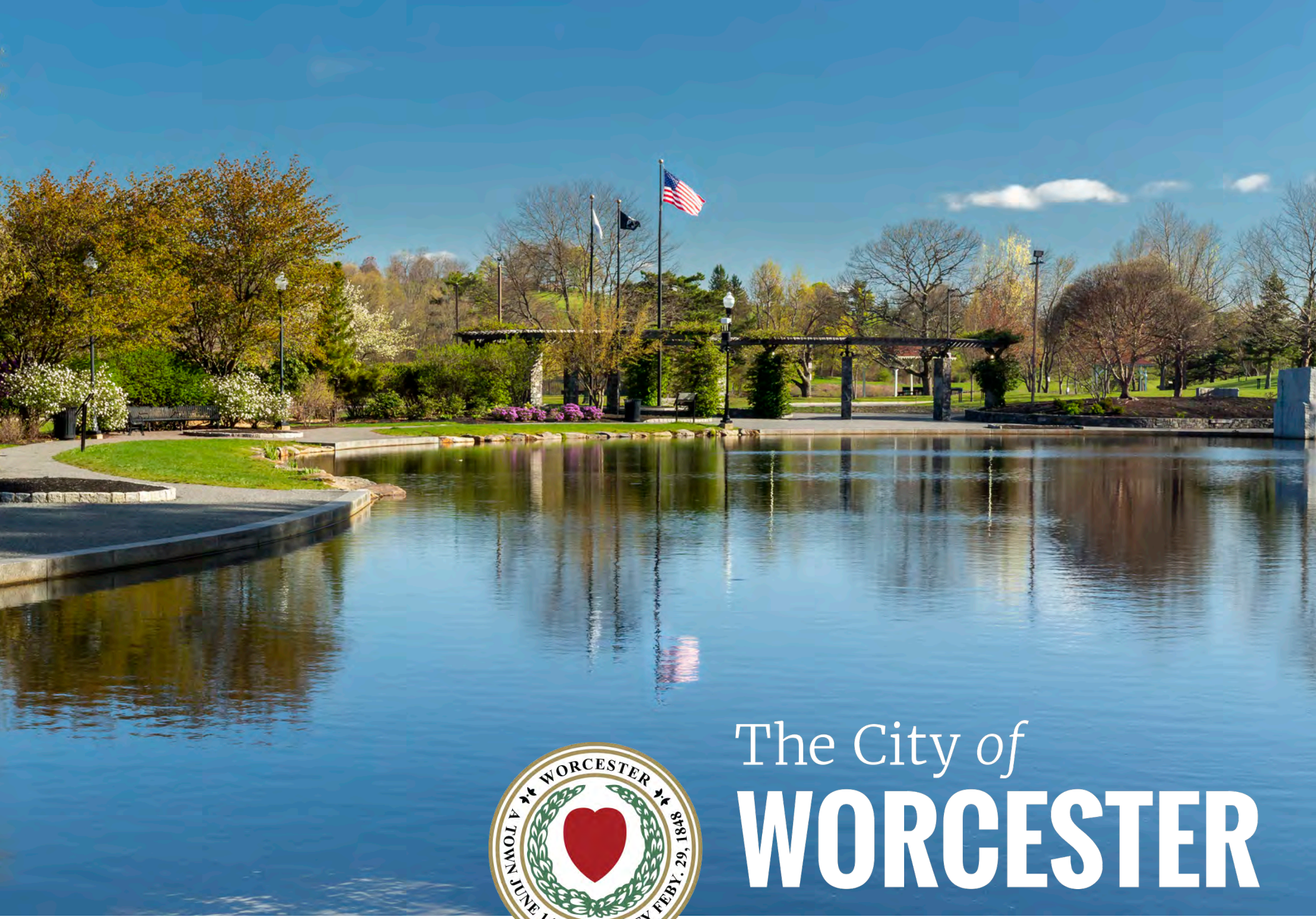
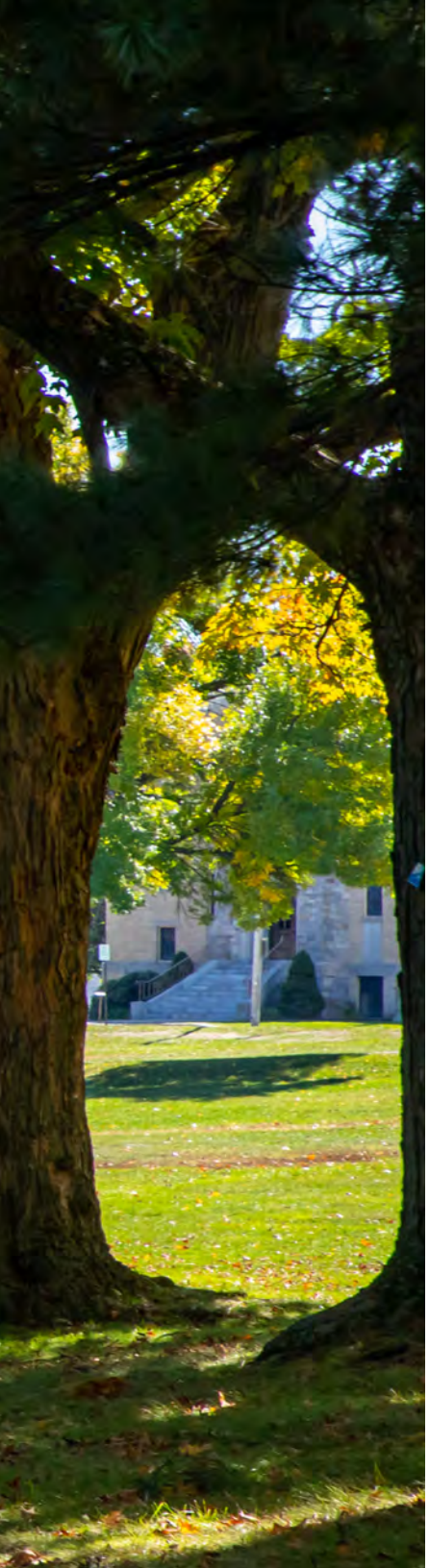


The City *of* WORCESTER

URBAN FOREST MASTER PLAN



The City of Worcester Urban Forest Master Plan

ACKNOWLEDGEMENTS

CITY MANAGER
Eric D. Batista

CITY COUNCIL
Joseph M. Petty, Mayor
Morris A. Bergman
Candy Mero-Carlson
Donna M. Colorio
Etel Haxhiaj
Khrystian E. King
Thu Nguyen
Sarai Rivera
Sean M. Rose
George J. Russell
Kathleen M. Toomey

URBAN FORESTRY TREE COMMISSION
Joy Winbourne, Chair
Alexander Elton
Robin Karoway-Waterhouse
Joseph Mogel
Kristin K. Wobbe

DEPARTMENT OF PUBLIC WORKS & PARKS
Jay J. Fink, PE., Commissioner
Robert C. Antonelli, Jr. CPRP, Assistant Commissioner
Brian Breveleri, City Urban Forester

DAVEY RESOURCE GROUP
Kerry Gray, Principal Consultant
Moriah Day, Associate Consultant
Ashley McElhinney, Associate Consultant

Thank you to the city departments, organizations, and individuals that helped in creating the Worcester Urban Forest Master Plan.

City of Worcester Department of Public Works & Parks
City of Worcester Department of Sustainability and Resilience
City of Worcester Office of Human Rights
City of Worcester Planning and Regulatory Services
Clark University
Greater Worcester Land Trust
New England Botanic Garden at Tower Hill
Mass Audubon
National Grid
Regional Environmental Council Worcester
Worcester GreenCorp (Chamber of Commerce)
Worcester Residents

The City of Worcester wants to thank the over one thousand residents who took their time to complete the survey or attend a public hearing in an effort to express their thoughts on the City of Worcester Urban Forest.

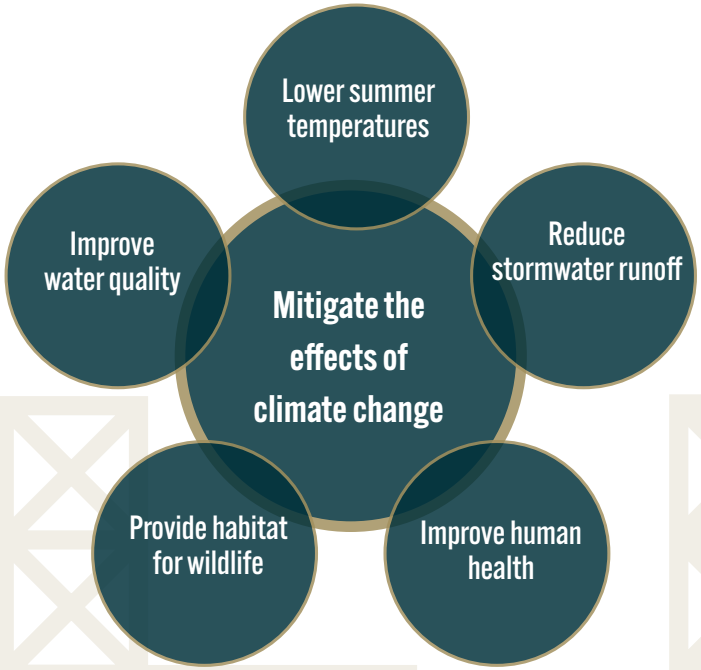

SEESAW

The City of Worcester Urban Forest Master Plan

EXECUTIVE SUMMARY

Vision for Worcester's Urban Forest

Our vision is for Worcester's urban forest to be a model of proactive management, sustainability, and climate resilience. We envision a city where the urban forest is well-cared for, with proactive measures in place to ensure its health and longevity. Through intentional planning and community engagement, we will ensure tree diversity and well-distributed tree canopy cover, care, and green spaces for the entire Worcester Community. Through nurturing a resilient and sustainable urban forest, we aim to create a greener, healthier, and more vibrant Worcester.



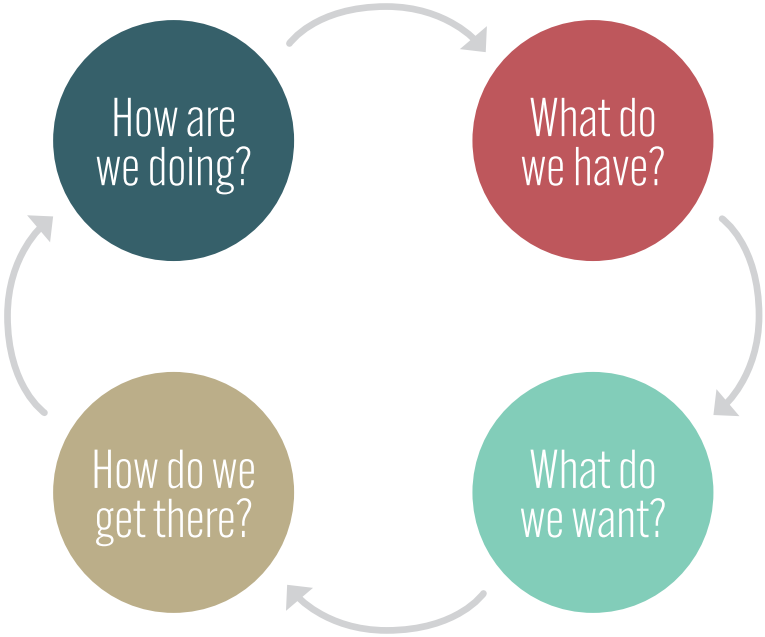
Worcester's urban forest — made up of a mosaic of trees growing along city streets and in public parks, open spaces, and private landscapes — provides essential environmental, economic, and social benefits to the community. The benefits shown in Figure 1, plus the many other benefits trees provide, highlight the essential role that the urban forest plays in the quality of life of the Worcester community.

In late 2021, the City of Worcester began the process to develop this plan, the city's first comprehensive Urban Forestry Master Plan (UFMP/Plan). The UFMP provides a framework to assist the city in maintaining a healthy, resilient, and sustainable urban forest by continuing its legacy of management, planting, and care. The Plan highlights the current state of Worcester's urban forest and outlines recommendations and actions to manage it as a sustainable community asset. While the urban forest includes all of the trees in the city — those on both public and private property — the plan focuses primarily on Worcester's public street and park trees that the City of Worcester Department of Public Works and Parks is directly responsible for managing.

Planning Process

The development, organization, and structure of Worcester's Urban Forest Master Plan is based on the principles of adaptive management, an approach commonly used for resource planning and management. This approach provides a useful conceptual framework for managing Worcester's urban forest resource by answering four key questions:

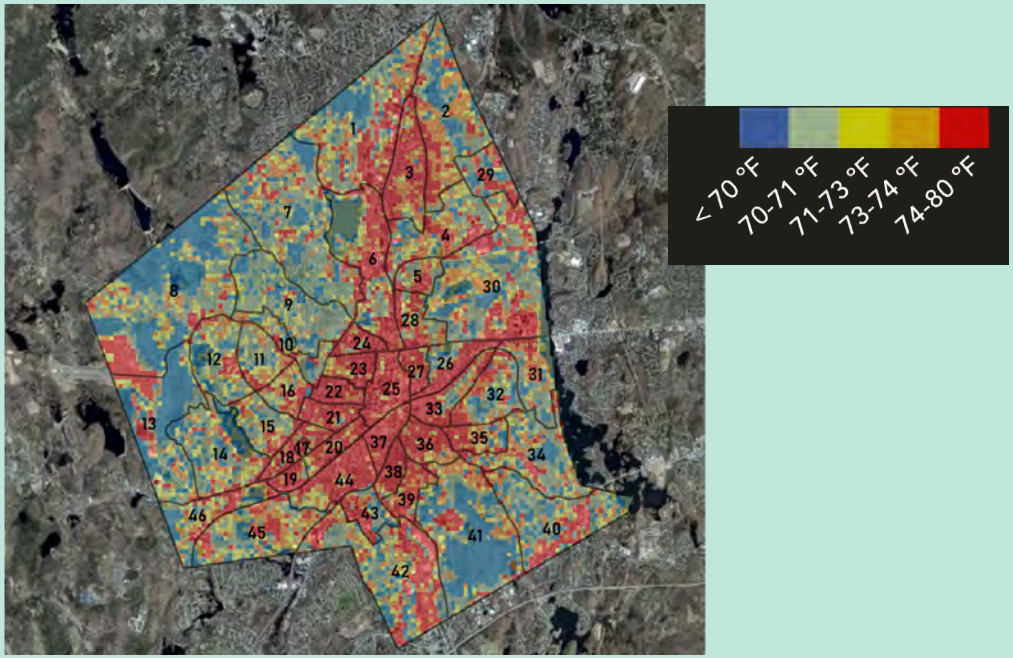
- ***what do we have?***
- ***what do we want?***
- ***how do we get there?***
- ***how are we doing?***



Worcester's Urban Forest

In spring 2022, the City of Worcester conducted a comprehensive inventory of public street trees, building upon a previous assessment completed in 2005. The 2022 street tree inventory, which identified 23,137 trees, reveals insights about Worcester's public trees, including size/age distribution, species diversity, condition, and maintenance requirements (summary of results shown to right).

A comprehensive assessment of Worcester's urban tree canopy involves evaluating both street trees and trees on public and private properties throughout the city. While this assessment has not been completed, a heat risk assessment conducted in 2022 provides initial baseline data on Worcester's tree canopy using satellite-based data. This assessment indicated that approximately 37% of the city's land is covered by tree canopy. American Forest's Tree Equity Score tool was used to analyze the distribution of this canopy cover, determining that overall, trees are distributed city-wide, except in the core downtown area that has limited planting areas. The Plan aims to guide efforts toe equitable access to tree canopy for all residents Worcester.



Size/Age Distribution

Overall, aligns closely with the industry recommendation, but some districts have notable deviations.

- 44% Young—40% Recommended
- 22% Established—30% Recommended
- 17% Maturing—20% Recommended
- 16% Mature—10% Recommended

Species Diversity

165 different tree species, a 68% increase from the 2005 inventory. Top species identified:

- Norway maple (28%)
- Cherry species (7%)
- Little-leaf linden (5%)
- Pin oak (5%)
- Honeylocust, red maple and silver maple (4%)

Vulnerability

- At least 65% of Worcester's street trees are susceptible to at least one significant pest or disease
- Some commonly found species in Worcester are forecasted to lose habitat suitability due to climate change

Condition

- Nearly 80% of the trees were in fair or good condition

Maintenance Needs

- 53% of established street trees need routine pruning
- 21% of young trees need training pruning
- 11% of trees need higher-priority (risk based) pruning

Public Tree Benefits

Worcester's inventoried street trees provide a multiplicity of benefits annually, including:

- Removing **7,940 pounds** of air pollutants
- Absorbing **181 tons** of carbon each year
- Intercepting and absorbing over **2.4 million gallons** of stormwater in their canopies and roots

These are just the benefits that can be quantified and only for those of the inventoried trees. Trees also increase property values, reduce energy costs, lower crime rates, help create more successful business districts, and support physical and mental health. When Worcester conducts an urban tree canopy assessment, benefits should be recalculated to determine the benefits of entire urban forest (public and private trees) using USDA Forest Service's tree benefits software, i-Tree Eco.

Managing Worcester's Urban Forest

The City of Worcester's Department of Public Works and Parks (DPW&P) Forestry Operations is responsible for managing over 23,100 street trees, 8,500 planting sites and 772 stumps along the city's 495 miles of public streets, and thousands of trees growing in city parks.

As with other infrastructure, like roads, bridges, and utilities, City-managed trees require proactive and routine maintenance to ensure a resilient, safe, and sustainable urban forest that maximizes benefits to the community. The care and maintenance of Worcester's public trees is primarily reactive, driven by resident requests, high risk trees identified by City staff, storms, and emergencies. The Plan serves as a guide for Worcester to transition to a proactive management program to improve efficiencies and create an urban forest that is both sustainable and resilient.

Engagement

Three main groups were engaged during the plan development process to determine the vision, goals, and recommendations of the UFMP.

Project Team, made up of City of Worcester staff and the Davey Resource Group consultant team, worked together to develop the plan development process, gather technical information, and form recommendations.

Stakeholders representing different organizations throughout Worcester that were interested, involved, or whose work impacted the urban forest to gather feedback on issues, challenges, and opportunities around Worcester's trees and urban forest. The following stakeholders provided input through focus groups and interviews:

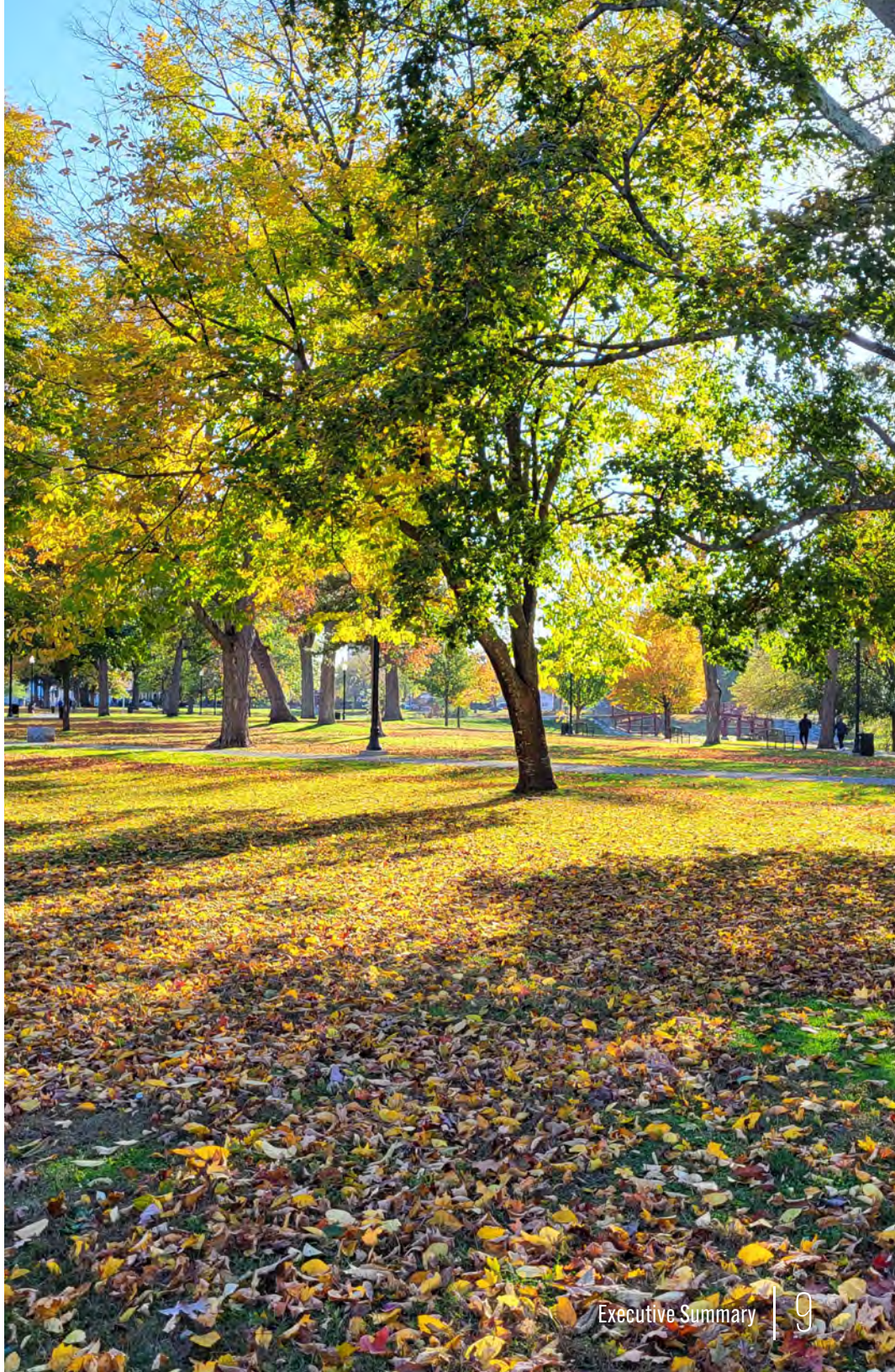
Community Organizations & Utilities

- New England Botanic Garden at Tower Hill
- Worcester GreenCorp (Chamber of Commerce)
- Mass Audubon
- Regional Environmental Council
- Greater Worcester Land Trust
- Clark University

City of Worcester

- Parks and Recreation
- Forestry Operations
- Sustainability and Resilience
- Planning and Regulatory Services
- Public Works
- Human Rights
- Transportation & Mobility

Worcester Community (public) was engaged to understand their values, needs and priorities related to Worcester's trees and urban forest. Worcester community input was gathered through community open houses, survey, and district meetings. A total of 1,131 people responded to the survey and over 95% of respondents strongly agree that trees are important to Worcester.

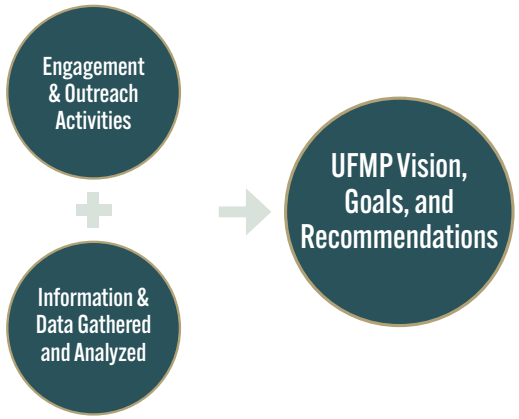


Themes and Priorities

The engagement and outreach activities identified a set of themes and priorities that were used in the development of the plan's vision, goals, and recommendations.

Urban Forest Master Plan Goals and Recommendations

The UFMP goals and their corresponding recommendations provide a framework for the proactive management, care, preservation, and growth of Worcester's urban forest. The Plan provides action items for each recommendation along with timeframes and resources that may be needed for completion. While these actions should serve as the basis for implementation of the plan, acceleration in implementation of recommendations and action items is encouraged as opportunities arise.



Plan Goals

Plan and manage Worcester's public trees through development and coordination in planning, design, and care to ensure its long-term health and sustainability.

Proactively grow and maintain public trees to create a healthy, equitable, and resilient urban forest that maximizes the environmental, quality of life, and climate mitigation benefits Worcester's trees provide.

Protect and preserve the urban forest from loss and threats to ensure the long-term sustainability of Worcester's tree canopy.

Connect and engage with the community about Worcester's urban forest and the important role they play in its growth and care.

The Plan Recommendations are listed by number for ease of identification and have not been prioritized.

Recommendation #1. Establish a proactive management program for Worcester's public trees that is beyond the current Customer Service based model.

Recommendation #2. Increase City staff and contractors to transition to a proactive public tree management program and support urban forest planning, operations, and education.

Recommendation #3. Revise and develop urban forestry processes to support improvements to customer service, service delivery, data, technology, and information management using national arboricultural standards and best management practices.

Recommendation #4. Expand and develop regulations, best management practices, and guidelines to support urban forest growth and preservation.

Recommendation #5. Ensure there is adequate space for trees to grow and thrive in Worcester's challenging urban environment.

Recommendation #6. Convene a panel of area experts in 2024 for the first annual Worcester Urban Forestry Research Summit and conduct a comprehensive urban tree canopy assessment for the City of Worcester.

Recommendation #7. Continue tree planting and care citywide with attention to areas that advance city sustainability resilience and equity priorities.

Recommendation #8. Strengthen and develop partnerships with community and regional partners to support implementation of the urban forest master plan.

Recommendation #9. Implement an urban forestry communication and outreach plan that supports the growth and care of Worcester's urban forest.

Recommendation #10. Expand development and implementation of a program to monitor and address environmental threats to Worcester's urban forest.

DAVEY Resource Group

DAVEY RESOURCE GROUP, INC.

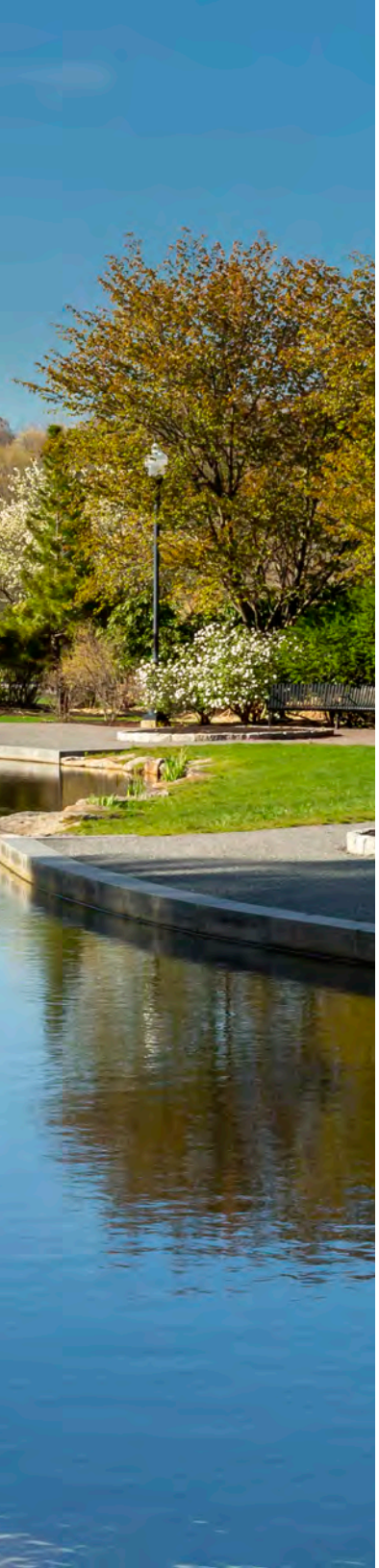
The City of Worcester selected Davey Resource Group , Inc. (DRG) to assist in the development of the Urban Forest Master Plan. DRG is recognized as a national leader in urban forestry. Over the last three decades, DRG has partnered with hundreds of municipalities across the United States to assist them in developing and implementing sustainable urban forestry programs.

CONTENTS

Section One

INTRODUCTION

"The trees in Worcester definitely add to the character of the community."
Worcester Resident



A Plan for Worcester's Urban Forest

The City of Worcester has been committed to the care, growth, and management of the city's urban forest since the late 1700s when it established its first tree ordinance.[1] Over the centuries, Worcester's resilient urban forest has seen the loss of thousands of trees to insects and diseases, hurricanes, ice storms, and even a tornado. Despite these historic disturbances and losses, Worcester's legacy of planting and care has allowed the urban forest to recover and remain a defining part of the city's landscape.

To build on this legacy of stewardship the City of Worcester has developed its first comprehensive Urban Forest Master Plan (UFMP/Plan**). The UFMP serves as a guide to aid Worcester in the development of an abundant, healthy, sustainable, and resilient urban forest.** The Plan provides insights into the current state of Worcester's urban forest and its management, and outlines recommendations and actions to ensure it is maintained as a sustainable community asset. While the urban forest encompasses all the trees in the city—those on both public and private property—the plan focuses primarily on Worcester's public street trees.

Plan Organization

The **Urban Forest Master Plan is designed to help Worcester continue its legacy of tree care and stewardship** by proactively managing, growing, caring for, and preserving the city's urban forest. The plan is organized into six sections and supporting appendices.

What is the urban forest?

The urban forest in Worcester is made up of all the trees in the city, including those along streets, in parks and open spaces, as well as in private yards and around businesses.

"Urban forests are systems of trees, other vegetation, and water within any urban area. They can be understood as dynamic green infrastructure that provides cities and municipalities with environmental, economic, and social benefits. Urban forests are forests for people." (Michael Leff, The Sustainable Urban Forest).

Leff, Michael. (2016). The Sustainable Urban Forest - A Step-by-Step Approach. Davey Institute. Retrieved from https://www.itreetools.org/documents/485/Sustainable_Urban_Forest_Guide_14Nov2016_pw6WcW0.pdf

History of Urban Forestry Management in Worcester

1761 — Worcester enacts its first tree ordinance.

1820-1830s — Public funds authorized for the planting and maintenance of street trees; first tree by-laws established to protect public trees in Worcester.

1851 — Worcester establishes a standing committee on Shade Trees and Public Grounds, making it one of the first communities in New England to assign public tree planting as a municipal responsibility.

1854 — Land is purchased for what will become Elm Park.

1863 — A prototype of a "setback tree planting program" was established, with the Shade Tree Commission paying $2 per tree planted by a citizen as a street tree.

1870-1890s — Major efforts toward public tree management including planting (mostly maples) and removal of hazardous trees made by Shade Tree Commission head, Edward Winslow Lincoln.

1880s — Massachusetts has lost around 70% of its forested land to farming and logging. Remaining forested areas are continuing to be heavily logged, sparking concern about forest conservation and protection of urban green spaces.[1]

April 30, 1885 — Nearly 500 public trees are planted in Worcester as part of Massachusetts' first celebration of Arbor Day.

1886 — Comprehensive municipal parks plan for Worcester is proposed, and 3 years later land for seven new parks has been acquired.

1890s — Early version of Massachusetts General Law 87, cementing protections for public shade trees, is established.[2]

1905 — Worcester acquires the land that will become Green Hill Park. While prior parks were mainly for the social elite, Green Hill is designated as a park specifically for the working class.

1910-1920s — Chestnut blight leads to death and removal of Worcester's American chestnuts.

1913 ↓

1910-1920s

Three-day ice storm damages 30,000 street trees and tens of thousands of park trees, mainly maple and elm.

Dutch elm disease leads to the decline and removal of most of Worcester's elm trees.

1913

Modifications to Massachusetts General Law 87 are made, bringing it to essentially the version that governs shade trees in Massachusetts today.[2]

November 1921

September 1938

Hurricane with gusts over 100 mph downs one-third of Worcester's public trees and damages many more.

1950-1970s

June 1953

A tornado touches down near the Quabbin Reservoir and tracks directly through Worcester, causing hundreds of thousands of dollars in damage to the city's infrastructure, including its public trees.

Aggressive replanting efforts are undertaken to restore canopy to areas ravaged by ALB. A mixture of pest-resistant species are chosen to decrease chances of future insect or disease-related tree loss.[5]

Asian longhorn beetle is discovered in Worcester, leading to the removal of over 27,000 public and private trees in the city.[4]

Comprehensive tree inventory finds Worcester's public tree population to be 44% smaller than previously estimated and identifies a monoculture of Norway maples.

2021-2023

Worcester partners with Davey Resource Group to conduct a comprehensive street tree inventory and develop this Urban Forest Master Plan.

2010s

2009

The Worcester Tree Initiative (WTI) a public-private partnership was initiated by U.S. Representative Jim McGovern and former Lieutenant Governor Tim Murray. The goal of the WTI was to plant 30,000 trees in the city of Worcester and surrounding areas to address tree removals from Asian longhorned beetle. Today, WTI is part of the New England Botanic Garden at Tower Hill's (NEBG) Community Greening Program.

2008

1990s

Asian longhorn beetle (ALB) arrives in Worcester but remains undiscovered.[5]

1988

1950-1960s

Strong public tree planting effort sees between 400 and 1,000 trees, mainly maples, added to public areas of the city each year in effort to replace the trees lost to earlier natural disturbances.

