean population density:

1. Airport
2. Dublin Road Corridor
3. Fort Hayes
4. Harmon Road Corridor
5. State of Ohio
6. Wolfe Park

These "communities" are land used for largely non-residential purposes, such as the John Glenn International Airport, industrial corridors, educational land, state land and City of Columbus Wolfe Park. While canopy coverage varies 7 to 49% when including all community boundaries in Columbus, for the purposes of this master plan we focused on the 35 communities with more normal population densities. Those communities, which we refer to as neighborhoods for clarity, varied 9 to 41% in tree canopy cover.

PRIORITY PLANTING ASSESSMENT

Summary

This project was conducted to assess priority planting locations for the City of Columbus. Data sources were sought across the board to analyze a variety of factors that can contribute to accessing tree canopy needs. Analysis included data sets from the City of Columbus, US Department of Agriculture, US Census Bureau and the Center for Disease Control (CDC). The resulting analysis found plantable areas in both public and private properties across the city.

Description

To help the City of Columbus increase its canopy coverage, an urban tree canopy assessment conducted by the city to assess land cover using 2013 aerial imagery. The study was completed in 2015. These data were used to find suitable planting locations within public rights-of-way (ROW) as well as private property. Further analysis to identify the most suitable locations was also conducted by analyzing each planting location to assign a priority ranking for stormwater, urban heat island, social equity and a composite overall ranking.

Each data source utilized the most current version available and described in the subsequent sections. US census data was taken from the 5-year American Community Survey (ACS) estimates ranging from 2014-2018. Imagery was provided by the City of Columbus as well as the landcover data. Crime data was provided by the Columbus Police Department and ranged from 2015-2019. Heat islands were derived from averaging Landsat 8 surface temperature data from September 16, 2016 and June 21, 2019 data to find hotspots at varying points in time to locate areas of potential heat mitigation. Finally, public health data was gathered from the 2019 Center for Disease Control (CDC) 500 Cities project. Sources for the data have been included in their individual breakdowns.

Methodology

In order to create a priority planting plan, the locations for planting must first be determined. Planting location polygons were created by taking all grass/open space and bare ground areas and combining them into a single dataset. Non-feasible planting areas such as agricultural fields, recreational fields, major utility corridors, airports, ROWs, etc. were restricted and noted as a query-able attribute in the final GIS dataset. This layer was reviewed and approved by the City of Columbus before the analysis proceeded. The remaining planting space was consolidated into a single feature and then exploded to multipart features creating separate, distinct polygons for each location. The final step broke polygons up again to note planting restrictions as their own feature.

Stormwater

To identify and prioritize planting potential based on the stormwater analysis, locations were assessed with several environmental features, including proximity to hardscape, proximity to canopy, floodplain proximity, soil permeability, slope and soil erosion factor (K-factor). These factors are based on numerous historic projects completed by DRG for stormwater analysis. Each factor was assessed using data from various sources and analyzed using separate grid maps. Values between zero and four (with zero having the lowest priority) were assigned to each grid assessed. A value of zero indicates that this classified piece of information yielded little or no overall value within the dataset. The grids were overlain with the values averaged to determine the priority levels at an area on the map. A priority ranging from Very Low to Very High was assigned to areas on the map based on the calculated average of all grid maps using quantile classification breaks within ArcGIS. This step of the process was completed to statistically subset data evenly into five classes of increasing importance. Areas of higher potential for runoff and erosion were considered higher priority due to their ability to diminish water quality within urban areas.

Urban Heat Island

To identify and prioritize planting potential based on heat islands, a land surface temperature analysis was conducted. Using Landsat 8 imagery data from the United States Geological Survey (USGS), a calculation of land surface temperature by using the Landsat 8 thermal bands. Imagery from September 16, 2016 and June 21, 2019 was used to find the radiance, at-satellite brightness temperature and proportion of vegetation, which were used to calculate the land surface temperature for each year. Surface temperatures were averaged and a priority ranking of Very Low to Very High was assigned based on the average temperatures using quantile classification breaks within ArcGIS. This step of the process was completed to statistically subset data evenly into five classes of increasing importance. Higher surface temperatures were considered higher priority due to the adverse effects of elevated microclimates within urban areas.

Social Equity

To identify and prioritize planting potential based on social equity, data was analyzed including census, crime and health data. Census data included ethnicity, median household income, education attainment and families in poverty. Crime was classified as property and violent crime. Health data was collected for asthma, chronic obstructive pulmonary disease (COPD) and mental health. Each factor was separated to its own grid map. The values were broken into five classes and ranked from 0 - 4 (with zero being the lowest priority and 4 being the highest priority). These factors were classified into five final rankings from Very Low to Very High for each of the social equity and public health criteria using quantile classification breaks within ArcGIS. This step of the process was completed to statistically subset data evenly into five classes of increasing importance. Identifying priorities based on this analysis help to focus efforts on providing trees and tree canopy to all residents regardless of social status or health. These priority areas are deemed to have the greatest return on mental and physical health due to their importance in helping to provide residents of the community with equal access to nature.

Composite Priority

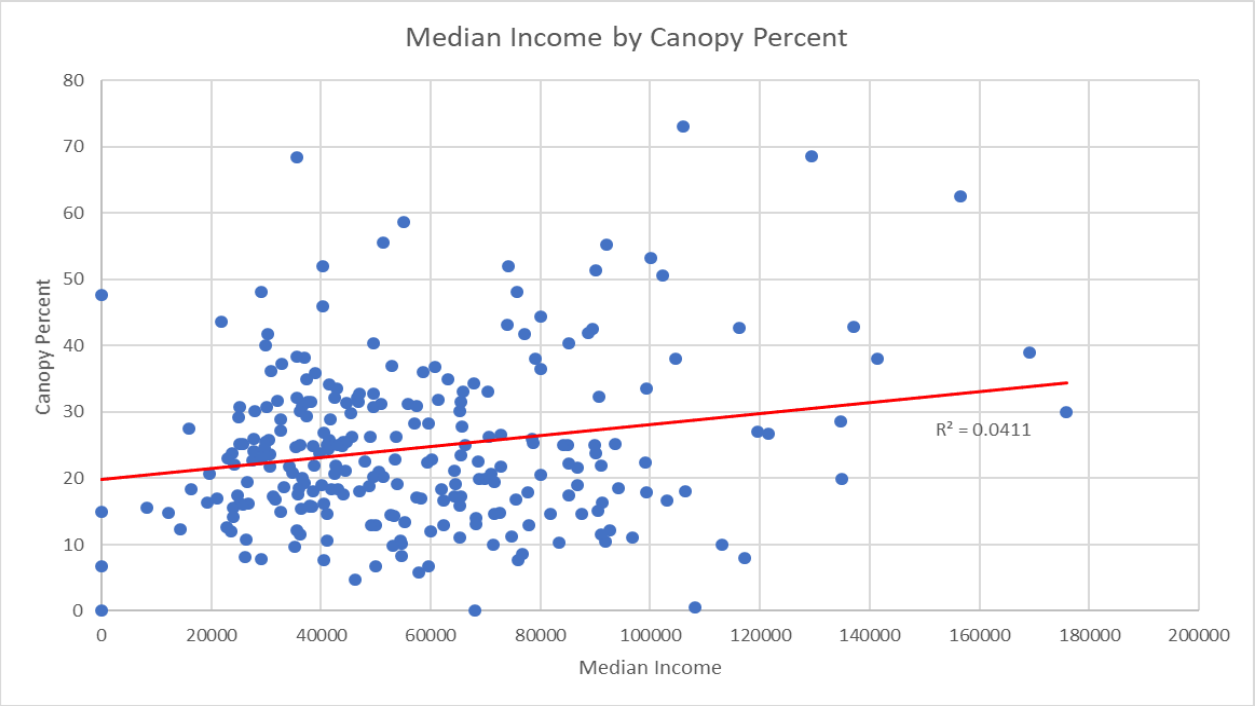
Using zonal statistics, raster data for stormwater, heat island and social equity were used to calculate a total aggregate value for each individual planting location polygon. The values for each factor were statistically binned into five classes using quantile classification within ArcGIS. This classification method distributes values into groups that have an equal number of values. The higher numbers indicate higher priority for planting when assessing all factors through the same scope. These classes ranged from Very Low to Very High to mirror the criteria group rankings. These rankings were then used to combine all criteria to create a composite ranking based on all analytical factors pertaining to the city.

