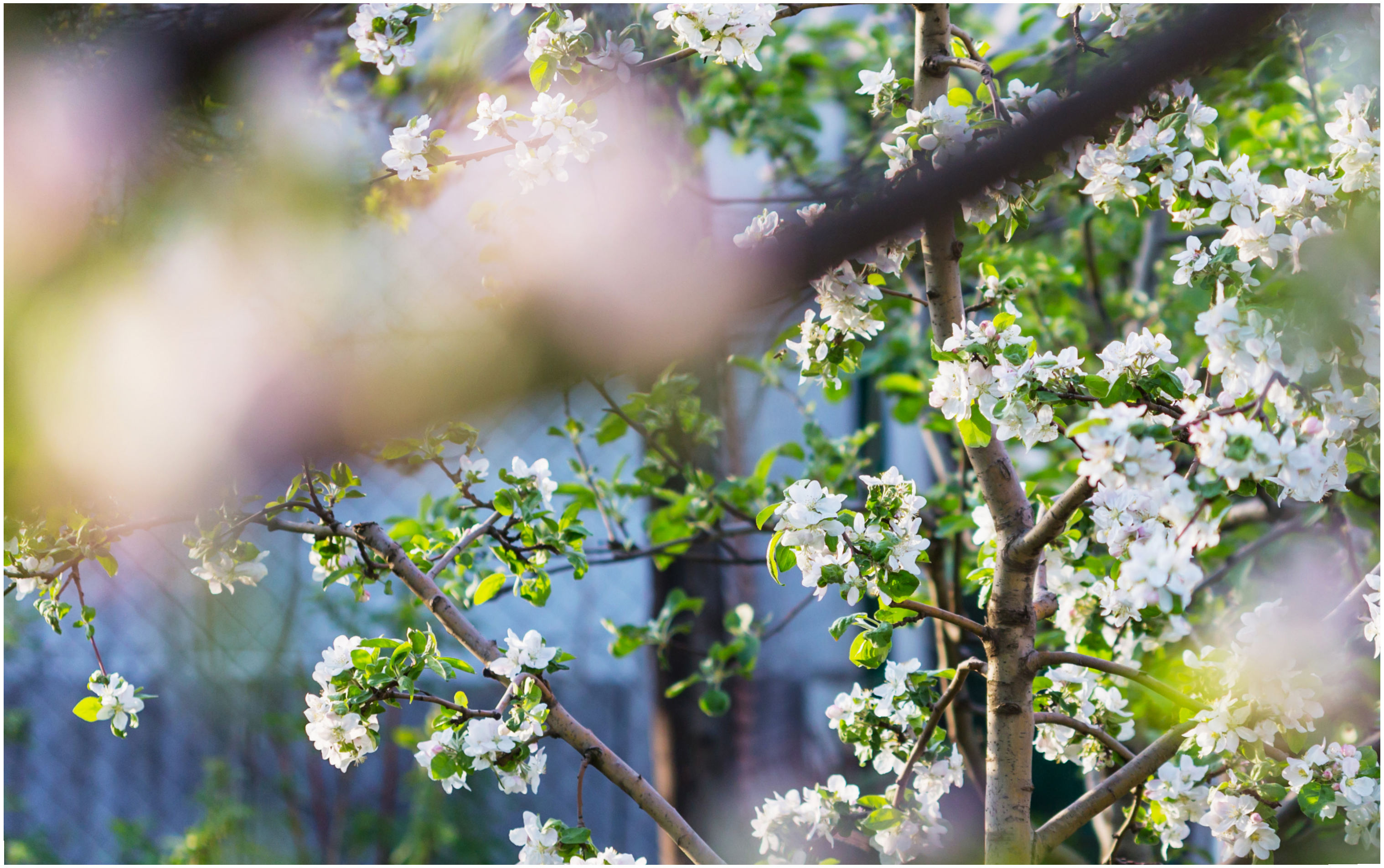
June 2020

Hartford Connecticut's

TREE CANOPY ACTION PLAN 2020

SEAL OF THE CITY OF HARTFORD CONNECTICUT
POST NUBILA PHŒBUS

todesign
SITE DESIGN
LANDSCAPE ARCHITECTURE
URBAN PLANNING



2020...
THE TIME FOR TREES IS NOW!

- Jack Hale, *Chair of the Tree Advisory Commission*

Connecticut State Capitol

Photo by Sean Pavone Photo

Acknowledgements

We recognize the abundance of professional data and community input compiled over the past 10 years that has propelled the support for Hartford's Tree Canopy Action Plan. The Office of Sustainability acknowledges that tree canopy is a major component of Hartford's green infrastructure system. Supporting city staff from the Department of Public Works Forestry Division, Hartford's Tree Advisory Commission, and the Mayor's Office of Sustainability, To Design assembled this action plan that charts an implementation course to allow the city the ability to protect and grow Hartford's canopy. The actions described within this plan are synthesized from the data and recommendations noted in the following reports:

- Hartford City Plan 2035, as prepared by the Planning and Zoning Commission
- Tree Resource Management Plan, City of Hartford, CT 2020
- 2019 Tree Inventory by Davey Tree Inventory and Management
- City of Hartford Tree Plan – 2018-2019, as prepared by the City of Hartford Tree Advisory Committee, October 15, 2019
- City of Hartford Climate Action Plan, September 2017
- Urban Tree Canopy Assessment and Planting Plan, as prepared by American Forests, 2015
- A Report on the City of Hartford, Connecticut's Existing and Possible Tree Canopy, as prepared by the University of Vermont, dated 2010

We express our appreciation for the extensive collaboration between municipal departments and outside stakeholders who provided critical leadership, guidance and information that molded this action plan.

Mayor Luke Bronin
Sara Bronin, Chair of Hartford Planning and Zoning Commission
Charmaine Craig, Vice Chair of the City of Hartford Tree Advisory Commission
Heather Dionne, City Forester, Forestry Division of Public Works
Patrick Doyle, Executive Director, KNOX Inc.
Jack Hale, Chair of the City of Hartford Tree Advisory Commission
Shubhada Kambli, Sustainability Coordinator, Office of Sustainability
Mike Looney, Director of the Department of Public Works
Chris McCleary, Davey Tree Inventory and Management
Thea Montanez, Chief Operating Officer
Sophia Rodbell, Davey Resource Group
Grace Yi, Green Infrastructure Assistant, Office of Sustainability

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This report was funded through the Partners for Places matching grant program, led by The Funders' Network (TFN) for Smart Growth and Livable Communities in partnership with the Urban Sustainability Directors Network.

Scion of the Charter Oak in Bushnell Park

Photo Courtesy of Hartford Office of Sustainability

Executive Summary

This plan represents a collaborative effort to protect and expand Hartford's urban forest through the implementation of tree management practices and an aggressive tree planting program to **achieve 35% tree canopy in 50 years.** The Tree Resource Management Plan provided by Davey Resource Group is a sister document to this report that documents tree management in depth.

The Who, What, Where, Why and How of the plan are:

Who: Everyone who lives, works, plays in or visits Hartford.

What: An action plan to address the city's need to protect and grow their tree canopy from 25% to 35%. Hartford currently has approximately 568,000 existing city-wide trees. Approximately 150,000 trees need to be planted within 50 years to achieve the 35% tree canopy goal.

Where: Every neighborhood, park, street, residence, business and institution within the City of Hartford.

Why: Hartford's trees provide environmental, health, social and economic benefits. However, the city's trees are aging if action is not taken now these benefits will decrease.

How: Fund a two-point approach to protect and expand the city's tree canopy:

(1) A proactive tree maintenance program

(2) A tree planting program.

The focus of this plan is to prioritize the community's safety, address arboreal inequalities, promote maintaining a healthy forest, engage the community and form partnerships to promote public and private tree plantings.

Hartford's tree canopy directly impacts everyone that lives in, works in, or visits the city. We must acknowledge and embrace the significance that Hartford's Tree Canopy provides. We must recognize and prioritize the financial needs and benefits associated with maintaining and expanding Hartford's tree canopy.

This report establishes an action plan based on past reports, stakeholder recommendations and precedence studies. The need for an action plan arose out of the current funding hardships for city tree plantings and maintenance. With input from Hartford's Department of Public Works, Tree Advisory Commission, and the Mayor's Office of Sustainability, this plan has been developed to protect and grow the tree canopy.

The overall vision for Hartford's urban tree canopy aligns with the Mayor's Climate Action Plan's goal to "chart a course to a cleaner environment that will improve immediate public health outcomes, advance the economy, and promote social equity." Trees are a key contributor to achieve these goals.

Goal: to achieve

35% TREE CANOPY

in 50 years

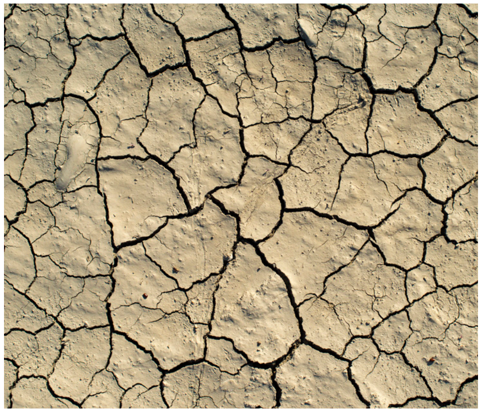
Sigourney Square

Current State of Hartford's Urban Forest

Like many cities, Hartford is losing trees due to age, storms and disease. Reports indicate that existing urban tree canopy is at 25%, however, half of this coverage is provided by only 10% of these trees. Many are mature trees with trunk diameters of 20 inches or more. Natural and human-driven tree loss occurs for many reasons, including:

- **Severe weather events**
- **Pest and disease**
- **Drought**
- **Lack of maintenance**
- **Land development**

Any tree loss is significant. Establishing annual budgets to enact a comprehensive tree planting program and institutionalize cyclical maintenance practices are a must to protect and expand Hartford's urban forest.



City Forester, Heather Dionne, Highlighting The Cost Benefits We Receive From A Tree In Bushnell Park

The Importance of Trees

Climate change is a grave environmental and social justice concern and the urgency to act increases daily. As temperatures rise, heat-related health issues do too. The growth and health of Hartford's tree canopy directly correlate with the health of Hartford residents. The importance of our forest cannot be overstated. The numerous benefits they provide include:

Environmental - Trees naturally cool the air by shading surfaces and releasing water vapor, provide habitat for wildlife, reduce storm-water runoff, and sequester carbon from the atmosphere, which helps to mitigate climate change.

Health – Trees produce oxygen and improve air quality by trapping and holding impurities, pollutants, and dust. Trees contribute to improved air quality, which helps decrease the risk of respiratory illness like asthma. Trees also cool the air, which helps mitigate heat related illnesses and deaths.

Economic – Trees increase property values, reduce cooling costs, and provide annual cost savings to cities/towns in the form of public health benefits, energy savings and environmental protection.

Social – Trees positively impact mental health and human well-being, reduce stress and encourage outdoor exercise.

Sustaining this important resource is an essential component of green infrastructure, and their benefits extend well beyond the city. Tree planting and urban forest maintenance help to reduce global warming which is crucial to the health and safety of the City of Hartford community.

Existing Tree Replacement Value	~$590 million
Annual Environmental Benefits of Existing Trees	$5.5 million
Annual Environmental Benefits at 35% Tree Canopy	$7.7 million (+$2,194,883)
Annual Environmental Benefits of reduced Tree Canopy (22%)	$4.8 million (-$660,094)

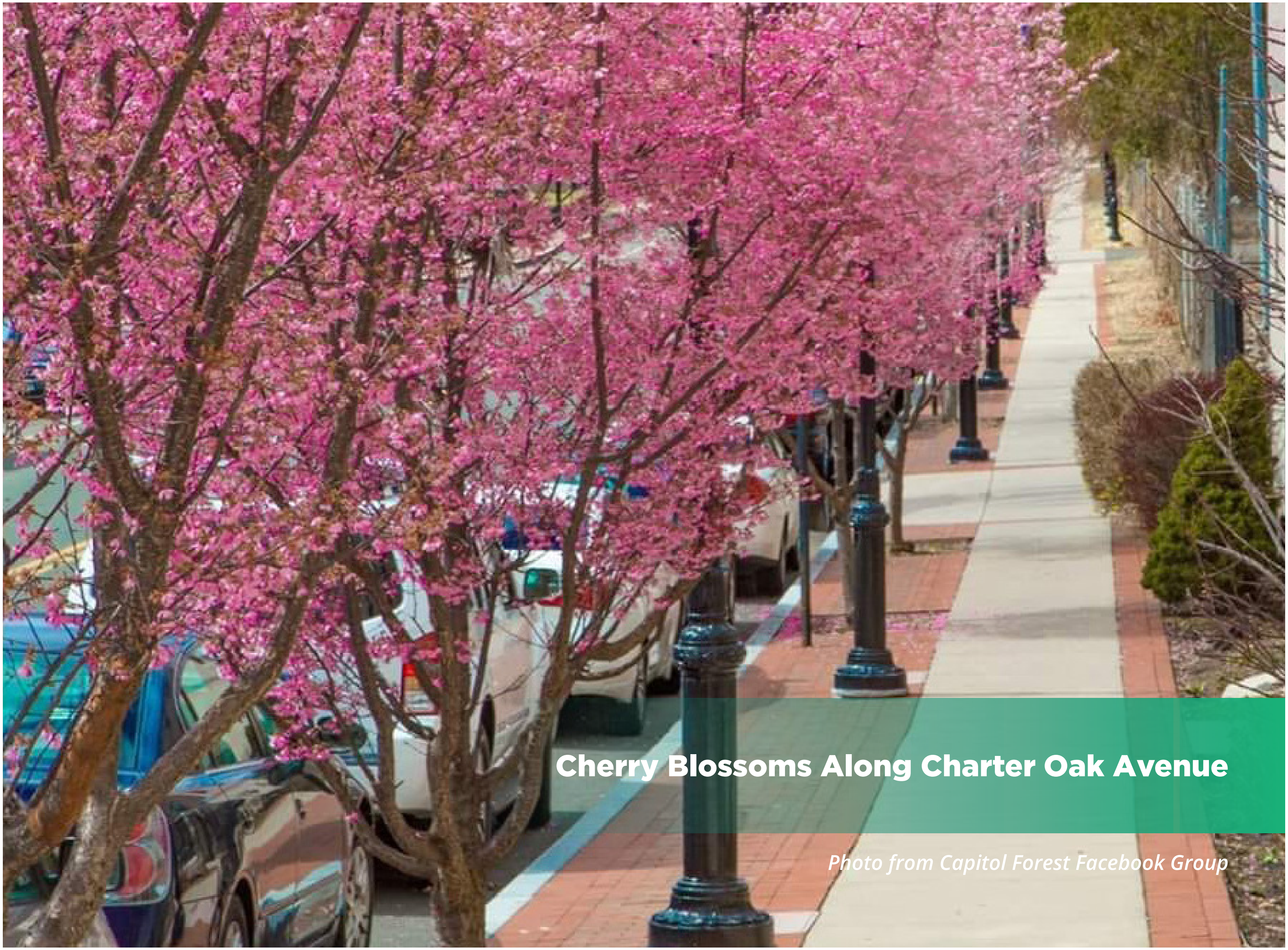


Photo from Capitol Forest Facebook Group

Trees as Green Infrastructure

Due to the prevalence of paved surfaces and the heat island effect, urban areas often experience higher temperatures than their suburbs. **Hartford has measured 19 degrees warmer than other nearby rural communities. Hartford's urban forest is a key part of the city's green infrastructure because of its ability to provide shade and lower temperatures.**

Urban trees also help to mitigate the adverse effects of stormwater runoff. The Environmental Protection Agency (EPA) lists tree canopy as a green infrastructure method and a "cost-effective and resilient approach to managing weather impacts that provides many community benefits." Trees are an effective tool in mitigating the adverse effects of stormwater runoff.

Trees in a streetscape, neighborhood and community can decrease the amount of stormwater runoff and pollutants that reach local and regional waters, such as the Connecticut River and Long Island Sound.

- Trees reduce stormwater runoff by capturing and storing rainfall in their canopy and releasing water into the atmosphere.
- Tree roots and leaf litter create soil conditions that promote the infiltration of rainwater into the soil.
- Trees help slow down and temporarily store runoff reducing the potential for pollution from runoff and combined sewer overflows.

Large trees have many benefits, but providing a planting area that enables trees to grow to their full size takes planning. Studies have shown that a tree's ability to establish, grow to its full potential, and remain healthy is largely dependent upon soil volume. If too little soil is available, the tree will not reach full size. Trees without adequate soil volume tend to be short-lived and do not function long-term as useful components of a city's infrastructure.

The following techniques should be used to enhance the effectiveness and longevity of urban trees:

- **Tree Pits/Trenches –** Area cut out in sidewalk to provide more capacity to intercept stromwater and return moisture into the soil.
- **Structural Soil –** Continuous soil under pavements to provide for root growth.
- **Structural Cells –** Modular, pre-engineered cell systems create large soil-filled spaces under the pavement.
- **Permeable Pavement –** Allows water to infiltrate through void space; Used in conjunction with the above techniques.

Hartford has measured

19° WARMER

than nearby rural communities

Keney Park in the Autumn

Photo from Keney Park Golf Course Facebook Groups

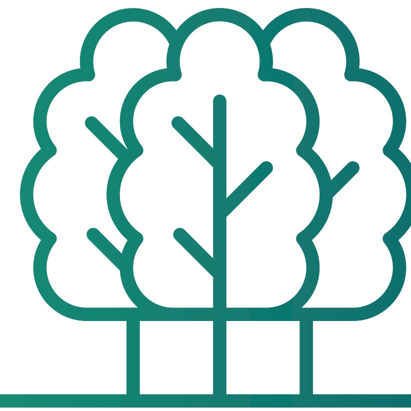
Tree Canopy Program Goals

Maintaining a safe, healthy, productive, and beautiful urban forest is crucial to the well-being of Hartford residents. This work requires a continuous, concerted and comprehensive effort by city staff, its citizens and property owners. To expand Hartford's urban forest, this plan establishes an aggressive tree planting and maintenance program which includes planting on public and private lands.

This goal cannot be achieved without proper funding and implementation of a public-private tree planting strategy. Studies have shown that forging a public-private partnership is the right formula to yield success. Municipalities and landowners that come together to plan for sustainable growth show a serious commitment to urban forest management.

In conjunction with the tree planting program, the city will establish a 3-year cyclical tree maintenance program to allow the Forestry Division to manage the existing canopy. This requires resources to employ best management practices, monitor inventory, perform cyclical maintenance and engage public outreach.

Hartford's **FOREST**



Existing Tree Canopy	25%
Hartford's Urban Tree Canopy Cover Goal	Increase to 35%
Initial Annual Tree Planting Goal	1,500 city-wide trees per year *Public 70% (1,050); Private 30% (450)*
5-Year Annual Tree Planting Goal	3,000 city-wide trees per year *Public 70% (2,100); Private 30% (900)*
11+ Year Tree Planting Goal	3,000 city-wide trees per year *Public 30% (900); Private 70% (2,100)*

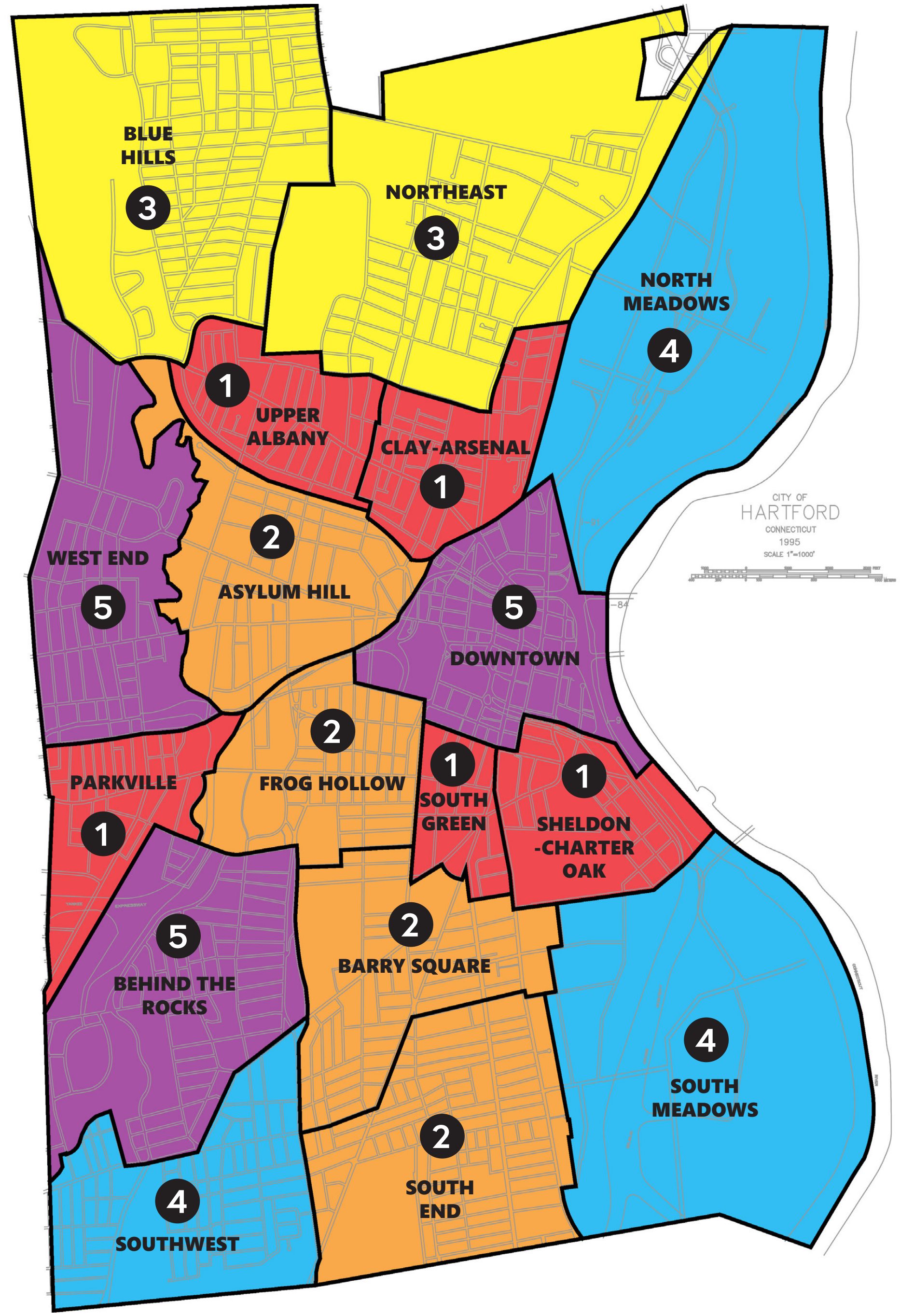
Neighborhood Tree Planting

PRIORITY MAP

In order to guide reforestation throughout the city, priority maps were developed for neighborhoods. Working with the City Forester and referencing previous reports that identify unequal distribution of trees throughout city neighborhoods, a priority ranking system of 1-5 was established and applied to each of the seventeen neighborhood zones. Priority #1 denotes those neighborhoods with the greatest need for tree plantings due to low existing tree canopy levels. Mapping of priority neighborhoods will guide the reforestation efforts to balance the tree canopy across the city. Understanding canopy distribution at the neighborhood level is significant and valuable to facilitate new tree plantings and engage community involvement.

A Priority Planting Park Map was also developed. This map assigns priority levels to parks within each neighborhood.

High Priority 1 2 3 4 5 Low Priority



Reforestation Strategies

An urban forest refers to all publicly and privately-owned trees, including those along streets and in backyards. Establishing trees in an urban environment can be challenging and requires careful planning and long-term programmatic support. There are 17 distinct neighborhood zones in Hartford and the amount of tree canopy coverage varies widely, therefore, prioritizing is key. The focus will start in residential areas that have a low existing tree canopy, such as Upper Albany and Sheldon-Charter Oak. Within those neighborhoods, public and private parcels, parks and streets will be identified to bridge the gap between tree canopy inequalities in neighborhoods.

The 2019 tree inventory by Davey Tree Inventory and Management identifies over 10,000 tree planting locations along the right-of-way (ROW) and high-use parks. To expand upon this Neighborhood Maps, developed for this report, target tree planting opportunities on public and private properties. The Neighborhood Maps will be used as a planning tool to identify additional opportunities to expand private planting even more. The Yearly Tree Planting Location Guide in this report outlines priority neighborhoods and estimated tree planting quantities for public properties such as parks, schools, and fire stations.

For the first five years, public tree planting goals can be met by planting identified opportunities from TreeKeeper. By year six, in order to meet public tree planting goals, parks, schools and other identified public tree planting opportunities as noted on the Neighborhood Maps and Yearly Tree Planting Location Guide, need to be integrated. Private property and beyond-the-right-of-way (BROW) planting opportunities need to be explored and integrated as well in order to continue to meet goals.

We recommend exploring planting opportunities located Beyond-the-Right-Of-Way (BROW). Planting trees in the BROW benefit the community by providing stormwater and heat island benefits. The larger areas of available soil allow trees to grow to full potential and provide maximum benefits for the community.

Building a municipal/non-profit partnership to expand existing yard tree planting programs, such as KNOX's Trees For Hartford Neighborhood (TFHN), offers a unique opportunity to address planting on private properties that benefits the homeowner and the Hartford community.

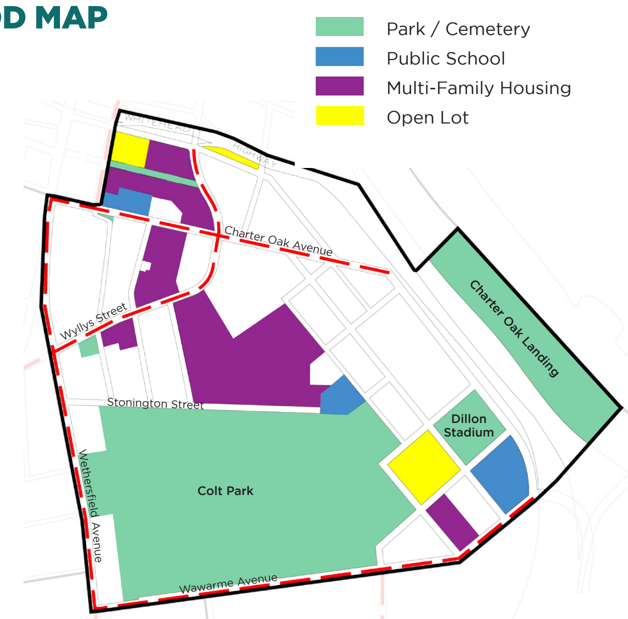
Offering tree giveaways, incentive and rebate programs are methods to further encourage residents to plant on private property.

EXAMPLE NEIGHBORHOOD MAP

Sheldon-Charter Oak

1 of 17 Neighborhood Maps.
See Appendix F for each Neighborhood Map.

Sheldon-Charter Oak Neighborhood: Public Tree Planting Opportunities	
Tree Opportunities Located by TreeKeeper	537
Parks	166-230
Schools	25-40
Fire Stations	0
Total Public Tree Planting Opportunities	**728-807**




STANLEY

Education and Outreach

This plan is intended to support reforestation and management through increased awareness of the importance of urban forests, their many benefits, and the various factors that challenge the management of these critical resources. Open and clear communication of the city's Tree Canopy Action Plan to protect and grow Hartford's urban forest is essential to engage the community in this campaign.

The education and outreach process should include:

- Establishment of a tree canopy marketing campaign.
- Further development of a City Forestry website to provide updates, information and procedures.
- Development of community programs and volunteer initiatives within neighborhoods.
- Development of program materials that are free (and downloadable) to support public education and publication of news releases for mainstream, and alternative media (social media).
- Promotion of the city's 311 hotline for residents and property owners to ask questions and report problems.

LOVE HARTFORD
GREEN HARTFORD

Implementation Plan

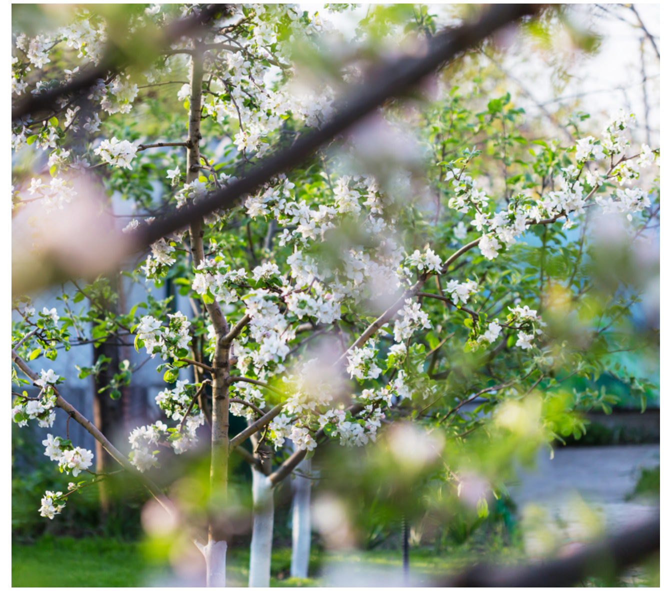
Implementation options include 1) Contractor Based, 2) City and 3) Joint Partnership with the city and one or more non-profits. Each has varying constraints, opportunities and costs associated with them. The city needs to select and fund a method of implementation. This report recommends a joint partnership between the city and a non-profit. This cost-effective approach illustrates a team mentality and has proven successful for other cities. This partnership would consist of shared costs. In the recommended strategy, the city would fund 85% of the tree planting costs, while the remaining 15% is provided by a non-profit through grants and donations.

Tree Planting Considerations

Hartford acknowledges the need to increase tree canopy cover to 35%. There are many opportunities to enhance tree canopy. Successful urban tree programs need to take into consideration site constraints, tree selection, and maintenance needs to preserve, protect, and expand Hartford's urban forest. Factors to consider include:

- Fall/Winter Planting – Focusing tree planting during the Fall and Winter months promote root growth before hot and dry weather. This encourages tree survival.
- Optimal locations relative to infrastructure.
- Site climate, sun exposure and exposure to salts/chemicals.
- Right Tree for the Right Place – Tree Selection should be based on growth rate, mature size, canopy shape, shade potential, ornamental traits, wildlife value, resistance to disease and pests, and species diversity. Costs in this report are based on a 2-2.5" caliper tree. However there are opportunities to use smaller sizes under the right conditions.
- Maintenance needs for watering, mulching and pruning.

The establishment period after a tree is planted is a critical time for its long-term health. Regular inspections and maintenance will help ensure consistent growth and success of urban trees.



Next Steps

Urban forests are dynamic ecosystems that provide critical benefits to people and wildlife. They form the green infrastructure on which communities depend. Management involves a variety of activities such as inventorying tree populations; enacting tree and land use planning ordinances and policies; developing and implementing long-term management and maintenance plans, annual work plans and budgets; and community education and participation.

The following actions and associated program costs are required for the tree management and planting programs to succeed:

1. Increase city funding for tree maintenance and planting in the Capital Improvements Plan (CIP).
2. Determine if supplemental funds from the Hartford Parks Trust Fund and Tree Fund are available.
3. Develop supplemental funding sources.
4. Hire Tree Planting Coordinators.
5. Increase the City Forestry Crews to 12.
6. Install annual public and private tree plantings in priority neighborhoods.
7. Provide annual maintenance as outline in the Tree Resource Management Plan.
8. Track removals and new plantings through TreeKeeper.
9. Remove and replace hazardous trees.
10. Manage trees affected by disease and pests.
11. Expand wood waste utilization opportunities.
12. Develop and maintain a fully functioning urban forestry website.
13. Document lessons learned.
14. Develop and establish public outreach programs to increase awareness and engagement.
15. Update City Tree Canopy assessment every 10 years.

Tree Planting Program Costs

Description	Annual Costs	Projected Workforce Additions
Tree Planting Coordinator (required)	$60,000	1
Tree Planting Coordinator Assistant (required)	$50,000	1
Forestry Department Administrator (required)	$40,000	1
Tree Planting Option 1: Contractor Installed	Year 1: $1.7 million Year 6: $2.5 million	
Contractor Watering	Year 1: $170,000 Year 6: $500,000	
Tree Planting Option 2: City Installed (includes additional staff)	Year 1: $1.1 million Year 6: $1.6 million	Minimum of 4 new staff Minimum of 8 new staff
City Watering for 2-years (Includes additional staff) (does not include equipment such as watering trucks)	Year 1: $150,000 Year 6: $350,000	4 to 13 people as planting goals increase
Additional Forestry Crew for Tree Planting	$200,000	4
Tree Planting Option 3 (Recommended): City/Non-Profit Tree Planting Partnership	Year 1: $1.4 million Year 6: $2.1 million	4 (through KNOX/non-profit) & Mayor's Youth Service Corps
Non-Profit Watering for 2-years (Includes additional staff)	Year 1: $170,000 Year 6: $500,000	4 to 13 people as planting goals increase. Staffed by KNOX

Tree Maintenance Program Costs

Description	Annual Costs	Projected Workforce Additions
3-year Tree Resource Management Plan Budget (excludes DRG recommended planting costs) (From The Tree Resource Management Plan, 2020 by Davey Resource Group)	Year 1-2 $1.9 million Year 3 $1.5 million Year 4+ $1 million	8 new forestry crew positions
Pest Management Plan	$18,000	
Wood Waste Utilization Equipment Cost	$175,000 (one-time total cost)	
Wood Waste Utilization Crew Cost	$100,800	2
Wood Waste Utilization Possible Mulch Revenue	+$92,460	
Milling Crew		1 (funded through KPSP)

Above is an itemized list noting budgetary costs associated with the planting and maintenance programs. The City is to select items to implement. It is essential to the success of this action plan to continually review these tasks and annual budgets for updating and lessons learned.

Participants in 2019 Tree Appreciation Celebrations

Conclusion

A comprehensive and effective urban forestry program is costly, but its cost does not compare to the costs of lost environmental services, reduced quality of life, and increased municipality liability if it is not properly supported.

Maintaining our forest is an investment in our future.

– Tree Advisory Commission

We must all act together. The time for trees is now!

We must act now to combat climate change and improve public health. City officials and residents alike recognize the important role that trees play. Both the city and the residents of Hartford are ready to embrace actions to protect and expand Hartford's tree canopy as Hartford residents list planting of trees as their top priority for green infrastructure.

Hartford's Tree Canopy Action Plan is intended to expand awareness of the benefits that our urban forests, and green infrastructure, provide to communities throughout Hartford. This plan serves as the framework for funding and priority planting recommendations for the urban forest.

Protecting and expanding the tree canopy in Hartford to 35% is a starting point, and we embrace it. Goals, actions, relationships and roles will naturally evolve over time as the initiative grows. As noted in Hartford's Climate Action Plan, we acknowledge that no sole individual or City department can achieve a goal as important and vast as Hartford's urban forest. It must be a collaboration between the city, residents, businesses, and non-profits.

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Bushnell Park in the Summer

Photo courtesy of the Bushnell Park Foundation Facebook Group.

Introduction

In the Hartford Climate Action Plan, Mayor Bronin's stated his vision is to "chart a course to a cleaner environment that will improve public health outcomes, advance the economy, and promote social equity." Trees support this overall vision in a myriad of ways.

This report addresses:

- The current state of the forest
- The importance of trees as green infrastructure
- Hartford's Tree Canopy Goals
- Reforestation
- Tree Planting Implementation
- Tree Management

A 32% tree canopy cover is the national average for cities with a population ranging from 100,000 to 250,000 people. Hartford's tree canopy is only 25.1%. The Hartford Tree Advisory Commission has set a goal to achieve 35% tree canopy cover in 50 years. To obtain this goal, a proactive maintenance plan needs to be implemented to preserve the existing canopy. In tandem, an aggressive tree planting program needs to be adopted for the tree canopy to grow and to equalize tree canopy disparities among neighborhoods. As noted in the City of Hartford Tree Plan, the Tree Advisory Commission states that in order to maintain the tree canopy at 25%, the city needs to plant 1,500 new city-wide trees annually. To grow the tree canopy to 35%, the city needs to plant 3,000 new city-wide trees annually.

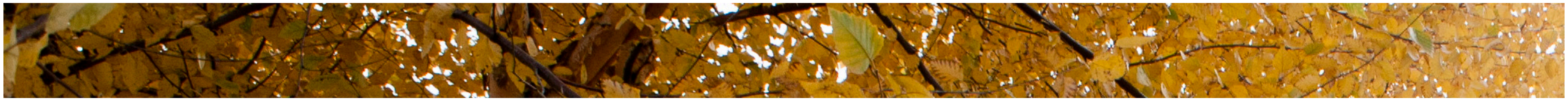
Urban communities need to take steps to protect and enhance their urban forests by establishing urban tree canopy (UTC) goals and implementation strategies for reforestation and management. The following table highlights twenty-three cities that have set current and future tree canopy goals.

While the City of Hartford is taking action by planting trees on public land, planting on private property is critical for tree canopy expansion. The City of Hartford Tree Plan notes that about 50% of the city's trees are located on private property. Planting on private property must be promoted and tracked through city regulations. Business, institutions and Hartford residents need to be engaged to take action on private property in order for Hartford's community to benefit from an expanded canopy. Previous reports have established that Hartford's existing tree canopy provides over $5.5 million in annual environmental benefits for the community. Environmental benefits include healthier living environments through cleaner air and cooler air temperatures. Beyond environmental benefits, trees provide economic benefits such as increased property values. These benefits will grow in parallel with the expansion of the tree canopy.

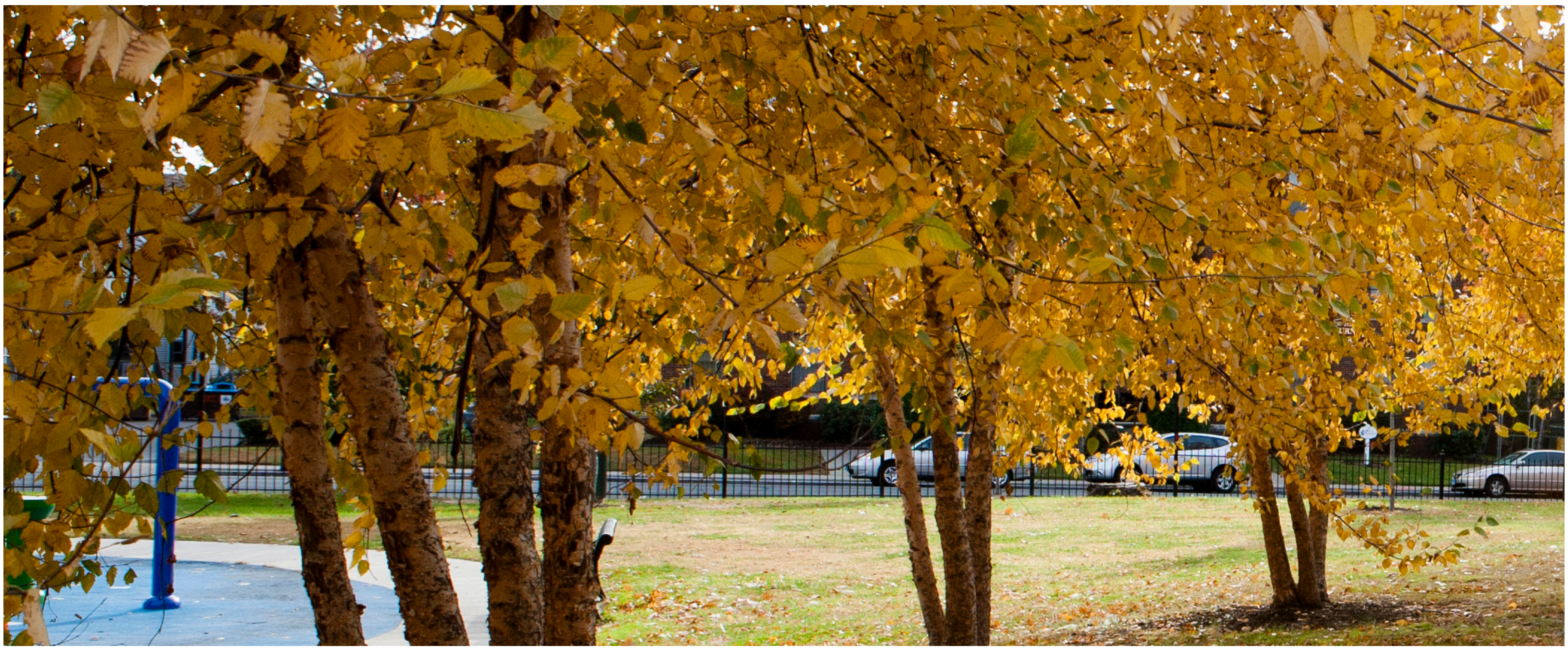
Nationwide Tree Canopy Goals

City, State/Province	Initial Canopy Cover Level		Canopy Cover Goal	
	UTC Cover	Year Assessed	UTC Cover	Target Date
Annapolis, MD	42.0%	2006	50%	30-year plan (2036)
Atlanta, GA	47.9%	2008	Increase	Ongoing
Austin, TX	32.0%	2006	40%	Ongoing
Baltimore, MD	20.0%	2007	40%	2036
Boston, MA	29.0%	2006	49%	10-year plan (2016)
Chicago, IL	17.2%	2007	25%	Ongoing
Denver, CO	16.4%	2010	31%	20-year plan (2025)
Detroit, MI	22.5%	2008	40%	Ongoing
Hartford, CT	25.1%	2015	35%	50-year (2070)
Indianapolis, IN	13.8%	2008	19%	10-year plan (2031)
Las Vegas, NV	8.6%	2012	20%	2035
Leesburg, VA	27.0%	2006	40%	25-yer plan (2031)
Los Angeles, CA	21.0%	2006	28%	2040
Milwaukee, WI	21.6%	2008	40%	Ongoing
New Haven, CT	38.0%	2009	Add 10K trees	5-year plan (2014)
New Orleans, LA	23.3%	2009	Increase	Ongoing
New York, NY	24.0%	2006	30%	2036
Philadelphia, PA	20.0%	2011	30%	15-year plan (2025)
Phoenix, AZ	10.0%	2007	25%	2030
Pittsburgh, PA	40.0%	2011	60%	20-year plan (2031)
Port Angeles, WA	27.3%	2011	40%	Ongoing
Portland, OR	29.9%	2014	33%	Ongoing
Providence, RI	23.0%	2007	30%	10-year plan (2020)
Sacramento, CA	5.2-15.4%	1998	35%	Ongoing
Seattle, WA	23.0%	2007	30%	30-year plan (2037)
Tacoma, WA	19.0%	2010	30%	20-year plan (2030)
Washington, DC	35.0%	2009	40%	20-year plan (2029)

Chart provided by Vibrant Cities Lab.



PART 1
Current State of Hartford's Forest



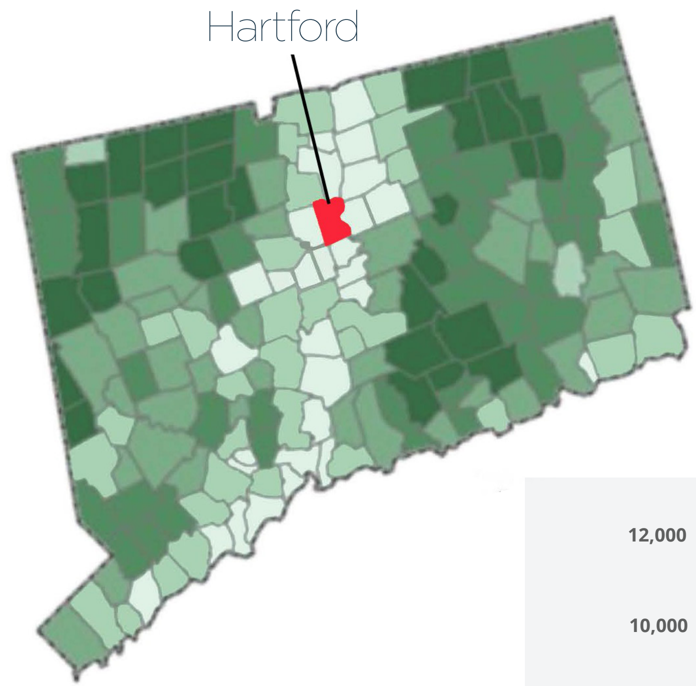
1.1 Hartford's Forest

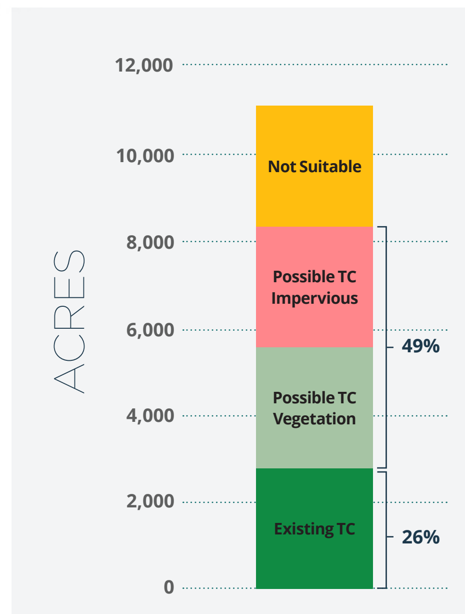
Hartford, home to the first publicly funded municipal park in the United States (Bushnell Park), has historically supported its urban forest. However, during recent city financial hardships, the budget for Hartford's trees has consistently been reduced. The 2014 Capital City Parks Guide notes that "Hartford staff maintains more acres with less money than comparably sized cities." The City of Hartford has appraised its urban forest by cataloging the existing tree canopy and has been named a Tree City USA for 25 consecutive years. The Tree City USA program celebrates cities that meet four core standards of forestry management: maintaining a tree department, having a community tree ordinance, spending at least $2 per capita on urban forestry and celebrating Arbor Day. Strong city zoning regulations promote maintaining and expanding the tree canopy. Despite these efforts, the City of Hartford's forest continues to be weakened by drought, severe weather, natural age decline and infestations. The lack of budget directly prevents sufficient maintenance to promote tree health and further prevents the addition of new tree plantings.

Existing Tree Canopy Summary

- The 2010 Existing and Possible Tree Canopy report by the University of Vermont found that the city has 26% existing tree canopy cover with a potential of 50%. However, the tree canopy is not equally dispersed throughout the city.
- According to New Britain's Urban Forest Report, the statewide average tree canopy cover is 64.5%. The average in urban areas is 49.3%.

CT Tree Canopy Coverage (New Britain's Urban Forest Report)



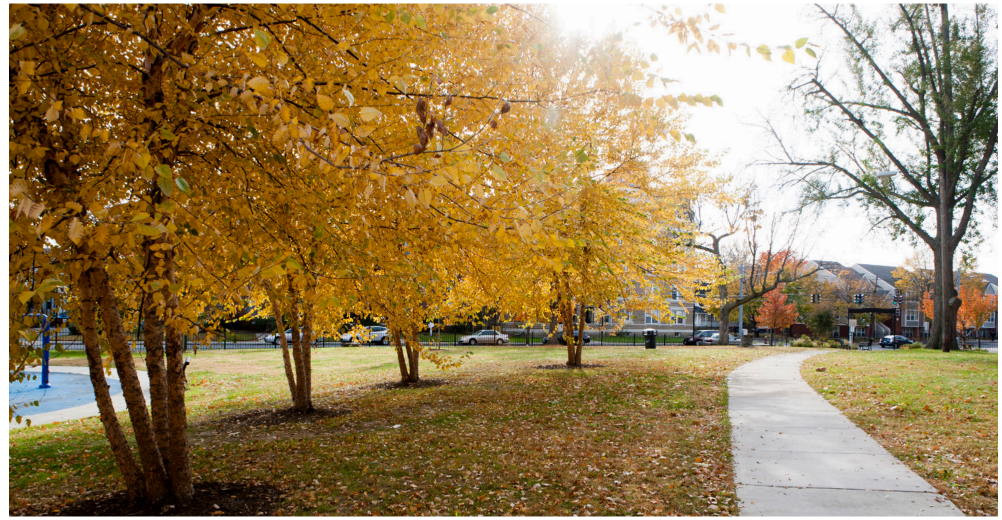


Possible Total Canopy (TC) chart as provided in the 2010 Existing and Possible Tree Canopy Report by UVM.

Existing Trees

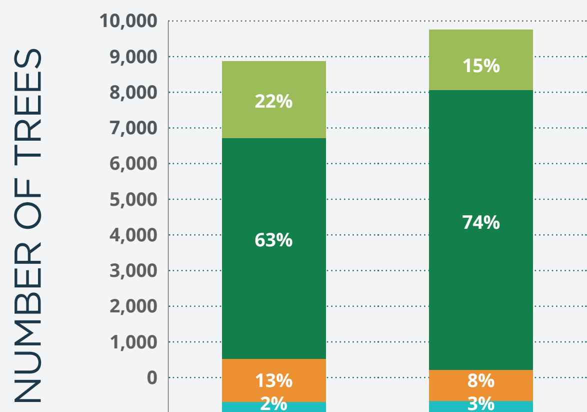
The Tree Resource Management Plan, City of Hartford, CT, 2020, provided by Davey Resource Group, divides the inventory into Right-of-Way (ROW) trees and other public trees. Refer to Appendix A for the entire Tree Resource Management Plan. Information regarding condition, age/size, condition and biodiversity is noted below:

- Condition: Overall, the inventoried trees are in fair condition with 81.7% of Hartford's inventoried forest is in good/fair condition. The trees in fair condition exhibit minor problems that can be corrected with a proactive maintenance program. See Appendix B for Tree Condition Criteria from Davey Resource Group.
- Age: The overall distribution of the age of the trees in the ROW trends toward ideal, while trees in parks are heavy on mature trees. Planting and preservation of mature trees should occur in the ROW and park trees.
- Biodiversity charts relate species at the 10-20-30 rule. The 10-20-30 rule is a best-management practice guideline that suggests the urban tree population should include no more than 10% of any species, 20% of any genus, or 30% of any family. The Davey Resource Group 2020 report indicate that maples should not be planted in the ROW or park areas as they exceed the recommended 10-20-30 tree population distribution. Similarly, Maples and Oaks should not be planted in parks as they exceed the 10-20-30 rule.



The City of Hartford Tree Plan 2018-19 documents that only 10% of our trees are over 20 inches in diameter, yet they account for 50% of the tree canopy cover.

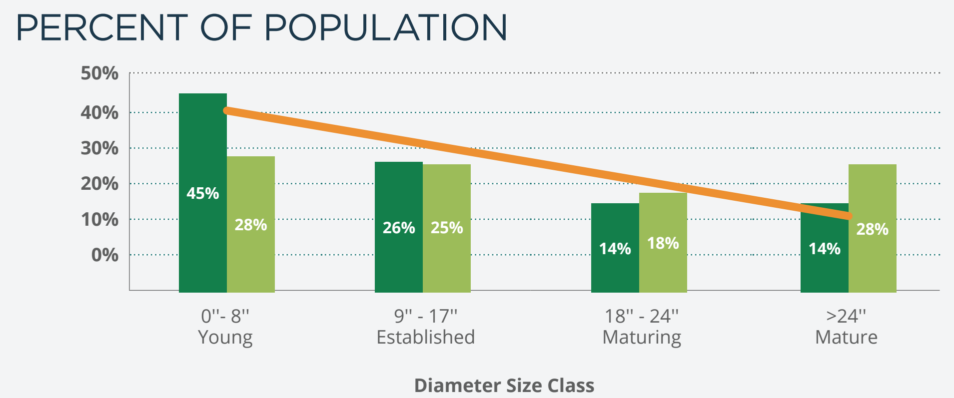
The age and size of our tree canopy is important, because it indicates that the forest is aging and therefore, at risk, and that each time we lose one of those trees, we lose a significant piece of our canopy.



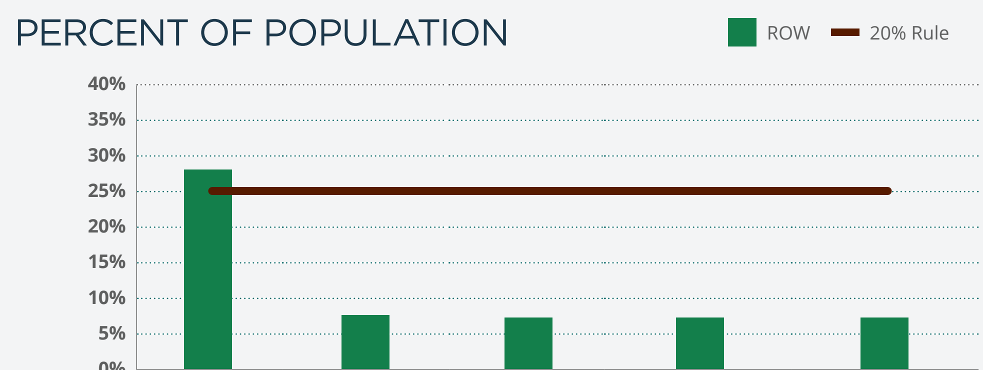
	ROW	Public Properties
Good	1,927	1,493
Fair	5,670	7,287
Poor	1,130	792
Dead	213	279

Condition of inventoried trees as provided by DRG Management Plan 2020

(Note that the existing trees inventoried area was restricted to the Right-of-Way (ROW) and parks. Although not all public spaces were in the inventory, publicly managed spaces such as community centers and cemeteries were included. Existing trees on other public property or private property was not included. Possible tree planting locations inside parks, on private property, Beyond-the-Right-of-Way (BROW), and other publicly-owned lands were not inventoried).



Age distribution of inventoried trees as provided by DRG Management Report 2020



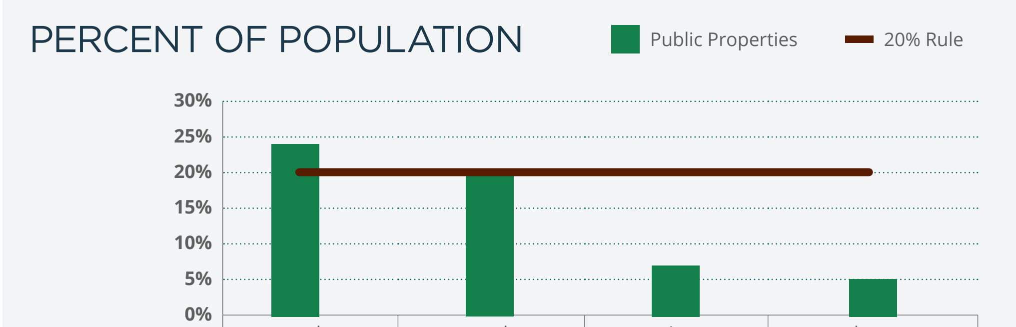
	maple	oak	cherry	honeylocust	pear
ROW	34%	7%	6%	6%	6%
20% Rule	20%	20%	20%	20%	20%

Inventoried tree population distribution of most abundant genus in the ROW provided by DRG Management Plan 2020

The 2020 Tree Resource Management Plan by Davey Resource Group further details the existing conditions of Hartford's inventoried trees by noting that only Emerald Ash Borer, Hemlock Wooly Adelgid, Gypsy Moth, and Dutch Elm Disease were detected. The report also notes the existing stock level is 45%. DRG acknowledges the potential to achieve the 90% recommended ROW Tree Stock level by planting 8,824 trees in the ROW. See Appendix A for the entire Tree Resource Management Plan.