ASIAN LONGHORNED BEETLE IN WORCESTER

Asian Longhorned Beetle (ALB, Anoplophora glabripennis) was discovered in Worcester in 2008 by a resident who found them feeding on their backyard maple trees. ALB, an invasive wood boring beetle, was first discovered in Brooklyn, NY in 1996. Since its discovery, ALB has been found in six states, New York, Illinois, New Jersey, Massachusetts, Ohio, and most recently in South Carolina in 2020.

While ALB feeds on a variety of hardwood tree species, it prefers maples (Acer). Unfortunately, for Worcester, the many disturbances to the urban forest over the centuries led to an overabundance of maple trees on both public and private property. This made Worcester an ideal habitat for ALB - allowing the insect's population to grow.

The discovery of ALB in Worcester led to the removal of over 30,000 public and private trees—which had a tremendous impact on the urban forest and the quality of life of residents, especially those in the Burncoat and Greendale areas that were hardest hit by ALB tree removals. The tree removals led to the formation of the Worcester Tree Initiative that helped to replant over 30,000 trees on public and private property in Worcester.

ALB has not been found in Worcester since 2015 but it continues to be intensively managed by the USDA Animal and Plant Health Inspection Service through surveying and monitoring.

Impacts of ALB on Worcester's Granville Ave.
Top: 2009 before ALB removals; Middle: 2009 after ALB removals; Bottom: 2017 8 years after replanting.
Images sources: Top/Middle: Kenneth R. Law, USDA APHIS, PPQ, bugwood.org; Bottom: Linda Hubley, USDA APHIS

Alsop, P. (2009 November). Invasion of the Longhorn Beetles. Smithsonian Magazine. https://www.smithsonianmag.com/

USDA Animal and Plant Health Inspection Service. (October 12, 2022). Asian Longhorned Beetle. Retrieved from https://www.aphis.usda.gov/aphis/ourfocus/planthealth/plant-pest-and-disease-programs/pests-and-diseases/asian-longhorned-beetle

Lyford, Joshua. (2019 February 6). Worcester Tree Initiative a strong force for county canopy. Worcester Magazine. https://www.worcestermag.com/

Section 1 provided a summary of Worcester's history and its legacy of tree stewardship, outlined the planning process, and shared the science and research behind the benefits trees provide.

Section 2 presents the current state of Worcester's street trees by summarizing information from the 2022 street tree inventory to establish a baseline of where the city's urban forest is today.

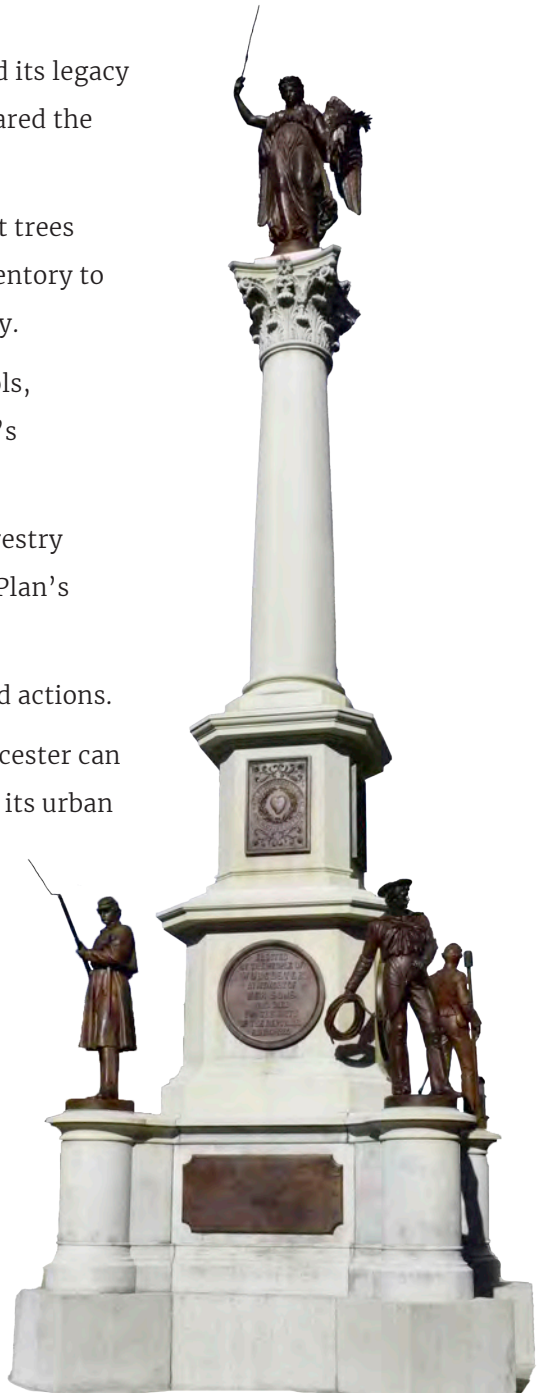
Section 3 provides an assessment and analysis of the tools, resources, plans, and programs used to manage Worcester's urban forest.

Section 4 outlines community and stakeholder urban forestry priorities and themes which were used in establishing the Plan's goals, recommendations, and actions.

Section 5 presents the Plan goals, recommendations, and actions.

Section 6, the plan's conclusion, outlines ways that Worcester can monitor and measure its progress in proactively managing its urban forest to create a sustainable and resilient resource.

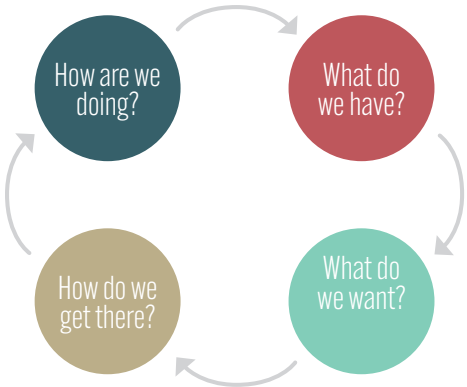
Appendices including the ordinance review provide supplemental information from the plan development process.



The Planning Process

The development of the Worcester Urban Forest Master Plan is based on the principles of *adaptive management*, which seeks to develop an effective plan by answering a series of questions about Worcester's present and future (Figure 1). Adaptive management is commonly used for resource planning and management and provides a useful conceptual framework for managing Worcester's urban forest resource. [8]

Figure 1. Adaptive management approach



Community Background

Worcester, Massachusetts, located halfway between Boston and Springfield, is New England's second-largest city and is known as "the Heart of the Commonwealth" (City of Worcester, n.d.) [9] Bordering the western shore of Lake Quinsigamond, the area marks the northern edge of the Blackstone Valley and includes the confluence of the Middle River and Mill Brook to form Blackstone River. Worcester falls within the Gulf of Maine Coastal Plain ecoregion and is slightly higher in elevation than much of eastern Massachusetts. The natural landscape is dominated by secondary growth oak-white pine forests with naturally loamy soils (37%), rocky outcrops (13%), and urban fill (44%).[10,11]

Worcester was originally inhabited by American Indians of the Nipmuc tribe living in scattered villages. Although the land that would eventually become Worcester was first purchased from the Nipmuc in 1673, it was not successfully settled by the colonial English until 1713. When Worcester was first incorporated as a town in 1722, it was a small collection of log cabins with only a couple hundred residents.[1]

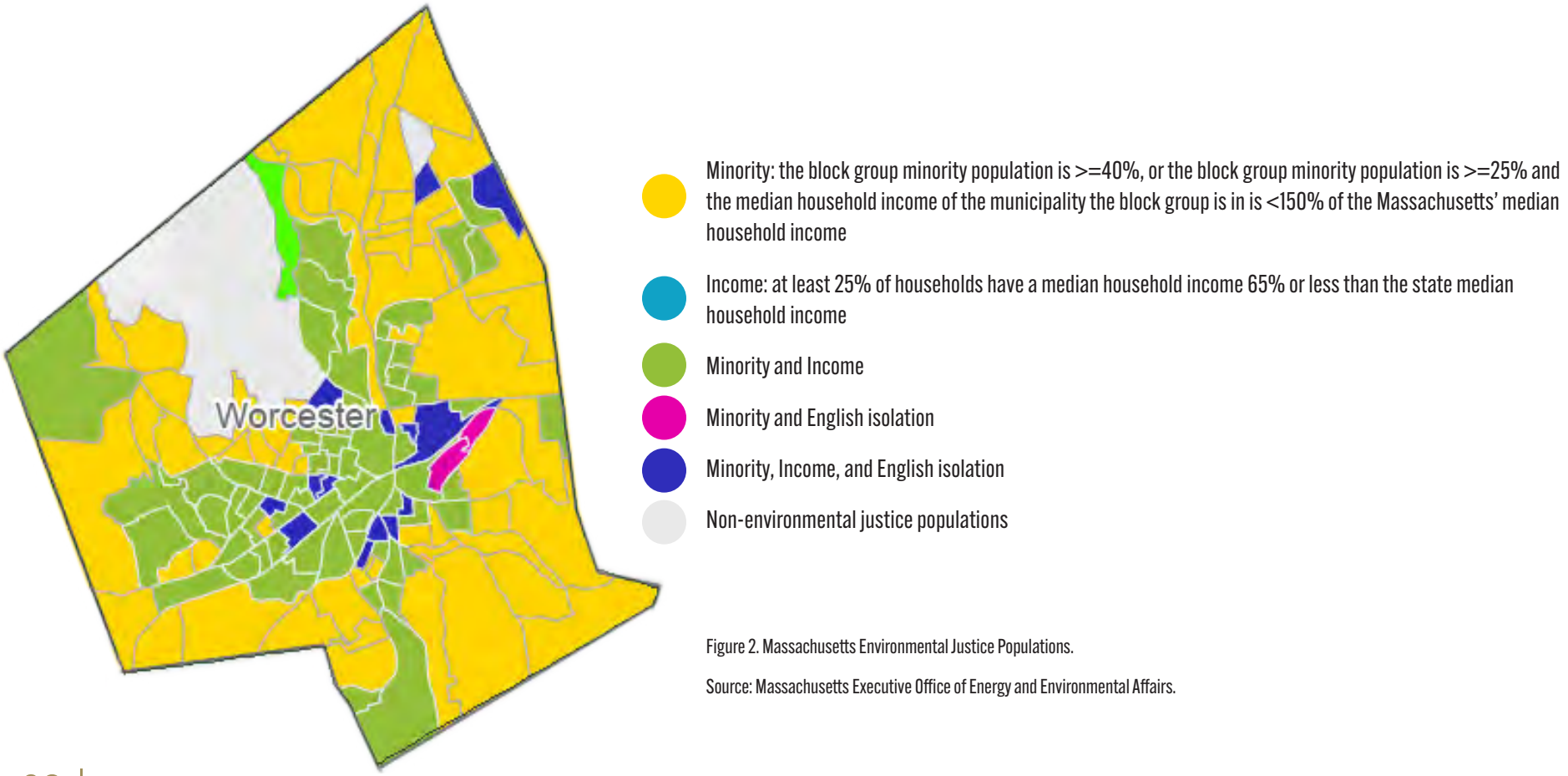


Figure 2. Massachusetts Environmental Justice Populations.

Source: Massachusetts Executive Office of Energy and Environmental Affairs.

The opening of the Blackstone Canal in 1828, which linked Worcester and Providence, Rhode Island, and the completion of the Boston and Worcester Railroad in 1835 paved the way for the industrialization of Worcester. The population of the town quadrupled between 1828 and 1850. Worcester was incorporated as a city in 1848 and became a major producer of machinery, wire products, and power looms.[12]

Increased manufacturing within the city led to an increase in the need for workers, and Worcester's population boomed after the American Civil War. The triple-decker homes Worcester is known for were constructed to house the increased working-class population, many of whom were foreign-born. The city became known as a center of reform and innovation, with major events in the abolitionist movement and women's suffrage movements taking place there.[12] After World War II, the city suffered as its manufacturing base was lost to cheaper, often overseas alternatives, and Worcester's population declined 20% to under 162,000 between 1950 and 1980.[13,14]

Worcester's population has rebounded in recent decades, becoming a center for biotechnological research, healthcare, and home to many renowned colleges and universities. Today, Worcester is home to over 206,000 people with a 2010-2020 population growth rate of 14%. The city is very diverse, with nearly half the population identifying as non-white. The median income is $48,139 with about 20% of residents living below the poverty line. Much of the city is considered an Environmental Justice area due to high minority populations, low income, and English language isolation (Figure 2).[17]

From 1901 to 2021 Massachusetts saw a 2.74° Fahrenheit (F) increase in temperature

Intercepted rainfall evaporates from leaves or slowly soaks into the ground, reducing stormwater runoff and pollutants by 20–60%

Worcester's Changing Climate

Like other cities, Worcester is facing warming temperatures and altered precipitation patterns caused by climate change. **From 1901 to 2021 Massachusetts saw a 2.74° Fahrenheit (F) increase in average annual temperature**.[18] This trend is expected to continue and by 2050 temperatures are predicted to be 2.9 to 6.3°F warmer than they are today.[19,20] Summers are predicted to feel like those in New York by 2030 and like Maryland by 2050. [21]

Extreme heat days, classified as days with a high temperature above 90°F, are expected to increase by up to 29 days in that same period.[20] While these projections have been made for Blackstone Basin at large, Worcester may see even more extreme warming due to the urban heat island effect. The urban heat island effect is caused primarily by a reduction of vegetation and the cooling effect they have on local air temperatures. Trees cool local air temperatures by increasing evapotranspiration, or the evaporation of water. Trees move water from the ground to the atmosphere where it evaporates. A healthy, mature street tree can move to the atmosphere upwards of 11,000 gallons of water per day where it evaporates and cools local air temperatures. Additionally, trees cool local air temperatures by shading pavement and buildings, which can absorb and hold onto heat.[22]

Over the last century, Central Massachusetts has also seen a **19.6% increase in precipitation**. Scientific research indicates that there will be a general increase in precipitation over the next 50 years, although it is expected to vary from year to year.[20] Worcester has historically had adequate and even rainfall throughout the year, averaging approximately 12 inches of precipitation per season, with around 72 inches of snowfall in the winter.[18] Although major shifts in the overall quantity of precipitation are difficult to predict, what is known based on current weather patterns is that more frequent extreme storm and precipitation events are likely.[19] Impervious surfaces can produce 5 times more runoff than forested area, leading to increased chances of combined sewer overflow and flooding in the more urbanized areas of Worcester.[24] More frequent severe wind events such as those commonly associated with thunderstorms and nor'easters will cause greater damage to trees and, in turn, to utilities and other infrastructure.[25] A healthy and well-distributed urban forest can help to mitigate the effects of increased temperatures, altered precipitation patterns, and more extreme weather.

The Benefits of Trees

Trees and the urban forest are constantly working to improve and enhance our environment, health, and quality of life. And unlike other types of infrastructure, the urban forest's value increases over time, returning on average $2.25 dollars in benefits per dollar spent. [26]

Trees Clean the Air. Trees intercept and filter particulate matter from the air, including dust, ash, pollen, and smoke. They absorb harmful gaseous pollutants like ozone, nitrogen dioxide, and sulfur dioxide; and reduce ozone formation by shading surfaces and reducing air temperatures**. Over 20 years, a single large, healthy red oak tree (*Quercus rubra*) growing in Worcester can remove over 33 pounds of pollutants from the air**.[27] Trees serve an important function in improving air quality and helping to lessen the public health effects of air pollution.

Worcester County's air quality was given a 'C' grade by the American Lung Association, although data over the last two decades shows a trend of general improvement over time. [28] The average asthma rate for adults in some areas of Worcester is 13% which is above Massachusetts's state average of 10.7%.[29,30] By intercepting particulate matter, **trees save over 850 lives and prevent 670,000 incidents of acute respiratory symptoms in the United States each year.** [31]

Trees Improve Water Quality and Reduce Flooding. Existing stormwater management systems are not always adequate to accommodate runoff, especially during heavy rainfall events. When a system is overloaded, stormwater may back up and cause flooding. **Trees help to prevent this back up by intercepting rainfall in their canopies** which reduces intensity of rainfall and runoff at ground level. Underground, tree root growth and decomposition increase the amount of water that soil can store, allowing for greater absorption of rain. [32] **Intercepted rainfall evaporates from leaves or slowly soaks into the ground, reducing stormwater runoff and pollutants by 20-60%**.[33]

Through these processes trees reduce stormwater runoff, flooding, and erosion, thereby preventing sediments and pollutants from entering local waterways. As extreme precipitation events in Worcester are predicted to increase in frequency and severity due to climate change, Worcester's *Municipal Vulnerability Preparedness Plan* lists trees and green infrastructure as an effective tool in mitigating stormwater runoff.

TREE CITY USA®

Tree City USA

The City of Worcester has been recognized by the Arbor Day Foundation as a Tree City USA for 36 consecutive years. The City has also been awarded the Arbor Day Foundation's Growth Award for 23 consecutive years for demonstrating increased levels of tree care and community engagement. The longevity of these accolades, in conjunction with the pioneering actions seen in the City's historic timeline, demonstrates Worcester's commitment to proper care and maintenance of the urban forest.

Trees Cool the City. Large, healthy urban trees help to lower peak summer temperatures through shading and transpiration. Shading reduces surface temperatures beneath trees, reducing peak summer temperatures by 2 to 9°F while transpiration reduces air temperature as water evaporates from leaf pores.[34,35]

As mentioned, Worcester is expected to experience more extreme heat days; with 36% of Worcester's land cover made up of impervious surface, like roads and buildings, urban heat island impacts from these extreme heat days can be significant.[36] These hot days lead to warmer nights, where temperatures do not fall below 75°F. Warm nights do not allow buildings and paved surfaces to cool off as quickly after hot days and can increase the risk of heat-related illness in city residents.[22]

Heat-related illnesses cause more deaths in the United States each year than any other weather event, including hurricanes, lightning, tornadoes, and floods.[37] Extreme heat is identified as a community hazard in Worcester's *Municipal Vulnerability Preparedness Plan.* For every 1°F increase in temperature during a heat wave, there is a 2.5% increase in the risk of heat-related mortality, in addition to respiratory difficulties, heat stroke or exacerbating existing chronic health problems.[38,39] **Trees have been shown to prevent 1,200 heat-related deaths each year in the U.S.**[40]

Trees Support Wildlife. Trees provide critical wildlife habitat for birds, mammals, reptiles, insects, fish, and other aquatic species. For birds in particular, the city's trees play a vital role during times of migration as stopover points for nesting and feeding. Tree flowers provide a valuable source of pollen and nectar to hundreds of species of native bees and other pollinators, and canopies provide both food and shelter to a variety of wildlife, increasing the biodiversity of the urban forest. Wildlife can help to manage insect pests, remove carrion, and disperse seeds. Worcester is home to Mass Audubon's Broad Meadow Brook, New England's largest urban wildlife sanctuary, which provides 400 acres of wildlife habitat.

Trees Mitigate Climate Change. Trees reduce greenhouse gases that can trap and retain heat in the atmosphere and cause the city to get warmer. Carbon dioxide, a major greenhouse gas, is absorbed (sequestered) in tree trunks, branches, leaves, and roots during photosynthesis. The amount of carbon that can be stored is directly related to the size of the tree— larger trees store more carbon. Proper investments in tree planting, care, and preservation can ensure that Worcester's trees reach maturity, when they are most effective at greenhouse gas capture. **Worcester's public street trees alone sequester 182 tons each year and store over 17,600 tons of carbon in trunks and branches over their lifetime.** This benefit can help to advance the vision presented in the *Green Worcester Plan* to eliminate GHG emissions citywide.

Trees Improve Human Health. People living in neighborhoods with more canopy cover have been shown to have better overall health, including lower rates of obesity, more social cohesion, less stress, and lower blood pressure.[41,42] A 2018 study showed that residents reporting poor mental health decreased 63% 18 months after vacant lots near their homes were planted with grass and trees.[43] Trees also improve human health by encouraging physical activity- **residents are three times more likely to be physically active when they live in areas with high levels of trees and vegetation**.[44] Tree canopy's ability to reduce surface temperatures allows for more comfortable walking, biking, and using public transit, and increases the appeal of cycling routes. These benefits contribute to the goals of *Worcester's Open Space and Recreation Plan, Worcester Now | Next,* and *Green Worcester Plan* to invest in streetscapes that prioritize safety, comfort, and sustainability for all users.

Trees Increase Safety and Community. Trees have been shown to enhance neighborhoods by increasing safety, strengthening ties between neighbors, and providing an overall sense of safety. [45] **A 10% increase in neighborhood tree canopy cover has been associated with a 12 to 15% reduction in violent and property crimes.**[46,47] Trees growing in street rights-of-way help slow traffic, making streets safer for pedestrians and cyclists.[48,49]

Trees Can Lower Utility Bills. By providing shade in the hot summer months and windbreak in the winter, trees can make a significant difference in building energy usage. **Properly placing three trees around a home can reduce energy costs for the average household by $100 to $250 per year**, while shading air conditioning units can help them run up to 10% more efficiently.[50]

Less electricity use has a secondary benefit of reducing power needs, thus a reduction in greenhouse gas emissions generated by power plants, supporting *Worcester Now | Next's* and *Green Worcester Plan's* goals of reaching net zero energy efficiency for the City of Worcester's facilities and operations.

Trees Increase Property Values and Business. Mature, healthy trees can increase property values for both residential and commercial properties by an average of 10%, as well as increase the value of neighboring properties.[51,52] This benefit can help in achieving *Worcester Now | Next's* priority goal of improving the quality of Worcester's existing housing by raising property value.

Studies have shown that a healthy tree canopy also increases business revenue. Shoppers spend more time and money in shopping districts with mature, healthy tree canopies and are willing to spend 9-12% more for products, services, and parking at businesses with trees in front of them.[53,54]

Moving Forward

Trees are essential to making Worcester sustainable and resilient and enhancing the quality of life for its residents. The Worcester Urban Forest Master Plan serves as a guide to harness and maximize the benefits that the urban forest provides through proactive management, care, and planting. The Plan's recommendations reflect the challenges that Worcester faces in being an older city that was not designed to accommodate all the needs of a modern living such as, roads to handle heavy traffic, parking, overhead and underground utilities, infrastructure, and of course trees.

Vision for Worcester's Urban Forest

Our vision is for Worcester's urban forest to continue to be a model of proactive management, sustainability, and climate resilience. We envision a city where the urban forest is well-cared for, with proactive measures in place to ensure its health and longevity. Through intentional planning and community engagement, we will ensure tree diversity and well-distributed tree canopy cover, care, and green spaces for the entire Worcester Community. Through nurturing a resilient and sustainable urban forest, we aim to create a greener, healthier, and more vibrant Worcester.

Plan Goals

Plan and Manage. Maintain Worcester's program to actively plan and manage the urban forest to support the City's sustainability, equity, and climate resilience goals and priorities.

Maintain & Grow. Increase Worcester's urban forest through continued proactive maintenance and protection to create a healthy, equitable, and resilient urban forest that maximizes the environmental, economic, and climate mitigation services trees provide.

Connect & Engage. Support and grow efforts to connect, educate, and engage with the Worcester community about the city's urban forest and the important role they play in its care and growth.

Plan Recommendations

1. Establish a proactive management program for Worcester's public trees that is beyond the current Customer Service based model.
2. Increase City staff and contractors to transition to a proactive public tree management program and support urban forest planning, operations, and education.
3. Revise and develop urban forestry processes to support improvements to customer service, service delivery, data, technology, and information management using national arboricultural standards and best management practices.
4. Expand and develop regulations, best management practices, and guidelines to support urban forest growth and preservation.
5. Ensure there is adequate space for trees to grow and thrive in Worcester's challenging urban environment.
6. Conduct a comprehensive urban tree canopy assessment for the City of Worcester.
7. Continue tree planting and care citywide with attention to areas that advance city sustainability, resilience, and equity priorities.
8. Strengthen and develop partnerships with community and regional partners to support implementation of the urban forest master plan.
9. Implement an urban forestry communication and outreach plan that supports the growth and care of Worcester's urban forest.
10. Expand development and implementation of a program to monitor and address environmental threats to Worcester's urban forest.

Section Two

THE STATE OF WORCESTER'S URBAN FOREST

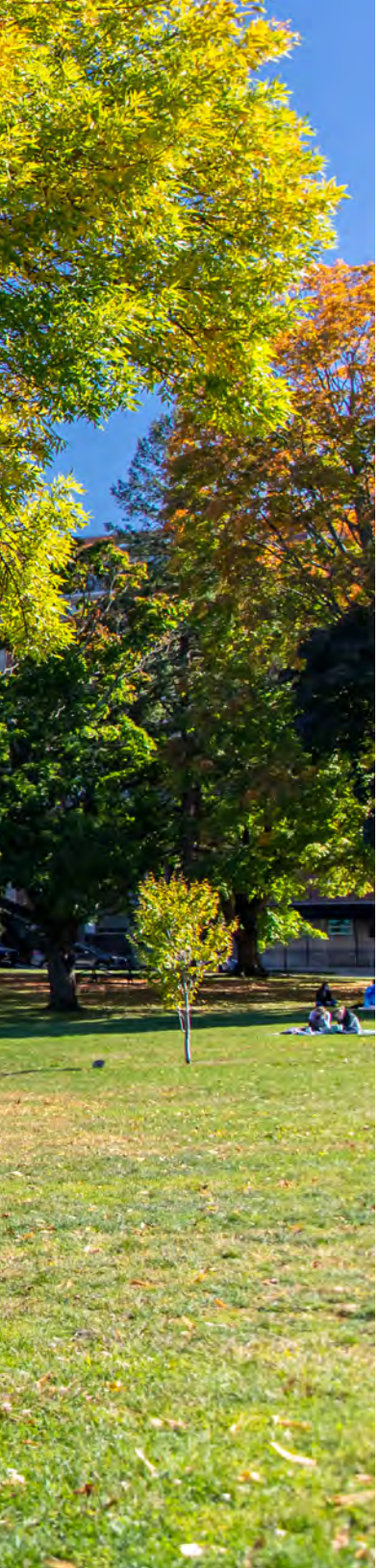
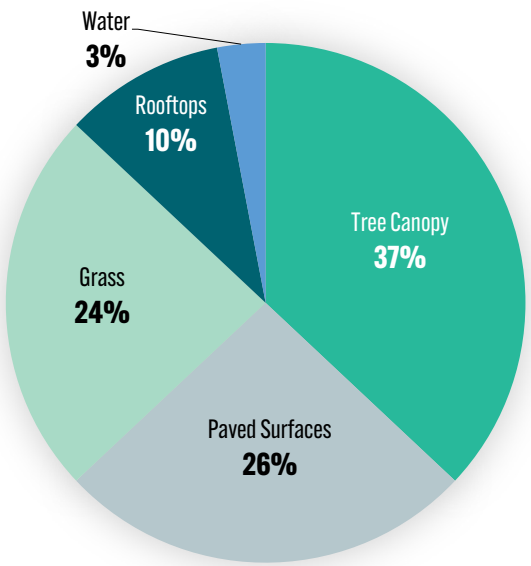


Figure 3. Land Cover



This section highlights the current conditions of Worcester's urban forest based on data and information gathered during the planning process. It focuses primarily on the city's street trees based on the 2022 street tree inventory. An inventory of park trees was not conducted as part of this project, however, students from Clark University were trained by Davey Resource Group, Inc. arborists and began data collection in City parks in fall 2022.

Tree Canopy and Land Cover in Worcester

The ability of Worcester's urban forest to provide the greatest benefits to the community is driven by the amount, location, and condition of its tree canopy. The healthier, more abundant the tree canopy cover is, the greater the benefits the urban forest provides.

An urban tree canopy assessment (UTC) uses high-resolution aerial imagery to map the amount and extent of tree canopy cover in a city on public and private property. Tree canopy refers to the combination of leaves, branches, and stems of trees and other woody plants that cover the ground when viewed from above. **The City of Worcester has not conducted a comprehensive urban tree canopy assessment,** however a heat risk assessment conducted in 2022 provides general baseline data on Worcester's tree canopy and land cover (Figure 3). The spatial scale that the heat risk assessment data is collected and analyzed has limitations when it comes to factors outside of heat island effects (e.g., stormwater, social equity factors, tree canopy benefits, etc.), as the focus is primarily on temperature variations with the urban environment.

The heat risk assessment study found:

37% *of Worcester is covered by **tree canopy***

36% *of the city is covered by **impervious surfaces**, including rooftops and paved surfaces like roads and sidewalks.*

24% *of Worcester's land is covered **by grass and other low growing vegetation**.*

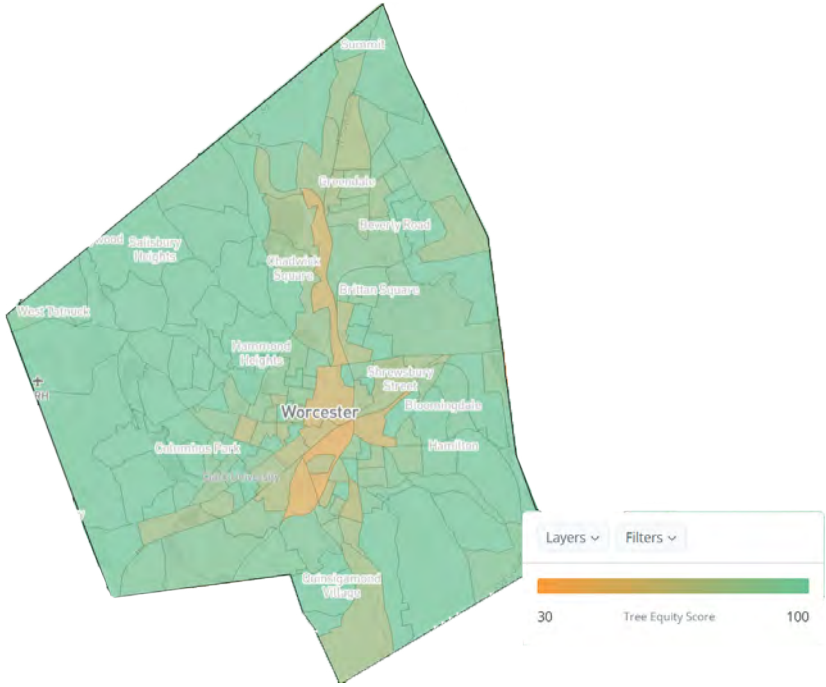
3% *of the city is **water.***

A comprehensive urban tree canopy assessment is recommended for Worcester. The assessment will provide accurate information on the distribution of Worcester's current canopy cover and benefits to guide tree planting and care activities.

American Forests' Tree Equity Score is a metric that assesses how equitably a city's urban forest is distributed based on tree canopy cover (30 meter resolution), climate, demographic, and socioeconomic data. Tree Equity Scores range from 0 - least equitable to 100 - most equitable. Although Worcester's American Forests Tree Equity citywide score is 89, which is high for an urban community, some areas of the city score as low as 45, indicating a need for more equitably distributed tree canopy in the city at large (Figure 4).[56]

The areas of Worcester with the lowest Tree Equity Scores also have some of the city's biggest challenges for growing trees, such as narrow sidewalks and planting strips, as well as underground and overhead utilities. While the Tree Equity Score map can be used to prioritize tree planting and care in the interim while an urban tree canopy assessment is being conducted – some of these areas will require creative and innovative solutions that may entail significant construction and site alterations or complete reconstruction to make them suitable for tree planting.

Figure 4. American Forest Tree Equity Score Map for Worcester.



Tree Equity scores range from 0 less equitable to 100 most equitable.

How does Worcester's tree canopy cover compare to other Northeastern US Cities? Worcester's tree canopy cover, at 37%, is higher than other Northeastern cities – whose tree canopy cover averages 26% (Figure 5).

Worcester's Publicly Managed Urban Forest

While the publicly managed urban forest includes trees growing along streets, in parks and other city properties that the City of Worcester is responsible for managing - in this section, the terms publicly managed urban forest and street trees are used interchangeably.

To view Worcester's street tree inventory data visit: https://worcesterma.treekeepersoftware.com/

Street Tree Inventory

As part of the development of the UFMP, a complete public street tree inventory was conducted in spring-summer of 2022. The inventory, which is an update to the city's 2005 inventory, was conducted by Davey Resource Group, Inc. (DRG) arborists who located and assessed all street trees, stumps, and potential planting locations within the City's right-of-way (ROW). A total of 23,137 trees, 772 stumps, and 8,494 potential sites that may be suitable for planting were inventoried. Figure 6 provides the breakdown of sites collected in each of Worcester's five Council Districts.

District 1 has the most street trees (36% of the total street trees) and the greatest tree density per public street mile (72 trees per mile). While District 4 has the least trees (6% of the total street trees) and the lowest tree density per street mile (24 trees per mile). The report *Municipal Tree Care and Management in the United States: A 2014 Urban & Community Forestry Census of Tree Activities* found, on average, communities had 76.1 trees per street mile. Using data from the 2022 street tree inventory and a 2005 inventory, Table 1 highlights changes in street tree populations by Council District and citywide from 2005 to 2022.