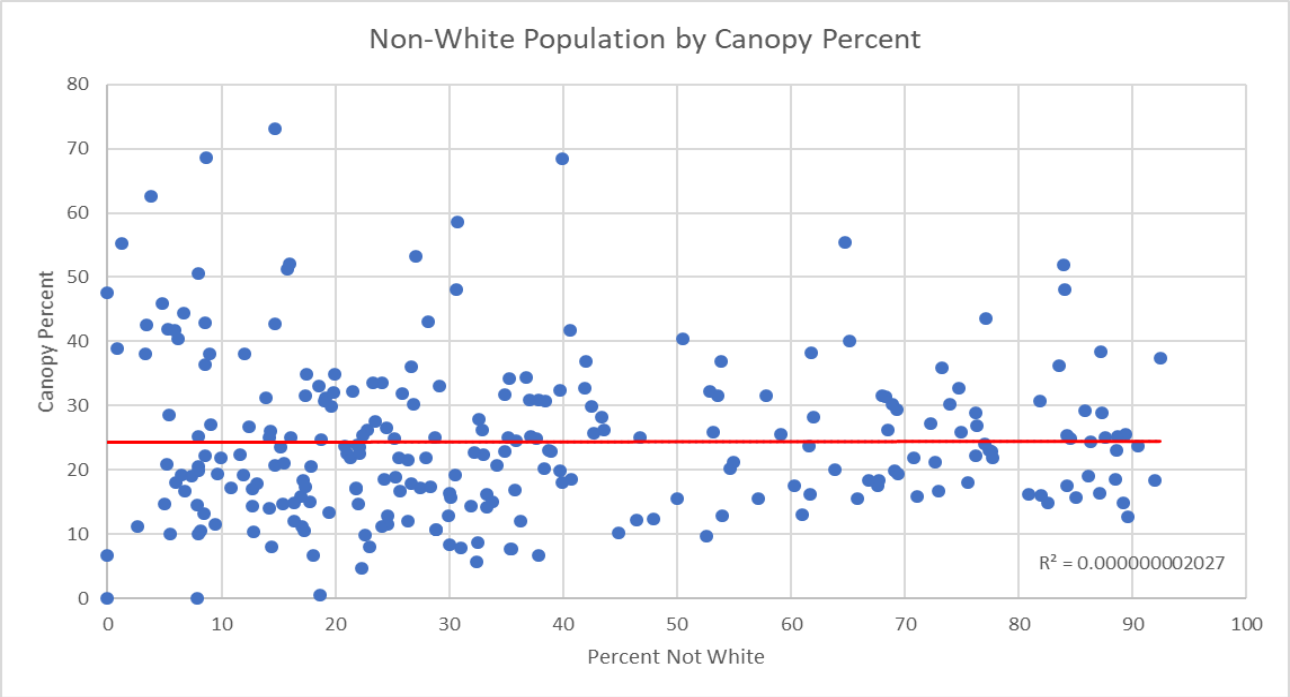
Once the process of identifying priority was completed, the development of planting strategies will be the next step in the process. While available planting sites may ultimately be planted over the next several decades, the trees that are planted in the next few years, should be planned for areas in most need and where they will provide the most benefits and return on investment given a particular set of circumstances and desires to fulfill certain obligations to the community. The City of Columbus can choose to target individual factors like heat islands for certain projects or select from the composite ranking to get the most return on investment across the board.

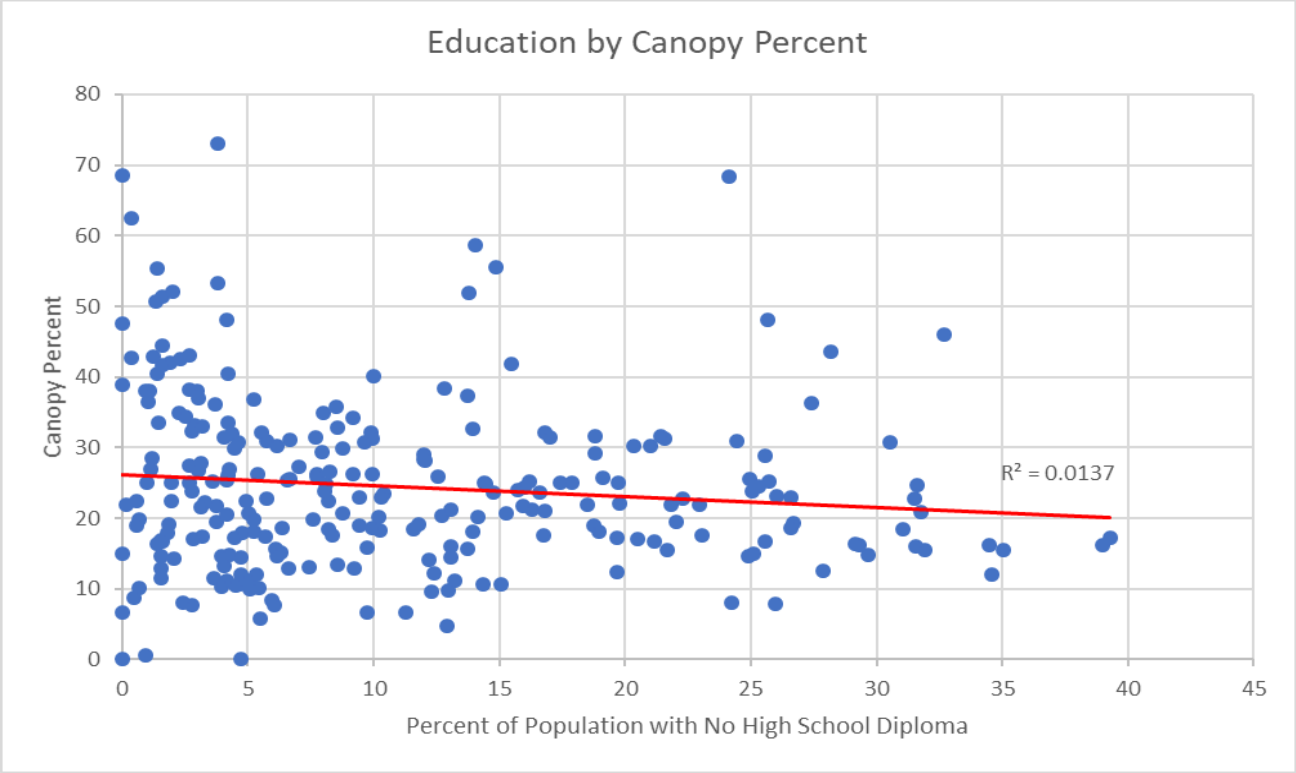
Selecting Priority Neighborhood Communities