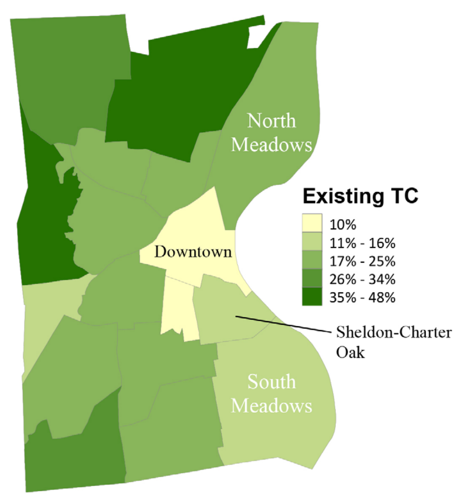
Tree Canopy Expansion Areas

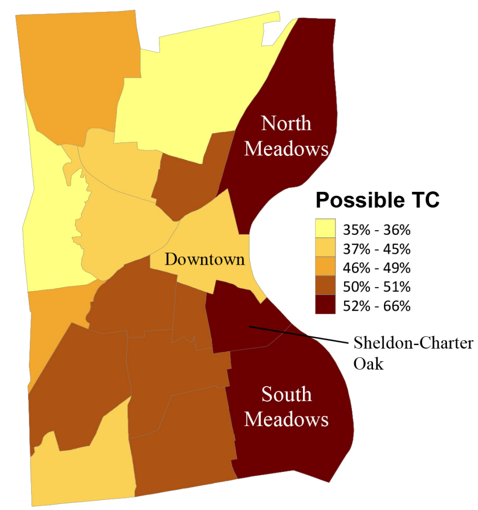
The maps below are from the 2010 Existing and Possible Tree Canopy report by the University of Vermont. The Existing Tree canopy (TC) map below indicates inequalities in the distribution of tree canopy throughout neighborhoods. The Possible Tree Canopy (TC) introduces the possible canopy growth throughout the neighborhoods. Some of the areas with the least existing tree canopy have the greatest potential for possible tree canopy. The chart below further breaks down canopy opportunities by neighborhoods.

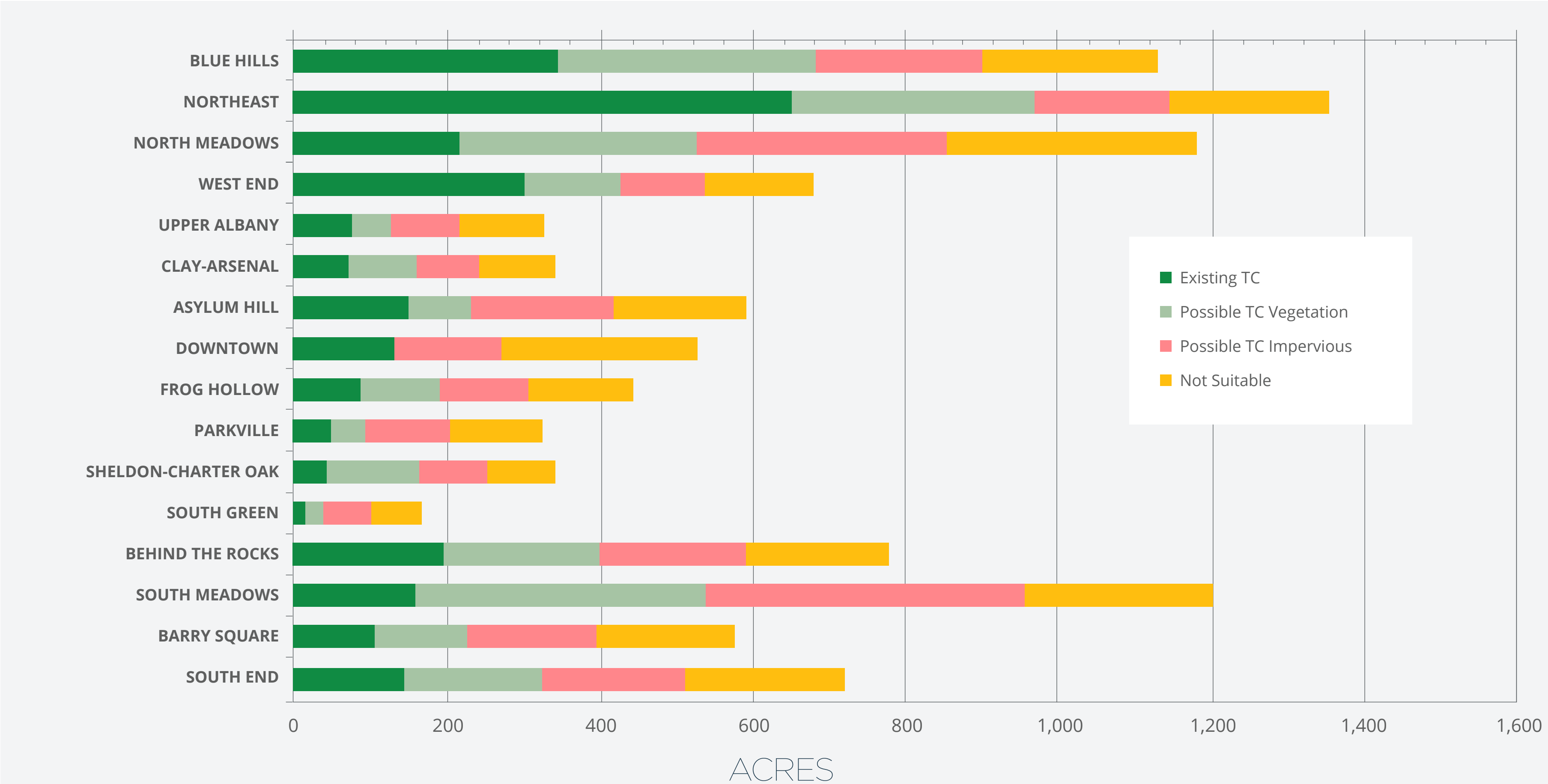


	oak	maple	pine	cherry
Public Properties	24%	20%	6%	5%
20% Rule	20%	20%	20%	20%

Inventoried tree population distribution of most abundant genus in the ROW provided by DRG Management Plan 2020



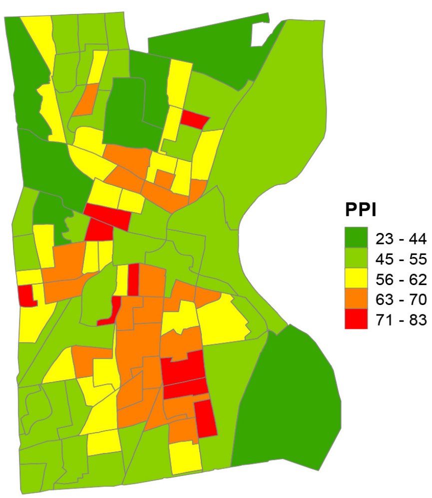




Maps from 2010 Existing and Possible Tree Canopy report by University of Vermont. This chart indicates tree canopy and possible tree canopy in relation to acres. Chart from the 2010 Existing and Possible Tree canopy report by the University of Vermont.

Priority Planting Index (PPI) mapped in the 2010 Existing and Possible Tree Canopy report by the University of Vermont considers population density, tree stocking levels, and per capita tree cover. A PPI score is assigned to each area in a range from 0-100, with higher values indicating a greater need for tree plantings. This map indicates that the need for tree planting is greater in some neighborhoods than others.

The chart below from the Tree Resource Management Plan identifies the quantity of inventoried trees, possible planting sites and stocking levels for each neighborhood. Refer to Appendix C for the criteria used to determine vacant lots. Note that in comparison, tree stocking levels can be high in a neighborhood that has relatively low total tree canopy, as there are minimal possible planting sites along the ROW that meet required criteria.



Neighborhood	Number of Trees	Number of Stumps & Vacant Sites	Total Sites	Stocking Level
Upper Albany	345	103	448	77%
S. Green	232	91	323	72%
South End	1,039	519	1,558	67%
Downtown	672	347	1,019	66%
Clay-Aresenal	220	163	383	57%
Frog Hollow	514	401	915	56%
Asylum Hill	428	379	807	53%
West End	927	839	1,766	52%
Barry Square	609	649	1,258	48%
Parkville	118	131	249	47%
Blue Hills	1,425	1,924	3,349	43%
Sheldon-Charter Oak	400	556	956	42%
Northeast	579	811	1,390	42%
Behind the Rocks	876	1,699	2,575	34%
South West	461	1,733	2,194	21%
North Meadows	67	445	512	13%
Total	**8,912**	**10,790**	**19,702**	**45%**

*Identified possible neighborhood ROW tree planting locations by Davey Resource Group. *Note that the identified locations were restricted to the Right-of-Way and is not fully representative of all possible tree planting locations. Other locations to include BROW (Beyond the Right-of-Way), Parks, Schools, and other publicly owned land. Does not include park trees located outside the Hartford city boundary. Does not include private property.*

Maintenance Program Summary

It is fiscally responsible to take a proactive approach to tree maintenance. Hartford saw the ramifications of years of neglect in the aftermath of the October 2011 snowstorm. Leading up to the 2011 storm, the tree maintenance program had been reactive. As a result, emergency funds provided by FEMA were required. Since then, the city has bolstered its forestry department with the addition of an Urban Forester (2012) and 4 full-time forestry crew members (2020). In the coming years, the forestry crew will be playing catch-up with the city forest after many years of minimal maintenance. Due to the historic lack of a full-time city forestry team, the current tree maintenance program is primarily focused on 311 calls for hazardous tree removals. When a 311 call is received, the City Forester will assess the tree, make recommendations for removal, and communicate this work to the city's on-call arborists. Maintenance pruning and other proactive maintenance have been minimal due to the lack of resources.

The continued support for the Forestry Department is imperative as they are the first line of defense in maintaining the health, safety and welfare of Hartford's citizens regarding trees.

As the Tree Advisory Commission notes in their report, there are substantial cost savings when the city employs their own forestry crew versus hiring outside contractors. The Tree Advisory Commission analysis suggests that "the funds expended to hire contractors could support a 3-person forestry crew." The commission further notes that "re-establishing a professional crew would save money and it would provide a higher level of service, quicker response to emergencies and 311 calls, and more attention to detail in management of the forest."

Tree Planting Program Summary

Tree Maintenance is only one part of the puzzle. An annual and systematic tree planting program that runs in tandem with a proactive tree maintenance program provides a reinforced approach to addressing the city's tree canopy. A tree planting program must encourage biodiversity and address arboreal inequalities that are apparent throughout the city. Hartford's forest cannot be regarded as a luxury, as all members of the community benefit. The benefits that green infrastructure provide are invaluable to the community. Trees must be budgeted and accounted for in future capital improvements budgets.

In How Cities Harness the Public Health Benefits of Urban Trees, the Nature Conservancy notes that **"the biggest reason for urban forest decline is disinvestment."**

Recent city financial constraints have severely limited city tree planting and maintenance budgets to the point that the budget was zeroed out for the fiscal years of 2018-2019 and no trees were planted in 2017-2018.

Despite the lack of consistent municipal funds for annual tree plantings, several groups continue to spearhead and organize tree plantings throughout the city. In 2020, the Department of Public Works designated money from the Hartford Tree Fund, which is part of the Hartford Parks Trust Fund, to ensure that the city funds some tree plantings in 2020. KNOX, a local non-profit that supports the Hartford community through horticultural practices (formerly known as KNOX Park Foundation), organizes several planting events throughout the year, such as one on Arbor Day. In 2019, KNOX planted 25 trees for Arbor Day and 35 trees in the Fall through a tree planting partnership with Travelers Insurance Company. Similarly, they have supported tree plantings on private properties in the past through their Trees for Hartford Neighborhoods program, which has planted more than 5,000 trees in Hartford neighborhoods since 2005.

1.2 Stakeholders

Hartford's tree canopy unifies the people of Hartford. Whether you are a resident that benefits from the cool and clean air provided by tree-lined streets, or a business professional that decompresses during a lunch hour stroll among the cherry trees in Bushnell Park, we all need the trees of Hartford. And, the trees of Hartford need us. Every person and every business within the Hartford boundary affect the tree canopy and can contribute to its protection and expansion. Below is a summary of the key members shaping the future of Hartford's Tree Canopy.

Davey Resource Group (DRG) – A private company that provides natural resource consulting services. The City of Hartford contracted them to complete the 2019 tree inventory as well as to provide the Tree Resource Management Plan. The full report can be found in Appendix A.

Department of Development Services, Planning Division – This department holds the authority to regulate tree preservation and required tree plantings. Hartford's stringent tree regulations provide a foothold in the private sector to protect existing trees and provide new plantings. The focus should shift to confirm and track tree requirements.

Department of Public Works, Forestry Division – This is the workhorse division for Hartford's public trees. The Forestry Division, led by the City Forester, is responsible for maintaining and enhancing Hartford's urban forest through maintenance and planting. The City Forester works along with the Planning Division to enforce tree-related regulations. The Forestry Division, along with the Tree Advisory Commission, are the primary advocates for Hartford's trees.

Hartford Residents – 50% of Hartford's trees are located on private land, thus, private owners are an integral part of a tree maintenance and planting program to succeed. Hartford's residents have the most to gain and lose from the success of this plan.

Keney Park Sustainability Project (KPSP) – offers invaluable exposure and education on forestry practices for Hartford's youth through outreach, education and workforce development. In 2019, the City of Hartford and KPSP opened a log milling facility that mutually benefits the City of Hartford and KPSP.

KNOX – is a local non-profit that supports the Hartford community through horticultural practices. KNOX's Trees for Hartford Neighborhoods Campaign has planted more than 5,000 trees in Hartford. KNOX also fosters workforce development for Hartford residents by hiring, educating and training in horticultural practices.

Mayor's Office of Sustainability – Extensive involvement in various city green initiatives provides insight and direction on how to knit various goals into one common outcome: a more sustainable Hartford.

Planning and Zoning Commission – Enforce tree-related zoning ordinances through the review of land use applications. Their enforcement of ordinances on plans help protect existing trees in Hartford and guide the required plantings of additional trees

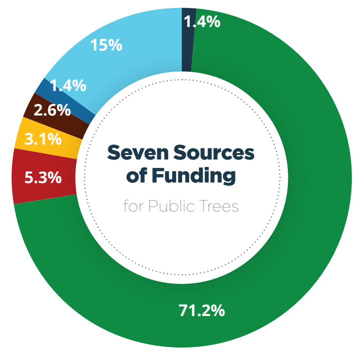
Tree Advisory Commission – This commission is a volunteer-based commission that advises the City Forester, City Council and Mayor on tree-related issues. Many of the recommendations in this report are based on commission input.

1.3

Historic City of Hartford Tree Budgets

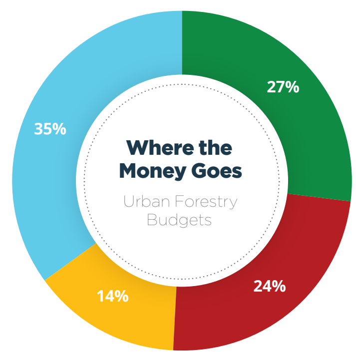
The 2014 Municipal Tree Care and Management in the U.S. report notes that the General Fund is typically the largest funding source for public tree planting at 71.2%. 51% of a forestry budget goes to maintenance costs. Furthermore, the 2014 Municipal Tree Care and Management report note that cities with a population range from 100,000 to 249,999 have a total median annual tree budget of $1,000,000.

Hartford Forestry staff is funded under the general operating budget of the Forestry Department, while tree maintenance and tree plantings are funded under Neighborhood Environmental Improvements in the Capital Improvements Plan budget.



Across the nation, the largest source of funding for public trees is, by far, the general fund.

71.2 %	General Fund
5.3 %	Assessment District
3.1 %	Gas Tax
2.6 %	State/Federal Grants
1.4 %	Stormwater/Utility Fees
15.0 %	Other
1.4 %	Permit Fees



Nationally, urban forestry budgets are generally allocated primarily for maintenance, administration and other expenditures, and planting.

27.0 %	Tree and Stump Removal
24.0 %	Pruning
14.0 %	Planting
35.0 %	State/Federal Grants

2014 Municipal Tree Care and Management in the US

Historic Hartford Tree Planting			
Fiscal Year	**Approximate Number of Trees Planted Using City Funds**	**Neighborhood Environmental Improvements / Forestry Budget**	**What Was Happening**
2012-13	900	$1,000,000	Tree Planting Focus
2013-14	900	$1,000,000	Tree Planting Focus
2014-15	400	$500,000	Tree Maintenance Focus; City Laid-Off City Arborists
2015-16	350	$1,000,000	Tree Maintenance Focus; Contractor Maintenance
2016-17	190	$1,500,000	Tree Maintenance Focus; Contractor Maintenance
2017-18	0	$1,000,000	Tree Maintenance Focus; Contractor Maintenance
2018-19	125 (Keep Kids Cool Fund)	$0	Tree Maintenance Focus; Contractor Maintenance
2019-20	Assumed 0-150	$713,838 (Transition year from contractor crew to Forestry crew)	Tree Maintenance Focus; Transition to New City Arborist Crew
Projected 2020-21		$500,000	Tree Maintenance Focus; Transition to New City Arborist Crew

*Fiscal Year Budgets as provided on City of Hartford website

Budget Trends

- In the last ten years, the budget has ranged from a low of zero dollars ($0) to a high of $1,500,000 in 2016-17.
- In the years 2012-2014, there was a focus on tree planting, as these were the years following severe storms that caused extensive tree damage and removals.
- Since 2014, the focus has shifted to tree maintenance and preservation.
- City financial hardships in 2016 led to the dismissal of the Forestry staff, except for the Urban Forester. This left the city solely reliant on outside contractors. The extensive costs related to outside contractors allowed minimal tree planting within the provided city budget.
- A zero-budget occurred in 2017 when the city experienced financial challenges.
- 2019-2020 was a year of transition, where the city budgeted for their new 4-person forestry crew, but still relied on contractor support until their crews were fully established. The City of Hartford Tree Plan notes cost-effectiveness for the city to staff their own forestry crews.
- The projected budget for 2020-2021 is $500,000.

Budget Goal

Increase budget to fund protection and expansion of the tree canopy through tree maintenance and plantings.

1.4

Existing Reports

Since 2007, a series of reports have thoroughly documented the City of Hartford's tree canopy. Our action plan synthesizes the recommendations from these reports and adds new recommendations.

Existing studies and reports include:

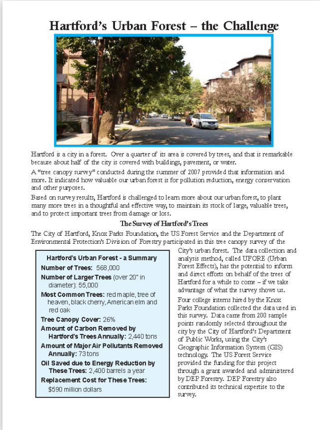
- 2007 - Hartford's Urban Forest – The Challenge by the City of Hartford, US Forest Service, Knox Parks Foundation and Department of Environmental Protection Division of Forestry.
- 2010 - A Report on the City of Hartford, Connecticut's Existing and Possible Tree Canopy, University of Vermont, June 2010.
- 2015 - Urban Tree Canopy Assessment and Planting Plan, American Forests.
- 2015 - Who lives in greener neighborhoods? The distribution of street greenery and its association with residents' socioeconomic conditions in Hartford, Connecticut, Xiaojiang Li, Chuanrong Zhang, Weidong Li, Yulia A. Kuzovkina and Daniel Weiner, Department of Geography and Plant Science University of Connecticut.
- 2017 - Hartford Climate Action Plan, City of Hartford.
- 2017 - Mapping Urban Tree Canopy, Urban Heat Island, and Extreme Heat Vulnerability in Hartford, Connecticut, Kate Richard.
- 2018 - The Effect of Tree Planting Strategy on Canopy Cover in the City of Hartford by Giles Lemmon.
- 2018-2019 - City of Hartford Tree Plan – 2018-2019, City of Hartford Tree Advisory Committee.
- 2019 Tree Inventory by Davey Tree Inventory and Management.
- 2020 - Hartford City Plan 2035, Planning and Zoning Commission.
- 2020 - Tree Resource Management Plan, City of Hartford, CT, Davey Resource Group.

Below is a summary of the reports with important findings:

Hartford's Urban Forest – The Challenge, 2007

City of Hartford, US Forest Services, Knox Parks Foundation, and Department of Environmental Protections Division of Forestry

This report gives insight to the make-up of Hartford's forest and the lack of diversity



Hartford's Urban Forest – the Challenge

Hartford is a city in a forest. Over a quarter of its area is covered by trees, and that is remarkable because about half of the city is covered with buildings, pavement, or water.

A "tree canopy survey" conducted during the summer of 2007 provided that information and more. It indicated how valuable our urban forest is for pollution reduction, energy conservation and other purposes.

Based on survey results, Hartford is challenged to learn more about our urban forest, to plant many more trees in a thoughtful and effective way, to maintain its stock of large, valuable trees, and to protect important trees from damage or loss.

The Survey of Hartford's Trees

The City of Hartford, Knox Parks Foundation, the US Forest Service and the Department of Environmental Protection's Division of Forestry participated in this tree canopy survey of the City's urban forest. The data collection and analysis method, called UFORE (Urban Forest Effects), has the potential to inform and direct efforts on behalf of the trees of Hartford for a while to come – if we take advantage of what the survey shows us.

Four college interns hired by the Knox Parks Foundation collected the data used in this survey. Data came from 200 sample points randomly selected throughout the city by the City of Hartford's Department of Public Works, using the City's Geographic Information System (GIS) technology. The US Forest Service provided the funding for this project through a grant awarded and administered by DEP Forestry. DEP Forestry also contributed its technical expertise to the survey.

Hartford's Urban Forest - a Summary

Number of Trees: 568,000

Number of Larger Trees (over 20" in diameter): 55,000

Most Common Trees: red maple, tree of heaven, black cherry, American elm and red oak

Tree Canopy Cover: 26%

Amount of Carbon Removed by Hartford's Trees Annually: 2,440 tons

Amount of Major Air Pollutants Removed Annually: 73 tons

Oil Saved due to Energy Reduction by These Trees: 2,400 barrels a year

Replacement Cost for These Trees: $590 million dollars

Cover of Hartford's Urban Challenge

- Counts approximately 568,000 city-wide trees
- Establishes an existing tree canopy cover of 26%
- 55,000 trees over 20" diameter account for 50% of the tree canopy and only 10% of the quantity
- Most common trees: Red Maple, Tree of Heaven, Black Cherry, American Elm and Red Oak
- Establishes $590 million dollar replacement cost for trees
- Establishes environmental impacts

    Annually removes 73 tons of major air pollutants

    Annually removes 2,440 tons of Carbon

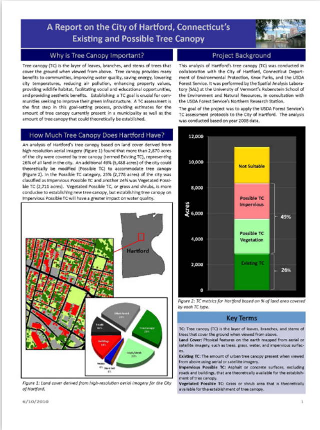
    Saves 2,400 barrels of oil annually from energy reductions

- Establishes an overall goal to increase canopy to 30-35%

A Report of the City of Hartford, Connecticut's Existing and Possible Tree Canopy, 2010

Jarlath O'Neil-Dunne and Keith Pelletier, University of Vermont, Spatial Analysis Laboratory

This report applies USDA Forest Service's Tree Canopy Assessment to the City of Hartford using data from 2008. The report analyzes variables such as tree canopy concerning zoning, parks, watersheds, neighborhoods and socioeconomic demographics. Key findings include:



A Report on the City of Hartford, Connecticut's Existing and Possible Tree Canopy

Why is Tree Canopy Important?

Tree canopy (TC) is the layer of leaves, branches, and stems of trees that cover the ground when viewed from above. Tree canopy provides many benefits to communities, improving water quality, saving energy, lowering city temperatures, reducing air pollution, enhancing property values, providing wildlife habitat, facilitating social and educational opportunities, and providing aesthetic benefits. Establishing a TC goal is crucial for communities seeking to improve their green infrastructure. A TC assessment is the first step in this goal-setting process, providing estimates for the amount of tree canopy currently present in a municipality as well as the amount of tree canopy that could theoretically be established.

Project Background

This analysis of Hartford's tree canopy (TC) was conducted in collaboration with the City of Hartford, Connecticut Department of Environmental Protection, Knox Parks, and the USDA Forest Service. It was performed by the Spatial Analysis Laboratory (SAL) at the University of Vermont's Rubenstein School of the Environment and Natural Resources, in consultation with the USDA Forest Service's Northern Research Station.

The goal of the project was to apply the USDA Forest Service's TC assessment protocols to the City of Hartford. The analysis was conducted based on year 2008 data.

How Much Tree Canopy Does Hartford Have?

An analysis of Hartford's tree canopy based on land cover derived from high-resolution aerial imagery (Figure 1) found that more than 2,870 acres of the city were covered by tree canopy (termed Existing TC), representing 26% of all land in the city. An additional 49% (5,488 acres) of the city could theoretically be modified (Possible TC) to accommodate tree canopy (Figure 2). In the Possible TC category, 25% (2,778 acres) of the city was classified as Impervious Possible TC and another 24% was Vegetated Possible TC (2,711 acres). Vegetated Possible TC, or grass and shrubs, is more conducive to establishing new tree canopy, but establishing tree canopy on Impervious Possible TC will have a greater impact on water quality.

Figure 1: Land cover derived from high-resolution aerial imagery for the City of Hartford.

Figure 2: TC metrics for Hartford based on % of land area covered by each TC type.

Key Terms

TC: Tree canopy (TC) is the layer of leaves, branches, and stems of trees that cover the ground when viewed from above.

Land Cover: Physical features on the earth mapped from aerial or satellite imagery, such as trees, grass, water, and impervious surfaces.

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

Impervious Possible TC: Asphalt or concrete surfaces, excluding roads and buildings, that are theoretically available for the establishment of tree canopy.

Vegetated Possible TC: Grass or shrub area that is theoretically available for the establishment of tree canopy.

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Cover of Hartford, Connecticut's Existing and Possible Tree Canopy report by the University of Vermont

- 26% (2,870 acres) existing tree canopy cover
- Quantifies Existing Tree Canopy, Possible Tree Canopy Vegetation, Possible Tree Canopy Impervious, and not Suitable
- Provides Priority Planting Index Map that considers population density, tree stock levels, per capita tree cover. This map identifies areas with the greatest need for tree plantings
- Identifies inequities in tree canopy distribution throughout Hartford
- Identifies that private land ownership controls the largest percentage of tree canopy
- Establishes the need for public outreach, education and incentives to engage the community
- Identifies the potential impact of street trees as the city's right-of-way contains 16% Existing Tree canopy and 32% Possible Tree canopy

Urban Tree Canopy Assessment & Planting Plan, Hartford, Connecticut, 2014

American Forests

This plan provides an urban canopy assessment that compares information from the 2010 University of Vermont study to 2014 tree canopy information and analyzes trends in the tree canopy of Hartford. The report analyzes different variables to consider when addressing the city's tree canopy management and new tree plantings. Such factors include urban heat island, stormwater management and neighborhood canopy.

- Reports 25.1% Existing Tree Canopy Cover with a maximum potential of 53.9% Tree Canopy Cover
- Notes over $5,000,000 in annual benefits from the city's trees; including the removal of 147,780 pounds of removed pollutants, 11,264 tons of carbon from the air while slowing 590 million gallons of stormwater from entering drains during peak storm events.
- Reinforces importance of public education and outreach
- Maps and records changes in tree canopy from 2008 to 2014
- Maps Right-Of-Way Tree Canopy
- Maps a Composite Priority Planting that maximizes the capturing of stormwater and reduces the urban heat island effect
- Notes cooperation between public and private will be essential to maintain and expand tree canopy
- Notes importance to increase biodiversity

Cover of the Urban Tree Canopy Assessment and Planting Plan

Who lives in greener neighborhoods? The distribution of street greenery and its association with residents' socioeconomic conditions in Hartford, Connecticut, 2015

Xiaojiang Li, Chuanrong Zhang, Weidong Li, Yulia A. Kuzovkina and Daniel Weiner, the Department of Geography and Plant Science at the University of Connecticut

This study compares various socioeconomic conditions to the levels of street greenery near living environments.

- Reinforces that people with lower incomes tend to live in areas with less greenery while those with higher incomes tend to live in areas with more street greenery in Hartford
- Green View Index map similar green distribution as University of Vermont's Priority Planting Index map
- Recommends planting attention in residential areas to balance living greenness
- Per capita income is a major contributor to the green index
- Families with young children in Hartford tend to live in neighborhoods with less greenery

Hartford Climate Action Plan, 2017

City of Hartford, CT

A comprehensive climate action plan put forth by the Hartford Climate Stewardship Initiative, a collaboration between the Hartford Climate Stewardship Council and Mayor Luke Bronin, that responds to climate change and environmental degradation. The tree canopy key findings include:

- A replacement value for the City of Hartford Trees at $600 million dollars
- Recommends planting more than 2,500 trees per year
- Recommends tree canopy assessment every 5 years
- Encourages the creation of a city-wide approach to plantings, maintenance care, and long-term health of trees
- Recommends the financing of tree planting and tree maintenance
- Recommends working through the Tree Advisory Commission and other partners.
- Calls to address arboreal inequalities

Mapping Urban Tree Canopy, Urban Heat Island, and Extreme Heat Vulnerability in Hartford, Connecticut, 2017

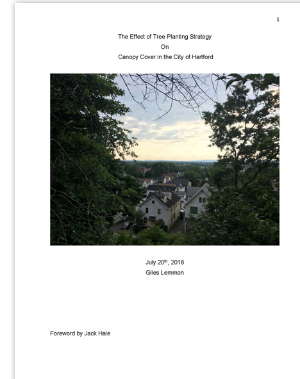
Kate Richard

This study summarizes the effects of heat as a top natural disaster-related cause of death in the United States. The report further investigates the effects of urban heat island on Hartford. It evaluates how the Urban Heat Island (UHI) can be addressed through tree planting.
The key findings include:

- Hartford has measured 19 degrees F warmer than other nearby rural areas
- A holistic approach to tree plantings can positively impact urban heat island effects, stormwater management, and neighborhood populations in a direct way
- Access to urban green spaces are associated with several health benefits
- Environmental justice communities are more likely to suffer from heat-related illnesses and it is critical that UHI interventions reach the areas at high risk from extreme heat
- While planning a neighborhood approach is adequate, a block-by-block analysis would be helpful to determine what part of each neighborhood needs trees the most
- Emphasizes importance on community engagement when outlining tree planting strategy for neighborhoods
- Resident stewardship improves tree survivability rates

The Effect of Tree Plant Strategy On Canopy Cover in the City of Hartford, 2018

Giles Lemmon in cooperation with the Office of Sustainability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The Effect of Tree Planting Strategy
On
Canopy Cover in the City of Hartford

July 20th, 2018
Giles Lemmon

Foreword by Jack Hale

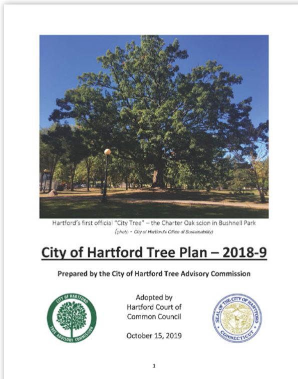
Using iTree, a peer-reviewed software suite from the USDA Forest Service, this study identifies the number of trees required to meet specific canopy goals. Key findings are:

- There is a disproportionate relationship between trees of 20 inches or larger (50% of the total canopy cover) which only accounts for 10% of the total quantity of trees
- Provides four planting scenarios and their corresponding effects on tree canopy:
  - Scenario A: If no new plantings were done then the tree canopy would drop to 22.03% by 2048
  - Scenario B: If 1,000 trees were planted annually the canopy would decrease to 24.16% by 2048
  - Scenario C: If 3,000 trees were planted annually the tree canopy cover would increase to 28.42% by 2048
  - Scenario D: If 1465 trees were planted annually then the tree canopy cover would be maintained at 26%
  - Appendix C notes the need to plant 6,085 trees annually for 30 years to reach 35% tree canopy
- The report further notes that the forecasted tree canopy does not take into effect the inevitable damage from disease, pests, inclement weather, and drought
- The tree canopy planting approach must be long-term and no actions will have devastating effects for Hartford's forest

2 018-2019 City of Hartford Tree Plan

City of Hartford Tree Advisory Commission

This plan documents current and historic tree management and planting efforts throughout the City of Hartford. Most importantly, the Tree Advisory Commission establishes tree planting goals based on "The Effect of Tree Planting Strategy on Canopy Cover in the City of Hartford" by Giles Lemmon. Key findings include:


Hartford's first official "City Tree" – the Charter Oak scion in Bushnell Park
(photo - City of Hartford's Office of Sustainability)

City of Hartford Tree Plan – 2018-9

Prepared by the City of Hartford Tree Advisory Commission

Adopted by
Hartford Court of
Common Council

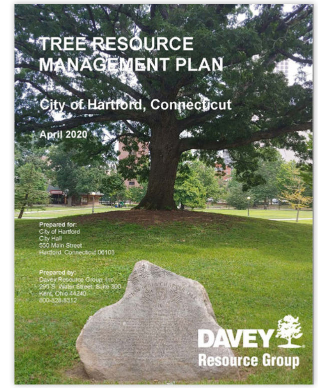
October 15, 2019

1

- Establishes a minimum planting recommendation of 1,500 trees per year
- Establishes a goal of reaching 35% UTC cover within 50 years (2068) by planting 3,000 trees annually
- Documents funds spent on contracted tree pruning, removal and maintenance
- Supports cost-effectiveness of City Forestry Staff
- Provides Tree Planting Plan with recommended trees of varying sizes

Davey Tree Experts Tree Inventory, 2019

Davey Tree Experts completed an inventory of more than 22,000 trees in the city Right-of-Way (ROW) and parks. They identified over 10,062 vacant/possible tree planting locations.



- Possible tree planting areas were restricted to the Right-of-Way (ROW) and don't include many tree planting opportunities on other city-owned properties such as schools, Beyond the Right-of-Way (BROW) and parks.
- TreeKeeper is the platform where the tree inventory data is stored. The intent is for the City Forestry Department and other departments to use this platform to track maintenance, 311 calls, hazardous trees, removals, new tree plantings and all tree related operations.
- Possible opportunities to grow this platform would allow resident stewardship tracking.

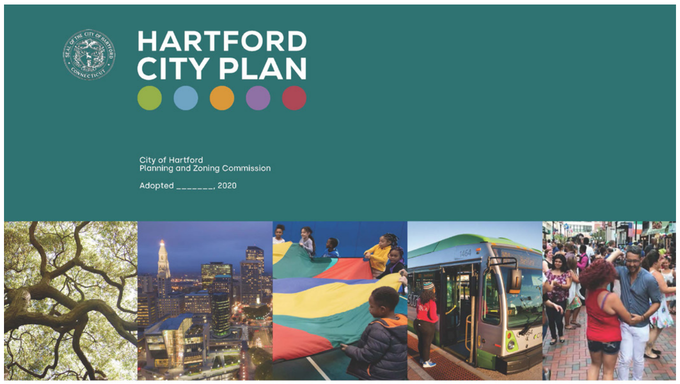
Hartford Management Plan, 2020

By Davey Tree Experts

Key findings include:

- Outlines a 3-year tree management plan and budget for inventoried trees
- Identifies the structure and composition of the inventoried trees
- Highlights tree benefits the city receives from the inventoried trees
- Provides a storm preparedness plan

Hartford 2035 City Plan, 2020



As prepared by the Planning and Zoning Commission

Key Goals include:

- Targets 3,000 city-wide annual tree plantings
- Targets new plantings to address heat island areas
- Prioritizes identification and remediation of pests and diseases
- Sets a goal to become a model for urban forestry
- Develop a front-yard fruit and nut tree program

1.5 Case Studies

The team not only used the existing reports and data to shape the action plan, but conducted precedence studies to capture lessons learned from other communities. Studies include NYCMillion Trees, TreeBaltimore, TreePhilly, Keep Durham Beautiful, TreeHaven 10K (New Haven and DDOT Washington DC. We greatly appreciate Colleen Murphy-Dunning from Urban Resource Initiative (URI), as well as Daniel Hickey, Alexander Johnson, and Glenn Slaton from the City of Durham General Services Department. Refer to Appendix D for more information on each case study.

Key Findings:

- Set a tree canopy/tree planting goal.
- Address tree planting and tree management in one comprehensive approach.
- Incorporate funding for tree management and planting into Capital Improvement Plans to ensure financial longevity that is required to meet tree canopy goals.
- It is critical to approach tree planting as a team approach between the city and a non-profit agency.
- The city is responsible for planting on public lands while the non-profit focuses on the private sector. Always work together towards a common goal.
- NYC set a 70% public and 30% private tree planting goal relationship.
- For tree planting efforts to be tracked efficiently, it is important to have a baseline of city tree data inventoried. Tree data should be mapped and available online for public access.
- Marketing, communication, education and outreach is critical to the success of the initiative.
- Funding can involve a combination of Municipal, State and Federal funds, as well as

sponsors, donations and grants.

- Resident Stewardship directly relates to the mortality of a tree.
- Consider BROW (Beyond the Right-of-Way) for tree planting locations to promote improved tree growing conditions. 10' beyond the property line still yields community benefits.
- Public tree planting partnerships between municipalities and non-profits allow for divided costs while working jointly towards a common goal.
- Watering during years 1 and 2 will benefit tree survivability. Plant fewer trees per year if more will survive.
- Fall/Winter tree planting is the best approach for tree survivability.

Million TreesNYC 2007-2014 – *New York City, NY*

- Goal: plant one million trees by 2017. Accomplished by 2014.
- Successful partnership with City Parks Department and non-profit (New York Restoration Project)
- The city focused planting on city-owned land and a non-profit was a liaison with residents and private property owners.
- Benchmarked shared plantings goals at 70% public and 30% private.
- Established neighborhood planting priorities.
- Interactive web-maps communicate goals and data.
- Interactive maps for stewardship.
- Aggressive marketing/community outreach campaign.
- Planting guidelines.
- Funding: Public and private.

TreeBaltimore – *Baltimore, Maryland*

- Goal: expand the existing tree canopy from 27.4% to 40% by 2037.
- Partnership with the city and multiple non-profits (Baltimore Tree Trust, Parks and People, Blue Water Baltimore and more).
- Tree inventory posted on public website by Davey Resource Group communicates existing trees, possible tree planting locations, and unsuitable planting locations.
- Maps that communicate goals and planting responsibilities of different groups involved.
- Funding: Local, State, Federal and private.
- Strong stewardship program.
- Aggressive marketing and outreach.

TreePhilly – *Philadelphia, Pennsylvania*

- Goal: Grow urban canopy from 20% to 30%
- Successful partnership with city and non-profit (Fairmount Park Conservancy).

- Funding: $7 million from the city and an additional $1.13 million from sponsors.
- Moderately aggressive marketing.
- Stewardship program.

Keep Durham Beautiful – *Durham, North Carolina*

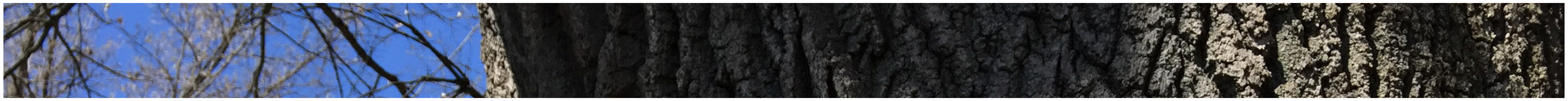
- Goal: Maintain existing 52% tree canopy; increase annual plantings to 1,500 trees.
- Successful Partnership with non-profit; city focuses planting on public land while the non-profit focuses on private property.
- Established planting priority neighborhoods.
- Established a Tree Maintenance Program.

TreeHaven 10K – *New, Haven, Connecticut*

- Goal: Plant 10,000 trees from 2009-2014. Has planted 6,000.
- Successful city/non-profit relationship (Urban Resource Initiative).
- City and URI divide costs of tree planting.
- URI installs all of city trees.
- Tree must be planted within 10' of ROW.

DDOT Trees – *Washington, DC*

- Goal: Increase tree canopy from 35% to 40% by 2035.
- Successful partnership with local non-profit Casey Trees.
- Divides tree installation between contractors and DC's Urban Forestry Administration (UFA).
- Good Communication: Regularly updates maps to illustrate proposed tree plantings and status of 311 calls regarding tree inspection, trimming or removal.
- UFA waters trees twice a month and installs tree watering bags. Residents are responsible for watering beyond year one.
- Increased tracking of trees to ensure inspections at the end of the warranty period so replacement trees can be requested.
- Request-A-Tree is the City's service where residents can request a street tree to be planted in the ROW at the front of their property. Request-A-Tree ends on June 5th.
- Requested trees are planted October through March.
- Focused on best management practice of Fall/Winter tree plantings.



PART 2
The Importance of Trees

Healthy, mature trees add an average of

10 PERCENT TO A PROPERTY'S VALUE.

2.1 Tree Benefits

A tree is a living organism that provides benefits for the community such as shade to reduce heat island effects, roots to mitigate stormwater through water absorption, and leaves to provide cleaner air by filtering pollutants. For Hartford's tree canopy to thrive, action must be taken to maintain the balance and biodiversity of the tree canopy ecosystem. Why should the city and its residents prioritize and invest in Hartford's tree canopy? Because the city reaps over $24 million dollars of environmental and socioeconomic benefits. The growth and health of Hartford's tree canopy is associated with the health of Hartford residents.

Environmental Benefits

The U.S. Department of Agriculture reports that "an acre of forest absorbs six tons of carbon dioxide and provides four tons of oxygen, enough to meet the annual needs of 18 people."

American Forests 2014, *Urban Tree Canopy Assessment & Planting Plan* note that Hartford's tree canopy annually:

- Provides over $5,000,000 in benefits.
- Removes 147,780 pounds of pollutants.
- Removes 11,264 tons of carbon from the air.
- Slows 590 million gallons of stormwater from entering drains during peak storm events.
- Reduces the heat island effect.
- Cools air temperature.
- Improves air quality.
- Supports wildlife.
- See chart below for associated cost savings:

Hartford Tree Benefits

	Existing Tree Canopy at 25% (savings noted in annual savings)	**Tree Canopy Increase to 35%** (savings noted in annual savings and annual net increase in savings)	**Tree Canopy Decrease to 22%** (within 30 years with no new tree plantings)
Stormwater	$4,728,178	$6,619,449 (+$1,891,271)	$4,160,797 (-$567,381)
Air Quality			
Carbon Removed	$3,600	$5,040 (+$1,440)	$3,168 (-$432)
Nitrogen dioxide Removed	$6,466	$9,052 (+$2,586)	$4,064 (-$2,401)
Ozone Removed	$198,218	$277,505 (+$79,287)	$174,431 (-$23,787)
Sulfur Dioxide	$369	$516 (+$147)	$324 (-$44)
Air Particulate	$47,437	$66,411 (+$18,974)	$41,744 (-$5,692)
Carbon Sequestered	$225,280	$315,392 (+$90,112)	$198,246 (-$27,033)
Energy Savings from Cooling	$277,665	$388,731 (+$111,066)	$244,345 (-$33,319)
TOTAL ANNUAL SAVINGS	$5,487,213 annual savings	$7,682,096 annual savings	$4,827,119 annual savings
Net Difference		+$2,194,883	-$660,094
Property Value Increase	$11,416,730 total	$15,983,422 total (+$4,566,692) total	$10,046,722 total (-$1,370,007) total
Carbon Storage	$7,474,180 total	$10,148,460 total (+$2,899,560) total	$6,379,032 total (-$869,868) total
TOTAL	$24,378,123	$33,813,978 +$9,435,855	$21,252,873 -$3,125,250

*Existing tree canopy benefits provided in American Forests 2014, Urban Tree Canopy Assessment & Planting Plan. Benefits from tree canopy increase and decrease extrapolated from existing benefits

Economic Benefits

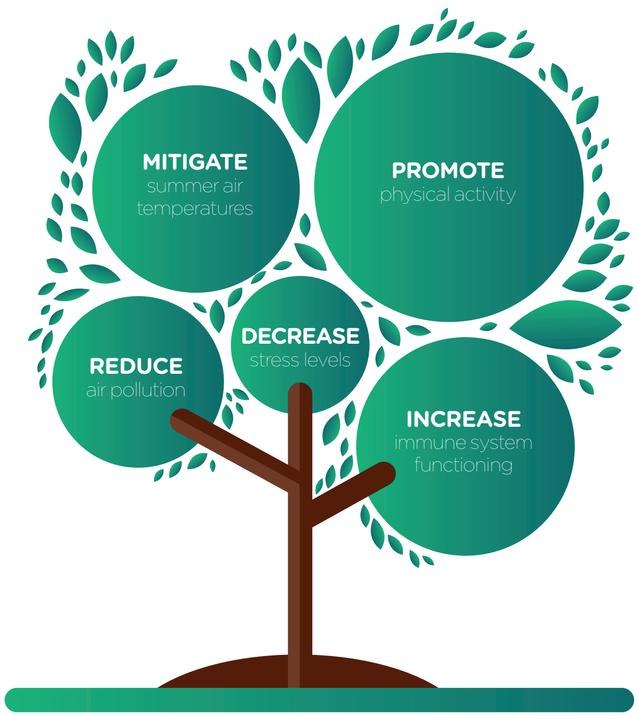
- "Trees can boost the market value of your home by an average of 6 or 7 percent" – USDA.
- "Trees can be a stimulus to economic development, attracting new business and tourism. Commercial retail areas are more attractive to shoppers."- Arbor Day Foundation.
- Decreases work absenteeism – *The Economics of Biophilia by Terrapin Bright Green.*
- Improves work productivity - *The Economics of Biophilia by Terrapin Bright Green.*

Health Benefits

- Decreases the risk of respiratory illness like asthma by improving air quality
- Helps mitigate heat related illnesses and deaths by cooling the air
- Decreases stress levels improving mental health
- Lowers blood pressure
- Encourages exercise and healthy lifestyles

Social Benefits

- Reduce energy consumption
- "Urban trees on average reduce air temperatures on summer days by 2-4 degrees Fahrenheit" – The Nature Conservancy, *Funding Trees for Health*
- Lowers crime rates – *Environment and Crime in the Inner City - Does Vegetation Reduce Crime? by Frances Kuo and William Sullivan*
- Acts as noise buffers
- Stress reduction
- Encourages socialization
- Improves street walkability
- Provides recreational opportunities
- Street beautification



Tree Benefits listed by Nature Conservancy "How Cities Can Harness the Public Health Benefits of Urban Trees"

2.2 The Benefits of Trees as Green Infrastructure

Trees are one important tool for implementing Green Infrastructure systems. Green infrastructure is an approach to water management that protects, restores, and mimics the natural water cycle. It can mean planting trees rather than building costly new water treatment plants. The New York City Parks and Recreation department reports that the average street tree in the city intercepts 1432 gallons of rainfall annually, while larger trees intercept almost 3,000 gallons.

The 2014 American Forests report note that in Hartford, the existing tree canopy slows 590 million gallons of stormwater during peak storm periods. They provide an associated cost benefit of $4,728,128. Hartford is a highly developed, dense urban city covered in impervious surfaces. These impervious surfaces do not allow water to soak into the ground, resulting in runoff. During major storm events, the stormwater flows over these surfaces and enters our 150-year-old combined sewer system, which collects both sewage and stormwater. When there is heavy rain, these combined pipes are overwhelmed, and excess sewage-stormwater mix overflows into our waterways. About half billion gallons of this untreated sewage-stormwater mix enters our waters every year.

The untreated sewage-stormwater mix can also cause flooding onto streets and in basements. In addition to the cost of treating stormwater needlessly, the bigger cost is an environmental one.

Hartford is the second largest city on the Connecticut River. The Connecticut River is the largest major freshwater tributary to the Long Island Sound. **It is critical to address water quality issues, which can have severe impacts on both local health as well as the integrity of the regional Connecticut River and Long Island Sound watersheds.**

The Environmental Protection Agency (EPA) “strongly encourages” the use of green infrastructure to address water quality issues. The Metropolitan District Commission (MDC) also includes green infrastructure considerations in their strategic plans for Hartford's stormwater and sanitary sewers. Large-scale implementation of green infrastructure can help address concerns related to stormwater management, while also providing many co-benefits such as cleaner air, cooler city streets, increased public green space, and enhanced wildlife habitat, all of which improve the quality of urban life.

Environmental Protection Agency

Tree canopy as green infrastructure. The EPA lists tree canopy as a green infrastructure method and a “cost-effective and resilient approach to managing wet weather impacts that provide many community benefits.” They note that “mature trees provide significant stormwater quantity and rate control benefits through soil storage, interception, and evapotranspiration. A tree with a 25-foot diameter canopy and associated soil can manage the 1-inch rainfall from 2,400 square feet of impervious surface.” The EPA identifies additional stormwater benefits from tree canopies:

- Improve water quality by filtering pollutants
- Reduces the effected impervious area
- Promotes infiltration

Strategically planted trees also can reduce energy costs by shading our homes and businesses, reduce flooding through the absorption of stormwater, reduce infrastructure costs (underground drainage facilities) and improve public health through the absorption of airborne pollutants (nitrogen dioxide, ozone, sulfur dioxide, and some particulates).

At different scales, trees can be extremely effective at absorbing stormwater:

Regional Scale

- Stream corridors
- Greenway trail systems

Neighborhood Scale

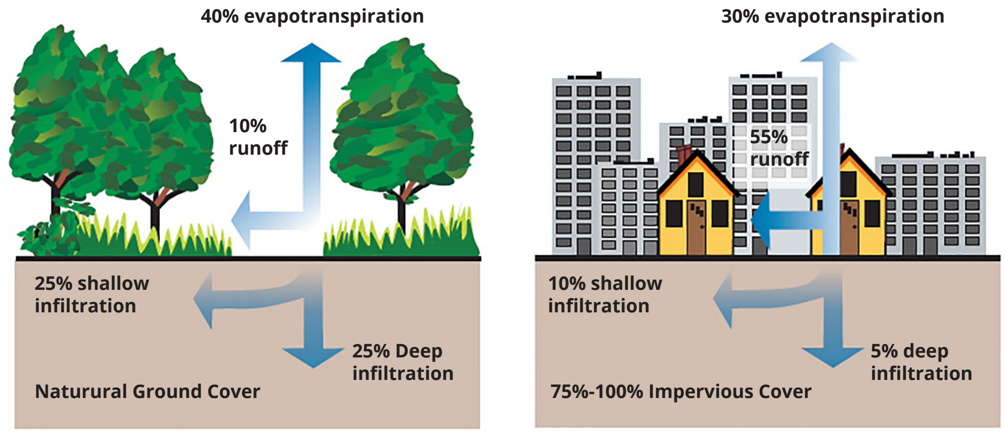
- Local Parks
- Streets

Municipal Scale

- Urban Parks
- Waterfronts
- Boulevards

Site Scale

- Residential Properties
- Courtyards
- Parking lots
- Building sites



Natural & Impervious Diagrams by U.S. Environmental Protection Agency "Protecting Water Quality from Urban Runoff"

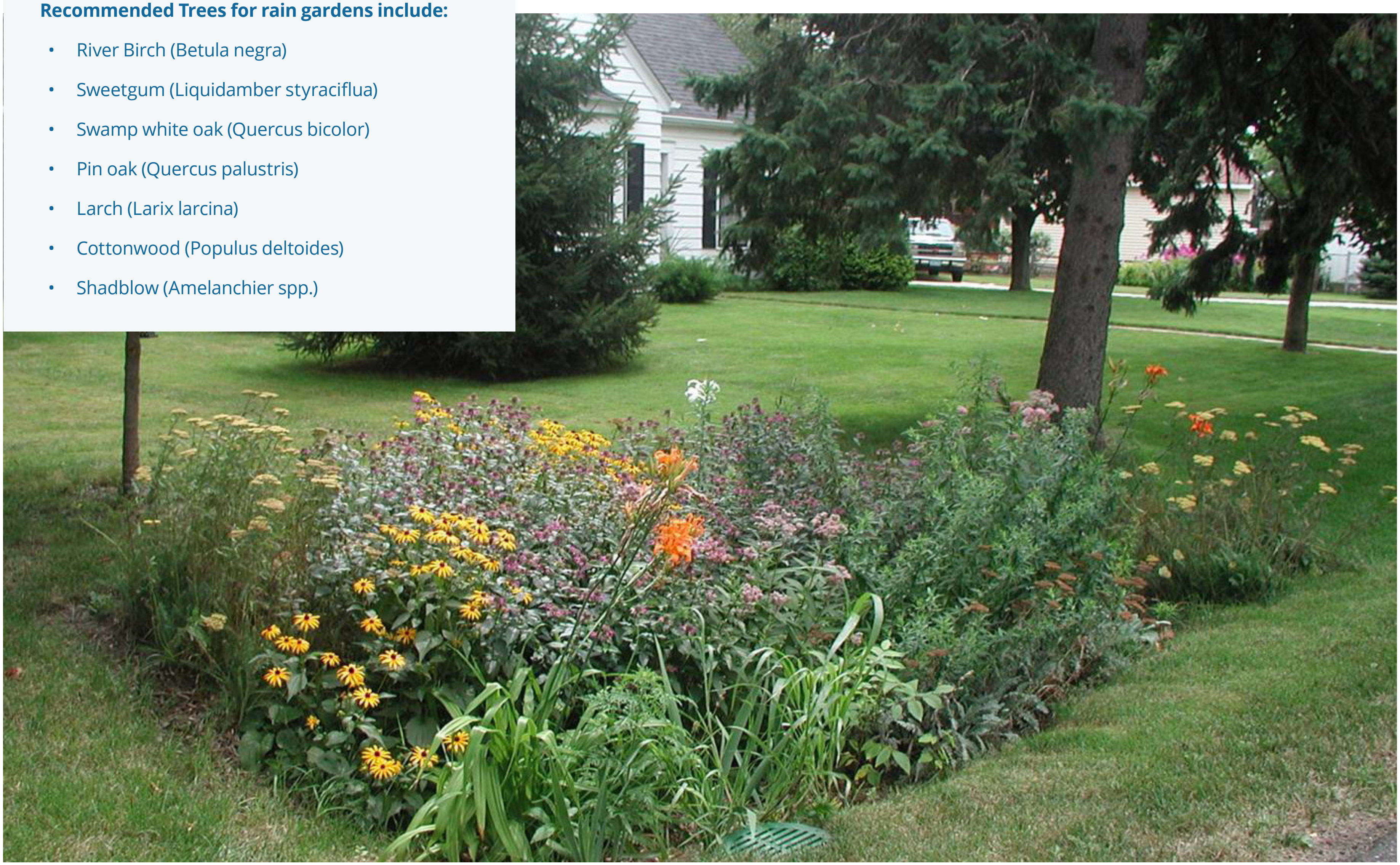
Specifically, trees are an effective tool as part of a rain garden or water quality swale. Planted as part of these systems, tree roots absorb a large volume of rain runoff. A rain garden is defined as “a strategically located low area that collects and absorbs stormwater runoff.” The area is typically planted with vegetation that has high water absorption qualities. A rain garden not only collects water that would otherwise go into a piped system, but the filtration of water through the plant roots and soils effectively cleans it of pollutants.