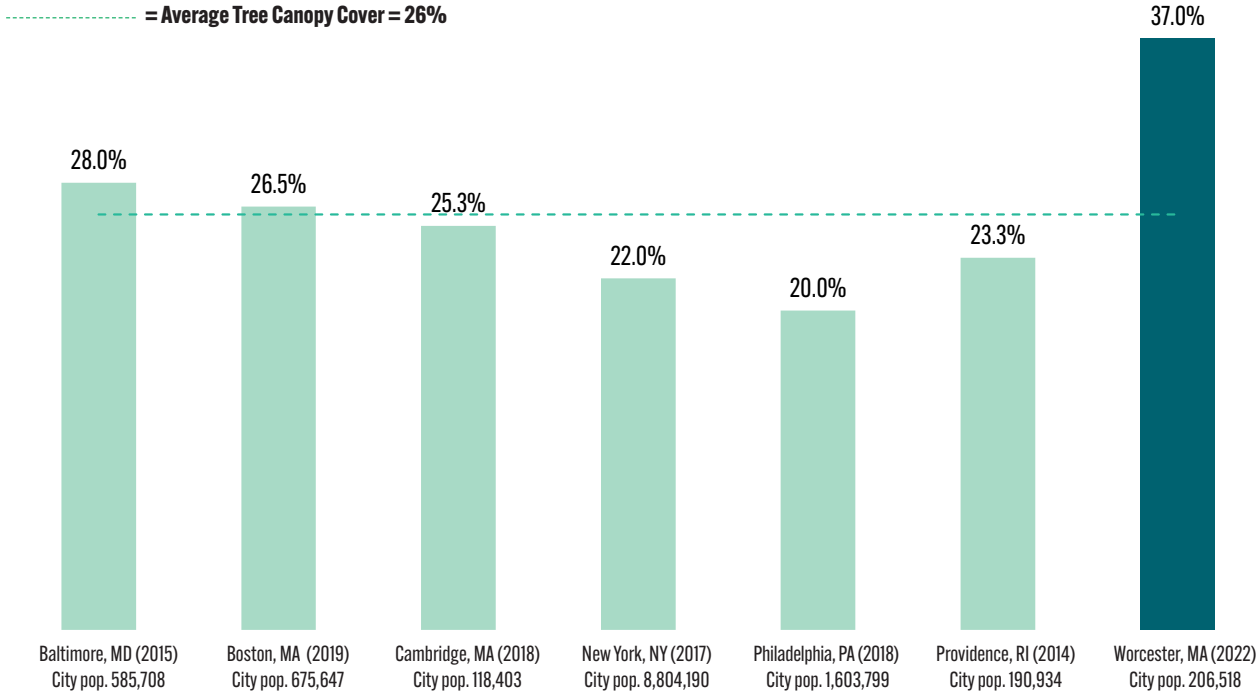


Figure 5. Worcester's 2022 tree canopy cover compared to Northeast U.S. cities.

Note: This information is provided for general comparison purposes only. The methodologies used to calculate tree canopy cover may differ between cities referenced and/or the information may be outdated.

Table 1. Street tree population changes 2005 to 2022 by Council District and citywide.

	District 1	District 2	District 3	District 4	District 5	Worcester
Number of Trees—2005	5,880	2,370	1,689	1,302	4,245	15,486
Number of Trees—2022	8,437	3,869	3,021	1,460	6,350	23,137
% change from 2005—2022	+43%	+63%	+79%	+12%	+50%	+49%
% trees per district—2022	36%	17%	13%	6%	27%	100%
Trees per public street mile—2022	72	33	36	24	55	47

Figure 6. Street trees, stumps and planting sites collected in each Council District and Worcester as whole during the 2022 street tree inventory.

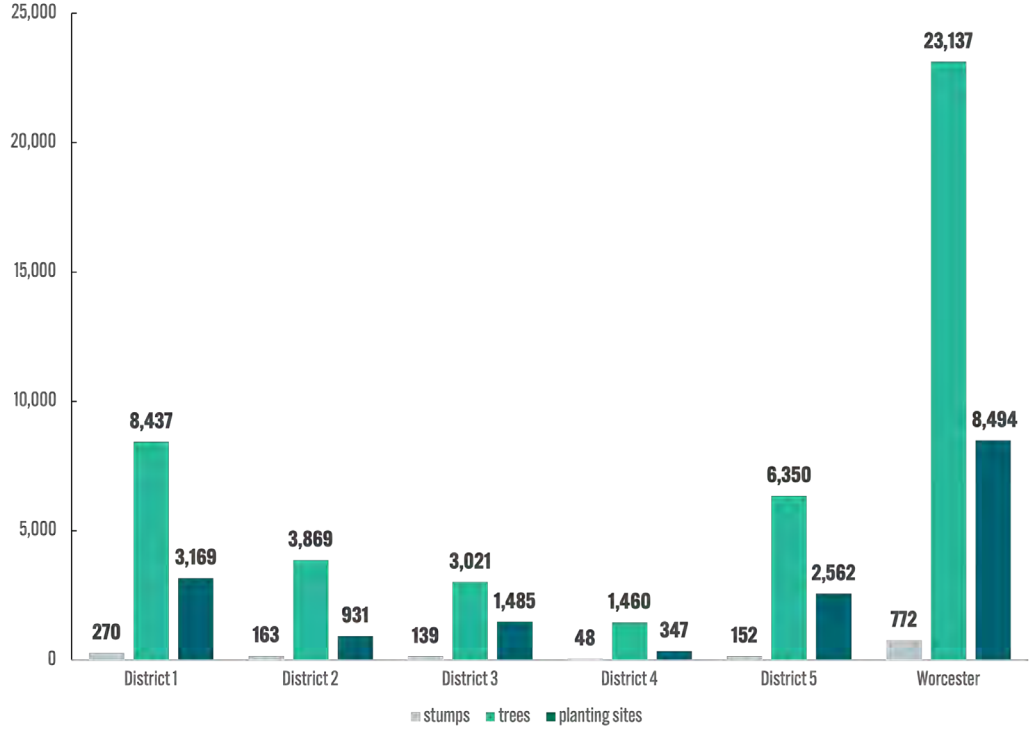
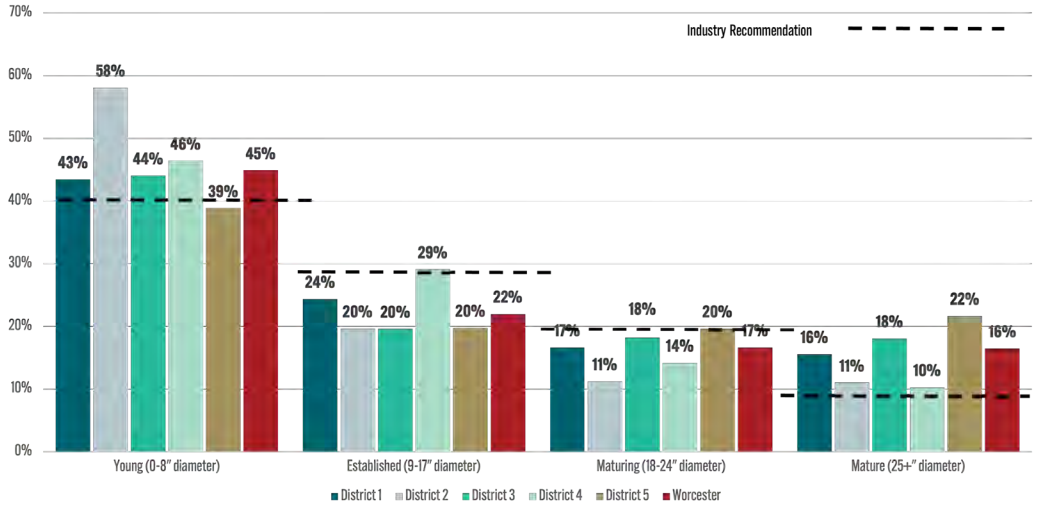


Figure 7. Size/Age distribution of Worcester's inventoried street trees



Size and Age Composition

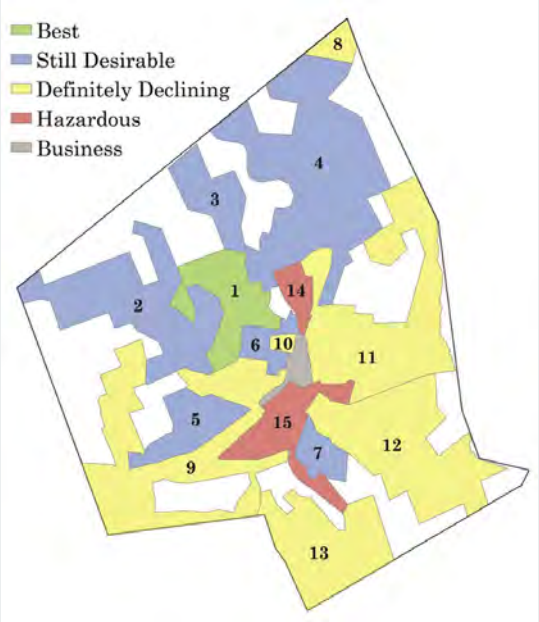
The size (diameter) of inventoried street trees can provide an estimate of the approximate age of the tree population. Since trees at different stages of development need different types and frequencies of maintenance, age structure can help inform management needs of the Worcester's publicly managed urban forest. Figure 7 compares the age structure of the trees in each district and Worcester as a whole to the industry recommended distribution.

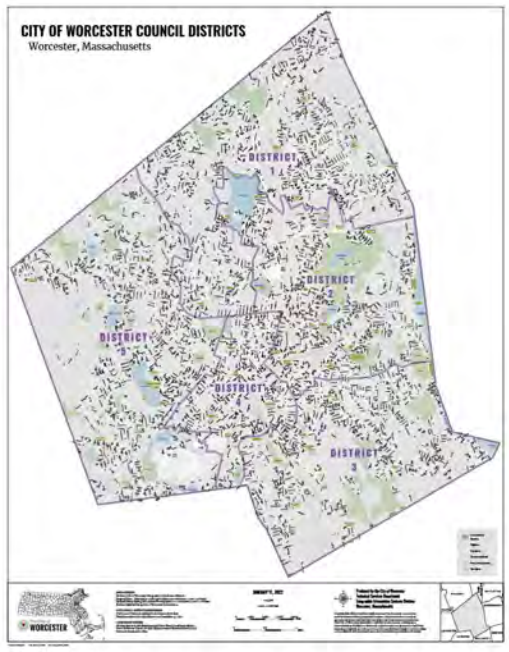
The size/age distribution of Worcester's street trees aligns closely with the industry recommendation, with more young trees and fewer trees in older age categories. Some districts have notable deviations from the industry recommendation, including District 2 which has 58% young trees, and District 5 which has 22% mature trees. Most districts have fewer trees in the established age class and more trees in the mature age class than is ideal. Continued investment in tree planting and care will help to bring the age structure of Worcester's urban forest closer to the industry recommendation over time.

Since there are so many young trees in Worcester as of 2022, investment in young tree structural training and watering programs is essential to their health, in turn reducing future maintenance costs and increasing benefits of Worcester's street trees. Districts with large populations of maturing and mature trees, particularly Districts 1, 3, and 5, are likely to need more interventions to prevent failure of branches or stems on trees which are nearing the end of their lives. These Districts are also likely to need more tree removals as older trees die or pose too great of a risk to remain on the streets.

REDLINING AND TREE CANOPY COVER

In Worcester, like many cities in the US, real estate redlining has had a lasting impact on certain neighborhoods. Redlining, a discriminatory practice in the US housing market which began in the 1930s, involved denying financial services based on racial or ethnic composition. Areas deemed less stable and desirable were "redlined," resulting in limited access to credit and other financial services. Although officially banned in 1968, the legacy of redlining persists today, with redlined neighborhoods, particularly in Council District 4, facing on-going challenges, including economic disparities, limited access to financial resources, and lower homeownership rates. Additionally, these areas lack tree canopy cover and have a higher proportion of impervious surfaces and limited planting space, exacerbating environmental challenges and contributing to issues such as the urban heat island effect. The Urban Forest Master Plan, together with other city initiatives, like the *Green Worcester Plan* and *Worcester Now | Worcester Next* aim to to address these inequities and by working towards providing equitable access to tree canopy cover and greenspace.





Map Left: Worcester Redlining Map. Source: Worcester Regional Research Bureau. (2022) Static Income, Rising Costs: Renting in the Heart of the Commonwealth. wrrb.org

Map Right: 2024 Worcester City Council District Map

Urban Forestry Industry Guidelines for Size/Age Distribution

Urban Forestry industry guidelines recommend that an ideal age distribution for a street tree population is:

40% Young (0-8 inch trunk diameter)

30% Established (9-17 inch trunk diameter)

20% Maturing (18-24 inch trunk diameter)

10% Mature (>25 inch trunk diameter)

This age distribution helps ensure that the overall canopy contains trees at varying stages of maturity. If most of a city's tree population is the same age, there is a risk of greatly reduced canopy cover when these trees die and are removed around the same time at the end of their natural lifespan.

Tree Diversity

Diverse urban forests are better able to withstand insect or disease outbreaks, extreme weather events, and climate change. The ALB infestation is an unfortunate example of why diversity matters - pre-ALB, Worcester's street trees were predominantly maple (~80%), the preferred host for the invasive insect, many of which had to be removed to help manage the infestation. Maintaining a more diverse street tree population in the future will help prevent significant losses of public trees when new threats to the urban forest arise.

Species diversity is the variety of different tree species in an urban forest. Increasing the number of tree species (greater diversity) maximizes the benefits of the urban forest, while improving its resilience to threats, including tree pests/diseases and extreme weather events like storms and drought. The inventory catalogued **165 different tree species** growing along Worcester's streets. The **top species** identified are **Norway maple (28%), cherry species (7%), little-leaf linden (5%), pin oak (5%), and honeylocust, red maple, and silver maple (4%).** These species **make up more than half (57%)** of the inventoried street tree population ("Table 2. Top 10 street tree species in Worcester 2005 and 2022").

Improving Tree Diversity in Worcester

The number of different tree species inventoried increased 68% - from 98 in 2005 to 165 in 2022, and the number of unique genera increased 31% — from 52 in 2005 to 68 in 2022.

Industry guidelines recommend that a single species should not compose more than 10% of the tree population to reduce the tree population's susceptibility to pests and diseases. While Norway maple exceeds the recommended 10% threshold – its proportion of the street tree population is trending in the right direction having decreased 30% since 2005.

Genus diversity is another way to measure the variety of trees in the urban forest—based on broader groupings of related tree species. As with species diversity, more genera (greater diversity) help make the urban forest resilient to threats. The 165 different tree species that were inventoried can be grouped into 68 different genera. Of these, **maple (38%) exceeds industry guidelines** that a single genus should not make up more than 20% of the tree population (Table 3).

When planting new street trees, Worcester should look at planting species that are less common but suitable for growing in Worcester climatic conditions, with a preference towards Massachusetts native tree species where appropriate and available.

Table 2. Top 10 street tree species in Worcester 2005 and 2022

	2005			2022		
	Species	Count	Percent of Total Population	Species	Count	Percent of Total Population
1	Norway maple *(Acer platanoides)*	9,364	60%	Norway maple *(Acer platanoides)*	6,522	28%
2	Sugar maple *(Acer saccharum)*	1,346	9%	Cherry *(Prunus spp.)*	1,700	7%
3	Red maple *(Acer rubrum)*	1,029	7%	Littleleaf linden *(Tilia cordata)*	1,161	5%
4	Silver maple *(Acer saccharinum)*	342	2%	Pin oak *(Quercus palustris)*	1,075	5%
5	Littleleaf linden *(Tilia cordata)*	335	2%	Honeylocust *(Gleditsia triacanthos)*	1,018	4%
6	Red oak (*Quercus rubra)*	327	2%	Red maple *(Acer rubrum)*	1,005	4%
7	Callery pear *(Pyrus calleryana)*	270	2%	Silver maple *(Acer saccharinum)*	820	4%
8	Pin oak *(Quercus palustris)*	265	2%	Red oak *(Quercus rubra)*	708	3%
9	White ash *(Fraxinus americana)*	225	1%	Northern white cedar *(Thuja occidentalis)*	671	3%
10	Japanese tree lilac *(Syringa reticulata)*	170	1%	Callery pear *(Pyrus calleryana)*	627	3%

Table 3. Top 10 street tree genus in Worcester 2005 and 2022

	2005			2022		
	Genus	Count	Percent	Genus	Count	Percent
1	Maple (Acer)	12,212	79%	Maple (Acer)	8,864	38%
2	Oak (Quercus)	767	5%	Oak (Quercus)	2,745	12%
3	Linden (Tilia)	378	2%	Cherry (Prunus)	2,048	9%
4	Ash (Fraxinus)	321	2%	Linden (Tilia)	1,221	5%
5	Pear (Pyrus)	271	2%	Honeylocust (Gleditsia)	1,032	4%
6	Cherry (Prunus)	184	1%	Arborvitae (Thuja)	736	3%
7	Honeylocust (Gleditsia)	182	1%	Pear (Pyrus)	630	3%
8	Lilac (Syringa)	173	1%	Zelkova (Zelkova)	591	3%
9	Elm (Ulmus)	156	1%	Apple (Malus)	585	3%
10	Apple (Malus)	108	1%	Elm (Ulmus)	419	2%

Species Vulnerability

CLIMATE CHANGE

Worcester's urban forest is vulnerable to the many effects of climate change, including flooding, extreme heat, and drought. By later in this century, the region's USDA plant hardiness zone is expected to move from 5b toward zone 6. As Worcester's climate warms, the types of trees that are planted in the city may need to change to ensure trees can survive summer heat waves and drought, as well as winter storms. Although tree species will vary in their ability to adapt to these changes, it is certain that habitat suitability will shift due to these climatic factors.

Table 4 lists species currently found growing in Worcester based on the 2022 street tree inventory and whether they are expected to gain, lose, or see no change to their habitat suitability. This information is provided by the USDA Forest Service Climate Change Tree Atlas, which models climate change scenarios to measure the current and future distribution of 134 native tree species in the eastern US. The model used for this table predicts these changes for the end of the century under a high emissions scenario in Worcester.

This information should be reviewed and updated regularly to provide an accurate projection of climate suitability. While choosing the right tree for the right place is a complex decision, considering projected climatic suitability during species selection will contribute to growing a resilient urban forest in Worcester.

Table 4. Predicted habitat change due to climate change of tree species growing in Worcester

Predicted Habitat Change	Tree Species- Common Name	Tree Species- Scientific Name
Species Habitat Predicted to INCREASE	Sugar maple	*Acer saccharum*
	Mockernut hickory	*Carya alba*
	Pignut hickory	*Carya glabra*
	American beech	*Fagus grandifolia*
	Eastern redcedar	*Juniperus virginiana*
	Sweetgum	*Liquidambar styraciflua*
	Yellow-poplar	*Liriodendron tulipifera*
	Chestnut oak	*Quercus prinus*
	Black oak	*Quercus velutina*
	Blackgum	*Nyssa sylvatica*
	Black cherry	*Prunus serotina*
Species Habitat NOT Predicted to Change	Yellow birch	*Betula alleghaniensis*
	White oak	*Quercus alba*
	Scarlet oak	*Quercus coccinea*
Species Habitat Predicted to DECREASE	Red maple	*Acer rubrum*
	Northern red oak	*Quercus rubra*
	Eastern hemlock	*Tsuga canadensis*

Tree Pests & Diseases

As Worcester is well aware of, insects and diseases can cause considerable damage and even death to trees. Their impacts can negatively affect the health, resilience, and benefits Worcester's urban forest provides; and can lead to unexpected costs to treat or remove affected trees. Climate change impacts, like drought, flooding, and high heat, will compound this issue by stressing trees and making them more vulnerable to invasion.

Overall, at least **65% of Worcester's street trees are susceptible to at least one significant pest or disease**. Insect and diseases of particular concern for Worcester's street tree population are spotted lanternfly (*Lycorma delicatula*), Asian longhorned beetle (*Anoplophora glabripennis*), European spongy moth (*Lymantria dispar*), emerald ash borer (*Agrilus planipennis),* and oak wilt (*Ceratocystis fagacearum).*

- **Spotted lanternfly** (*Lycorma delicatula*) is a non-native, invasive planthopper that feeds on a wide variety of hosts, including fruit, ornamental, and hardwood trees, vegetables, herbs, grains, and vines. It was confirmed in Worcester in September 2022. Spotted lanternfly (SLF) does not typically cause tree death, although it may weaken trees and make them more susceptible to secondary pests and diseases. It is considered a more significant public nuisance than tree-damaging agent and could have a negative impact on outdoor recreation in Worcester if it becomes established. The invasive tree-of-heaven is a preferred host for SLF, however, very few tree-of-heaven are present among the street tree population in Worcester.
- **Asian longhorned beetle** (*Anoplophora glabripennis*) is an invasive wood boring beetle that feeds on a variety of hardwood tree species - this insect is all too familiar to Worcester. ALB was first discovered in Worcester in 2008 and led to the removal of thousands of public and private trees throughout the city. It is currently being intensively managed by the federal government via survey and removal of infested trees. Depending on the Council District, between 35% and 51% of street trees are potential hosts for ALB.

- **European spongy moth** (*Lymantria dispar*) is a highly invasive pest known for defoliating oak trees. Trees can typically withstand more than one year of defoliation, but multiple years can cause stress and eventual decline. Between 23-38% of street trees in each Council District are susceptible to this insect.
- **Emerald ash borer** (*Agrilus planipennis)*is an invasive wood boring beetle that feeds on and kills all North American species of ash (*Fraxinus*). All species of ash trees are susceptible to emerald ash borer (EAB) and without treatment, trees can die from infestations. EAB was discovered in Worcester in 2016. Worcester has a relatively small population of ash species – approximately 2% (405 trees) of the city's street trees are susceptible to EAB.

- **Oak wilt** (*Bretziella fagacearum)* is a vascular disease that primarily affects oak trees (*Quercus* spp.) caused by a fungus. Oak wilt, while not yet found in Massachusetts, has been making its way further north in the past decade and has been identified in Long Island as well as several other areas of New York. This fungal pathogen can infect all oaks, although it tends to kill those in the red oak group more rapidly than those in the white oak group. Although limited to oak species, oak wilt has the potential to impact between 10% and 15% of the street trees in Worcester.

It is important to remember that the number of trees that are susceptible to notable pests and diseases only represent Worcester's inventoried street trees. Many more trees throughout Worcester, including those on private property and Conservation Commission properties, may be susceptible to hosting these and other invasive pests. **Routine inspection of City trees for signs and symptoms of pests and diseases should be conducted** to catch and control infestations early before they can become well established within Worcester's urban forest.

Street Tree Condition

The condition of the inventoried tree population provides insight into its health and sustainability. Overall, nearly 80% of the trees were in fair or good condition (Figure 8). Dead trees were uncommon and accounted for 1–2% of the street trees. District 5, notably, had more trees in poor condition than other Districts, likely due to the overall older canopy within that district (Figure 8). Regular and proactive maintenance will help improve the condition of Worcester's trees.

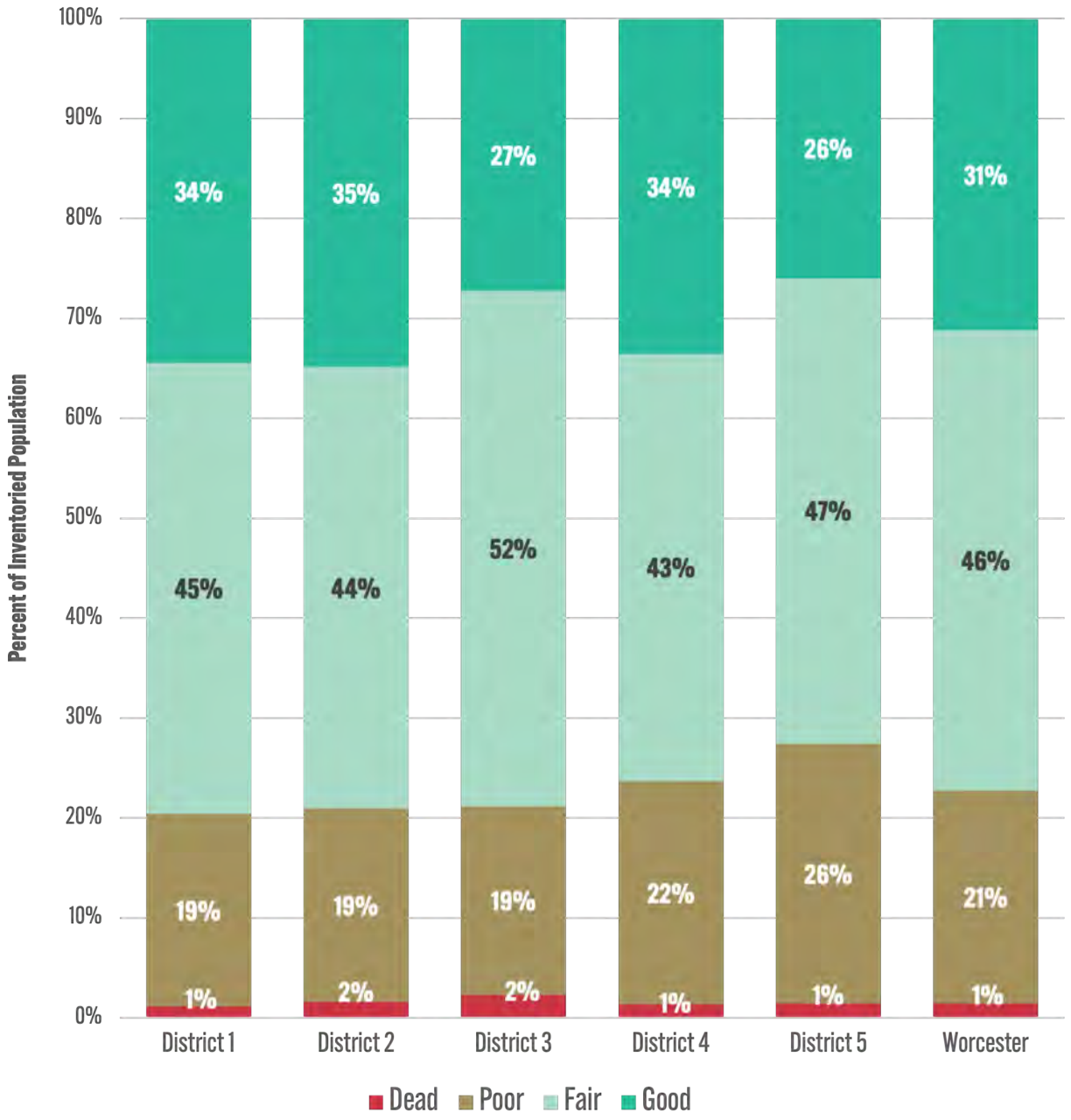


Figure 8. Condition of Worcester's street trees by Council District and Citywide

Street Tree Maintenance Needs

Each site assessed was assigned a maintenance need, indicating the type of tree work needed to improve tree health, mitigate defects, or grow the public urban forest (Figure 9). The **most common maintenance need of inventoried sites is pruning with 63% of trees needing some type of pruning – training pruning of young trees, high-priority (risk-based) pruning, or routine (general maintenance) pruning.** Tree maintenance activities are prioritized based on risk and available resources with tree removals and high priority pruning addressed first before routine pruning, stump grinding, and other activities.

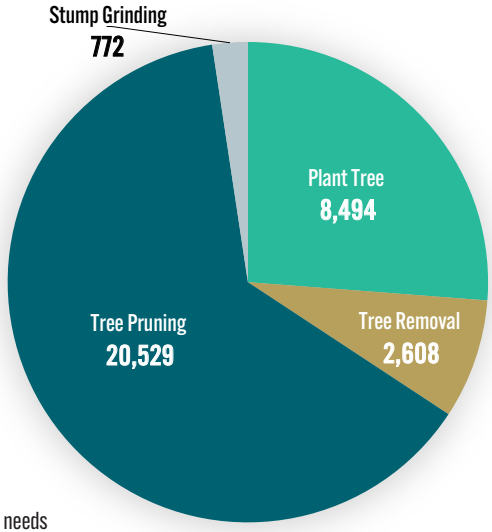


Figure 9. Street tree maintenance needs

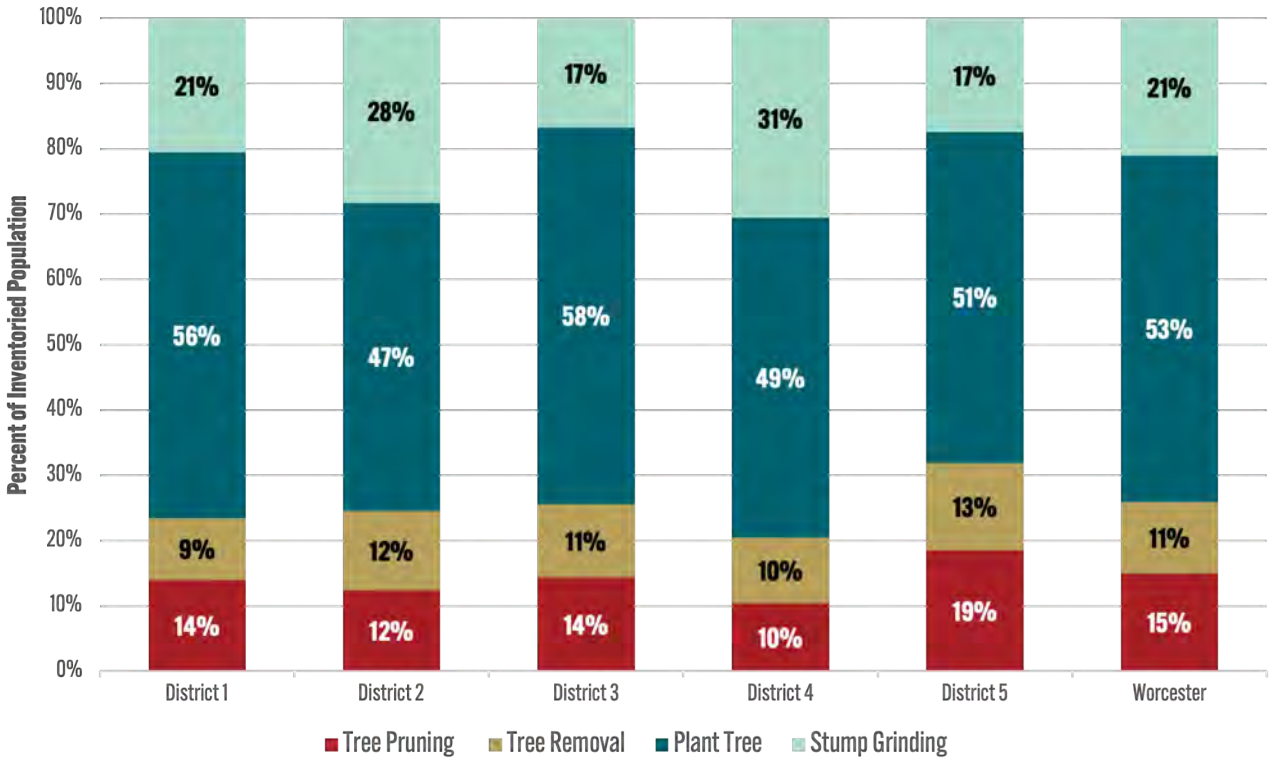


Figure 10. Street tree pruning and removal needs by Council District and City-wide (Worcester)

District 5, which has a larger population of mature trees and trees in poor condition, received more recommendations for priority pruning than the other Districts (Figure 10). Districts 2 and 4, with large populations of young trees, required more young tree training pruning. Removals were relatively consistent between Districts, with between 9% and 13% of all trees recommended for removal.

CARBON BENEFIT

Over their lifetime – Worcester's street trees ,as of 2022,have stored over 17,600 tons of carbon.

1 ton = 2,200 pounds

The amount of carbon stored in Worcester's street trees is equal to the carbon emissions from 12,500 cars.*

THE VALUE OF ONE TREE

As trees grow and mature the amount of carbon they absorb and store increases - for example**:

A 10" pin oak (*Quercus palustris*) can absorb 29 pounds of carbon each year and over its lifetime will have stored 356 pounds of carbon.

While a 24" pin oak can absorb 60 pounds of carbon each year and will have stored 2,090 pounds of carbon during its lifetime.

*USDA Forest Service i-Tree Tools. (2023). i-Tree Ecosystem Analysis: Worcester Tree Benefits Report.