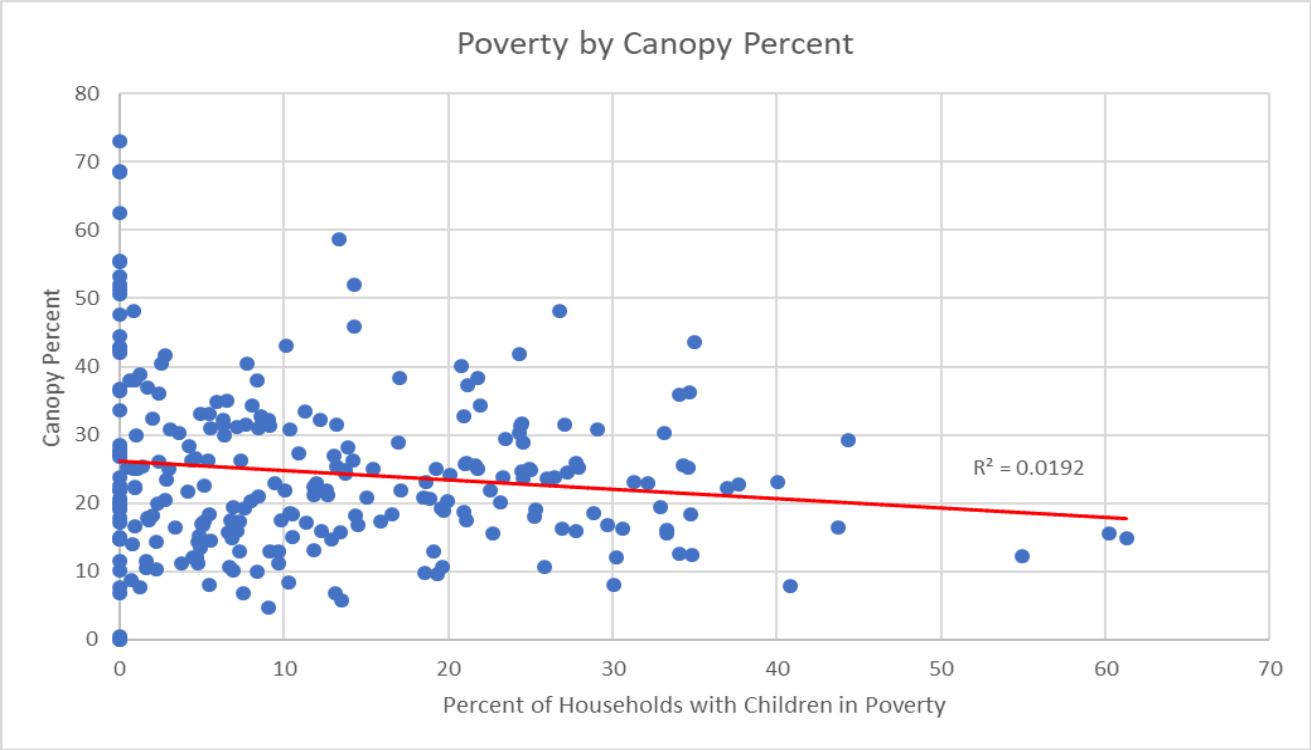
Through statistical analysis and scatterplot graphs (see below), priorities were set to indicate target areas for each criterion based on social equity. Each of the nine individual social equity criteria were analyzed within an Excel scatterplot to determine trends within the datasets. All census tracts that were statistically below the mean were identified as priority. To place significance on a recognizable scale, neighborhood communities were overlain on top of the census tract. Through grouping and visual assessment, neighborhood communities were selected that had the highest occurrence of social equity needs from the statistical analysis. These census tracts were selected and recorded in a spreadsheet for further analysis of neighborhood communities and their presence within each criterion. The top five highest priority communities were identified and highlighted in the spreadsheet.

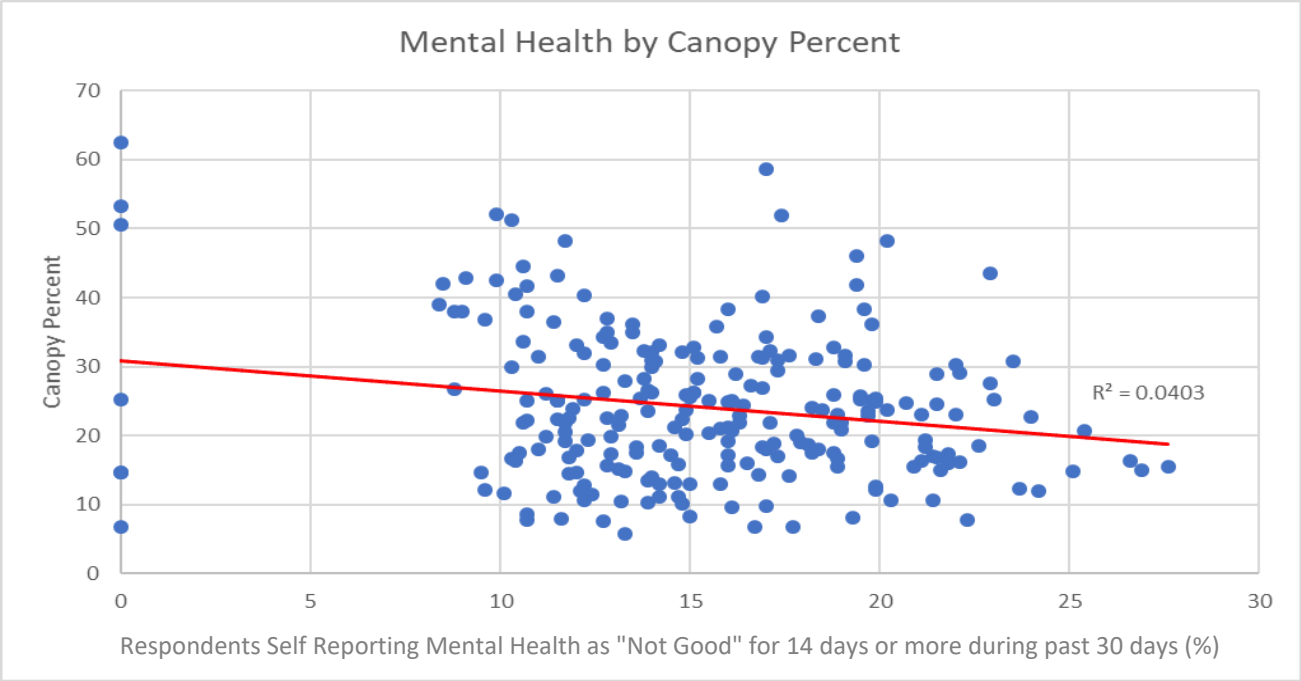
To display the results, bi-variate choropleth matrix maps were created for each criterion with census data results and neighborhood community boundaries. The top five highest priority neighborhood communities were highlighted on the maps as those in need of trees and tree canopy.