Rain gardens have great potential at the residential/homeowner scale, reducing the issues of flooding basements, ponding water and wet lawns.

Helpful information available to homeowners regarding the implementation of rain gardens is available from the UCONN Cooperative Extension Service through the publication “Rain Gardens in Connecticut, a Design Guide for Homeowners”.

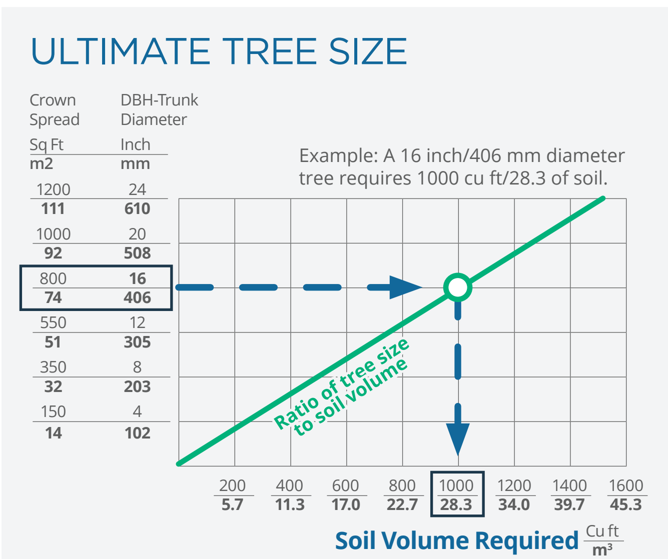
Recommended Trees for rain gardens include:

- River Birch (Betula negra)
- Sweetgum (Liquidamber styraciflua)
- Swamp white oak (Quercus bicolor)
- Pin oak (Quercus palustris)
- Larch (Larix larcina)
- Cottonwood (Populus deltoides)
- Shadblow (Amelanchier spp.)



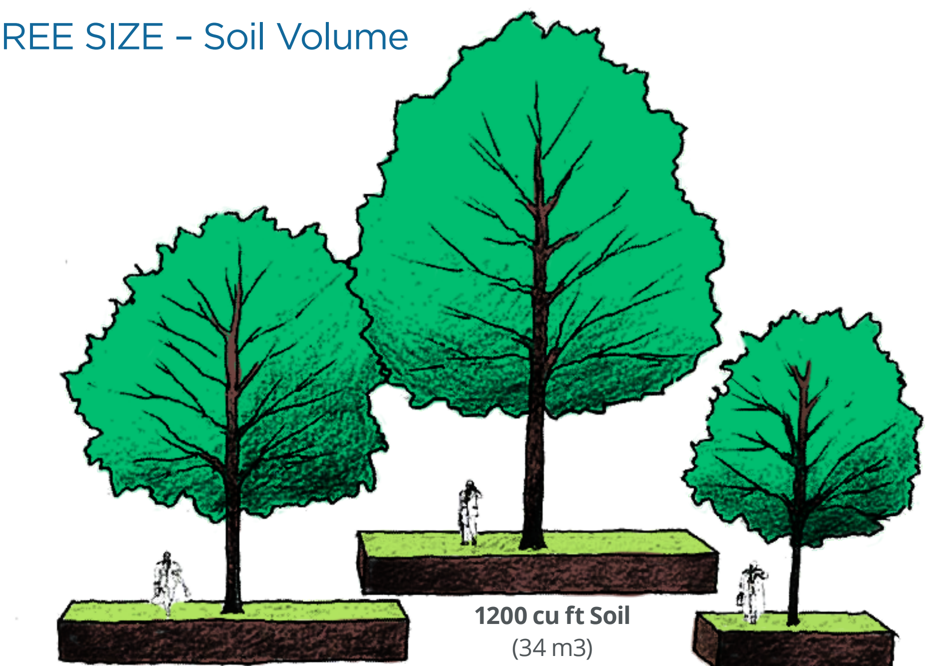
2.3 Benefits of Soil Volume for Tree Planting

Large trees produce greater benefits than smaller trees



by filtering more pollutants out of the air and absorbing more rainwater through greater root and canopy systems. To allow a tree to grow to its full potential, adequate soil volume must be provided. Landscape architect and author James Urban directly relates soil volume to tree size and life expectancy in *Up By Roots*. If 1,000 cubic feet of soil is provided, a tree is expected to grow to 16" diameter-at-breast-height (DBH) with a 32" diameter crown. However, urban environments make it hard to provide adequate soil volumes. Permeable pavement, structural cells, suspended sidewalks, and structural soils are a few methods that work.

TREE SIZE – Soil Volume



Methods to Expand Soil Volume

Permeable Pavement – provides the structure of pavement while allowing water to infiltrate through void space. Materials that can be used for permeable pavement include pervious concrete, porous asphalt, and permeable pavers. Permeable pavement allows water to infiltrate into the ground, however, it does not increase soil volume unless it is used in conjunction with another technique.

Structural Cells – or soil cells are a below-ground support system that maximizes soil and root volume while providing the structural support for the above pavement. This system not only increases soil volume, but allows air and water to circulate.

Suspended Sidewalks – requires structural support to support a suspended portion of the sidewalk. Loose soil is used under the sidewalk, providing an increase in soil volume.

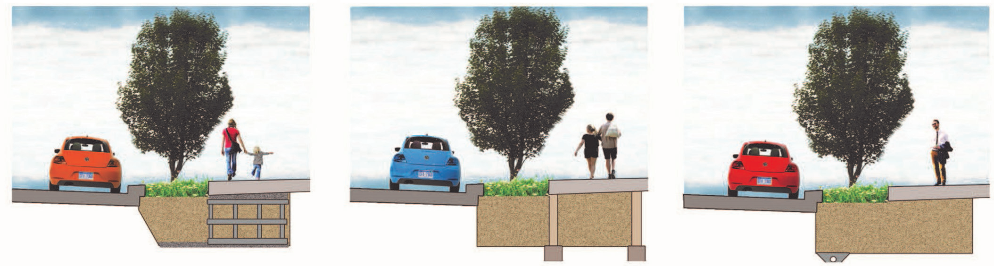
Structural Soils – blend of soil, stone, and hydrogel polymer that provides an improved root growing environment under pavements while maintaining the structural characteristics needed for subgrade under the pavement.

Tree Pits – are planting areas cut out of impervious pavement. Tree pits allow water and air to access the tree's root system. The size of tree pits directly affect the amount of soil volume provided for plantings.

Structural Cells
Modular manufactured cells that support pavement and are filled with loose soils that encourage root growth.

Suspended Sidewalks
Sidewalks with a supporting understructure that allows loose root-friendly soils to be continued under the walk.

Structural Soils
A blend of crushed rock and soil that is able to support pavement and can also support root growth.



EPA Stormwater Trees Technical Memorandum, September 2016

Conclusion

Given the right growing environment, trees provide a myriad of benefits for the City of Hartford. These benefits directly relate to the growth of the tree canopy. If the city does not prioritize the tree canopy, the benefits will decline as will the city's benefits and cost savings.

Structural Soil Feature

Hartford, Connecticut

In 2015, eight Elm Trees were planted in tree pits that extended structural soil under the adjacent sidewalks to provide additional soil volume on Ford Street in Hartford. On the opposite side of the street, eight more were planted in traditional tree pits with no additional soil volume. The diameter of trees planted in structural soils grew on average 27% more than the traditional trees. Structural soils are more expensive initially, but has the potential to be more cost-effective due to the additional environmental benefits and reduced cost of replacement trees.

PART 3
Hartford's Tree Canopy Goals

Hartford's tree canopy goals are set from a 2-pronged approach: tree maintenance and tree planting.

Establishing a 3-year proactive tree maintenance program will allow the City Forestry Department to manage the existing canopy through the promotion of a healthy forest. There are opportunities to expand the Forestry crew and decrease the use of outside tree contractors. Funding an annual tree planting program will allow the tree canopy to sustain at 25% and grow to 35%. *The Urban Tree Canopy Assessment and Planting Plan* by American Forests notes a maximum potential of 53.9% tree canopy cover for Hartford. This indicates that Hartford has the potential to reach their set goal of 35% and beyond.

Hartford's Tree Maintenance Goals: Establish a proactive tree maintenance program. Maintain the existing tree canopy at 25%.

Tree Maintenance Actions:

- Fund 12-person Forestry crew to achieve tree maintenance actions as outlined by the DRG report.
- Employ best-management practices that include a proactive and systematic approach to city-wide pruning, removals and management. Annual removals and pruning are outlined in the *Tree Resource Management Plan* by Davey Resource Group.
- Establish a 3-year cycle for tree maintenance based on the Tree Maintenance Priority Map (Part 6, Management of the Urban Forest).
- Record tree removals, tree maintenance, tree health, and city-wide tree planting in TreeKeeper, the city's tree database, so the city can effectively track the forests' status.
- Educate and engage the community about the benefits of tree planting on public and private property and how to maintain trees through community outreach and education.
- Update the city-wide inventory every 10 years.
- Efficiently manage wood waste to produce usable products and divert waste from landfills.
- Manage pests and diseases.

Parkville School Tree Planting

Expanding Hartford's Tree Canopy Through Tree Planting

In agreement with the Tree Advisory Commission and their recommendations, the immediate city-wide tree planting goal is 1,500 per year, with a phased target of 3,000 annual city-wide tree plantings by year five. What does annual city-wide tree plantings mean? This program includes all trees planted on City of Hartford public and private lands. To achieve this objective, the city needs to 1) Fund tree plantings and 2) Inventory and track tree plantings.

Precedence studies have shown that a partnership forged between a city and a non-profit for tree planting yields success. Working under the same initiative and common goal, a public-private partnership is the right formula for a successful tree planting program. For example, the MillionTreesNYC initiative which has successfully planted over one million trees in NYC since 2007, is a public-private partnership between New York City Department of Parks and Recreation and New York Restoration Project (NYRP), a non-profit organization. The NYC Department of Parks and Recreation manages all plantings in the Right-of-Way (ROW) and parks, while the NYRP's focus is plantings on private properties. The MIllionTreesNYC annual city-wide tree planting goal is typically 70% plantings on public lands and 30% on private lands.

If we apply the same methodology to Hartford, the breakdown of public-private tree plantings would yield 1,050 annual tree plantings on public property and 450 annual plantings on private property. Hartford tree planting quantities will grow respectively as the goal increases to 3,000 city-wide tree plantings at year five. Over time, as public tree opportunities are fully planted, the tree planting program will predominantly shift to private property.

Hartford Annual Tree Planting Goals

Year	Total City-Wide Annual Tree Plantings	Public Property	Private Property
Years 1-4	1,500	70%: 1,050 trees	30%: 450 trees
Years 5-10	3,000	70%: 2,100 trees	30%: 900 trees
Years 11+	3,000	30%: 900 trees	70%: 2,100 trees

Continually tracking new tree plantings through TreeKeeper is necessary to ensure canopy inequalities are addressed and the progress of public and private tree planting initiatives is monitored. A tree canopy assessment should be conducted every 10 years.

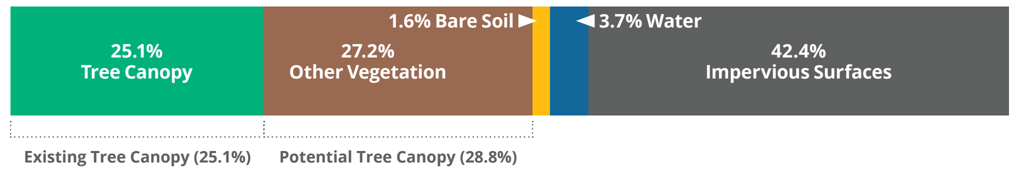
PART 4
Reforestation

4.1 Reforestation Strategy

According to the U.S. Census Bureau (2010), the total land area for the City of Hartford is 17.4 square miles. Baseline data from the forest assessment indicates that Hartford's maximum potential for urban tree canopy could reach 53.9%. This information is insightful as it shows that Hartford's urban forest has growth potential beyond the goals set forth in this report.

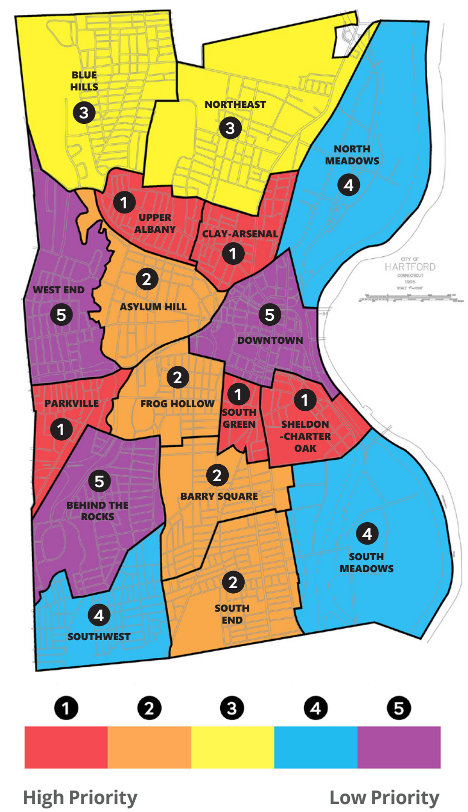
To sustain and expand Hartford's urban forest to 35%, priorities must first be set to balance the existing inequalities of tree canopy coverage across the city. This plan outlines strategies and administrative needs to implement this program: planning tools to set priorities and identify public and private property opportunities, public outreach and education initiatives, and associated program costs. Optimizing tree canopy will allow the city's urban forestry program to reap the full benefits and functions that trees provide.

Summary of Hartford's 2014 Urban Tree Canopy and Other Land Cover



Reforestation Priorities

To guide reforestation throughout the city, priority maps were developed for neighborhoods. Working with the City Forester and referencing previous reports that identify unequal distribution of trees throughout city neighborhoods, a priority ranking system of 1 -5 was established and applied to each of the seventeen neighborhood zones. Priority #1 denotes those neighborhoods with the greatest need for tree plantings due to low existing tree canopy levels. The primary focus is to plant new trees in these neighborhoods to improve the environmental, health, economic and social benefits in our most vulnerable neighborhoods. In contrast, neighborhoods designated as Priority #5 may have higher existing tree canopy coverage, but still offer additional opportunities to expand tree canopy cover through tree plantings. Refer to Appendix E. for Priority Neighborhood Tree Planting Map.



Identifying Tree Planting Opportunities

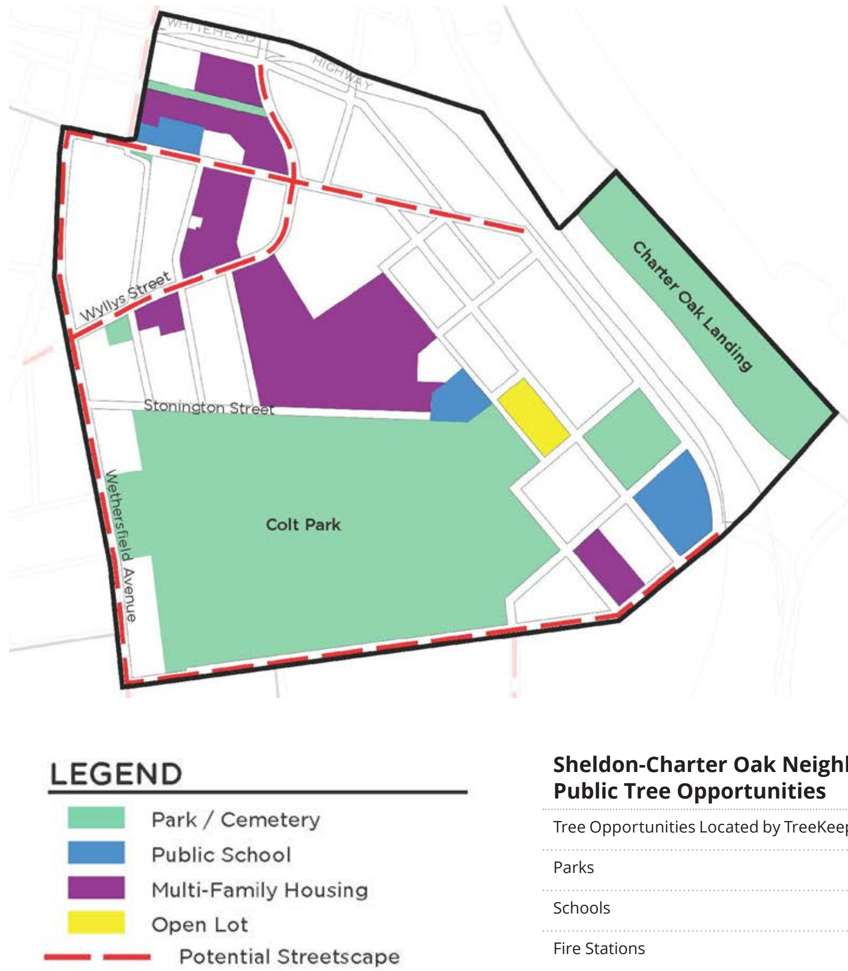
To reach the aggressive goals established in this report, the city plans to plant 1,500 trees city-wide in years 1-4, ramping up to 3,000 annual tree plantings in year 5 and beyond. Using individual Neighborhood Maps, targeted planting opportunities can be identified on public and private properties at all levels of the community to fulfill the city's reforestation needs. Prioritizing tree planting on public and private properties maximizes environmental, health, economic and social benefits for the entire Hartford community.

Neighborhood Maps

Even if a tree is not located in a front yard, communities benefit from neighborhood tree plantings. Neighborhood Maps, developed for each priority neighborhood, identify additional city-owned properties that provide tree planting opportunities. The maps also identify potential private properties that should be engaged in the tree planting program. Refer to Appendix F for all Neighborhood Maps.

NEIGHBORHOOD MAP EXAMPLE

Sheldon-Charter Oak (1 of 17 Neighborhoods)



Sheldon-Charter Oak Neighborhood Map Public Tree Opportunities

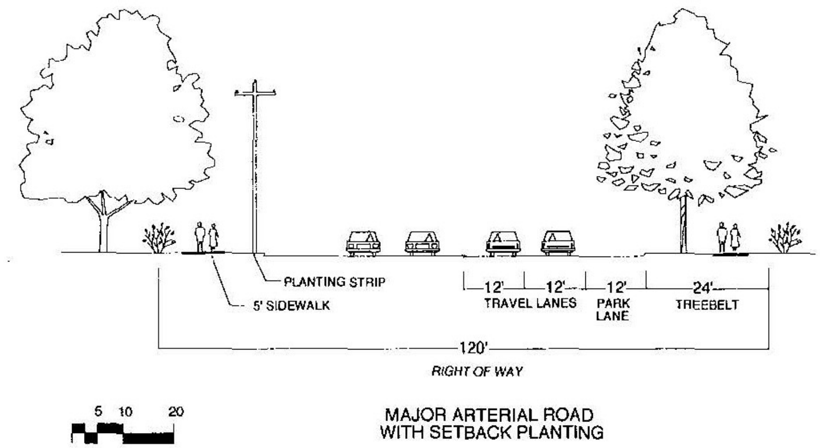
Tree Opportunities Located by TreeKeeper	537
Parks	166-230
Schools	25-40
Fire Stations	0
Total Public Tree Planting Opportunities	**728-807**

Public Property

For the purpose of this report, public property is defined as property-owned by the City of Hartford and dedicated for public use. As such, the city is responsible for planting, maintenance and removal of trees on public property. Current neighborhood mapping (via TreeKeeper and Neighborhood Maps) start to identify the following tree planting opportunities on public property:

- Within the Right-of-Way (ROW)
- Within 10' Beyond the Right-of-Way (BROW)
- Parks and Cemeteries
- Public Schools
- Municipal Facilities
- Hartford Housing Authority Properties
- Fire Departments/Police Departments
- City-Owned Open/Vacant Lots

There are additional planting opportunities located Beyond the Right-of-Way (BROW). Many probable tree planting locations are in narrow planting strips between the curb and sidewalk. Better tree planting locations may be Beyond-Right-Of-Way (BROW), which provide more soil volume and less exposure to salt and damage. An improved growing environment will yield a healthier and larger tree while providing public benefits.



Cross section of a Major Arterial Road with setback planting to avoid the utility lines.

BROW diagram by David V. Bloniarz and H. Dennis P. Ryan III "Designing Alternatives to Avoid Street Tree Conflicts". They recommend for States and local municipalities to look into planting BROW to avoid conflicts with utility lines and to decrease the future need for tree trimming.

Beyond the Right-of-Way (BROW) refers to the area of land located on private property beyond the city-established Right-of-Way (ROW). This approach is also known as Setback Planting and aims to locate proposed trees in an area that provides the most available soil volume, least conflicts, and healthiest location for a tree planting. Many states have adopted this technique to encourage healthy tree growth. Other cities such as New Haven and New Britain support this planting approach. Historically, Hartford has planted both in the ROW and BROW. A signed agreement from the homeowner is obtained prior to planting.

Private Property

Ownership of private properties is usually by an individual or corporation. The property owner is typically responsible for the planting, maintenance and care of trees on private property. Future tree planting must occur on private property in order for the city's tree canopy goals to be met. While tree plantings on private property provide benefits for the property owner and users, they also contribute to the overall neighborhood tree canopy which benefits the community as a whole. Current neighborhood mapping starts to identify the following tree planting opportunities on private property:

- Homeowner/Private Residences
- Private schools K-12
- Colleges/Universities
- Private Multi-Family Housing
- Businesses/Corporations
- HealthCare Institutions
- Churches
- New Developments
- Redevelopment of Existing Private Property

Additional planting opportunities also exist on individual homeowner and private residences. Existing tree planting programs, such as Knox's Trees for Hartford Neighborhoods, should be acknowledged as a partner in Harford's reforestation goals as they plan to plant over 100 trees per year on residential private properties. As the focus shifts to planting on private property, the city and KNOX have the opportunity to partner and expand the Trees for Hartford Neighborhoods yard tree planting program.

Furthermore, new developments and redevelopments can expand upon tree canopy by protecting existing trees and installing new trees per municipal codes.

As the tree planting program progresses and the city has planted out their public properties, the focus will shift to private properties. From a municipality standpoint, the city should support and engage private property owners through outreach, education and other planting incentives. The Neighborhood Maps begin to identify large-scale private property planting opportunities such as multi-family housing developments and colleges. Corporations and institutions should also be engaged to promote tree canopy growth on their campuses.

TreeKeeper

Hartford's TreeKeeper is the database platform where all tree information is stored. In 2019, a tree inventory was performed by Davey Tree Inventory and Management to identify, locate and evaluate existing trees along the Right-of-Way (ROW) and within high use areas of specific parks, cemeteries and other public properties (See Appendix A for the Tree Resource Management Plan). This information was entered into this database, as well as potential ROW locations for additional tree planting. Parks, other public properties and private properties were not evaluated for potential tree planting locations.

TreeKeeper is a valuable tool that allows the city to track tree removals, tree plantings and the health of the inventoried trees. Tracking the tree program is crucial to ensure tree canopy inequalities are addressed and to efficiently manage tree maintenance and tree planting efforts.

TreeKeeper is also a valuable communication tool. A limited version of TreeKeeper is available to the public on the internet. This allows the Hartford community to see how many existing trees Hartford has, where potential tree planting locations are, and the benefits that these trees provide. There are opportunities to further develop this platform to improve the transparency of forestry actions, such as integrating 311 reports and responses.

Tree Management Program Administration

The Forestry Division of the Department of Public Works will be the lead department responsible for overseeing and implementing Hartford's Tree Canopy Action Plan. Major duties include tree maintenance as outlined by DRG in the *Tree Resource Management Plan* and executing the tree planting plan as outlined in this report. Program tasks and responsibilities include, but are not limited to:

- Delegating tree removals and pruning to the crews.
- Managing forestry crews which is proposed to be expanded to 12 people.
- Entering all removals and pruning activities in TreeKeeper.
- Responding to 311 calls.
- Surveying city trees for pest and disease threats.
- Delegating and coordinating tree plantings on public property.
- Quality control of contracted plantings.
- Enter all tree plantings on public property in TreeKeeper.
- Identify private property tree planting opportunities and record in TreeKeeper.
- Engage private property owners in tree planting.
- Record verified new tree plantings on private property in TreeKeeper.
- Engage landscape architectural professionals to prepare plans for tree plantings in parks and schools as needed.
- Education and outreach of tree benefits.

Additional staffing is required to support the tree management program. Below is an overview of the staff additions.

- **Tree Planting Coordinator I & II (required):** The responsibility for these two new positions include community outreach and education, tracking tree plantings in the TreeKeeper database, and quality control of contracted plantings. The Coordinator shall facilitate discussions with residents, NRZ's, institutions, and other private property owners to promote planting on private property. The Tree Planting Coordinator will locate additional tree planting opportunities and engage landscape architectural services to prepare plans as needed.
- **Forestry Administrative Assistant (required)** An Administrative Assistant is needed for the City Forester. This would allow the City Forester to focus their energy on the city's forest and managing the arborist crews.

Reforestation Goals

Initial tree planting goals can be met for the first five years by planting trees in ROW locations within priority neighborhoods, as over 10,000 tree planting locations have been identified by TreeKeeper. In year six and beyond, tree plantings should continue in locations identified by TreeKeeper and expand throughout priority neighborhoods to other city-owned properties noted on the Neighborhood Maps (Refer to Appendix F for all Neighborhood Maps) and Yearly Tree Planting Location Guide (Appendix M).

To achieve the overall growth of expanding Hartford's Tree Canopy to 35%, significant tree planting needs to happen on private property. As public properties are fully planted during years 1-10, reforestation goals will shift to prioritize tree planting on private property (30% public and 70% private beginning in year 11 and beyond). Public outreach and education programs must be established to garner community support and encourage tree planting programs on private property.

Reforestation Considerations on Public Property

Planting Along the Right-of-Way (ROW)

The following steps need to occur before planting in the Right-of-Way:

- Confirm: Perform site visits to confirm possible tree planting locations as noted in TreeKeeper.

Hartford Annual Tree Planting Goals

Year	Total Annual City-Wide Tree Plantings	Public Property	Private Property
Years 1-4	1,500	70%: 1,050 trees	30%: 450 trees
Years 5-10	3,000	70%: 2,100 trees	30%: 900 trees
Years 11+	3,000	30%: 900 trees	70%: 2,100 trees

- Engage Residents: Residents must accept tree planting in the ROW before tree planting can occur. This is essential as other planting programs have shown that the survivability of a tree planted in the ROW is greatly impacted by resident acceptance. Resident acceptance includes that they agree to a new tree and will water and maintain the tree.

Beyond the Right-of-Way (BROW)

Locate BROW opportunities. Written consent from the owner must be obtained for this option. Target plantings in areas with excessive impervious surfaces to reduce the heat island effect as noted in the 2020 City Plan. Use Davey Resource Priority Planting Location Maps from 2017 to identify target blocks within a neighborhood for future BROW plantings (Refer to Appendix G).

Tree Planting Considerations

- Follow tree planting considerations as outlined later in this report as a guide for tree species selection, growing space and ideal planting recommendations.

Request A Street Tree

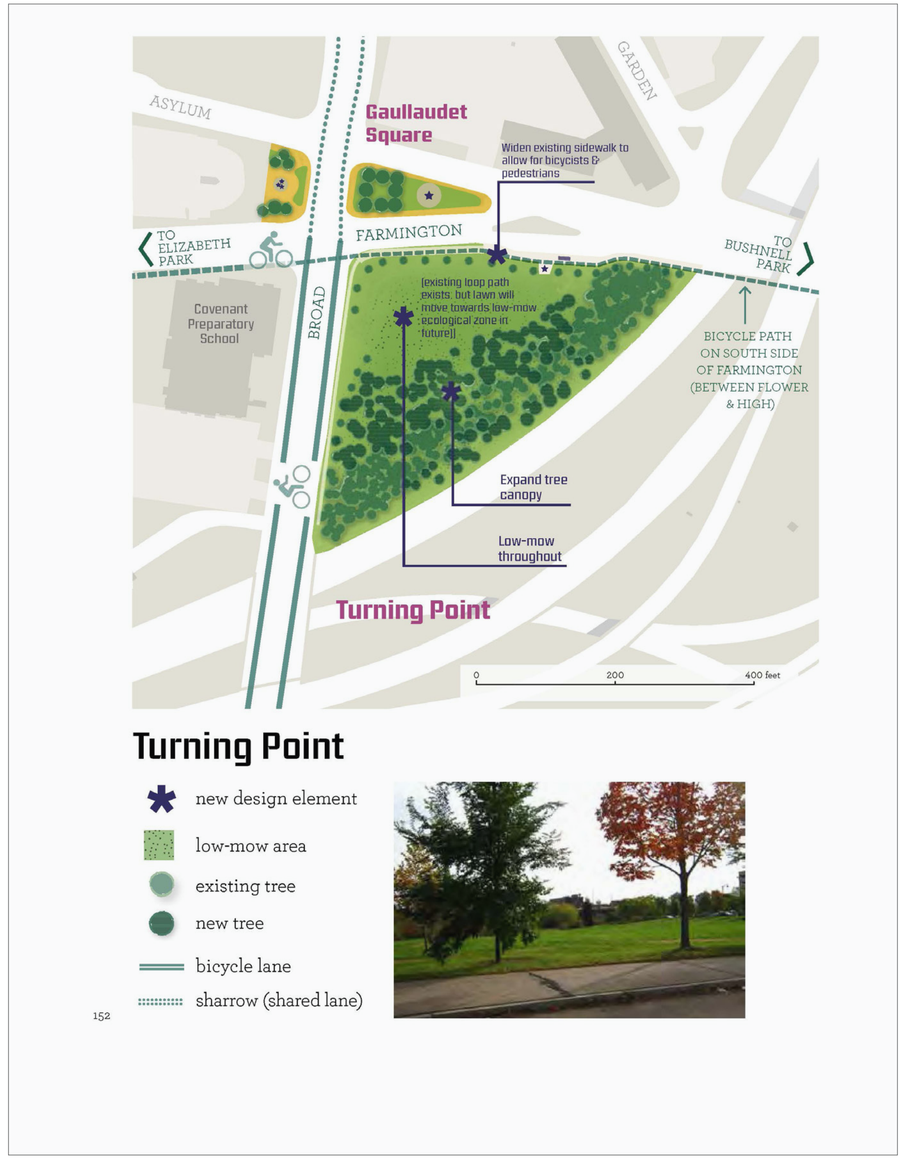
The city should establish a "Request A Street Tree" on the Forestry website. This program would allow a resident to request a street tree to be planted in the ROW. Tree requests do not have to be located within the current priority neighborhood planting areas, but should not exceed 10% of the city-wide targeted tree planting total for public areas.

Additional Plan Resources for Parks

Tree plantings in parks are an easy and low-cost method to increase overall tree canopy. Prioritize park plantings per the Park Priority Planting Map. Refer to Appendix H for Park Planting Priority Map.

Concept and Schematic Plans are available from previous reports. Consult the following:

- 2014 Capital City Parks Guide: Section I provides concept plans for all the parks in the city. These concept plans locate existing and proposed vegetation and provide a great starting point to identify locations in parks for tree plantings. Refer to Appendix I for Section I of the Capital City Parks Guide.
- Existing Park Master Plans, such as Colt Park and the 1992 Hartford Parks Master Plan. Refer to Appendix J and K for the Colt Park Master Plan and the 1992 Hartford Parks Master Plan.



Example Concept Plan from Capital City Parks Guide

1. CLAY ARSENAL/ PARKVILLE/ SHELDON CHARTER OAK/ SOUTH GREEN/ UPPER ALBANY

- Colt Park
- Porter Memorial
- Pulaski Mall
- Old North Cemetery
- Willie Ware Park
- South Green/ Barnard Park
- Harriet Tubman Park
- Julio Lozada Park
- West Quirk Turf
- Pope Park West
- George Day Park

2. ASYLUM HILL/ BARRY SQUARE/ FROG HOLLOW/ SOUTH END ZION HILL CEMETERY

- Pope Park
- Baby Pope Park
- Columbus Green
- Old South Cemetery
- Turning Point Park
- Bond Street Parkett
- Campfield Memorial Grounds
- Campfield Green
- Gallaudet Square
- Goodwin Park
- Columbus Park
- Sigourney Square Park

3. BLUE HILLS/ NORTHEAST

- Joseph V. Cronin Park
- Roberta Jones Playground
- Northwood Cemetery/ Soldiers Field
- Keney Waverly Park
- Brackett Park
- Keney Woodland Park
- Keney Barbour Park

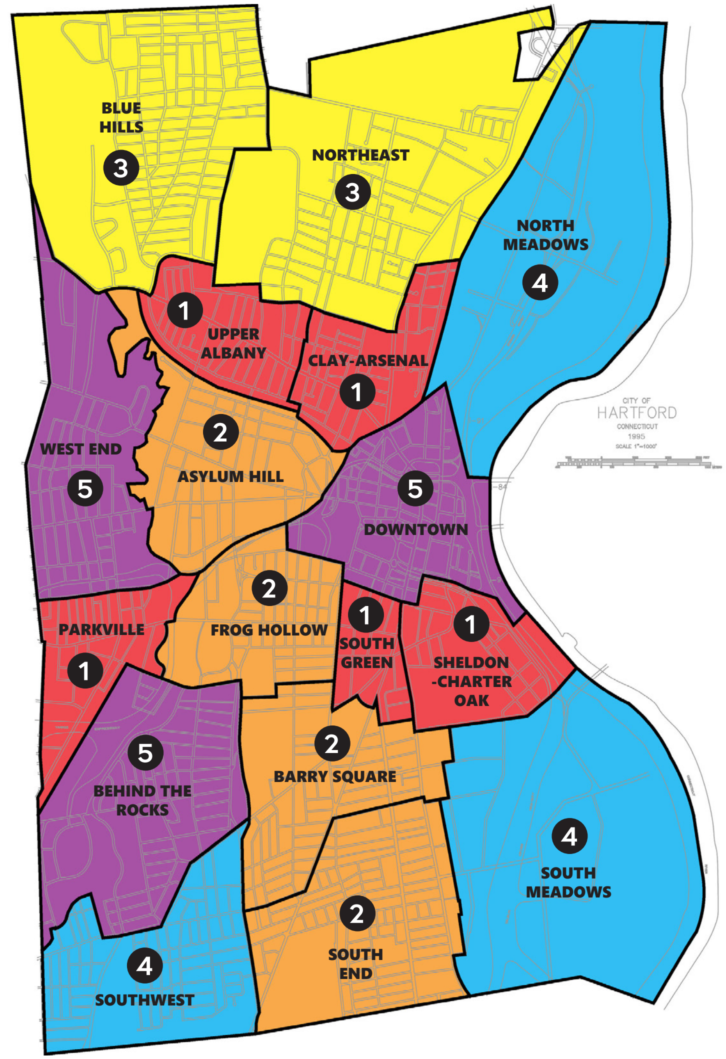
4. NORTH MEADOWS/ SOUTHWEST/ SOUTH MEADOWS

- Thomas J. Hyland Memorial
- Forster Park
- New Britain Ave Triangle
- Riverside Park
- Charter Oak Landing

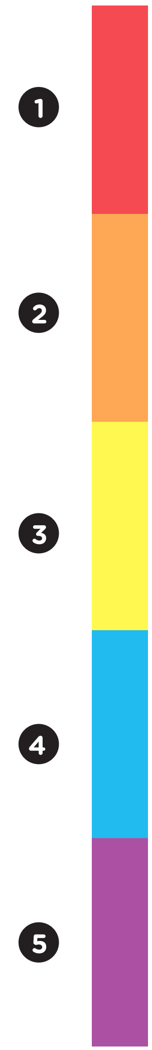
5. BEHIND THE ROCKS/ DOWNTOWN/ WEST END

- Rocky Ridge Park
- Buckingham Square
- Keney Memorial Clock Tower
- Bushnell Park
- New Ross County Wexford Park
- Elizabeth Park
- Ancient Burying Grounds
- Pulaski Circle

MAP PRIORITY PLANTING PARK MAP



High Priority



Low Priority

Reforestation Considerations on Private Property

City/Non-Profit Yard Tree Planting Program Partnership: The City of Hartford has an important and long-standing relationship with KNOX, a local non-profit that supports the Hartford Community through horticultural practices. Through the years KNOX has supported the City of Hartford tree planting program, not only by planting city-contracted trees, but also through their Trees for Hartford Neighborhoods (TFHN) campaign that plants trees on private property. KNOX also facilitates community outreach and education programs. Most importantly, KNOX supports the continued growth of the Hartford community by staffing its' workforce with Hartford residents that they train and educate in horticultural practices. To date, KNOX has planted more than 5,000 trees in Hartford neighborhoods, parks and schools.

Maintaining this established relationship offers a unique opportunity to convey a united front, between a municipality and non-profit, working together side by side to achieve a common goal. Expansion of the Trees for Hartford Neighborhoods program with a city/non-profit partnership should be explored to promote planting on private property through a city-wide yard tree planting program.

Photo credit: Knox.com

KNOX
People Planting Programs

The expanded yard tree planting program highlights:

- City/non-profit shared costs and installation of yard trees.
- Strong marketing to promote the subsidized yard tree planting program.
- Methods for resident outreach should include door-to-door as well as a Request-A-Yard-Tree webpage. Door-to-door practices should be focused throughout priority neighborhoods. While tree requests from the Request-A-Yard-Tree web page should be limited to 10% outside the priority neighborhoods. Outside priority neighborhood requests beyond the 10% are to be cataloged and given priority the following year.
- Engage the resident through tree selection.
- Incorporate a fruit/nut tree planting program as an incentive per the 2035 City Plan.
- Yard tree program guidelines must be formalized. Guidelines to include consent form that identifies an agreement between the resident and city that the resident accepts the tree being planted on the private property and accepts future tree maintenance which includes watering. Consent form to indemnify the city from future responsibilities of tree care, replacement or removal. See example guidelines in Appendix L from Silverton, Ohio.

Cost-saving options that should be considered include:

- Utilizing a #20 container tree (typical 1.75" caliper).
- Consider resident buy in to encourage resident ownership and stewardship.
- Tree Giveaway verse including installation.

- **Riverfront:** There are ample tree planting opportunities along the Connecticut River. The City has the opportunity to work along with MDC and Riverfront Recapture to maximize tree plantings along the river.
- **Colleges / Universities:** Engage with colleges and universities to encourage tree plantings on their campuses.
- **Corporations and Institutions:** Work with companies and institutions to promote a healthy work environment and mitigate the heat island effect through tree plantings on their campuses. Target properties identified in the Planting Priority Maps by Davey Resource Group in 2017 identify heat island concerned areas. See Appendix G.
- **Multi-Family Housing Developments:** Targeting large housing sites with single ownership will allow tree plantings to impact many residents while negotiating with minimal people.
- **Neighborhood Opportunities to Promote Private Property Reforestation:**

  Refer Appendix F for Neighborhood Maps

- Private Schools K-12	- Churches
- Developers	- Universities/ Colleges
- Large Institutions	- NRZ Neighborhood Groups
- Hospitals	- Housing Developments

Tree Baltimore Tree-Give-A-Way program. Photo credit: Treebaltimore.com

Examples of Creative Ways Other Cities Have Promoted Tree Planting on Private Properties

Chicago – Sustainable Backyards Program

Chicago's Sustainable Backyards Program promotes sustainable stewardship through educational workshops and rebate programs. They offer a 50% rebate on tree purchases up to $100.

Vancouver, WA – Annual Tree Giveaway

After a 2011 tree canopy assessment indicated that private properties have the most potential for trees, the city started to fund an annual fall tree giveaway program where each household is allowed to take home one tree. The resident is responsible for planting and tree care. The city provides a tree planting demonstration and provides the resident with a free bag of mulch and educational material regarding tree planting and tree care.

Baltimore –
TreeBaltimore Tree Give-A-Way and Discounted Trees

TreeBaltimore serves as an umbrella program for all City agencies, private organizations and individuals involved in the effort to increase Baltimore's tree canopy. TreeBaltimore offers Tree Give-A-Way several times a year at various locations around the City. These events provide a free 1-gallon tree for residents. Similarly, they offer coupons from a tree nursery if a resident wants to purchase their own tree.

Durham – Keep Durham Beautiful Tree Giveaway

Established in 2004, Keep Durham Beautiful is a non-profit, working in partnership with the City of Durham, that unites communities and businesses to promote stewardship throughout Durham. They run a tree giveaway program where a resident is allowed one tree per household. Residents must reserve their tree in advance as the program is limited to 300 trees a year. During the giveaway, educational demonstrations on how to plant and maintain a tree are also provided.

New York City – NYRP Tree Adoption

New York Restoration Project is the non-profit affiliated with the MillionTreesNYC initiative. They worked jointly with the New York City Parks Department to plant over 1 million trees in New York City. Since the completion of the MillionTreesNYC in 2015, NYRP continues to promote tree plantings on private properties through their Tree Adoption Program. Registration and selection of tree is required in advance as quantities are limited. Information regarding tree planting and tree care are provided with every tree.

Orlando – Energy Saving Tree Program

The Arbor Day Foundation has partnered with cities and utility companies to fund trees on private properties. These carefully located trees provide energy benefits for the homeowner, while also promoting a cooler, greener and more energy efficient community.

ENERGY-SAVING TREES®
An Arbor Day Foundation Program

4.2

Reforestation Costs

Many factors affect the annual tree planting budget. Replacement trees and annual planting goals heavily impact the first five years of the tree planting program. But by year six, replacements are limited, and the planting goals are maximized.

Cost Summary

- Costs years 1-4 range from $1.5 million to $1.9 million.
- Costs at year 5 are estimated at $2.5 million.
- By year 6, costs stabilize at $2.6 million when planting goals are maximized at 3,000 trees per year and tree replacements are limited.

Additional Budget Notes

- Adjust the budget annually for inflation (2.5%) on yearly basis to factor in increasing costs.
- An emergency fund should be established for large storm events to hire contractors when necessary.

See Appendix M, the Yearly Tree Planting Location Guide, for a detailed breakdown of tree planting locations and quantities.

Year 1 Tree Planting Costs	
Tree Planting Coordinator I	$60,000
Tree Planting Coordinator II	$50,000
Administrative Assistant	$40,000
Tree Plantings (1,500 x $650/planting) **Installed in Priority #1 Neighborhoods** (See detailed breakdown locations and quantities in Appendix M)	$975,000
Replacement Tree Plantings (634 x $650) (As identified in the Tree Resource Management Plan)	$412,100
Watering Needs (1,684 Trees at $100/tree) (New Trees and Replacements; excludes watering on private property)	$168,400
TOTAL TREE PLANTING COST	**$1,705,500**

Year 2 Tree Planting Costs	
Tree Planting Coordinator I	$60,000
Tree Planting Coordinator II	$50,000
Administrative Assistant	$40,000
Tree Plantings (1,500 x $650/planting) **Installed in Priority #2 Neighborhoods** (See detailed breakdown locations and quantities in Appendix M)	$975,000
Replacement Tree Plantings (631 x $650) (As identified in the Tree Resource Management Plan)	$410,150
Watering Needs (3,365 Trees at $100/tree) (Watering for Year 1 & 2 New Trees and Replacements; excludes watering of private property)	$336,500
TOTAL TREE PLANTING COST	**$1,871,650**

Year 3 Tree Planting Costs	
Tree Planting Coordinator I	$60,000
Tree Planting Coordinator II	$50,000
Administrative Assistant	$40,000
Tree Plantings (1,500 x $650/planting) **Installed in Priority #3 Neighborhoods** (See detailed breakdown locations and quantities in Appendix M)	$975,000
Replacement Tree Plantings (634 x $650) (As identified in the Tree Resource Management Plan)	$293,150
Watering Needs (1,684 Trees at $100/tree) (Watering for Year 2 & 3 New Trees and Replacements; excludes watering of private property)	$318,200
TOTAL TREE PLANTING COST	**$1,736,350**

Year 4 Tree Planting Costs	
Tree Planting Coordinator I	$60,000
Tree Planting Coordinator II	$50,000
Administrative Assistant	$40,000
Tree Plantings (1,500 x $650/planting) **Installed on Public Property Priority #4 Neighborhoods** (See detailed breakdown locations and quantities in Appendix M)	$975,000
Replacement Tree Plantings (90 x $650) (As identified in the Tree Resource Management Plan)	$58,500
Watering Needs (2,641 Trees at $100/tree) (Watering for Year 3 & 4 New Trees and Replacements; excludes watering of private property)	$264,100
TOTAL TREE PLANTING COST	**$1,447,600**

Year 5 Tree Planting Costs	
Tree Planting Coordinator I	$60,000
Tree Planting Coordinator II	$50,000
Administrative Assistant	$40,000
Tree Plantings (3,000 x $650/planting) **Installed on Public Property Priority #5 Neighborhoods** (See detailed breakdown locations and quantities in Appendix M)	$1,950,000
Replacement Tree Plantings (90 x $650) (As identified in the Tree Resource Management Plan)	$58,500
Watering Needs (3,330 Trees at $100/tree) (Watering for Year 4 & 5 New Trees and Replacements; excludes watering of private property)	$333,000
TOTAL TREE PLANTING COST	**$2,491,500**

Year 6+ Tree Planting Costs	
Tree Planting Coordinator I	$60,000
Tree Planting Coordinator II	$50,000
Administrative Assistant	$40,000
Tree Plantings (3,000 x $650/planting) **Installed on Public Property Priority #1 Neighborhoods** (See detailed breakdown locations and quantities in Appendix M)	$1,950,000
Replacement Tree Plantings (90 x $650) (As identified in the Tree Resource Management Plan)	$58,500
Watering Needs (4,380 Trees at $100/tree) (Watering for Year 5 & 6 New Trees and Replacements; excludes watering of private property)	$438,000
TOTAL TREE PLANTING COST	**$2,596,500**

4.3

Municipal Regulations

Zoning Regulations

Reforestation on private and public properties is directly influenced by municipal codes. The City of Hartford takes a firm stance in its Municipal Codes to protect and expand their City canopy. Tree ordinances fall under Chapter 28: Planning and Development Regulations. These ordinances require tree removal permits for all trees and require an inch-for-inch replacement for any tree greater than 13- inches in caliper or deemed significant by the City Forester. Similarly, a fine of $250/day can be applied for the removal of any tree without a required permit. The Tree Ordinance outlines that utility companies are to obtain a public utility permit from the City Forester before performing any maintenance work that would cause injury to a city tree.

Refer to the following sections of the municipal codes for more detail:

- Sec. 28-160, Tree removal
- Sec. 28-161, Protection during construction
- Sec. 28-162, Tree replacement
- Sec. 28-163, Planting requirement
- Sec. 28-164, Hartford Tree Account

Goals

- Communicate tree canopy goal within zoning regulations.
- Strengthen tree protection requirements.
- Strengthen proposed tree planting requirements.

Actions

To strengthen the city's commitment of expanding their urban tree canopy, the goal should be conveyed within the zoning regulations. Below are suggested modifications to Section 1.0 and 6.0 of the zoning regulations to encourage new tree planting:

- 1.3.3-B(6), Existing Natural Conditions Plan: Add the following language "to include mapping location of existing trees, tree type, caliper, and critical root zones. Critical root zones to be shown on all exterior improvement plan sheets."
- 6.1.1, Intent: Include a city-wide tree canopy goal of 35%.
- 6.2.3H, Permeable Surface: Adjust language to make minimum soil volumes a requirement, not a recommendation.
- 6.2.3, Requirements: Add section J for Required Soil Volume: When the required soil volume as outlined in Figure 6.4-E cannot be achieved, the following minimum requirements are to be met:
- Minimum of 5x10x3 (150 cu ft) of soil is to be provided.
- Required volume can be achieved by the use of structural cells or another City Forester approved method.
- 6.4.D, Alternate Compliance: Add language about alternate compliance by paying a penalty fee to the Hartford Tree Fund.
- Figure 6.4-D: Update with revised City Approved Tree List (See Appendix N).

- Figure 6.4-E: Column heading Soil Surface Area – Update soil depth to 3'.
- 6.6.3: Add more specific language regarding fines and penalty costs in accordance with the Tree Ordinance.
- 6.7.3B Clear Branch Height: Add 5' minimum branching height with a preferred 6' branching height at time of planting for all trees planted adjacent to a sidewalk or street.
- 6.7.3-D(4) Tree Wells: Increase tree wells from 4'x8' to 5'x10'.

Plans Exempt from Site Plan Review

Strong Zoning Regulations require City Forester approval of site plan applications. However, the City Forester review may not be prompted when proposed work does not have obvious impacts on trees (such as new site lighting in a park). To visualize possible tree impacts, all site plans should include mapped locations of existing trees, tree type, tree caliper, and critical root zones. Critical root zones should be shown on all site plans. Mapped critical root zones in relation to proposed work should act as a visual cue if the areas overlap and should also trigger review by the City Forester.

Department Communication

All city departments need to cooperatively work toward the overall tree canopy goal of 35% through open dialogue and communication. The Department of Public Works has started to achieve this through its monthly Tree Maintenance Working Group. Members of this working group include representatives from DPW Forestry Division, Tree Commission, Office of Sustainability, Corporation Council and local non-profits. We suggest adding a representative from the Department of Development Services Planning Division to promote the tracking of trees on private developments.

Department Opportunities:

- Planning Division to track and verify all trees installed per site plan approvals. This can be done in various ways; by the Zoning Enforcement Officer at the time of the Certificate of Occupancy (CO) inspection, by an intern or the Tree Planting Coordinator. The Planning Department needs to communicate tree totals directly with the Forestry Department to be entered into the TreeKeeper database.
- Planning Division to continue to enforce tree planting requirements as outlined in city zoning regulations.
- City Forester to continue to enforce tree removal permits on private properties.
- City Forester to extend enforcement of fines and penalties.
- City Forester to develop a site plan review checklist to ensure requirements are met or the allocated contribution is made to the Hartford Tree Fund.
  - Checklist to include:
    - ☑ Tree Protection Requirements
    - ☑ Tree Removal Requirements
    - ☑ Tree Planting Requirements
- Strengthen Tree Removal monitoring on private properties through improved outreach with the City of Hartford Neighborhood Revitalization Zones
- Strengthen Tree Removal vigilance by including a Tree Removal Form Report on the Forestry website page.
- Sidewalk replacement campaigns can effectively pair with tree planting programs to provide more soil volume through the use of structural soils, structural cells or suspended sidewalks during sidewalk construction.

4.4 Education and Outreach

The city's urban forestry program cannot succeed without the active support and engagement of the community. Community appreciation of tree benefits and engagement in urban forest planning, tree preservation and tree planting efforts are necessary to ensure the long-term sustainability of this valued resource. The goal is to inspire the community to take ownership of efforts to protect and expand Hartford's urban forest. Strategies need to be formed to encourage public participation in the shared vision, goals, planning and management of Hartford's Tree Canopy Action Plan at the community level.

Community needs relate to how the public perceives and interacts with the urban forest and the local urban forest management program. Examples of community needs include:

- Increased public awareness of the value and benefits of trees.
- Promoting better private tree care through better public understanding of the biological needs of trees.
- Fostering community support for the urban forest management program.
- Encouraging conservation of the urban forest by focusing public attention on all tree age classes, not just large heritage trees.

It is important to encourage private landowners to plant and maintain trees on their land as well as acknowledge that urban trees require public acceptance. Forestation on private properties starts with education and outreach. In 2019, the city surveyed the community through the Hartford 400 survey which asked the public to prioritize areas of green infrastructure. Planting trees was the top choice. Open communication regarding the city's overall tree canopy goals and actions is essential for the community to gain confidence in the city's Tree Maintenance and Tree Planting Programs.

Education and Outreach Goals:

- Establish a Tree Canopy marketing campaign.
- Communicate campaign goals and information.
- Engage, educate, and extend the community.

Outreach Actions

Marketing: A strong marketing campaign that brands the initiative will allow stakeholders to recognize the actions and partnerships that are happening to support the common goal. After a discussion with the Director of Community Engagement, we strategically suggest **LOVE HARTFORD / GREEN HARTFORD**. See the adjacent logo. This name is familiar throughout the city through the anti-litter campaign called LOVE HARTFORD.

LOVE HARTFORD GREEN HARTFORD

Communication: The intentions and proposed actions regarding public and private tree planting, and tree maintenance can be effectively conveyed to the community through various means as outlined below:

- TreeKeeper – Periodically updating the TreeKeeper database on the City Forestry website/webpage will illustrate tree planting campaigns. An opportunity to integrate maintenance calls into this platform would promote transparency of the maintenance program.
- Forestry Website/Webpage: Complete Forestry webpage to include integral tree-related information.
- Flagging Proposed Locations - Flagging locations for proposed tree plantings visually informs the community of proposed work. Flags should be labeled with the **LOVE HARTFORD / GREEN HARTFORD** logo.

LOVE HARTFORD GREEN HARTFORD

Proposed tree planting locations marked by flags or sidewalk sticker to communicate future tree locations to the community through the MillionTreesNYC campaign. Photos by MillionTreesNYC.org

- Informational Tree Tags - When a tree is planted, an informational tree tag should be visible. Key information includes the type of tree, watering requirements, maintenance requirements, and tree benefits. Tags are to be bi-lingual. Integrating a QR (quick response) code onto each label would provide an opportunity to easily track stewardship and maintenance actions for each tree.

- Informational Flyer: Informational flyers regarding general tree care, pruning and watering needs should be developed and provided to residents at time of planting. This should also be available to download in the Forestry webpage.