Benefits of Worcester's Street Trees

Worcester's inventoried street trees provide significant environmental benefits. These annual benefits were estimated using the i-Tree Eco modeling software (Table 5). The software tools in i-Tree are routinely updated based on the latest science and research, however, the tools may over or under estimate the actual benefits of the urban forest. Worcester's inventoried street trees:

- **Remove 7,940 pounds of air pollutants**, including ozone, nitrogen dioxide, sulfur dioxide, carbon monoxide and fine particulate matter. This helps improve air quality and reduce the public health effects of air pollution as well as reduce atmospheric warming. **Absorb 181 tons of carbon each year** helping to reduce the amount of carbon dioxide in the atmosphere. Carbon dioxide is a greenhouse gas that traps and retains heat in the atmosphere causing the city to get warmer.
- **Intercept and absorb over 2.4 million gallons of stormwater** in their canopies and roots, helping to reduce the amount of water entering Worcester's storm sewer system, reducing flooding potential, and improving water quality.

As the street tree population continues to grow in size and composition, the benefits it provides will continue to increase.

While i-Tree quantifies some tree benefits, as highlighted in Section 1, trees also lower summer temperatures, boost property values, reduce energy costs, lower crime rates, and help create more successful business districts.

Table 5. Street tree benefits by Council District and city-wide (City of Worcester)

	Trees	Total Carbon Storage		Annual Carbon Sequestration		Annual Stormater Avoided Runoff		Annual Pollution Removal		Replacment Value
	#	(ton)	($)	(ton/ year)	($/year)	(gallons/year)	($/year)	(pounds/year)	($/year)	($)
District 1	8,409	6,205	$1,058,341	68	$11,528	940,017	$8,400	3,040	$27,093	$14,557,627
District 2	3,856	2,116	$360,889	24	$4,013	314,775	$2,813	1,020	$9,072	$4,973,095
District 3	2,976	2,533	$432,002	25	$4,310	342,050	$3,057	1,110	$9,858	$5,497,379
District 4	1,453	886	$151,170	11	$1,804	133,199	$1,190	420	$3,839	$2,095,784
District 5	6,311	5,899	$1,006,010	54	$9,285	729,347	$6,517	2,360	$21,021	$12,635,331
City of Worcester	23,005	17,639	$3,008,412	182	$30,940	2,459,388	$21,977	7,950	$70,883	$39,759,216

The structural value (or the replacement value) of Worcester's inventoried street trees is **$39.8 million dollars** (or on average $1,728.51 per street tree). Structural value represents the cost to replace a given tree with one of a similar size and species. While this is not typically practical - for example, it is not possible to replace a 20-inch diameter oak tree with another 20-inch tree instantly - replacement value can provide an estimate of the overall value of Worcester's street tree population. Structural value increases over time as more trees are planted and existing trees mature. The total value of Worcester's publicly managed urban forest will increase considerably in future years as the Worcester's young tree grow and the City works towards achieving the Urban Forest Master Plan goals.

The recommended UTC will provide estimates on the benefits provided by Worcester's entire urban forest, not just the street trees, and help to identify how those are changing with time.

Worcester's changing street trees—2005 to 2022

Worcester's street tree population is larger, younger, healthier, and more diverse today than it was in 2005.

SPECIES DIVERSITY.

- From 2005 to 2008 **the proportion of maple (*Acer*) street trees decreased from 79% to 38%.**
- **Norway maple (*Acer platanoides*), the most predominant street tree species, decreased** from 60% of the population in 2005 to 28% of the population in 2022.
- Populations of other species, including oak, cherry, linden, honeylocust and other **non-ALB host species increased 1000%.**

INVESTMENT IN STREET TREE PLANTING.

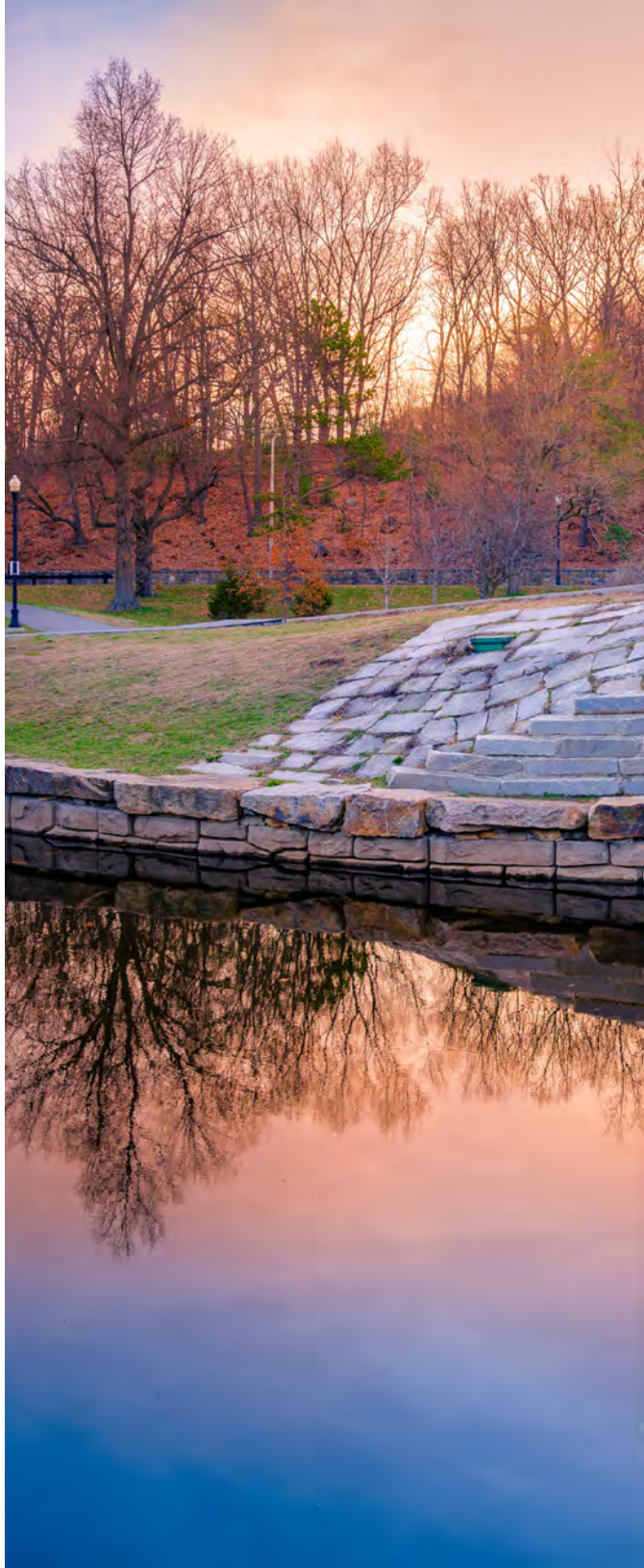
- Despite the significant street tree losses from ALB beginning in 2008, the **total number of public street trees increased by 49%.** All Council Districts saw a net increase in public street trees.

AGE DIVERSITY.

- In 2005, young trees made up 17% of the street tree population. Due to increased tree planting, young trees make up 45% of the street tree population in 2022.
- Maturing and mature trees made up 57% of the population in 2005; this overabundance is being addressed and the population of this age category decreased to 33% in 2022.

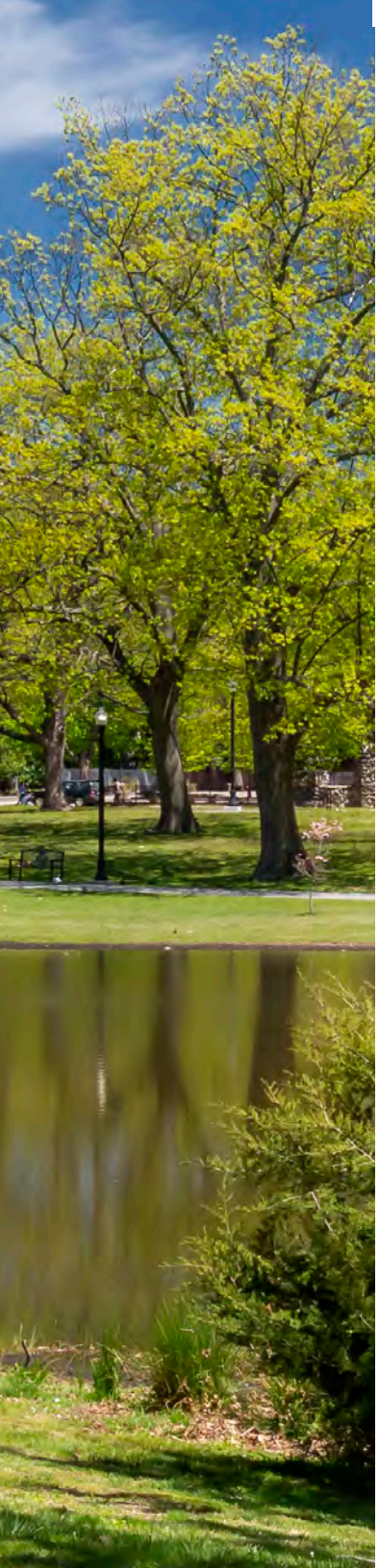
IMPROVED TREE HEALTH.

- The condition of Worcester's street trees has improved significantly since 2005. **In 2022, 31% of street trees are listed in good condition, while only 7% were listed in good condition in 2005.**



Section Three

MANAGING WORCESTER'S URBAN FOREST



Indicators of a Sustainable Urban Forest

The *Indicators of a Sustainable Urban Forest* is a program assessment tool that uses industry standards and best management practices to assess a city's urban forest, its management, and the community and stakeholders that influence it. To establish the current sustainability performance level of Worcester's urban forest, the city was assessed on 29 urban forest indicators, broadly categorized into three components: The Trees, The Players, and The Management Approach. For each component, a list of indicators and metrics were used to assess Worcester's current performance level related to that component.

A variety of sources of information - staff and stakeholder interviews, policies and plans, GIS and inventory data, work records, national industry standards and best management practices - were used in Worcester's assessment ("Table 6. Worcester's Assessment of The Trees and Urban Forest Indicators of a Sustainable Urban Forest", Table 7, "Table 8. Worcester's assessment of the Management Approach Indicators of a Sustainable Urban Forest").

Worcester's current assessed performance level for each component:

The Trees & Urban Forest: ***MODERATE***

The Players (Community & Stakeholders): ***LOW-MODERATE***

The Management Approach: ***MODERATE***

The results of the assessment highlights the strengths and identifies areas where Worcester's urban forestry program can be improved. The results were used in development of the Plan's recommendations.

The sections that follow provide details into the factors that influenced Worcester's assessment.

Indicators of a Sustainable Urban Forest Assessment Summary

21% of Indicators assessed as LOW

28% of Indicators assessed as LOW-MODERATE

24% of Indicators assessed as MODERATE

17% of Indicators assessed as MODERATE-HIGH

10% of Indicators assessed as HIGH

Table 6. Worcester's Assessment of The Trees and Urban Forest Indicators of a Sustainable Urban Forest

The Trees and Urban Forest	City of Worcester assessed Performance Level		
	Low	Moderate	High
Urban Tree Canopy No canopy goals have been set and an urban tree canopy (UTC) assessment has not been completed.	■		
Equitable Distribution There is support from the City, partners, and residents to focus planting efforts on neighborhoods with low tree canopy. However, planting in these neighborhoods is often difficult or impossible due to a lack of viable planting sites in the City right-of-way.		■	
Size/Age Distribution The age distribution citywide is close to the ideal guidelines.			■
Condition of Public Trees - Streets, Parks Street tree inventory was updated in 2022. An inventory of park trees is underway by Clark University students.		■	■
Condition of Public Tree - Natural Areas Assessments of City-owned natural areas have not been done.	■		
Trees on Private Property Information is not available for trees on private property.	■		
Species Diversity Norway maple exceeds the recommended 10% species maximum and maple species exceeds the recommended 20% genus maximum.		■	■
Suitability Most City trees are appropriate species for the urban environment and Worcester's current climate.		■	

Table 7. Worcester's assessment of The Players (Community and Stakeholder) Indicators of a Sustainable Urban Forest

The Players (Community & Stakeholders)	City of Worcester assessed Performance Level		
	Low	Moderate	High
Neighborhood Action There were very active citizen groups in the wake of Asian longhorned beetle (ALB), but they have disbanded. City Forestry and partners work with homeowners to select and site new plantings, recognizing the importance of neighborhood buy-in.	■	■	
Large Private and Institutional Landholder Involvement Large landholders include hospitals, colleges/universities, railroad, and private citizens. The level of involvement in City urban forestry initiatives is low.	■		
Green Industry Involvement The City has an active partnership with the New England Botanic Garden at Tower Hill. Involvement of other green industry partners is limited.	■	■	
City Department/Agency Cooperation There are good working relationships among city departments and Forestry but coordination is not standardized and is mainly reactive, and at times may not occur.	■	■	
Funder Engagement Funding is primarily through the City of Worcester budget. The City also receives funding from the Commonwealth and is participating in the Massachusetts Department of Conservation and Recreation *Greening the Gateway* program.		■	
Utility Engagement Forestry Division has a good relationship with National Grid and works with them on utility pruning practices.		■	
State Engagement Worcester is participating in the *Greening the Gateway* Cities with the Massachusetts Department of Conservation (DCR).			■
Developer Engagement Developers are not currently engaged in City urban forestry initiatives.	■		
Public Awareness The Urban Forest Master Plan community survey highlighted that residents understand the benefits and value Worcester's trees and urban forest. Engagement around tree care and City Forestry operations needed.		■	■
Regional Collaboration Partnerships exist outside Worcester, including with the New England Botanical Garden at Tower Hill. Opportunities for partnerships with other cities and the county exist.	■	■	

Table 8. Worcester's assessment of the Management Approach Indicators of a Sustainable Urban Forest

The Management Approach	City of Worcester Assessed Performance Level		
	Low	Moderate	High
Tree Inventory Street tree inventory updated in 2022. Park tree inventory began in fall 2022 and is being conducted by Clark University students.		■	■
Canopy Assessment Heat study conducted by Worcester's Department of Sustainability and Resilience in 2022. While not a complete urban tree canopy assessment but provides land cover data that can be used as a baseline.	■	■	
Management Plan An urban forest management plan is not currently in place. Worcester is developing an Urban Forest Master Plan to guide management (2023).	■	■	
Risk Management Program Street tree inventory updated in 2022. Forestry prioritizes work based on high-risk trees identified in the tree inventory and resident requests.		■	■
Maintenance of Publicly-Owned Trees (ROWs) Street tree maintenance is primarily request driven but is beginning to transition to proactive maintenance.	■	■	
Maintenance of Publicly-Owned Natural Areas Forestry does not manage natural area trees. The Division of Planning and Regulatory Services oversees Conservation Commission properties. No management plans are currently in place to manage these properties.	■		
Planting Program Consideration is given to planting the "right tree in the right place" and to improving canopy cover in areas that are lacking trees when possible.		■	
Tree Protection Policy Shade trees are somewhat protected under the Massachusetts Shade Tree Act but there are no tree protection regulations for trees in Worcester on either public or private property.	■	■	
City Staffing and Equipment Accredited and professional Forestry staff. Staffing levels and positions are not adequate to meet resource needs and operate a proactive program. Equipment is adequate or better and is maintained and replaced routinely.		■	
Funding Funding comes from City general fund and primarily covers reactive management.		■	
Disaster Preparedness & Response Worcester's Department of Emergency Communications and Management oversees disaster preparedness planning in the city. The Local Emergency Planning Committee is responsible for annually updating the city's plan.	■	■	
Communication Communication avenues are in place, however, better processes for proactive communication and coordination internally and externally are needed.		■	

Worcester's Urban Forest Management Program

Like other city infrastructure, including roads, bridges, and utilities, Worcester's trees require proactive and routine maintenance to ensure a safe, resilient, and sustainable urban forest. Proactive tree maintenance:

- ***improves public safety & manages risk*** by addressing the maintenance needs of trees that pose the highest risk first.
- ***lowers per tree pruning costs*** compared to reactive pruning done in response to requests, emergencies, and storms.
- ***lessens storm damage*** through regular pruning that supports the development of proper tree form and structure.
- ***reduces future tree care costs*** as trees pruned frequently, especially when young, require less maintenance as they age.
- ***improves customer service*** by pruning and removing trees before they become a problem or risk.
- ***creates a sustainable & equitable urban forest*** by systematically maintaining all public trees– not just ones where maintenance has been requested.

However, due to limited resources, Worcester's public tree maintenance program is primarily reactive. **Tree care activities are driven by resident requests, emergency work, and storm events**. This section describes Worcester's urban forestry program, and the tools and resources needed to manage it.

Department of Public Works and Parks, Forestry Operations

The City of Worcester's Department of Public Works and Parks (DPW&P) Forestry Operations* is responsible for managing over 23,100 street trees, 8,500 planting sites, and 772 stumps along the city's 495 miles of public streets, as well as thousands of trees growing in city parks. Forestry does not prerform tree maintenance activities on private property.

The Worcester City Forester and a team of staff in DPW&P manage the street and parks trees through:

- tree pruning
- tree removal
- tree planting
- conducting tree inspections
- site plan and construction plan review for private and public projects
- interdepartmental coordination
- tree data management
- customer service support

*Forestry Operations and Forestry are used interchangeably throughout this document.

National and Regional Benchmarking

Worcester's urban forestry program was benchmarked against national and regional communities using the report Municipal Tree Care and Management in the United States: A 2014 Urban & Community Forestry Census of Tree Activities (2014 Municipal Tree Care Census). This is the fifth edition of the report which was first published in 1976.

The 2014 Municipal Tree Care Census is based on data from 667 communities throughout the United States. The report contains information and statistics on urban forestry funding, policies, staffing and other urban forest management program elements. The report analyzes data for all communities combined, as well as, for communities organized by geographic region and population size.

Benchmarking Worcester's urban forestry program to national and regional communities is a helpful exercise to see how program elements align and identify program needs and priorities.

Hauer R. J. and Peterson W. D. (2016). Municipal Tree Care and Management in the United States: A 2014 Urban & Community Forestry Census of Tree Activities. Special Publication 16-1, College of Natural Resources, University of Wisconsin - Stevens Point. 71 pp. Ottman, K.A. and J.J. Kielbaso. (1976). Managing Municipal Trees, Urban Data Service Reports. Volume 8(11). International City Management Association, Washington, DC. 16 pp.

BUDGET AND FUNDING

Worcester's urban forestry program is funded through tax levy, tax levy capital, Commonwealth funding, and grants. Figure 11 displays Forestry's Operations and Maintenance budgets from 2019-2022. **Forestry's budget has seen an increase in funding** over that time period.

Worcester's urban forestry budget was compared to U.S. communities that completed the 2014 Municipal Tree Census (see National and Regional Benchmarking sidebar). Worcester's per street tree spending, while higher than other northeast cities, is **7% lower than "All Cities" and 39% lower than cities with populations similar to Worcester between 100,000 and 249,999 people** (Figure 12). It should be noted that over one-third 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 is also true for Worcester.

Forestry's limited budget resources have led Worcester to operate a reactive program. A reactive urban forestry program leads to inefficient service delivery, low customer satisfaction and negatively impacts the overall condition, value, and sustainability of Worcester's trees.

A goal of the Urban Forest Master Plan is to move the Worcester's Forestry management program from reactive to proactive. However, as it currently stands Forestry's budget is not sufficient to proactively care for the public tree population and address resident requests, resulting in a backlog of tree removal and pruning work orders.

While understanding that the average community budget in the 2014 Municipal Tree Care Census may not be adequate to manage a community's public trees, **a sustained increase of $500,000 per year to Forestry's budget** is needed for Worcester to achieve the $80.77 per street tree average for cities with populations between 100,000 and 249,999.

With this increase, Worcester could fund activities, including:

- addressing the backlog in tree maintenance work orders and requests.
- shifting to proactive maintenance, including implementing an annual street tree pruning cycle.
- increasing the use of contractors to support tree removal, tree planting, stump grinding, storm response, and tree maintenance activities for City projects and other departments.

In addition to City budget dollars, alternative sources of funding should be explored to expand investment in Worcester's public urban forest (see sidebar *Exploring New Sources of Funding to Support Worcester's Urban Forest).*

Figure 11. Worcester's Forestry budget by fiscal year 2019-2022

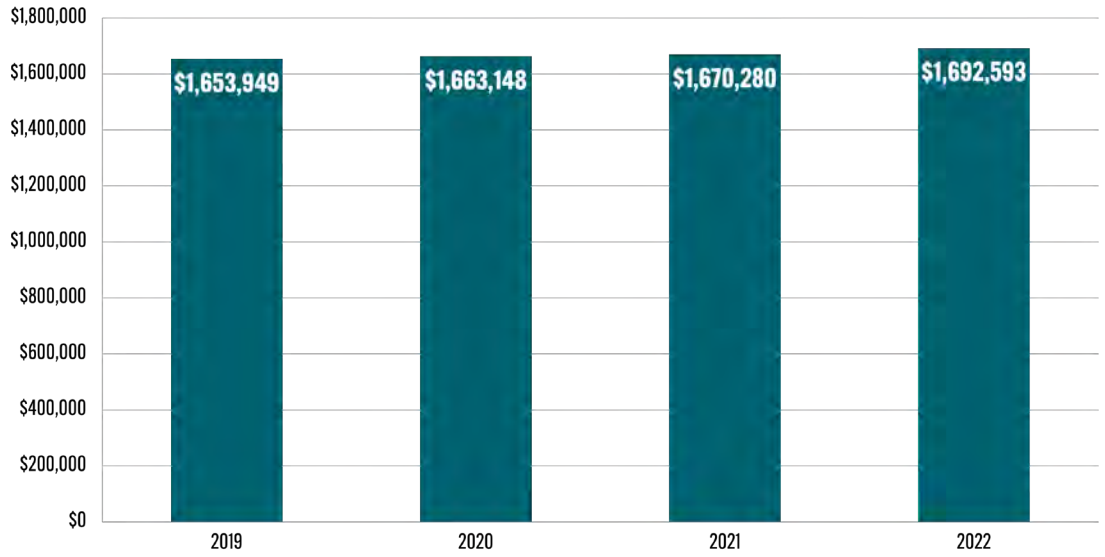
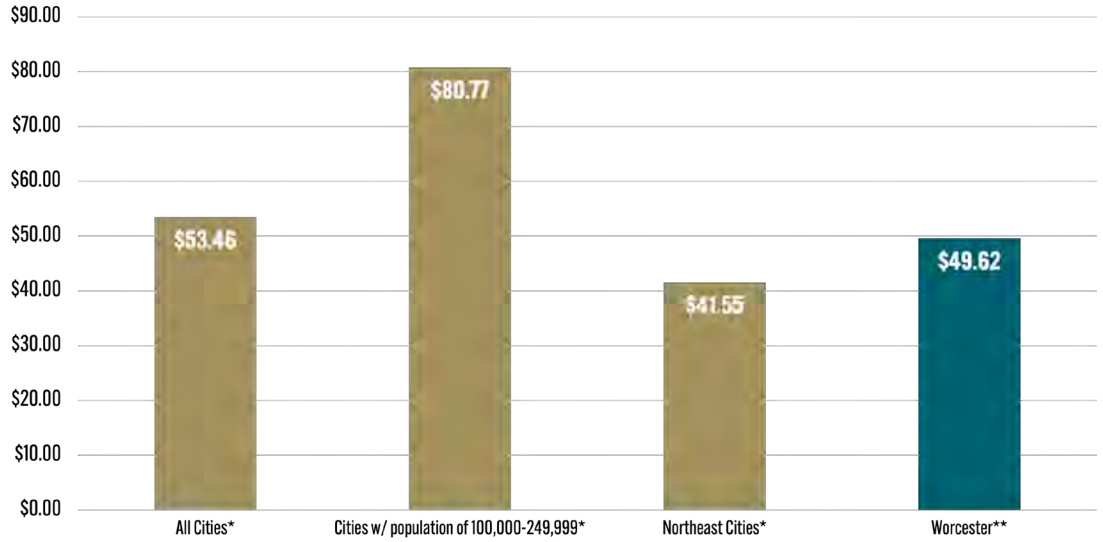


Figure 12. Worcester's estimated per street tree spending compared to respondents of the 2014 Municipal Tree Care Census.



*2014 Municipal Urban Forest Census. Per street tree costs have been adjusted for inflation and represent October 2022 costs (based on CPI inflation calculator)

**Approximately 17% of Forestry's annual operating budget goes towards non-tree care and planting related activities, including leaf pick and biomass recycling.

Managing Conservation Commission Properties

The Worcester Conservation Commission (ConCom) oversees the management of approximately 830 acres of mostly forested land, which play a vital role in Worcester's environmental well-being. These properties offer numerous benefits, such as cooling effects, water quality protection, flood reduction, wildlife habitat, and greenspaces for public enjoyment.

Currently, the management of ConCom properties is primarily reactive due to limited resources and staff in Planning and Regulatory Services. Management activities focus on addressing issues like hazard tree complaints and illegal dumping. However, according to the approved *Worcester Open Space & Recreation Plan Update 2021*, there is a significant need to adopt a more proactive approach to planning and management. Recognizing the substantial natural resources present on these properties, increased funding for their management and maintenance, along with the addition of a dedicated staff position for land management, would enable a more comprehensive and proactive strategy.

Proper management and preservation of the Worcester Conservation Commission properties will not only protect important habitats but also contribute towards meeting city resiliency goals and enhance the well-being and quality of life for the community as a whole.

EXPLORING NEW SOURCES OF FUNDING TO SUPPORT WORCESTER'S URBAN FOREST

As Worcester looks to increase investment in the urban forest, alternative funding sources should be identified and explored, including:

Street Tree Assessment. In Ohio, state code (Ohio Revised code Chapter 721.011) permits municipalities to collect fees for the planting, care, and maintenance of public trees. This assessment is utilized by many communities in Ohio, including Cincinnati and Toledo. The most common method of assessment is charging a fee based on the amount of right-of-way frontage - amounts range from $0.19 -$1.16 per foot of right-of-way frontage.

"Percent for Trees" Program. Investigate development of a program where a percentage of all City Capital Improvement Project budgets are set aside for public tree maintenance and planting related to or within a project area. This type of program has been used in communities to fund art programs.

Fees. Institute fee-based Forestry plan review and inspections for both private and public activities.

Stormwater Enterprise Fund. Explore development of a stormwater utility that could direct funding to the forestry program in recognition of the stormwater benefits that the City's street trees provide. The city's 23,000 plus street trees alone intercept over 2.4 million gallons of stormwater each year.

Special Taxing Districts/Assessment District. Designate an area as a special taxing district, where property owners allow the City to provide a public improvement or special service through a non-ad valorem assessment (not based on property value).

Internal Budget Transfers Between Departments. Conduct a budget analysis to identify where Forestry can recoup costs for work provided to other city departments. Determine if there may be justifiable reallocations of budget resources or opportunities to share resources between departments.

Grant Opportunities. Explore grant opportunities that connect to the benefits trees provide to Worcester, like improving air quality (public health) and increasing canopy in low-income/low canopy neighborhoods (equity and environmental justice) and support management needs for ConCom properties and conducting an urban tree canopy assessment.

Enhance collaborations with academic institutions and non-profit organizations to facilitate joint efforts in applying for grants.

STAFF

In 2023, Forestry has 10 budgeted positions: a City Forester, a foreman, two working foreman, and six arborists ("Table 9. Worcester DPW&P Forestry Division positions"). In addition to the direct Forestry positions, the Assistant Commissioner of Department of Public Works and Parks (DPW&P) serves as Worcester's Tree Warden – overseeing the care and maintenance of city trees – as mandated by Massachusetts General Law.

Table 9. Worcester DPW&P Forestry Division positions

Full Time Positions	Number of Budgeted Positions	Number of Vacancies	Current Duties
City Forester	1	0	Manages and administers Worcester's urban forestry program.
Foreman	1	0	Oversees crews, reviews service requests, creates, and delegates work assignments, conducts tree inspections, and supports City Forester.
Working Foreman	2	0	Leads city tree crews and performs tree maintenance activities and supports Foreman and City Forester with assignments.
Arborist	6	1	Performs tree maintenance activities.

The 2014 Municipal Tree Care Census found the average number of street trees per forestry employee for "All Cities" was 4,821.[70], Worcester has 16% less trees per employee then the national "All Cities" average (Figure 13). It is important to note the street tree per employee calculations do not take into consideration cities that contract all or part of their street tree maintenance operations.

While Worcester is below the "All Cities" street tree per employee average – the reactive nature of its program indicates that it does not have sufficient resources to transition to a more proactive program.

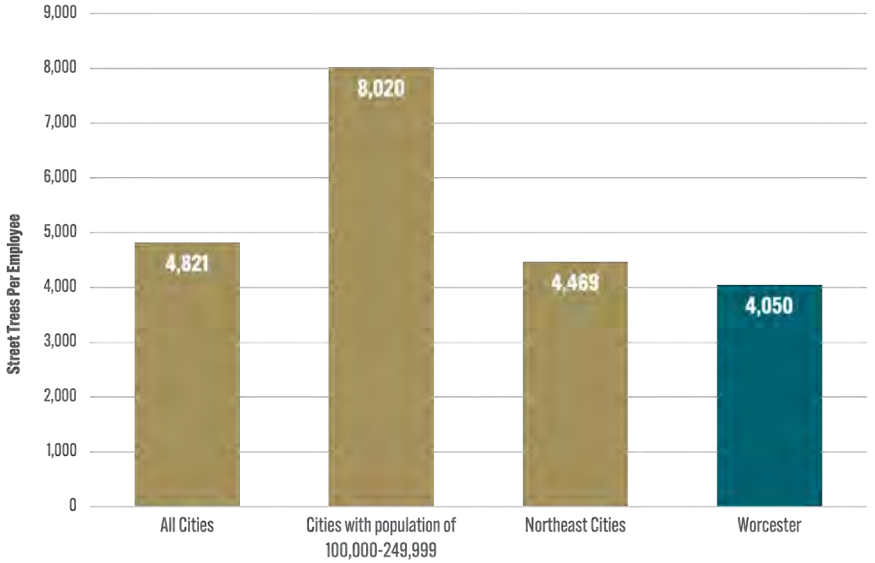


Figure 13. Street trees per Forestry employee Worcester and 2014 Municipal Tree Care Census respondents.

Worcester Urban Forestry Tree Commission

The Worcester Urban Forestry Tree Commission, established by City Council in 2022, is a 5-member advisory board that "aids the Department of Public Works and Parks, Transportation Advisory Group and the Tree Warden in proactive research, tree inventory, tree campaigns and help increase and protect the City's shade tree canopy and help improve the City's urban community forest overall."

Source: City of Worcester Board and Commissions https://www.worcesterma.gov/boards-commissions

EQUIPMENT

To perform routine tree pruning, tree removal, stump grinding, tree planting, and inspections, Forestry Operations uses a variety of small and large power equipment, bucket trucks, and chippers (Table 10). In general, Forestry's equipment is in good to fair condition, and with the exception of a backhoe to assist with tree planting, no other equipment needs were identified.

As new Forestry staff are hired and new crews and contractors are brought online, equipment should be re-evaluated to ensure it is safe, reliable, and meets the needs of the crews.

Table 10. DPW&P Forestry Operations equipment (2022)

Type of Equipment	Quantity
Aerial Bucket Truck 75-foot (2004)	1
Aerial Bucket Truck 65-foot (2014)	1
Chip Truck (2017, 2018)	2
Morbark Chippers (2019)	3
Pickup Trucks (2019)	2
Log Truck with Storm Body (2018)	1
Log Truck (2016)	1

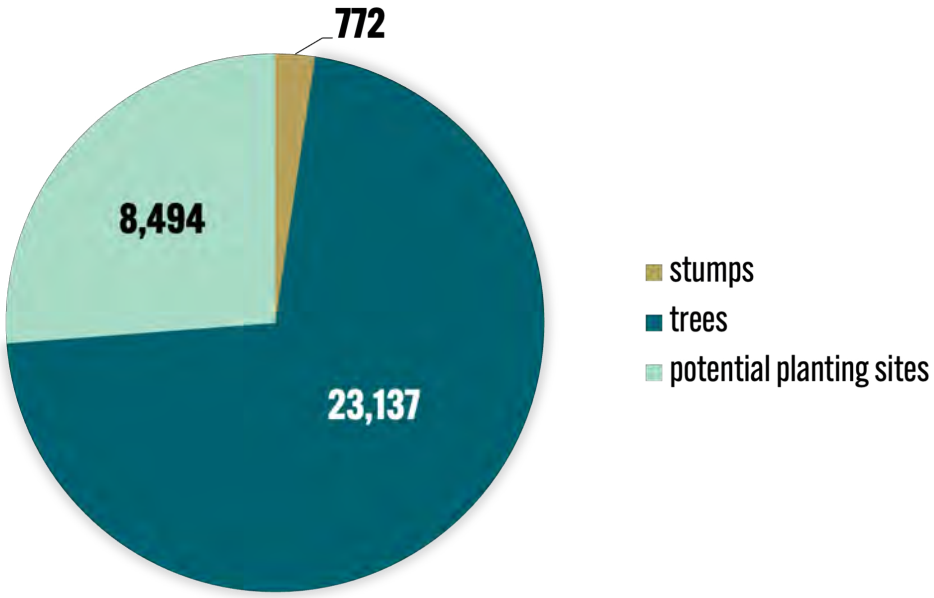
TREE INVENTORY

As outlined in Section 2, an update of Worcester's street tree inventory was conducted in 2022. The inventory identified 23,137 street trees, 772 stumps, and 8,494 potential planting sites (Figure 14). A park tree inventory is currently being conducted by Clark University students. Note while the tree inventory identified over 8,000 potential planting sites, not all of these sites will be suitable for planting due to width of planting strip, above and below ground utilities and infrastructure, and roadway requirements.