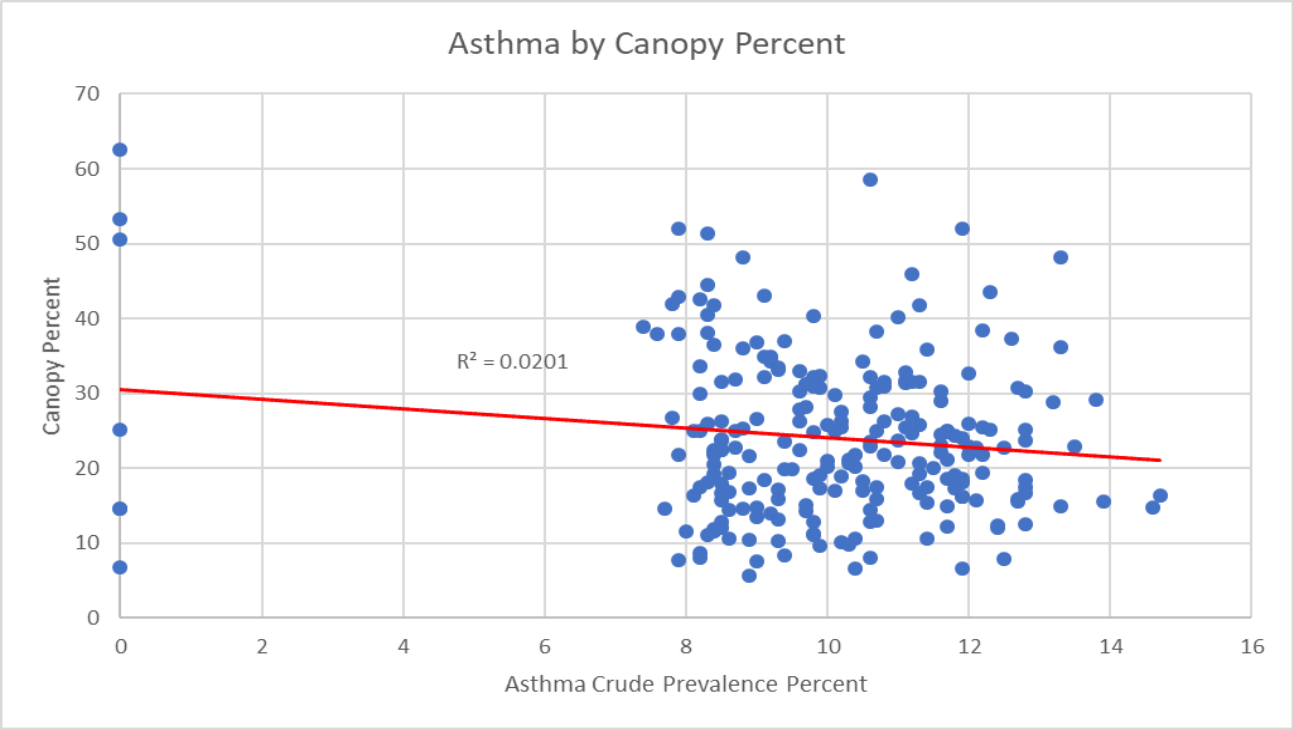

Median Income by Canopy Percent
Canopy Percent
Median Income
R² = 0.0411
0
10
20
30
40
50
60
70
80
0
20000
40000
60000
80000
100000
120000
140000
160000
180000
200000

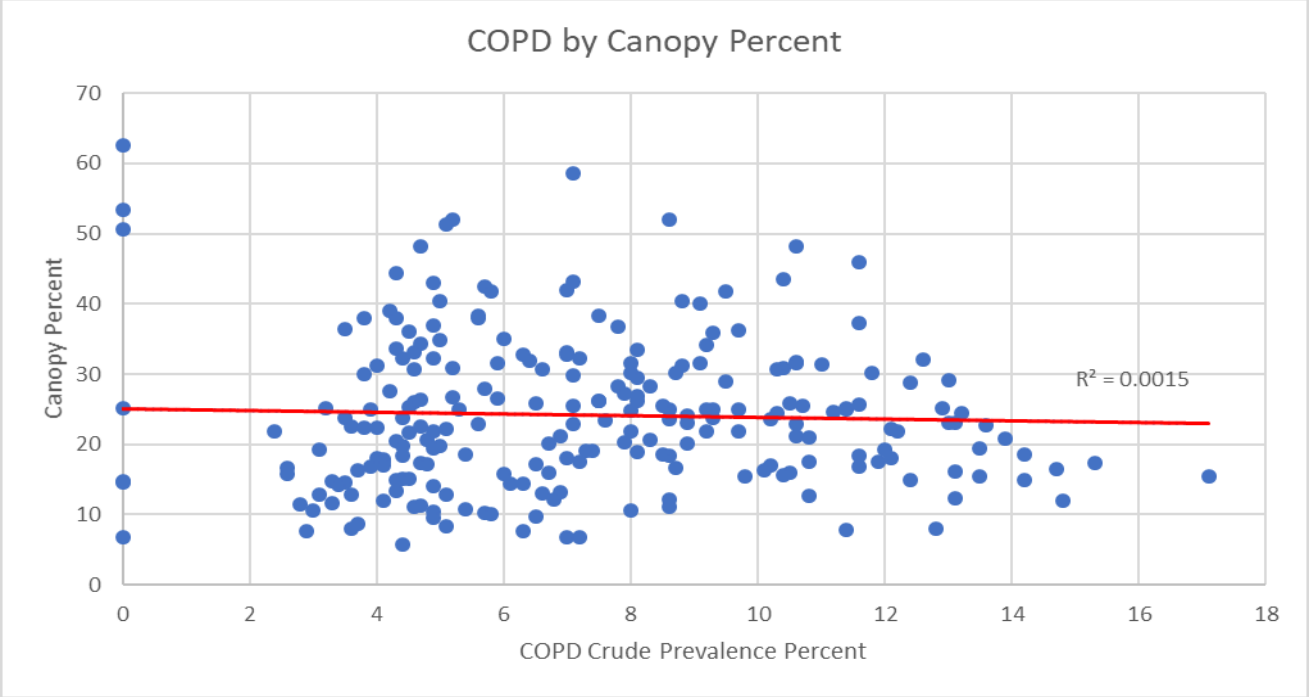

Non-White Population by Canopy Percent
Canopy Percent
Percent Not White
R² = 0.000000002027
0
10
20
30
40
50
60
70
80
90
100