Community Engagement:

- The City Legacy Tree program is a program to acknowledge notable trees around the city. The program encourages community involvement by asking the public to nominate city trees. Similarly, the city appoints a "City Tree" every 3 years. Both of these programs highlight community trees and provide an opportunity to educate and engage the community.
- Another opportunity to engage the community is through annual Earth Day and Arbor Day celebrations. Historically, KNOX hosts an Arbor Day celebration with a tree planting event at a school or park. Trees are donated through corporate sponsors. The city has the unique opportunity to demonstrate a joint city/non-profit effort by planting trees in neighborhoods surrounding the Arbor Day celebrations. Arbor Day locations should be coordinated with current priority neighborhoods and park areas.
- Other service-learning projects specifically related to enhancing students' knowledge of trees through planting trees on school grounds and in communities.

Tree Stewardship Program:

- Whether you are a Weed Warrior from Baltimore or a Super Steward from New York City, many cities have successfully increased tree mortality through the development of tree stewardship programs. Generally, a city will offer training and education for program volunteers in their communities which builds public awareness of the value of trees while teaching the fundamentals of trees and tree care. The volunteers then provide reports to the city of completed maintenance, health and condition of the trees, and other neighborhood tree-related issues.
- Reaching out to existing horticultural groups and horticultural enthusiasts in Hartford may be the key to starting Hartford's own tree stewardship program.

Education Actions

More public education is needed to provide informed decision making and support for the development and maintenance of Hartford's urban forest. Effectively communicating the benefits of urban trees to the public is the first step towards understanding how trees affect every aspect of community wellness.

- Educational Opportunities: Studies have found that people do not fully understand the plethora of environmental, health, economic and social benefits that trees provide. For the campaign to be embraced by not only policy makers, but by Hartford residents, tree benefits need to be communicated and reinforced.
  - Harnessing the networking opportunity that public schools offer by focusing on outreach and education efforts through a coordinated school curriculum will expose students and parents to the ample benefits of trees.
  - The Tree Planting Coordinator, along with non-profit groups, should coordinate arboreal education and events with local schools.

- Extended Educational Opportunities: Education regarding the benefits of trees needs to be communicated to residents. Suggestions on how to approach this include:
    - Continue the Legacy Tree Campaign
    - Start a Request a Street Tree Program on the city website
    - Educational door hangers when seeking street tree locations in English and Spanish
    - Educational tags on new trees in English and Spanish
    - Educational Posts on social media
    - Action posts on social media regarding City Tree Maintenance and Tree Planting
    - Outreach to NRZ leaders to communicate the importance of tree plantings
    - Support educational efforts through KNOX or other non-profits
    - Support development of a tree steward program
- Tree Maintenance Education
    - Promoting the use of 311 to notify the city of hazardous tree conditions.
    - Continue social media posts from the City Forester educating the community about Hartford's trees, pests, hazards, and tree care/planting tips.

Stakeholder Outreach Actions

Beyond private residences, the city and non-profits should engage and educate the following stakeholders to develop their own tree planting campaigns on private properties and campuses. When engaging these stakeholders, communicate tree benefit information that is relevant to that stakeholder.

- Churches
- Developers
- Private Schools K-12
- Universities
- Large Institutions
- Hospitals
- Housing Developments
- NRZ Neighborhood Groups

Reforestation Conclusion

As outlined in this section, tree planting opportunities exist everywhere in Hartford. By using the Priority Neighborhood Map, Park Tree Planting Map, and Neighborhood Maps, the city as well as non-profits can coordinate targeted tree-planting campaigns within identified neighborhoods on both public and private property. This works toward a balanced tree canopy between neighborhoods and the overall city-wide goal of 35% canopy cover. Teamwork and effective communication will empower the tree planting community in Hartford to grow and achieve an expanded tree canopy that is balanced throughout the Hartford's neighborhoods.

Scion of the Charter Oak in Bushnell Park

Photo Courtesy of Hartford Office of Sustainability

PART 5
Tree Planting Implementation

5.1

Tree Planting Considerations

Many factors influence successful tree planting. Site evaluations can improve the longevity and health of trees through proper site selection. Avoiding underground and above-ground utilities and locating a tree where the most soil volume is available are two important considerations when selecting the optimal tree planting site. Environmental impacts such as pollution, drought and exposure to radiant heat from streets will also affect the health of a tree. Understanding all site limitations should be considered when selecting the tree that is most suitable for growing conditions.

Tree Planting Budget Considerations

Budgets are greatly affected by warranty, watering and tree sizes.

- Approximately $100/tree is added for every year of watering by a contractor.
- Not only does tree selection matter, but also tree size. The City Forester recommends a minimum of 2-2.5" ball and burlapped (B&B) trees. Opportunities to use smaller sized caliper of 1.75" in a #20 container, in appropriate areas such as parks and private yards in the expanded yard tree planting program, can extend a budget. However, every tree planting site is unique and smaller tree planting sizes should be considered outside the recommended sizes when conditions are warranted.
- Approximately $120/tree is added for every additional year of warranty.
- Interdepartmental coordination regarding sidewalk repairs and installation of structural soil when planting trees in the grass strip between curb and sidewalk can influence tree growth, longevity and cost.

Budgeting for Water

Budgeting for water can greatly impact cost. If the city wants to prioritize the survival of tree plantings, water needs to be addressed. Best management practices recommend providing supplemental watering for the first 2 years, with weekly watering provided May to October. This can be accomplished in various ways as described below.

Resident Watering

Many of Hartford's public trees will be planted in residential neighborhoods. Tree planting campaigns in cities such as New Haven and Durham, North Carolina, require the resident to accept the tree and watering responsibilities before the tree is planted. Continuous outreach and education are needed for community acceptance, and to encourage and remind residents of their watering responsibilities. This offers a no-cost option for the city and encourages a joint effort among the entire community. Resident watering coupled with a stewardship program can further educate and motivate residents to participate in city tree watering and maintenance campaigns.

Example of resident watering. Photo courtesy of ourcityforest.org

Contractor Watering

Assuming a 2 year watering requirement, approximately $200 should be added to each tree cost. Given the reforestation outline in this report, annual contractor-based watering costs would range from $168,400 to $438,000 for watering requirements provided May to October.

City Watering

If the city is responsible for watering trees planted on public property (and BROW) for 2 years, additional staff is needed. On an average work day, it is estimated that one city employee could water approximately 72 trees a day. Assumptions: 5 minutes to refill a gator bag; 2 hours driving, truck refilling, and lunch. Given the reforestation outline in this report, annual watering costs would range from $150,000 to $350,000. Water to be provided May to October. Watering budgets do not include watering trucks. Additional staff would range from four people to 13 people as the planting goals increase. Although city watering is more cost-effective, contractors may void their warranty if they are not granted a watering contract for trees they installed.

New Technology for Watering

New technologies such as the Tree Diaper highlight hopeful results in tree health and survivability in comparison to the traditional Tree Gator watering bag. The Tree Diaper is a product that absorbs and stores water then slowly releases it into the soil over time. The Tree Diaper may be most beneficial for trees planted in park settings, where watering trucks cannot access. A Tree Gator bag costs $28 while the Tree Diaper costs $40. Similarly, a new water polymer called APSA-80 has been shown to dramatically increase water infiltration rates. Adding the water polymer at the first watering will encourage water infiltration deep into the soil.

A Tree Diaper absorbs and stores water from rain events to eliminate weekly watering. Photo courtesy of Nashville Tree Conservation Corps.

Example of weekly watering through the use of Tree Gator watering bags. Water bags need to be refilled at least once a week. Photo courtesy of the Green Thumb 2.0.

Timing of Planting & Tree Mortality

Tree mortality has been shown to decrease with Fall/Winter planting. Fall planting allows time for trees to root in before the hot and dry months, and is the most cost-effective, best-management practice to encourage tree survival. Planning for Fall planting requires tagging trees in the spring and purchasing them in the Fall. Since the city's annual budget is usually set in July with availability of funds in the Spring, Fall tree plantings must be tagged and paid for with the previous year's budget.

Tree Selection

"The Right Tree in the Right Place" is the Arbor Day Foundation mantra for tree planting. This ideology states that tree selection should consider both tree species and site conditions. Biologically, a tree must be able to withstand the conditions it is planted in. Sun exposure, soil type, drainage, salt exposure, and growing space above and below ground all must be considered. Similarly, the promotion of biodiversity encourages the selection of a wide range of trees. A diverse forest is not as susceptible to complete decimation from disease and pest infestations.

The Tree Resource Management Plan acknowledges the biodiversity of Hartford's Right-of-Way (ROW) and parks in their 10-20-30 population analysis. This report notes the abundance of Maples and Oaks, and recommends that their quantities should be limited in future plantings. The City Forester and The Tree Advisory Commission developed planting lists to encourage biodiversity and selection of the right tree for the right place. The City Forester developed the Hartford Tree Recommendations (Appendix N) which is an extensive tree list that considers various tolerances, conditions and disease /pest concerns. Similarly, the Tree Advisory Commission developed the 2018-2019 Hartford Tree Planting Plan (Appendix O) that provides ten recommended trees for each size range (small, medium and large). Tree selection to promote wildlife should also be taken into consideration

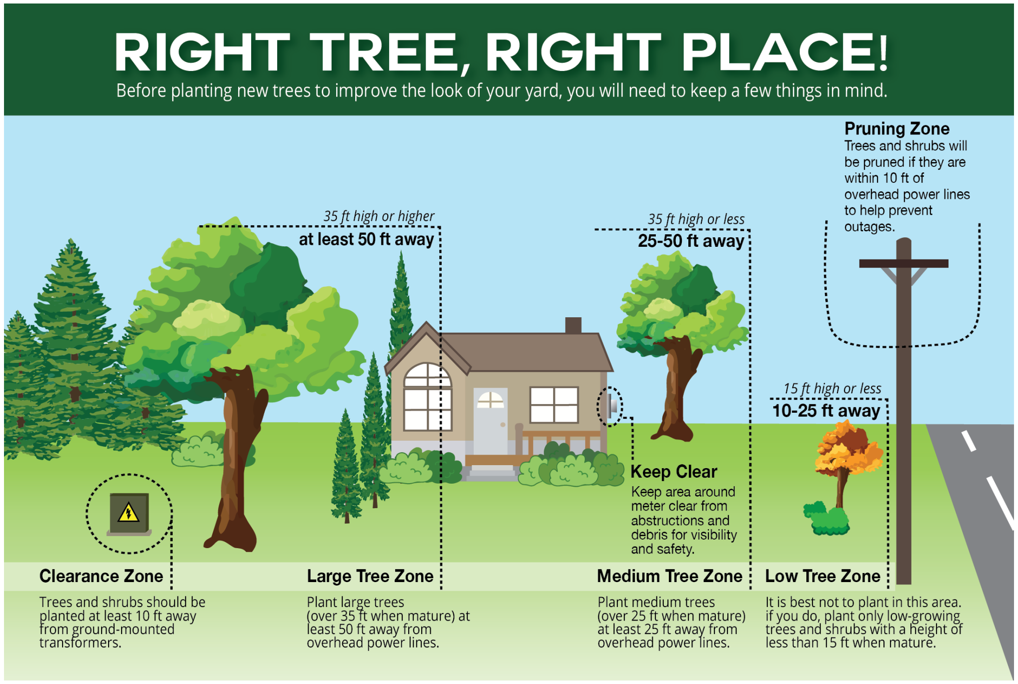


Photo courtesy of Carthage Water & Electric Plant

The 10-20-30 Rule is a best management practice guideline that suggests an urban population should include no more than 10% of any species, 20% of any one genus, or 30% of any family.

This philosophy helps reduce the risk of forest decimation due to an infestation of pest or disease.

Based on the 2019 Davey Tree Inventory, Hartford's inventoried existing tree canopy exceed the recommended 30% family in Maples. Consequently, to encourage diversity, the Tree Advisory Commission does not include Maples at this time on their recommended tree list.

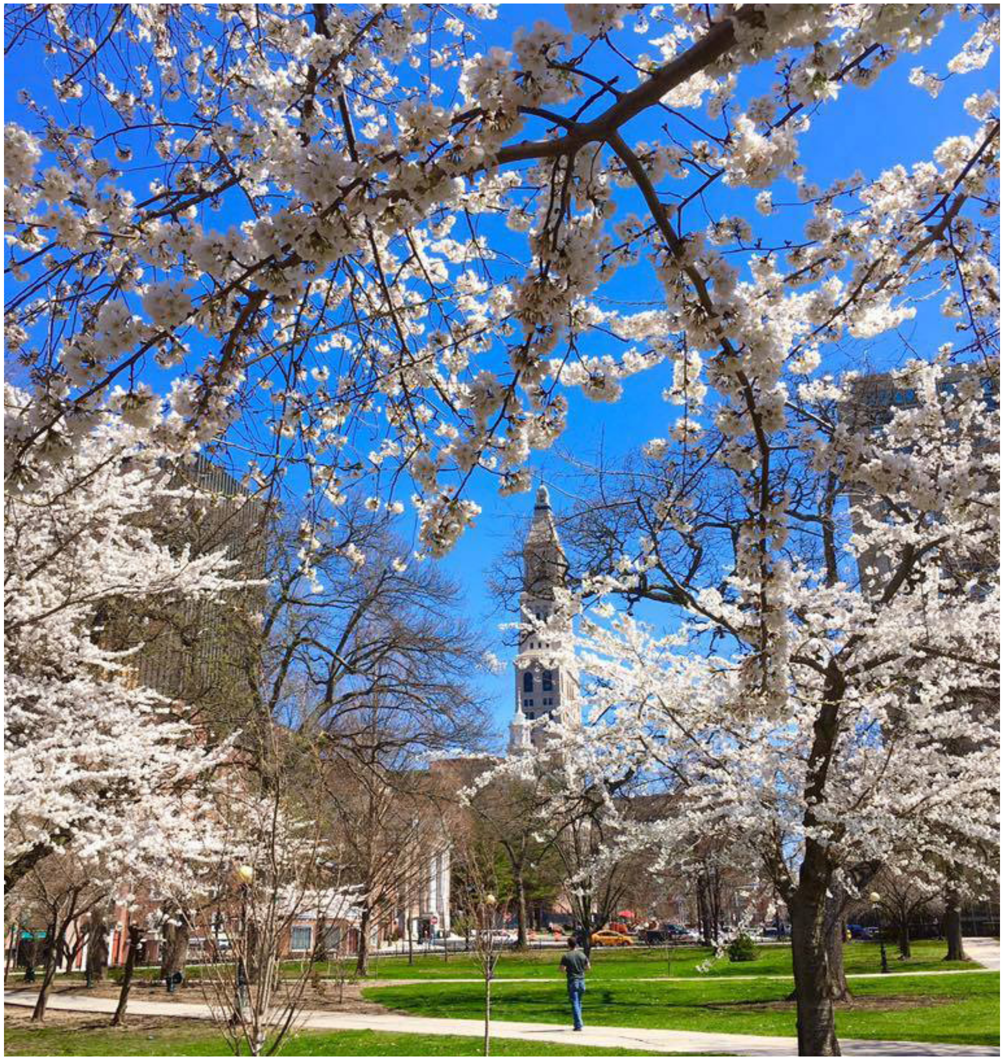


Photo courtesy Bushnell Park Foundation Facebook Group.

Growing Space

Soil volume directly relates to tree size and life expectancy. Growing space above ground and below ground needs to be considered when locating a tree. The space offering the most soil volume should be prioritized. Trees in restricted soil volume may survive but will never reach a mature size. It is worth noting that street trees planted in an urban environment, in limited soil volumes, have an average life span of 7-10 years. Refer to Part 2: Benefits of Soil Volume for more information.

Budgeting for Soil Volume

When a proposed tree is to be located in the grass median between a curb and sidewalk, further coordination regarding soil volume needs to be considered. Adequate soil volume directly relates to tree growth and mortality. Use of structural soil, structural cells or suspended sidewalks should be employed when locating a new tree in a grass median if the planting strip is less than 3' wide. This will increase the cost of planting in these areas, however, larger trees provide more environmental benefits over time and replacement costs are reduced. Similar locations in BROW should be evaluated for tree location alternatives as generally there is more soil volume available in these areas.

Planting Recommendations

The Connecticut Tree Owner's Manual is a reference guide that addresses tree selection, tree installation and tree maintenance (Refer to Appendix P for the entire CT Tree Owner's Manual).

Below are the minimum planting requirements:

Time of Planting:

- Deciduous Trees: (Spring) March 15 to May 15 or (Fall- Preferred) September 15 to December 15
- Evergreen Trees: (Spring) March 15 to May 15 or (Fall-Preferred) September 1 to November 15

Site Selection: Assumed on public land, first obtain a tree planting permit from the City Forester, then follow the below recommendations.

- Confirm no underground utilities.

Planting Area Size Requirements:

- Tree Well Size: 5'Wx10'Lx3'D minimum (150 cu ft of soil).
- Follow Recommend Soil Volumes and Permeable Area recommendations per, Figure 6.4-D, from the Zoning Regulations. Below is a modified chart with adjusted soil depth to the recommended 3' depth.
    - Use structural cells (recommended), structural soil, suspended walks in combination with permeable paving to achieve required soil volumes and permeable area.

Required Soil Volumes and Permeable Area (rev. 2020)

Tree Size	Soil Volume	Soil Surface Area with 3' Soil Depth	Permeable Surface Area Requirement
Very Small	217 cu. ft.	72 sf. (approx. 8.5' x 8.5')	25 sf. (5' x 5')
Small	867 cu. ft.	294 sf. (approx. 17' x 17')	100 sf. (10' x 10')
Medium	3,468 cu. ft.	1141 sf. (approx. 34' x 34')	225 sf. (15' x 15')
Large	7,500 cu. ft.	2681 sf. (approx. 50' x 50'	400 sf. (20' x20')

Species Selection:

- Analyze sun exposure, salt exposure, wind exposure, available growing space, aboveground utilities, and hardiness zone.
- Select a tree that meets all exposure requirements from the 2018-2019 Hartford Tree Planting Plan List (Hartford Tree Advisory Commission) or Hartford's Recommended Tree List.
- If planting in a TreeKeeper identified location, refer to noted TreeKeeper sizes (small, medium, large) as this refers to the suggested tree size.

Tree Size: 2-2.5" minimum caliper; 5' minimum, 6' preferred branching height for trees in a sidewalk or adjacent.

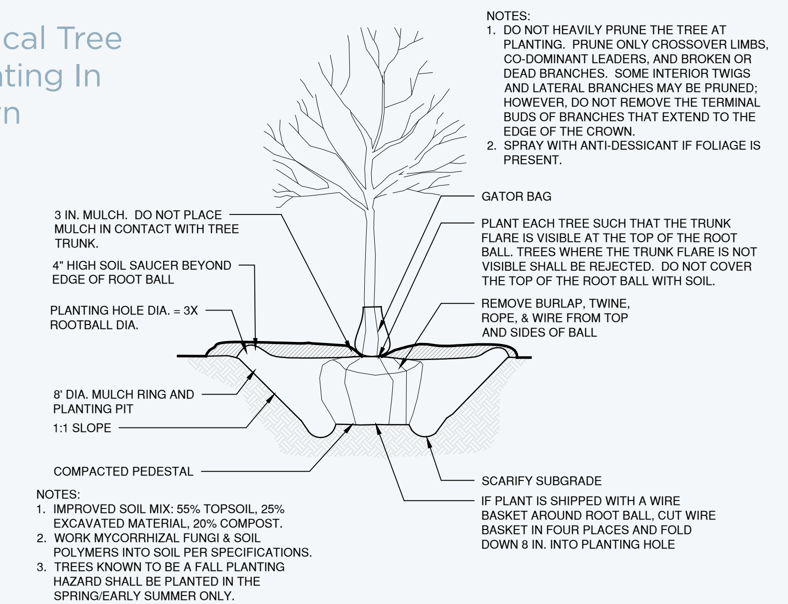
Tree Selection: Purchase a well-shaped, fully branched, healthy, vigorous tree that's free of disease, pests, eggs, larvae, and defects such as knots, sun scald, injuries, abrasions, and disfigurement.

Tree Planting: Refer to the Connecticut Tree Owner's Manual in Appendix P for full recommendations.

Minimum required planting recommendations:

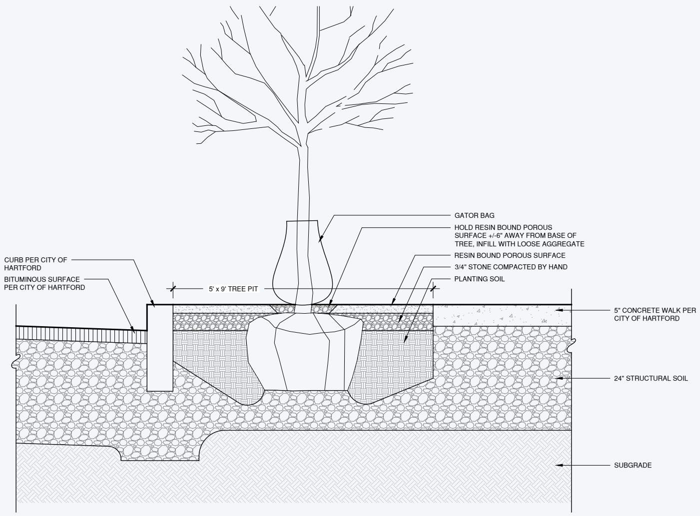
- Remove all tags, twine or wrapping that is on the tree
- Dig width of the hole 3 times the size of the root ball
- Dig depth of the hole to match the depth of the root ball
- Locate trunk flare. Remove soil if necessary.
  - Balled and Burlap: Cut twine, and unfold burlap
- Containerized Trees: Remove entire container, expose trunk flare and loosen roots if they are matted from the container.
- Set plant plumb and in center of planting pit or trench with root flare 2 inches above adjacent finish grades.
- After placing some backfill around the root ball to stabilize the plant, carefully cut and remove burlap, rope, and wire baskets from tops of root balls and sides, but do not remove from under root balls. Do not use planting stock if root ball is cracked or broken before or during the planting operation.
- Backfill around root ball in layers, tamping to settle soil and eliminate voids and air pockets. When planting pit is approximately one-half filled, water thoroughly before placing remainder of backfill. Repeat watering until no more water is absorbed.
- Continue backfilling process. Water again after placing and tamping final layer of soil.

Typical Tree Planting In Lawn



LOVE HARTFORD GREEN HARTFORD

Tree Planting with Structural Soil



Tree Planting With Adjacent Structural Cells Under Walk

KEY PLAN

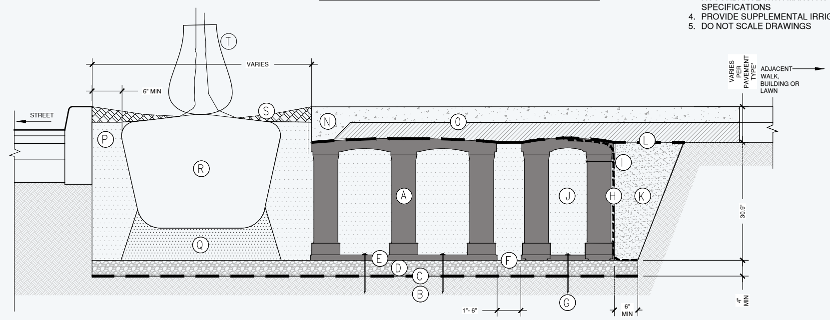
- (A) STRUCTURAL CELL SYSTEM (DECK, BASE, AND POSTS)
- (B) SUBGRADE, COMPACTED
- (C) GEOTEXTILE FABRIC, PLACED ABOVE SUBGRADE
- (D) 4" MIN AGGREGATE SUB BASE, COMPACTED TO 95% PROCTOR
- (E) STRUCTURAL CELL BASE SLOPE, 10% MAX
- (F) 1" TO 6" SPACING BETWEEN STRUCUTRAL CELLS AT BASE
- (G) ANCHORING SPIKES, CONTACT DEEPROOT FOR ALTERNATIVE
- (H) GEOGRID, WRAPPED AROUND PERIMETER OF SYSTEM, WITH 6" TOE (OUTWARD FROM BASE) AND 12" EXCESS (OVER TOP OF DECK)
- (I) CABLE TIE, ATTACHING GEOGRID TO SILVA CELL AT BASE OF UPPER LEG FLARE, AS NEEDED
- (J) PLANTING SOIL, PER PROJECT SPECIFICATIONS, PLACED IN LIFTS AND WALK-IN COMPACTED TO 75-85% PROCTOR
- (K) COMPACTED BACKFILL, PER PROJECT SPECIFICATIONS
- (L) GEOTEXTILE FABRIC TO EDGE OF EXCAVATION
- (M) RIBBON CURB AT TREE OPENING (TO BE USED WITH PAVERS OR ASPHALT)
- (N) THICKENED EDGE AT TREE OPENING (TO BE USED WITH CONCRETE)
- (O) PAVEMENT AND AGGREGATE BASE PER PROJECT *
- (P) DEEPROOT ROOT BARRIER, 12" OR 18", DEPTH DETERMINED BY THICKNESS OF PAVEMENT SECTION, INSTALL DIRECTLY ADJACENT TO CONCRETE EDGE RESTRAINT
- (Q) PLANTING SOIL BELOW ROOT BALL, COMPACTED WELL TO PREVENT SETTLING
- (R) ROOT BALL
- (S) TREE OPENING TREATMENT, PER PROJECT SPECIFICATIONS
- (T) GATOR BAG

*MINIMUM PAVEMENT PROFILE OPTIONS TO MEET H-20 LOADING

PAVEMENT	+ AGGREGATE BASE COURSE
4" CONCRETE	+ 4" AGGREGATE
3" PAVER	+ 12" AGGREGATE
4" ASPHALT	+ 12" AGGREGATE
2.6" PAVER	+ 5" CONCRETE

NOTES

1. **SEVERAL STRUCUTRAL CELL PRODUCTS ARE AVAILABLE: SILVA CELLS AND STRATACELLS ARE TO NAME TWO.**
2. EXCAVATION SHALL BE DONE IN ACCORDANCE WITH ALL APPLICABLE HEALTH AND SAFETY REGULATIONS
3. INSTALLATION TO BE COMPLETED IN ACCORDANCE WITH MANUFACTURER'S SPECIFICATIONS
4. PROVIDE SUPPLEMENTAL IRRIGATION
5. DO NOT SCALE DRAWINGS



5.2

Funding Trees

Expanding and preserving the city's tree canopy is not a 1- or 2-year campaign. To be effective, it is a multi-year program that cannot be eliminated or reduced in scope or budget from year to year. For this reason, the success of the tree canopy management program relies on funds that are constant and dependable. Most of the funding should come from the Capital Improvements Plan to guarantee program longevity and success. Understandably, Hartford's financial challenges add significant constraints on immediate funding through the CIP.

The Nature Conservancy states the biggest reason for urban tree canopy decline is disinvestment.

> A study in California by U.S. Forest Service and University of California, Davis researchers found that for every $1 spent in California cities on tree planting and maintenance, there were $5.82 in benefits."
>
> *– The Nature Conservancy, Funding Trees for Health*

Below are prioritized funding goals.

Immediate City Funding Goals:

- Additional Forestry Staff:
  - Tree Maintenance Crew with (2) additional 4-person full-time crews. Total of 12 people.
  - Tree Planting Coordinator I, Tree Planting Coordinator II and Administrative Assistant.
- Tree Maintenance: Fund tree removals and pruning as outlined in the Tree Resource Management Plan by Davey Resource Group.
- Tree Planting: Fund 1,500 new trees plus tree replacements to maintain the existing 25% tree canopy.

Long-Term City Funding Goals:

- Forestry Staff: Continue to fund the City Forester, Tree Planting Coordinator I, Tree Planting Coordinator II, Administrative Assistant and a 12-person forestry crew.
- Tree Maintenance: Fund annual tree removals and pruning as outlined in the Tree Resource Management Plan by Davey Resource Group.
- Tree Planting: Fund 3,000 new trees plus replacements to expand the tree canopy to 35%.

City Funding Actions:

- Incorporate tree planting and tree maintenance costs into CIP budget.
- Expand the collection of fines per Zoning Regulations.
- Per Sec. 28-164.b1 of the Tree Ordinance, up to 5% of the income from the annual Hartford Park's Trust Fund can be directed to the tree fund. Ensure this is requested and deposited annually into the Hartford Tree Fund.
- Seek supplemental funding sources.

Funding Opportunities

To sustain and expand urban tree canopy, many cities have dedicated and enhanced funding resources for urban forestry. Below are funding approaches the City of Hartford should consider to fund their tree canopy campaign.

City Budgets, Taxes, Special Assessments and Special Tax Districts

- Milwaukee, Wisconsin includes tree costs in their Right-Of-Way Improvement budget.
- San Francisco utilizes Tax Increment Financing, Landscape and Lighting Assessment Districts and Parcel Tax.
- Cincinnati, Ohio has a state-authorized special assessment on all properties abutting the public Right-of-Way.
- St. Louis, Illinois funds tree planting through a combination of property and sales tax transfer.
- Burlingame, California uses a portion its gas tax.
- Milwaukee, Wisconsin increased stormwater fees to help fund tree plantings.

Supplemental Funding Sources:

- **Sponsors: Ex. TD Bank is sponsoring $1.5 million to TreePhilly**
- US Forestry Services
- US EPA (Urban Waters Small Grants, Environmental Justice and 319 Grants)
- Private Donations
- Corporate Donations
- Neighborhood Groups Donations
- Adopt A Tree
- Memorial/Honor Tree
- Tree Society Memberships
- Creative Funding:
    - City Forest Credits: City Forest Credits pilot programs are being evaluated in Austin, Texas and Seattle, Washington. The program allows companies to engage in carbon trading techniques that include funding planting of trees.
    - Linking Tree Benefits to HealthCare Costs: Studies are being done to quantify benefits trees have on physical and mental health and ultimately healthcare costs. The Nature Conservancy reports in their How Cities can Harness the Public Health Benefits of Urban Trees that urban trees can remove enough particulate matter to reduce annual health impacts by amounts ranging from $1.1 million to $60.1 million. Similarly, the Nature Conservancy also documents a research team that analyzed the effects that a mature tree buffer located between a school and a busy road had on the particulate matter. They found that the particulate matter was 60% lower behind the planted buffer.

Establishing funding for the tree maintenance and planting within the Capital Improvements Plan and other funding strategies is essential in guaranteeing the longevity and growth of the urban tree canopy program.

5.3

Implementation Strategies

Annual tree planting goals have been established to sustain and expand Hartford's urban tree canopy to 35%. There are three possible methods in which to accomplish city-wide tree planting implementation.

1) Contractor-Based

2) City-Based

3) Joint Partnership between the municipality and one or more non-profits

Each approach has varying constraints, opportunities and associated costs. The city needs to select and fund a method of implementation. This report recommends a joint partnership between the city and one or more non-profits as a cost-effective approach that illustrates a team mentality and has proven successful for other cities. This partnership would consist of shared costs. The city would fund 80% of the tree planting costs, while the remaining 20% is provided by a non-profit through grants and donations. This approach engages community involvement and promotes the tree planting program at all levels of the community.

Keney Park in the Autumn. Photo from Keney Park Golf Course Facebook Group

The implementation strategies are as follows.

Tree Planting Strategy #1 – Traditional Contractor Pricing

Based on experience, the cost for a contractor to install a tree, mulch, provide a gator bag, and a 2-year warranty are noted below. Pricing does not include weekly watering. Watering May through October for two years would add $200. Engaging residents to accept watering trees in the ROW and BROW is the most cost-effective method.

- 2-2.5" caliper = $800.00
- 20 container @ 1.75" caliper = $620.00

Opportunities:

- Eliminates overhead for additional City staff
- Provides 2-year warranty
- Option to add contractor-based watering for additional $200/ tree

Constraints:

- Cost

Tree Planting Strategy #2 – City Planting

This strategy assumes that the city will fund all costs and plant trees using city employees.

Costs:

$500/tree; includes a 2-2.5" caliper tree and labor

Description	Cost
2-2.5" Tree	$300.00
Two Employees to plant tree at 1 hour each at $40.00/hr	$80.00
Two employees to transport tree at .5 hours each at $40.00/hr	$40.00
Gator Bag, Mulch, Fertilizer, etc.	$80.00
Total	**$500.00**

Opportunities:

- Cost saving opportunities with the elimination of contractor's overhead and profit
    - Assumed 1,500 tree plantings = $750,000.00
    - City could save approximately $300.00/ tree when compared to contractor rates. This equates to $450,000.00 in possible savings per year.

Constraints:

- Budgeting for watering is not included. ROW/ BROW tree plantings are reliant on resident acceptance of tree, as well as acceptance of tree stewardship responsibilities which include weekly watering, weeding and recommended mulching.
- Budgets to accommodate city watering are noted earlier in this report under Tree Planting Considerations.
- Requires additional salaried staff: assume one four-person crew just for tree planting. This would grow to two four-person crews as tree planting goals increase.
- No warranty/replacement.
- Equipment (assumed to be minimal as the size of the proposed plantings are small). Efficiency could be improved through the use of a skid steer with tree hole digging attachment.

Tree Planting Strategy #3 (Recommended) – Joint Partnership Between the City and One or More Non-profits

Costs:

- Shared cost program based on similar City of New Haven Tree Planting Program with URI. In New Haven, the city provides 75% of the tree planting cost and the non-profit contributes 25%. The non-profit contribution is provided by grants and donations. Due to the proposed scale of the proposed Hartford program, we estimate an 80% / 20% shared cost relationship is reasonable.
    - Material cost of planting a 2.5" caliper tree = $800
        - $650 (80%) total recommended city cost; $150 (20%) recommended non-profit cost
            - 1,500 @ $650=$975,000
        - $225,000 in possible savings when compared to a contractor

Opportunities:

- Portrays a "teamwork" mentality to achieve the tree canopy goals between the city and non-profit.
- Eliminates overhead for additional city staff.
- Provides two-year warranty.
- Includes additional outreach and educational opportunities through a partnership with the non-profit.
- More cost-effective than hiring a contractor.

Constraints:

- Dependent on grant funds.
- Budgeting for watering is not included. ROW/BROW tree plantings are reliant on resident acceptance of tree, as well as acceptance of tree stewardship responsibilities – weekly watering, weeding and recommended mulching at a minimum.
- Budgets to accommodate watering are noted earlier in this report under Tree Planting Considerations.
- Requires coordination and communication between the Tree Planting Coordinator and the non-profit.

Cucumber Magnolia. Photo from Capital Forest Facebook Groupaa

Tree Planting Diagrams

Below are illustrations that shozw varying scenarios of how tree plantings can transform a neighborhood.

Existing conditions

Proposed ROW Tree Planting on Lisbon Street illustrate tree planting opportunities in a neighborhood. Trees would mitigate the heat island effect, help manage stormwater, and transform the streetscape into a walkable and inviting space.

Existing conditions

Proposed BROW Tree Plantings offer more soil volume for the tree to grow in. This will allow the tree to grow to full potential and to provide maximum benefits for the community

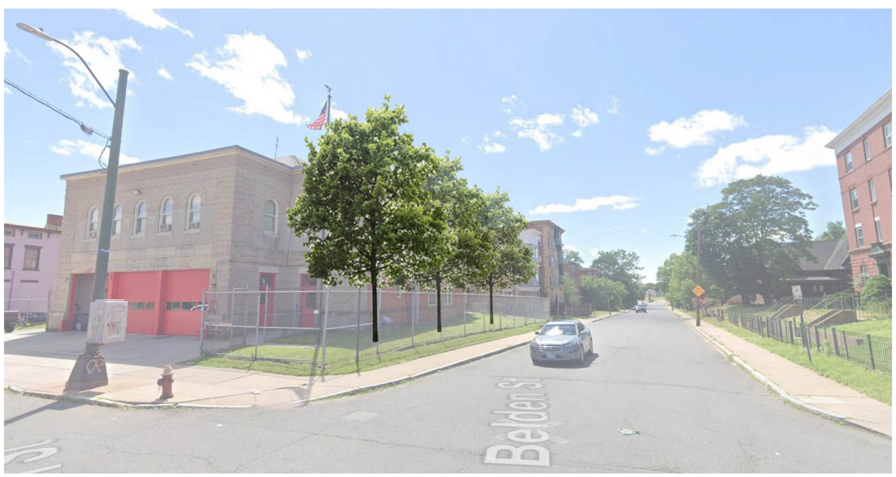
Diagram of Tree Planting of Vacant Impervious Lot (Huyshope Avenue)

Existing Aerial

Proposed Parking Lot with Tree Plantings per the Colt Park Master Plan. Trees in parking lots absorb stormwater and cools pavement.

Diagram of Tree Planting on other Public Land (Firehouse)

Existing Firehouse located at 1515 Main Street



Proposed Firehouse Tree Planting

Diagram of Streetscape Tree Planting

Existing Ann Uccello Street

Proposed Streetscape on Ann Uccello Street

PART 6
Management of the Urban Forest

6.1 Tree Resource Management Plan Summary

To sustain and expand Hartford's tree canopy, a two-point is recommended: 1) A proactive tree maintenance program and 2) A tree planting program.

Previous sections in this report discussed the recommended tree planting program. The Tree Resource Management Plan provided by Davey Resource Group is a sister document to this report that documents tree management in depth. Together, the reports recommend a collaborative effort to protect and expand Hartford's urban forest to 35% tree canopy in 50 years. Refer to Appendix A for the entire Tree Resource Management Report.

Tree Resource Management Plan Summary

Davey Resource Group (DRG) provides a recommended 3-year management plan for Hartford's inventoried ROW and Park trees. The report details the structure and composition of the inventoried trees, identifies benefits, provides a 3-year management plan and a storm preparedness plan. Refer to Appendix A for the complete report.

The 3-year management plan identifies removals, priority pruning, routine pruning, young tree training, and tree planting. Below is an overview of the recommended management plan. Excluding planting, the management report calls for approximately $1.9 million in funding for years 1 and 2. $1.5 million for year 3. Once hazardous removals are addressed the annual budget stabilizes at $1 million. The recommendations prioritize removals and pruning according to risk ratings to ensure community safety. As identified by DRG, "the recommended proactive maintenance will improve the overall condition of the inventoried trees and may eventually reduce program costs." Once the outlined pruning and removals are accomplished, the forestry crew should follow the Tree Maintenance Priority Map for their 3-year neighborhood maintenance cycles.

Removal
- Total = 1,716 trees
- Extreme Risk = 6 trees
- Moderate Risk = 296 trees
- Low Risk = 1,348
- Stumps = 1,238

Priority Pruning
- Total = 863 trees
- Extreme Risk = 2 trees
- High Risk = 84 trees
- Moderate Risk = 777

Routine Pruning Cycle
- Total = 11,445 trees
- Number of trees in cycle each year= approximately 3,815

Young Tree Training Cycle
- Total = 4,738 trees
- Number of trees in cycle each year= at least 1,579

Tree Planting
- Number of trees in cycle each year= at least 2,197

Year 1 — $3,579,918
- 188 Extreme, High, and Moderate Risk Removals
- 433 Extreme, High, and Moderate Risk Prunes
- 446 Low Risk Removals
- 412 Stump Removals
- RP Cycle: 1/3 of Public Trees Cleaned
- YTT Cycle: 1,579 Trees
- 2,198 Trees Recommended for Planting and Follou-Up Care
- Newly Found Priority Tree Work (Removal or Pruning): Costs TBD

Year 2 — $3,569,195
- 180 Moderate Risk Removals
- 430 Moderate Risk Prunes
- 451 Low Risk Removals
- RP Cycle: 1/3 of Public Trees Cleaned
- YTT Cycle: 1,579 Trees
- 2,198 Trees Recommended for Planting and Follup-Up Care
- Newly Found Priority Tree Work (Removal or Pruning): Costs TBD

Year 3 — $3,170,270
- 180 Moderate Risk Removals
- 430 Moderate Risk Prunes
- 451 Low Risk Removals
- RP Cycle: 1/3 of Public Trees Cleaned
- YTT Cycle: 1,579 Trees
- 2,198 Trees Recommended for Planting and Follup-Up Care
- Newly Found Priority Tree Work (Removal or Pruning): Costs TBD

Year 4 — $2,696,045
- RP Cycle: 1/3 of Public Trees Cleaned
- YTT Cycle: 1,579 Trees
- 2,197 Trees Recommended for Planting and Follow-Up Care
- Newly Found Priority Tree Work (Removal or Pruning): Costs TBD

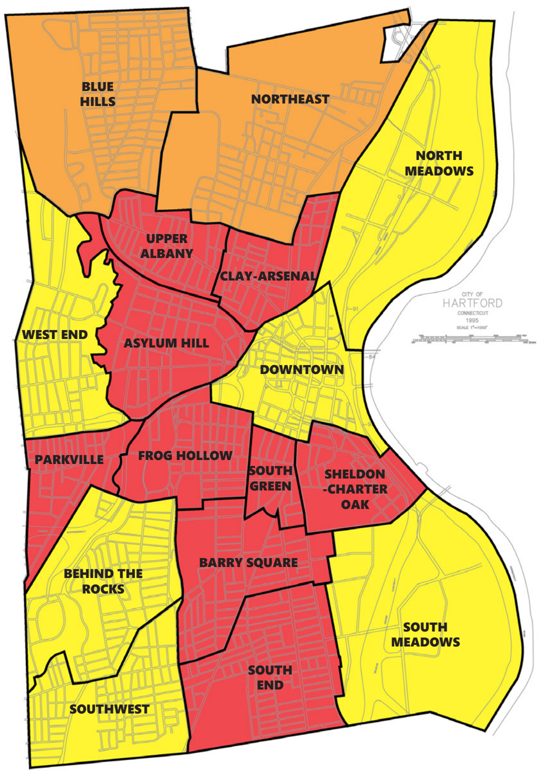
Year 5 — $2,696,355
- RP Cycle: 1/3 of Public Trees Cleaned
- YTT Cycle: 1,579 Trees
- 2,197 Trees Recommended for Planting and Follow-Up Care
- Newly Found Priority Tree Work (Removal or Pruning): Costs TBD

Working along with the City Forester, a Tree Maintenance Priority Map was developed that divides the neighborhoods into a three-year cyclical maintenance plan.

Tree Maintenance Priority Map

3 Year Cycle

- Year 1: Red Area (Planting Priority Areas 1-2)
- Year 2: Orange Area (Planting Priority Area 3)
- Year 3: Yellow Area (Planting Priority Areas 4-5)



6.2

Wood Waste Utilization

Existing Wood Utilization Summary

As the City of Hartford transitions from a contractor-based tree maintenance program to city crew-based tree maintenance program, the city has the opportunity to refine its wood waste utilization program into one that operates in a sustainable and cost-effective manner. There are opportunities to reduce expenses through program development and opportunities to promote various community programs.

Wood waste is generated from tree removals, tree pruning, resident curb-side pick-up and resident drop-off. The city produce its own wood chips. They utilize them in community gardens, park trails, park wood lines and for erosion control. However, they currently rely on an outside contractor and their tub grinder equipment to produce double ground mulch. Mulch is generated from the city's wood waste. Rental equipment that is required to process mulch has an annual cost of $82,000.

In efforts to redirect wood waste into useful materials, a log milling facility was opened in 2019. The milling facility is a joint effort between the City of Hartford and the Keney Park Sustainability Project (KPSP). Currently, the city provides usable logs that are milled into boards, constructed into site furnishings, and sold to the city at reduced rates. However, the amount of production is limited by the need to subcontract a mill. Currently KPSP produces approximately 8,000 board feet a season with the mill being rented two or three times a season. Currently, the city seeks the following site furnishings: picnic tables, signs, kiosks, benches and fencing.

Similarly, a possible joint effort between the city and Open Hearth offers a collaborative opportunity in firewood production. Open Hearth is a Hartford-based non-profit that provides workforce opportunities for homeless men as well as shelter, healthcare, and access to

Wood Waste Utilization Summary	
Quantity	**Description**
176	Trees Removed in 2019
140	Trees Pruned in 2019
2,922 tons	Tons of wood chips produced
1,381 tons (1,541 tons hauled away)	Tons of wood chips left on site for use
25 tons	Tons of mulch produced
$81,208	Annual Cost of mulch processing
$1,500-$1,800 paid through DEEP Grant	Mill Rental
7,000 to 8,000 board feet/ year	Saw Log production
$10,500 – 12,000/ year @ $1.50/ boardfoot	Current Saw Log Profits
Projected Wood Waste Summary (assuming similar quantity of trees removed; 175)	
Approximately 1,400 tons	Tons of wood chips produced
Approximately 1,500 tons	Tons of mulch produced
35,000 board feet/ year	Projected Saw Log production
$87,500 – 113,000/ year @$2.35 to $2.50/ boardfoot	Projected Saw Log Profits
50	Cords of firewood

continued education. The city could deliver excess logs that can be used by Open Hearth for firewood production at the Open Hearth facility.

Wood Waste Utilization Goals:

To expand the management of Hartford's wood waste utilization practices in a sustainable and cost-effective manner while capitalizing on opportunities and best management strategies related to urban wood utilization.

Wood Waste Utilization Actions:

- Promote overall sustainable practices and tree stewardship.
- Reuse of wood waste through the development of a city mulch program.
- Generate revenue through the production of city mulch.
- Increase reuse of city wood resources through continued development of the Keney Park Sustainability Project log milling program.
- Reduce city expenses through the purchase of milled boards and site furnishings at a reduced cost from KPSP.
- Reduce overall wood waste through the support of the Open Hearth firewood program.

Scarlett Oak Removal - Logs to KPSP and the rest mulch. Photo courtesy of Capital Forests Facebook Group.

Opportunity Summary

- Potential revenue through the production of city mulch. Excess mulch can be purchased by residents.
- Expense reduction through the production of city mulch through the elimination of contracted tub grinder. Equipment costs pay for themselves after year 2.
- Continue collaboration with KPSP.
- Potential for KPSP to increase board production to 35,000 board feet with the purchase of a portable mill.
- City expense reduction through the continued purchase of boards and site furnishings through Keney Park Sustainability Project at reduced rates.
- A possible collaboration between Open Hearth and city for firewood program.
- Educational opportunity to use the log milling site to educate and train the workforce regarding forestry wood management.

Co-benefiting Community Impacts

Keney Park Sustainability Project

Outreach, education and workforce development through Keney Park Sustainability Project offers invaluable exposure and education to forestry practices to the youth of Hartford. This program processes logs into boards or site furnishings that the city is able to buy back at a reduced price.

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Wood Waste Management Costs

Many of the goals associated with improving Hartford's wood waste management practices require additional staff and equipment. Below are costs associated with improved practices.

#1 Mulching Operations Costs

Cost	Description
$75,000	Morbark 1100 Tub Grinder
$75-$100,000	Mid-size Payloader
$100,800	2-people/seasonal city staff
*Note current annual cost to produce mulch is $82,000 annually	
Profit	
$92,460	Potential Mulch Profit @ $20/cubic yard
*assumed 1,500 tons of excess mulch; 4623 cubic yards of mulch	

#2 Milling Operations Costs

Cost	Description
$72,000 (KPSP to seek grant funding to pur-chase mill)	TimberKing 2500
$15,000 (1-person/ full-time/seasonal)	KPSP Staff
(*Note existing cost of mill rental is $1,500-1,800 and paid through a Deep grant)	
Profit	
$2.50-3.25/ board foot	Price per board foot
$87,500 – 113,000	Projected Profit
$65,000 – 89,000	Projected Net Profit (in-cludes salary)

#3 Milled Board Storage Shelter

Cost	Description
$20,000	25'x45' Milled Board Storage Shelter

Open Hearth is a Hartford-based non-profit program that provides workforce opportunities for homeless men as well as shelter, healthcare, and access to continued education. Their current wood program educates, trains and provides real-world work experience regarding fire wood management. The city has an opportunity to collaborate with this program by providing tree logs that can be used for firewood through the Open Hearth program. The Forestry Department projects that they could deliver enough wood for 50 cords of firewood production annually.

Local Artisans are offered specialty wood for purchase at a reduced rate for use on their own projects. Similarly, the city may contract a local artisan to provide a custom piece for a special city project.

Conclusion

A proactive maintenance plan to preserve mature trees, accompanied by a robust tree planting and tree care program will allow urban wood waste strategies to be sustained by the overall improved health of the city's forest. Proceeding with sustainable best management practices, the city has the opportunity to reduce expenses, reuse wood waste, and possibly generate revenue. More so, the city has opportunities to support programs that are invested in revitalizing the Hartford community through workforce development.

Photo courtesy of Capital Forests Facebook Group

6.3 Pest and Disease Management

Summary

Trees provide numerous benefits including stormwater runoff reduction, energy conservation, air pollution reduction, carbon sequestration and storage, and a host of additional social and human health benefits. Healthy urban trees provide economic development and support livable communities that foster physical and psychological health, creating a greater sense of place.

However, trees in Hartford are at risk from the introduction and rapid spread of invasive forest pests and diseases. Continued loss of major forest species is the greatest single danger to our urban forests. Pests and diseases introduced from overseas threaten our trees because native species lack effective defense mechanisms and beneficial biological organisms to combat foreign pests and diseases.

Proactive maintenance to keep trees healthy is the best way to protect the existing mature canopy. However, despite best efforts, trees will be weakened over time from climate change and will become more susceptible to disease and pests.

Similarly, invasive pests have infected our urban forest and future infestations will remain a threat. Proactive management coupled with community education should both be employed.

Pest and Disease Management Goal

Effectively treat or remove public trees from the city's forest in response to pests and disease detection. Communicate early detection indicators to the public so they can monitor private trees.

Pest and Disease Management Action

Incorporate best management practices into proactive maintenance cycle in response to identified pests and diseases.

Summary of Threats

Tree inventory of pests and diseases affecting Hartford urban forest as inventoried by Davey Resource Group (DRG), identifies 74 trees for immediate removal.

Tree Report Disease/Pest and Condition Comparison	Good	Fair	Poor	Dead	Totals
Emerald Ash Borer (Agrilus planipennis)	1	56	55	1	113
Hemlock Woolly Adelgid (Adelges tsugae)	3	15	16		34
Gypsy Moth (Lymantria dispar)	3	1			4
Dutch Elm Disease (Ophiostoma ulmi)		1	2		3
	7	73	73	1	156
Total Year One Removals = 74					

Emerald Ash Borer

Emerald ash borer (EAB), Agrilus planipennis (Fairmaire):

- A small, green (jeweled), wood boring beetle
- Adult EABs are relatively slender and between 0.3 to 0.55 inches in length
- Feed on ash species (Fraxinus spp.): White Ash (Fraxinus Americana), Green Ash (Fraxinus pennsylvanica, and European Ash (Fraxinus excelsior)
- The adults feed for about two weeks before they mate and the females begin laying eggs.
- Females lay eggs in bark crevices on ash trees, and larvae feed underneath the bark of ash trees to emerge as adults in one to two years.

Pest Detection

Scientific Name	Common Name	Number of Trees	Percent
Agrilus planipennis	emerald ash borer	114	0.6%
Adelges tsugae	hemlock woolly adelgid	34	0.2%
Lymantria dispar dispar	gypsy moth	4	<0.1%
Ophiostoma ulmi	Dutch elm disease	3	<0.1%
Anoplophora glabripennis	Asian longhorned beetle	0	0.0%
Dendroctonus frontalis	southern pine beetle	0	0.0%
Dendroctonus terebrans	black turpentine beetle	0	0.0%
Dendroctonus valens	red turpentine beetle	0	0.0%
Lycorma delicatula	spotted lanternfly	0	0.0%
Lymantria mathura	rosy gypsy moth	0	0.0%
Operophtera brumata	winter moth	0	0.0%
Pityophthorus julandis	walnut twig beetle	0	0.0%
Sirex noctilio	sirex woodwasp	0	0.0%
Tomicus piniperda	pine shoot beetle	0	0.0%
Bretziella fagacearum	oak wilt	0	0.0%
Geosmithia morbida	thousand cankers disease	0	0.0%
Phytophthora orana	sudden oak death	0	0.0%
none		18,636	99.2%
Total		**18,791**	**100.0%**

Pest Detection Chart provided by DRG Tree Resource Management Plan 2020. This chart identifies all the pests and diseases that were both found and not found during the tree inventory.

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Signs and Symptoms

Ash trees tend to die within 2-3 years after becoming infested with EAB, while stands of trees often succumb within 8 years of the insect entering the stand. Warning signs that an ash tree may be infested include:

- The entire upper crown of the tree is thinning or dead.
- The presence of a D-shaped exit hole in the bark.
- Numerous shoots from the lower part of the trunk or the root flare.
- In heavily infested trees, one can scrape back the bark to reveal the S-shaped tunnels characteristic of the burrowing EAB larvae.
- The presence of woodpecker activity feeding on the larvae. This results in stripping of the outer bark off in patches and pecking holes

Photo from USDA Emerald Ash Borer Program Manual

EAB Management Actions

Because EAB is already established, eradication is no longer a goal. Instead, focus is on slowing or preventing the spread of the insect into new areas while managing and reducing its numbers in places where it is already found. In Connecticut, a quarantine is in place to keep any infested ash materials from leaving the state and going to an area that does not yet have EAB. There is also ban on the importation of firewood into Connecticut through border states - unless it is properly certified that it has not come from an area already infested.

Hartford currently treats infected Ash Trees with Tree-age which is an injectable insecticide. Davey Resource Group inventoried 466 Ash Trees with 113 of them were detected with EAB. 1 was in good condition, 56 in fair, 55 in poor and 1 dead. The trees listed in poor and dead condition, should be removed in year 1.

Although an additional 57 Ash Trees are infected, they are listed in good or fair condition. Some would suggest removing all infested Ash Trees. However, a high quantity of tree removals tends to draw criticism from the public and is strenuous on a city budget. Continuing treatment with Tree-age will allow the City Forester to balance maintenance and budget by addressing Ash Trees listed in poor or dead condition first, then strategically removing additional Ash Trees if their condition deteriorates. Treatment with Tree-age should continue for the 57 trees listed in fair and good condition. Currently the cost for Tree-age is $8.90/DBH inch. Which ranges from $17-18,000 dollars a year; treatments are on a 2-year cycle. Most recently, money from the Hartford Parks Trust Fund paid for the EAB treatment.

Photo from Pittsburgh Post-Gazette

Public Outreach and Communication

The four most important ways in which the public can be engaged are:

- Communicate how to identify Ash Trees and symptoms. Communication can be through social media, fliers, or booths at public events.
- Act quickly to report any ash trees that are declining that may pose a danger to people or structures.
- Be especially careful when moving any firewood or young trees.
- Communicate the use of 311 with possible detection.

Asian Longhorned Beetle

The Asian Longhorned Beetle (ALB), Anoplophora glabripennis, is a threat to America's hardwood trees because there is no current cure. Early identification and eradication are critical to its control.

Asian Longhorned Beetle (Anoplophora Glabripennis):

- A large, jet black, shiny beetle with wing covers marked with distinct white patches.
- The body of an adult is 1-2" in length, 1/2" width.
- Antennae can be up to twice the length of the beetle's body.
- A destructive wood-boring pest of maple and other hardwoods.