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 the city's publicly managed trees. Data from the tree inventory is instrumental in the development of plans and programs that sustainably manage the public urban forest to maximize its benefits and minimize its risk. It also aids in identifying work priorities and ensuring there are adequate resources, like funding, staff, and equipment to sustainably, efficiently, and cost effectively manage and care for the urban forest.

Urban forestry industry standards recommend that municipal tree inventories are updated on a regular basis and re-inventoried every 7-10 years.

Figure 14. Sites identified in Worcester's 2022 street tree inventory.



TREE INVENTORIES ON OTHER PUBLIC PROPERTIES

Tree inventories are valuable tools for assessing and managing Worcester's urban forest beyond the public street and park trees. Conducting tree inventories on Conservation Commission properties schools, public facilities, and other properties helps create a more complete understanding of the city's urban forest These inventories, which can range from a sample inventory to comprehensive inventory of all trees on a site, involve cataloging information such as tree species, size, condition, and location. With this data land managers can make informed decisions regarding tree care, maintenance, and planning. Tree inventories also aid in identifying potential risks, such as hazardous tree or invasive species, and enable the development of proactive management strategies.

URBAN TREE CANOPY ASSESSMENT

The City of Worcester has not conducted a comprehensive urban tree canopy (UTC) assessment. As discussed in Section 2, Worcester's Office of Sustainability and Resilience worked with Urban Climate Consulting to conduct a heat risk assessment for Worcester in 2022. The assessment provides general baseline information on land cover in Worcester including tree canopy cover (37%). While the heat risk study provides important information on areas of Worcester where mitigation strategies, like tree planting and roofing materials, can help reduce summer temperatures, a comprehensive UTC assessment is needed.

The heat risk study and UTC differ in that the heat risk study uses specific data and imagery resolutions to focus analysis on temperature and urban heat island impacts.

A UTC assessment provides a more comprehensive analysis using high-resolution aerial imagery along with environmental and census data to measure Worcester's current and historic canopy cover, quantify its environmental benefits, and prioritize areas for tree planting, preservation, and care.

Industry standards recommend UTC assessments are conducted every 5-10 years, or more often dependent on natural disasters, development, or other community disturbances.

URBAN FOREST MANAGEMENT PLANS AND PROGRAMS

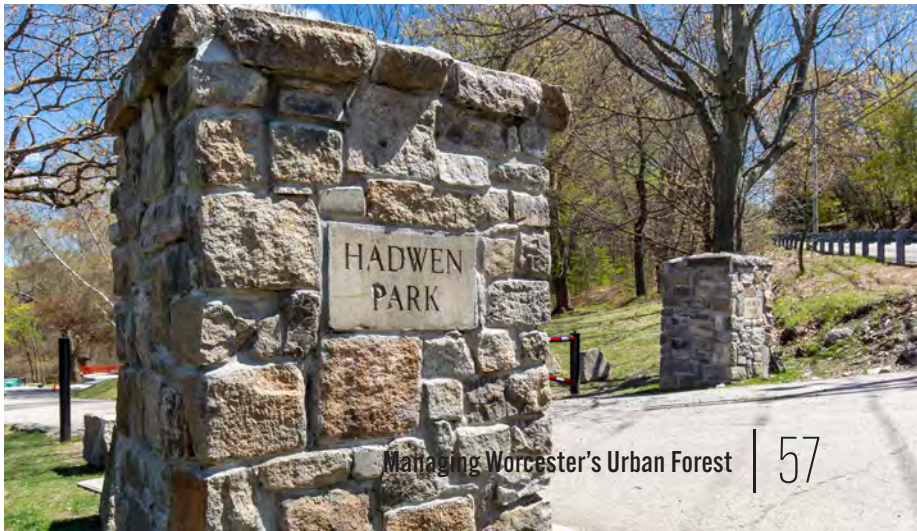
The *Indicators of a Sustainable Urban Forestry* and industry best management practices have identified the following plans and programs that a city should have in place to create a sustainable and proactively managed urban forest.

- Urban Forest Management Plan
- Proactive Risk Management Program
- Public Tree Maintenance Program
- Urban Forest Disaster Preparedness & Response Plan

TREE PLANTING PLAN

The review of Worcester's program identified opportunities to formally document and clarify the City's tree management processes and priorities through the development of these management plans and programs. The creation of the Urban Forest Master Plan is an important step for Worcester in developing these other formal plans and programs. While the Urban Forest Master Plan serves as a visioning document, a management plan utilizes tree inventory data to prioritize and plan work over a 3-5 year timeframe. The data from the newly updated street tree inventory will serve as the basis for developing Worcester's urban forest management plan. The management plan can fold in many of the other plans and programs that Worcester is missing (Risk Management, Public Tree Maintenance, Disaster Preparedness) to develop a comprehensive plan.

A sample Work Plan has been developed for Worcester based on the 2022 street tree inventory. The Work Plan can be used as is or modified depending on Worcester's priorities, needs, and resources.



TREE MAINTENANCE ACTIVITIES

As detailed previously, due to limited resources Worcester's Forestry program is predominately reactive based - driven by resident requests, emergency work, and storm events. Tree maintenance activities are assigned to crews on a daily basis based on the level of risk assigned during tree inspections conducted by the City Forester, Foreman, and Working Foreman.

Forestry strives to address requests as quickly as practical, however, there is a backlog in tree maintenance activities. Additional resources - funding, staff/contractors - along with planning, will aid in addressing the work order backlog and improve customer service.

Figure 5 provides the tree maintenance and inspection activities completed in Worcester from fiscal year 2019 to 2022. On average Forestry:

- **Prunes (trims) 283** trees per year
- **Removes 234** trees per year
- **Plants 229** trees per year
- **Inspects 693** trees per year

URBAN FOREST MANAGEMENT PLANS AND PROGRAMS

Urban Forest Management Plan focuses specifically on the maintenance needs of Worcester's street and park trees. Using the city's current tree inventory data it establishes a 3-5 year work plan to address risk and maintenance needs of Worcester's urban forest.

Risk Management Program focuses on proactively managing Worcester's street and park trees to reduce risks and eliminate hazards with a focus on public safety. Worcester's current tree inventory is the foundation for the establishment of a risk management program.

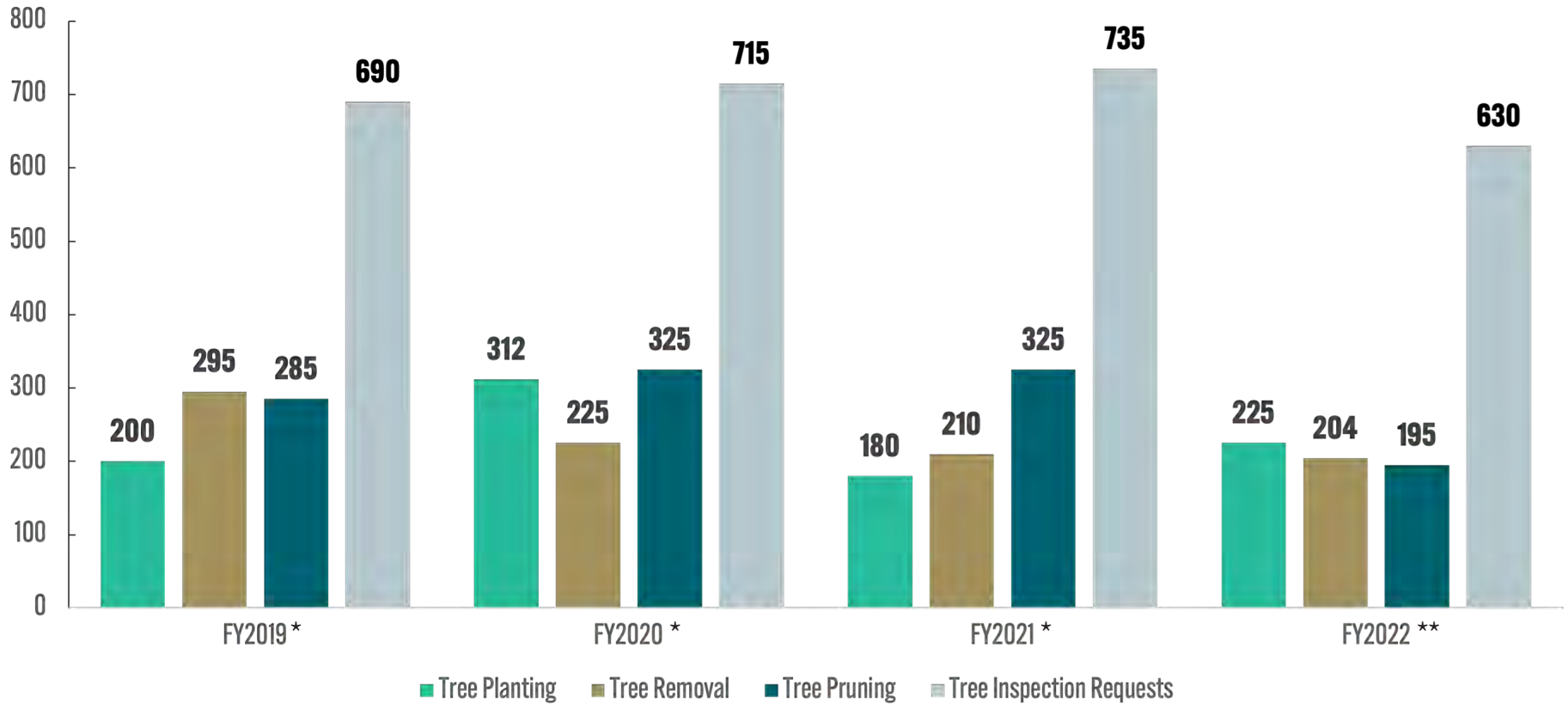
Urban Forest Disaster and Preparedness Response Plan addresses how Worcester responds to disasters that impact trees and the urban forest. The Plan establishes staff roles, contracts, response priorities, debris management and communication plans.

Tree Planting Plans use data from the tree inventory and an urban tree canopy assessment to identify and establish tree planting priorities. The plan establishes areas of tree planting over a 1-5 year time frame. By using species data from the tree inventory the plan is an important tool in improving species diversity in new tree plantings.

TREE PLANTING AND REMOVALS

Tree planting is an important activity for Worcester in maintaining a sustainable urban forest - to ensure there is not only tree canopy today but for future generations. For Worcester's public street and park trees the City should, at a minimum, strive to plant as many trees as it removes each year. On average over the last four fiscal years, Worcester has removed slightly more trees (234) than have been planted (229) each year representing a net loss (Figure 6). Careful planning along with a policy change from request only tree planting to requiring planting on all viable vacant sides will be needed to ensure that planting outpaces removals, while also considering future maintenance costs.

Figure 15. Worcester tree maintenance and inspection activities by fiscal year (July 1 - June 30)



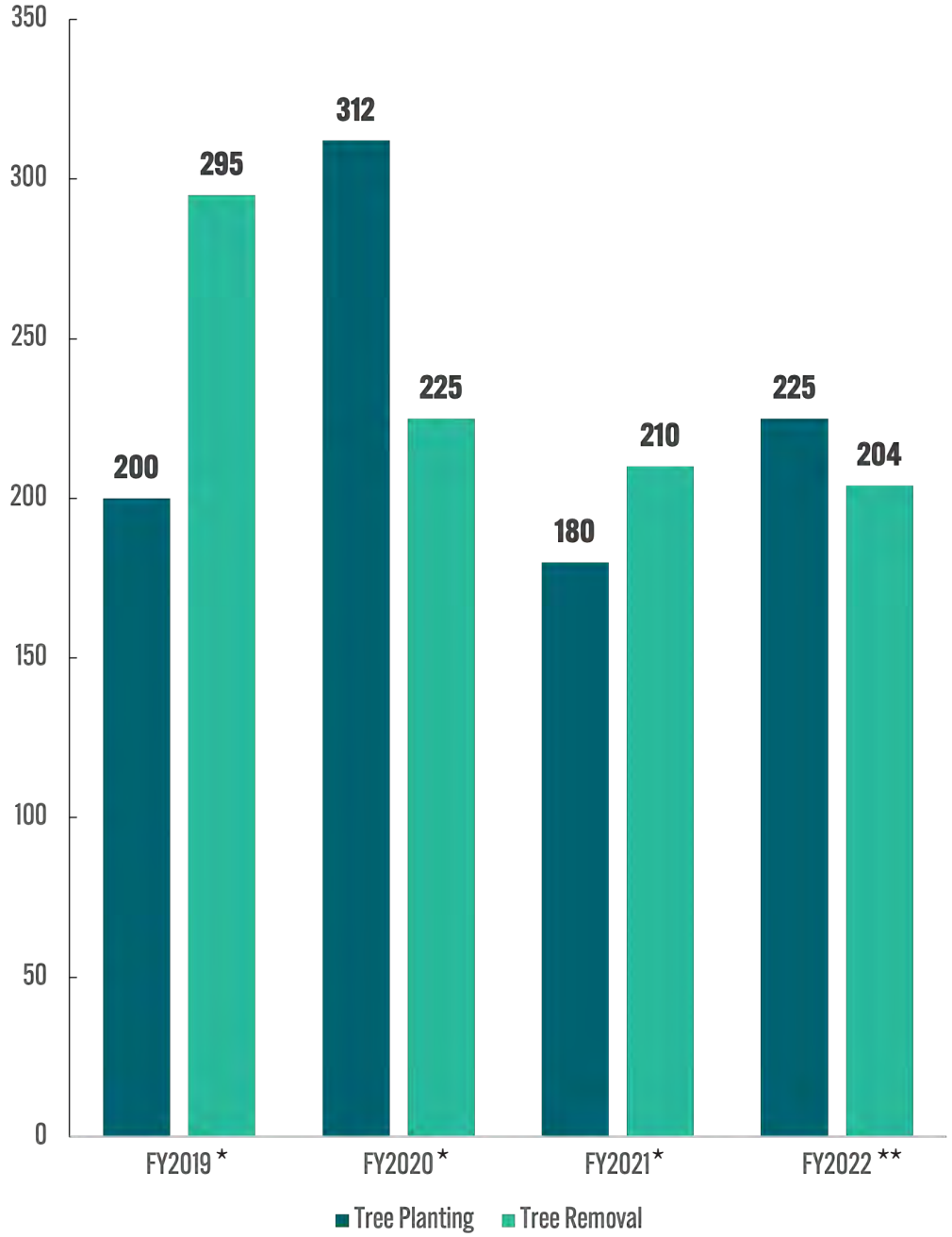
*Worcester Tree City USA application data | ** Worcester Customer Service System data

City Plans and Standards

The City of Worcester is constantly striving to enhance, improve, and develop new services for the community. To do this, plans, studies, and strategies are developed by city departments and divisions across the City of Worcester. A review of select City of Worcester plans, studies, policies, and standards was conducted to evaluate the degree to which tree preservation, protection, and planting are incorporated. The purpose of the review is to identify opportunities or gaps in plans policies and provide recommendations that will improve Worcester's urban forest resource ("Table 11. Worcester Plans and Studies Review").

- Worcester Streetscape Policy (2012)
- Worcester Urban Design Guidelines (2012)
- Complete Streets Policy (2017)
- Worcester Municipal Vulnerability Preparedness Plan (2019)
- Worcester Open Space and Recreation Plan (2020)
- The Green Worcester Sustainability and Resilience Strategic Plan (2021)
- Worcester Now | Next (*In Progress – anticipated completion 2023)*

Figure 16. Tree planting versus tree removal from fiscal year 2019-2022



*Worcester Tree City USA application data | ** Worcester Customer Service System data

FORESTRY BEST MANAGEMENT PRACTICES

A common theme identified during the planning process was the need for formalized and documented urban forestry policies, standards, and guidelines. The development of a best management practices (BMP) manual is needed to guide Forestry's work and that of other City departments and contractors to ensure that trees are protected, maintained, and planted properly.

A set of BMPs are in development that focus on:

- Tree protection during construction
- Tree planting
- Tree species selection
- Trees and sidewalks
- Tree removal

These BMPs will be incorporated into a new Worcester Urban Forestry Best Management Practices manual. Additional BMPs will need to be developed around topics, which may include:

- Resident notification of upcoming activities
- Resident outreach and engagement regarding forestry activities
- Process for regular urban tree canopy assessment updates
- Tree Inventory update procedures and standards
- Post-planting care procedures and requirements
- Improving soil quality and increasing soil quantity
- Pruning and maintenance practices
- Tree removal decision processes
- Risk management
- Stormwater management
- Standard construction details to support trees
- Coordination practices between city departments and external organizations

Commonwealth of Massachusetts Shade Tree Laws

The Commonwealth of Massachusetts is unique in that it has state laws in place to protect public shade trees.

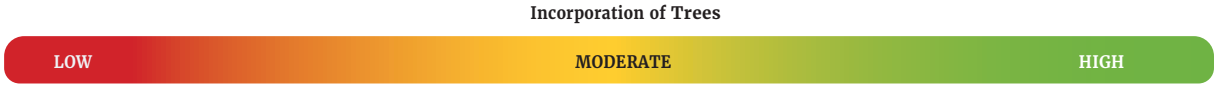
Massachusetts General Law, Chapter 87: Requires that each Massachusetts community have a Tree Warden and outlines the power and duties of the position. It provides procedures for the planting and removal of public shade trees and establishes penalties for violating the law.

Massachusetts General Law, Chapter 40: This chapter supplements Chapter 87 by providing requirements for the removal of trees on Scenic Roads.

Commonwealth of Massachusetts General Laws - https://malegislature.gov/Laws/GeneralLaws/

Table 11. Worcester Plans and Studies Review

Worcester Plans and Studies



WORCESTER STREETSCAPE POLICY (2012) | WORCESTER URBAN DESIGN GUIDELINES (2012)

Description: Pilot policy developed for the Downtown and Canal District. The policy and guidelines include specific requirements for street tree and planting pit construction,
Opportunities/Gaps: The standards detailed in the streetscape policy and guidelines do not support large canopy trees.
Recommendation: Review and revise guidelines for future projects to ensure the location, design, and construct of tree pits and planting areas meeting industry standard best management practices and can support the long-term growth and survival of both small and large shade trees.

COMPLETE STREETS POLICY (2017)

Description: Policy developed to create a multi-modal transportation system that provides options for Worcester residents to safely move around the city.
Opportunities/Gaps: Policy outlines steps for successful implementation, including early engagement with city departments and stakeholders and development of a checklist.
Recommendation: Trees are an important part of the streetscape and creating safe transportation corridors. As part of the development of a complete streets project, an inventory of all street and park trees should be conducted to develop a preservation, removal, and tree planting plan to ensure trees are considered throughout the planning process.

WORCESTER OPEN SPACE AND RECREATION PLAN (2021)

Description: The Worcester Open Space and Recreation Plan adopted in 2021 provides a 7-year action plan to address Worcester's "most critical open space and recreation needs."
Opportunities/Gaps: The plan establishes 12 goals and establishes objectives and action items to achieve them. It includes specific objectives and action items related to trees, including in Objectives 2b3, 7b, and 10a.
Recommendation: Implementation of the Urban Forest Master Plan, including conducting an urban tree canopy assessment to identify canopy gaps will help in achieving many of the tree-related objectives and action items in the 2021 Open Space and Recreation Plan.

WORCESTER MUNICIPAL VULNERABILITY PREPAREDNESS PLAN (2019)

Description: Developed with funding through the Massachusetts Executive Office of Energy and Environmental Affairs' (EEA) Municipal Vulnerability Preparedness (MVP) program the plan, developed in collaboration with community stakeholders, identified local climate-change natural hazards that are of the greatest concern and developed priority actions to address them. The plan identifies flooding from extreme precipitation, ice and snowstorms coupled with extreme cold, and extreme heat coupled with drought as the three greatest natural hazards facing Worcester in the future.
Opportunities/Gaps: Trees and green infrastructure were included in the Plan's recommended action items to address urban heat island effects and flooding.
Recommendation: Implementation of the recommendations of the Urban Forest Master Plan, especially those related to establishing proactive maintenance practices, will help in achieving the MVP Preparedness Plan recommended action steps and help create community resilience.

GREEN WORCESTER SUSTAINABILITY AND RESILIENCE STRATEGIC PLAN (2021)

Description: The purpose of the Green Worcester Plan is to make "...Worcester one of the most sustainable and climate-resilient mid-sized cities in America by 2050." The plan focuses on prioritizing action items that promote climate sustainability and resilience, have "co-benefits" and improve the quality of life, equitable access and prosperity of the Worcester community.
Opportunities/Gaps: Trees provide many "co-benefits" and are an important tool in reaching the goals of the Green Worcester Plan. Other ways that trees can be used to meet Green Worcester Plan goals that are not listed in the Plan, include, proper placement and planting of trees around buildings to help reduce energy usage; planting street trees to provide shade along streets, sidewalks, and bus stops; evaluating the development of food forests/orchards with proper maintenance in parks and open spaces; planting trees to reduce the urban heat island effect, manage stormwater and improve air quality.
Recommendation: Trees are an important solution identified to help meet the goals of The Green Worcester Plan, and one of the ten "early action" items identified in the Green Worcester Plan is development of an Urban Forestry Master Plan. Implementation of the Urban Forestry Master Plan will assist in meeting the goals of the Green Worcester Plan.

WORCESTER NOW | NEXT (DRAFT - 2022)

Description: Description: The Worcester Now | Next Plan is a is a citywide planning process (anticipated to be completed in 2023) to update the City's 1987 comprehensive master plan. It will integrate past planning efforts with current planning initiatives and the community's visions to create a comprehensive roadmap to guide the development and evolution of Worcester for the next 30 years.
Opportunities/Gaps: Draft goal 2 under the Recreation, Open Space & Environment theme of the Worcester Now | Worcester Next plan is to "Invest and support Worcester's urban forest and green infrastructure." Recommendations under this goal support implementation of the Urban Forest Master Plan and support the growth of Worcester's urban forest on public and private property.
Recommendation: Collaborate with Worcester Now | Next Planning process to ensure that the draft goals and recommendations that support Worcester's urban forest are adopted in the final plan and prioritized for implementation.

Worcester City Ordinances, Codes and Commonwealth Laws

A review of the following ordinances, codes and laws was conducted:

- **Chapter 12 - Streets and Sidewalks Section 28 - Protection of Public Trees (Adopted 2009)**
- **Zoning Ordinance (Adopted 1991/amended April 2021)**
- **Subdivision Regulations (Adopted 1992/ amended April 2013)**
- **Wetland Protection Ordinance and Regulations (Adopted 1990/amended June 2019)**
- **Rules and Regulations for Site Plan Approval (Adopted 1991/amended April 2013)**
- **Local Historic District Rules and Regulations (Adopted 1975)**
- **City Charter, Article 5, Department of Public Works and Parks**
- **General Laws - Commonwealth of Massachusetts - Chapter 87 - Shade Trees**

WORCESTER ORDINANCES, CHARTER & COMMONWEALTH LAWS

A review of Worcester ordinances, charter and Commonwealth Laws related to tree protection, preservation, and planting on public lands was conducted. The review was based on survey categories identified in the 2014 Municipal Tree Care Census, as well as industry standards.

The full review is in "Appendix A.". Boxes in the table in Appendix A with an "X" indicate regulations that are in place in Worcester and gray highlighted boxes indicate areas that are missing or partially addressed in current code. The following are recommendations to strengthen city code.

- Develop and/or strengthen tree protection and preservation measures for public trees.
- Require adherence to ANSI A300 standards and best management practices for public trees.
- Require ISA Certified Arborists for public tree work conducted by outside contractors.
- Create tree protection standards for public trees, including penalties for encroachment into a tree's drip line or critical root zone.
- Annually update the formula for determining the monetary value of removed or damaged public trees.
- Establish penalties for non-compliance with city code and standards outlined in the new Forestry Best Management Practices Manual.
- Establish tree planting requirements for development projects, including bolstering requirements for tree planting in and around parking lots.
- Require maintenance of tree planting locations (tree pits, grass strips) by adjacent property owners.
- Add diversity guidelines for development projects.
- Strengthen requirements for conserving existing trees and planting new trees in wetland resource areas, related riparian buffer zones, and floodplain.

Ensuring adequate tree protection and planting standards are in place and enforced is a real concern for the community. Based on current staffing there is not sufficient staff in place in Worcester to proactively enforce City ordinances and regulations. In addition to establishing and strengthening regulations, the City needs to increase staffing to provide adequate, consistent, and strong enforcement of City codes.

Partners

The City has strong existing partnerships with local non-profit organizations, educational institutions, utility providers, and state departments that have provided support in growing and maintaining Worcester's urban forest throughout the years.

Clark University, located in Worcester, facilitates an undergraduate research program to help answer research questions to support activities of the City of Worcester, the US Department of Agriculture and Massachusetts Department of Conservation. Their past work has produced invaluable data, including the impacts of Asian longhorned beetle related tree removals on temperature and utility costs, the potential for planting trees in Worcester, flooding patterns, and air quality levels. The University owns Hadwen Arboretum, a 22-acre forest plot set in a dense residential neighborhood.

Greater Worcester Land Trust owns 460 acres in Worcester, primarily forest land and parks. Their work includes forest regeneration, American chestnut (*Castanea dentata*) restoration, remediating forests by logging, and creating pocket parks to mitigate urban heat islands and groundwater.

Mass Audubon is a nonprofit organization dedicated to protecting the nature of Massachusetts. They host educational programs and conduct restoration and research projects throughout the city.

Massachusetts Department of Conservation & Recreation has included Worcester in their Greening the Gateway Cities program beginning in 2022 to conduct street tree planting in high-need, low canopy neighborhoods.

National Grid provides tree maintenance to many of Worcester's private and public trees to ensure safe and reliable electrical power.

New England Botanic Garden at Tower Hill is a nonprofit organization that has a strong partnership with the City of Worcester to assist in providing public education, tree planting, and care on both public and private property.

Broad Meadow Brook Stream

The Broad Meadow Brook Stream project is a partnership with the Mass Audubon Broad Meadow Brook, City of Worcester, Clark University, and the Massachusetts Department of Conservation and Recreation that will be a showpiece of climate resilience urban stream restoration. The goals of the project are to increase flood resilience in the face of climate change, insulate neighborhoods from flooding impacts, increase wildlife habitat, improvise public access and recreation, and engage Clark University students.

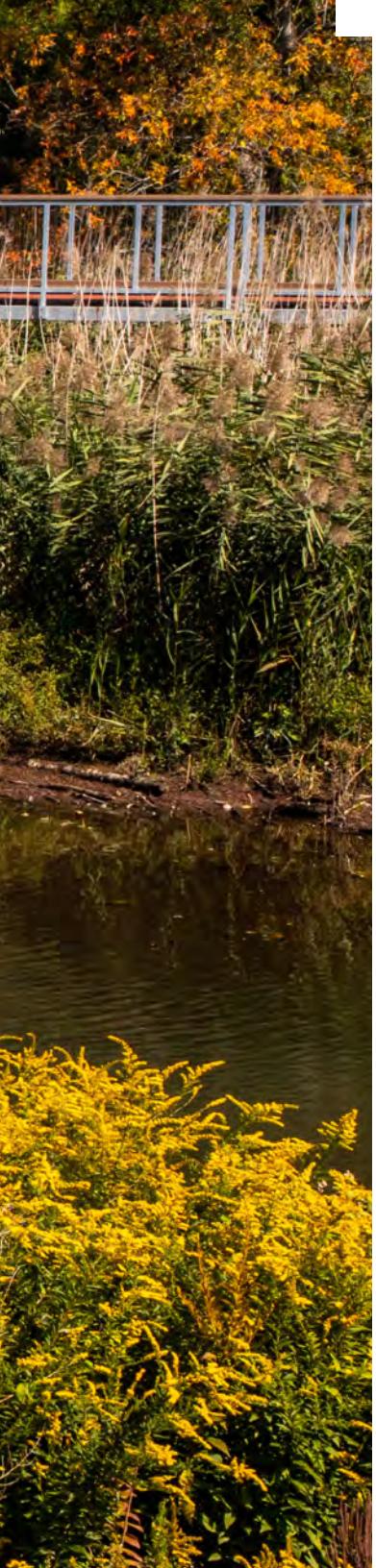
Regional Environmental Council focuses on food justice in the Worcester area. Their programs vary from supporting 60+ schools, community gardens, and urban farms; youth programming and at-risk youth employment; distributing at farmers markets and bringing markets through the city by truck. They grow food producing trees and nut trees in their community gardens and other public spaces to increase food security.

Worcester GreenCorp (Chamber of Commerce) is a collaborative program of the Worcester Regional Chamber of Commerce, the City of Worcester, Worcester Community Action Council, and the United Way of Central Massachusetts. Established in May 2021, its aim is to clean and beautify Worcester's streets and green spaces and to provide income and job training to Worcester's youth.

Worcester Polytechnic Institute often contributes urban forestry data and information from staff and student research projects.

Section Four

ENGAGEMENT & OUTREACH: THEMES & PRIORITIES



Engagement & Outreach

Community and stakeholder engagement played an essential role in the development of the Worcester Urban Forest Master Plan. The planning process included a variety of engagement and outreach activities to gain an understanding of the priorities, issues, and opportunities around Worcester's trees and urban forest. Three main groups were engaged during the plan development process – Project Team, Stakeholders, Worcester Community (public).

Project Team. The Project Team's role was to provide technical input, feedback, and guidance throughout the plan development process. The Project Team provided insights into the engagement and outreach plan, reviewed stakeholder and community feedback, and provided guidance and direction on the Plan's recommendations. The Project Team was made up of staff from the City of Worcester DPW & Parks and the Davey Resource Group consultant team.

Stakeholders. Stakeholders represented different organizations throughout Worcester that were interested, involved, or whose work impacted the urban forest. Stakeholders were engaged through interviews and focus groups designed to gather targeted feedback on their specific issues, challenges, and opportunities around Worcester's trees and urban forest. The following City departments and organizations provided input through focus groups and interviews:

City of Worcester

- Parks and Recreation
- Forestry Operations
- Sustainability and Resilience
- Planning and Regulatory Services
- Public Works
- Human Rights
- Transportation & Mobility

Community Organizations & Utilities

- New England Botanic Garden at Tower Hill
- Worcester GreenCorp (Chamber of Commerce)
- Mass Audubon
- Regional Environmental Council
- Greater Worcester Land Trust
- Clark University

Worcester Community.

The Worcester community (public) was extensively engaged to understand their values, needs and priorities related to Worcester's trees and urban forest. Worcester community input was gathered through community open houses, survey, and district meetings.

- **Community Open Houses.** Community meetings were held at Stearns Tavern and Green Hill Park in June 2022. The meetings were an open-house format that allowed residents to provide comments and feedback on various urban forestry-related topics.

- **Community Survey.** The Worcester Urban Forest Master Plan Community Survey was open from May 1 - August 19, 2022. A total of 1,131 people responded to the survey which asked a range of questions about Worcester's trees to identify themes and priorities that should be considered in the plan.

- **District Meetings.** In September and October 2022, a series of meetings were held in Worcester's five Council Districts. The meetings presented the District-specific results of the street tree inventory and provided a summary of the themes and priorities identified during the survey and stakeholder engagement activities. The meetings sought feedback on the themes and priorities identified to confirm and identify any missing priorities before plan recommendations were drafted.

The next section presents the themes and priorities identified during the community and stakeholder engagement activities.