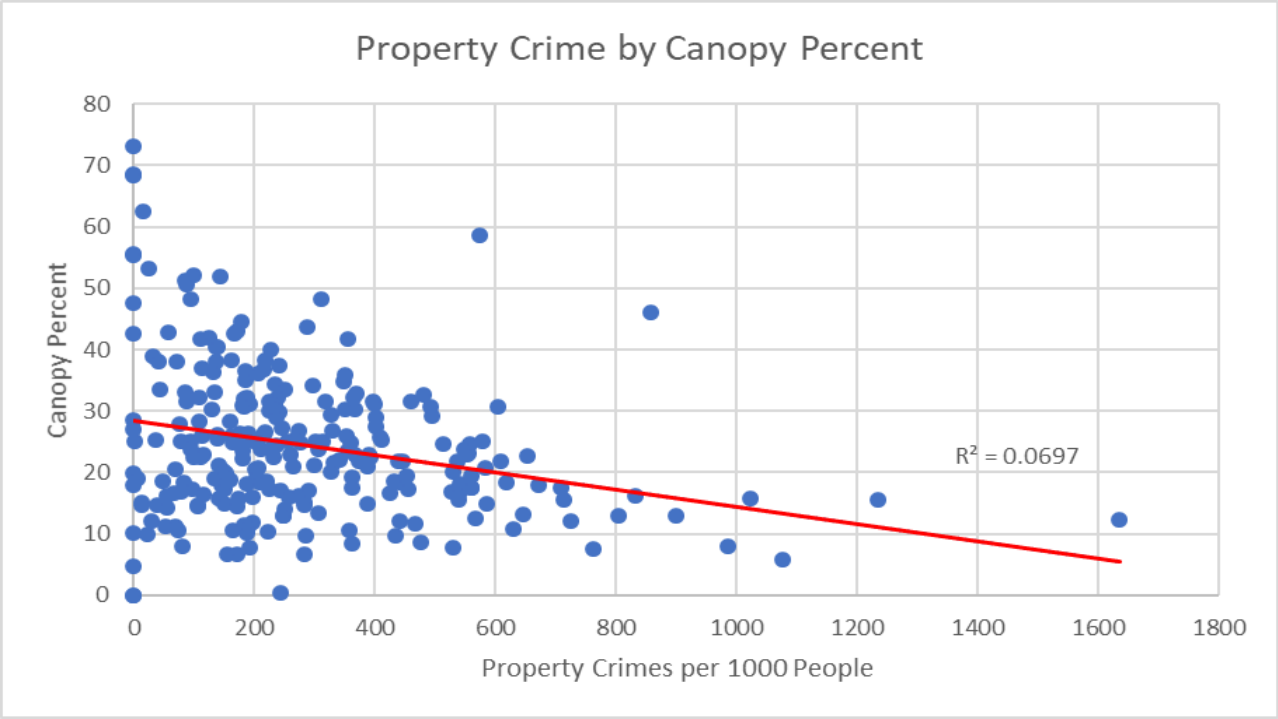

Education by Canopy Percent
Canopy Percent
Percent of Population with No High School Diploma
R² = 0.0137
0
5
10
15
20
25
30
35
40
45

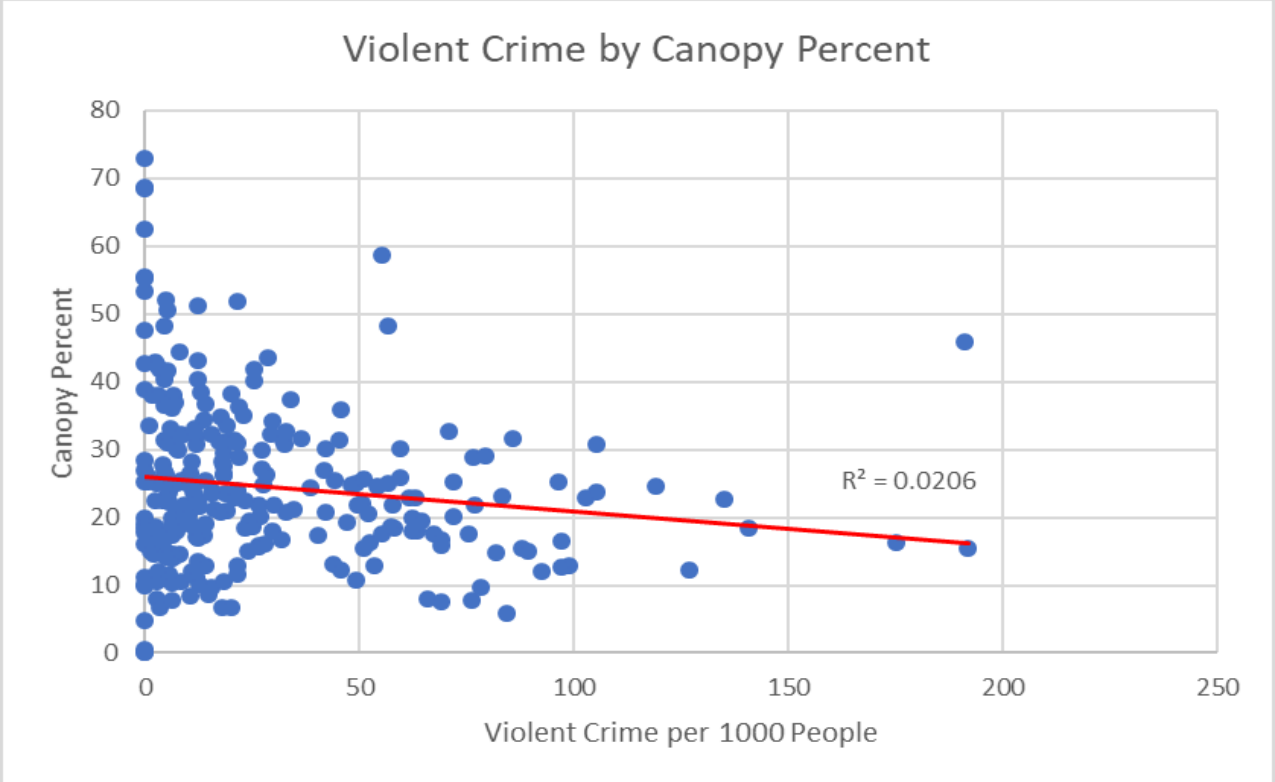

Poverty by Canopy Percent
Canopy Percent
Percent of Households with Children in Poverty
R² = 0.0192
0
10
20
30
40
50
60
70
80


Mental Health by Canopy Percent
Canopy Percent
Respondents Self Reporting Mental Health as "Not Good" for 14 days or more during past 30 days (%)
R² = 0.0403
0
5
10
15
20
25
30


Asthma by Canopy Percent
Canopy Percent
Asthma Crude Prevalence Percent
R² = 0.0201
0
10
20
30
40
50
60
70
0
2
4
6
8
10
12
14
16


COPD by Canopy Percent
Canopy Percent
COPD Crude Prevalence Percent
R² = 0.0015
0
10
20
30
40
50
60
70
0
2
4
6
8
10
12
14
16
18


Property Crime by Canopy Percent
Canopy Percent
Property Crimes per 1000 People
R² = 0.0697
0
10
20
30
40
50
60
70
80
0
200
400
600
800
1000
1200
1400
1600
1800


Violent Crime by Canopy Percent
Canopy Percent
Violent Crime per 1000 People
R² = 0.0206
0
10
20
30
40
50
60
70
80
0
50
100
150
200
250

Group	Criteria	Data Origin	Last Update	Weighting
Stormwater	Distance to Hardscape	Columbus Urban Tree Canopy Assessment	2018	0.30
	Distance to Canopy	Columbus Urban Tree Canopy Assessment	2018	0.10
	Floodplain	National Hydrologic Dataset	2018	0.20
	Soil Permeability	Natural Resource Conservation Service	2018	0.10
	Soil Erosion	Natural Resource Conservation Service	2018	0.10
	Slope	National Elevation Dataset	2018	0.20
Urban Heat Island	Heat Islands – September 16, 2016	Earth Explorer - USGS	2016	
	Heat Islands – June 21, 2019	Earth Explorer - USGS	2019	
Census	Families in Poverty	U.S. Census Bureau	5-year American Community Survey 2014-2018	
	Education Attainment – No Diplomas over the age of 25	U.S. Census Bureau	5-year American Community Survey 2014-2018	
	Median Household Income	U.S. Census Bureau	5-year American Community Survey 2014-2018	
	Percent Non-White Population	U.S. Census Bureau	5-year American Community Survey 2014-2018	
Health	Asthma Prevalence	CDC 500 Cities Project	2019	
	COPD	CDC 500 Cities Project	2019	
	Mental Health	CDC 500 Cities Project	2019	
Crime	Property Crime (per 1000 people)	City of Columbus	2019	
	Violent Crime (per 1000 people)	City of Columbus	2019	

DATA DETAILS

Stormwater

Source: Columbus Urban Tree Canopy Assessment | *Data: Distance to Impervious*

Distance to hardscape is derived by selecting the impervious surfaces data from the Columbus landcover layer. This impervious raster is used as an input layer into the Euclidean Distance tool within ArcGIS to create a layer that measures straight-line distance from each impervious surface location within the city. These distances are grouped into five classes from 0 - 4 with 4 being the closest to impervious surfaces and, therefore, the highest priority. The further a location is from an impervious surface, the lower the ranking it receives. A ranking of 0 is given to locations that are currently represented as impervious surfaces in the land cover data while the value of 4 indicates that the open area next to the impervious surface is available for planting trees to reduce the amount of runoff and sedimentation.