The ALB continually re-infests the same tree. Even though ALB is partial to Red Maples (Acer rubrum), it will make do with a wide range of host tree species that include:

- Horsechestnuts (Aesculus)
- Paper, Grey and White Birches (Betula)
- Sycamores and London Planes (Platanus occidentalis, Plantanus x acerifolia)
- Weeping Willows (Salix)
- American Elms (Ulmus Americana)
- Eastern Cottonwood/Popular (Populus deltoides)
- Other Maples – Sugar, Silver and Boxelder (Acer saccharum, Acer saccharinum, Acer negundo)

ALB Sign and Symptoms

Best indicators that your tree is infested:

- Observing the insect
- Exit Holes (circular and large, 1/4" - 1/2" dia.)
- Pit sites (chewed holes in bark 1/2"+ dia.)
- Frothing sap (at the site of the pit hole)
- Wood shavings/sawdust at the base of the trunk or protruding from cracks in the bark
- Crown dieback and weakened branches broken during storm events

ALB Management Actions

Currently, Hartford removes upon detection. This strategy should continue. The Asian longhorned beetle is a significant threat because thus far it doesn't respond well to any known biological or chemical controls; once it infests a tree, that tree must be removed. The longer an infestation persists, the larger the population of beetles will grow, and the greater the extent of the impact will be," CT DEEP said. Early detection is key!

Hemlock Woolly Adelgid

Hemlock Woolly Adelgid (HWA) attacks Canadian hemlocks (Tsuga canadensis). HWA was first reported to the Connecticut Agricultural Experiment Station in New Haven in 1985 and by 1997, was found throughout the state.

In October 2019, the USDA declared New York City free of the Asian Longhorned Beetle in the boroughs of Brooklyn and Queens. The methods used to eliminate the beetle were to regulate the movement of tree host (firewood and woody debris). They also removed all infested trees (over 5,200 infested trees), and treated approximately 67,600 at-risk trees.

– Read more: ***https://www.aphis.usda.gov/aphis/newsroom/news/sa_by_date/sa-2019/alb-ny***

Hemlock Woolly Adelgid, Adelges tsugae:

- A small, blackish-gray, soft-bodied insect less than 1/16" in length

Sign and Symptoms

- White, woolly covering of a cotton-swab like texture found on the undersides of hemlock needles from October through May

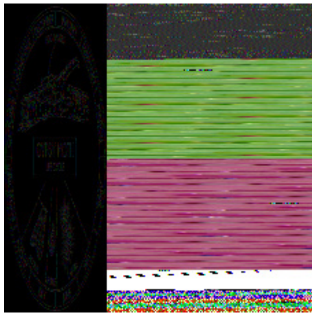
HWA Management Actions

Long-term research conducted at the Connecticut Agriculture Experimental Station (CAES) has shown that severe winter events can markedly reduce infestations for the following spring, allowing trees to recover. The use of horticultural oil or insecticidal soap applied once or twice annually in May and late June can also control HWA-infested hemlocks in the garden landscape. However, these are costly, laborious methods.

Connecticut has been managing HWA for over 34 years, implementing statewide biological control with the Japanese ladybeetle predator of HWA, Sasajiscymnus tsugae, and many of the state's forest hemlocks have survived and persisted since the initial waves of tree mortality.

Davey Resource Group identified 34 infected trees, 16 are listed in poor condition. These 16 trees should be removed in year 1. The other 18 trees should be monitored and removed if health deteriorates.

European Gypsy Moth



The European gypsy moth, (EGM), Lymantria dispar is well-known among the general public and periodically inflicts serious damage to woodland and shade trees. It has been in Connecticut since 1905 and can be a serious pest consuming foliage voraciously. Normally, the EGM population is low and the damage it does is fairly restricted. However, when it enters into outbreak status, it can be a significant problem.

The EGM undergoes a complete metamorphosis, but it is the caterpillar stage of the insect that is infamous for its appetite. Oaks are its first choice, but it readily consumes beech, birch, elm, maples, and most other hardwoods. During heavy infestations, it will also consume pine, spruce and hemlock needles.

Signs and Symptoms

- Visible egg masses covered with buff or yellowish hair from the abdomen of the female
- Visible caterpillars
- Visible adult moths: male moths are brown with a darker brown pattern on their wings while females are slightly larger and nearly white
- Defoliated trees

EGM Management Actions

Although EGM has not been detected in Hartford, the European gypsy moth is potentially one of the most destructive pests of our hardwoods. Early detection is critical to limiting the spread of the EGM. To help prevent the further spread of this destructive pest, it is essential for homeowners and residents to:

- Regularly inspect their property and outdoor areas.
- Report findings of egg masses on trees, lawn furniture, fences, walls or elsewhere on private property to the City Forester.
- Cooperate with all restrictions that might be imposed locally because of an EGM detection.
- Allow authorized city workers access to properties to install and inspect insect-monitoring traps.

Starting in 1989, a fungus has re-appeared annually that specifically attacks the gypsy moth caterpillars. This fungus needs rain to become activated and has kept the gypsy moth population in check. However, since 2015, tree mortality has continued due to the lingering effects of the gypsy moth and drought conditions.

Photo from UMass Amherst The Center for Agriculture, Food, and the Environment

Dutch Elm Disease (Ophiostoma Ulmi)

Connecticut's stately elms began to die in the 1930s. A fungal infestation, spread by bark beetles, ravaged the closely planted elms that once lined Connecticut streets. Isolated trees continue to survive, but they remain vulnerable. If infected, the fungus proceeds through the vascular system of the tree and can kill a large tree in three or four years.

Recent efforts to treat the endangered trees with herbicides and to develop disease-resistant strains offer hope that these beautiful and godly trees will remain a part of the Connecticut landscape for years to come.

Signs and Symptoms

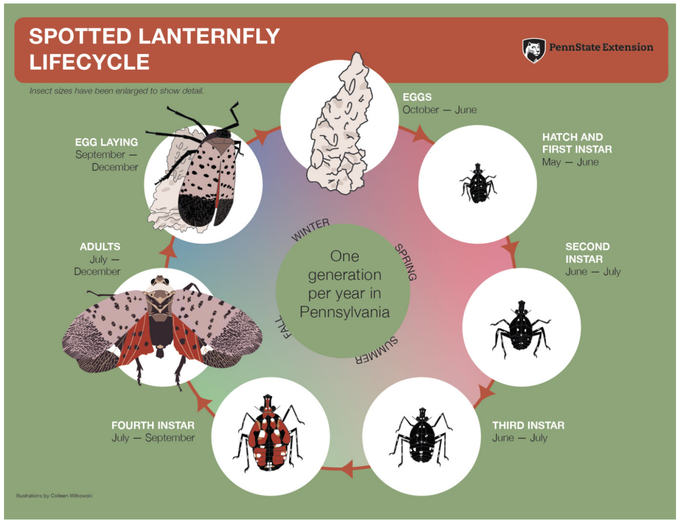
- Yellowing and wilting of leaves on individual branches
- Brown and curled up dead leaves that drop
- Branches and stems develop dark streaks of discoloration

DED Management Actions

For control of the disease, the best course is to control the elm bark beetles. Branches with symptoms should be pruned 10 feet below symptoms to prevent spread of the fungus in the tree. Dead trees should be promptly removed from areas with living elms, as beetles carrying the fungus may emerge from the dead bark in the spring. Currently, treatment would cost approximately $10,000.

A number of new cultivars are available with some resistance to this pathogen. Due to the continued pressure of Dutch elm disease (DED), only cultivars selected with reported disease resistance should be planted.

- Delaware #2
- Liberty/American Liberty
- Princeton
- Valley Forge



Spotted Lanternfly

The spotted lanternfly, (SLF), Lycorma delicatula adult is approximately 1” long and 1/2” wide with large and colorful wings. The front wings of the spotted lanternfly are light brown with black spots in the center. Their hind wings have contrasting patches of red and black with a white band in between. The legs and head are black, and the abdomen is yellow with broad black bands.

The spotted lanternfly is an insect with a large and diverse host range. It feeds on about 60 genera of the trees and plants found in North America. In Connecticut, many hardwood trees (maples, oaks, popular, sycamore, willow, walnut) are considered potentially susceptible to the SLF. Many fruit trees grown in Connecticut, such as apples, cherries, and peaches, are also considered to be vulnerable. Even if the insect does not kill the trees, it could destroy the value of the fruit. Grapes are likewise vulnerable. The impact on the agricultural industry of Connecticut could be devastating.

The SLF is a planthopper. It can walk, jump, or, as an adult, fly short distances, but it is a hitchhiking insect. It lays eggs on almost any surface, including vehicles, trailers, outdoor equipment, and patio furniture, and can be spread long distances when people move infested material.The adults and immatures of this species damage host plants by feeding on sap from stems, leaves, and the trunks of trees. Adults appear in late July and tend to focus their feeding on Tree of Heaven (Ailanthus altissima) and grapevine (Vitus vinifera).

Signs and Symptoms:

- Plants that ooze or weep and have a fermented odor
- The buildup of sticky fluid (honeydew) on plants and on the ground underneath infested plants
- Black sooty mold on infested plants
- Egg mass: Gray, clay-like at first, turns brown and cracked. As they age, the egg masses look as if they are coated with gray mud, which eventually takes on a dry/cracked appearance. Very old egg masses may look like rows of 30-50 brown seed-like structures aligned vertically in columns. Coated egg masses may look like “weird gypsy moth egg masses”, but they are not.

SLF Management Actions

Although SLF has not been detected in Hartford yet, the degree of impact of the SLF on Connecticut's urban and rural forest trees is uncertain. It may result in minor impact on our forest health, however, there is the potential that it could cause much more significant damage. Single SLF adults have been found in New York, Massachusetts, Maryland, and Connecticut; however, no infestations have been reported in these states as of April 2019. To reduce the risk, these important steps should be followed:

- Homeowners shall regularly inspect their property and outdoor areas. Check for egg masses and excretions of honeydew.
- Report findings of egg masses on trees, lawn furniture, fences, walls or elsewhere on private property to the City Forester.
- Removal of Tree of Heaven which is a popular host. The Davey Resource Inventory identified 230 trees in Hartford.

Oak Wilt

Oak wilt (Ceratocystis fagacearum) is an aggressive disease that affects many species of oak (Quercus spp.). It is one of the most serious tree diseases in the Eastern United States, killing thousands of oaks each year in forests, woodlots, and home landscapes. Oak wilt is a vascular disease, caused by the fungus Bretziella fagacearum. The fungus grows on the outer sapwood of oak trees restricting the flow of water and nutrients through the tree.

All oak species are susceptible and at risk. The red oak group (red, black, pin) is the most susceptible, with mortality frequently occurring within one growing season. Oaks in the white oak group (white, bur) are also affected but are more resistant. Early detection of this disease in any new location is critical to attempting to eradicate the problem before it becomes widespread.

Signs and Symptoms:

- Leaves turn dull green, brown or yellow
- Discoloration of leaves progressing from the edge of the leaf to the middle
- Wilting and bronzing of foliage starting at top of the tree and moving downwards
- Premature leaf drop (including green leaves)
- White, grey or black fungal mats just under the bark that emit a fruity smell
- Vertical bark cracks in the trunk and large branches as a result of the fungal spore mats exerting outward pressure on the bark

Oak Wilt Management Actions

Oak Wilt has not been detected in Hartford, however, there is no cure for oak wilt infected trees. The best approach is to avoid or reduce infection in areas where disease occurs by:

- Identifying and removing diseased trees
- Preventing the formation of, or severing, existing root connections between diseased and healthy trees
- Minimizing wounds on healthy trees during the flight period of potential insect carriers.

Two Lined Chestnut Borer

Two Lined Chestnut Borer, (TLCB), Agrilus bilineatus, is a native boring insect that hosts on stressed oak, beech and hornbeam trees. Healthy trees are usually able to resist the small number of attacks that occur. As trees become weaken from other factors such as gypsy moth and drought, the opportunist TLCB has started to affect Connecticut and Hartford forests. By the time symptoms become visible, the damage to the host tree is complete as the crown shows symptoms in the first year and then spreads to the remaining live portions in the branches and trunk for the second and third year.

Signs and Symptoms:

- D-shaped exit holes
- Browning of leaves near the top of the tree during the summer
- Brown leaves will start to move down the tree as the summer progresses
- Branches will not produce leaves the following year

TLCB Management Actions

- Preventative bark drench using a pesticide Bifenthrin for high valued trees
- Natural controls include wasp and woodpeckers
- Timed cutting and pruning of infested material
- Timed tree removal during the summer months

Pest and Disease Educational and Outreach Strategies

It is never too early to begin the education and outreach process. Listed below are suggested initiatives:

1. Continue to update the City Forestry website to provide vital updates, identification information and procedures.
2. Firewood messaging. “Do not move firewood” and “Burn it (firewood) where you buy it” speaks to firewood as a vector for pests and pathogens and supports proactive environmental stewardship.
3. Develop and maintain a website to provide access to current information on pest and disease management, quarantines, survey areas, etc.
4. Develop program materials that are available free of charge (and downloadable) to support public education or arrange for publication of news releases for mainstream, electronic, and alternative media (social media). Information should include photos to aid tree and pest identification.
5. Communicate use of the 311 hotline which is available for all residents to report pest and disease concerns as well as hazardous trees.

6. Catalog and monitor existing informational materials to prevent duplication of effort and ensure consistency.
7. Engage the media regarding program activities, when appropriate.
8. Keep local officials, local government, community leaders, neighborhood leaders, etc. informed about the program.
9. Arrange, moderate, and provide presentations and support at public meetings. Public meetings or informational open houses take place when deemed necessary and/or appropriate. These meetings address public concerns, communicate the program strategy and actions, and help to garner community support and compliance.
10. Periodically meet with program staff for program feedback, problems, concerns, etc. Engage and encourage open dialogue.
11. Continually refine and develop communication vehicles (brochures, posters, newsletters, etc.) to ensure accuracy and current program information.

Other potential pest and disease can be found here: https://portal.ct.gov/CAES/PDIO/Alerts/Whats-New This website should be monitored regularly for updates, alerts, and news.

Conclustion

A proactive 3-year maintenance cycle and early detection can effectively manage pest and diseases throughout the city's forest. Balancing tree removals and treatment will allow budget management while maintaining good public relations. Educating the community to promote early detection in the private sector will greatly benefit the overall city forest. Similarly, another best management practice to discourage pests and diseases is to promote biodiversity when installing new tree plantings. Refer to chapter 5 for more detail on tree planting diversity. Furthermore, tracking pests and diseases as well as treatment through TreeKeeper will efficiently track the health of the City's forest and facilitate tree management efficiencies.

PART 7 Conclusion

7.1

Next Steps

Immediate 2020 Goals

Track Through TreeKeeper

- All city removals and new plantings
- Zoning Enforcement Officer to communicate verified removals and installations on developments
- Communicate with KNOX to track plantings from Trees for Hartford Neighborhoods & other tree planting campaigns

Tree Planting:

- Replacement Tree Plantings for Hazardous Tree Removals at a minimum of 1:1 ratio; preferred inch to inch match
- Determine Tree Implementation Strategy for public trees
- Determine strategies for private tree plantings.
- Use money from Hartford Tree Fund to facilitate tree planting

Maintenance:

- Refer to Davey Resource Group Tree Resource Management Plan for recommended removals and pruning.

Funding

- Start discussions on how to incorporate tree maintenance and planting into the CIP budget
- Apply for grants and seek sponsors

Outreach

- Continue Hartford Forestry website page improvements
- Work with the director of Community Engagement to market campaign
- Continue social media posts (Facebook, Twitter, Instagram and blogs).

Short Term (Year 1-4)

- Track Through TreeKeeper – As described above
- Tree Planting:
  - Hire Additional Staff: Tree Planting Coordinator I, Tree Planting Coordinator II and Administrative Assistant.
  - City-Wide 1500 annual tree planting goal (70%/30%)
    - 1,050 ROW Tree Plantings in Priority Neighborhood 1,2,3 & 4. One neighborhood each year.
    - 450 Private property tree plantings at residential properties in Priority Neighborhood 1,2,3 & 4. One neighborhood each year.

Private Tree Plantings Opportunities:

  - Develop City/Non-Profit partnership for yard tree planting program.
  - Engage discussions with multi-family housing developments, institutions, corporations and other private property owners to encourage tree planting on private property as located on Neighborhood Maps
- Engage Landscape Architectural design services for park master plans.
- Locate BROW planting opportunities in neighborhoods 1-5.

Maintenance:

- Refer to Davey Resource Group Tree Resource Management Plan for recommended removals and pruning.
- Acquire two additional four-person arborist crew to bring total to (3) four-person crews.
- Funding – As described above

Outreach

- Add Request-A-Street Tree to Forestry webpage.
- Add Request-A-Yard Tree to Forestry webpage.
- Engage with Hartford Next
- Promote Tree Planting and Maintenance Program on social media (Facebook, Twitter, Instagram and blogs).
- Engage with local non-profits on outreach campaigns at schools
- Engage with local non-profits on door-to-door tree planting request and education

Long Term Goals (Years 5-10)

- Track Through TreeKeeper – As described above
- Tree Planting:
  - City-Wide 3,000 annual tree planting goal (70%/30%)
    - 2,100 public tree plantings in Priority Neighborhood 5 (then cycle back to 1). Install trees in the following areas: the ROW, BROW, schools, parks, and other public property. One priority neighborhood group each year.
    - 900 private property tree plantings at residential properties in Priority Neighborhood 5 (then cycle back to 1). One priority neighborhood group each year.

Long Term (Year 11+)

- Track Through TreeKeeper – As described above
- Tree Planting:
  - City-Wide 3,000 annual tree planting goal (30%/70%) transitions to focus on private properties as public planting opportunities are fully planted.
  - 900 public tree plantings in Priority Neighborhood 1 (then continue the cycle). Install trees in the following areas: the ROW, BROW, schools, parks, and other public property. One priority neighborhood group each year.
  - 2,100 private property tree plantings at residential properties in Priority Neighborhood 1 (then continue the cycle). One neighborhood each year.
- Private Tree Plantings: As described above

Private Tree Plantings: As described above

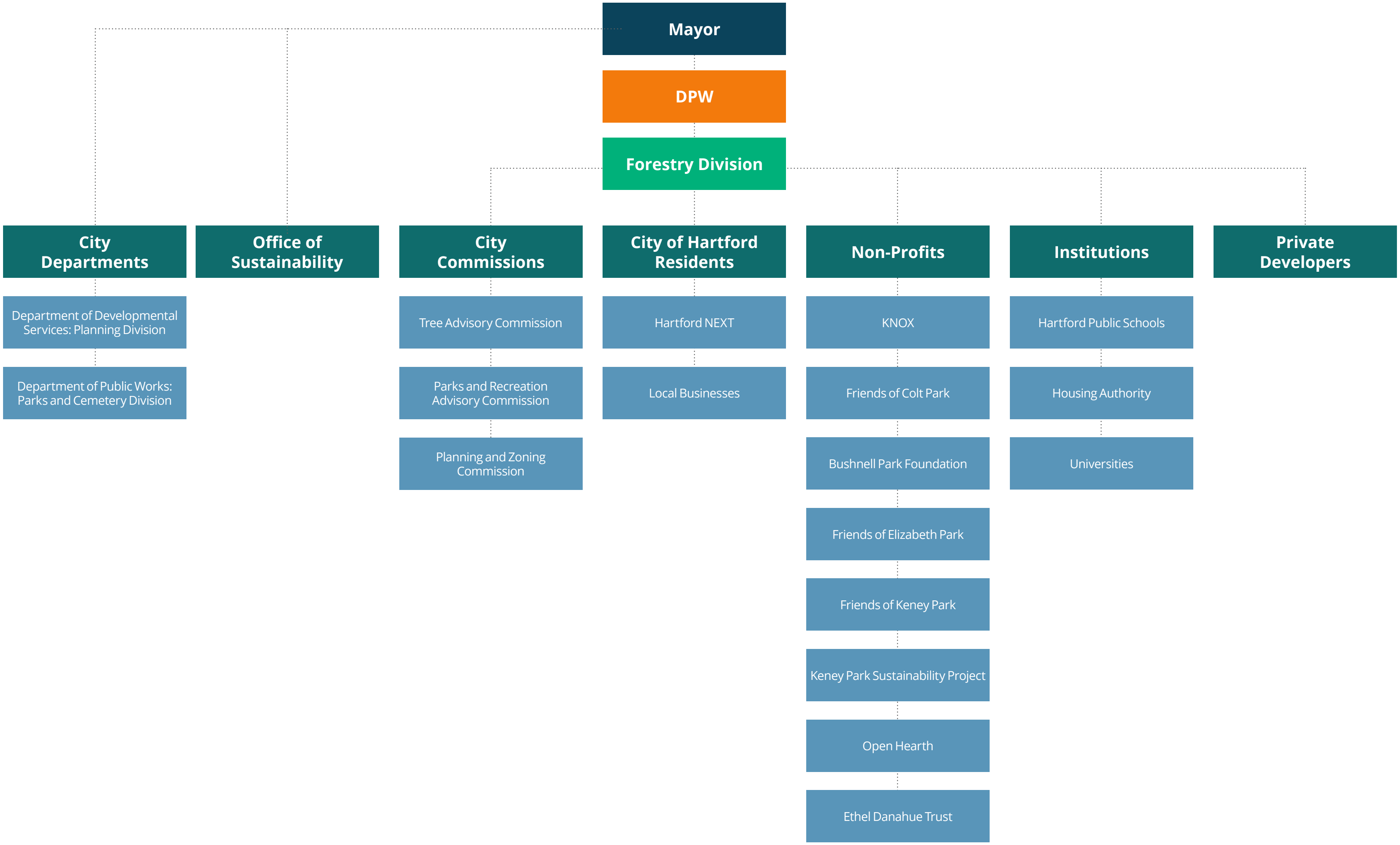
- Maintenance – As described above
- Funding – As described above
- Outreach – As described above

7.2

Roles and Responsibilities

Roles and Responsibilities Summary

Many departments and organizations are involved in Hartford's tree canopy campaign. However, all decisions are to be made with the inclusion of the Forestry Division. Below are key roles and responsibilities.


Mayor
DPW
Forestry Division
City Departments
Office of Sustainability
City Commissions
City of Hartford Residents
Non-Profits
Institutions
Private Developers
Department of Developmental Services: Planning Division
Department of Public Works: Parks and Cemetery Division
Tree Advisory Commission
Parks and Recreation Advisory Commission
Planning and Zoning Commission
Hartford NEXT
Local Businesses
KNOX
Friends of Colt Park
Bushnell Park Foundation
Friends of Elizabeth Park
Friends of Keney Park
Keney Park Sustainability Project
Open Hearth
Ethel Danahue Trust
Hartford Public Schools
Housing Authority
Universities

City of Hartford – Mayor and Council

- Support Forestry tree management goals fundamentally and fiscally

Department of Public Works – Forestry Division

The Forestry Division is to be the point of contact for implementation and planning of tree management, including both maintenance and planting.

- Department of Public Works to receive city funding for tree maintenance and tree planting programs via Neighborhood Environmental Improvements section
  - Department of Public Works to determine tree planting implementation strategy.
- Provide a list of all city funded projects to the City Forester for review
- City Forester to lead proactive Tree Maintenance Program through oversight of city crew and contracted crews
  - Responsible for inputting any documented tree removals or tree maintenance, on public or private properties, into TreeKeeper
  - City crew to support tree planting efforts as determined by the Department of Public Works
- Tree Planting Coordinator to lead tree planting programs
  - To communicate and coordinate program goals and priority planting areas with City Forester and any other city or non-profit planting efforts
  - Responsible for inputting any documented new tree plantings, on public or private properties, into TreeKeeper
  - Responsible for development of educational and outreach initiatives

Department of Public Works – Parks and Cemetery Division – City Architect

- Communicate tree health concerns to the City Forester
- Provide a list of all park projects to the City Forester for review
- Coordinate any proposed tree plantings with the City Forester and Tree Planting Coordinator
- Coordinate tree maintenance efforts with the City Forester and Tree Planting Coordinator and provide personal support as available

Hartford Public Schools, Fire Departments, Police Departments and Other Public Facilities

- Communicate tree health concerns to the City Forester.

Department of Developmental Services – Planning Division

- Continue to enforce zoning ordinances in efforts to preserve existing trees and promote new trees on plans submitted for approval
- Communicate confirmed tree installations on approved projects
- Update Planning and Zoning Regulations as recommended

Office of Sustainability

- Investigate supplemental funding sources for tree management (tree maintenance and tree planting) goals as outlined. Communicate and coordinate with the Central Grants Administration as necessary
- Continue tree canopy advocacy with network of related groups

Office of Community Engagement

- City Forester and Tree Planting Coordinator to engage Office of Community Engagement to facilitate marketing campaign for the **LOVE HARTFORD / GREEN HARTFORD** initiative, including door hangers, informational handouts, tree informational tags

Tree Advisory Commission

- Continue monitoring and promotion of City Trees
- Continue recommendations to the Forestry Division regarding tree maintenance and tree planting

- Continue to provide annual "State of the Forest Report"
- Continue to provide updated Master Tree Plan every 5 years
- Work with Tree Planting Coordinator to identify additional tree planting opportunities on public and private properties. Tree Advisory Commission representative to engage in private property communication along with the Tree Planting Coordinator.

Knox/ Other Non-Profits

- Communicate and coordinate with the Tree Planting Coordinator to align targeted areas for Trees for Hartford Neighborhood campaign with Prioritized Neighborhood and Park Tree Plantings Areas
- Continue community educational, outreach and workforce development services
- Engage in possible tree planting partnership with the city for public and private tree plantings
- All plantings to be located on private property, outside the ROW, unless approved by the City Forester otherwise
- Consider possible expansion of programs to include Tree Give-A-Way
- Obtain grants for city partnered funding of new tree plantings

Friends of Hartford Park Groups

- Coordinate any proposed tree plantings with the City Forester and the Tree Planting Coordinator
- Communicate tree health concerns to the City Forester

Hartford Next/ Residents

- Communicate city tree maintenance and tree planting goals to the neighborhoods
- Communicate neighborhood goals and concerns to the City Forester and Tree Planting Coordinator
- Encourage neighborhood stewardship

7.3 Conclusion

This report provides a comprehensive approach that when implemented, will promote the health and growth of the tree canopy through a proactive tree maintenance program and robust tree planting program. For Hartford's future canopy to thrive, action must be taken now to maintain the balance and biodiversity of the tree canopy ecosystem.

The long-term goal is for Hartford's tree canopy to grow to 35%. By nature, newly planted trees take time to grow and will contribute more and more each year to the growth of the city's canopy. Although we provide recommended tree planting quantities in this report, the overarching goal is canopy growth.

TreeKeeper is an impressive tool that will help Hartford manage their urban forest. TreeKeeper currently has inventoried data of existing trees in the ROW, parks and other public property. However, it lacks inventory on private property. There are opportunities for volunteer groups to gather information. With this information, the city's comprehensive urban canopy inventory can expand, as can its management and planting programs.

The future of Hartford's forest and the health of Hartford's residents are depending on action to be taken now.

2020... THE TIME FOR TREES IS NOW!

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APPENDIX

Appendix

A. Tree Resource Management Plan Hartford 2020, Davey Resource Group Report

B. Davey Resource Group Tree Condition Criteria

C. Davey Resource Group Vacant Lot Criteria

D. To Design Case Study, January 2020.

E. Priority Planting Neighborhood Maps

F. Neighborhood Maps

G. Priority Planting Locations (2017), by Davey Resource Group

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I. Capital City Parks Guide (Sasaki Master Plans 2014)

J. Colt Park Master Plan

K. Hartford Parks Master Plan

L. Silverton Tree Giveaway Program Guidelines

M. Yearly Tree Planting Location Guide

N. Hartford Tree Recommendations (August 2018)

O. 2018-2019 Hartford Tree Planting Plan

P. Connecticut Tree Owner's Manual

Q. Tree Maintenance Map

APPENDIX A

Tree Resource Management Plan Hartford 2020, Davey Resource Group Report

TREE RESOURCE MANAGEMENT PLAN

City of Hartford, Connecticut

April 2020

Prepared for:
City of Hartford
City Hall
550 Main Street
Hartford, Connecticut 06103

Prepared by:
Davey Resource Group, Inc.
295 S. Water Street, Suite 300
Kent, Ohio 44240
800-828-8312

DAVEY® Resource Group

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ACKNOWLEDGMENTS

This project supports the City of Hartford’s vision to promote and enhance community well-being through public tree conservation and improved forestry management practices. This management plan, informed by Hartford’s public tree inventory, offers expertise in maintaining and expanding the urban canopy so the environmental and economic benefits it provides continue for generations.

The July–September 2019 tree inventory was funded by the City of Hartford Capital Improvement Program. The City of Hartford also recognizes the support of the following groups:

Connecticut Agricultural Experiment Station
Connecticut Department of Energy and Environmental Protection
Connecticut Audubon
Connecticut Forest and Parks Association
Connecticut Notable Trees
Connecticut Urban Forest Council
Hartford Fire Department
Hartford Office of Sustainability
Hartford Police Department
Keney Park Sustainability Project
Knox Inc.
New England Forestry
Park and Recreation Advisory Commission
Tree Advisory Commission
Tree Wardens’ Association of Connecticut
United States Forest Service
University of Connecticut Extension Service

Notice of Disclaimer: Inventory data provided by Davey Resource Group, Inc. “DRG” are based on visual recording at the time of inspection. Visual records do not include individual testing or analysis, nor do they include aerial or subterranean inspection. DRG is not responsible for the discovery or identification of hidden or otherwise non-observable hazards. Records may not remain accurate after inspection due to the variable deterioration of inventoried material. DRG provides no warranty with respect to the fitness of the urban forest for any use or purpose whatsoever. Clients may choose to accept or disregard DRG’s recommendations or to seek additional advice. Important: know and understand that visual inspection is confined to the designated subject tree(s) and that the inspections for this project are performed in the interest of facts of the tree(s) without prejudice to or for any other service or any interested party.

EXECUTIVE SUMMARY

The City of Hartford *Tree Resource Management Plan*, written by Davey Resource Group, Inc. "DRG", focuses on quantifying the benefits provided by the inventoried tree resource and addressing its maintenance needs. DRG completed a tree inventory for the City of Hartford in July–September 2019. DRG analyzed this inventory data to understand the structure of Hartford's inventoried tree resource and to recommend a prioritized maintenance schedule for future tree care. DRG also estimated the economic values of the various environmental benefits provided by Hartford's inventoried tree resource by analyzing inventory data with i-Tree Eco.

Structure and Composition of the Tree Resource

The July–September 2019 inventory included trees, stumps, and planting sites along public street rights-of-way (ROW), and in high-use areas of specified parks, cemeteries, and other public properties. The parks, cemeteries, and other public properties selected for the inventory include: The Ancient Burying Ground, Barnard Park, Buckingham Square, Bushnell Park, Charter Oak Monument, Charter Oak Park (also called Charter Oak Landing), City Hall and Burr Mall, Colt Park, Columbus Green, Elizabeth Park, Forster Park (also called Forster Heights Playground), Franklin Avenue Recreation Center (also called Columbus Park), George Day Park, Goodwin Park, Hartford Police Affleck Street Substation, Hartford Public Safety Complex, Hartford Public Works Department, Hyland Park, Joseph V. Cronin Park, Keney Clock Tower, Keney Park, Keney Park Golf Course, Lozada Park, Marcus Garvey Park, Northwood Cemetery, Old North Cemetery, Old South Cemetery, Pope Park, Pope Park North, Pulaski Circle, Pulaski Mall, Riverfront Plaza (also called Riverfront Park), Riverside Park, Rocky Ridge Park, Sigourney Square, Tower Square (also called Traveler's Tower), Wexford Park, and Zion Hill Cemetery. The 2019 tree inventory was focused on public street ROW trees, and trees on private property and within forested or unmaintained areas of public properties were not included in this inventory. Furthermore, the neighborhood of South Meadows was not fully inventoried in 2019 due to time and budgetary constraints. A total of 30,091 sites were recorded during the inventory: 18,791 trees, 1,238 stumps, and 10,062 planting sites. Analysis of the tree inventory data found the following:

- The genus *Acer* (maple) comprises 34% of Hartford's inventoried ROW tree resource, which is much higher than DRG's recommended threshold of 20% for any genus. The genera *Quercus* (oak) and *Acer* each comprise more than 20% of the inventoried park, cemetery, and other public property population (hereafter referred to as the public properties population).
- 34% of the inventoried ROW tree resource is in the *Sapindaceae* family, which exceeds DRG's recommended 30% threshold, but this sub-population is almost entirely maple.
- Hartford's inventoried ROW tree resource trends toward the ideal age distribution, with more Young trees (45%, ideal 40%) and Mature trees (14%, ideal 10%) and fewer Maturing trees (14 %, ideal 20%) and Established trees (26%, ideal 30%). The inventoried public property population has a flatter distribution (28% Young, 25% Established, 18% Maturing, and 28% Mature) that deviates more from the ideal.

- 63% of Hartford's inventoried ROW tree resource is in Fair condition, 22% is in Good condition, and 15% is in Poor or Dead condition. 74% of Hartford's inventoried public property tree resource is in Fair condition, 15% is in Good condition, and 11% is in Poor or Dead condition.
- 58% of the inventoried tree resource is a host to granulate ambrosia beetle (GAM, *Xylosandrus crassiusculus*) and around 30% is a host to gypsy moth (*Lymantria dispar* dispar), spotted lanternfly (*Lycorma delicatula*), Asian longhorned beetle (ALB, *Anoplophora glabripennis*), and locust leafminer (*Odontota dorsalis*), making these pests the greatest threats to Hartford's tree resource.
- 2% of the inventoried trees are conflicting with overhead utilities and another 16% are not currently conflicting with overhead utilities but may in the future. Less than 5% of the inventoried trees are conflicting with infrastructure such as homes, signal lights, and street signs.
- Hartford's ROW stocking level is 45%, which is much lower than DRG's recommended 90% stocking level.

Functions and Benefits of the Tree Resource

Hartford's inventoried tree population provides benefits with an estimated total value of $116,384 annually:

- *Runoff Reduction:* An estimated 327,332 cubic feet (2,448,443 gallons) per year, valued at $21,881.
- *Pollution Removal:* An estimated 9,440 pounds (4.72 tons) per year, valued at $66,171.
- *Carbon Sequestration:* An estimated 232,240 pounds (166.12 tons) per year, valued at $28,332.

The functions of Hartford's inventoried tree population throughout its trees' lifetimes are worth an estimated $42,910,726:

- *Carbon Storage:* An estimated 36,308,360 pounds (18,154.18 tons) stored, valued at $3,096,212.
- *Replacement (Structural) Value:* The cost of replacing Hartford's inventoried tree resource is an estimated $39,814,515.

Recommended Management of the Tree Resource

Breakdown of recommended maintenance tasks:

- Stump Removal (4% of inventoried sites).
- Tree Planting (33% of inventoried sites).
- Tree Maintenance (62% of inventoried sites), including:
    - Tree Removal (9% of inventoried trees).
    - Priority Pruning (5% of inventoried trees).
    - Routine Pruning Cycle (61% of inventoried trees).
    - Young Tree Training Cycle (25% of inventoried trees).

DRG recommends prioritizing the following maintenance tasks:

- Many Extreme, High, and Moderate Risk trees were assessed (0.05%, 0.84%, and 5.86% of the inventoried trees, respectively). These trees are hazardous and should either be removed or pruned immediately to improve public safety.
- The maintenance tasks for all Low Risk trees that were inventoried should be addressed after all Extreme and High Risk tree maintenance has been completed.
- Hartford's tree resource would benefit from a three-year Young Tree Training Cycle and a three-year Routine Pruning Cycle. Proactive maintenance improves the overall condition of inventoried trees and may eventually reduce program costs.
- 1,579 young trees should be structurally pruned each year during the Young Tree Training Cycle to develop or maintain a dominant leader.
- 3,815 trees should have any dead, dying, diseased, and weakly attached branches removed each year during the Routine Pruning Cycle.
- Tree planting should at least replace all trees recommended for removal and should ideally establish new canopy in areas where there are gaps in the existing canopy (see Appendix A for guidelines on tree planting).
- Planting of tree species in the *Acer* (maple) genus and the *Sapindaceae* (soapberry) family should be limited until the genus and family distribution in the ROW becomes more ideal. In parks, planting of tree species in the *Quercus* (oak) or *Acer* genera should be limited until the species and genus distribution becomes more ideal.
- The estimated total cost for the first year of this five-year management program is $3,579,918. Extreme and High Risk removals and pruning are costly, and because this maintenance should be completed immediately, the budget is higher for the first year of this program. All budget estimates are based on the cost of hiring outside contractors to complete the necessary maintenance. In-house costs are likely to be less than these estimates.
- After hazardous trees have been addressed, the management program will mostly involve proactive maintenance, which is generally less costly. Updating the inventory using

TreeKeeper® or a similar software is crucial for making informed management decisions and projecting accurate maintenance budgets.

Year 1 **$3,579,918**

- 188 Extreme, High, and Moderate Risk Removals
- 433 Extreme, High, and Moderate Risk Prunes
- 446 Low Risk Removals
- 412 Stump Removals
- RP Cycle: 1/3 of Public Trees Cleaned
- YTT Cycle: 1,579 Trees
- 2,198 Trees Recommended for Planting and Follow-Up Care
- Newly Found Priority Tree Work (Removal or Pruning): Costs TBD

Year 2 **$3,569,195**

- 180 Moderate Risk Removals
- 430 Moderate Risk Prunes
- 451 Low Risk Removals
- 414 Stump Removals
- RP Cycle: 1/3 of Public Trees Cleaned
- YTT Cycle: 1,579 Trees
- 2,198 Trees Recommended for Planting and Follow-Up Care
- Newly Found Priority Tree Work (Removal or Pruning): Costs TBD

Year 3 **$3,170,270**

- 451 Low Risk Removals
- 412 Stump Removals
- RP Cycle: 1/3 of Public Trees Cleaned
- YTT Cycle: 1,579 Trees
- 2,197 Trees Recommended for Planting and Follow-Up Care
- Newly Found Priority Tree Work (Removal or Pruning): Costs TBD

Year 4 **$2,696,045**

- RP Cycle: 1/3 of Public Trees Cleaned
- YTT Cycle: 1,579 Trees
- 2,197 Trees Recommended for Planting and Follow-Up Care
- Newly Found Priority Tree Work (Removal or Pruning): Costs TBD

Year 5 **$2,696,355**

- RP Cycle: 1/3 of Public Trees Cleaned
- YTT Cycle: 1,579 Trees
- 2,197 Trees Recommended for Planting and Follow-Up Care
- Newly Found Priority Tree Work (Removal or Pruning): Costs TBD

INTRODUCTION

The City of Hartford is home to nearly 123,000 residents (U.S. Census Bureau 2018) benefiting from public trees in their community. The city's Public Works Department manages all trees, stumps, and planting sites along the street rights-of-way (ROW) and throughout public properties. The city is currently reinstating an in-house forestry crew to provide exceptional care to Hartford's urban forest.

Urban forestry program budgets are funded by the city's Capital Improvement Program, Forestry General Funds, and the Hartford Tree Fund. Hartford has a tree commission and a tree ordinance, celebrates Arbor Day, and has been a Tree City USA community for 26 years. The City of Hartford has long understood the importance of tree inventories in managing their urban forest, with the first street tree inventory occurring in 1906. The July–September 2019 tree inventory builds on data from the prior tree inventory, conducted in the 1980s.

Our Approach to Tree Management

An effective approach to tree resource management follows a proactive and systematic program that sets clear and realistic goals, prescribes future action, and periodically measures progress. A robust urban forestry program establishes tree maintenance priorities and utilizes modern tools, such as a tree inventory accompanied by TreeKeeper® or other asset management software.

In July–September 2019, the City of Hartford worked with DRG to inventory its public trees and develop this management plan. Consisting of four sections, this plan considers the diversity, distribution, and condition of the inventoried tree population and provides a prioritized system for managing the inventoried tree population.

- *Section 1: Structure and Composition of the Public Tree Resource* summarizes the tree inventory data by presenting observations and trends to represent the current state of the inventoried trees.
- *Section 2: Functions and Benefits of the Public Tree Resource* summarizes the estimated economic and environmental benefits provided to the community by the inventoried trees' various functions.
- *Section 3: Recommended Management of the Public Tree Resource* presents a prioritized maintenance schedule and an estimated future budget for these maintenance activities over a five-year period.
- *Section 4: Storm Preparedness Plan* provides broad guidelines for effective storm preparedness plans, with a focus on proactive tree maintenance to minimize storm damage to the urban forest.

SECTION 1: STRUCTURE AND COMPOSITION OF THE PUBLIC TREE RESOURCE

Photograph 1. *DRG arborists assessed park and ROW trees in Hartford, CT during the July–September 2019 tree inventory.*

In July–September 2019, DRG arborists collected site data on trees, stumps, and planting sites along the street ROW and in parks, cemeteries, and other public properties for a tree inventory contracted by the City of Hartford (see Appendix B for information on data collection and site location methods used). Of the total 30,091 sites inventoried, 66% were collected along the street ROW and the remaining 34% were collected in public properties. Figure 1 breaks down the total sites inventoried by type for each location. Vacant sites in public properties were only collected along park edges or in empty tree wells, resulting in very small numbers of vacant sites within public properties.

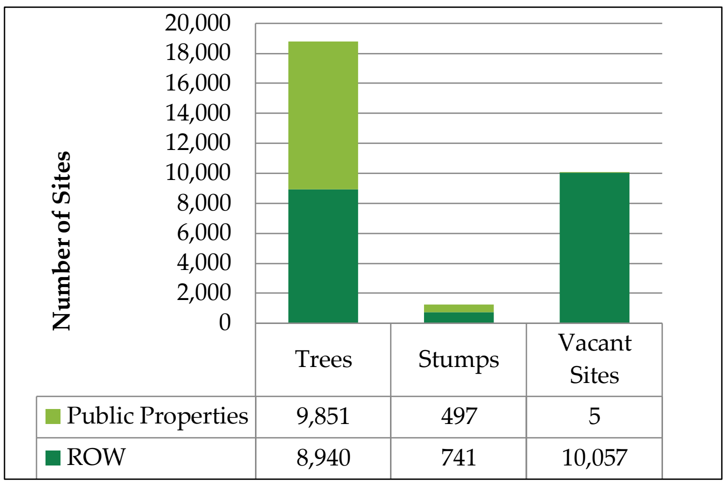


Figure 1. Number of inventoried sites by location and type.

The City of Hartford designated all city street ROW as the project area and 38 public properties for DRG to collect site data for the tree inventory. Inventoried public properties include: The Ancient Burying Ground, Barnard Park, Buckingham Square, Bushnell Park, Charter Oak Monument, Charter Oak Park (also called Charter Oak Landing), City Hall and Burr Mall, Colt Park, Columbus Green, Elizabeth Park, Forster Park (also called Forster Heights Playground), Franklin Avenue Recreation Center (also called Columbus Park), George Day Park, Goodwin Park, Hartford Police Affleck Street Substation, Hartford Public Safety Complex, Hartford Public Works Department, Hyland Park, Joseph V. Cronin Park, Keney Clock Tower, Keney Park, Keney Park Golf Course, Lozada Park, Marcus Garvey Park, Northwood Cemetery, Old North Cemetery, Old South Cemetery, Pope Park, Pope Park North, Pulaski Circle, Pulaski Mall, Riverfront Plaza (also called Riverfront Park), Riverside Park, Rocky

Resilience Through Diversity

The Dutch elm disease epidemic of the 1930s provides a key historical lesson on the importance of diversity. The disease killed millions of American elm trees, leaving behind enormous gaps in the urban canopy of many communities throughout the United States. In the aftermath, Ash trees became popular replacements and were heavily planted along city streets. History repeated itself in 2002 with the introduction of the emerald ash borer into America. This invasive beetle devastated ash tree populations across the country. Other invasive pests spreading across the country threaten urban forests, so it's vital that we learn from history and plant a wider variety of tree genera to develop a resilient public tree resource.

Ridge Park, Sigourney Square, Tower Square (also called Traveler's Tower), Wexford Park, and Zion Hill Cemetery. Trees located on private property or in forested areas of public properties were not assessed during the inventory. It is important to keep in mind that all analysis and recommendations provided in this report pertain only to the inventoried tree resource and should not be considered an accurate representation of Hartford's entire urban forest, which includes trees on both public and private properties.

Species, Genus, and Family Distribution

The 10-20-30 rule is a common standard for tree population distribution which states that a single species should compose no more than 10% of the tree population, a single genus no more than 20%, and a single family no more than 30%.

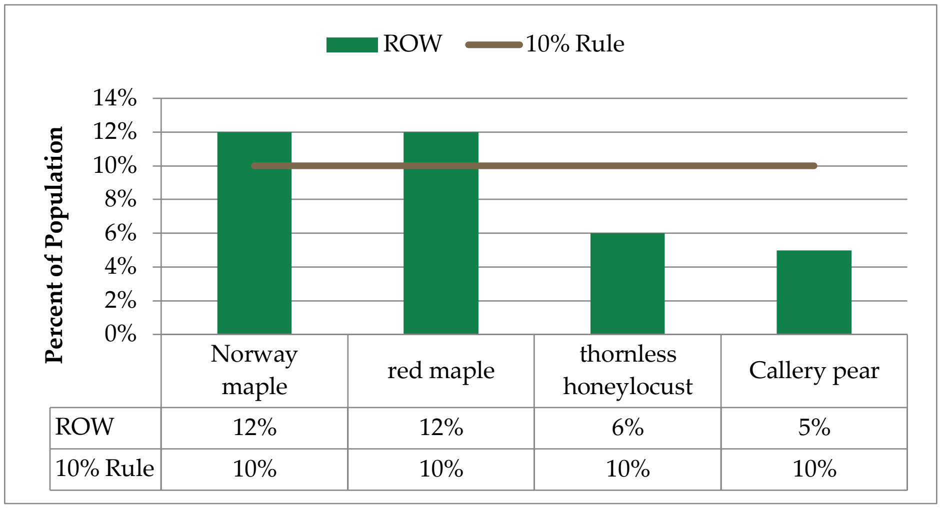


Figure 2. Inventoried tree population distribution of most abundant species in the ROW.

Figure 2 shows Hartford's distribution of the most abundant tree species inventoried in the ROW compared to the 10% threshold. *Acer platanoides* (Norway maple) and *A. rubrum* (red maple) are the most abundant species, each comprising 12% of the ROW population. Figure 3 shows the distribution of the most abundant tree species in Hartford's inventoried pubic properties. *Quercus palustris* (pin oak) is the most abundant species in the public properties, comprising 11% of the inventoried population with *A. rubrum* a close second (9%). Ideally, no single species should comprise more than 10% of a tree population in order to promote resilient urban forests.

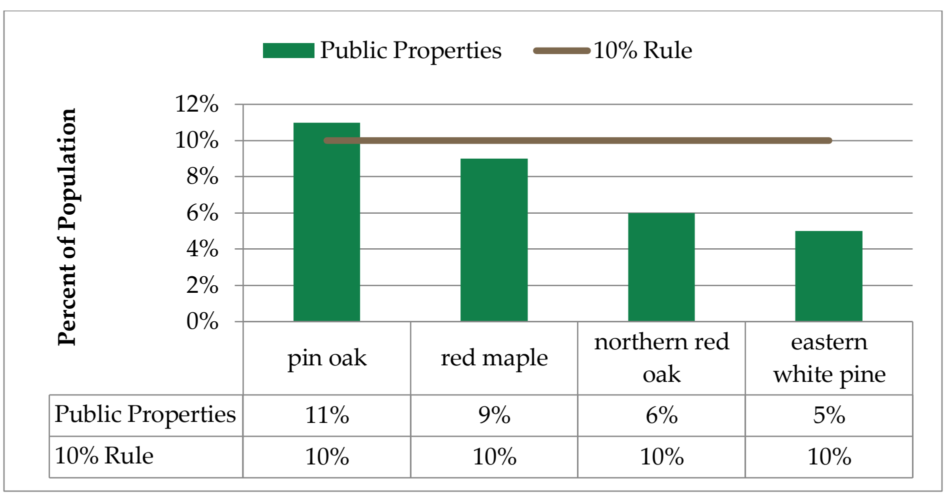
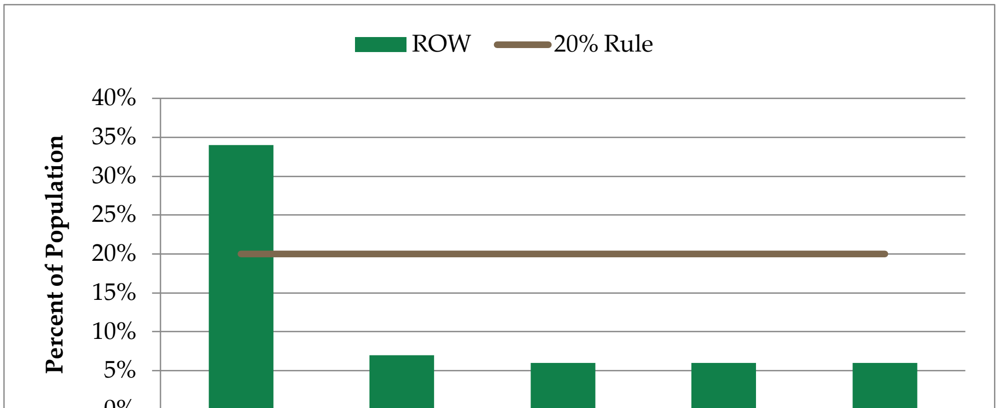


Figure 3. Inventoried tree population distribution of most abundant species on public properties.

Genus distribution is an important consideration because some pests, such as emerald ash borer (EAB, *Agrilus planipennis*), target a single genus as their host. Figure 4 shows the city's distribution of the most abundant tree genera inventoried in the ROW. Only *Acer* (maple) exceeds the 20% threshold for a single genus in a tree population, comprising 34% of the inventoried ROW. In the public properties, however, two genera meet or exceed the 20% rule (Figure 5). *Quercus* (oak) and *Acer* make up 24% and 20%, respectively, of the inventoried tree population in the city's public properties.



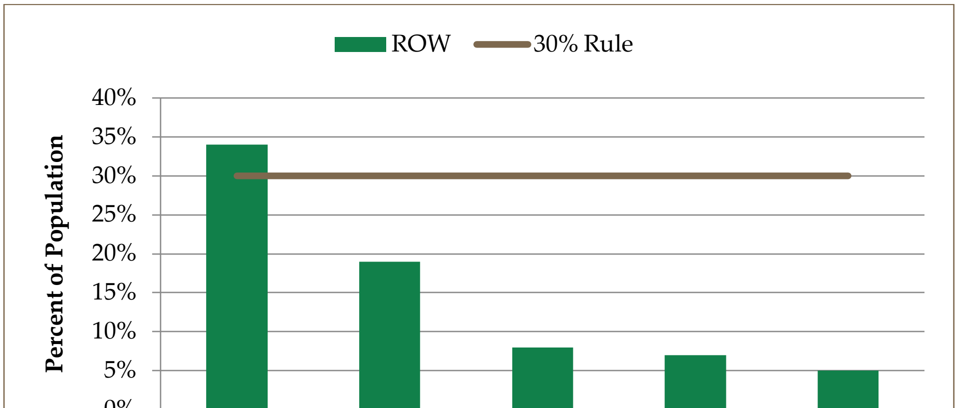
	maple	oak	cherry	honeylocust	pear
ROW	34%	7%	6%	6%	6%
20% Rule	20%	20%	20%	20%	20%

Figure 4. Inventoried tree population distribution of most abundant genera in the ROW.

	oak	maple	pine	cherry
Public Properties	24%	20%	6%	5%
20% Rule	20%	20%	20%	20%

Figure 5. Inventoried tree population distribution of most abundant genera on public properties.

Some pests also target a single family as their host, such as the bacterium *Erwinia amylovora*, commonly known as fireblight. Fireblight only affects plants in the *Rosaceae* (rose) family, such as *Amelanchier* (serviceberry), *Crataegus* (hawthorn), *Malus* (apple/crabapple), *Prunus* (cherry/plum), and *Pyrus* (pear). Figures 6 and 7 shows the city's distribution of the most abundant tree families inventoried in the ROW and public properties, respectively, compared to the 30% threshold. While no single family comprises more the 30% of the inventoried public property population, the *Sapindaceae* (soapberry) family comprises 34% of the ROW population. Most of the overabundance of the soapberry family in Hartford's ROW can be attributed to the high percentage of maples in this population.



	soapberry	rose	legume	beech/oak	elm
ROW	34%	19%	8%	7%	5%
30% Rule	30%	30%	30%	30%	30%

Figure 6. Inventoried tree population distribution of most abundant families in the ROW.

	beech/oak	soapberry	pine	rose	cypress
Public Properties	25%	21%	10%	8%	5%
30% Rule	30%	30%	30%	30%	30%

Figure 7. Inventoried tree population distribution of most abundant families on public properties.

Pest Susceptibility

Early diagnosis of disease and pest infestation is essential to ensuring the health and continuity of Hartford's public tree resource. Appendix C has additional resources and websites where more detailed information on the pests and diseases threatening Hartford's urban forest can be found.