Community Meetings

June 1, 2022
UFMP Community Open House (Stearns Tavern)

June 2, 2022
UFMP Community Open House (Green Hill Park)

September 21, 2022
District #2 UFMP Meeting

September 22, 2022
District #5 UFMP Meeting

October 17, 2022
District #1 UFMP Meeting

October 19, 2022
District #3 UFMP Meeting

October 20, 2022
District #4 UFMP Meeting

URBAN FORESTRY SURVEY RESULTS

1,131 Respondents

Over **50%** of respondents have lived in Worcester for over 11 years

70% respondents own their home;
while **30%** of respondents rent their home

95% Strongly Agree that trees are important to Worcester

92% feel that there are too few trees in Worcester

69% feel that there are too few trees in their neighborhood

85% Agree that planting trees on private property is important

96% Agree that planting trees in public parks and on streets is important

94% Agree that large, mature trees should be preserved on public property

84% Agree that large, mature trees should be preserved on private property

32% Agree that street trees seem well cared for in Worcester

70% Agree that the City of Worcester does not spend enough money on trees

95% Agree that having trees is worth the financial cost of maintaining them

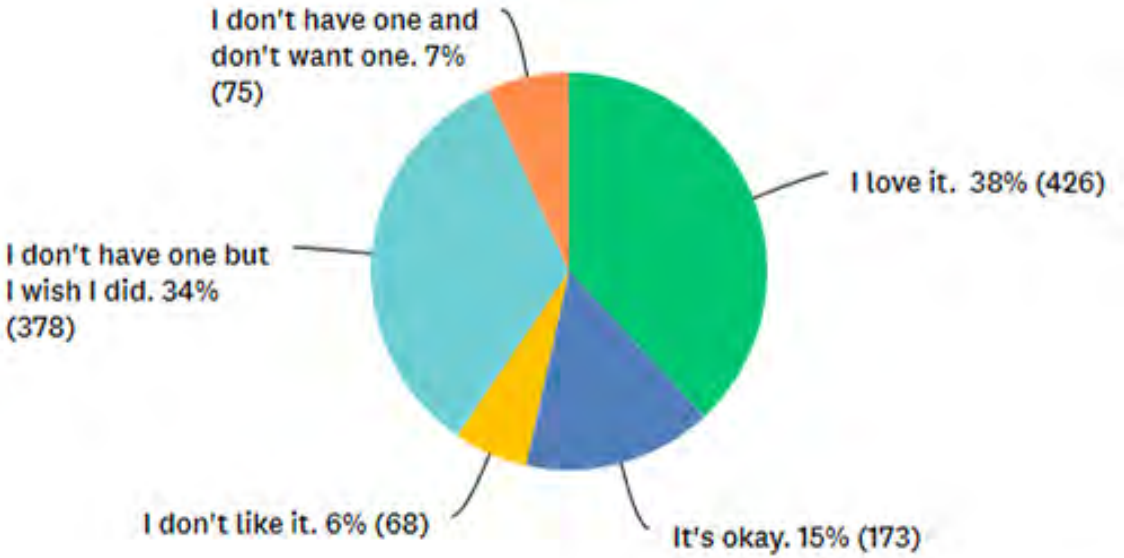
Top 5 Most Valued Tree Benefits

1. Improve air quality
2. Create shade
3. Prevent the City from becoming hotter —reduce summer temperatures
4. Provide wildlife habitat
5. Reduce flooding

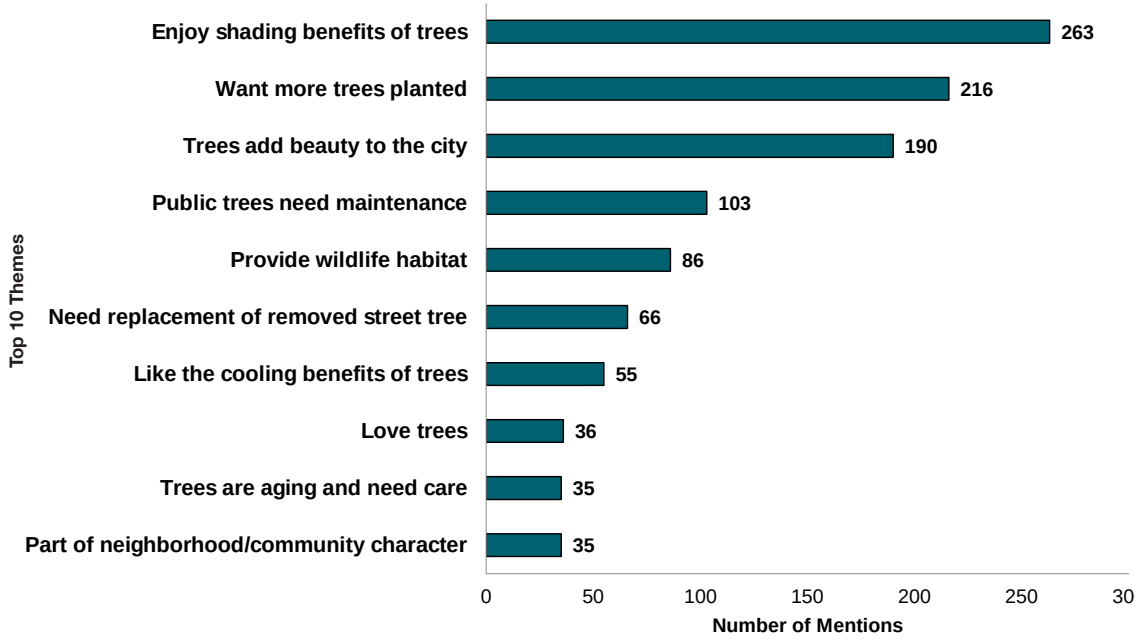
Top Challenges of Trees

1. Causes sidewalk damage
2. Blocks signs, street lights and visibility when driving
3. Damages underground and overhead utilities
4. Causes damage to property
5. Blocks sunlight/shades garden & yard

How do you feel about the street tree in front of your home?



Why do you feel the way you do about your street tree?



Urban Forestry Themes and Priorities

The engagement and outreach activities identified a set of themes and priorities, that together with the results of Worcester's assessment of the *Indicators of a Sustainable Urban Forest* provided the foundation for the Plan's recommendations. Many of the themes and priorities are interconnected and addressing one will have ripple effects that will lead to improvements in other areas leading to the creation of a sustainable and resilient urban forest for Worcester.

- **Worcester community has diverse views on trees.** The Worcester community understands and values the benefits that trees provide to the city. There are, however, concerns about the risk that large, aging trees in the city pose to the community.
- **Tree Planting & Care.** Increased street tree planting and young tree care was a top theme identified by the community. Ensuring that trees are planted where they are needed most (equity), the right tree is planted in the right location, and space/engineering design for trees were considerations mentioned within this theme.
- **Public Tree Maintenance.** Need for increased, adequate, and stable urban forestry funding and investment to support prioritization of proactive tree maintenance that focuses on establishment and the long-term care and maintenance of trees.
- **Proactive Management & Planning.** To ensure a sustainable urban forest in Worcester proactive planning and management must occur. Areas of focus for this theme included ensuring no net loss in public trees, planning for tree planting and care, and establishing processes and criteria for tree inspection, tree removals, and resident engagement.
- **Sidewalk and Infrastructure.** Community and stakeholders expressed concerns with the damage that trees can cause to sidewalks, infrastructure (utilities), and property. Damage to sidewalks can impact accessibility which has equity implications. Proper planning to reduce future conflicts and proactive care must be prioritized.
- **Policies and Standards.** There is a need for Worcester to develop and formally adopt and implement urban forestry best management practices and guidelines to support tree preservation, planting, and care, including in street and site design.
- **Tree Preservation and Protection.** With the significant loss of trees to the Asian longhorned beetle – the community supports stronger regulations and protections for large trees while also requiring replacements for trees removed.
- **Ordinances/Regulations**. There was a general sentiment that Worcester's tree ordinances and regulations need to be strengthened to support the growth and protection of Worcester's urban forest. Increased regulations around preservation of existing trees and increasing tree planting requirements in/around parking lots and new developments were mentioned.
- **Species Selection and Diversity.** With the impacts of the Asian longhorned beetle the importance of species selection and diversity are very important issues for the community. As the climate changes, and new tree diseases and pests emerge, Worcester needs to ensure they are planting a wide variety of species while promoting the use of native species (as available and where appropriate). Key considerations identified in this theme include the importance of considering a variety of factors during species selection, including but not limited to form, invasive potential, climate resilience, wildlife benefits, solar access, infrastructure, and adjacent property use.
- **Composition of City Trees.** Ensuring that the composition of Worcester's city trees is resilient and sustainable as it ages and faces challenges including climate change and other threats. Proactive planning for the removal and replacement of aging tree canopy is a key consideration

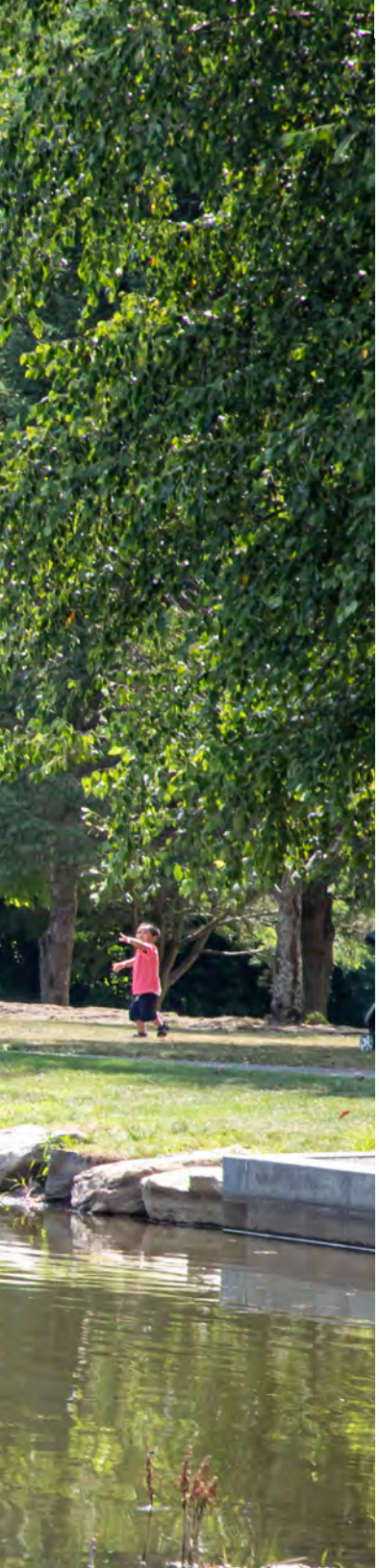
mentioned within this theme.

- **Legacy of Asian Longhorned Beetle (ALB).** With the discovery of ALB in Worcester in 2008 and the subsequent removal of over 30,000 trees on public and private property – its impacts and legacy are still felt today. This theme focuses on resilience and sustainability and the importance the community places on species diversity and ensuring the replacement of trees removed from ALB.
- **Staffing and Resources.** The City of Worcester does not have adequate resources to provide proactive and responsive service for public street and park trees and Conservation Commission properties. This has led to a backlog in tree maintenance needs and an inability to meet the public's level of service expectations.
- **Interdepartmental Coordination.** Good working relationships exist between DPW & Parks, Forestry Operations, and other City departments; however, communication typically occurs late in construction and design projects or when there is a conflict between trees and a City construction/ infrastructure project. Improved communication and collaboration processes need to be established to ensure trees are considered early on during City projects.
- **Communication, Education, and Outreach.** A need for improved City communication around trees, forestry, and how tree maintenance decisions are made was identified. Topics needed for outreach and education include proper tree care, benefits of trees, and rental property engagement.
- **Partnerships.** Fostering and developing partnerships with the many organizations in Worcester that can support urban forestry initiatives helps build capacity needed to grow and care for Worcester's urban forest. Partners can assist the City in outreach and education activities.

Now that we understand the current state of Worcester's urban forest and the needs and priorities of the community and stakeholders – it is time to get to work! The next section details the Plan's goals, recommendations, and actions to support the development of sustainable and resilient urban forest in Worcester.

Section Five

GOALS, RECOMMENDATIONS & ACTION STEPS



The goals, recommendations, and actions of the Worcester Urban Forest Master Plan are based on Worcester's assessment on the *Indicators of a Sustainable Urban Forests,* the themes and priorities identified during engagement and outreach activities, along with information, and data gathered and analyzed during the planning process.

Vision for Worcester's Urban Forest

Our vision is for Worcester's urban forest to continue to be a model of proactive management, sustainability, and climate resilience. We envision a city where the urban forest is well-cared for, with proactive measures in place to ensure its health and longevity. Through intentional planning and community engagement, we will ensure tree diversity and well-distributed tree canopy cover, care, and green spaces for the entire Worcester Community. Through nurturing a resilient and sustainable urban forest, we aim to create a greener, healthier, and more vibrant Worcester.

Plan Goals

Plan and Manage.

Maintain Worcester's program to actively plan and manage the urban forest to support the City's sustainability, equity, and climate resilience goals and priorities.

Maintain & Grow.

Increase Worcester's urban forest through continued proactive maintenance and protection to create a healthy, equitable, and resilient urban forest that maximizes the environmental, economic, and climate mitigation services trees provide.

Connect & Engage.

Support and grow efforts to connect, educate, and engage with the Worcester community about the city's urban forest and the important role they play in its care and growth.

Recommendations

1. Establish a proactive management program for Worcester's public trees, going beyond the current Customer Service-based model.
    - » **Target: Develop, fund, and implement a proactive management program within 2 years, focusing on tree health, maintenance, and preservation.**
2. Increase City staff and contractors to transition to a proactive public tree management program and support urban forest planning, operations, and education.
    - » **Target: Increase Forestry's annual operating budget to hire additional staff (25% increase in City forestry staff) and contractors (100% increase in contracted services) within 3 years to support the proactive management program.**
3. Revise and develop urban forestry processes to support improvements in customer service, service delivery, data, technology, and information management using national arboricultural standards and best management practices.
    - » **Target: Review and update urban forestry processes within 1 year, aligning them with national arboricultural standards and best management practices.**
4. Expand and develop regulations, best management practices, and guidelines to support urban forest growth and preservation.
    - » **Target: Develop, fund, and implement comprehensive regulations, best management practices, and guidelines to support urban forest growth and preservation within 2 years.**
5. Ensure there is adequate space for trees to grow and thrive in Worcester's challenging urban environment.
    - » **Target: Implement measures to provide adequate space for tree growth and health, including tree-friendly infrastructure and appropriate planting spaces, as soon as practical for current public right-of-way construction projects and immediately for projects in design.**

6. Convene a panel of area experts in 2024 for the first annual Worcester Urban Forestry Research Summit and conduct a comprehensive urban tree canopy assessment for the City of Worcester.
    - » **Target: Complete a comprehensive urban tree canopy assessment within 2 years, providing accurate data on tree cover and distribution.**
    - » **Target: Worcester Urban Forestry Research Summit will examine existing datasets in order to identify tree canopy goals, priorities, and strategies for the City of Worcester. The findings of the summit will guide an annual tree planting and maintenance plan and form the basis for defining a comprehensive Urban Tree Canopy goal no later than January 2025. Within two years of the summit, complete a comprehensive urban tree canopy assessment to provide higher spatial resolution on tree cover and distribution for planning efforts.**
7. Continue tree planting and care citywide with attention to areas that advance city sustainability, resilience, and equity priorities.
    - » **Target: Fund, plant and maintain a minimum of 3:1 replacement of trees when removing trees in the right-of-way to help ensure that, at a minimum, there is no net loss in tree canopy cover in the city. Replacement trees can be planted outside the right-of-way on public and private property, provided that the Tree Commission and/or volunteer groups work with nearby landowners to site new trees on private property.**
8. Strengthen and develop partnerships with community and regional partners to support the implementation of the urban forest master plan.
    - » **Target: Engage with at least 5 community and regional organizations within 2 years, collaborating on initiatives outlined in the urban forest master plan.**
9. Implement an urban forestry communication and outreach plan that supports the growth and care of Worcester's urban forest.
    - » **Target: Develop and execute an urban forestry communication and outreach plan within 2 years, aiming to increase awareness and engagement in tree care and planting.**
10. Expand development and implementation of a program to monitor and address environmental threats to Worcester's urban forest.
    - » **Target: Develop and expand a program for monitoring and mitigating environmental threats to the urban forest, including pests, diseases, and climate change impacts, within 3 years.**

1. ESTABLISH A PROACTIVE MANAGEMENT PROGRAM FOR WORCESTER'S PUBLIC TREES THAT IS BEYOND THE CURRENT CUSTOMER SERVICE BASED MODEL.

» PLAN GOALS: Plan & Manage; Maintain & Grow

To transition Worcester's program from primarily reactive to proactive will require developing an urban forest management plan. A management plan differs from a master plan in that it focuses specifically on the operational needs of Worcester's public trees and the programs, policies and activities that must be done to sustainably manage them. It provides an assessment based on public tree inventory data that identifies and prioritizes risk and maintenance needs, outlines budget and resources needed to address them, and provides a schedule for completion.

Action Steps

- **1.1.** Prioritize completing maintenance tasks for high and moderate risk trees identified in the recently updated street tree inventory and based on updated inspections completed by City staff.
- **1.2.** Use the updated street tree inventory to develop an urban forest management plan that includes a risk management program, public tree maintenance program, and disaster preparedness and response plan. Incorporate information into Hazard Mitigation Plan updates.
  - » **1.2.1.** Develop a routine pruning schedule for established trees and the structural training of young trees.
- **1.3.** Develop plans to address aging tree canopy cover and establish successional plans to ensure that canopy cover is continuously maintained, especially in Districts 1, 3, and 5 where the public tree population age distribution exceeds industry recommendations.
- **1.4.** Assess budget needs and secure funding to proactively manage Worcester's public trees using information from the urban forest management plan.
  - » **1.4.1.** Establish an interim funding goal to increase Forestry's annual budget by $500,000 to exceed the $80.77 per street tree funding identified in the 2014 Municipal Tree Care Census.
  - » **1.4.2.** Explore new and alternative funding sources – see Exploring New Sources of Funding to Support Worcester's Urban Forest sidebar in Section 3.
- **1.5.** Conduct other planning efforts while the management plan is being developed.
  - » **1.5.1.** Continue to develop an annual Work Plan that prioritizes tree risk and then establishes a routine pruning cycle.
  - » **1.5.2.** Update the City's street tree planting plan annually and formally establish a young tree pruning program.
    - » **1.5.2.1.** Explore establishment of a young tree pruning cycle to cyclically prune young trees during their first 10 years.
- **1.6.** Conduct baseline assessments of forested Conservation Commission properties to identify species composition, as well as threats and opportunities for the land's trees and natural resources.
  - » **1.6.1.** Use data from baseline assessments to develop forest management plans for Conservation Commission properties.

2. INCREASE CITY RESOURCES TO TRANSITION TO A PROACTIVE PUBLIC TREE MANAGEMENT PROGRAM AND SUPPORT URBAN FOREST PLANNING, OPERATIONS, AND EDUCATION.

» PLAN GOALS: Plan & Manage; Maintain & Grow; Connect & Engage

To proactively maintain a sustainable and resilient urban forest requires Worcester to not only focus on daily tree care and management operations but also on planning, outreach, and coordination. The current positions within Worcester's Forestry program focus on the operational tasks required to care for the public street and park trees and respond to resident and City department requests. However, dedicated resources are not currently available to focus on urban forestry program planning and implementation, construction plan review and inspections, tree planting programming, policy development, and public outreach. These duties are currently done, in part, by the Assistant Commissioner of DPW & Parks and City Forester, however, with all the other duties assigned to their positions many of these tasks cannot be completed.

Table 12. Phase 1 Ideal Forestry Staffing Scenario

Positions (Full-time)	Number of Positions
City Forester	1
Foreman	1
Working Foreman	2
Arborists	7
TOTAL	11

For the City of Worcester to develop a sustainable urban forest and transition to a proactive program, will require additional resources to assist with tree maintenance, planning, and outreach needs. The phase 1 staffing scenario for Forestry (Table 12) would increase the number of City staff by one, adding a new Arborist position. This new position would create capacity within Forestry to allow the Working Foreman the ability to conduct plan reviews and inspections along with the City Forester and Working Foreman without demands of performing tree maintenance activities. Additional staffing needs may be required as Forestry implements the UFMP, and needs are identified. The use of contractors will also be essential in maintaining a proactive program. City staff and contractors each offer a special set of skills, equipment, operational efficiencies, and strengths that allow the City to gain the greatest value and productivity in the management of the urban forest. A benefit of using contractors is that Forestry's service needs can easily be matched to available funding and workloads.

The talents of students from local colleges and universities (e.g., Clark University, Worcester Polytechnic Institute, Worcester State University, and Quinsigamond Community College) can be utilized by developing an urban forestry internship program. Interns can help with tree inventory data management/entry, outreach efforts, inspections, and minor tree maintenance tasks.

Action Steps

- **2.1.** Implement staffing scenario by adding and hiring a new arborist position and continue to reevaluate staff each fiscal year as the Urban Forest Master Plan is implemented.
- **2.2.** Utilize maintenance needs identified in Recommendation #1 to develop a plan to utilize tree care contractors to perform tree removals, stump grinding, tree planting, storm response, and tree maintenance for city projects and departments to allow Worcester Forestry crews to focus on activities that transition the program to proactive management.
- **2.3.** Contract with partner organizations to provide education and outreach support.
- **2.4.** Develop staff succession plans to ensure transfer of institutional and technical knowledge as Forestry staff transition into retirement.
- **2.5.** Develop training plans for Forestry staff and identify training opportunities to maintain certifications and stay up to date on the latest arboricultural techniques and urban forestry best management practices.
- **2.6.** Evaluate establishment of an urban forestry internship program to assist Forestry with tree inventory data management/entry, outreach efforts, inspections, and minor tree maintenance tasks.
- **2.7.** Implement the goals and objectives of the approved *Worcester Open Space and Recreation Plan Update 2021* to support increasing resources for the proactive management of Conservation Commission properties.

Urban Forestry Best Management Practices

As part of the development of the Urban Forest Master Plan, a set of best management practices were developed that focus on tree protection; tree planting; tree species selection; trees and sidewalks; and tree removal.

These BMPs will be incorporated into a new Worcester Urban Forestry Best Management Practices manual. Additional BMPs will need to be developed around topics, including:

- Resident notifications
- Outreach and engagement regarding
- Process for regular urban tree canopy assessment updates
- Tree Inventory update procedures and standards
- Post-planting care procedures and requirements
- Improving soil quality and increasing soil quantity
- Pruning and maintenance practices
- Tree removal decision processes
- Risk management
- Stormwater management
- Standard construction details to support trees
- Coordination practices between city departments and external organizations

3. REVISE AND DEVELOP URBAN FORESTRY PROCESSES TO SUPPORT IMPROVEMENTS TO CUSTOMER SERVICE, SERVICE DELIVERY, DATA, TECHNOLOGY, AND INFORMATION MANAGEMENT USING NATIONAL ARBORICULTURAL STANDARDS AND BEST MANAGEMENT PRACTICES.

» PLAN GOALS: Plan & Manage; Maintain & Grow

- The City of Worcester utilizes a customer service request system (CSR) to input and manage resident service requests, including those related to tree maintenance. Together with the CSR system, Forestry uses the asset management software TreeKeeper® to view and update data in the public tree inventory and manage and prioritize tree maintenance activities. To maximize operational efficiencies, processes and procedures need to be established and revised for using and updating Worcester's tree inventory, service requests, and management data.

Action Steps

- **3.1.** Revise Forestry's service request letter to remove the timeline for completing tree maintenance activities to allow flexibility based on staff resources, emergencies (e.g., storms), and identification of higher risk trees that may need to be addressed first. **Note:** If the current Forestry timeline remains in place, an additional increase in funding & resources (above what has already been requested) needs to be allocated permanently to meet demand.
- **3.2.** Document standard operating procedures (SOPs) for:
  - » entering, updating, completing, and closing Forestry work records in TreeKeeper® and CSR service requests.
  - » updating the tree inventory after work has been completed, including tree pruning, tree removal, stump grinding, and tree planting.
- **3.3.** Create a quick guide document for Worcester Customer Service agents on inputting forestry service requests and properly categorizing emergency tree work.
- **3.4.** Establish, document, and implement a process for Forestry crews and contractors to access work records directly through TreeKeeper® on tablets/mobile devices.
- **3.5.** Cyclically re-inventory and build onto the inventory by assessing all trees and planting sites every 7—10 years.
  - » **3.5.1.** Advocate for a specific budget line item for street tree inventory updates.
  - » **3.5.2** Make tree inventory data available to other city departments and the public.

4. DEVELOP REGULATIONS, BEST MANAGEMENT PRACTICES, AND GUIDELINES TO SUPPORT TREE CANOPY GROWTH AND PRESERVATION.

» PLAN GOALS: Plan & Manage; Maintain & Grow

The needs of gray infrastructure (e.g., utilities and roads) and development are typically prioritized over trees in Worcester. When done without coordination and oversight, certain activities such as cutting tree roots during excavation, trimming for utility clearance, tree removal for development, and post-development tree planting can have a negative impact on public trees and Worcester's overall urban forest. The planning process identified a need for Forestry to have formalized policies, standards, and best management practices in place that can be used by both City departments and outside contractors. A review of City ordinances, plans, and policies identified areas that can be strengthened and improved to protect, care for, and ensure the long-term survival of trees in Worcester.

Development of practices, policies, guidelines, and regulations ensures that tree planting, care, and preservation activities are conducted based on urban forestry industry and arboricultural best management practices. Of particular importance for Worcester as they work to increase tree canopy in more urbanized areas of the city is to ensure that the location, design, and construction of tree pits and planting areas can support the long-term growth and survival of both small and large shade trees.

Action Steps

- **4.1.** Periodically review, revise, and add to the new Urban Forestry Best Management Practices (BMP) manual.
- **4.2.** Create DPW & Parks workflow review process for City projects that includes Forestry and other city departments/divisions to ensure that trees are adequately planned for, best management practices are used, and opportunities for collaboration are identified early in the process.
- **4.3.** Implement solutions identified in the best management practices manual to reduce tree and sidewalk conflicts and help preserve public trees.
- **4.4.** Develop a policy that addresses trees and residential/commercial solar energy access.
- **4.5.** Revise city policies and guidelines, including the Complete Streets Policy (2017), the Worcester Streetscape Policy (2012) and Urban Design Guidelines (2012) to include guidelines and standards from the newly adopted Urban Forestry BMP Manual.
- **4.6.** Revise City Codes and Ordinances to strengthen the protection of public trees and private trees (see Appendix A. Worcester Ordinance Review).
  - » **4.6.1.** Explore incentives for tree planting and preservation (e.g., reduce parking requirements to encourage tree planting; allow for higher building density or increases in height building limits in exchange for the preservation of trees; tax incentives for planting on private property).
  - » **4.6.2.** Revise policies to include tree planting and canopy cover requirements for all development projects that require plan review by the city, as well as all parking lots being constructed or renovated. Secure funding for staff oversight during the plan review phase as well as during construction and up to two years after the project has been completed.
- **4.7.** Ensure there are sufficient staff to enforce tree protection and preservation regulations on public property.
- **4.8**. Evaluate development of a policy that shifts Worcester's request based street tree planting program to requiring tree planting on all viable planting locations.

5. ENSURE THERE IS ADEQUATE SPACE FOR TREES TO GROW AND THRIVE.

» PLAN GOALS: Plan & Manage; Maintain & Grow

As an older city, Worcester was not designed to accommodate all the modern needs of the public right of way, including cars, parking, utilities, and street trees. This has led to a lack of adequate space to plant and grow trees, especially large shade trees in Worcester's downtown neighborhoods. While this is an obstacle to growing overall city canopy, it has a significant impact on areas with low canopy cover, high building density, and narrow or no tree lawns. In other areas of the city, trees planted decades ago in tree lawns too small to accommodate their mature size have caused heaving and damage to sidewalks that impacts their accessibility.

Public construction and design projects have involved Forestry too late in the process to provide input on tree preservation and the location and size of new trees which has led to trees being planted in locations where they are unable to grow and thrive.

"Right tree, right place" is an important best management practice concept in urban forestry. Originally developed by the utility industry to reduce conflicts between trees and utilities on residential properties - it has been expanded and adopted by the field of urban forestry. Planting the right tree in the right place helps to maximize tree benefits by ensuring that trees have adequate space to grow and thrive, while avoiding future conflicts with infrastructure, utilities, and buildings. Providing adequate space will require early input from City departments/divisions, including Forestry. A willingness to consider constructing new or retrofitting existing sites and using existing and new technologies to increase soil volume for trees (e.g., structural soil, Silva Cells) and site-specific alternatives (e.g., street bump-outs, street tree planters, green roofs, planting beyond the right-of-way) will be needed.

Action Steps

- **5.1.** Use the principles of right tree, right place, and the BMP manual (Recommendation #4) to ensure the location, design, and construction of tree pits and planting areas can support the long-term growth and survival of both small and large shade trees.
- **5.2.** Advocate for Forestry's participation in the City's capital improvement plan development process to identify future projects where existing trees may be impacted, or new trees may be planted. Use DPW & Parks workflow process to assist with implementation (Recommendation #4).
- **5.3.** Develop tree species selection guidelines/lists that evaluate a variety of factors during tree species selection, including form, invasive potential, impacts on infrastructure, climate resilience and wildlife benefits to ensure the right tree is planted in the right location for the right reason.
- **5.4.** Pilot the use of new or existing soil volume technologies (e.g., structural soil, Silva Cells) and site-specific alternatives (e.g., street bump-outs, street tree planters) for new downtown street tree planting projects. Evaluate tree growth, survivability and impacts on site design and use.
- **5.5.** Promote Worcester's set-back street tree planting program, which allows for the planting of street trees in front yards of private property in areas where the right-of-way is not sufficient to support a street tree.

6. CONVENE A PANEL OF AREA EXPERTS IN 2024 FOR THE FIRST ANNUAL WORCESTER URBAN FORESTRY RESEARCH SUMMIT AND CONDUCT A COMPREHENSIVE URBAN TREE CANOPY ASSESSMENT FOR THE CITY OF WORCESTER.

» PLAN GOALS: Plan & Manage; Maintain & Grow; Connect & Engage

A comprehensive urban tree canopy (UTC) assessment has not been conducted for the City of Worcester. As highlighted in Section 2, a heat risk study was conducted in 2022. While the study provides general baseline data on Worcester's tree canopy cover it does not provide data and detailed analyses for urban forestry planning and management. A comprehensive UTC is a key component in understanding Worcester's urban forest on both public and private property; **however, a lack of a UTC should not keep Worcester from beginning to plant in high priority areas identified in other studies.** In Fall of 2024, the first annual Worcester Urban Forestry Research Summit will be convened to bring area experts together to set a comprehensive urban tree canopy goal by January 2025.

A comprehensive UTC assessment uses high-resolution aerial imagery to map the amount and extent of tree canopy cover, both public and private, in the city. The assessment can include a variety of analyses based on the priorities and needs of Worcester, including measuring tree canopy by environmental factors (e.g., temperature, stormwater/flooding); social/economic factors (e.g., income, ethnicity, age); health factors (e.g., populations with asthma and heart disease); and canopy change over time. It is recommended the following analyses, at a minimum, are conducted for Worcester as part of a comprehensive UTC:

Historic Tree Canopy Change. Measures tree canopy changes over a set time period to measure trends in tree canopy cover. This analysis can help understand how City policies and procedures are impacting canopy cover.

Social Equity. A study published in 2021 found that cities in the northeastern United States, including Worcester, have the highest disparities between tree canopy cover and low-income neighborhoods. A social equity analysis explores census data related to factors which can include, income, population density, race/ethnicity, age, education, and homeownership to assess tree cover and how it relates to social vulnerability, equity, and community resilience to help prioritize tree planting and care activities on public and private property.

Priority Planting. An analysis that prioritizes preferred planting areas based on a set of city-specific focal issues, which may include socio-demographics, population density, water quality, topography, ownership (public/private), linkages to greenways and parks, stormwater priorities, and urban heat island. This analysis provides a flexible tool that helps to focus tree planting in areas of highest need based on city priorities.

- Data and information from the UTC assessment can be used to:
- Prioritize tree planting and care where it is needed most in Worcester.
- Establish tree canopy goals for Worcester.
- Measure trends in tree canopy growth and loss that can be used as ordinances and regulations are reviewed and updated.

Industry standards recommend UTC assessments be conducted every 5-10 years, or more often depending on natural disasters or development, to measure changes and serve as a tool for understanding how city policies and procedures are impacting canopy cover. UTC updates will provide critical information on the trending direction of canopy cover in Worcester.

Action Steps

- **6.1.** Convene panel of area experts at first annual Worcester Urban Forestry Research Summit.
  - » **6.1.1.** Review existing datasets in order to identify tree canopy goals, priorities, and strategies for the City of Worcester.
- **6.2.** Secure funding to conduct a comprehensive UTC assessment without affecting operational resources.
  - » **6.2.1.** Pursue grant opportunities, including those that focus on sustainability and equity (Recommendation #8).
- **6.3.** Develop a cycle and funding mechanism to update the UTC assessment every 5-10 years.
- **6.4.** Conduct a historic change analysis to compare canopy cover change over time to identify canopy trends.
- **6.5.** Identify socio-economic and environmental analyses (e.g., population characteristics, income, urban heat island, flooding) based on Worcester priorities to analyze in the UTC assessment.
- **6.6.** Utilize UTC assessment data to revise established tree canopy goals for Worcester.

7. FOCUS TREE PLANTING AND CARE IN LOCATIONS THAT ADVANCE CITY SUSTAINABILITY, RESILIENCE, AND EQUITY GOALS AND PRIORITIES.

» PLAN GOALS: Plan & Manage; Maintain & Grow; Connect & Grow

Trees provide many benefits to Worcester, including improving air quality, reducing stormwater runoff, and absorbing and storing carbon. They are an important tool in helping the City to achieve its sustainability goals and priorities; however, Worcester's tree canopy cover varies across the city (Figure 17). This variability, which is common in many cities, can be due to economics, development patterns, historic redlining practices, land uses, land ownership, disturbance events (e.g., storms or tree insect/disease pests), or other factors, leads to an inequitable distribution of tree canopy cover. **This means that neighborhoods with lower tree canopy receive less tree benefits** such as improved air quality and lower temperatures, which impacts public health, property values and overall quality of life. In addition, since Worcester's tree management program is primarily reactive, tree care may disproportionately be provided to areas of the city with high tree canopy cover because those residents request tree care activities from the city more frequently.