Distance to Hardscape	
Rank	**Distance to Impervious (ft)**
0	**0**
1	**Over 100**
2	**51 - 100**
3	**26 – 50**
4	**1 – 25**

Weighted Overlay Equation for stormwater priority: ("ImperviousDistance" * 0.30) + ("Floodplain" * 0.20) + ("SoilPermeability" * 0.10) + ("SoilErosion" * 0.10) + ("CanopyDistance" * 0.10) + ("SlopePercent" * 0.20)

Distance to Canopy

Source: Columbus Urban Tree Canopy Assessment | *Data: Distance to Canopy*

Distance to canopy is derived by selecting the tree canopy data from the Columbus landcover layer. This canopy raster is used as an input layer into the Euclidean Distance tool within ArcGIS to create a layer that measures straight-line distance from each canopy location within the city. These distances are grouped into five classes from 0 - 4 with 4 being the closest to Canopy and therefore the highest priority. The further a location is from the canopy, the lower the ranking it receives. A ranking of 0 is given to locations that are currently occupied by tree canopy and not plantable. Higher values in this ranking will prioritize areas that have small gaps that can be filed in order to increase tree canopy closure, which has great impact of wildlife habitat by providing larger corridors to support a variety of different species.

Distance to Canopy	
Rank	**Distance to Canopy (ft)**
0	**0**
1	**Over 200**
2	**101 - 200**
3	**51 - 100**
4	**1 - 50**

Floodplain

Source: National Hydrologic Dataset – USDS Geospatial Data Gateway | Data Attribute: Cost Distance

Link: https://datagateway.nrcs.usda.gov/

The floodplain is derived by using the hydrography lines from the United States Department of Agriculture (USDA) website and the Slope Percent Rise (found by calculating Slope using the Digital Elevation Model (DEM) from the USDA website). The Cost Distance tool within ArcGIS was used with these layers to create a raster dataset that shows a cost-weighted distance from the hydrography lines based on the percent rise of the land. This process identifies the first major slope break which indicates the normal stream bank channel that will fill during flooding events. The resulting data layer will show locations of where water will travel during periods of flood. These distances are grouped into five classes from 0 - 4 with 4 being in the floodplain area and therefore the highest priority. The further a location is from the floodplain, the lower the ranking it receives. A ranking of 0 is given to locations that are the furthest from the floodplain.

Floodplain - Cost Distance	
Rank	**Cost Distance (ft)**
0	**Over 2,500**
1	**1,001 - 2,500**
2	**501 - 1,000**
3	**101 - 500**
4	**0 - 100**

Soil Permeability

Source: Natural Resource Conservation Service – USDA Web Soil Survey | Data Attribute: Hydrologic Soils Group (HSG)

Link: https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx

Soil Permeability is found by analyzing the Hydrologic Soils Group (HSG) information from the USDA Soil Surveys. This data is classified into four classes: A, B, C and D. Group A soils have a high infiltration rate, Group B has a moderate infiltration rate, Group C has a slow infiltration rate and Group D has a very slow infiltration rate. The remaining values are classified as W denoting water. These areas are typically larger bodies of water such as ponds, lakes, or rivers. The rankings range from 0 - 4 with 4 being the highest priority. A ranking of 4 is given to the D classification due to its low infiltration rate. Planting in these locations will increase stormwater uptake and therefore, reduce the amount of runoff. Lower rankings are given to the A, B and C classes as these classes have higher infiltration rates where water is able to percolate through the soil without creating surface runoff leading to a decrease in harmful pollutants and sediment into streams and stormwater infrastructure over time. The W class is given a 0 ranking because these areas are classified as water and have no bearing of runoff.

Soil Permeability - HSG	
Rank	**Threat**
0	**W**
1	**A**
2	**B**
3	**C**
4	**D**

Soil Erosion

Source: Natural Resource Conservation Service – USDA Web Soil Survey | Data Attribute: K-factor

Link: https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx

Soil Erosion is found by analyzing the K-factor information from the USDA Soil Surveys. This data is classified into decimal numbers that range from 0.02 – 0.69. The higher numbers within this range mean that the area is more susceptible to sheet and rill erosion by water. Remaining values are given a value of 0 of which can represent water, quarries, pits and other harder surface types. Water features are typically ponds, lakes and rivers. Rankings for this data are based on the susceptibility to erosion. A 0 ranking is given to areas that have little to no risk of erosion. The ranking increases as the risk of erosion increases with the highest ranking being 4. Planting in these priority areas will help decrease erosion vulnerability.

Soil Erosion – K-factor	
Rank	**K-factor (expressed as whole numbers)**
0	**0 - 10**
1	**11 - 20**
2	**21 - 30**
3	**31 - 37**
4	**Over 38**

Slope

Source: National Elevation Dataset – USDA Geospatial Data Gateway | Data: DEM

Link: https://datagateway.nrcs.usda.gov/

Slope is calculated by using the Digital Elevation Model (DEM) from the USDA and finding the slope percent rise of the DEM. The Percent Rise results were grouped into five classes from 0 - 4 with 4 being the highest priority as shown below. The rankings for this data are based on the percent rise of the area. The larger the percent rise of the land, the higher the planting priority. A ranking of 0 is given to areas of no percent rise and the rankings then increase as the percent rise increase with the highest ranking being 4. Planting trees on areas of high percent rise can help decrease stormwater runoff.

Slope – Percent Rise	
Rank	**Percent Rise**
0	**0**
1	**0 - 3**
2	**3 - 6**
3	**6 - 12**
4	**Over 12**

Urban Heat Islands

Land Surface Temperature (LST)

Source: Earth Explorer (USGS) Landsat 8 Thermal Imagery | Data Attribute: Land Surface Temperature (LST)

Link: https://earthexplorer.usgs.gov/

Land surface temperature is calculated using Landsat 8 imagery thermal bands. Using both thermal bands, a conversion from Digital Number (DN) to radiance, at-satellite brightness temperature and proportion of vegetation can be calculated. These values are used to find the land surface temperature. Imagery from September 16, 2016 and June 21, 2019 was used to create two separate surface temperature raster datasets. The two years were averaged and binned into five class from 0 - 4 based on a quantile classification with ArcGIS. Rankings are determined by the surface temperature ranges. The lowest surface temperature range received a 0 ranking. The ranking will increase as the surface temperature increases with the high rank being 4. Planting in areas of high surface temperature helps mitigation urban heat islands by providing more shade to cool not only air temperature but heat absorbed by pavements.

Land Surface Temperature – June 21, 2019	
Rank	**Temperature (Fahrenheit)**
0	**46.7 - 74.8**
1	**74.9 - 78.3**
2	**78.4 - 81.0**
3	**81.1 - 83.6**
4	**83.7 - 114.4**

Land Surface Temperature – September 16, 2016	
Rank	**Temperature (Fahrenheit)**
0	**51.3 - 69.4**
1	**69.5 - 73.2**
2	**73.3 - 75.8**
3	**75.9 - 77.8**
4	**77.9 - 102.2**

Families in Poverty

Source: US Census Bureau - Poverty Status in the Past 12 Months of Families by Family Type by Presence of Related Children Under 18 Years: Census Data Table: B17010

Data Attribute: AJY5E004 – Married couple in poverty with child under 18, AJY5E011 – Single male in poverty with child under 18 and AJY5E017 – Single female in poverty with child under 18

Link: https://www.nhgis.org/documentation/tabular-data

Data shows the percentage of families in each census tract living below the poverty line in the past twelve months. Percentages are classified into five groups using quantile classification within ArcGIS and ranked from 0 - 4 and based on the amount of the percentage. A low ranking of 0 is given to areas with little to no families with children under the poverty line. This ranking increases as the rate of poverty increase with a ranking of 4 given to areas that have largest percentages of families in poverty. Planting in these high priority areas may help address social equity issues and provide residents equal access to nature as well as possibly increase property values.