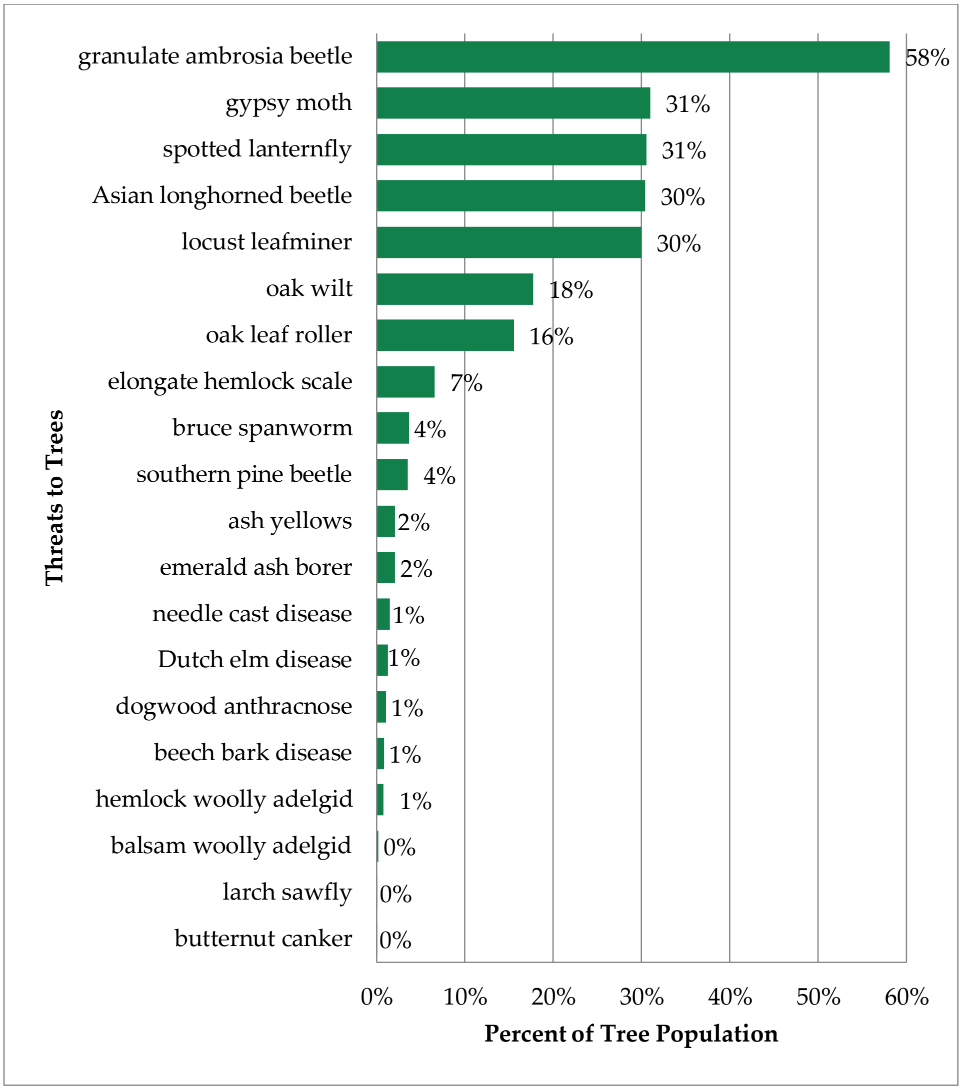


Figure 8. Public tree resource susceptibility to pests with a regional presence.

Figure 8 shows the percent of inventoried trees susceptible to some of the known pests and diseases in and around Connecticut. Since disease and insect pests do not distinguish between ROW and public property trees, these two inventoried populations have been combined for this portion of the analysis. It is important to remember that this figure only represents data collected during the inventory. Many more trees throughout Hartford, including those on private property or in forested areas of public properties, may be susceptible to these pests and diseases. Granulate ambrosia beetle (GAM, *Xylosandrus crassiusculus*) is a threat to 58% of the inventoried tree population. Another 30% to 31% of the inventoried population is susceptible to gypsy moth (*Lymantria dispar dispar*), spotted lanternfly (SLF, *Lycorma delicatula*), Asian longhorned beetle (ALB, *Anoplophora glabripennis*), and/or locust leafminer (*Odontota dorsalis*).

Pest Detection

During the 2019 inventory, DRG arborists inspected the inventoried trees to determine if signs or symptoms of pests and diseases were present. Table 1 shows the results of the cursory pest inspection conducted in 2019. The pest most frequently suspected to be present was emerald ash borer (114 trees, 0.6% of the inventoried tree population). Only three other pest species were detected during the inventory, including hemlock woolly adelgid (34 trees, 0.2%), gypsy moth (4 trees, <0.1%), and Dutch elm disease (3 trees, <0.1%); 99.2% of the inventoried tree resource was free from signs or symptoms of the pest insects and diseases listed in Table 1.

Table 1. *Pest species detected during the inventory*

Pest Detection			
Scientific Name	Common Name	Number of Trees	Percent
Agrilus planipennis	emerald ash borer	114	0.6%
Adelges tsugae	hemlock woolly adelgid	34	0.2%
Lymantria dispar	gypsy moth	4	<0.1%
Ophiostoma ulmi	Dutch elm disease	3	<0.1%
Anoplophora glabripennis	Asian longhorned beetle	0	0.0%
Dendroctonus frontalis	southern pine beetle	0	0.0%
Dendroctonus terebrans	black turpentine beetle	0	0.0%
Dendroctonus valens	red turpentine beetle	0	0.0%
Lycorma delicatula	spotted lanternfly	0	0.0%
Lymantria mathura	rosy gypsy moth	0	0.0%
Operophtera brumata	winter moth	0	0.0%
Pityophthorus julandis	walnut twig beetle	0	0.0%
Sirex noctilio	sirex woodwasp	0	0.0%
Tomicus piniperda	pine shoot beetle	0	0.0%
Bretziella fagacearum	oak wilt	0	0.0%
Geosmithia morbida	thousand cankers disease	0	0.0%
Phytophthora orana	sudden oak death	0	0.0%
none		18,636	99.2%
Total		**18,791**	**100.0%**

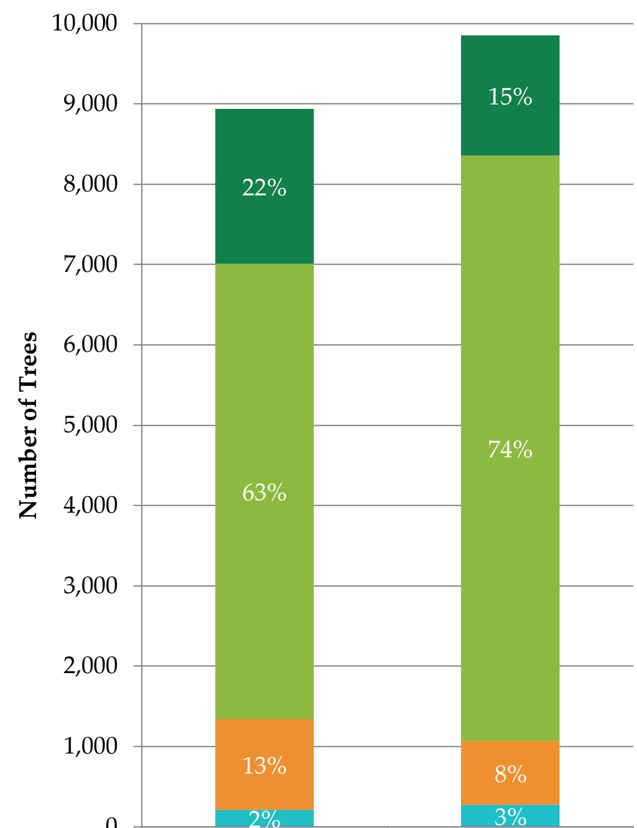
Recommendations

The overabundance of maple and oak in Hartford's tree resource is a management concern because it creates unnecessary risk in the event of a pest or disease outbreak. The abundance of these species not only present more tree resource to lose in the event of an insect or disease outbreak, but also provide more habitat for the pests and diseases they're susceptible to, such as granulate ambrosia beetle and gypsy moth, making it easier for these pests or diseases to spread. Increasing species diversity is a critical goal that will help Hartford's tree resource be resilient in the event of future pest invasions and disease outbreaks. For this reason, Hartford should limit planting of *Acer* species in the ROW and both *Acer* and *Quercus* species in public properties until the species and genus distributions align more closely with the 10-20-30 rule guidelines. Hartford should use its resources to inspect maple and oak trees for signs of pest infestation or disease on a routine basis, so affected trees can be quarantined to contain the pest or disease before an outbreak starts.

While most of the pest insects and diseases of concern in Connecticut were not found in Hartford during the 2019 inventory, several important qualifiers should be kept in mind. First, not all signs and symptoms of insect and disease pests are visible at all times of the year, and the July–September inventory may have missed signs or symptoms that are primarily evident during the winter or spring. Second, a Level 2 ground survey was conducted during the inventory and subtler signs and symptoms, such as exit holes or egg casings located high in tree canopies may not have been visible to arborists on the ground. Third, the pest inspection conducted during the inventory was quick and cursory. Further signs and symptoms of insects or disease may be identified during a full insect pest evaluation and detection (IPED) survey or other survey geared specifically toward identifying signs and symptoms of tree pests. Finally, only ROW trees and those in high-traffic areas of selected public properties were assessed during the inventory. Other diseases and insect pests may be present on private properties or within forested areas of public properties which were not assessed during the 2019 inventory.

Condition

Several factors affecting condition were considered for each tree, including visible root characteristics, branch structure, trunk, canopy, foliage condition, and the presence of pests. The condition of each inventoried tree was rated by DRG arborists as Good, Fair, Poor, or Dead. The general health of the inventoried tree population was characterized by the most prevalent condition assigned during the inventory.



	ROW	Public Properties
Good	1,927	1,493
Fair	5,670	7,287
Poor	1,130	792
Dead	213	279

Figure 9. Condition of inventoried trees.

Most of the inventoried trees in both public properties and the ROW were recorded to be in Fair condition (63% and 74%, respectively, Figure 9). Based on these data, the general health of the entire inventoried tree population is rated Fair. Another 22% of the ROW population and 15% of the public property population were rated Good, while 15% of the ROW population and 11% of the public property population were rated Poor or Dead. Figures 10 and 11 illustrate that the distribution of condition ratings was consistent across relative age classes in both the ROW and public properties.

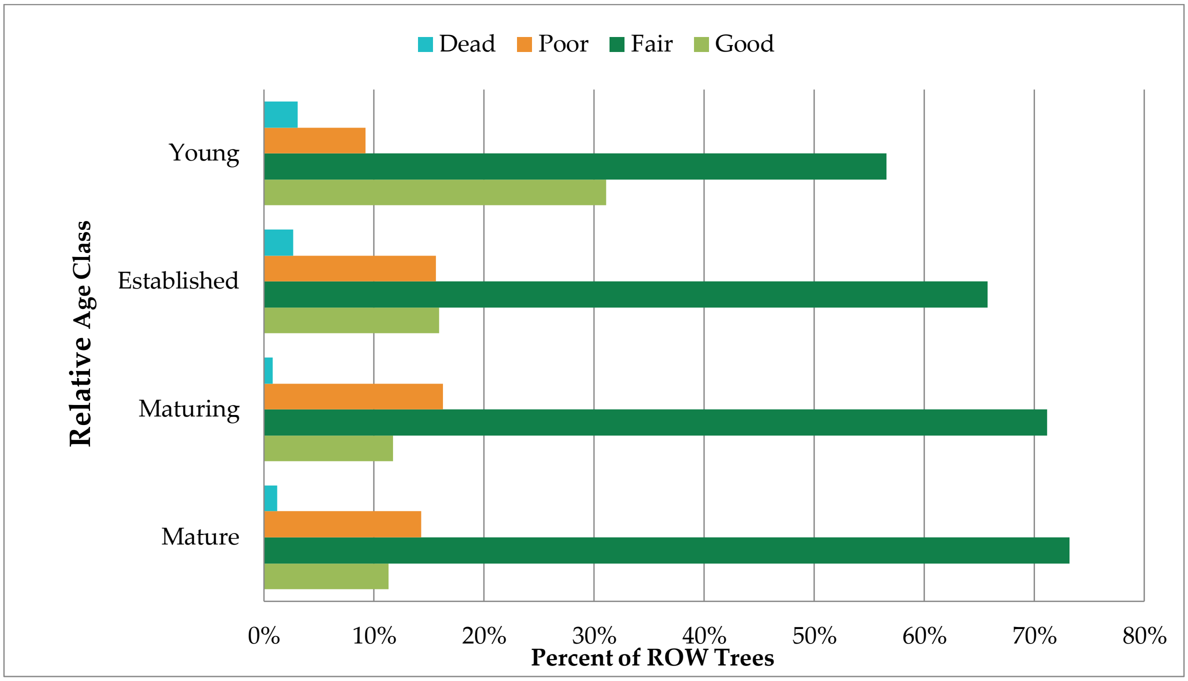


Figure 10. Tree condition by relative age in the ROW.

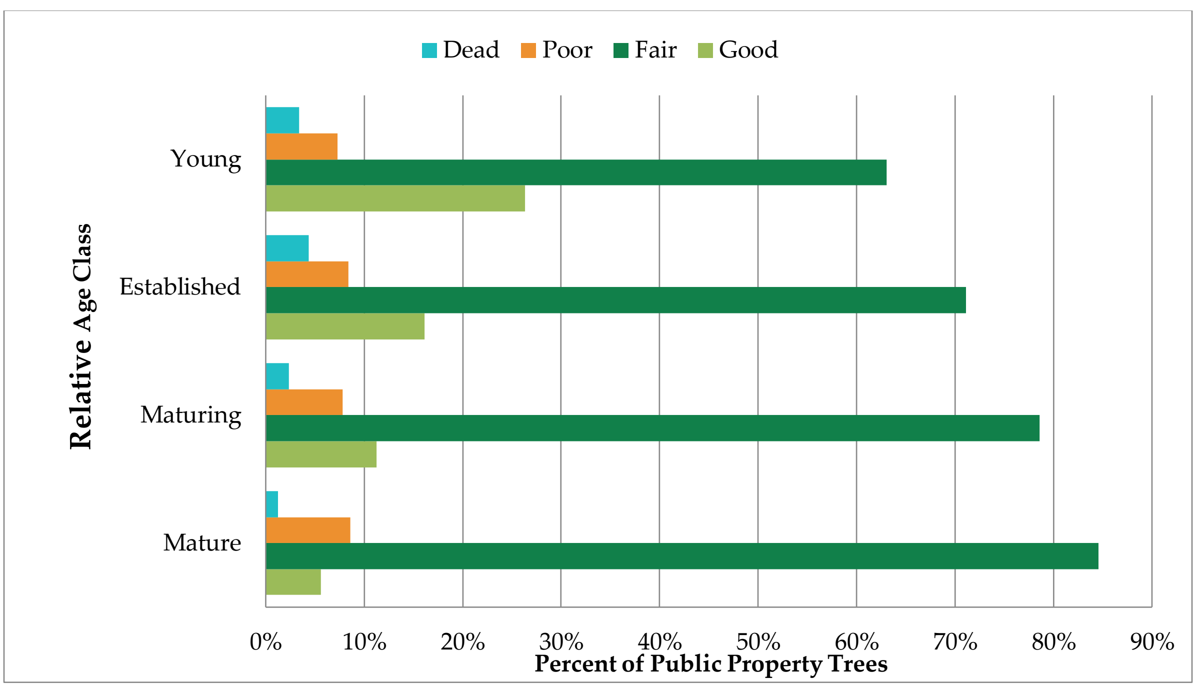


Figure 11. Tree condition by relative age on public properties.

Recommendations

Photograph 2. *Trees in poor condition which are unlikely to rebound without significant investments of time and money should be removed to improve public safety.*

Dead trees and most trees in Poor condition should be removed as soon as possible because the health of these trees is unlikely to recover even with increased care, and such trees often present an elevated risk to the public. Younger trees rated in Fair or Poor condition may benefit from structural pruning to improve their health over time. Pruning should follow *ANSI A300 (Part 1)* guidelines. Poor condition ratings among mature trees were generally due to visible signs of decline and stress, including decay, dead limbs, sparse branching, or poor structure. If not recommended for removal, these trees will likely require corrective pruning and intensive plant health care to improve their vigor and should be monitored for deteriorating conditions that may make them hazardous.

Relative Age Distribution

Analysis of a tree population's relative age distribution was performed by assigning age classes to the size classes of inventoried trees, offering insight into the maintenance needs of Hartford's tree resource. The inventoried trees were grouped into the following relative age classes:

- Young trees (0–8 inches DBH)
- Established trees (9–17 inches DBH)
- Maturing trees (18–24 inches DBH)
- Mature trees (greater than 24 inches DBH)

These size classes were chosen so that the inventoried tree resource can be compared to the ideal relative age distribution, which holds that the largest proportion of the inventoried tree population (approximately 40%) should be young trees, while the smallest proportion (approximately 10%) should be mature trees (Richards 1983). Since tree species have different lifespans and mature at different diameters, actual tree age cannot be determined from diameter size class alone.

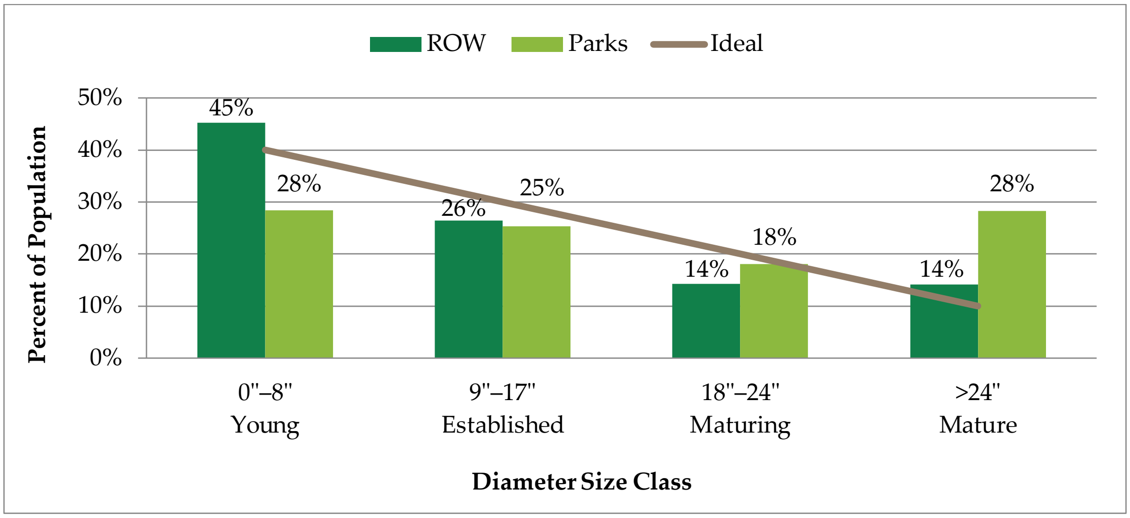


Figure 12. Relative age distribution of the inventoried trees.

Figure 12 compares Hartford's relative age distribution of the inventoried tree population to the ideal. The city's inventoried ROW tree resource trends toward the ideal, with Young and Mature trees exceeding the ideal by only 5% and 4%, respectively, and Established and Maturing trees falling short of the ideal by only 4% and 6%, respectively. The inventoried public property tree resource deviates much more strikingly from the ideal, with a nearly equal distribution of trees across the four age classes (28% Young, 25% Established, 18% Maturing, and 28% Mature). However, data collection procedures, such as not collecting trees within forested areas of public properties, could have skewed the public property relative age distribution.

Figures 10 and 11 cross-analyze the condition of the inventoried tree resource with its relative age class, providing insight into the inventoried population's stability. Across both ROW and public property populations and all age classes, most trees were rated Fair or Good. Eighty-four percent of Mature ROW trees and 83% of Maturing ROW trees are rated in Fair condition or better, which is significant because these larger trees would have a more damaging impact in the event of failure. Eighty-two percent of Established ROW trees and 88% of Young ROW trees are rated in Fair condition or better, so it's important to provide the maintenance they need to remain healthy as they age and grow. The condition ratings across age classes were similar for the inventoried public property population, with 91% of public property Mature trees and 90% of public property Maturing trees rated in Fair condition or better and 87% of public property Established trees and 89% of public property Young trees rated in Fair condition or better.

Recommendations

Hartford has a nearly ideal age class distribution within the ROW tree population. DRG recommends that the city implement a robust maintenance program, to conserve the condition of Young trees as they age so they replace removed trees and fill canopy gaps in maturity. The city should also focus on tree preservation and proactive care, to protect Mature and Maturing trees from unnecessary removal and to prevent them from succumbing to treatable defects. Tree planting efforts should continue to ensure that this distribution remains near ideal in the future. On public properties, Hartford should focus on preserving and prolonging the longevity of the existing Young, Established, and Maturing trees while investing in young plantings to bring the public property age distribution more in line with the ideal over time.

Defect Observations

For each tree inventoried, DRG assessed the structural defects present and recorded the most significant defect. Defects were limited to the following categories: dead and dying parts, broken and/or hanging branches, cracks, missing or decayed wood, tree architecture, weakly attached branches and codominant stems, root problems, other, or none.

Table 2. *Defect observations recorded during the tree inventory*

Defects	Number of Trees	Percent
Dead and Dying Parts	10,260	55%
Missing or Decayed Wood	1,755	9%
Weakly Attached Branches and Codominant stems	1,042	6%
Broken and/or Hanging Branches	916	5%
Tree Architecture	445	2%
Other	396	2%
Root Problems	220	1%
Cracks	51	0%
None	3,706	20%
Total	**18,791**	**100%**

The most frequently observed defect was dead and dying parts, recorded for 55% of the inventoried population. None, indicating no major defect, was the second most common, recorded for 20% of the inventoried population.

Recommendations

Of the 10,260 trees with the recorded defect "dead and dying parts", 906 (9%) were recommended for removal. Of the 1,755 trees with the defect "missing or decayed wood", 367 (21%) were recommended for removal. Trees with these two defects which are not recommended for removal should be pruned to remove dead or diseased wood from the crown and to improve public safety.

Photograph 3. *Many trees were recorded with missing or decayed wood. This tree has both missing and decayed wood and weakly attached branches or codominant stems.*

When considering the defect recorded for each tree, there are two important qualifiers to consider. First, the categories are broadly inclusive. For example, the "Dead and Dying Parts" category can include trees with just one or two smaller diameter dead limbs as well as trees found with large-diameter dead limbs or entire sections of dead canopy. Therefore, inferences on overall tree condition or risk rating cannot be derived solely from the presence or absence of a defect recorded during the inventory. Second, an inventoried tree may have multiple defects; the 2019 Hartford inventory recorded only the most significant defect observed for each tree. These two qualifiers are important to keep in mind when considering urban forest management planning and the prioritization of maintenance or monitoring activities.

Infrastructure Conflicts

In an urban setting, space is limited both above and below ground. Trees in this environment may conflict with infrastructure such as buildings, sidewalks, utility wires, and pipes, which could pose risks to public safety. Existing or possible conflicts between trees and infrastructure recorded during the inventory include:

- *Overhead Utilities*—The presence of overhead utility lines above a tree or planting site was noted; it is important to consider these data when planning pruning activities and selecting tree species for planting. For the 2019 inventory, *overhead utilities* were defined as primary and secondary electrical lines only and did not include service drops or telecommunication lines.
- *Infrastructure Conflicts*—Trees conflicting with signal lights, signs, residential homes, or other infrastructure were noted. These trees may need to be pruned or removed to improve visibility or mitigate risk to structures and their occupants.

Photograph 4. *Trees which obscure important traffic signs should be pruned to improve visibility. In this instance, the sign being obscured is a parking sign, which could potentially be moved to avoid the need for repeated pruning of the tree.*

Table 3. *Trees noted to be conflicting with infrastructure*

Conflict	Presence	Number of Trees	Percent
Infrastructure conflicts	Other	494	3%
	Sign	96	1%
	Residential Home	64	<1%
	Signal Light	13	<1%
	None	18,124	96%
Total		**18,791**	**100%**
Overhead Utilities	Present and Conflicting	367	2%
	Present and Not Conflicting	3,033	16%
	Not Present	15,391	82%
Total		**18,791**	**100%**

Table 3 shows that relatively few inventoried trees were conflicting with infrastructure or utilities. Less than 5% of the inventoried population was conflicting with infrastructure such as signs or signal lights. The most common infrastructure conflict was "other", with 494 trees (3%) conflicting. The "other" category primarily included conflicts with fences, although conflicts with streetlights and fire hydrants, among others, were also noted.

Only 2% of the inventoried population was recorded to be conflicting with overhead utilities. Another 16% of the inventoried population had overhead utilities present but were not conflicting with them at the time of the 2019 inventory. Since overhead utilities were defined as only primary or secondary electrical lines for the purposes of this inventory, conflicts with telecommunication lines or service drops for buildings were not considered and may be more plentiful than recorded conflicts with overhead utilities.

Recommendations

Planting only small-growing trees within 20 feet of overhead utilities, medium-size trees within 20–40 feet, and large-growing trees outside 40 feet will help improve future tree conditions, minimize future utility line conflicts, and reduce the costs of maintaining trees under utility lines.

New planting locations should be carefully assessed to ensure that trees won't obscure signs or traffic signal lights or conflict with buildings as they grow. DRG recommends that planting sites be, at minimum: 30 feet from intersections, 20 feet from fire hydrants, 20 feet from stop signs, 10 feet from other street signs, 15 feet from utility poles, 15 feet from buildings, and 10 feet from any underground utilities. Trees which are currently obscuring important traffic signals and signs should be pruned or removed to improve visibility for drivers and make the roads safer for everyone. Trees which are currently conflicting with buildings should be pruned or removed to mitigate or eliminate the possibility of damage to structures from failing tree parts.

When planting around hardscape, it is important to give the tree enough growing room above ground. Guidelines for planting trees among hardscape features are as follows: give small-growing trees 4–5 feet, medium-growing trees 6–7 feet, and large-growing trees 8 feet or more between hardscape features. In most cases, this will allow for the spread of a tree's trunk taper, root collar, and immediate larger-diameter structural roots.

Growing Space

Information about the type of the growing space was recorded. Growing space types are categorized as follows:

- Island—surrounded by pavement or hardscape (for example, parking lot dividers).
- Median—located between opposing lanes of traffic.
- Natural Area—open sites that are in areas that do not appear to be regularly maintained.
- Open/Unrestricted—open sites with unrestricted growing space on at least three sides.
- Raised Planter—in an above-grade or elevated planter.
- Tree Lawn—located between the street curb and the public sidewalk.
- Tree Well/Pit—at grade level and surrounded by sidewalk.
- Other

Most (92%) trees along the street ROW were located in tree lawns or in open/unrestricted areas (Table 4). Another 4% of the inventoried ROW trees were located in tree wells/pits. The majority (70%) of vacant planting sites and stumps, which can be considered as potential planting sites if the stump is removed, were located in tree lawns, with another 28% located in open/unrestricted areas. The majority (94%) of public property trees were located in open/unrestricted areas.

Table 4. *Growing spaces types recorded during the inventory*

Growing Space Type	ROW Trees	ROW Stumps/ Vacant Sites	ROW Total	Public Property Trees
Tree Lawn	4,201	7,510	11,711	137
Open/Unrestricted	3,498	3,055	6,553	9,725
Tree Well/Pit	726	102	828	90
Planter	179	23	202	6
Island	133	67	200	83
Median	115	30	145	43
Natural Area	60	5	65	267
Other	28	6	34	2
Total	**8,940**	**10,798**	**19,738**	**10,353**

Recommendations

Creating larger growing sites for trees in the city ROW can be the single most beneficial management practice to improve the survival rate of planted and developing trees. Increasing planting space can also reduce the amount of tree-related infrastructure conflicts, as it allows trees to be planted further from curbs and sidewalks. Depending on the site, there are several methods available to create and/or increase the growing space for newly planted trees:

- Install or enlarge tree wells/pits in existing sidewalks. Ideally, the minimum growing space of a small-sized tree is 32 square feet. Where Hartford has sidewalks of a sufficient width, the city could install tree pits with enough space remaining for the sidewalk to still comply with American Disability Act (ADA) standards.
- Planting trees 4 feet behind a curb without a sidewalk or 4 feet behind an existing sidewalk can be a low-cost alternative to more construction intensive methods. This can result in less damage to the sidewalk and give tree roots room to grow into the open soil.
- Re-routing the sidewalk around an area to create designated large tree sites is a relatively cost-effective method to increase growing spaces. This method can also be applied to existing large tree sites, where tree roots have already come in conflict with the sidewalk.
- A landscape bump-out/curb extension is a vegetative area that protrudes into the parking lane of a street to provide a growing space for plants or trees. These spaces can be used quite effectively by municipalities to beautify a streetscape, provide greater storm water retention, and slow car speeds at the bump-out location.

The useful life of a public tree ends when the cost of maintenance exceeds the value contributed by the tree. This can be due to increased maintenance required by a tree in decline, or it can be due to the costs of repairing damage caused by the tree’s presence in a restricted site. To prolong the useful life of street trees, small-growing tree species should be planted in growing spaces 4 to 6 feet wide, medium-size tree species in growing spaces 6 to 8 feet wide, and large-growing tree species in growing spaces 8 feet wide or larger.

Stocking Level

Stocking level is a traditional forestry metric used to measure the density and distribution of trees. For an urban/community forest, stocking level is used to evaluate the proportion of available planting sites which are occupied by a tree along the street ROW. Park trees and other non-ROW public property trees are excluded from this measurement.

Photograph 5. *Poorly stocked street ROW have many potential planting sites but few existing trees.*

Stocking level is the ratio of street ROW spaces occupied by trees to the total street ROW spaces suitable for trees. For example, if a municipality conducts a street tree inventory and finds 750 existing trees and 250 vacant planting sites, then the stocking level would be 75%, based on the following calculation:

750 street trees ÷ (750 street trees + 250 planting sites) = 75% stocked

DRG found that the City of Hartford had 10,057 planting sites and 741 stumps (which should be considered as possible planting sites once the stump is removed) on the ROW. Based on the data collected during this inventory, the current street ROW tree stocking level for the city is 45%. The formulas below show how the stocking level was calculated.

8,940 existing ROW trees + 10,057 ROW planting sites + 741 ROW sites with stumps

= 19,738 total grow space sites within the ROW

8,940 existing ROW trees ÷ 19,738 ROW grow spaces = ***45% stocked***

In general, DRG recommends that urban areas maintain a street ROW stocking level of at least 90%. At 45% stocked, the Hartford public tree resource has a current deficit of 8,824 trees:

19,738 total ROW grow spaces × 90% = 17,764 trees required to achieve 90% stocking level

17,764 trees required **–** *8,940 existing ROW trees =* ***8,824 additional trees*** *to reach 90%*

Over the course of the 5-year program, a total of 1,716 existing trees are recommended for removal. Additionally, the tree resource is susceptible to various threats including storms, invasive pests, and disease. Typical annual mortality rates range from 1–3% of the population. Given the inventoried population's overall condition rating of Fair, Hartford's tree resource is more likely to be on the lower end of the given range. Using a 1% annual mortality rate of 89.4 ROW trees per year, the city can anticipate removing an additional 447 trees over a 5-year period. When accounting for scheduled removals and annual mortality, DRG finds it necessary to plant 10,987 trees over the course of 5 years in order to achieve the 90% stocking ideal by Year 5 of the tree management program.

8,824 trees to reach stocking level of 90%

+

1,716 trees recommended for removal

+

447 additional trees lost over 5 years (+/-1% annual mortality rate of 8.65 trees/year)

=

10,987 total trees required to achieve 90% stocking level by Year 5.

Current stocking level varies by neighborhood within Hartford (Table 5). South Meadows was not included in the analysis as it was not fully inventoried during the 2019 inventory. Upper Albany had the highest stocking level (77%) followed by South Green (72%), South End (67%), and Downtown (66%). North Meadows had the lowest stocking level (13%), followed by South West (21%) and Behind the Rocks (34%).

Table 5. *Stocking level of Hartford neighborhoods*

Neighborhood	Number of Trees	Number of Stumps & Vacant Sites	Total Sites	Stocking Level
Upper Albany	345	103	448	77%
South Green	232	91	323	72%
South End	1,039	519	1,558	67%
Downtown	672	347	1,019	66%
Clay-Arsenal	220	163	383	57%
Frog Hollow	514	401	915	56%
Asylum Hill	428	379	807	53%
West End	927	839	1,766	52%
Barry Square	609	649	1,258	48%
Parkville	118	131	249	47%
Blue Hills	1,425	1,924	3,349	43%
Sheldon-Charter Oak	400	556	956	42%
Northeast	579	811	1,390	42%
Behind the Rocks	876	1,699	2,575	34%
South West	461	1,733	2,194	21%
North Meadows	67	445	512	13%
Total	**8,912**	**10,790**	**19,702**	**45%**

Recommendations

DRG recommends that urban areas maintain a street ROW stocking level of at least 90%, so that no more than 10% of the potential planting sites along the street ROW are vacant. An ideally stocked urban forest promotes canopy continuity and environmental sustainability while increasing the benefits provided by the urban forest. Knowledge of the existing stocking level within a tree population will inform a community's planting needs and associated budget. Generally, this entails a planned planting program that includes new installations, plant health care, and routine maintenance activities. At the current stocking level of 45%, accounting for recommended removals and anticipating a 1% annual tree mortality rate, the city needs 10,987 additional trees to achieve the ideal stocking level by the end of the five-year management plan.

Hartford has a stated goal of increasing canopy coverage within the city from ~25% to 35% and has estimated that, in order to reach this goal, approximately 3,000 trees must be planted per year over the next 50 years. While canopy coverage and stocking level are not directly comparable measurements of urban forest density, increasing stocking level will increase canopy cover and vice versa. In order to reach the ideal stocking level of 90%, DRG strongly recommends that the City of Hartford invest in planting at least 2,197 new trees per year during the 5-year tree management program. Planting programs should focus on residential neighborhoods with the lowest stocking levels, such as Behind the Rocks, before filling planting sites in well-stocked residential neighborhoods like South End. Some neighborhoods with relatively high stocking levels but few trees, such as Upper Albany, may benefit from the creation of new planting sites. Aiming for a more even stocking level across the city will help to ensure that all citizens of Hartford can enjoy the benefits of a flourishing urban forest. While increasing plantings within the city ROW and on public properties will help to achieve Hartford's canopy coverage goals, attaining a 10% increase in canopy cover cannot be achieved by increasing ROW plantings alone. Hartford will need to work with private landowners in order to increase canopy cover to 35% as outlined in the City of Hartford Tree Plan 2018-19. See Appendix A for general planting guidelines and Appendix D for a tree species planting list recommended by DRG.

SECTION 2: FUNCTIONS AND BENEFITS OF THE PUBLIC TREE RESOURCE

Public trees play an important role in improving the quality of life within a community. For example, a tree's natural beauty can soften the stark appearance of some urban landscapes. When properly maintained, trees provide communities with abundant environmental, economic, and social benefits far exceeding the investments in planting, maintaining, and removing trees throughout their lifespan.

Environmental Benefits

- Trees decrease energy consumption and moderate local climates by providing shade and acting as windbreaks.
- Trees act as mini reservoirs, helping to slow and reduce the amount of stormwater runoff that reaches storm drains, rivers, and lakes. One hundred mature tree crowns intercept roughly 100,000 gallons of rainfall per year (U.S. Forest Service 2003a).
- Trees help reduce noise levels, cleanse atmospheric pollutants, produce oxygen, and absorb carbon dioxide.
- Trees can reduce street-level air pollution by up to 60% (Coder 1996). Lovasi (2008) suggested that children who live on tree-lined streets have lower rates of asthma.
- Trees stabilize soil and provide a habitat for wildlife.

Economic Benefits

- Trees in a yard or neighborhood increase residential property values by an average of 7%.
- Commercial property rental rates are 7% higher when trees are on the property (Wolf 2007).
- Trees moderate temperatures in the summer and winter, saving on heating and cooling expenses (North Carolina State University 2012, Heisler 1986).
- On average, consumers will pay about 11% more for goods in landscaped areas, with this figure being as high as 50% for convenience goods (Wolf 1998b, Wolf 1999, and Wolf 2003).
- Consumers also feel that the quality of products is better in business districts surrounded by trees than those considered barren (Wolf 1998b).
- The quality of landscaping along the routes leading to business districts had a positive influence on consumers' perceptions of the area (Wolf 2000).

Social Benefits

- Tree-lined streets are safer; traffic speeds and the amount of stress drivers feel are reduced, which likely reduces road rage/aggressive driving (Wolf 1998a, Kuo and Sullivan 2001a).
- Chicago apartment buildings with medium amounts of greenery had 42% fewer crimes than those without any trees (Kuo and Sullivan 2001b).
- Chicago apartment buildings with high levels of greenery had 52% fewer crimes than those without any trees (Kuo and Sullivan 2001a).
- Employees who see trees from their desks experience 23% less sick time and report greater job satisfaction than those who do not (Wolf 1998a).
- Hospital patients recovering from surgery who had a view of a grove of trees through their windows required fewer pain relievers, experienced fewer complications, and left the hospital sooner than similar patients who had a view of a brick wall (Ulrich 1984, 1986).

Scientific research has repeatedly demonstrated and validated the importance of urban trees. Trees reduce air pollution, improve public health outcomes, reduce stormwater runoff, store carbon, reduce energy use, and increase property value. Using advanced analytics, such as i-Tree Eco and the i-Tree software suite, DRG calculated the benefits provided to Hartford by the inventoried tree population. Estimates of the benefits provided by the inventoried tree resource can help the city and its citizens understand the importance of maintaining the urban forest.

i-Tree Eco Analysis

i-Tree Eco is a United States Forest Service (USFS) sponsored software model that utilizes tree inventory data along with local air pollution and meteorological data to quantify the functional benefits of a community's tree resource. By framing trees and their benefits in a way that everyone can understand, dollars saved per year, i-Tree Eco helps a community to understand trees as both a natural resource and an economic investment. Knowledge of the composition, functions, and monetary value of trees helps to inform planning and management decisions, assists in understanding the impact of those decisions on human health and environmental quality, and aids communities in advocating for the necessary funding to manage their vested interest in the public tree resource appropriately.

Key Terms and Methods

Structural value, also termed 'replacement value', is a compensatory value calculated based on the local cost of having to replace a tree with a similar tree. In other words, it is a measurement of the value of the resource itself. The structural value of an urban forest is the sum of the structural values of all the individual trees contained within. Monetary values are assigned based on valuation procedures of the Council of Tree and Landscape Appraisers using information on species, diameter, condition, and location (McPherson 2007) and (Nowak et al. 2008).

The importance of a single tree species to the community can be derived from measuring the benefits provided by a particular species relative to the size of its population. This *Importance Value* (IV) calculated by the i-Tree Eco model factors in each species percentage of the total population and each species total leaf area. Analysis of the IVs can show how reliant the community is on certain tree species to provide ecosystem benefits.

Carbon sequestration refers to the capture and storage of carbon from the earth's atmosphere. The i-Tree Eco analysis reports on the gross annual amount of carbon sequestered as well as the total amount of *carbon stored* over the lifetime of the tree. For this analysis, carbon storage and sequestration values are calculated at a rate of $171 per ton. Carbon storage is considered both a functional benefit and a structural benefit of trees. *Functional benefits* are those which are produced due to physiological processes carried out by trees, while *structural benefits* are those which are produced due to the physical arrangement and composition of trees and tree parts. In i-Tree Eco, functional benefits are estimated on a yearly basis while structural benefits must be estimated over the lifespan of a tree.

Air pollution removal refers to the removal of ozone (O_3), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO), and particulate matter less than 2.5 microns ($PM_{2.5}$). For this analysis, the pollution removal value is calculated based on the prices of $4.39 per pound ($8,780/ton) of ozone, $0.23 per pound ($460/ton) of sulfur dioxide, $0.68 per pound ($1,360/ton) of nitrogen dioxide, $0.66 per pound ($1,320/ton) of carbon monoxide, and $171.16 per pound ($342,320/ton) of particulate matter less than 2.5 microns.

Avoided runoff measures the amount of surface runoff avoided when trees intercept rainfall during precipitation events. Surface runoff from rainfall contributes to the contamination of streams, rivers, lakes, and wetlands by washing oils, pesticides, and other pollutants, either directly into waterways or into drainage infrastructure that ultimately empties into waterways. For this analysis, annual avoided runoff is calculated based on the estimated amount of intercepted rainfall and the local weather in Hartford, CT, where annual precipitation in 2016 equaled 31.7 inches. The monetary value of avoided runoff is based on the U.S. Forest Service's Community Tree Guide Series at a rate of $0.07 per cubic foot.

For the purposes of calculating the economic benefits provided by Hartford's inventoried tree population, the ROW and public property populations were analyzed together. Keep in mind that i-Tree Eco only models benefits based on the data provided – since the inventoried population does not include trees on private property or in forested areas of public properties, it is safe to assume that the economic benefits provided by Hartford's entire urban forest are higher than the benefits estimated in this report. It is also important to note that i-Tree Eco does not analyze every tree collected during the inventory. Trees entered as 'unknown' species are not analyzed. The 'unknown' species designation was used only if a tree was completely dead and did not have sufficient distinguishing characteristics remaining to identify the genus or species. A total of 285 dead trees (1.52% of the inventoried tree population) were entered as 'unknown' species during the 2019 Hartford tree inventory, and thus the total number of trees analyzed in i-Tree Eco was 18,506 rather than 18,791. This means that for the purpose of this benefits section of the management plan, tree population numbers and percentages may be slightly different from those quoted elsewhere in this report.

Annual Return on Investment from the Public Tree Resource

The i-Tree Eco analysis of Hartford's inventoried trees quantified the annual functional benefits of three critical ecosystem services that they provide: air pollution removal, carbon sequestration, and avoided surface runoff.

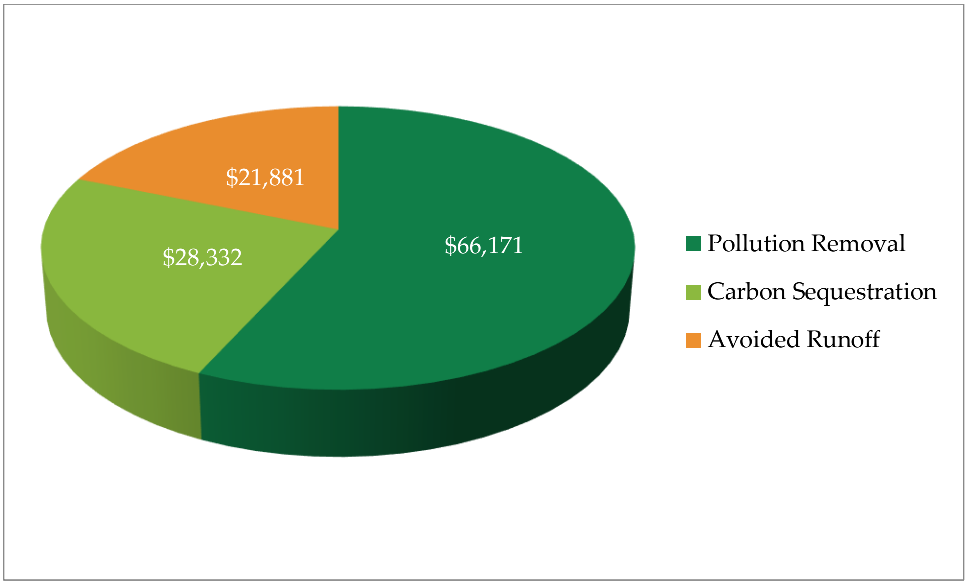


Figure 13. Estimated annual value of the inventoried tree resource functional benefits.

As seen in Figure 13, the estimated annual value of:

- All quantified functional benefits provided by the inventoried tree resource is $116,384.
- Improved air quality benefits from removing 9,440 lbs. (4.72 tons) of airborne pollutants is $66,171.
- Sequestering 332,240 lbs. (166.12 tons) of CO_2 is $28,332.
- Avoiding 2,448,440 gal (327,312 ft^3) of runoff is $21,881.

Urban environments have unique challenges that make the functional benefits provided by a public tree resource essential to the community's well-being. Compared to rural landscapes, urban landscapes are characterized by high population and high pollutant emissions in a relatively small area, often harming public health. Carbon monoxide, ozone, and other air pollutants can aggravate public health concerns and trees help to remove these pollutants from the air. Carbon dioxide, another pollutant, also causes damage as the primary greenhouse gas driving climate change, which public trees reduce by being carbon sinks that absorb and sequester carbon. Carbon sinks are the opposite of carbon sources; while carbon is emitted from cars, carbon is deposited into trees. Avoiding stormwater runoff reduces the risk of flooding and combined sewer overflow, both of which impact people, property, and the environment.

Table 6 provides a summary of the benefits provided by the most common trees in Hartford's urban forest. All tree species which comprise >1.00% of the analyzed population are listed in the table, along with the amount and value of carbon stored, amount and value of carbon sequestered per year, amount and value of avoided runoff per year, amount and value of pollution removal per year, structural value, and scaled importance value for each species.

Table 6. *Functional benefits of inventoried tree species comprising >1.00% of the inventoried population*

Most Common Trees Collected During Inventory		Number of Trees	Percent of Total Trees	Benefits Provided By Inventoried Trees									Importance Value (IV)
				Carbon Stored		Carbon Sequestered		Avoided Runoff		Pollution Removal		Structural Value	
Common Name	Botanical Name		%	tons	$ value	tons / yr	$ value / yr	ft^3 / yr	$ value / yr	tons / yr	$ value / yr	$	0-200
red maple	*Acer rubrum*	1,928	10.42%	2,004.60	$341,885.99	19.45	$3,316.91	39,270.41	$2,625.06	0.57	$7,938.64	$4,967,475.77	22.4
Norway maple	*Acer platanoides*	1,456	7.87%	1,077.09	$183,698.12	11.82	$2,016.29	36,429.65	$2,435.17	0.53	$7,364.37	$2,735,028.19	19.0
pin oak	*Quercus palustris*	1,326	7.17%	3,328.57	$567,691.18	26.65	$4,545.09	35,840.61	$2,395.80	0.52	$7,245.29	$5,314,346.28	18.1
northern red oak	*Quercus rubra*	674	3.64%	1,741.91	$297,084.34	12.21	$2,081.98	17,093.24	$1,142.61	0.25	$3,455.45	$2,895,065.42	8.9
thornless honeylocust	*Gleditsia triacanthos v. inermis*	666	3.60%	351.09	$59,878.08	4.81	$819.16	4,653.71	$311.08	0.07	$940.76	$986,799.87	5.1
cherry	*Prunus* spp.	603	3.26%	159.48	$27,199.19	2.53	$432.19	3,861.55	$258.13	0.06	$780.62	$429,726.88	4.4
sugar maple	*Acer saccharum*	573	3.10%	915.60	$156,155.65	7.94	$1,353.69	14,566.88	$973.74	0.21	$2,944.74	$2,108,217.23	7.5
Callery pear	*Pyrus calleryana*	528	2.85%	112.99	$19,270.34	2.28	$389.49	2,963.01	$198.06	0.04	$598.98	$442,902.72	3.8
eastern white pine	*Pinus strobus*	521	2.82%	398.52	$67,968.69	3.80	$647.90	12,470.40	$833.59	0.18	$2,520.93	$1,892,906.07	6.6
London planetree	*Platanus hybrida*	434	2.35%	396.58	$67,637.18	4.59	$781.63	12,967.86	$866.85	0.19	$2,621.49	$996,994.80	6.3
littleleaf linden	*Tilia cordata*	415	2.24%	238.33	$40,648.20	2.70	$461.03	8,416.98	$562.64	0.12	$1,701.52	$930,246.89	4.8
silver maple	*Acer saccharinum*	409	2.21%	961.98	$164,065.80	5.69	$969.82	16,489.86	$1,102.28	0.24	$3,333.48	$1,393,076.90	7.2
apple	*Malus* spp.	379	2.05%	109.51	$18,677.15	1.64	$279.91	2,388.88	$159.69	0.03	$482.92	$330,250.26	2.8
green ash	*Fraxinus pennsylvanica*	378	2.04%	144.59	$24,659.17	1.33	$227.14	5,417.93	$362.17	0.08	$1,095.25	$561,290.61	3.7
black cherry	*Prunus serotina*	331	1.79%	128.60	$21,933.46	1.83	$311.42	2,764.91	$184.82	0.04	$558.94	$295,815.45	2.6
black oak	*Quercus velutina*	315	1.70%	1,076.08	$183,527.23	7.44	$1,268.90	7,009.10	$468.53	0.10	$1,416.91	$1,332,429.23	3.8
serviceberry	*Amelanchier* spp.	280	1.51%	5.43	$926.49	0.22	$38.15	341.69	$22.84	0.00	$69.07	$38,629.03	1.6
swamp white oak	*Quercus bicolor*	269	1.45%	651.42	$111,100.45	4.82	$822.53	6,546.98	$437.64	0.09	$1,323.49	$1,010,016.15	3.5
American elm	*Ulmus americana*	239	1.29%	138.97	$23,701.58	1.32	$225.38	4,265.23	$285.11	0.06	$862.23	$368,225.40	2.6
Freeman maple	*Acer x freemanii*	237	1.28%	24.51	$4,180.41	0.64	$109.88	1,799.25	$120.27	0.03	$363.72	$114,593.65	1.8
tree of heaven	*Ailanthus altissima*	230	1.24%	80.65	$13,754.98	1.02	$173.95	1,836.72	$122.78	0.03	$371.30	$122,782.06	1.8
white oak	*Quercus alba*	228	1.23%	624.27	$106,470.67	4.90	$835.96	5,915.76	$395.44	0.09	$1,195.89	$1,042,769.12	3.0
Kousa dogwood	*Cornus kousa*	218	1.18%	17.40	$2,967.26	0.46	$77.92	947.61	$63.34	0.01	$191.56	$88,472.03	1.5
Japanese tree lilac	*Syringa reticulata*	209	1.13%	7.91	$1,348.34	0.26	$43.93	185.83	$12.42	0.00	$37.57	$47,724.38	1.2
flowering dogwood	*Cornus florida*	195	1.05%	10.85	$1,849.91	0.34	$57.19	733.34	$49.02	0.01	$148.25	$60,636.26	1.3
American sweetgum	*Liquidambar styraciflua*	195	1.05%	100.20	$17,089.05	1.11	$189.00	3,545.36	$236.99	0.05	$716.71	$386,655.51	2.1
other trees	~71 genera and ~189 species	5,270	28.48%	3,347.05	$570,842.60	34.32	$5,855.96	78,608.82	$5,254.69	1.12	$15,891.02	$8,921,438.82	51.3
Inventory Total	**~87 genera and ~215 species**	**18,506**	**100.00%**	**18,154.18**	**$3,096,211.51**	**166.12**	**$28,332.40**	**327,331.57**	**$21,880.76**	**4.72**	**$66,171.10**	**$39,814,514.98**	**-**

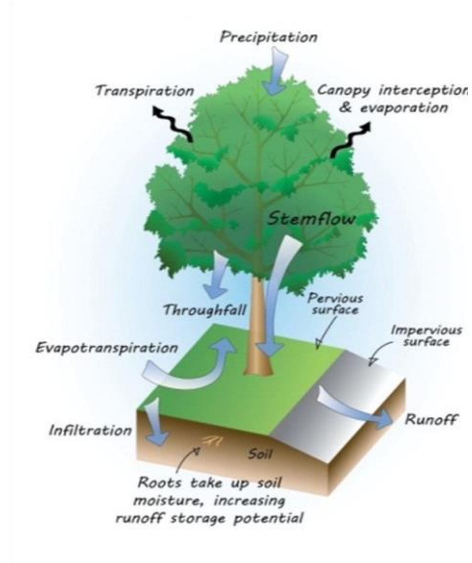
Controlling Stormwater

Trees intercept rainfall, which helps lower stormwater management costs by avoiding runoff. The inventoried trees in the City of Hartford intercept 327,332 ft^3 (2,448,443 gallons) of rainfall annually, worth an estimated $21,881. Avoided runoff comprises 19% of the annual functional benefits the inventoried trees provide.

Of all species inventoried, *Acer rubrum* (red maple) contributed the highest annual stormwater benefits. The red maple population (10.42% of the inventoried tree population analyzed in i-Tree Eco) intercepts almost 300,000 gallons of rainfall (39,270 ft^3), a service valued at $2,625 annually. However, it is not surprising that red maple contributes so greatly to reduction in stormwater runoff, as it is the most abundant tree in the i-Tree Eco dataset. Similarly, *A. platanoides* (Norway maple), *Quercus palustris* (pin oak), and *Q. rubra* (northern red oak), the next most abundant tree species, also contribute greatly to annual runoff reductions. However, *A. saccharinum* (silver maple), which is the 12th most abundant species in the inventory (409 trees, 2.21% of the dataset), was the fifth largest contributor to annual runoff reductions, diverting 123,344 gallons (16,490 ft^3) per year, a service valued at $1,102 annually.

On a per-tree basis, large trees with leafy canopies provided the most functional benefits. Callery pear (*Pyrus calleryana*) and silver maple comprised 2.85% and 2.21% of the i-Tree Eco dataset and were the 8th and 12th most abundant species in the dataset, respectively. On a per tree basis, silver maple absorb 302 gallons (302 ft^3) of rainfall annually, over seven times as much as Callery pear (42 gal. or 6ft^3 annually). This illustrates how large-statured trees with wide canopies provide significantly greater benefits than small stature trees. Another interesting comparison can be made between silver maple and thornless honeylocust (*Gleditsia triacanthos v. inermis*). On a per-tree basis, thornless honeylocust intercept 52 gallons (7ft^3) of rainfall per tree annually, less than 1/5 of the rainfall diverted by a single silver maple. This illustrates how trees with denser canopies can provide greater benefits than trees of similar stature with thinner canopies.

CANOPY FUNCTIONS



Trees provide many functions and benefits all at once simply by existing, such as:

- Catching rainfall in their crown so it drips to the ground with less of an impact or flows down their trunk
- Helping stormwater soak into the ground by slowing down runoff
- Creating more pore space in the soil with their roots, helping stormwater to move through the ground
- Cooling the surrounding landscape by casting shade with their canopy and releasing water from their leaves
- Catching airborne pollutants on their leaves and absorbing them with their roots when they wash off in the rain
- Transforming some pollutants into less harmful substances and preventing other pollutants from forming

Improving Air Quality

The inventoried tree population removes 9,440 lbs. (4.72 tons) of air pollutants annually, including sulfur dioxide (SO_2), carbon monoxide (CO), nitrogen dioxide (NO_2), ozone (O_3), and particulate matter ($PM_{2.5}$). The i-Tree Eco model estimated the value of this benefit at $66,171, which is 57% of the value of all annual benefits. As shown in Figure 14, a small reduction in $PM_{2.5}$ results in the larger dollar value of the pollutants analyzed (197 lbs. removed valued at $33,723). As with runoff reduction, the population of red maple (*Acer rubrum*, 10.42% of the i-Tree Eco dataset) provides the largest collective benefit, removing 1,140 lbs. (0.57 tons) of pollutants annually, valued at $7,939. The populations of *A. platanoides* (Norway maple), *Quercus palustris* (pin oak), and *Q. rubra* (northern red oak) are the next largest contributors to air pollution reduction. On a per-tree basis, *Juglans nigra* (black walnut) remove the largest amount of air pollution annually (1.50 lbs. per tree per year), followed by *Platanus occidentalis* (American sycamore, 1.46 lbs. per tree per year), *Betula alleghaniensis* (yellow birch, 1.25 lbs. per tree per year), and *A. saccharinum* (silver maple, 1.17 lbs. per tree per year).