An equity and sustainability focused approach to tree planting, establishment, and care can help to ensure that trees and the benefits they provide are available to all Worcester residents**.** Comparing data on city social equity and sustainability priorities (e.g., health, demographic, economic, high heat/temperature, air quality, stormwater runoff) and the location of tree canopy across Worcester can help prioritize tree planting and care in neighborhoods with fewer trees and the highest need. The Tree Equity score tool from American Forests along with information from a comprehensive UTC assessment (Recommendation #6) and local social equity and environmental data can provide information for the development of the program.

The program will need to include **both public and private property tree planting and care.** As an older city Worcester's public right-of-way was not designed or laid out to accommodate all of the city's current needs – like roads, parking, utilities, and trees. The areas of the city with the lowest canopy cover also present the biggest challenges for planting in the right-of-way primarily due to a lack of space, and the best opportunities to increase tree canopy cover may be on private property in these areas.

Action Steps

- **7.1.** Convene panel of area experts at Worcester Urban Forestry Research Summit.
- **7.2.** Conduct a comprehensive UTC assessment (Recommendation #6).
- **7.3.** Utilize the results of the Worcester Urban Forestry Research Summit and UTC assessment to create an annual tree planting and maintenance plan that aligns with city sustainability and equity priorities.
  - » **7.3.1.** Plan elements should include standards for species selection based on location (right tree, right place), public and private property opportunities, and a 3-year post-planting care and maintenance plan to ensure successful establishment.
- **7.4.** Develop and strengthen partnerships to support outreach efforts focused on increasing tree planting in low canopy areas of Worcester (Recommendations #8 & #9).
- **7.5.** Develop targeted outreach and engagement plans focused on residents and landowners in low canopy areas to gather input and support for planting plans and provide educational resources, in a variety of languages on tree planting and care (Recommendation #9).

8. STRENGTHEN AND DEVELOP RELATIONSHIPS AND PARTNERSHIPS WITH COMMUNITY AND REGIONAL PARTNERS TO SUPPORT IMPLEMENTATION OF THE URBAN FOREST MASTER PLAN.

» PLAN GOALS: Plan & Manage; Connect & Engage

Worcester has good working relationships with community and regional partners, especially the New England Botanic Garden at Tower Hill who assists the city in tree planting and public outreach. For Worcester to successfully implement the UFMP and develop a sustainable and resilient urban forest will require strengthening and developing its network of community, regional, and state partners.

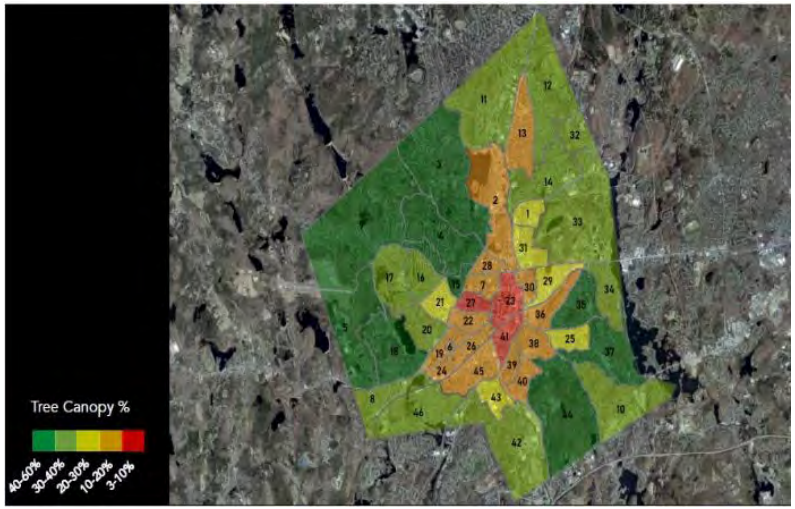


Figure 17. Worcester Tree Canopy Cover from the 2022 Worcester Heat Risk Study

Fostering and nurturing partnerships can help align the goals of the UFMP with those of partnering organizations which can serve as a catalyst to support urban forestry efforts in Worcester. During the plan development process stakeholders and community partners, including the New England Botanic Garden at Tower Hill, Greater Worcester Land Trust, Massachusetts Audubon Society, Regional Environmental Council, Massachusetts Department of Conservation, and Clark University expressed interest in partnering to support urban forestry management and planning efforts in Worcester.

This recommendation aligns with objectives in the 2021 Open Space and Recreation Plan.

Action Steps

- **8.1.** Collaborate with the New England Botanic Garden at Tower Hill to plan and host a "Worcester Tree Summit." The Summit would bring together public, private, and non-profit organizations that are involved with trees or other environmental efforts to foster collaboration, education, and engagement about trees in Worcester and implementation of the Urban Forest Master Plan. The Worcester Tree Commission could spearhead the Summit.
- **8.2.** Share data and the benefits information about Worcester's urban forest with existing and new partners.
- **8.3.** Identify research needs and offer study locations to Worcester's local college, universities, and non-profits (Mass Audubon) to foster collaboration and student engagement.
- **8.4.** Share information about Worcester's urban forest that can be used to support other City initiatives (e.g., Green Worcester Plan implementation; capital improvement projects; urban revitalization plan implementation).
- **8.5.** Partner with non-profit organizations (e.g., Mass Audubon's Broad Meadow residential intern program, New England Botanic Garden's summer program, and Worcester Green Corp) to train people on young tree care and provide workforce development opportunities.

9. DEVELOP AND IMPLEMENT AN URBAN FORESTRY COMMUNICATION AND OUTREACH PLAN.

» PLAN GOALS: Plan & Manage; Maintain & Grow; Connect & Grow

Communication and outreach are essential elements to care and grow Worcester's urban forest sustainably and equitably. Key outreach topics identified during community and stakeholder engagement include proper tree care, benefits of trees, and targeted engagement of rental property owners. Improved City communication around trees, the role of Forestry Operations and transparency in decision-making were also identified as important topics. Residents and stakeholders are unclear on the process for how tree care decisions are made, particularly around tree removals, and in some cases, are not aware that Worcester Forestry Operations maintains public street and park trees.

Development of an urban forestry communication strategy is important for Worcester to build community awareness and support for the urban forest and for promoting action. To be effective the program needs to be transparent, responsive, emphasize two-way communication, and identify unique ways to reach and target different audiences using traditional and innovative engagement tools. Understanding reasons why residents and property owners may not be supportive of trees (e.g., concerns over storm damage; loss of parking) can help identify solutions to address their concerns.

Action Steps

- **9.1.** Use the City's Forestry webpage as a "one-stop-shop" for all things tree-related in Worcester.
- **9.2.** Partner with New England Botanic Garden & Worcester Technical High School to create education and outreach materials on topics, including:
  - » Worcester's Forestry division and city tree maintenance - tree life cycle, why maintenance is needed, how tree maintenance decisions are made, and how residents can request tree planting and maintenance.
  - » Tree planting - right tree, right place
  - » Value and benefits of trees – telling the story of the benefits trees provide.
  - » Promoting the City's set-back street tree planting program.
- **9.3.** Tailor urban forestry outreach and information to the needs of specific groups, like rental property owners, renters, homeowners, developers, and business owners.
- **9.4.** Support, enhance, and develop programs with community partners that encourage and support active participation by community partners and volunteers in the planting and care of Worcester's urban forest.
- **9.5.** Develop a one-page annual State of the Urban Forest update to communicate the work that Forestry accomplishes each year, including tree maintenance activity totals, UFMP implementation accomplishments, neighborhoods engaged, and periodic review and updates to the Urban Forest Master Plan.
- **9.6.** Explore with the Urban Forestry Tree Commission how they can support outreach and education, including assisting in the development of the outreach and education plan, attendance and participation at community events, District and neighborhood meetings, rotating Tree Commission meetings around the City to hear about issues in different areas of the city; development of the annual State of the Urban Forest Update.

10. CREATE AND IMPLEMENT A PROGRAM TO MONITOR AND ADDRESS ENVIRONMENTAL THREATS TO WORCESTER'S URBAN FOREST.

» PLAN GOALS: Plan & Manage; Maintain & Grow; Connect & Engage

With the Asian longhorned beetle (ALB) infestation and the history of tornadoes and ice storms, Worcester is all too familiar with the impacts that these disturbance events can have on their urban forest. To ensure that Worcester's urban forest is resilient and adaptable to these environmental threats, a program needs to be established to actively monitor and address threats. Worcester's urban forest is an ever-changing, dynamic system where both living and non-living elements can have a substantial impact on its condition, quality, and health. It is threatened by factors including insects, diseases, climate change (e.g., high heat, flooding), invasive species, wildlife, and storms.

Action Steps

- **10.1.** Identify current and potential threats of highest concern to Worcester's urban forest (e.g., emerald ash borer, spotted lanternfly, oak wilt, invasive plants, and extreme weather) and develop strategies for monitoring, control, removal, and replanting.
  - » **10.1.1.** Ensure staff stay up to date on new threats to the urban forest by supporting attendance at conferences and webinars.
- **10.2.** Promote and require species diversity in tree planting.
- **10.3.** Periodically review and revise the City's tree species planting list considering current and potential future threats.
- **10.4.** Develop an urban tree health program to scout/monitor for threats, including in natural areas and Conservation Commission properties. This program can benefit from a combination of professionals and trained volunteers and could be led by the New England Botanic Garden and supported by local schools and academic institutions.

Action and Implementation

"Table 13. Action and Implementation Plan" outlines an action and implementation strategy for the City of Worcester's Urban Forest Master Plan. While the strategy lays out general timeframes, implementation of the plan should remain flexible and fluid to allow for shifts and changes in needs, priorities, resources, and opportunities in Worcester.

While many of the recommendations of the Urban Forest Master Plan will require City resources and effort – the UFMP offers many opportunities for residents, stakeholders, and partners to help in its implementation.

Table 13. Action and Implementation Plan

RECOMMENDATION 1:
Establish a proactive management program for Worcester's public trees that is beyond the current Customer Service Model.

Action Steps	Priority	Resources	Responsibility	Percent Complete
1.1. Prioritize completing maintenance tasks for high and moderate risk trees identified in the recently updated street tree inventory and based on updated inspections completed by City staff.	2024	**Staff** **Additional Funding** ***Estimated costs:*** *To be* *Will require reallocation of current resources and new funding to transition from proactive service delivery model.*	Forestry Operations	
1.2. Use the updated street tree inventory to develop an urban forest management plan that includes a risk management program, public tree maintenance program, and disaster preparedness and response plan. Incorporate information into Hazard Mitigation Plan updates.	2025	**Staff/Consultant** **Additional Funding** ***Estimated costs:*** *$25,000 (2023 dollars) – one-time. May be eligible for grant funding.*	Forestry Operations, Emergency Management	
1.2.1 Develop a routine pruning schedule for established trees and the structural training of young trees.	Yearly	**Staff/Consultant** **Additional Funding** ***Estimated costs:*** *To be determined based on length of cycle.* Costs, in 2023 dollars, range from $210,000 (15-year cycle) to $450,000 (7-year cycle). Funding may be reallocated from the current budget or new funding may be needed.	Forestry Operations	
1.3. Develop plans to address aging tree canopy cover and establish successional plans to ensure that canopy cover is continuously maintained, especially in Districts 1, 3, and 5 where the public tree population age distribution exceeds industry recommendations.	2027	**Staff/Consultant** **Additional Funding** ***Estimated costs:*** *To be determined based on completing 1.2.*	Forestry Operations	

Action Steps	Priority	Resources	Responsibility	Percent Complete
1.4. Assess budget needs and secure funding to proactively manage Worcester's public trees based on the urban forest management plan.	FY 2024 & Beyond	**Staff** **Additional Funding** ***Estimated costs:*** *To be determined based on completing 1.2.*	Forestry Operations	
1.4.1. Establish an interim funding goal to increase Forestry's annual budget by $500,000 to exceed the $80.77 per street tree funding identified in the 2014 Municipal Tree Care Census.	FY 2024	**Staff** **Additional Funding** ***Estimated costs:*** *$500,000 (annually)*	Forestry Operations, Urban Forestry Tree Commission	
1.4.2. Explore new and alternative funding sources – see Exploring New Sources of Funding to Support Worcester's Urban Forest sidebar in Section 3.	FY 2024	**Staff**	Forestry Operations, Planning and Regulatory Services, Department of Sustainability and Resilience	
1.5. Conduct other planning efforts while the management plan is being developed.	Yearly	**Staff** **Additional Funding**	Forestry Operations	
1.5.1 Continue to develop an annual Work Plan that prioritizes tree risk and then establishes a routine pruning cycle.	Yearly/2028	**Staff** **Additional Funding** ***Estimated costs:*** *Costs to implement the plan to be determined as part of plan development.*	Forestry Operations	
1.5.2. Update the City's street tree planting plan annually and formally establish a young tree pruning program.	2024 / On-going		Forestry Operations	
1.5.2.1. Explore establishment of a young tree pruning cycle to cyclically prune young trees during their first 10 years	2028		Forestry Operations	
1.6. Conduct baseline assessments of forested Conservation Commission properties to identify species composition, as well as threats and opportunities for the land's trees and natural resources.	FY 2024 & Beyond	**Staff** **Additional Funding** ***Estimated costs:*** *$50,000 per year*	Planning and Regulatory Services, Conservation Commission	
1.6.1. Use data from baseline assessments to develop forest management plans for Conservation Commission properties.				

RECOMMENDATION 2:
Increase City resources to transition to a proactive public tree management program and support urban forest planning, operations, and education

Action Steps	Priority	Resources	Responsibility	Percent Complete
2.1. Implement staffing scenario by adding and hiring a new arborist position and continue to reevaluate staff each fiscal year as the Urban Forest Master Plan is implemented.	FY2024	**Staff** **Additional Funding** ***Estimated costs:*** *$150,000 fully loaded rate to hire a new staff person; additional staffing costs to be determined.*	Forestry Operations	
2.2. Utilize maintenance needs identified in Recommendation #1 to develop a plan to utilize tree care contractors to perform tree removals, stump grinding, tree planting, storm response, and tree maintenance for city projects and departments.	On-going	**Staff/Contractors** **Additional Funding** ***Estimated Costs:*** *To be determined based on Recommendation #1.*	Forestry Operations	
2.3. Contract with partner organizations to provide education and outreach support.	On-going	**Staff/Partner Organizations** **Additional Funding** ***Estimated Costs:*** *$75,000 annually (2023 dollars). May be eligible for grant funding.*	Forestry Operations, Partner Organizations	
2.4. Develop staff succession plans to ensure transfer of institutional and technical knowledge as Forestry staff transition into retirement.	Complete	**Staff**	Forestry Operations	

Action Steps	Priority	Resources	Responsibility	Percent Complete
2.5. Develop training plans for Forestry staff and identify training opportunities to maintain certifications and stay up to date on the latest arboricultural techniques and urban forestry best management practices.	On-going	**Staff** **Additional Funding** ***Estimated Costs:*** *Training budget of $1,500 per employee annually (2023 dollars).May be eligible for grant funding.*	Forestry Operations	
2.6. Evaluate establishment of an urban forestry internship program to assist Forestry with tree inventory data management/ entry, outreach efforts, inspections, and minor tree maintenance tasks.	2025	**Staff** **Additional Funding** ***Estimated Costs:*** *$30,000 annually (2023 dollars). May be eligible for grant funding.*	Forestry Operations	
2.7. Implement the goals and objectives of the *Worcester Open Space and Recreation Plan Update 2021* to support increasing resources for the proactive management of Conservation Commission properties.	On-going	**Staff** **Additional Funding** **Estimated costs:** *$300,000 per year (includes new staff)*	Planning and Regulatory Services, Conservation Commission	

RECOMMENDATION 3:
Revise and develop urban forestry processes to support improvements to customer service, service delivery, data, technology, and information management using national arboricultural standards and best management practices.

Action Steps	Priority	Resources	Responsibility	Percent Complete
3.1. Revise Forestry's service request letter to remove the timeline for completing tree maintenance activities to allow flexibility based on staff resources, emergencies (e.g., storms), and identification of higher risk trees that may need to be addressed first. Note: If the current Forestry timeline remains in place, an additional increase in funding & resources (above what has already been requested) needs to be allocated permanently to meet demand.	2023	**Staff**	Forestry Operations	
3.2. Document standard operating procedures (SOPs) for: (1) entering, updating, completing, and closing Forestry work records in TreeKeeper® and CSR service requests. (2) updating the tree inventory after work has been completed, including tree runing, tree removal, stump grinding, and tree planting.	2023	**Staff/Consultant**	Forestry Operations	
3.3. Create a quick guide document for Worcester Customer Service agents on inputting forestry service requests and properly categorizing emergency tree work.	2023	**Staff**	Forestry Operations	
3.4. Establish, document, and implement a process for Forestry crews and contractors to access work records directly through TreeKeeper® on tablets/mobile devices.	2023	**Staff**	Forestry Operations	
3.5. Cyclically re-inventory and build onto the inventory by assessing all trees and planting sites every 7–10 years.	2030	**Staff/Consultant** **Additional Funding** ***Estimated costs:*** *$125,000-$175,000 depending on scope every 7-10 years (2023 dollars).*	Forestry Operations	
3.5.1. Advocate for a specific budget line item for street tree inventory updates.	FY 2025	**Staff** ***Estimated costs:*** *See 3.5. May be eligible for grant funding.*	Forestry Operations, Urban Forestry Commission	
3.5.2 Make tree inventory data available to other city departments and the public.	On-going	**Staff**	Forestry Operations	

RECOMMENDATION 4:
Develop regulations, best management practices, and guidelines to support tree canopy growth and preservation.

Action Steps	Priority	Resources	Responsibility	Percent Complete
4.1. Periodically review, revise, and add to the new Urban Forestry Best Management Practices (BMP) manual.	2023/ On-going	**Staff/Consultant Additional Funding** ***Estimated costs:*** *To be determined based on BMP needs. May be eligible for grant funding.*	Forestry Operations, DPW & Parks, Planning and Regulatory Services, Department of Sustainability and Resilience, Urban Forestry Tree Commission	
4.2. Create DPW & Parks workflow review process for City projects that includes Forestry and other city departments/divisions to ensure that trees are adequately planned for, best management practices are used, and opportunities for collaboration are identified early in the process.	2024	**Staff** **Additional Funding** ***Estimated costs:*** *Additional funding may be needed to implement solutions to preserve and protect trees.*	Forestry Operations, DPW & Parks, Planning and Regulatory Services, Department of Sustainability and Resilience, & Other City Departments	
4.3. Implement solutions identified in the best management practices manual to reduce tree and sidewalk conflicts and help preserve public trees.	2025	**Staff/Consultant/ Contractor Additional Funding** ***Estimated costs:*** *To be determined based on solution implemented.*	Forestry Operations, DPW & Parks	

Action Steps	Priority	Resources	Responsibility	Percent Complete
4.4. Develop a policy that addresses trees and residential/ commercial solar energy access.	2025	**Staff**	Forestry Operations, Planning & Regulatory Services, Department of Sustainability and Resilience, Urban Forestry Tree Commission	
4.5. Revise city policies and guidelines, including the Complete Streets Policy (2017), the Worcester Streetscape Policy (2012) and Urban Design Guidelines (2012) to include guidelines and standards from the newly adopted Urban Forestry BMP Manual.	2026	**Staff/Consultant Additional Funding** ***Estimated costs:*** *Additional funding will be needed if completed by consultants.*	Forestry Operations, DPW & Parks, Planning and Regulatory Services, Transportation, & Mobility, Department of Sustainability and Resilience, & Other City Departments	
4.6. Revise City Codes and Ordinances to strengthen the protection of public and private trees (see Appendix A. Worcester Ordinance Review).	2023	**Staff/Consultant Additional Funding** ***Estimated costs:*** *Additional funding will be needed if completed by consultants. May be eligible for grant funding.*	Forestry Operations, DPW & Parks, Planning and Regulatory Services, Transportation & Mobility, Department of Sustainability and Resilience, Other City Departments	

Action Steps	Priority	Resources	Responsibility	Percent Complete
4.6.1. Explore incentives for tree planting and preservation (e.g., reduce parking requirements to encourage tree planting; allow for higher building density or increases in height building limits in exchange for the preservation of trees; tax incentives for planting on private property).	2027	**Staff/Consultant** **Additional Funding** ***Estimated costs:*** *Additional funding will be needed if completed by consultants.*	Forestry Operations, Planning and Regulatory Services, Urban Tree Commission	
4.6.2. Revise policies to include tree planting and canopy cover requirements for all development projects that require plan review by the city, as well as all parking lots being constructed or renovated. Secure funding for staff oversight during the plan review phase as well as during construction and up to two years after the project has been completed.				
4.7. Ensure there are sufficient staff to enforce tree protection and preservation regulations on public property	2026	**Staff** **Additional Funding** ***Estimated costs:*** *$150,000 fully loaded rate to hire a new staff person; additional staffing costs to be determined.*	Planning and Regulatory Services, Conservation Commission	
4.8. Evaluate development of a policy that shifts Worcester's request based street tree planting program to requiring tree planting on all viable planting locations.	2025	**Staff** **Additional Funding** *for tree planting (to be determined) will be required if policy is established*	Forestry Operations	

RECOMMENDATION 5:
Ensure there is adequate space for trees to grow and thrive.

Action Steps	Priority	Resources	Responsibility	Percent Complete
5.1. Use the principles of right tree, right place, and the BMP manual (Recommendation #4) to ensure the location, design, and construction of tree pits and planting areas can support the long-term growth and survival of both small and large shade trees.	On-going	**Staff/Consultant/ Contractor Additional Funding** ***Estimated costs:*** *To be determined based on scope and size of project.*	Forestry Operations, Department of Public Works and Parks, Transportation & Mobility	
5.2. Advocate for Forestry's participation in the City's capital improvement plan development process to identify future projects where existing trees may be impacted or new trees may be planted. Use DPW & Parks workflow process to assist with implementation (Recommendation #4).	2023	**Staff**	Forestry Operations	
5.3. Develop tree species selection guidelines/lists that evaluate a variety of factors during tree species selection, including form, invasive potential, impacts on infrastructure, climate resilience and wildlife benefits to ensure the right tree is planted in the right location for the right reason.	On-going	**Staff**	Forestry Operations, DPW & Parks, Planning and Regulatory Services, Department of Sustainability and Resilience	
5.4. Pilot the use of new or existing soil volume technologies (e.g., structural soil, Silva Cells) and site-specific alternatives (e.g., street bump-outs, street tree planters) for new downtown street tree planting projects. Evaluate tree growth, survivability and impacts on site design and use.	2026	**Staff/Consultant/ Contractor Additional Funding** ***Estimated costs:*** *To be determined based on size, scope and technology/alternative used.*	Forestry Operations, DPW & Parks, Planning and Regulatory Services	
5.5. Promote Worcester's set-back street tree planting program, which allows for the planting of street trees in front yards of private property in areas where the right-of-way is not sufficient to support a street tree.	On-going	**Staff**	Forestry Operations, Urban Forestry Tree Commission	

RECOMMENDATION 6:
Convene a panel of area experts in 2024 for the first annual Worcester Urban Forestry Research Summit and conduct a comprehensive urban tree canopy assessment for the City of Worcester.

Action Steps	Priority	Resources	Responsibility	Percent Complete
6.1. Convene panel of area experts at first annual Worcester Urban Forestry Research Summit.	2024/ On-going	**Partner Organizations**	Partners	
6.1.1. Review existing datasets in order to identify tree canopy goals, priorities, and strategies for the City of Worcester.				
6.2. Secure funding to conduct a comprehensive UTC assessment without affecting operational resources.	2024	**Staff/Consultant/ Contractor Additional Funding** ***Estimated costs:*** *$50,000–100,000 depending on scope (2023 dollars) every 5–10 years beginning in 2025. May be eligible for grant funding.*	Forestry Operations, Planning and Regulatory Services, Department of Sustainability and Resilience	
6.2.1. Pursue grant opportunities to fund project, including those that focus on sustainability and equity (Recommendation #8).	2024/ On-going	**Staff/Partner Organizations**	Forestry Operations, DPW & Parks, Planning and Regulatory Services, Department of Sustainability and Resilience, Transportation & Mobility, Urban Forestry Tree Commission	

Action Steps	Priority	Resources	Responsibility	Percent Complete
6.3. Develop a cycle and funding mechanism to update the UTC assessment every 5-10 years.	2032	**Staff** **Additional Funding** ***Estimated costs:*** *See 6.2*	Forestry Operations, Planning and Regulatory Services, Department of Sustainability and Resilience, Urban Forestry Tree Commission	
6.4. Conduct a historic change analysis to compare canopy cover change over time to identify canopy trends.	2032	**Staff** **Consultant** **Additional Funding** ***Estimated costs:*** *See 6.2*	Forestry Operations	
6.5. Identify socio-economic and environmental analyses (e.g., population characteristics, income, urban heat island, flooding) based on Worcester priorities to analyze in the UTC assessment.	2025	**Staff** **Consultant** **Additional Funding** ***Estimated costs:*** *See 6.2*	Forestry Operations, Planning and Regulatory Services, Department of Sustainability and Resilience, Urban Forestry Tree Commission	
6.6. Utilize UTC assessment data to establish tree canopy cover goals for Worcester.	2026	**Staff**	Forestry Operations, Planning and Regulatory Services, Department of Sustainability and Resilience, Urban Forestry Tree Commission	

RECOMMENDATION 7:
Focus tree planting and care in locations that advance city sustainability, resilience, and equity goals and priorities.

Action Steps	Priority	Resources	Responsibility	Percent Complete
7.1. Convene panel of area experts at Worcester Urban Forestry Research Summit.	2024/ On-going	**Organizations**	Partners	
7.2. Conduct a comprehensive UTC assessment (Recommendation #6).	2025	**Staff/Consultant** ***Estimated costs:*** *See 6.2.*	Forestry Operations	
7.3. Utilizing the results from the UTC assessment create an annual tree planting and maintenance plan that aligns with city sustainability and equity priorities. **7.3.1.** Plan elements should include standards for species selection based on location (right tree, right place), public and private property opportunities, and a 3-year post-planting care and maintenance plan to ensure successful establishment.	2026	**Staff**	Forestry Operations, Planning and Regulatory Services, Department of Sustainability and Resilience	
7.4. Develop and strengthen partnerships to support outreach efforts focused on increasing tree planting in low canopy areas of Worcester (Recommendations #8 & #9).	2026	**Staff/Partner Organizations Additional Funding** ***Estimated costs:*** *$75,000 annually (2023 dollars)— may be coordinated with Action 2.3. May be eligible for grant funding.*	Forestry Operations, Department of Sustainability and Resilience, Urban Forestry Tree Commission	
7.5. Develop targeted outreach and engagement plans focused on residents and landowners in low canopy areas to gather input and support for planting plans and provide educational resources, in a variety of language on tree planting and care (Recommendation #9).	2027	**Staff/Partner Organizations Additional Funding** ***Estimated costs:*** *To be determined with plan development. May be eligible for grant funding.*	Forestry Operations, Planning and Regulatory Services. Department of Sustainability and Resilience, Urban Forestry Tree Commission, Partner Organizations	

RECOMMENDATION 8:
Strengthen and develop relationships and partnerships with community and regional partners to support implementation of the urban forest master plan.

Action Steps	Priority	Resources	Responsibility	Percent Complete
8.1. Collaborate with the New England Botanic Garden at Tower Hill to plan and host a "Worcester Tree Summit." The Summit would bring together public, private, and non-profit organizations that are involved with trees or other environmental efforts to foster collaboration, education, and engagement about trees in Worcester and implementation of the Urban Forest Master Plan. The Worcester Tree Commission could spearhead the Summit.	On-going	**Staff** **Partner Organizations** **Additional Funding** ***Estimated costs**: To be determined. May be eligible for grant funding.*	Forestry Operations, New England Botanic Garden, Urban Forestry Tree Commission	
8.2. Share data and the benefits information about Worcester's urban forest with existing and new partners.	On-going	**Staff**	Forestry Operations, Planning and Regulatory Services, Department of Sustainability and Resilience, Urban Forestry Tree Commission	
8.3. Identify research needs and offer study locations to Worcester's local colleges, universities, and non-profits (Mass Audubon) to foster collaboration and student engagement.	On-going	**Staff**	Forestry Operations, Planning and Regulatory Services, Department of Sustainability and Resilience, Other City Departments, Urban Forestry Tree Commission	

Action Steps	Priority	Resources	Responsibility	Percent Complete
8.4. Share information about Worcester's urban forest that can be used to support other City initiatives (e.g., Green Worcester Plan implementation; capital improvement projects; urban revitalization plan implementation).	On-going	**Staff**	Forestry Operations, Planning and Regulatory Services, Department of Sustainability and Resilience, Other City Departments, Urban Forestry Tree Commission	
8.5. Partner with non-profit organizations (e.g., Mass Audubon's Broad Meadow residential intern program, New England Botanic Garden's summer program, and Worcester Green Corp) to train people on young tree care and provide workforce development opportunities.	On-going	**Staff** **Partner Organizations**	Partner Organizations, Forestry Operations, Department of Sustainability and Resilience	

RECOMMENDATION 9:
Develop and implement an urban forestry communication and outreach plan.

Action Steps	Priority	Resources	Responsibility	Percent Complete
9.1. Use the City's Forestry webpage as a "one-stop-shop" for all things tree-related in Worcester.	2024	**Staff/Consultant** **Additional Funding** ***Estimated costs:*** *To be determined based on scope.*	Forestry Operations, Urban Forestry Tree Commission	
9.2. Partner with New England Botanic Garden & Worcester Technical High School to create education and outreach materials on topics, including: • Worcester's Forestry division and city tree maintenance - tree life cycle, why maintenance is needed, how tree maintenance decisions are made, and how residents can request tree planting and maintenance. • Tree planting - right tree, right place. • Value and benefits of Worcester's trees. • Promoting the City's set-back street tree planting program.	On-going	**Staff/Partner Organizations** **Additional Funding** ***Estimated costs:*** *$75,000 annually (2023 dollars)—may be coordinated with Actions 2.3 and 7.4. May be eligible for grant funding.*	Forestry Operations, New England Botanic Garden, Worcester Technical High School, Urban Forestry Tree Commission	
9.3. Tailor urban forestry outreach and information to the needs of specific groups, like rental property owners, renters, homeowners, developers, and business owners.	On-going	**Staff/Partner Organizations** **Additional Funding** ***Estimated costs:*** *see Action 7.5.*	Forestry Operations, Planning and Regulatory Services, Department of Sustainability and Resilience, Other City Departments, Urban Forestry Tree Commission, Partners	

Action Steps	Priority	Resources	Responsibility	Percent Complete
9.4. Support, enhance, and develop programs with community partners that encourage and support active participation by community partners and volunteers in the planting and care of Worcester's urban forest.	On-going	**Staff** **Partner Organizations** **Additional Funding** ***Estimated costs:*** *To be determined. May be eligible for grant funding.*	Forestry Operations, Department of Sustainability and Resilience, Urban Forestry Tree Commission, Partners	
9.5. Develop a one-page annual State of the Urban Forest update to communicate the work that Forestry accomplishes each year, including tree maintenance activity totals, UFMP implementation accomplishments, neighborhoods engaged, etc.	2024/on-going	**Staff**	Forestry Operations, Urban Forestry Tree Commission	
9.6. Explore with the Urban Forestry Tree Commission how they can support outreach and education, including assisting in the development of the outreach and education plan, attendance and participation at community events, District and neighborhood meetings, rotating Tree Commission meetings around the City to hear about issues in different areas of the city; development of the annual State of the Urban Forest Update; and periodic review and updates to the Urban Forest Master Plan.	On-going	**Staff**	Forestry Operations, Urban Forestry Tree Commission	

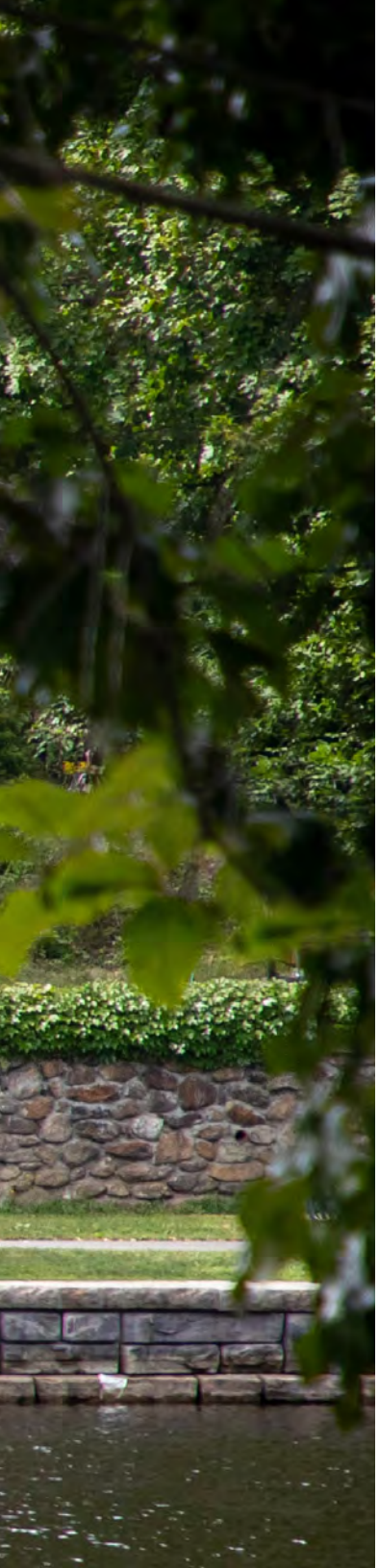
RECOMMENDATION 10:
Create and implement a program to monitor and address environmental threats to Worcester's urban forest.