US Census - Families in Poverty	
Rank	**Poverty Percent**
0	**0 - 0.5%**
1	**0.5% - 5.5%**
2	**5.5% - 12.0%**
.3	**12.0% - 23.0%**
4	**Over 23.0%**

Education Attainment

Source: US Census Bureau - Educational Attainment for the Population 25 Years and Over: Census Data Table B15003 | Data Attribute: AJYPE002 - AJYPE016: No Schooling Completed – 12th Grade, No Diploma

Link: https://www.nhgis.org/documentation/tabular-data

Data shows the percentage of population 25 years and over in each census tract that have not obtained a high school diploma or GED. Percentages are classified into five groups using quantile classification within ArcGIS and ranked from 0 - 4 based on the amount of the percentage. A low ranking of 0 is given to areas with lower percentages of people that have not obtained a high school diploma or GED. A higher ranking is given to areas that as the percentages of No Diploma increase with the top rank being 4. Planting in these high priority areas may help address social equity issues and provide residents equal access to nature.

US Census – Educational Attainment	
Rank	**Percent of No Diploma**
0	**0 - 2.8%**
1	**2.8 - 5.5%**
2	**5.5 - 11.3%**
3	**11.3 - 19.7%**
4	**Over 19.7%**

Median Household Income

Source: US Census Bureau - Median Household Income in the Past 12 Months: Census Data Table B19013

Data Attribute: AJZAE001 - Median household income in the past 12 months

Link: https://www.nhgis.org/documentation/tabular-data

Data shows the median household income earnings for each census tract. Median incomes are classified into five groups using quantile classification within ArcGIS and ranked from 0 - 4 based on the amount of income. A ranking of 0 is given to areas with high incomes. The lower the income is, the higher the ranking. A ranking of 4 is given to areas that have the lowest median income. Like with the poverty data. Planting in these high priority areas may help address social equity issues and provide residents equal access to nature.

U.S. Census – Median Income	
Rank	**Median Income ($)**
0	**$80,000 - $175,915**
1	**$59,500 - $80,000**
2	**$42,500 - $59,500**
3	**$31,600 - $42,500**
4	**$0 - $31,600**

Non-White Population

Source: US Census Bureau - Race: Census Data Table B02001

Data Attribute: AJWNE003 – AJWNE008 (Black or African American alone, American Indian and Alaska Native alone, Asian alone, Native Hawaiian and other Pacific Islander alone, Some other race alone, Two or more races.

Link: https://www.nhgis.org/documentation/tabular-data

Data shows percentage of population that are non-white in each census tract. Percentages are classified into five groups using quantile classification within ArcGIS and ranked from 0 - 4 based on the amount of the percentage. A ranking of 0 is given to areas with lower percentages of non-white population. This ranking increases as the percentage of non-white residents increases. Planting in these high priority areas may help address social equity issues and provide residents equal access to nature.

US Census – Ethnicity	
Rank	**Non-White Percent**
0	**0.0 - 14.2%**
1	**14.3 - 23.5%**
2	**23.5 - 36.8%**
3	**36.8 - 67.7%**
4	**Over 67.7%**

Asthma

Source: Center for Disease Control (CDC) 500 Cities Project | Data Attribute: Crude Prevalence

Link: https://chronicdata.cdc.gov/browse?category=500+Cities

Crude Prevalence is calculated using respondents of the Behavioral Risk Factor Surveillance System (BRFSS) survey or National Survey of Children's Health. This number is a percentage that is calculated by dividing the weighted total of people who have asthma or who have been told they have asthma from a doctor by the weighted number of people who responded to either survey excluding the answers of "don't know" or "refused" in regards to Asthma. Data is recorded by census tract. The asthma rates are grouped into five classes using quantile classification within ArcGIS and ranked from 0 - 4. A ranking of 0 is given to the lowest prevalence recorded. This ranking increases as the asthma rates increase with the highest ranking being 4. Planting in these priority areas will potentially help decrease asthma prevalence.

CDC - Asthma	
Rank	**Crude Prevalence**
0	**0.0 - 8.5**
1	**8.6 - 9.7**
2	**9.8 - 10.7**
3	**10.8 - 11.8**
4	**11.9 - 14.7**

COPD

Source: Center for Disease Control (CDC) 500 Cities Project | Data Attribute: Crude Prevalence

Link: https://chronicdata.cdc.gov/browse?category=500+Cities

Crude Prevalence is calculated using respondents of the BRFSS survey or National Survey of Children's Health. This number is a percentage that is calculated by dividing the weighted total of people who have been told they have COPD from a doctor by the weighted number of people who responded to either survey excluding the answers of "don't know" or "refused "in regards to COPD. Data is recorded by census tract. The COPD rates are grouped into five classes using quantile classification within ArcGIS and ranked from 0 - 4. A ranking of 0 is given to the lowest prevalence. This ranking increases as the COPD rates increase with the highest ranking being 4. Planting in these priority areas will potentially help decrease COPD prevalence.

CDC - COPD	
Rank	**Crude Prevalence**
0	**0.0 - 4.4**
1	**4.5 - 5.9**
2	**6.0 - 8.1**
3	**8.2 - 10.6**
4	**10.7 - 17.1**

Mental Health

Source: Center for Disease Control (CDC) 500 Cities Project | Data Attribute: Crude Prevalence

Link: https://chronicdata.cdc.gov/browse?category=500+Cities

Crude Prevalence is calculated using respondents of the BRFSS survey or National Survey of Children's Health. This number is a percentage that is calculated by dividing the weighted total of people who have reported 14 or more days during the past 30 in which their mental health was not good by the weighted number of people who responded to either survey excluding the answers of "don't know" or "refused" in regards to mental health. Data is recorded by census tract. The mental health rates are grouped into five classes using quantile classification within ArcGIS and ranked from 0 - 4. A ranking of 0 is given to the lowest prevalence. This ranking increases as the mental health rates increase with the highest ranking being 4. Planting in these priority areas will potentially help decrease mental health prevalence.

CDC – Mental Health	
Rank	**Crude Prevalence**
0	**0.0 - 11.7**
1	**11.8 - 14.0**
2	**14.1 - 16.7**
3	**16.8 - 19.5**
4	**19.6 - 27.6**

Property Crime (Annual per 1,000 People)

Source: Columbus Police Department

Property Crime Types: Arson, Burglary – Commercial, Burglary – Residential, Burglary from Motor Vehicle, Motor Vehicle Theft, Theft, Theft – Other, Vandalism

Crime data were analyzed over five years (2015-2019) from the Columbus Police Department. Each crime was given a XY coordinates. These coordinates were turned into points in ArcMap. All five years of data were combined into one shapefile and were totaled by census tract, then averaged. These averages were converted into a ratio of property crime per 1,000 people within each census tract. The results were grouped into five classes as shown below. The property crime rates are grouped into five classes using quantile classification within ArcGIS and ranked from 0 - 4. A ranking of 0 is given to areas of little or no crime. This ranking increases as the property crime rates increase with the highest ranking being 4. Planting in these priority areas will potentially help decrease property crime.