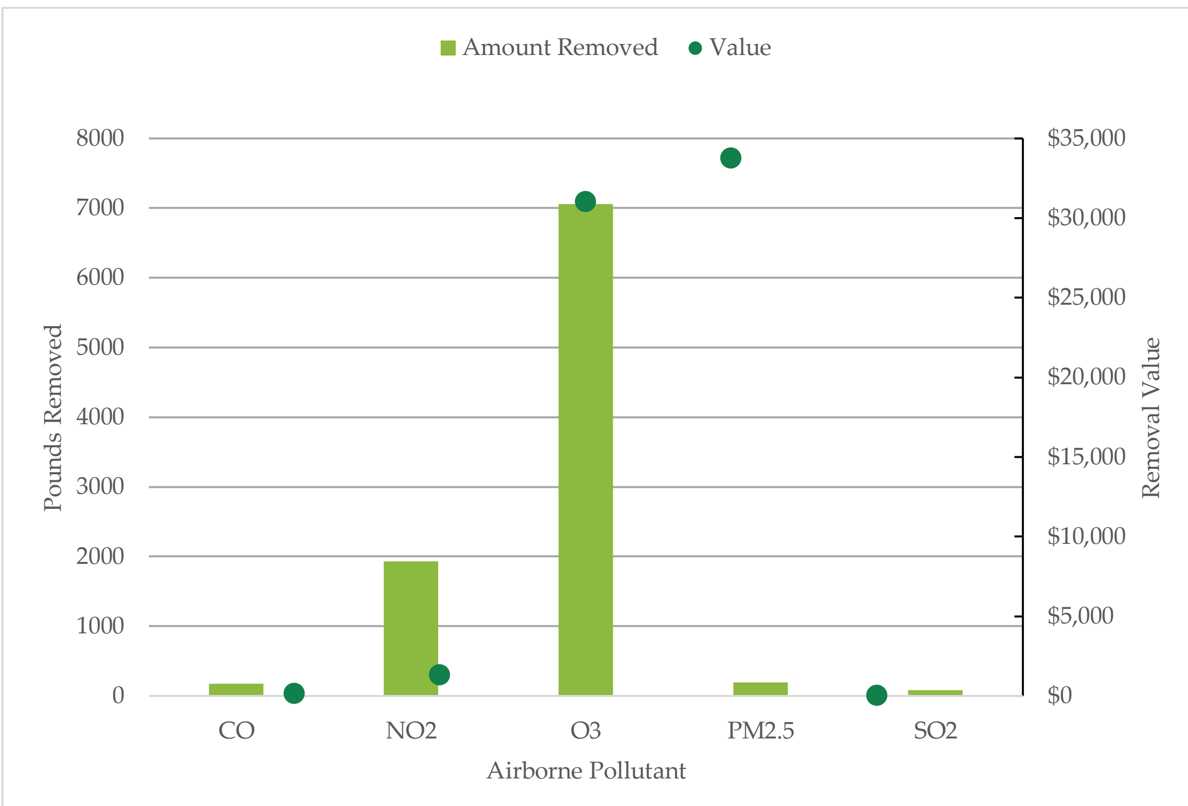


Figure 14. Estimated value of removing airborne pollution by weight and type.

Sequestering and Storing Carbon

Trees sequester carbon during photosynthesis and store it in their tissue as they grow. The i-Tree Eco model estimates both the amount of carbon sequestered per year and total carbon stored during a tree's lifetime. Hartford's inventoried trees store an estimated 18,154 tons (36,308,300 lbs.) of carbon, with an additional 166 tons (332,240 lbs.) of carbon sequestered each year. The annual carbon sequestration is valued at $28,332 and accounts for 24% of the total annual functional benefits provided by Hartford's tree resource.

Of the tree species populations analyzed, *Quercus palustris* (pin oak) currently store and sequester the most carbon in Hartford. Hartford's population of pin oak (7.17% of the analyzed population) store 6,657,140 lbs. (3,328 tons) of carbon and sequester another 53,300 lbs. (27 tons) of carbon annually, a service valued at $4,545 per year. The population of *Acer rubrum* (red maple) provides the next largest carbon storage and sequestration benefits, currently storing over 4 million lbs. (2,005 tons) of carbon and sequestering another 38,900 lbs. (19 tons) of carbon annually.

On a per tree basis, *Q. prinus* (chestnut oak), *Q. coccinea* (scarlet oak), and *Q. velutina* (black oak) provide the largest annual carbon sequestration benefits. Chestnut oak (0.03% of the i-Tree Eco dataset) sequester 68.00 lbs. of carbon per tree per year, scarlet oak (0.32% of the dataset) sequester 51.86 lbs. of carbon per tree per year, and black oak (1.7% of the dataset) sequester 47.24 lbs. of carbon per tree per year. When considering carbon storage per tree, the top performers are *Q. × leana* (Lea oak, 0.01% of the dataset) with 8.12 lbs. of carbon stored; *Q. cerris* (turkey oak, 0.02% of the dataset) with 6.68 lbs. of carbon stored; and *Ulmus procera* (English elm, 0.01% of the dataset) with 5.01 lbs. of carbon stored. However, the populations of these three species were very small and their individual carbon storage capacity may have been skewed by the large DBHs of the few individuals included in the dataset.

Energy Reduction

Trees cast shade over buildings, causing a natural cooling effect and reducing electricity use for air conditioning in the summer. Trees also divert wind around buildings, reducing natural gas use for heating in the winter. While the i-Tree Eco model used for this analysis did not have all the required inputs to calculate the annual energy benefits provided by Hartford's tree resource, the TreeKeeper® software used for this inventory utilizes an older version of i-Tree Eco (i-Tree Streets) to calculate some basic energy benefit values for the inventoried tree population . The annual energy reduction caused by the 18,747 inventoried trees included in the i-Tree Streets calculation is 1,660,274 kWh of electricity and 584,855 therms of natural gas, an annual energy savings valued at $1,056,081. This number is not included in the total annual benefits calculation due to the differences in methodology used between i-Tree Eco and i-Tree Streets. It is also important to note that i-Tree Streets is known to overestimate benefits, so these numbers may be higher than the actual energy savings provided by Hartford's inventoried trees.

Importance Value (IV) & Structural Value

The importance of a single tree species to the community can be derived from measuring the benefits provided by that species relative to the size of its population. The IV calculated by the i-Tree Eco model is the sum of the species' percentage of the inventoried population and the species' percentage of the total inventoried leaf area. The IV can range from 0 to 200, with higher IVs suggesting greater dominance of a species within the urban forest. Since leaf area is an important input into many of the benefit calculations used in i-Tree Eco, as is the size of the species population, higher IVs can suggest higher reliance on a given species to provide ecosystem benefits to the community.

Table 7. *Inventoried species with an importance value of ≥2*

Common Trees Collected During Inventory		Number of Trees	Percent of Total Trees	Percent Leaf Area	Importance Value
Common Name	Botanical Name		%	%	0-200
red maple	*Acer rubrum*	1,928	10.4%	11.1%	22.4
Norway maple	*Acer platanoides*	1,456	7.9%	10.9%	19.0
pin oak	*Quercus palustris*	1,326	7.2%	5.2%	18.1
northern red oak	*Quercus rubra*	674	3.6%	4.5%	8.9
sugar maple	*Acer saccharum*	573	3.1%	5.0%	7.5
silver maple	*Acer saccharinum*	409	2.2%	3.8%	7.2
eastern white pine	*Pinus strobus*	521	2.8%	4.0%	6.6
London planetree	*Platanus hybrida*	434	2.3%	1.5%	6.3
thornless honeylocust	*Gleditsia triacanthos v. inermis*	666	3.6%	2.6%	5.1
littleleaf linden	*Tilia cordata*	415	2.2%	1.2%	4.8
cherry	*Prunus* spp.	603	3.3%	0.9%	4.4
Callery pear	*Pyrus calleryana*	528	2.9%	2.1%	3.8
black oak	*Quercus velutina*	315	1.7%	1.7%	3.8
green ash	*Fraxinus pennsylvanica*	378	2.0%	2.0%	3.7
swamp white oak	*Quercus bicolor*	269	1.5%	1.8%	3.5
white oak	*Quercus alba*	228	1.2%	0.7%	3.0
apple	*Malus* spp.	379	2.0%	0.8%	2.8
black cherry	*Prunus serotina*	331	1.8%	1.3%	2.6
American elm	*Ulmus americana*	239	1.3%	1.4%	2.6
Norway spruce	*Picea abies*	145	0.8%	1.1%	2.2
American sweetgum	*Liquidambar styraciflua*	195	1.1%	1.1%	2.1
Japanese zelkova	*Zelkova serrata*	179	1.0%	1.1%	2.0
other trees	*~73 genera and ~193 species*	6,315	34.1%	34.2%	56.3
Inventory Total	**~87 genera and ~215 species**	**18,506**	**100.0%**	**100.0%**	**-**

As shown in Table 7, the i-Tree Eco assessment found that *Acer rubrum* (red maple), the most common species in the inventoried population, comprising 10.4% of the dataset, has the highest IV in Hartford's analyzed public tree resource at 22.4. *A. platanoides* (Norway maple) and *Quercus palustris* (pin oak), the next most common species in the dataset (7.9% and 7.2%, respectively) also had the next largest IVs (19.0 and 18.1, respectively). Despite being as abundant as *Q. rubra* (northern red oak), *Gleditsia triacanthos* var. *inermis* (thornless honeylocust) had a lower IV (5.1 compared to 8.9 for red oak). This can be attributed to the lower percent leaf area of thornless honeylocust (2.6% compared to 4.5% for northern red oak), demonstrating how trees with denser canopies contribute more to the benefits produced by the urban forest than trees with thinner canopies. The relatively high IVs of *A. saccharum* (sugar maple), *A. saccharinum* (silver maple), and *Platanus hybrida* (London planetree) indicate that these species likely provide more benefits to the community than their abundance alone would lead one to believe.

Structural value, also called replacement value, can be defined as the cost of replacing a tree with a similar tree, and thus is a measurement of value of the tree resource, itself. Structural values for the most abundant species in the Hartford inventory can be found in Table 6. The species with the highest total structural value was pin oak, with a structural value of $5,314,346. The populations of red maple, northern red oak, and Norway maple also had high structural values ($4,967,476, $2,895,065, and $2,735,028, respectively). On a per tree basis, *Q. cerris* (turkey oak), *Q*. x *leana* (Lea oak), and *Tilia tomentosa* (silver linden) had the highest structural values ($12,950 per tree, $11,913 per tree, and $9,740 per tree, respectively). These species represented very small proportions of the inventoried population and their high structural values are likely due to the size of the few individuals included in the inventory

Benefits of Increasing the Urban Canopy

Hartford has an ambitious goal of increasing tree canopy coverage from 2019 levels (~25%) to 35%. In order to accomplish this task, around 3,000 new trees will need to be planted every year for the next 50 years (City of Hartford Tree Plan 2018-19). Such a vigorous planting program will require significant investment of time and money and will necessitate a strong commitment from Hartford's city foresters, forestry crew, Department of Public Works, outside contractors, and city government. The city will not only need to increase the stocking level of public streets within Hartford but will also need to incentivize private landowners to plant and care for trees on their properties. Achieving this ambitious goal will not be easy; however, the potential benefits of increasing canopy cover in Hartford are significant. Table 8 provides a comparison of the benefits provided by the inventoried tree canopy versus three scenarios: first, that no trees are planted over a ten-year period; second, that 50 trees are planted each year for 10 years; and third, that the DRG recommended 2,197 trees are planted each year for 5 years (refer back to Section 1, Stocking Level, for an explanation of how the 2,197 planting number was derived). In all future scenarios, a standard rate of tree removal is assumed, which is either partially or totally offset by new plantings under the two future scenarios which include tree planting.

Photograph 6. *A dense urban canopy provides many benefits to the community, including carbon storage/sequestration, improved air quality, runoff reduction, and aesthetic value.*

As shown in Table 8, Hartford could see a reduction of over $2M in benefits, nearly 2/3 of the benefits provided by the trees inventoried in 2019, if no planting occurs over the next ten years. This reduction in benefits under a scenario with no planting can be attributed to a reduction in tree canopy as trees fail and are removed without replacement. Under a planting scenario where 50 trees are planted annually for 10 years, some of the benefits provided by Hartford's urban canopy increase, including nitrogen dioxide removal, property values, and stormwater benefits. However, these increases do not offset the losses in all other benefit categories, and even while planting 50 new trees per year, Hartford would still stand to lose over $1M of the benefits currently provided by the inventoried urban forest. Some of the reduction in benefits under this planting scenario can be attributed to replacing mature, failing trees with young trees – the smaller size of young plantings will not immediately offset the loss of mature trees. However, considering that 1,716 trees were recommended for removal during the 2019 inventory, the planting of 500 trees over 10 years would not replace even these anticipated removals, let alone increase canopy cover. Under the DRG recommended planting program of 2,197 trees planted each year for five years, not only would losses due to tree removals be offset, but the benefits provided by Hartford's tree canopy would increase by over 600 times current levels, primarily through increased carbon storage capacity. Keep in mind that these are only the short-term benefits of an ambitious planting program – as new plantings grow and mature, benefits will increase even further. This illustrates that, while Hartford's goal of planting 3,000 trees a year for the next 50 years may be challenging to complete, the benefits that could be provided by such a dramatic increase in urban canopy would be well worth the investments of time and money needed.

Table 8. *Monetary tree benefits under three tree planting scenarios*

Hartford, CT Monetary Tree Benefits				
Benefits	Inventoried Tree Canopy	Tree Canopy Decrease (10 years)	Tree Canopy Decrease (10 years)	Tree Canopy Increase (5 years)
	Inventory collected 2019-2020	No trees have been replaced	50 trees planted at a DBH of 2" every year for 10 years	2,197 trees planted at a DBH of 2" every year for 5 years
Carbon (ton)				
Carbon Storage	$3,096,211.51	$826,657.85	$2,018,544.53	$2,506,581,706.95
Carbon Sequestration	$28,332.40	$211.48	$9,271.10	$12,233.55
value based on price of $170.55 per ton				
Air Quality				
Carbon	$114.70	$3.08	$79.77	$101.48
value based on price of $0.66 per pound				
Nitrogen dioxide	$130.37	$29.45	$925.06	$1,204.84
value based on price of $0.68 per pound				
Ozone	$31,007.53	$722.32	$21,868.41	$28,359.19
value based on price of $4.39 per pound				
Sulfur dioxide	$18.96	$0.43	$12.81	$16.58
value based on price of $0.23 per pound				
Particulate matter	$33,723.33	$686.01	$24,099.91	$31,829.46
value based on price of $171.16 per pound				
Miscellaneous				
Property Value	$549,570.61	$516,596.37	$582,544.85	$584,523.30
based on PNW Research Station of 6% value change				
Stormwater	$21,880.76	$21,545.76	$22,215.70	$30,141.52
value based on price of $0.067 cubic feet				
Total	**$3,760,990.17**	**$1,366,452.75**	**$2,679,562.14**	**$2,507,270,116.87**
Change from 2019 inventory	**-**	**-$2,394,537.42**	**-$1,081,428.03**	**$2,503,509,126.70**

Interpreting Table 8

A great deal of information can be derived from the scenarios laid out in Table 8. For an example of how to interpret the information given for a single benefit, see the example below.

Stormwater: The current value of stormwater runoff reduction provided by the inventoried trees is estimated at $21,881. If no trees are planted over the next ten years, this value will drop to $21,546 by the end of the tenth year. Under a scenario in which 50 trees are planted annually for the next ten years, this value will increase to $22,216 by the end of the tenth year. Under DRG's recommended planting program (2,197 trees per year for the next five years) this value will increase to $30,142 by the end of the fifth year.

Recommendations

Carbon storage (total value of the carbon stored by trees throughout their lifetimes) and structural value (total cost of replacing all analyzed inventory trees) were valued at $3,096,212 and $39,814,515, respectively. With a $42.9M price tag on the city's inventoried tree population and $116,384 worth of benefits provided every year, it becomes clear why this public resource is worthy of investment. In Hartford, *Acer rubrum* (red maple), *A. platanoides* (Norway maple), and pin oak *Quercus palustris* (pin oak) account for more than a quarter of the analyzed tree resource as well as a third of the functional benefits it provides. If any of these species were lost to invasive pests, disease, or other threats, the loss would be felt more than the community may realize. It is critical to promote species diversity with future plantings to minimize exposure to future threats and to plant large-statured broadleaf tree species wherever possible to maximize potential environmental and economic benefits. See Appendix D for a tree species planting list recommended by DRG.

SECTION 3: RECOMMENDED MANAGEMENT OF THE TREE RESOURCE

Extreme & High Risk

- All Extreme and High Risk tree maintenance should be completed as soon as possible because these trees have serious defects that are a public safety concern.

Further Inspection

- Trees with a requirement in the Further Inspection data field have defects that could become worse and increase their risk, which should be assessed by an arborist as soon as possible.

Moderate Risk

- All Moderate Risk tree maintenance should be evaluated and considered after all Extreme and High Risk tree maintenance has been completed, because these trees have defects with greater risk.

Routine Inspection

- Routine Inspections detect significant defects before their risk level increases. Inventoried trees should be routinely inspected using windshield surveys and attended to as needed.

Routine Pruning

- Routine Pruning cycles correct defects before their risk level increases, and should begin after all Extreme and High Risk tree maintenance has been completed.

Young Tree Training

- Young Tree Training cycles improve tree structure so they do not develop defects that become risks in the future, and should begin when Routine Pruning cycles begin.

Low Risk

- All Low Risk tree maintenance should be performed when convenient, after all Extreme, High, and Moderate Risk tree maintenance has been completed.

Stump Removal

- Stump removals should be performed when convenient, ideally before a planting season begins so additional planting sites become available.

Tree Planting

- Tree planting is important for replacing removed trees, reaching ideal stocking levels, and meeting canopy goals, but tree maintenance is often a greater priority.

During the inventory, both a risk rating and a recommended maintenance activity were assigned to each tree. DRG recommends prioritizing and completing each tree's recommended maintenance activity based on the assigned risk rating. See Appendix E for further information on the risk assessment and rating system and priority versus proactive maintenance. This five-year tree management program takes a multi-faceted and proactive approach to tree resource management.

Risk Management and Recommended Maintenance

Although tree removal is usually considered a last resort and may sometimes create a reaction from the community, there are circumstances in which removal is necessary. Trees fail from natural causes, such as diseases, insects, and weather conditions, and from physical injury due to vehicles, vandalism, and root disturbances. Trees should be removed when corrective pruning will not adequately eliminate the hazard or when correcting problems would be cost-prohibitive. Trees that cause obstructions or interfere with power lines or other infrastructure should be removed when their defects cannot be corrected through pruning or other maintenance practices. Diseased and nuisance trees also warrant removal. Even though large short-term expenditures may be required, it is important to secure the funding needed to complete priority tree removals, as expedient removal reduces risk and promotes public safety. DRG recommends that tree maintenance activities are prioritized and completed based on the risk rating that was assigned to each tree during the inventory. The following section describes recommended maintenance for each risk rating category.

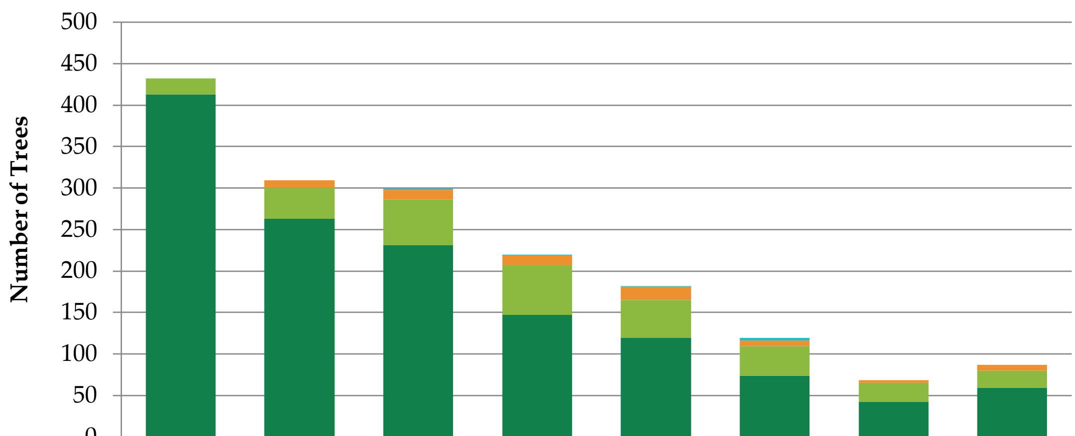
High Priority Recommended Maintenance

Pruning or removing Extreme, High, and Moderate Risk trees is strongly recommended to be prioritized and completed as soon as possible. Addressing Extreme, High, and Moderate Risk trees in a timely and proactive manner may require significant resources to be secured and allocated. However, peforming this work expediently will mitigate risk, improve public safety, and reduce long-term costs.

High Priority Removals

This maintenance should be performed immediately based on assigned risk rating and may be performed concurrently with other Extreme, High, and Moderate Risk pruning. Extreme, High, and Moderate Risk trees recommended for removal generally have extensive defects that cannot be resolved through pruning or other maintenance procedures and are located in places where their failure is likely to cause property damage or bodily harm to Hartford's citizens. Extreme, High, and Moderate Risk removals may be costly, but it is important to secure funding to complete these tasks in a timely manner to improve public safety and mitigate risk.

Photograph 7. *Dead and decaying trees along major streets can pose a significant risk to people and property and should be removed immediately.*



	1″–5″	6″–10″	11″–15″	16″–20″	21″–25″	26″–30″	31″–35″	≥36″
Extreme	0	0	1	1	1	3	0	0
High	0	9	12	12	16	7	3	7
Moderate	19	37	55	60	46	35	23	21
Low	413	263	231	147	119	74	42	59

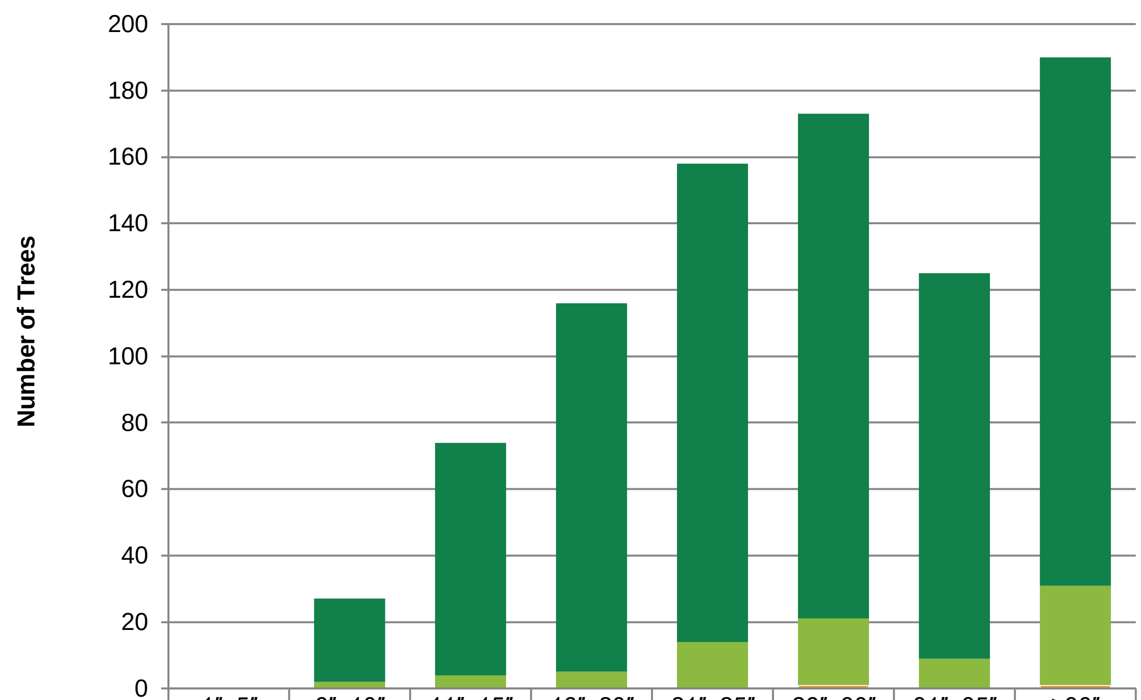
Diameter Size Class

Figure 15. Recommended removals by size class and risk rating.

The July–September 2019 inventory identified 6 Extreme Risk trees (<1% of total recommended removals), 66 High Risk trees (4% of total recommended removals), and 296 Moderate Risk trees (17% of total recommended removals) recommended for removal (Figure 15). Most of these trees were between 6" and 30" DBH.

High Priority Pruning

This maintenance should be performed immediately based on assigned risk rating and may be performed concurrently with other Extreme, High, and Moderate Risk removals. Extreme, High, and Moderate Risk pruning generally requires removing defects such as dead, decaying, and/or broken branches that may be present in the crown of both small and large trees, even when most of the tree is sound. In these cases, pruning the defective branch(es) can correct the problem, reducing risk associated with the tree and promoting healthy growth.



	1″–5″	6″–10″	11″–15″	16″–20″	21″–25″	26″–30″	31″–35″	≥36″
Moderate	0	25	70	111	144	152	116	159
High	0	2	4	5	14	20	9	30
Extreme	0	0	0	0	0	1	0	1

Figure 16. Priority pruning by risk rating.

The 2019 inventory identified a total of 863 trees recommended for priority pruning. Figure 16 presents these trees categorized by risk rating and diameter size class. Less than 1% of these were Extreme Risk trees (2 trees), 10% were High Risk trees (84 trees), and 90% were Moderate Risk trees (777 trees). Most trees recommended for priority pruning were larger than 16” DBH.

Recommendations

DRG recommends that trees be removed when pruning will not correct their defects, eliminate the hazards that their defects cause, or when corrective pruning would be cost-prohibitive. The 2019 inventory identified 368 Extreme, High, and Moderate Risk trees recommended for removal. These trees should be removed immediately based on their risk rating and size class. A further 863 Extreme, High, and Moderate Risk trees were recommended for pruning. These trees, while not requiring removal, should be pruned immediately to remove defective parts and mitigate risk. Prompt attention to these trees is important not only to prevent injury or property loss in the event of tree failure, but to promote healthy growth and prolong the useful life of these public assets. Extreme, High, and Moderate Risk removals and pruning can be done concurrently. Trees with the highest risk ratings and DBHs should be dealt with first, followed by lower risk ratings and smaller DBHs.

Further Inspection

In the ANSI A300 system, there are three levels of risk assessment. Each level is built on the one before it. The lowest level is designed to be a cost-effective approach to quickly identifying tree risk concerns while the highest level is intended to provide in-depth information about a tree. These levels are:

- **Level 1** inspection is defined as a Limited Visual assessment, which is often conducted as a walk through or windshield survey designed to identify obvious defects or specified conditions. Level 1 inspections should be done annually and after storm events.
- **Level 2** inspection is defined as a Basic assessment and is a detailed, 360-degree visual inspection of a tree and its surrounding site, and a synthesis of the information collected. A level 2 inspection of all inventoried trees was conducted as part of the 2019 Hartford inventory.
- **Level 3** inspection is an Advanced assessment and is performed to provide detailed information about specific tree parts, defects, targets, or site conditions. A level 3 inspection may use specialized tools or require the input of an expert.

The Further Inspection data field indicates whether a tree requires additional and/or future inspections to assess and/or monitor conditions that may cause it to become a risk to people, property, or other trees. The inventory identified 439 trees (2% of the inventoried tree population) requiring one of three inspection types. Further Inspections are beyond the scope of a standard tree inventory, and can be one of the following:

- Multi-year annual inspection (e.g., a healthy tree that has been impacted by recent construction, weather, or other damage OR a tree with a defect that does not yet merit removal but will likely require extra care or removal should the defect worsen).
- Level III risk assessment (e.g., a tree with a defect requiring additional or specialized equipment for investigation).
- Insect/disease monitoring (e.g., a tree that appears to have an emerging insect or disease problem).

- No further inspection required

The 2019 Hartford inventory found 214 trees recommended for an advanced Level 3 inspection, 64 trees recommended for annual/multi-year inspections, and 161 trees recommended for insect and disease monitoring (Table 9).

Table 9. *Trees recommended for further inspection*

Further Inspection	Number of Trees	Percent
Level 3 Assessment	214	1.1%
Insect/Disease Monitoring	161	0.9%
Multi-Year Annual	64	0.3%
None	18,352	97.7%
Total	**18,791**	**100.0%**

Recommendations

Trees with a Further Inspection requirement should be assessed by an ISA certified arborist as soon as possible because the longer hazardous conditions are left unaddressed, the greater a risk that a tree becomes. For the same reason, the management that the arborist recommends should be performed as soon as possible to minimize risk.

The 214 trees recommended for a Level 3 inspection should be assessed by an ISA certified arborist as soon as possible. These trees may require more detailed inspection of the crown using a bucket truck or further investigation of root damage or stem decay using advanced methods such as root excavation or sonic tomography.

Many of the 161 trees recommended for insect/disease monitoring are *Fraxinus* spp. (ash) or *Tsuga canadensis* (eastern hemlock) with signs or symptoms of emerald ash borer (EAB, *Agrilus planipennis*) or hemlock woolly adelgid (HWA, *Adelges tsugae*). Trees recommended for insect or disease monitoring should be inspected by a qualified arborist to verify the presence of an insect or disease pest, and appropriate mitigation strategies should be taken to avoid or control the spread of the insect or disease pest to uninfected trees.

The 64 trees recommended for annual/multi-year inspections were mostly trees with missing or decayed wood which, while not immediately requiring tree removal, will likely worsen over time and eventually necessitate the removal of these trees. However, if continued surveys of these trees show them to be providing community benefits while posing a low risk to public safety, it is beneficial to retain them.

Low Priority Recommended Maintenance

Tree removals and pruning of Low Risk trees are recommended to be completed after all trees in the Extreme, High, and Moderate Risk categories have been addressed.

Low Priority Pruning & Removals

The 2019 Hartford inventory identified 8,025 Low Risk trees recommended for pruning (Figure 17) and 1,348 Low Risk trees recommended for removal (Figure 15). Low Risk trees requiring pruning or removal are generally small dead trees, invasive species or trees that have poor form or structure. If corrective pruning cannot address a tree's issues and/or adequately eliminate the hazard than the tree should be removed. Low Risk tree removals should be addressed after all higher risk tree maintenance activities have been completed. Low Risk trees designated for pruning should be included in a proactive Routine Pruning Cycle after all the higher risk trees are addressed.

Recommendations

DRG identified 1,348 Low Risk trees recommended for removal. Low Risk removals pose little threat; these trees are generally small, dead, invasive, or poorly formed trees that need to be removed. Eliminating these trees will reduce breeding site locations for insects and diseases and will increase the aesthetic value of the area. Healthy trees growing in poor locations or undesirable species are also included in this category. Low Risk trees should be removed when convenient and after all Extreme, High, and Moderate Risk removals and pruning have been completed.

DRG identified 8,025 Low Risk trees recommended for pruning. Low Risk pruning may include routine crown cleaning for small dead limbs, structural pruning to correct defects before they become problems, and removal of larger dead limbs or other defects from trees in more remote areas where tree failures are unlikely to impact people or property. Tree recommended for Low Risk pruning should be included in a three-year routine pruning cycle once all priority work has been completed.

Routine Inspections

Inspections are essential to uncovering potential problems with trees. They should be performed by a qualified arborist who is trained in the art and science of planting, caring for, and maintaining individual trees. Arborists are knowledgeable about the needs of trees and are trained and equipped to provide proper care. Ideally, the arborist will be International Society of Arboriculture (ISA) Certified and hold the ISA Tree Risk Assessment Qualification (TRAQ) credential.

Recommendations

All trees along the street ROW and in high-use areas of public properties should be regularly inspected and attended to as needed. When trees require additional or new work, they should be added to the maintenance schedule. The budget should also be updated to reflect the additional work. Utilize computer management software such as TreeKeeper® to make updates, edits, and keep a log of work records. In addition to locating potential new hazards, inspections also present an opportunity to look for signs and symptoms of pests and diseases. Hartford has a large population of trees that are susceptible to pests and diseases, including ash, maple, and oak.

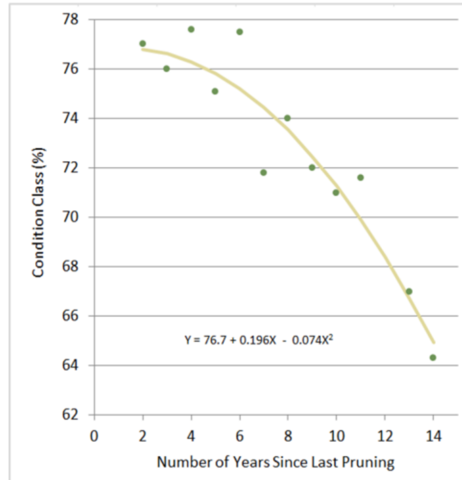
DRG recommends that Hartford perform inspections of inventoried trees by windshield survey (inspections performed from a vehicle) in line with *ANSI A300 (Part 9)* guidelines annually and after all severe weather events to identify new potential hazards, signs of pests, and symptoms of disease. When trees need additional maintenance, they should be added to the work schedule immediately. Use asset management software such as TreeKeeper® to update inventory data and schedule work records.

Routine Pruning Cycle

The Routine Pruning Cycle includes all Low Risk trees that received a primary maintenance need of Prune or None during the inventory. Over time, routine pruning can minimize reactive maintenance, limit instances of elevated risk, and provide the basis for a robust risk management program. Included in this cycle are Low Risk trees that require pruning and pose some risk but have a smaller defect size and/or a lower probability of impacting a target and trees which do not currently require pruning but which should still be assessed for pruning and other maintenance needs routinely.

The length of the Routine Pruning Cycle is primarily driven by the number of trees that a municipality can feasibly prune each year with its budget and is secondarily driven by the size of the public tree resource. The Routine Pruning Cycle duration selected by Hartford is three years but may extend up to seven years if resources are not available to maintain a three-year pruning cycle. However, extending the Routine Pruning Cycle beyond seven years is not recommended, because tree condition has been demonstrated to deteriorate significantly when routine pruning cycles are longer than seven years. This is because long periods between routine maintenance allow once-minor defects to worsen, reducing tree health and potentially increasing risk (Miller and Sylvester 1981).

PROACTIVE PRUNING



Relationship between tree condition and years since previous pruning. (adapted from Miller and Sylvester 1981)

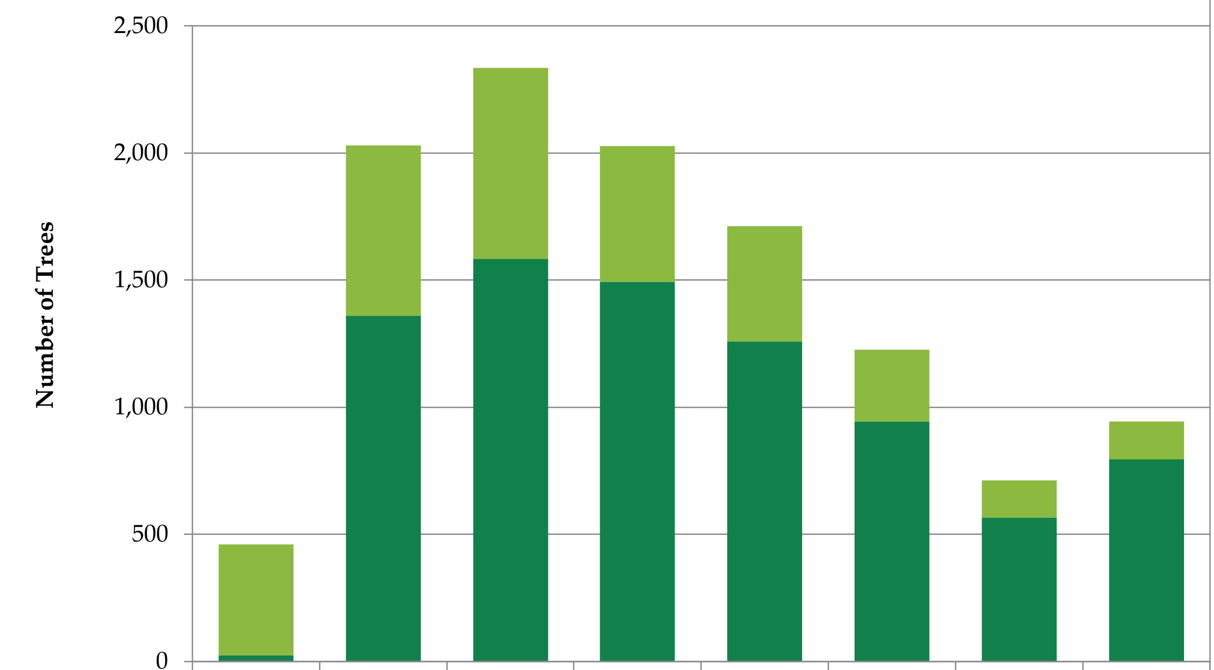
Miller and Sylvester studied the pruning frequency of 40,000 street trees in Milwaukee, Wisconsin. Trees that had not been pruned for more than 10 years had an average condition rating 10% lower than trees that had been pruned in the previous several years. Their research suggests that a five-year pruning cycle is optimal for urban trees.

Routine pruning cycles help detect and correct most defects before they become hazardous. DRG recommends that pruning cycles begin after all Extreme and High Risk tree maintenance has been completed.

DRG recommends two pruning cycles: a Young Tree Training Cycle and a Routine Pruning Cycle. A newly planted tree will enter the Young Tree Training Cycle once it becomes established and will move into the Routine Pruning Cycle when it reaches maturity. A tree should be removed and eliminated from the Routine Pruning Cycle when it outlives its usefulness.

Approximately 61% of the inventoried tree population would benefit from routine pruning. Figure 17 shows that a variety of size classes are recommended for routine pruning; however, most of the trees were smaller than 25” DBH. Most trees less than 6” DBH were recommended for the Young Tree Training Cycle. Trees less than 6” DBH that were included in the Routine Pruning Cycle were small diameter conifers with minor defects that could be corrected by pruning or that were interfering with overhead utilities.

Photograph 8. *This tree has small dead branches in the crown that should be removed during the Routine Pruning Cycle. Routine pruning of this tree when it was younger could have prevented the weakly attached codominant stems that have formed.*



	1″–5″	6″–10″	11″–15″	16″–20″	21″–25″	26″–30″	31″–35″	≥36″
Low Risk None	437	669	751	534	453	281	146	149
Low Risk Prune	24	1,360	1,584	1,492	1,259	945	565	796

Diameter Size Class

Figure 17. Routine Pruning Cycle by diameter class.

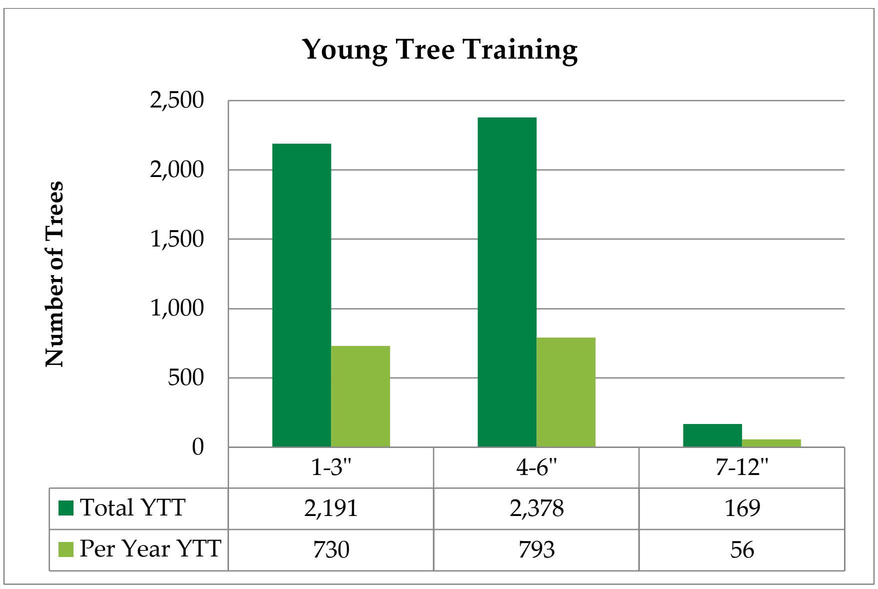
Recommendations

Hartford's inventory found 11,445 trees that should be routinely pruned. This works out to around 3,815 trees that should be pruned each year during the three-year Routine Pruning Cycle duration selected by the city. If a three-year cycle proves unfeasible, a five-year Routine Pruning Cycle with approximately 2,289 trees pruned each year, a six-year Routine Pruning Cycle with approximately 1,907 trees pruned each year, or a seven-year Routine Pruning Cycle with approximately 1,635 trees pruned each year is acceptable considering the inventoried tree population's size. DRG recommends that the Routine Pruning Cycle begins in Year One of this five-year plan, after all Extreme and High Risk Recommended Maintenance is complete.

Young Tree Training Cycle

Trees included in the Young Tree Training Cycle are generally less than 8 inches DBH but may be up to 12 inches DBH. These younger trees sometimes have branch structures that can lead to potential problems as the tree ages. Potential structural problems include codominant leaders, multiple limbs attaching at the same point on the trunk, or crossing/interfering limbs. If these problems are not corrected, they may worsen as the tree grows, increasing its risk rating and creating potential liability. The recommended length of a Young Tree Training Cycle is three years because young trees tend to grow at faster rates than mature trees.

The Young Tree Training Cycle differs from the Routine Pruning Cycle in that the Young Tree Training Cycle generally only includes trees that can be pruned from the ground with a pole pruner or pruning shear.



	1-3"	4-6"	7-12"
Total YTT	2,191	2,378	169
Per Year YTT	730	793	56

Figure 18. Young Tree Training Cycle by diameter class.

Recommendations

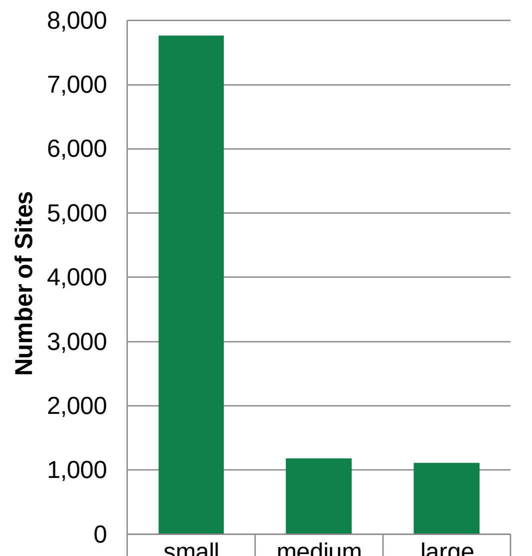
DRG recommends that Hartford implement a three-year Young Tree Training Cycle beginning after the completion of all Extreme and High Risk Recommended Maintenance activities. During the inventory, 4,738 trees less than or equal to 12 inches DBH were inventoried and recommended for young tree training. Since Hartford has so many young trees, the Young Tree Training Cycle is vital for the future condition of the inventoried tree population. An average of 1,579 trees should be trained with structural pruning each year over three years, beginning in Year One of the management program.

When new trees are planted, they should enter the Young Tree Training Cycle after establishment, typically within 2–3 years after planting. In future years, the number of trees in the Young Tree Training Cycle will be based on tree planting efforts and growth rates of young trees. The city should strive to training prune approximately one-third of its young trees each year.

Tree Planting and Stump Removal

The inventory identified 1,238 stumps recommended for removal. There was a wide range of stump sizes from 1 inch to 84 inches DBH. Stump removals should occur when convenient and be converted to vacant planting sites if the site is appropriate for tree plantings.

The inventory identified 10,062 vacant sites. Only five of these sites were located on public properties, either along the edges of the parks within the ROW or in tree wells in the parks. Of the 10,062 total vacant sites identified, the majority (7,769 sites, 77%) were small vacant sites. These sites have a minimum dimension of 4 to 6 feet and as such are only suitable for planting small stature trees. A further 12% (1,180) of the sites were medium vacant sites with a minimum dimension of 6 to 8 feet, and the remaining 11% (1,113 sites) were large vacant sites with a minimum dimension of at least 8 feet. Figure 19 shows the number of each type of vacant site collected during the inventory.



	small	medium	large
Hartford	7,769	1,180	1,113

Figure 19. Vacant planting sites.

Recommendations

Planting new trees in areas where there is sparse canopy should be a priority. It is also important to plant more trees in areas with poor canopy continuity or gaps in existing canopy because while Hartford as a whole receives value from the ecosystem services provided by the public tree resource, those benefits are not distributed evenly across the city. Planting should focus on residential neighborhoods with low stocking levels (refer to Table 5) and should prioritize installing medium and large stature trees whenever possible to maximize the benefits provided by new plantings.

The useful life of a public tree ends when the cost of maintenance exceeds the value contributed by the tree. This can be due to increased maintenance required by a tree in decline, or it can be due to the costs of repairing damage caused by the tree's presence in a restricted site. The Right Tree in the Right Place is a mantra for tree planting used by the Arbor Day Foundation and many utility companies nationwide. Trees come in many different shapes and sizes, and often change dramatically over their lifetimes. Before selecting a tree for planting, make sure it is the right tree—know how tall, wide, and deep it will be at maturity. Equally important to selecting the right tree is choosing the right spot to plant it. Blocking an unsightly view or creating shade may be a priority, but it is important to consider how a tree may impact existing utility lines and hardscape as it grows taller, wider, and deeper. If the tree at maturity will reach overhead lines, or conflict with sidewalks and curbs, it is best to choose another tree or a different location. To prolong the useful life of street trees, small-growing tree species should be planted in growing spaces 4 to 6 feet wide, medium-size tree species in growing spaces 6 to 8 feet wide, and large-growing tree species in growing spaces 8 feet wide or larger.

Creating larger growing sites for trees in the city ROW can be the single most beneficial management practice to improve the survival rate of planted and developing trees. Increasing planting space can also reduce the amount of tree-related infrastructure conflicts, as it allows trees to be planted further from curbs and sidewalks. Depending on the site, there are several methods available to create and/or increase the growing space for newly planted trees:

- Install or enlarge tree wells/pits in existing sidewalks. Ideally, the minimum growing space of a small-sized tree is 32 square feet. Where Hartford has sidewalks of a sufficient width, the city could install tree pits with enough space remaining for the sidewalk to still comply with American Disability Act (ADA) standards.
- Planting trees 4 feet behind a curb without a sidewalk or 4 feet behind an existing sidewalk can be a low-cost alternative to more construction intensive methods. This can result in less damage to the sidewalk and give tree roots room to grow into the open soil.
- Re-routing the sidewalk around an area to create designated large tree sites is a relatively cost-effective method to increase growing spaces. This method can also be applied to existing large tree sites, where tree roots have already come in conflict with the sidewalk.
- A landscape bump-out/curb extension is a vegetative area that protrudes into the parking lane of a street to provide a growing space for plants or trees. These spaces can be used quite effectively by municipalities to beautify a streetscape, provide greater storm water retention, and slow car speeds at the bump-out location.

The ideal stocking level for street ROW recommended by DRG is 90%. By comparison, Hartford's stocking level is only 45%. In order to achieve a 90% stocking level by year five of the five-year management plan, DRG recommends that the city plant at least 2,197 trees each year. For Hartford to achieve its stated goal of increasing canopy coverage from ~25% to 35% over the next 50 years, even more than 2,197 trees will need to be planted each year and for a much longer duration than just five years. Such extensive planting will require the city to not only fill extant vacant sites along the street ROW, but to also create new planting sites both on public and private property. The city will need to encourage private landowners to plant new trees on their properties and care for existing trees in order achieve this ambitious canopy coverage goal.

A list of suggested tree species for Hartford to plant is provided in Appendix D. These tree species are specifically selected for Hartford's climate and the species, genus, and family composition of the inventoried tree resource. This list is not exhaustive but can be used as a guideline for species that meet community objectives and are readily available through growers. The provided species lists may be used in conjunction with any existing list of approved species for the city. Although not always possible, choosing native species to plant rather than exotic species can help to improve habitat for Hartford's wildlife and insects.

Maintenance Schedule and Budget

Utilizing 2019 City of Hartford tree inventory data, an annual maintenance schedule was developed detailing the recommended tasks to complete each year. DRG made budget projections using industry knowledge and public bid tabulations. ***Projected costs are based on the estimated price of hiring contractors to complete all management tasks, and as such, will overestimate the cost of completing management tasks using city owned equipment and in-house staff.*** A complete table of estimated costs for Hartford's three-year tree management program follows (Table 10).

This schedule provides a framework for completing the recommended inventoried tree maintenance over the next three years. Years four and five are included to provide an estimate of the annual cost of routine maintenance activities including routine pruning, young tree training, and planting. Following this schedule can shift tree maintenance activities from being reactive to a more proactive tree care program, and costs will decrease somewhat as costly priority pruning and removals are completed.

To implement the maintenance schedule, Hartford's tree maintenance budget should be:

- No less than $3,579,918 for the first year of implementation.
- No less than $6,739,465 for the second and third years combined.
- No less than $2,696,355 per year for the final two years of the maintenance schedule.

The above estimates were made using the DRG recommended 2,197 new tree plantings each year for five years in order to increase the ROW stocking level to 90% (refer to Section 1, Stocking Level, for details on the derivation of this planting goal). However, if Hartford wants to achieve the city's goal of increasing canopy coverage to 35%, then around 3,000 new plantings will need to be installed every year for the next 50 years (City of Hartford Tree Plan 2018–19). The cost of this aggressive planting program alone would be around $2,400,000 per year. The planting costs provided in the budget table assumed that purchased trees will be 2 to 2.5 inch caliper, balled and burlapped trees with a one-year warranty. Watering costs are based on a single watering at the time of planting.

Long-term, additional budget funds are needed to ensure that Extreme and High Risk trees are expediently managed and that the vital Young Tree Training and Routine Pruning cycles can begin to reduce long-term tree risk concerns. In addition to the funding needed for these routine maintenance cycles, additional funding should be set aside for storm response, similar to how funding is currently allocated for snow removal. Storm response can be very costly, and having a dedicated fund for such activities as debris removal and post-storm tree inspection and pruning will help Hartford to be prepared for future extreme weather events (see Section 4: Storm Preparedness Plan for further information on storm response). If routing efficiencies and/or contract specifications allow more tree work than expected to be completed in a given year, or if this maintenance schedule requires adjustment to meet budgetary or other needs, then the maintenance schedule should be modified accordingly. Unforeseen situations such as severe weather events may arise and change the maintenance needs of trees. If maintenance needs change, then budgets, staffing, and equipment should be adjusted to meet the new demand. The urban forestry program should use this report to help advocate for increased funding.

It is important to understand that the budgetary outlines provided in this plan are aspirational. While it may not be possible to achieve the recommendations outlined here immediately, these budgetary figures do reflect the concept that a healthy, vibrant, and well-managed urban forest requires monetary investment. To achieve the benefits Hartford desires from its urban trees, additional resources beyond the current urban forestry budget are necessary. This plan can help the city advocate for additional funds. Any additional funding, however modest, will help Hartford improve its urban forestry program.

Table 10. *Estimated costs for five-year tree management program*

Estimated Costs for Each Activity			Year 1		Year 2		Year 3		Year 4		Year 5		Five-Year Cost
Activity	Diameter	Cost/Tree	# of Trees	Total Cost	# of Trees	Total Cost	# of Trees	Total Cost	# of Trees	Total Cost	# of Trees	Total Cost	
Extreme, High, and Moderate Risk Removals	1-5"	$90	10	$900	9	$810	-	-	-	-	-	-	$1,710
	6-10"	$225	23	$5,175	23	$5,175	-	-	-	-	-	-	$10,350
	11-15"	$575	34	$19,550	34	$19,550	-	-	-	-	-	-	$39,100
	16-20"	$1,080	37	$39,960	36	$38,880	-	-	-	-	-	-	$78,840
	21-25"	$1,820	32	$58,240	31	$56,420	-	-	-	-	-	-	$114,660
	26-30"	$2,430	23	$55,890	22	$53,460	-	-	-	-	-	-	$109,350
	31-35"	$2,900	14	$40,600	12	$34,800	-	-	-	-	-	-	$75,400
	>35"	$3,900	15	$58,500	13	$50,700	-	-	-	-	-	-	$109,200
Activity Total(s)			**188**	**$278,815**	**180**	**$259,795**	**-**	**-**	**-**	**-**	**-**	**-**	**$538,610**
Low Risk Removals	1-5"	$90	137	$12,330	138	$12,420	138	$12,420	-	-	-	-	$37,170
	6-10"	$225	87	$19,575	88	$19,800	88	$19,800	-	-	-	-	$59,175
	11-15"	$575	77	$44,275	77	$44,275	77	$44,275	-	-	-	-	$132,825
	16-20"	$1,080	49	$52,920	49	$52,920	49	$52,920	-	-	-	-	$158,760
	21-25"	$1,820	39	$70,980	40	$72,800	40	$72,800	-	-	-	-	$216,580
	26-30"	$2,430	24	$58,320	25	$60,750	25	$60,750	-	-	-	-	$179,820
	31-35"	$2,900	14	$40,600	14	$40,600	14	$40,600	-	-	-	-	$121,800
	>35"	$3,900	19	$74,100	20	$78,000	20	$78,000	-	-	-	-	$230,100
Activity Total(s)			**446**	**$373,100**	**451**	**$381,565**	**451**	**$381,565**	**-**	**-**	**-**	**-**	**$1,136,230**
Extreme, High, and Moderate Risk Pruning	1-5"	$62	-	-	-	-	-	-	-	-	-	-	-
	6-10"	$126	14	$1,764	13	$1,638	-	-	-	-	-	-	$3,402
	11-15"	$183	37	$6,771	37	$6,771	-	-	-	-	-	-	$13,542
	16-20"	$223	58	$12,934	58	$12,934	-	-	-	-	-	-	$25,868
	21-25"	$275	79	$21,725	79	$21,725	-	-	-	-	-	-	$43,450
	26-30"	$312	87	$27,144	86	$26,832	-	-	-	-	-	-	$53,976
	31-35"	$415	63	$26,145	62	$25,730	-	-	-	-	-	-	$51,875
	>35"	$450	95	$42,750	95	$42,750	-	-	-	-	-	-	$85,500
Activity Total(s)			**433**	**$139,233**	**430**	**$138,380**	**-**	**-**	**-**	**-**	**-**	**-**	**$277,613**
Routine Pruning (3-year cycle based on Low Risk Pruning)	1-5"	$40	154	$6,160	154	$6,160	153	$6,120	154	$6,160	154	$6,160	$30,760
	6-10"	$80	676	$54,080	676	$54,080	677	$54,160	676	$54,080	676	$54,080	$270,480
	11-15"	$150	778	$116,700	778	$116,700	779	$116,850	778	$116,700	778	$116,700	$583,650
	16-20"	$220	675	$148,500	675	$148,500	676	$148,720	675	$148,500	675	$148,500	$742,720
	21-25"	$280	571	$159,880	571	$159,880	570	$159,600	571	$159,880	571	$159,880	$799,120
	26-30"	$310	408	$126,480	409	$126,790	409	$126,790	408	$126,480	409	$126,790	$633,330
	31-35"	$370	237	$87,690	237	$87,690	237	$87,690	237	$87,690	237	$87,690	$438,450
	>35"	$460	315	$144,900	315	$144,900	315	$144,900	315	$144,900	315	$144,900	$724,500
Activity Total(s)			**3814**	**$844,390**	**3815**	**$844,700**	**3816**	**$844,830**	**3814**	**$844,390**	**3815**	**$844,700**	**$4,223,010**
Young Tree Training (3-year cycle)	1-12"	$45	1,579	$71,055	1,579	$71,055	1,579	$71,055	1,579	$71,055	1,579	$71,055	$355,275
Activity Total(s)			**1,579**	**$71,055**	**1,579**	**$71,055**	**1,579**	**$71,055**	**1,579**	**$71,055**	**1,579**	**$71,055**	**$355,275**

Estimated Costs for Each Activity			Year 1		Year 2		Year 3		Year 4		Year 5		Five-Year Cost
Activity	Diameter	Cost/Tree	# of Trees	Total Cost	# of Trees	Total Cost	# of Trees	Total Cost	# of Trees	Total Cost	# of Trees	Total Cost	
Tree Planting	Purchasing	$550	2,198	$1,208,900	2,198	$1,208,900	2,197	$1,208,350	2,197	$1,208,350	2,197	$1,208,350	$6,042,850
	Planting	$220	2,198	$483,560	2,198	$483,560	2,197	$483,340	2,197	$483,340	2,197	$483,340	$2,417,140
	Watering	$30	2,198	$65,940	2,198	$65,940	2,197	$65,910	2,197	$65,910	2,197	$65,910	$329,610
Activity Total(s)			**6,594**	**$1,758,400**	**6,594**	**$1,758,400**	**6,591**	**$1,757,600**	**6,591**	**$1,757,600**	**6,591**	**$1,757,600**	**$8,789,600**
Stump Removals	1-5"	$50	57	$2,850	57	$2,850	56	$2,800	-	-	-	-	$8,500
	6-10"	$100	56	$5,600	56	$5,600	55	$5,500	-	-	-	-	$16,700
	11-15"	$125	56	$7,000	57	$7,125	56	$7,000	-	-	-	-	$21,125
	16-20"	$195	53	$10,335	53	$10,335	54	$10,530	-	-	-	-	$31,200
	21-25"	$250	49	$12,250	50	$12,500	50	$12,500	-	-	-	-	$37,250
	26-30"	$310	39	$12,090	39	$12,090	39	$12,090	-	-	-	-	$36,270
	31-35"	$375	31	$11,625	31	$11,625	31	$11,625	-	-	-	-	$34,875
	>35"	$425	71	$30,175	71	$30,175	71	$30,175	-	-	-	-	$90,525
Activity Total(s)			**412**	**$91,925**	**414**	**$92,300**	**412**	**$92,220**	**-**	**-**	**-**	**-**	**$276,445**
Admin, Legal, Outreach, Training				$10,000		$10,000		$10,000		$10,000		$10,000	$50,000
Inspections and Inventory Updates				$3,000		$3,000		$3,000		$3,000		$3,000	$15,000
Infrastructure Repair and Storm Response				$10,000		$10,000		$10,000		$10,000		$10,000	$50,000
Activity Grand Total			**13,466**		**13,463**		**12,849**		**11,984**		**11,985**		**63,747**
Cost Grand Total				**$3,579,918**		**$3,569,195**		**$3,170,270**		**$2,696,045**		**$2,696,355**	**$15,711,783**

SECTION 4: STORM PREPAREDNESS PLAN

Introduction

The City of Hartford, Connecticut lies in a climate zone that exhibits four distinct seasons. This creates the potential for rapid changes in temperature, humidity, and barometric pressure, and sets the stage for severe weather events, such as tornadoes, thunderstorms, hurricanes, hail, high winds, ice, and snow.