Action Steps	Priority	Resources	Responsibility	Percent Complete
10.1. Identify current and potential threats of highest concern to Worcester's urban forest (e.g., emerald ash borer, spotted lanternfly, oak wilt, invasive plants, and extreme weather) and develop strategies for monitoring, control, removal, and replanting.	On-going	**Staff/Consultant** **Additional Funding** ***Estimated costs**: To be determined based on scope and strategy. May be eligible for grant funding.*	Forestry Operations, Planning & Regulatory Services, Conservation Commission, Urban Forestry Tree Commission	
10.1.1. Ensure staff stay up to date on new threats to the urban forest by supporting attendance at conferences and webinars.	On-going	**Staff/Consultant** **Additional Funding** ***Estimated costs:** May be coordinated with Action 2.5.*	Forestry Operations	

Action Steps	Priority	Resources	Responsibility	Percent Complete
10.2. Promote and require species diversity in tree planting.	On-going	**Staff**	Forestry Operations	
10.3. Periodically review and revise the City's tree species planting list considering current and potential future threats.	On-going	**Staff**	Forestry Operations	
10.4. Develop an urban tree health program to scout/monitor for threats, including in natural areas and Conservation Commission properties. This program can benefit from a combination of professionals and trained volunteers and could be led by the New England Botanic Garden and supported by local schools and academic institutions.	On-going	**Staff/Partner Organizations Additional Funding** ***Estimated costs:*** *$75,000 annually (2023 dollars) — may be coordinated with Actions 2.3, 7.4, and 9.2. May be eligible for grant funding.*	Forestry Operations	

Section Six

CONCLUSION



Measuring progress

The Worcester Urban Forest Master Plan is a living document that will evolve and change over time. For it to be an effective tool in creating a sustainable and resilient urban forest in Worcester, both its implementation and the condition of Worcester's urban forest must be regularly monitored and assessed. Progress assessment will help to identify urban forestry plan successes that can be used in building momentum around trees and also identify emerging opportunities and challenges that may need to be incorporated into the Plan.

Periodic Review and Updates of the UFMP

As a living document, the Plan is designed to be periodically reviewed and updated (every 3-5 years) based on the changing needs of Worcester's trees, community priorities, new opportunities, and successes in Plan implementation. The data and information from the other tools to measure progress, detailed below, are essential for conducting the review and updating the Plan. The City of Worcester's Urban Forestry Tree Commission should be a key player in the review and update process.

Tree Inventory Updates

A public tree inventory provides critical information to manage and maintain Worcester's public tree resource and provides an opportunity to monitor the resource over time. Urban forestry industry standards recommend that municipal tree inventories are updated on a regular basis, as planting, maintenance, and removals occur and that public trees are re-inventoried at least once every 7-10 years. As Worcester's public trees are inventoried and re-inventoried, the City can monitor changes in:

- Tree genus and species composition
- Number and location of trees
- Size/age composition
- Condition
- Maintenance needs

Assessing these changes can help measure progress in implementing the UFMP's recommendations. Note: The original inventory data should be downloaded after the inventory has been completed to provide the baseline data to compare with future inventory data.

Changes in Tree Benefits

Worcester's trees and urban forest provide quantifiable benefits to the community. Measuring Worcester's progress in growing and caring for its urban forest can be done by examining changes in these tree benefits. Did the amount of air pollutants removed increase or decrease over time? Does the canopy intercept more gallons of stormwater? Has the amount of carbon stored increased? i-Tree—the USDA Forest Service's suite of tools that measures and quantifies the benefits of trees—can be used to measure changes in tree benefits over time. The software tools in iTree are routinely updated based on the latest science and research. To measure changes in benefits over time both the new and previous UTC assessment data and tree inventory data must be analyzed through the same version of i-Tree.

Indicators of a Sustainable Urban Forest

The *Indicators of a Sustainable Urban Forest* were used to establish a baseline assessment of Worcester's urban forestry program.

The Indicators – broadly categorized into three groups: The Trees, The Players, and The Management – use urban forestry industry standards and best management practices to evaluate and rate Worcester's trees, how they are managed, and the level of engagement there is around trees and urban forestry activities.

For each Indicator, Worcester's current performance level was rated as low, moderate, or high by the Project Team and the Consultants based on information, data, and public and stakeholder engagement during the Plan's discovery phase. The assessment identified areas where the city's urban forest can be improved and was used in the development of the UFMP recommendations. Worcester's current overall performance for each component is:

The Trees: MODERATE

The Players: LOW-MODERATE

The Management: MODERATE

As the UFMP is implemented periodic re-assessments (every 3-5 years) of the Indicators of a Sustainable Urban Forest should be conducted. The re-assessments can highlight successes in implementation, identify areas for improvement, and establish new program priorities, recommendations, and action steps that can be used in UFMP updates.

Conclusion

As detailed throughout the Urban Forest Master Plan, trees play an essential role in the quality of life, resilience, and sustainability of Worcester. To ensure that its benefits are maximized today and into the future – the Plan provides a path to proactively manage, grow, preserve, and care for Worcester's trees. The Introduction (Section 1) highlighted the essential benefits trees provide to Worcester. Section 2 presented the current state of Worcester's street trees by providing information based on the 2022 street tree inventory to establish a baseline of where the city is today. An assessment of the tools, resources, plans, and programs used to manage Worcester's urban forest were presented in Section 3. Section 4 outlined the community and stakeholder priorities and themes which were used in establishing the Plan's goals, recommendations, and actions. The Plan goals, recommendations, and actions were shared in Section 5. They focus on improving Worcester's urban forest through proactive planning, management, and engagement. And this section, Section 6, outlined ways that Worcester can monitor and measure its progress in proactively managing its urban forest to create a sustainable and resilient resource. Ultimately, the Urban Forest Master Plan serves as a roadmap to guide the development of an abundant, healthy, sustainable, and resilient urban forest in Worcester that we can all play a role in creating. There's work to do – let's get started!

Appendix A.

WORCESTER ORDINANCE REVIEW

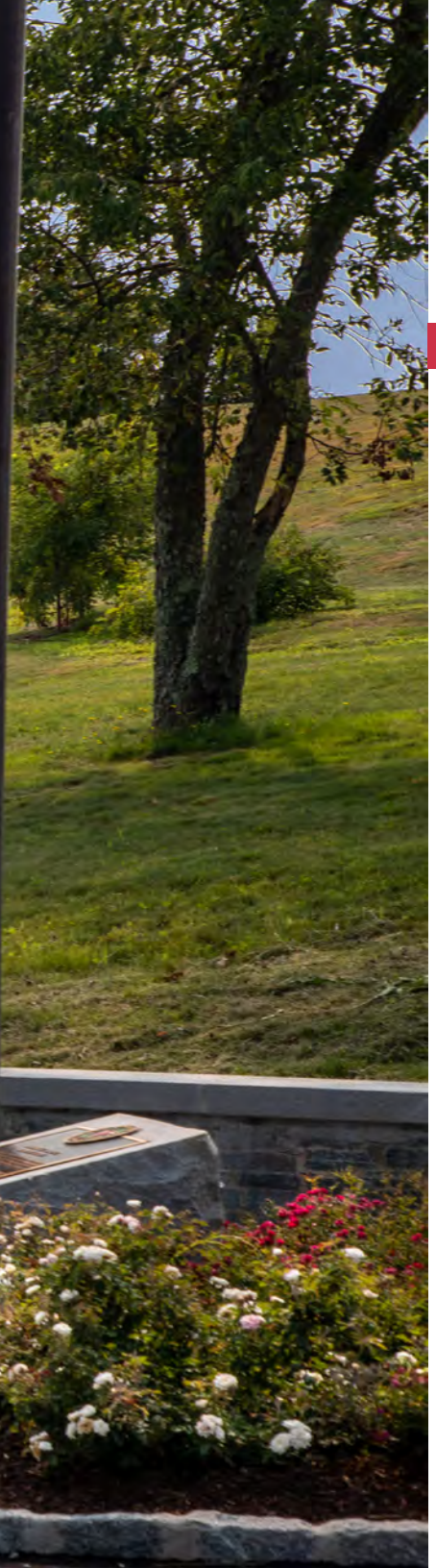
Ordinance Topic	Addressed (X)	Chapter & Section
CREDENTIALS		
Requires certified arborist for paid private tree work		
Requires Certified Arborist for public tree work	X	Chapter 12, Section 28 (f)
Requires licensing of private tree care firms		
Defines official authority for public tree management	X	Chapter 12, Section 28 (f)
PUBLIC TREE MANAGEMENT AND PROTECTION		
Establishes/Authorizes City Forester to regulate public trees	X	Chapter 12, Section 28(c); General Laws - Commonwealth of Massachusetts - Chapter 87 - Shade Trees , Section 13
Establishes/Authorizes City position (e.g. Mayor, City Administrator, DPW Director) to regulate public trees	Partially	Chapter 12, Section 1 (does not explicitly mention street and park trees); General Laws - Commonwealth of Massachusetts - Chapter 87 - Shade Trees, Sections 2 and 13
Established a community Tree Board or Commission	X	Article 5 (Dept. of Public Works and Parks); Section 16
Defines public trees	X	Chapter 12, Section 28 (Protection of Public Trees); General Laws - Commonwealth of Massachusetts - Chapter 87 - Shade Trees , Section 1
Requires annual community tree work plans		

Ordinance Topic	Addressed (X)	Chapter & Section
PUBLIC TREE MANAGEMENT AND PROTECTION (continued)		
Identifies formula for determining monetary tree value	X	Chapter 12, Section 29 (c)(2) and (m)
Requires regular public tree maintenance	N/A	
Requires particular types of maintenance (e.g., pruning)	N/A	
Requires adherence to ANSI A300 standards and best management practices		
Establishes permit system for work on public trees	X	Chapter 12, Section 28 (c)
Requires payment of fees for the removal of public trees	X	Chapter 12, Section 28 (c) (1, 2, 3)
Establishes provisions for penalties for non-compliance	X	Chapter 12 Sections 28 (c)(3) and (m); Chapter 15 (Fines and Penalties), Section 2(b)(28); General Laws - Commonwealth of Massachusetts - Chapter 87 - Shade Trees , Section 12
Restricts tree removal on public property	X	Chapter 12 Section 28 (c) Wetlands Protection Ordinance
Permit or approval required for tree removal, pruning or excavating near public trees	X	Chapter 12, Section 28 (c)

Ordinance Topic	Addressed (X)	Chapter & Section
PUBLIC TREE MANAGEMENT AND PROTECTION (continued)		
Requires protection of public trees during construction, repairs or utility work	X	Chapter 12, Section (h)
Prohibits damage to public trees (e.g. attaching ropes, signs, wires, chemicals, storing materials, excavation etc.)	X	General Laws - Commonwealth of Massachusetts - Chapter 87 - Shade Trees' , Section 9; Zoning Ordinance, Article 4, Section 6 (signs) (E)(1)(c)(vii)(aa)
Establishes provisions for trimming for overhead utility line clearance	X	Chapter 12, Section 28 (g); General Laws - Commonwealth of Massachusetts - Chapter 87 - Shade Trees, Section 14
Restricts burning of solid wood waste		
Establishes a wood utilization program		
Establishes an insect/disease control strategy		
Prohibits tree topping	X	Chapter 12, Section 28 (f)(1)
Regulates abatement of hazardous or nuisance trees on private property	X	Chapter 8 Public Health, Section 42 (b)(2), Chapter 12, Section 21(g)
Regulates removal of dead or diseased trees	X	Chapter 12, Section 28 (i)

Ordinance Topic	Addressed (X)	Chapter & Section
TREE PLANTING		
Regulates tree species which may or may not be planted on **private** property (approved tree list)	X	Subdivision Regulations, Section X (Required Improvements) (J) (1) and Appendix II ("List of Recommended Street Trees"); Zoning Ordinance Article 5, Section V (C) (Landscape Design Standards)(1)(b)(i)
Requires tree planting around and within parking lots	X	Chapter 12, Section 28 (j); Zoning Ordinance, Article 5, Section V (C) (Landscape Design Standards); Zoning Ordinance - Off-Site Accessory Parking Requirements (Note 6 - Interior Landscaping)
Requires replacement of removed publicly owned trees	X	Chapter 12, Section 28 (c)(1)(3)
Permits public tree planting - beyond the right-of-way	X	Chapter 12, Section 28 (e)(1)
Requires tree plantings around new developments (see also trees in parking lots)	X	Chapter 12, Section 28 (i); Subdivision Regulations X (Required Elements)(J) Zoning Ordinance, Article 5, Section V (C) (Landscape Design Standards); Zoning Ordinance - Off-Site Accessory Parking Requirements (Note 6 - Interior Landscaping)
Regulates tree species which may or may not be planted on **public** property (approved tree list)	X	Chapter 12, Section 28 (e)


MEMORIAL GROVE



Appendix B.

ENDNOTES

1. Herwitz, E. (2001). Trees at risk : reclaiming an urban forest, a case history of Worcester, Massachusetts. Chandler House Press.
2. New England Forestry Foundation. Our History. https://newenglandforestry.org/about/our-history/
3. Massachusetts Tree Warden and Foresters Association (n.d.). Laws. https://masstreewardens.org/laws/
4. Massachusetts Department of Conservation and Recreation. (n.d.) Asian Longhorned Beetle in Massachusetts. https://www.mass.gov/guides/asian-longhorned-beetle-in-massachusetts
5. Massachusetts Audubon Society. (n.d.). Asian Longhorned Beetles. https://www.massaudubon.org/learn/nature-wildlife/insects-arachnids/asian-longhorned-beetles
6. Middaugh, P. (2019). Worcester's response to Asian longhorned beetle: Reforestation, stewardship, and sustainability. In: Campbell, Lindsay K.; Svendsen, Erika; Sonti, Nancy Falxa; Hines, Sarah J.; Maddox, David, eds. Green readiness, response, and recovery: A collaborative synthesis. Gen. Tech. Rep. NRS-P-185. Newtown Square, PA: U.S. Department of Agriculture, Forest Service. 104-115. https://doi.org/10.2737/NRS-GTR-P-185-paper7
7. New England Botanic Garden at Tower Hill – www.nebg.org
8. Miller, R. W. (1988). Urban Forestry: Planning and Managing Urban Greenspaces. New Jersey: Prentice Hall.
9. City of Worcester (n.d.). Quick Facts. Retrieved September 8, 2022 from https://www.worcesterma.gov/quick-facts
10. Grow Native Massachusetts. (n.d.). Ecoregions of Massachusetts. Retrieved on December 12, 2022 from https://grownativemass.org/Our-Commonwealth/ecoregions
11. Natural Resource Conservation Service. (n.d.) Web soil science survey. Retrieved on December 12, 2022 from https://websoilsurvey.nrcs.usda.gov/
12. Worcester Historical Museum (n.d.). Worcester History. https://www.worcesterhistory.org/worcesters-history/
13. ,US Department of Commerce. (September 1951). 1950 Census of Population Advance Reports. https://www2.census.gov/library/publications/decennial/1950/pc-08/pc-8-20.pdf
14. US Department of Commerce. (December 1981). 1980 Census of Population. Volume 1 Characteristics of Population. Chapter A Number of Inhabitants. Part 23 Massachusetts. https://www2.census.gov/prod2/decennial/documents/1980a_maABC-01.pdf
15. UMass Chan Medical School (n.d.). Worcester: A History Lesson. Retrieved on December 12, 2022 from https://www.umassmed.edu/about/worcesterhistory/
16. US Census Bureau (n.d.). Quick Facts Worcester city, Massachusetts. Retrieved on December 12, 2022 from https://www.census.gov/quickfacts/worcestercitymassachusetts

17. MA Executive Office of Energy and Environmental Affairs. (n.d.). Environmental Justice Populations in Massachusetts. Retrieved on December 12, 2022 from https://mass-eoeea.maps.arcgis.com/apps/MapSeries/index.html?appid=535e4419dc0545be980545a0eeaf9b53

18. US Environmental Protection Agency. (Updated December 20, 2022). Climate Change Indicators in the United States. Retrieved on January 10, 2022 at https://www.epa.gov/climate-indicators

19. National Oceanic and Atmospheric Administration. (n.d.). National Centers of Environmental Information – U.S. Climate Normals Quick Access. Retrieved on December 14, 2022 at https://www.ncei.noaa.gov/access/us-climate-normals/#dataset=normals-annualseasonal&timeframe=30&location=MA&station=USW00094746

20. Resilient MA – Climate Change Clearinghouse for the Commonwealth. (2018). Massachusetts Climate Change Projections - Statewide and for Major Drainage Basins: Temperature, Precipitation, and Sea Level Rise Projections. Northeast Climate Adaptation Science Center - University of Massachusetts Amherst. https://www.mass.gov/doc/climate-change-projections-for-major-drainage-basins-in-massachusetts/download?_ga=2.106408131.1988038156.1673230572-1121829753.1671655890

21. Resilient MA (2) - Climate Change Clearinghouse for the Commonwealth (2022). 2022 Massachusetts Climate Change Assessment. Retrieved at https://www.mass.gov/info-details/massachusetts-climate-change-assessment#climate-change-in-massachusetts-

22. Winbourne, J. B., Jones, T. S., Garvey, S. M., Harrison, J. L., Wang, L., Li, D., Templer, P. H., & Hutyra, L. R. (2020). Tree transpiration and urban temperatures: Current understanding, implications, and future research directions. BioScience, 70(7), 576-588. https://doi.org/10.1093/biosci/biaa055

23. US Environmental Protection Agency (2). (Updated December 20, 2022). Climate Change Indicators in the United States. Retrieved on January 10, 2022 at https://www.epa.gov/climate-indicators

24. US Environmental Protection Agency (3). (2003). Protecting Water Quality from Urban Runoff. https://www3.epa.gov/npdes/pubs/nps_urban-facts_final.pdf

25. Resilient MA (3) – Climate Change Clearinghouse for the Commonwealth. (n.d.) Extreme Weather. https://resilientma.mass.gov/changes/extreme-weather

26. McPherson, E.G., Simpson, J.R., Peper, P.J., Maco, S.E., & Xiao, Q. (2005). Municipal forest benefits and costs in five U.S. cities. Journal of Forestry, 103(8), 411-416.

27. USDA Forest Service i-Tree [Computer software]. MyTree 2.4.16 benefits tool. www.itreetools.org

28. American Lung Association. (2022). State of the Air 2022 Worcester County. https://www.lung.org/research/sota/city-rankings/states/massachusetts/worcester

29. Center for Disease Control and Prevention. (n.d.). PLACES: Local Data for Local Health. https://experience.arcgis.com/experience/22c7182a162d45788dd52a2362f8ed65

30. Center for Disease Control and Prevention (2). (n.d.) Most recent asthma state or territory data. https://www.Cdc.Gov/asthma/most_recent_data_states.Htm

31. Nowak, D.J., Hirabayashi, S., Bodine, A., & Greenfield, E. (2014). Tree and Forest Effects on Air Quality and Human Health in the United States. Environmental Pollution, 193, 119–129., https://doi.org/10.1016/j.envpol.2014.05.028.

32. McPherson, E.G,. Xiao, Xl, Maco, S.E., VanDerZanden, A., Simpson, J.R., Bell, N., & Peper, P.J. (2002). Western Washington and Oregon Community Tree Guide: Benefits, Costs and Strategic Planting. Center for Urban Forest Research Pacific Southwest Research Station.

33. Johnson, Z. S., Koski, T., &O'Conner, A. (2017). The hidden value of landscapes. http://webdoc.agsci.colostate. edu/ hortla/Colorado_Water_2017.pdf

34. US Environmental Protection Agency (4). (n.d.) Using Trees and Vegetation to Reduce Heat Islands. https://www.epa.gov/heatislands/using-trees-and-vegetation-reduce-heat-islands

35. Shah, A.M., Liu, G., Huo, Z., Yang, Q., Zhang, W., Meng, F., Yao, L., & Ulgiati, S. (2022). Assessing Environmental Services and Disservices of Urban Street Trees. an Application of the Emergy Accounting. Resources, Conservation and Recycling, 186, 106563. https://doi.org/10.1016/j.resconrec.2022.106563.

36. City of Worcester Department of Sustainability and Resilience and Urban Climate Consulting. (DRAFT 2022). Worcester Heat Risk Assessment. [DRAFT - not published].

37. National Weather Service. (n.d.). Weather Related Fatalities and Injury Statistics. https://www.weather.gov/hazstat/

38. Anderson, G. B., & Bell, M. L. (2011). Heat waves in the United States: mortality risk during heat waves and effect modification by heat wave characteristics in 43 U.S. communities. Environmental health perspectives, 119(2), 210–218. https://doi.org/10.1289/ehp.1002313

39. Kalkstein, L.S., Eisenman, D.P., de Guzman, E.B. & Sailor, D.J. (2022) Increasing trees and high-albedo surfaces decreases heat impacts and mortality in Los Angeles, CA. Int J Biometeorol, 66, 911–925. https://doi.org/10.1007/s00484-022-02248-8

40. McDonald, R.I., Kroeger, T., Zhang, P. & Hamel, P. (2020). The Value of US Urban Tree Cover for Reducing Heat-Related Health Impacts and Electricity Consumption. Ecosystems, 23, 137–150. https://doi.org/10.1007/s10021-019-00395-5

41. Ulmer, Jared M., Wolf, K.L., Backman, D.R., Tretheway, R.L., Blain, C.J., O'Neil-Dunne, J.P., & Frank, L.D. (2016). Multiple Health Benefits of Urban Tree Canopy: The Mounting Evidence for a Green Prescription. Health & Place, 42, 54–62. https://doi.org/10.1016/j.healthplace.2016.08.011.

42. Roe, J., Thompson, C.W., Aspinall, P.A., Brewer, M.J., Duff, E.I., Miller, D. Mitchell, R. & Clow, A. (2013). Green Space and Stress: Evidence from Cortisol Measures in Deprived Urban Communities. International Journal of Environmental Research and Public Health, 10(9), 4086–4103. https://doi.org/10.3390/ijerph10094086.

43. South, E. C., Hohl, B. C., Kondo, M. C., MacDonald, J. M., & Branas, C. C. (2018). Effect of Greening Vacant Land on Mental Health of Community-Dwelling Adults: A Cluster Randomized Trial. JAMA network open, 1(3), e180298. https://doi.org/10.1001/ jamanetworkopen.2018.0298

44. Ellaway, A., Macintyre, S. & Bonnefoy, X. (2005). Graffiti, Greenery, and Obesity in Adults: Secondary Analysis of European Cross-Sectional Survey. British Medical Journal 331: 611-2.

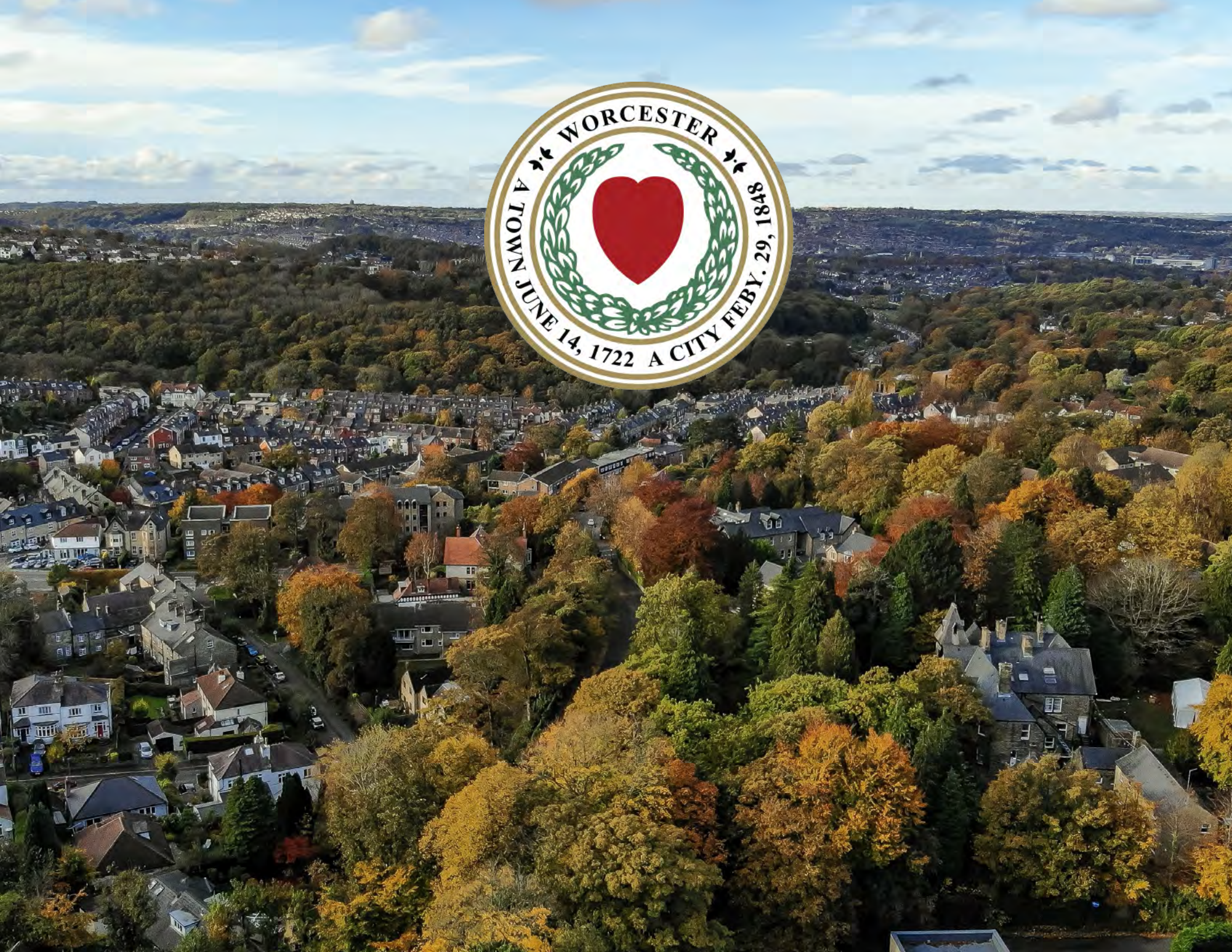
45. Kuo, F. E. (2003). The role of arboriculture in a healthy social ecology. Journal of Arboriculture, 29(3), 148–155.

46. Gilstad-Hayden, K., Wallace, L.R., Carroll-Scott, A., Meyer, S.R., Barbo, S., Murphy-Dunning, C., & Ickovics, J.R. (2015). Research Note: Greater Tree Canopy Cover Is Associated with Lower Rates of Both Violent and Property Crime in New Haven, CT. Landscape and Urban Planning, 143, 248–253. https://doi.org/10.1016/j.landurbplan.2015.08.005. Source 2: Troy, A., J.M. Grove & J.

47. O'Neil-Dunn. (2012). The relationship between tree canopy and crime rates across an urban–rural gradient in the greater Baltimore region. Landscape and Urban Planning, 106, 262–270.

48. Swift, P., Painter, D., & Goldstein, M. (1997). Residential street typology and injury accident frequency. Swift and Associates.

49. Ewing, R., & Dumbaugh, E. (2009). The built environment and traffic safety: a review of empirical evidence. Journal of Planning Literature, 23(4), 347-367.
50. US Department of Energy (6). (n.d.). Landscaping for Energy-Efficient Homes. https://www.energy.gov/energysaver/design/landscaping-energy-efficient-homes
51. USDA Forest Service. (2011). Trees pay us back in the Inland Empire Region. https://www.fs.fed.us/psw/topics/urban_forestry/products/18/804uesd_uep_tpub_InlandEmpire.pdf
52. Siriwardena, S.D., Boyle, K.J., Holmes, T.P. & Wiseman, E. (2016). The implicit value of tree cover in the U.S.: A meta-analysis of hedonic property value studies, Ecological Economics, 128, 68-76. https://doi.org/10.1016/j.ecolecon.2016.04.016.
53. Wolf, K.L. (2005). Business district streetscapes, trees, and consumer response. Journal of Forestry, 103(8), 396-400. https://nacto.org/docs/usdg/city_trees_retail_wolf.pdf
54. Hughes, N. (2013, May 29). Trees Mean Business. Invest From the Ground Up, California Urban Forests Council. https://investfromthegroundup.org/trees-mean-business/.
55. City of Worcester Department of Sustainability and Resilience and Urban Climate Consulting. (DRAFT 2022). Worcester Heat Risk Assessment. [DRAFT - not published].
56. American Forests (n.d). Tree Equity Score. Retrieved on December 12, 2022 at https://treeequityscore.org/.
57. Richards, N.A. (1983). Diversity and Stability in a Street Tree Population. Urban Ecology, 7(2), 159–171.
58. Vogt, J., Hauer, R.J. & Fischer, B.C. (2015). The Costs of Maintaining and Not Maintaining the Urban Forest: A Review of the Urban Forestry and Arboriculture Literature. Arboriculture and Urban Forestry, 41(6), 293-323.
59. Santamour, F.S. (1990). Trees for Urban Planting: Diversity, Uniformity, and Common Sense. U.S. National Arboretum: Agricultural Research Service.
60. Genus (plural, genera): A category of scientific classification consisting of related species of organisms. For example the tree species, red oak (Quercus rubra) and pin oak (Quercus palustris) are both in the genus oak (Quercus).
61. USDA Office of Sustainability and Climate. (2021). Climate Change Pressures in the 21st Century. https://storymaps.arcgis.com/stories/9ee0cc0a070c409cbde0e3a1d87a487c
62. USDA Forest Service. Climate Change Atlas. Retrieved from https://www.fs.fed.us/nrs/atlas/
63.
64. Childs, R. (2016). Asian Longhorned Beetle. University of Massachusetts, Amherst, UMass Extension Landscape, Nursery, and Urban Forestry Program.
65. Haugen, L., Juzwik, J., Chavez, Q. & Crocker, S. (2022). Oak Wilt in the Northeastern and Midwestern States. U.S. Department of Agriculture, Forest Service, Eastern Region. https://doi.org/10.2737/R9-2022-INT-OakWiltNEMW.
66. Clark, J. R., Matheny, P.D. Cross, G., & Wake, V. (1997). A model of urban forest sustainability. Journal of Arboriculture, 23(1), 17 – 30.
67. Kenney, W. A., van Wassenaer, P.J.E., & Satel, A.L. (2011). Criteria and indicators for sustainable urban forest planning and management. Arboriculture & Urban Forestry, 37(3), 108 – 117.
68. Leff, M. (2016). The Sustainable Urban Forest - A Step-by-Step Approach. Davey Institute. https://www.itreetools.org/documents/485/Sustainable_Urban_Forest_Guide_14Nov2016_pw6WcW0.pdf
69. *Forestry Operations and Forestry are used interchangeably throughout this document.
70. Hauer R. J. & Peterson W. D. (2016). Municipal Tree Care and Management in the United States: A 2014 Urban & Community Forestry Census of Tree Activities. Special Publication 16-1, College of Natural Resources, University of Wisconsin – Stevens Point.
71. McDonald R.I., Biswas, T., Sachar, C., Housman, I., Boucher T.M., Balk, D., Nowak, D., Spotswood, E., Stanley, C.K. & Leyk, S. (2021). The tree cover and temperature disparity in US urbanized areas: Quantifying the association with income across 5,723 communities. PLoS ONE, 16(4): e0249715. https://doi.org/10.1371/journal.pone.0249715
72. American National Standards Institute. (2017). ANSI A300 (Part 9): Tree, Shrub, and Other Woody Plant Management Standard Practices (Tree Risk Assessment a. Tree Failure). Tree Care Industry Association, Inc.
73. Smiley, T.E., Matheny, N. & Lilly, S. (2017). International Society of Arboriculture Best Management Practices: Tree Risk Assessment.
74. Miller, R. W. & Sylvester, W.A. (1981). An Economic Evaluation of the Pruning cycle. Journal of Arboriculture 7(4): 109–112.


WORCESTER
A TOWN JUNE 14, 1722 A CITY FEBY. 29, 1848