Property Crime – Annual per 1,000 People	
Rank	**Crime Average**
0	**0.0 - 19.0**
1	**19.1 - 36.5**
2	**36.6 - 54.6**
3	**54.7 - 88.1**
4	**Over 88.1**

Violent Crime (Annual per 1,000 People)

Source: Columbus Police Department

Violent Crime Types: Homicide, Attempted Homicide, Sexual Assault, Robbery – Commercial, Robbery – Individual, Aggravated Assault

Crime data were analyzed over five years (2015-2019) from the Columbus Police Department. Each crime was given a XY coordinates. These coordinates were turned into points in ArcMap. All five years of data were combined into one shapefile and were totaled by census tract, then averaged. These averages were converted into a ratio of property crime per 1,000 people within each census tract. The results were grouped into five classes as shown below. Violent crime rates are grouped into five classes using quantile classification within ArcGIS and ranked from 0 - 4. A ranking of 0 is given to areas of little or no crime. This ranking increases as the violent crime rates increase with the highest ranking being 4. Planting in these priority areas will potentially help decrease violent crime.

Violent Crime – Annual per 1,000 People	
Rank	**Crime Average**
0	**0.0 - 0.9**
1	**1.0 - 2.2**
2	**2.3 - 4.4**
3	**4.5 - 10.7**
4	**Over 10.7**

APPENDIX B. City of Columbus Ordinance Review

Priority Level Key: 1 = High Priority, 3 = Low Priority | **-** = adequate regulations in place

Topic	Addressed (X)	Chapter & Section	Comments	Priority Level
Credentials				
Requires certified arborist for paid private tree work				3
Requires Certified Arborist for public tree work				1
Requires licensing of private tree care firms				3
Defines official authority for public tree management	**X**	Chapter 912 § 912.02	City of Columbus - Recreation & Parks Department	-
Public Tree Management and Protection				
Establishes/Authorizes City Forester to regulate public trees			Chapter 912 establishes Recreation & Parks Department as the authority but does not establish or authorize a City Forester	1
Establishes/Authorizes City position (e.g., Mayor, City Administrator, DPW Director) to regulate public trees	**X**	Chapter 912 § 912.01	Recreation and Parks Director, or their designee	-
Requires annual community tree work plans				2
Identifies formula for determining monetary tree value				1
Establishes responsibility for public tree maintenance (e.g., City, adjacent property owner)	**X**	Chapter 912 § 912.02	City of Columbus Recreation & Parks Department	-
Requires regular public tree maintenance				2
Requires particular types of maintenance (e.g., pruning)				2
Requires adherence to ANSI A300 standards and best management practices				1
Establishes permit system for work on public trees	**X**	Chapter 912 § 912.10		-
Establishes provisions for penalties for non-compliance	**X**	Chapter 912 § 912.99		-

Topic	Addressed (X)	Chapter & Section	Comments	Priority Level
Public Tree Management and Protection (cont.)				
Restricts tree removal on public property	**X**	Chapter 912 § 912.11		-
Permit or approval required for tree removal, pruning or excavating near public trees	**X**	Chapter 912 § 912.09; 912.10; 912.11		-
Prohibits damage to public trees (e.g. attaching ropes, signes, wires, chemicals, storing materials, excavation etc.)	**X**	Chapter 912 § 912.17; 912.20; 912.22		-
Restricts burning of solid wood waste	**X**	Chapter 912 § 912.17	Burning is prohibited where it will injure any tree in a public street, park, or public place	3
Establishes a wood utilization program				2
Establishes an insect/disease control strategy				1
Defines tree maintenance requirements on public property			Chapter 910 § 910.06 for permittees "...tree trimming, in accordance with good engineering and construction practice..." Adherence to tree care industry standards not required.	2
Prohibits tree topping				1
Regulates abatement of hazardous or public nuisance trees				1
Regulates removal of dead or diseased trees	**X**	Chapter 912 § 912.21		-
Tree Fund	**X**	Chapter 912 § 912.15	Public Trees - "Plant Material Fund"	1
Tree Planting				
Regulates tree species which may or may not be planted on **private** property (approved tree list)				1
Requires replacement of removed publicly owned trees				1
Regulates tree species which may or may not be planted on **public** property (approved tree list)	**X**	Chapter 912 § 912.09, Chapter 912 § 912.16, Chapter 3320 § 3320.13	Approved Tree List; all planting permits/plans must be approved by the City Forester or a development director and native species are recommended.	-

Topic	Addressed (X)	Chapter & Section	Comments	Priority Level
Tree Planting (cont.)				
Requires tree planting around reconstructed parking lots	**X**	Chapter 3312 § 3312.21, Chapter 3325 § 3325.361, Chapter 3372 § 3372.33 & 3372.807		-
Requires tree plantings around new parking lots	**X**	Chapter 3312 § 3312.21, Chapter 3325 § 3325.361, Chapter 3372 § 3372.33		-
Requires tree plantings around new developments	**X**	Chapter 3321 § 3321.07 & 3321.13, Chapter 3325 § 3325.261, Chapter 4307 § 4307.23		-
Private Tree Protection and Preservation				
Restricts tree removal on private property	**X (Limited)**	Chapter 3325 § 3325.903 (University District Overlay)		1
Permit or approval required for tree removal on private property				1
Requires preservation of trees during development on private property	**X (Limited)**	Chapter 3325 § 3325.903 (University District Overlay)		1
Prohibits damage to preserved/protected trees				1
Prohibits damage or removal of trees on another person's property	**X (Limited)**	Chapter 4501 § 4501.155	Prohibits graffiti including on public and private trees	1
Inventory of trees on site required				1
Identification of forests/woodlands required				1
Specific species and/or size tree regulated (e.g,. heritage/significant trees)	**X (Limited)**	Chapter 3320 § 3320.21		1
Location of Critical Root Zone/Dripline required				1
Minimum canopy coverage requirement set				1

Topic	Addressed (X)	Chapter & Section	Comments	Priority Level
Private Tree Protection and Preservation (cont.)				
Identification of riparian buffers, natural areas, preservation zones	**X (Limited)**	Chapter 919 § 919.09, Chapter 3372 § 3372.904 & 3372.905, Chapter 3361 § 3361.03	Chapter 3372 only pertains to the Hellbranch Run watershed; Chapter 3361 requires description of natural environment (topography, soils, wetland, drainage pattern, streams and vegetation)	1
Tree protection/preservation plan required				1
Identification of prohibited activities in dripline/critical root zone				1
Tree protection fencing required				1
Location/type of other tree protection measures (e.g., root pruning, aeration, vertical mulching, trunk/soil protection, irrigation,) on development plans (e.g., site plans, construction plans, etc.)				1
Provide credits/incentives for tree preservation				1
Landscape plan with proposed landscaping and mitigation trees to be planted	**X (Limited)**	Chapter 3321 § 3321.07 & 3321.13 (University District Overlay)	Only applies to Apartment land use in the University District Overlay	1
Requires Grading plan to include protected/preserved trees				1
Utility plan with trees to include protected/preserved trees				1
Tree planting requirements for removal of regulated trees	**X (Limited)**	Chapter 3321 § 3321.13, Chapter 3325 § 3325.903 (University District Overlay)	Only applies to Apartment land use in the University District Overlay	1
Fee in Lieu of planting mitigation trees				1
Tree mitigation survival requirements				1
Fine for removal of regulated trees				1
Penalties established for damage and removal of preserved/saved trees				1
Bonding utilized to discourage tree removals				1
Tree Fund	**X**	Chapter 912 § 912.15	Public Trees - "Plant Material Fund"	1

APPENDIX C. References

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