Severe weather can cause catastrophic damage and create significant volumes of vegetative debris that requires processing. To prepare for these scenarios, proactive cities have developed emergency response and recovery plans. Traditionally, these plans address serious public safety and health issues, but commonly overlook the necessity of addressing trees and woody debris in the mitigation efforts.

When catastrophic disasters, such as tornadoes, ice storms, and severe straight-line winds strike a metropolitan center, thousands to millions of cubic yards of debris are produced. Trees and vegetation can account for approximately 30% of this debris volume. Beyond the task of collecting and disposing of this debris are additional urban forest management considerations, including increased threat to life, hindrance to life-saving efforts, power outages, and personal and public property damage. The impacts of these additional tree-related considerations are not always quantifiable but can overwhelm the city's storm response services and slow down the recovery process.

Severe Weather Events in Hartford

The severe weather events most commonly experienced in Connecticut include snow and ice storms, tornadoes, and tropical storms/hurricanes. These types of severe weather events generally include high winds that can cause partial or whole tree failure, particularly in trees with preexisting defects. Full canopies on trees during the summer and fall months when tornadoes and hurricanes are most common and accumulation of ice and snow on branches during the winter when blizzards and ice storms manifest can increase the dynamic loading experienced by trees and tree parts during severe weather events, increasing the chances of failure.

Even relatively low wind speeds can cause tree damage in trees that are fully leafed-out. Wind speeds from 45 to 57 miles per hour can cause small, healthy limbs to break as well as damaging larger dead or weakened branches. At 58 to 74 miles per hour, large, healthy branches will break, and shallowly rooted trees may be uprooted. Widespread tree damage with trees snapped or uprooted can occur at wind speeds from 75 to 89 miles per hour, and above 90 miles per hour even large and healthy trees may be snapped or uprooted. Full tree failure may occur at wind speeds as low as 30 miles per hour if the soil is heavily saturated, while much higher wind speeds may be required to cause damage when trees are not leafed out.

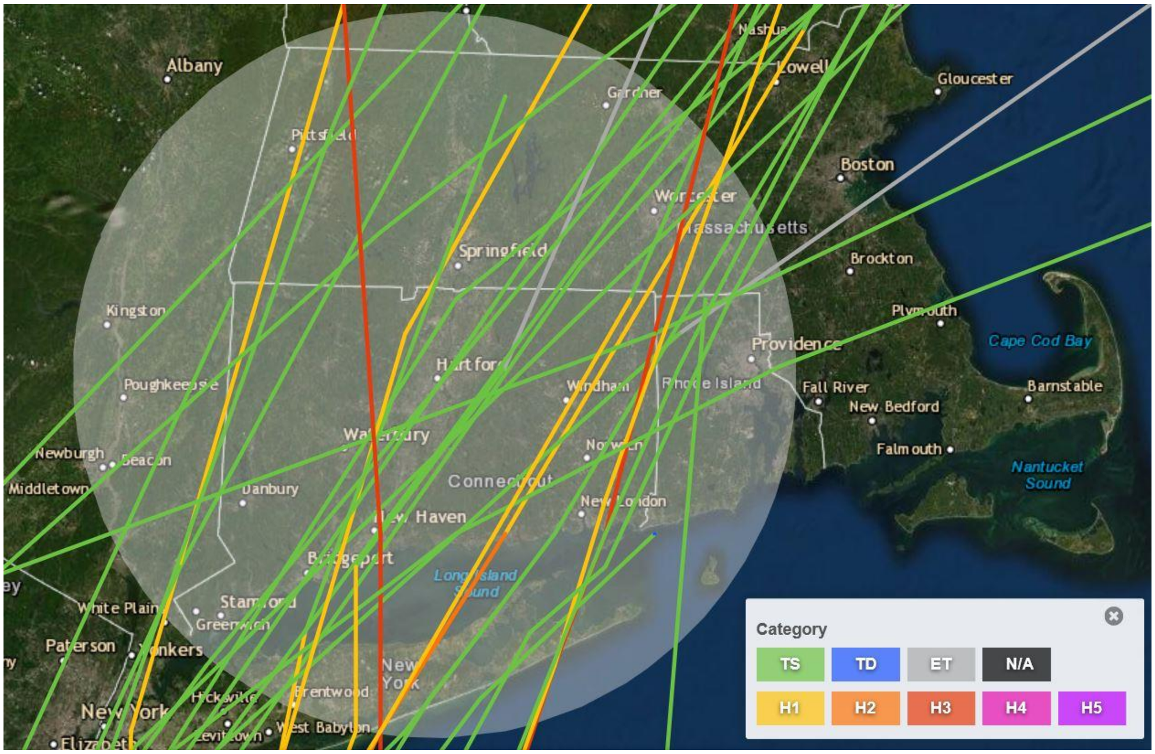


Figure 20. Tropical storm and hurricane tracks within 65 nautical miles of Hartford, CT since 1851. Figure courtesy of the Historical Hurricane Track tool, NOAA.

According to the National Oceanic and Atmospheric Administration's Historical Hurricane Tracking tool, a total of 23 tropical storms and 9 hurricanes have made landfall within 65 nautical miles of Hartford since 1851 (Figure 20). The most severe hurricanes to impact the Hartford area were an unnamed Category 3 hurricane in 1938 (colloquially referred to as "The Long Island Express" or "Great New England Hurricane") and Hurricane Carol in 1954. The most recent tropical storm to impact the Hartford area was Irene in 2011. Tropical storms produce winds between 39 and 73 miles per hour, while the most severe hurricanes experienced by Connecticut have been category 3 hurricanes, which can produce sustained wind speeds of up to 129 miles per hour. Even category 1 hurricanes, with wind speeds not exceeding 95 miles per hour, can uproot poorly rooted trees and snap large branches.

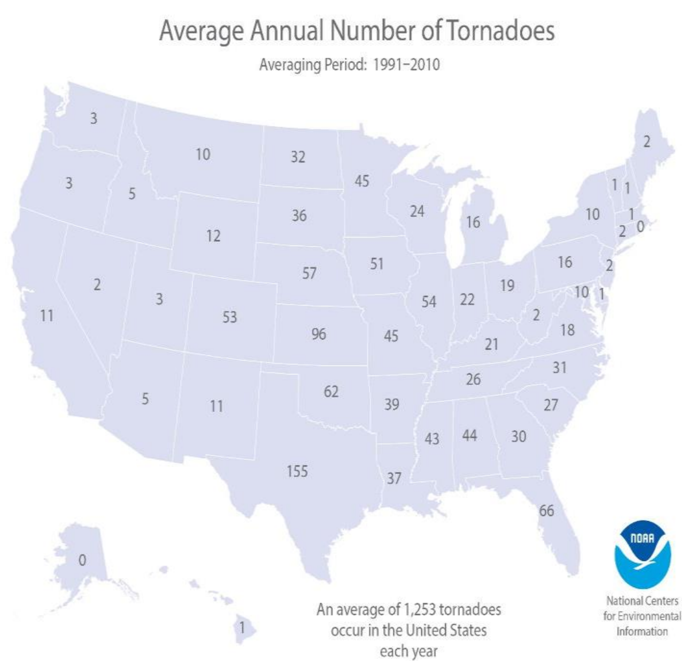


Figure 21. Average annual number of tornadoes by state, 1991–2010. Figure courtesy of Climate.gov and NOAA.

The National Weather Service's Storm Prediction Center reports that since 1950, 109 tornadoes touched down in Connecticut, 19 of which touched down directly in Hartford County. These tornadoes have ranged in magnitude from F0 to F4 on the Fujita Scale. F0 magnitude tornadoes have winds less than 73 miles per hour while F4 tornadoes can produce winds up to 260 miles per hour. Even winds below 73 miles per hour can uproot poorly rooted trees and break branches, particularly if a tree has a preexisting defect. On average, Connecticut experiences two tornadoes every year (Figure 21).

Other high wind events are also common in Connecticut. Between 1996 and 2019, 30 high wind events were recorded in Hartford County, with a minimum windspeed of 40 miles per hour and a maximum wind speed of 71 miles per hour. A further 328 thunderstorm wind events were recorded during the same time period, which produced gusts of at least 58 miles per hour.

A total of 61 winter storms and winter weather events, including one blizzard in 2013 and four ice storms, have been recorded by the National Center for Environmental Information in Hartford County since 1996. These types of storms, in addition to producing wind gusts of at least 58 miles per hour, frequently produce large quantities of ice and snow which may build up on trees, exacerbating wind loading and leading to tree damage. Many Hartford residents have vivid memories of October 2011 when Winter Storm Alfred dumped feet of snow and ice on the city. The damage caused by this storm was particularly severe, as trees had not yet dropped their leaves for the season, and roads were blocked for days with snow, downed trees, and, most concerningly, live electrical wires brought down by snow and tree failures. City residents were without power for days or weeks as electric companies scrambled to effectively clear streets and restore power and concerns remain that electric grid restoration priorities within Hartford are not clearly defined, slowing power restoration efforts after major storms.

While any individual type of severe weather event may seem uncommon, when considered together, severe weather is not a rarity for Hartford. Many types of weather events can produce the high winds required to cause significant damage to Hartford's urban forest. Proactive maintenance is the best form of preparation a community can take for the potential damage brought by severe weather.

Impact of Climate Change

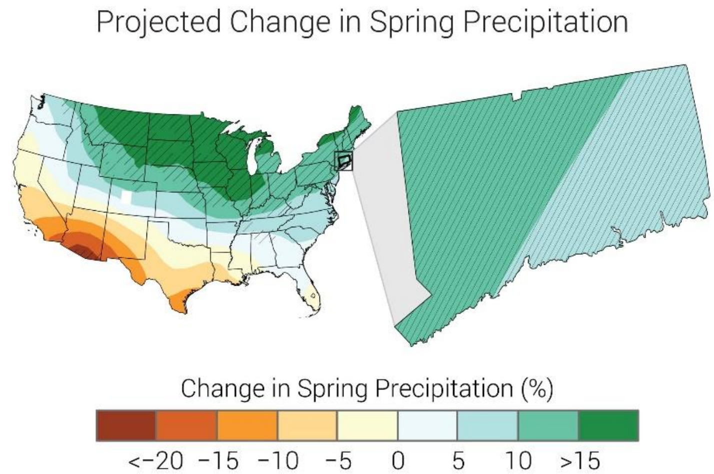


Figure 22. Projected spring precipitation increase by the middle of the 21st century under a higher emissions pathway.

Figure courtesy of National Centers for Environmental Information and NOAA.

The climate is changing, both worldwide and in Connecticut, specifically. 2019 was the second-warmest year on record, and nine of the ten warmest years on record have occurred since 2005. Since 1950, the average temperature in Hartford has risen by almost 2º F, while the state as a whole has warmed by nearly 3º F, twice the warming experienced by the contiguous United States as a whole over the past 100 years. Heavy precipitation events, driven by increases in temperature, have increased by 55% in New England in the past 60 years, with flash floods becoming more and more common. Meanwhile, drought conditions have also worsened, with increases in precipitation occurring during the winter and spring months but no concurrent increase in summer and fall precipitation to offset hotter conditions.

Global climate change has sparked a sense of urgency for urban forestry professionals, as weather and climate are integrally tied to urban forest health. As a result of climatic changes, increases in the frequency and severity of storms are occurring throughout the East Coast. This impacts urban forests in several ways:

- Increased drought conditions lead to more stress on urban trees, weakening natural resistance to extreme weather events.
- More storm damage and subsequent loss of trees.
- Poorly or infrequently managed trees are more susceptible to breakage in storms.
- Premature post-storm tree removals on private land tend to occur, often as a result of fear and lack of professional assessment.
- More frequent power outages from trees situated next to power lines.
- High volumes of stormwater runoff due to extensive impervious surfaces and shrinking amounts of green land cover, exacerbating existing issues of erosion and pollution.

A comprehensive urban forest management plan greatly reduces storm hazards through proper planting and preventative maintenance. However, when disasters occur, an emergency plan as an addendum to this plan can provide solid data, facts, and protocols to ensure service continuity and timely recovery and restoration.

Funding and Budget for Urban Forest Emergencies

While the scope of this plan does not permit detailed budgeting estimates, Hartford is strongly encouraged to analyze past catastrophic storm events (hurricanes, tornadoes, flooding) and provide for enough regular funding and contingency funding to support an adequate response for various levels of storm damage. Information on storm emergency categories can be found in Appendix F. Storm and emergency response will require funding for staff overtime, contractual services, and equipment rental.

Removal of debris from public property is eligible for reimbursement from the Federal Emergency Management Agency (FEMA) under most cases when a federal disaster has been declared and when it constitutes an immediate threat to life, public safety, or improved property. This includes the removal of tree debris (downed limbs, trees) and the pruning or removal of trees to remove imminent hazards (hanging limbs or trees so damaged that they are structurally unstable). Any tree debris located on public rights-of-way are eligible. This includes material that originated on private property that is dragged to the right-of-way by residents during a specified period.

In order to receive FEMA funding, it is critical to be prepared and fully document all losses and money spent. Most damage assessments through FEMA must be done immediately after the disaster event. The calculated dollar amount is then sent to the County Emergency Management Director. FEMA has a public assistance program that is open to municipal departments and nonprofit hospitals. These grants can be applied for to assist with a variety damages, including debris removal and emergency protective measures.

Historically, FEMA funding for storm damage mitigation reimbursements have been made available in Connecticut. Most recently, over $1 million in public assistance grants were provided in the state after a severe storm and flooding in September of 2018.

Storm-Related Training

The Hartford DPW and forestry staff should receive safety and technical training through in-the-field and classroom methods. To ensure safe and effective work, staff should receive regular and updated training sessions for first-aid, CPR, chainsaw use, tree risk assessment, and minimum approach distances for energized electric lines. These topics should be considered as basic minimum training opportunities.

Additional training should be provided to key personnel in topics that include electric hazard assessment (EHAP), aerial lift training, advanced climbing, crane operations, and aerial rescue. Consider having key staff members receive training to become ISA Certified Arborists. Develop annual “scenario training” with tree emergency response topics and situations. DRG also strongly recommends that Hartford train key urban forestry staff in FEMA documentation procedures to ensure that the city does not miss opportunities to be reimbursed for storm-related damages.

Population Characteristics Related to Storm Damage

With the recent 2019 public tree inventory data, the vulnerability of Hartford's urban forest to severe weather events can be assessed more accurately. Certain species of trees are more prone to breaking and splitting in storms and high winds, for example, *Acer saccharinum* (silver maple) and *Pyrus calleryana* (Callery pear). Trees that are under utility lines and have been poorly pruned in the past are more prone to storm damage, as are trees in poor condition or with crown, trunk, or root defects. Trees under stress from insect and disease pressures are also more likely to fail in a storm. Therefore, it is beneficial to examine the urban forest data to do a generalized vulnerability assessment of Hartford in terms of its urban forest resource. Keep in mind that only trees which were inventoried in 2019 are included in the following assessment; trees located on private property and in forested areas of public properties were not inventoried but are also susceptible to storm damage.

Tree Condition, Defects, and Maintenance

Generally, trees in poorer condition and with more severe defects are more susceptible to storm damage than healthy trees. Storm preparedness maintenance activities should prioritize mitigation of the defects on poorer condition trees. Trees with the defects of dead and dying parts, missing or decayed wood, and weakly attached branches and codominant stems are at increased risk of failure during storm-related events. Tree location should also be considered when prioritizing storm preparedness plans. Maintenance needs of trees along primary transportation routes should be prioritized in order to avoid road blockages. Maintenance of trees near electric lines should also be prioritized in order to avoid interruptions in electric service and mitigate electrical hazards.

Extreme, High, and Moderate risk removals and pruning should be completed immediately to mitigate risk as outlined in Section 3 of this management plan. Additional proactive storm preparedness maintenance should be prioritized based on tree condition, maintenance recommendation, and primary defect. Trees with Poor or Fair condition ratings, an existing defect (especially dead and dying parts, weakly attached branches, or missing or decayed wood) and which are recommended for pruning to reduce risk associated with their condition and defects can be considered at an elevated risk of failure during extreme weather events. Hartford's city-wide 2019 tree inventory identified 7,930 trees with a condition rating of Poor or Fair, a defect other than None, and a primary maintenance need of Prune in order to mitigate the defect; 605 (8%) of these storm-susceptible trees are in Poor condition and 7,325 (92%) are in Fair condition. Among the trees in Fair condition, 5,544 (76%) are noted with dead and dying parts, 384 (5%) are noted with weakly attached branches and codominant stems, and 457 (6%) are noted with missing or decayed wood. These trees can be considered at an elevated risk of failure during storm events and should be pruned, removed, or otherwise maintained to decrease the chance that they will fail in storm events.

Of the 7,930 storm-susceptible trees, 1,517 (19%) are located near primary or secondary electrical lines. These trees are likely to have been utility pruned to provide clearance for aerial electrical lines. Utility pruning, while important to prevent tree interference with important electric utilities, often creates unbalanced crowns which can predispose trees near utility lines to failure under increased loading from wind or ice. Topping cuts, which are common in utility pruning, can promote the growth of poorly attached branches which may become large enough to cause damage if they fail. Partial or complete failure of these trees could result in electrical hazards or power interruptions to Hartford's residents.

In addition to health of a tree, age has shown to be a factor during storms. Mature trees tend to be larger in size with more severe consequences from failure. Storm preparedness management for the urban forest should prioritize maintenance work by emphasizing mature trees, using tree DBH as a proxy for age. Any mature trees that have been around recent construction pose an increased risk due to potential for stress and damage to root zones. Of the 7,325 storm-susceptible trees listed in Fair condition, 4,434 (61%) are 18" DBH and larger. The largest storm susceptible tree in Fair condition is 80" DBH.

Trees under stress due to insect or disease pressures are at a higher risk of complete or partial failure during storms. Signs and symptoms of pest insects or diseases, including emerald ash borer, hemlock wooly adelgid, gypsy moth, and Dutch elm disease, were identified on 155 trees during the 2019 tree inventory. These trees should be monitored for defects that could predispose them to failure under storm conditions and appropriate maintenance actions should be taken to reduce the risk of these trees becoming a hazard. Hartford has many public trees that are susceptible to insect and disease threats in and around Connecticut (see Section 1, Pest Susceptibility for a list of these pests). Susceptible species should be inspected on a regular schedule to identify diseases and insects early and prevent the threat from destabilizing large portions of the urban forest.

Tree Species Prone to Storm Damage

Fast-growing, weak-wooded species have the highest potential to create large amounts of debris after storms. However, wood characteristics alone cannot accurately predict which trees or which species will be vulnerable to storm damage. Branching habit, crown shape, and preexisting defects all play a large role in determining the likelihood of storm damage. Since these characteristics tend to be shared within a species, certain tree species may be predisposed to failure under storm conditions. *Quercus palustris* (pin oak), for example, have proven to be more susceptible to storm damage than other oak species due to their horizontal branching habit. Research has shown that certain characteristics, including weak branch junctures, fine branching, dead and decaying branches, root damage, broad crowns, and horizontal branching habit, can increase a tree's susceptibility to wind and ice damage. These characteristics, much like crown shape and branching habit, are often shared within a species. For example, *Pyrus calleryana* (Callery pears) are prone to forming weak branch connections with included bark, while *Ulmus pumila* (Siberian elms) have many fine branches, providing greater surface area for ice buildup. Both species are at high risk of damage during wind and ice events due to their inherent characteristics. Tables 11 and 12 provide a list of tree species and their resistance to wind and ice damage.

Table 11. *Susceptibility of common urban forest species to wind damage*

High		Medium-High		Medium-Low		Low	
Common Name	Botanical Name	Common Name	Botanical Name	Common Name	Botanical Name	Common Name	Botanical Name
Bradford pear	*Pyrus calleryana*	American elm	*Ulmus americana*	Japanese maple	*Acer palmatum*	flowering dogwood	*Cornus florida*
tuliptree	*Liriodendron tulipifera*	black cherry	*Prunus serotina*	sugar maple	*Acer saccharum*	inkberry	*Ilex glabra*
Chinese elm	*Ulmus parvifolia*	silver maple	*Acer accharinum*	river birch	*Betula nigra*	American holly	*Ilex opaca*
Leyland cypress	*x Cupressocyparis leylandii*	boxelder	*Acer negundo*	ironwood	*Carpinus caroliniana*	crape myrtle	*Lagerstroemia indica*
		red maple	*Acer rubrum*	pignut hickory	*Carya glabra*	southern magnolia	Magnolia grandiflora
		common hackberry	*Celtis occidentalis*	mockernut hickory	*Carya tomentosa*	baldcypress	Taxodium distichum
		red mulberry	*Morus rubra*	red bud	*Cercis canadensis*		
		sycamore	*Platanus occidentalis*	fringe tree	*Chionanthus virginicus*		
		white oak	*Quercus alba*	sweetgum	*Liquidambar styraciflua*		
		willow oak	*Quercus phellos*	saucer magnolia	*Magnolia x soulangiana*		
		weeping willow	*Salix babylonica*	blackgum	*Nyssa sylvatica*		
				American hophornbeam	Ostrya virginiana		
				winged elm	Ulmus alata		

Table 12. *Susceptibility of common urban forest species to ice damage*

High		Moderate		Low	
Common Name	Botanical Name	Common Name	Botanical Name	Common Name	Botanical Name
silver maple	*Acer saccharinum*	boxelder	*Acer negundo*	balsam fir	*Abies balsamea*
river birch	*Betula nigra*	red maple	*Acer rubrum*	Norway maple	*Acer platanoides*
common hackberry	*Celtis occidentalis*	sugar maple	*Acer saccharum*	Amur maple	*Acer tataricum ginnala*
thornless honeylocust	*Gleditsia triacanthos*	yellow birch	*Betula alleghaniensis*	yellow buckeye	*Aesculus flava*
butternut	*Juglans cinerea*	paper birch	*Betula papyrifera*	Ohio buckeye	*Aesculus glabra*
jack pine	*Pinus banksiana*	gray birch	*Betula populifolia*	American hornbeam	*Carpinus caroliniana*
pitch pine	*Pinus rigida*	American beech	*Fagus grandifolia*	bitternut hickory	*Carya cordiformis*
eastern cottonwood	*Populus deltoides*	white ash	*Fraxinus americana*	pignut hickory	*Carya glabra*
bigtooth aspen	*Populus grandidentata*	green ash	*Fraxinus pennsylvanica*	shagbark hickory	*Carya ovata*
quaking aspen	*Populus tremuloides*	tamarack	*Larix laricina*	northern catalpa	*Catalpa speciosa*
pin cherry	*Prunus pennsylvanica*	tuliptree	*Liriodendron tulipifera*	ginkgo	Ginkgo biloba
black cherry	*Prunus serotina*	sourwood	*Oxydendrum arboreum*	Kentucky coffeetree	*Gymnocladus dioicus*
Bradford pear	*Pyrus calleryana*	red pine	*Pinus resinosa*	witchhazel	*Hamamelis virginiana*
black oak	*Quercus velutina*	eastern white pine	*Pinus strobus*	black walnut	*Juglans nigra*
black locust	*Robinia pseudoacacia*	Scotch pine	*Pinus sylvestris*	eastern redcedar	*Juniperus virginiana*
willow	*Salix* spp.	loblolly pine	*Pinus taeda*	European larch	*Larix decidua*
Japanese pagodatree	*Styphnolobium japonicum*	London planetree	*Platanus hybrida*	sweetgum	*Liquidambar styraciflua*
American linden	*Tilia americana*	American sycamore	*Platanus occidentalis*	crabapple	*Malus spp.*
American elm	Ulmus americana	common chokecherry	*Prunus virginiana*	blackgum	*Nyssa sylvatica*
Siberian elm	*Ulmus pumila*	Douglas-fir	*Pseudotsuga menziesii*	American hophornbeam	*Ostrya virginiana*
slippery elm	*Ulmus rubra*	scarlet oak	*Quercus coccinea*	Norway spruce	*Picea abies*
		pin oak	*Quercus palustris*	white spruce	*Picea glauca*
		chestnut oak	*Quercus prinus*	Colorado blue spruce	*Picea pungens*
		northern red oak	*Quercus rubra*	white oak	*Quercus alba*
				swamp white oak	*Quercus bicolor*
				bur oak	*Quercus macrocarpa*
				European mountainash	*Sorbus acuparia*
				baldcypress	*Taxodium distichum*
				eastern arborvitae	*Thuja occidentalis*
				littleleaf linden	*Tilia cordata*
				eastern hemlock	*Tsuga canadensis*

The species composition of Hartford's inventoried tree population translates to vulnerability to storm-related damage; 21% of the inventoried trees have high or medium-high susceptibility to wind damage (Table 13) and a further 17% are highly susceptible to ice damage (Table 14). Another 34% of the inventoried tree population is moderately susceptible to ice damage. These lists of storm-susceptible species should be considered when prioritizing maintenance activities for storm preparedness and future planting plans should incorporate storm-resistant species listed in Tables 11 and 12. Tree loss during storm events can be an opportunity to replant and increase species diversity and urban forest resilience in the face of climate-driven pests and severe weather.

Table 13. *Inventoried trees with high susceptibility to wind damage*

Storm Susceptible Species Collected During Inventory		Susceptibility to Wind Damage	Number of Trees	Percent of Trees
Common Name	Botanical Name			
tuliptree	*Liriodendron tulipifera*	high	63	0.34%
Callery pear	*Pyrus calleryana*	high	528	2.81%
Chinese elm	*Ulmus parvifolia*	high	33	0.18%
Leyland cypress	*x Cupressocyparis leylandii*	high	0	0.00%
boxelder	*Acer negundo*	medium-high	59	0.31%
red maple	*Acer rubrum*	medium-high	1,928	10.26%
silver maple	*Acer saccharinum*	medium-high	409	2.18%
common hackberry	*Celtis occidentalis*	medium-high	28	0.15%
red mulberry	*Morus rubra*	medium-high	49	0.26%
sycamore	*Platanus occidentalis*	medium-high	41	0.22%
black cherry	*Prunus serotina*	medium-high	331	1.76%
white oak	*Quercus alba*	medium-high	228	1.21%
willow oak	*Quercus phellos*	medium-high	4	0.02%
weeping willow	*Salix babylonica*	medium-high	5	0.03%
American elm	*Ulmus americana*	medium-high	239	1.27%
Total			**3,945**	**20.99%**

Table 14. *Inventoried trees with high susceptibility to ice damage*

Storm Susceptible Species Collected During Inventory		Susceptibility to Ice Damage	Number of Trees	Percent of Trees
Common Name	Botanical Name			
silver maple	*Acer saccharinum*	high	409	2.18%
river birch	*Betula nigra*	high	158	0.84%
common hackberry	*Celtis occidentalis*	high	28	0.15%
thornless honeylocust	*Gleditsia triacanthos*	high	666	3.54%
butternut	*Juglans cinerea*	high	3	0.02%
jack pine	*Pinus banksiana*	high	0	0.00%
pitch pine	*Pinus rigida*	high	1	0.01%
eastern cottonwood	*Populus deltoides*	high	59	0.31%
bigtooth aspen	*Populus grandidentata*	high	2	0.01%
quaking aspen	*Populus tremuloides*	high	1	0.01%
pin cherry	*Prunus pennsylvanica*	high	0	0.00%
black cherry	*Prunus serotina*	high	331	1.76%
Bradford pear	*Pyrus calleryana*	high	528	2.81%
black oak	*Quercus velutina*	high	315	1.68%
black locust	*Robinia pseudoacacia*	high	134	0.71%
willow	*Salix* spp.	high	23	0.12%
Japanese pagodatree	*Styphnolobium japonicum*	high	9	0.05%
American linden	*Tilia americana*	high	109	0.58%
American elm	*Ulmus americana*	high	239	1.27%
Siberian elm	*Ulmus pumila*	high	58	0.31%
slippery elm	*Ulmus rubra*	high	49	0.26%
Total			**3,122**	**16.61%**

Storm Prone Species by Hartford Neighborhood

Storm-damage-prone species are not evenly distributed throughout Hartford. Table 15 provides a summary of the number of trees in each of Hartford's neighborhoods that are highly susceptible to wind or ice damage. South End, Northeast and Blue Hills have the most trees which are highly susceptible to wind damage, while Downtown, Frog Hollow, West End, and Behind the Rocks have the most trees which are highly susceptible to ice damage. When considering both ice and wind susceptible trees together, South End, Downtown, and Northeast have the most trees that are highly susceptible to storm damage. However, when considering the percentage of neighborhood trees that are highly susceptible to storm damage, South Green is the most at risk, with 38% of the trees in the neighborhood at high risk of wind or ice damage. Upper Albany and North Meadows are at the next highest risk, with 28% and 27% of the trees in these neighborhoods at high risk of storm damage, respectively. The percentage of trees in a neighborhood at high risk of storm damage is important to consider because these neighborhoods stand to lose a greater portion of their urban canopy in the event of a severe storm. Proactive storm preparedness maintenance should prioritize pruning or removals in neighborhoods with a high percentage of at-risk species. Storm recovery planning should also consider that neighborhoods with higher numbers of storm-damage-prone trees are likely to need more funding for clean-up, replanting, and tree repair after storms than other neighborhoods. Please note that the low numbers of trees in South Meadows is due to incomplete inventory of this neighborhood during the 2019 inventory.

Table 15. *Wind and ice susceptibility by neighborhood*

Neighborhood	Number of Wind Susceptible Trees	Number of Ice Susceptible Trees	Total Number of Susceptible Trees	Total Neighborhood Trees	Percent of Neighborhood Trees Susceptible
Asylum Hill	89	79	116	859	13.5%
Barry Square	118	66	153	1,337	11.4%
Behind the Rocks	310	282	451	2,692	16.8%
Blue Hills	343	244	468	3,381	13.8%
Clay-Arsenal	67	75	114	673	16.9%
Downtown	286	340	508	2,179	23.3%
Frog Hollow	252	287	442	1,914	23.1%
North Meadows	172	202	267	990	27.0%
Northeast	387	183	476	2,783	17.1%
Parkville	62	62	67	281	23.8%
South Green	74	93	136	356	38.2%
Sheldon-Charter Oak	252	193	369	1,839	20.1%
South End	530	270	582	2,608	22.3%
South Meadows	14	7	18	94	19.1%
South West	174	141	199	2,544	7.8%
Upper Albany	99	75	140	503	27.8%
West End	220	284	366	2,370	15.4%
Total	**3,449**	**2,883**	**4,872**	**27,403**	**337.6%**

Debris Removal Priorities

Severe weather events can cause large amounts of woody debris to be deposited on and around public roadways. The same weather events also tend to increase the need for emergency vehicles, including fire trucks and ambulances, utility workers, and Department of Public Works staff, to travel public roadways. Both during and after extreme weather events, clearing of major roadways is essential to allow emergency vehicles to travel unimpeded. In the event of an emergency evacuation, major routes of ingress and egress from the city or areas of the city need to be navigable.

Table 16. *Traffic counts for high-volume roads*

Road	Counter Location	Road Owner	Average Daily Traffic 2012
Brainard Road	North of US 5 NB	town	26,900
Route 44 (Albany Avenue)	multiple	state	8,000-22,600
Columbus Boulevard	multiple	town	17,900-21,300
Route 530 (Airport Road)	multiple	state	19,700-21,200
Route 189 (Bloomfield Avenue)	NW of US 44	state	19,900
Sisson Avenue	South of Warrenton Avenue	town	17,800
State Street	West of Columbus Blvd	town	17,200
Main Street	multiple	town	7,000-16,600
Weston Street	multiple	town	450-16,300
Asylum Avenue	NW of Woodland Street	town	16,000
Wyllys Street	NE of Norwich Street	town	15,800
Route 529 (New Britain Avenue)	multiple	state	15,300-15,800
Asylum Street	West of High Street	town	15,200
Woodland Street	South of Homestead Ave	town	15,100
Spring Street	NE of Garden Street	state	14,200
Farmington Avenue	West of Girard Avenue	town	13,800
Boce Barlow Way	West of Weston Street	town	13,700
Scarborough Street	South of US 44	town	13,300
Central Row	East of Main Street	town	13,200
Route 187 (Blue Hills Avenue)	multiple	state	13,000-13,100
Ford Street	NW of Pearl Street	town	12,800
Park Terrace	South of Ward Street	town	11,600
Washington Street	North of Brownell Avenue	town	11,400
Capitol Avenue	East of Arbor Street	town	11,300
Flatbush Avenue	multiple	town	7,100-11,100
Wethersfield Avenue	North of Preston Street	town	11,000
Newfield Avenue	multiple	town	10,400-11,000
Homestead Avenue	East of Sigourney Street	town	10,800
Sigourney Street	multiple	town	10,500-10,700
West Boulevard	West of SR 503	town	10,700
Tower Avenue	West of Waverly Street	town	10,400
Retreat Avenue	NE of Essex Street	town	10,100

Table 16 presents the average daily traffic counts for high-volume roads in Hartford. According to Hartford City data on yearly average daily traffic counts, as of 2012, the busiest roadway in Hartford was Brainard Road, located in the South Meadows neighborhood. This section of roadway, which provides access to the Hartford-Brainard Airport, sees nearly 27,000 vehicles every day. Route 44, also called Albany Avenue, was the second busiest roadway, with most sections seeing well over 10,000 vehicles each day. Other very busy roadways in Hartford include Columbus Boulevard, Route 530 (Airport Road), Route 189 (Bloomfield Avenue), Sisson Avenue, State Street, Main Street, Weston Street, Asylum Avenue, and New Britain Avenue.

However, daily traffic counts are not an ideal method of determining priority routes for clearing after storms. While a complete analysis of priority routes for debris removal is outside of the scope of this report, Hartford should invest in such an analysis to provide guidance in the wake of severe weather events. Priority routes will include those that supply access to critical services, such as hospitals, fire stations, and food stores. Furthermore, the city will need to work with local electric distribution companies to identify essential areas of the electric grid within Hartford that require priority clearance after storms in order to restore power to citizens as quickly as possible. Routes for snowplowing may provide a reasonable starting point for Hartford's list of roads requiring priority debris removal after storms.

Discussion

Hartford has many trees that are at an elevated risk of failure during severe weather events. As outlined in Section 3 of this management plan, all Extreme, High, and Moderate Risk trees recommended for pruning or removal should be attended to immediately to mitigate the risk associated with these trees. However, in order to lessen the damage associated with major storms, Low Risk trees with poorer condition ratings, preexisting defects, and pruning recommendations should also be considered a maintenance priority after elevated risk trees have been dealt with. Special attention should be paid to trees which have the potential to impact aerial electrical lines, as the failure of these trees may result in power interruptions or electrical hazards. Future planting efforts should take storm damage susceptibility into consideration when choosing which species to plant.

Trees species with an elevated chance of failure during storms are not evenly distributed throughout the city. Neighborhoods with large numbers or high proportions of highly susceptible trees should be prioritized for proactive storm preparedness maintenance to mitigate the potentially devastating impacts of a storm on these parts of the city. These neighborhoods should also be considered priorities for debris removal after storms, as they are likely to have more downed woody debris than neighborhoods with smaller populations of storm-vulnerable species. Special attention should be paid to trees along the city's busiest roadways and roads marked for priority debris removal. ***Proactive pruning and other maintenance can help prevent trees along vital roadways from becoming hazards or dropping significant woody debris into important routes during storms.***

Hartford should invest in an analysis of which roads within the city should be considered priorities for debris clearance, basing these decisions on traffic volume counts, location of hospitals and other emergency services, location of DPW properties, and key electrical grid locations.

The occurrence of severe weather cannot be controlled, but the severity of a storm's impact on the urban forest can be mitigated with the creation and implementation of an effective storm preparedness plan. A comprehensive plan that explicitly considers the urban forest will equip the City of Hartford to effectively manage future severe weather events from both an operational and financial perspective.

Partners

Successful creation, implementation, and execution of a storm preparedness plan will require the resources and expertise of a variety of external partners. Multiple partnerships are a reality in storm response given the variety of legal, jurisdictional, and operational missions within a municipal boundary. Partnerships can present challenges but can also result in an effective and efficient response when the expertise and resources of each partner are acknowledged and roles are properly delineated.

The following is a brief description of Hartford's major partners in a storm emergency and during recovery efforts.

1. **Utility Agencies**
   Electric distribution lines in Hartford are controlled by Eversource, who is a key partner during a storm emergency. Only Electrical Hazards Awareness Program (EHAP) trained staff are qualified to work around energized lines. They have the resources to mobilize quick and appropriate responses to emergency situations involving trees and utilities. During a widespread storm event, Hartford will likely also need to communicate and coordinate with the Connecticut Public Utilities Regulatory Authority. Where whole trees or limbs are down or resting on energized lines, rescue and clean-up efforts cannot proceed until power lines have been addressed by the trained personnel of these agencies. Prioritization of where utility agencies respond first generally are: three-phase aerial electric lines; single-phase aerial electric lines; secondary electric lines; and then service (or residential) drops.

2. **Connecticut Department of Transportation (DOT)**
   The Connecticut DOT is responsible for the safety and maintenance of interstate and state routes within and around Hartford. During a storm emergency, they can respond with staff and equipment to clear state-owned ROW and assist with city streets if authorized. The DOT will likely have a priority of clearing routes which may affect debris staging or removal patterns for Hartford. Check with the local district DOT authority to determine their responsibilities and the municipal expectations for each storm category (Appendix F).

3. **Contractors**
   Labor and equipment for debris clearance, removal, and disposal should be available from local contractors. It is advisable to have contractors, such as tree service companies, debris processing companies, and equipment and tool rentals, already under contractual agreements with the municipality before a storm event occurs. During an emergency, the city can enter into new emergency contracts and modify existing contracts to supply the personnel and equipment necessary to efficiently deal with storm mitigation efforts if needed.

4. **State of Connecticut**

   When the response efforts appear to be beyond the capability of Hartford, the State can normally provide the next level of assistance by declaring a state of emergency. The Connecticut State Division of Emergency Management and Homeland Security (DEMHS) aids local emergency response leaders for major or complex emergencies or disasters. The division also assists local jurisdictions with recovery from natural or man-made disasters, in addition to coordinating mitigation programs designed to reduce the impact of future disasters on a community. The division typically evaluates the disaster situation and provides advice to the governor on the availability of state resources to assist local efforts. Hartford falls within DEMHS Region 3.

   The DEMHS website (portal.ct.gov/DEMHS) offers a toolbox of information to assist with the process of requesting aid and making claims for reimbursement. It offers several guide sheets and forms that provide excellent information about the application process and how to maintain adequate records of debris cleanup costs and contracting procedures.

5. **Federal Government**

   The U.S. Army Corps of Engineers may be able to respond for up to 10 days without a Presidential Declaration; the Federal Highway Administration may provide grant assistance to states for debris clearing, tree removal, and repair of roads; and the Federal Emergency Management Agency (FEMA) provides financial and administrative assistance after storms that are declared a federal emergency.

   FEMA is the major federal agency that will be a partner of Hartford in the event of a severe storm emergency. FEMA recommends that communities have an *Emergency Operation Plan* and, since debris removal is reported as the most significant storm-related problem, communities should have a *Debris Management Plan.*

   FEMA will reimburse Hartford for debris removal costs if a federal disaster is declared. FEMA will also reimburse Hartford for removing certain trees during a federal disaster. Trees which sustain greater than 50% crown loss and are on the public right-of-way are eligible for removal cost reimbursement. However, trees that are completely on the ground after a storm and can be moved away with other debris are usually included in the debris estimates. FEMA often does not cover stump removal unless a hazard situation is present.

   FEMA will also reimburse Hartford for hazard reduction pruning immediately following a storm during a federal disaster. In general, broken or hanging branches that are 2 inches or greater in diameter and that are still in the crown of a tree can be pruned under the hazard reduction reimbursement policy. The pruning cost is not extended to the entire tree but is limited only to the removal of branches contributing directly to the hazard.

   Final reimbursement of storm-related damages from FEMA is dependent on accurate record keeping and documentation of storm-related cleanup work, so it is essential that Hartford retain staff members who are trained on FEMA protocols and documentation requirements in order to ensure the city is able to receive reimbursement.

Summary of Recommendations

- Be sure all staff are signed up for the Connecticut Emergency Alert System through www.ctalert.gov.
- Utilize Hartford's 311 hotline to collect information about areas requiring cleanup or attention during and after storm events. Promote the use of the 311 hotline to citizens, as it is the most expedient way for citizens to let the city know about potential hazards caused by storms.
- Invest in an analysis of priority routes for debris clearing. This analysis will require coordination between utility companies, emergency services, and city DPW workers to identify roads that need to kept clear in the event of a major storm event.
- Establish communication protocol for storm events. Both during and after a storm emergency, the City of Hartford may be relying on and working with multiple departments and levels of government. Effective communication is key to effective and expedient action. An effective plan ensures that all potentially involved or relevant departments understand their roles in the storm response effort.
- Routinely update the tree inventory as maintenance activities occur or as otherwise warranted. The most effective storm preparedness and management plans rely on current data to prioritize work and ultimately reduce future storm damage.
- Annually review the storm preparedness and response plan and update as necessary.
- Utilize the Homeland Security office to provide quick notification to the Connecticut State Division of Emergency Management and Homeland Security (DEMHS) and FEMA if reimbursement from disaster funds is anticipated. Understand in advance the FEMA system for reimbursement and develop a clear system of record keeping in order to streamline and expedite reimbursement.
- Promptly address elevated risk trees to remove them from the population or otherwise mitigate risk in order to reduce potential storm damage.
- Prioritize proactive tree maintenance activities by considering tree condition, the presence and type of defect, age of tree, and tree location.
- Remove Low Risk but storm-damage-prone species from the population when their service lives are over and replace with more resilient species.
- Provide staff training, particularly on tree risk and working in environments with potential electrical hazards.
- Commit to providing the citizens timely messaging about Hartford's response and recovery activities and about tree damage and correction topics. Prepare public relations materials ahead of time so that they are easily accessible when storms strike.

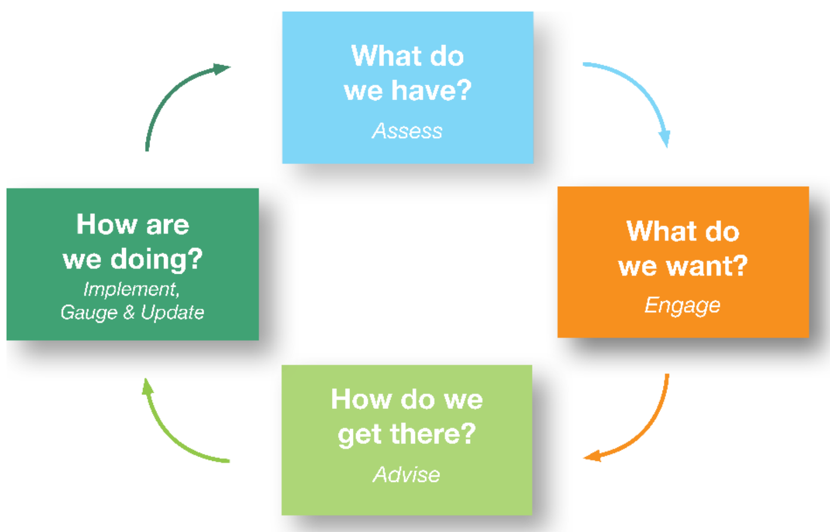
CONCLUSION

When properly maintained, the valuable benefits trees provide far exceed the time and money invested in planting, pruning, and inevitably removing them. The 18,791 public trees inventoried provide $116,384 in estimated annual economic value by reducing runoff, removing air pollutants, and sequestering carbon. As the urban forest grows, the benefits enjoyed by the City of Hartford and its residents will increase as well. Inventoried trees are only a fraction of the total trees in Hartford when including private property, which is why it is important to incentivize private landowners to care for their trees and to plant new ones.

If this management program is successfully implemented, the health of Hartford's public trees and the safety of the city's residents will be maintained in the years to come. The program is ambitious and is a challenge to complete in three years, but priority tree maintenance should be completed as soon as possible and can be done concurrently while advocating for an increased urban forestry budget to fund the remaining work in the future.

Evaluating and Updating This Plan

This *Tree Resource Management Plan* provides management priorities for the next three years, and it is important to update the tree inventory using TreeKeeper® as work is completed, so the software can provide updated species distribution and benefit estimates. This empowers Hartford to self-assess the city's progress over time and set goals to strive toward. The adaptive management cycle is an effective framework with which to approach this, represented by the graphic below. Some ways of implementing the steps of an adaptive management cycle include:



- Comparing Hartford's actual urban forestry budget to the management plan's estimate. Is the city's current budget enough to complete all priority maintenance in a reasonable timeframe? If not, demonstrate the need for an increased urban forestry budget.
- Preparing planting plans well enough in advance to schedule and complete stump removal in the designated area and selecting species best suited to the available sites.
- Comparing the number of trees planted to the number of trees removed and the number of vacant planting sites remaining annually, then adjusting future planting plans accordingly.

- Comparing the species distribution of the inventoried tree resource with the previous year after completing planting plans to monitor recommended changes in abundance.
- Including data collection such as measuring DBH and assessing tree condition into the standard procedure for tree work and routine inspections so that changes over time can be monitored.
- Updating the city's tree inventory on a regular basis whenever trees are planted, removed, pruned, or otherwise maintained.
- Performing an update of the tree inventory and Level 2 inspection every 7–10 years. This effort can be completed by city staff, contractors, or trained temporary staff, depending on resource availability, accuracy needs, and city priorities.

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GLOSSARY

address (data field): The address number was recorded based on the visual observation by the Davey Resource Group arborist at the time of the inventory of the actual address number posted on a building at the inventoried site. In instances where there was no posted address number on a building or sites were located by vacant lots with no GIS parcel addressing data available, the address number assigned was matched as closely as possible to opposite or adjacent addresses by the arborist(s) and the suffix field (assigned address field) was set to "Yes".

air pollution removal: In i-Tree Eco, air pollution removal refers to the removal of ozone (O_3), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO), and particulate matter less than 2.5 microns ($PM_{2.5}$).

American National Standards Institute (ANSI): ANSI is a private, nonprofit organization that facilitates the standardization work of its members in the United States. ANSI's goals are to promote and facilitate voluntary consensus standards and conformity assessment systems, and to maintain their integrity.

***ANSI A300*:** Tree care performance parameters established by ANSI that can be used to develop specifications for tree maintenance.

arboriculture: The art, science, technology, and business of commercial, public, and utility tree care.

assigned address (data field): see **suffix**

avoided runoff: In i-Tree Eco, avoided runoff measures the amount of surface runoff avoided when trees intercept rainfall during precipitation events.

canopy: Branches and foliage that make up a tree's crown.

canopy cover: As seen from above, it is the area of land surface that is covered by tree canopy.

Carbon Monoxide (CO): A colorless, odorless, highly toxic gas formed as a result of the incomplete combustion of a carbon or carbon compound.

carbon sequestration: The capture and storage of carbon from the Earth's atmosphere. In i-Tree Eco, carbon sequestration is calculated as an annual functional benefit of trees.

carbon storage: Storage of carbon in plant tissue. In i-Tree Eco, carbon storage is calculated as a structural benefit over the lifetime of the tree.

comments (data field): Additional comments on the state of the inventoried site. Comments may include the number of stems if the tree was multi-stemmed, additional defects that were significant but not the primary defect, explanations for why further inspection is needed, and other general information considered important by the inventory arborist.

community forest: see **urban forest**.

condition (data field): The general condition of each tree rated during the inventory according to the following categories adapted from the International Society of Arboriculture's rating system: Good, Fair, Poor, or Dead.

cycle: Planned length of time between vegetation maintenance activities.

defect: See **structural defect**.

defect (data field): The primary defect noted by the inventory arborist. Defects include missing or decayed wood, dead or dying parts, broken or hanging branches, weakly attached branches and codominant stems, cracks, root problem, tree architecture, other, and none.

diameter: See **tree size**.

diameter at breast height (DBH): See **tree size**.

Extreme Risk tree: Applies in situations where tree failure is imminent, there is a high likelihood of impacting the target, and the consequences of the failure are “severe.” In some cases, this may mean immediate restriction of access to the target zone area in order to prevent injury.

failure: In terms of tree management, failure is the breakage of stem or branches, or loss of mechanical support of the tree’s root system.

functional benefit: In i-Tree Eco, a benefit which is due to the physiological processes carried out by trees, calculated on an annual basis.

further inspection (data field): Notes that a specific tree may require an annual inspection for several years to make certain of its maintenance needs. A healthy tree obviously impacted by recent construction serves as a prime example. This tree will need annual evaluations to assess the impact of construction on its root system. Another example would be a tree with a defect requiring additional equipment for investigation.

genus: A taxonomic category ranking below a family and above a species and generally consisting of a group of species exhibiting similar characteristics. In taxonomic nomenclature, the genus name is used, either alone or followed by a Latin adjective or epithet, to form the name of a species.

geographic information system (GIS): A technology that is used to view and analyze data from a geographic perspective. The technology is a piece of an organization’s overall information system framework. GIS links location to information (such as people to addresses, buildings to parcels, or streets within a network) and layers that information to provide a better understanding of how it all interrelates.

global positioning system (GPS): GPS is a system of earth-orbiting satellites that make it possible for people with ground receivers to pinpoint their geographic location.

grow space size (data field): Data field which records the size of the smallest dimension of the growing space in which a site is located.

grow space type (data field): The type of growing space in which a site is located, such as tree well or tree lawn.

High Risk tree: The High Risk category applies when consequences are “significant” and likelihood is “very likely” or “likely,” or consequences are “severe” and likelihood is “likely.” In a population of trees, the priority of High Risk trees is second only to Extreme Risk trees.

importance value (IV): A calculation in i-Tree Eco displayed in table form for all species that make up more than 1% of the population. The IV calculated by the i-Tree Eco model factors in the total number of trees for each species, each species' percentage of the total population, and each species' total leaf area. The IV can range from 0 to 200, with higher IVs indicating higher reliance on one species to provide ecosystem services. IVs offer valuable information about a community's reliance on certain species to provide functional benefits.

infrastructure conflict (data field): Indicates the presence or absence of a conflict with signs, signal lights, residential buildings, or other above ground infrastructure.

invasive, exotic tree: A tree species that is out of its original biological community. Its introduction into an area causes or is likely to cause economic or environmental harm, or harm to human health. An invasive, exotic tree can thrive and spread aggressively outside its natural range. An invasive species that colonizes a new area may gain an ecological edge since the insects, diseases, and foraging animals that naturally keep its growth in check in its native range are not present in its new habitat.

inventory: See **tree inventory**.

i-Tree Eco: i-Tree Eco is a street tree management and analysis tool that uses tree inventory data to quantify the dollar value of annual environmental benefits, including runoff reduction, air pollution reduction, and carbon sequestration, as well as life-long structural benefits trees provide, including carbons storage and structural value.

i-Tree Streets: i-Tree Streets is a street tree management and analysis tool that uses tree inventory data to quantify the dollar value of annual environmental and aesthetic benefits: energy conservation, air quality improvement, CO_2 reduction, stormwater control, and property value increase. While i-Tree Streets was not used for the tree benefits analysis in this management plan, it is still used as the basis for the tree benefits tab in TreeKeeper®.

i-Tree Tools: State-of-the-art, peer-reviewed software suite from the USDA Forest Service that provides urban forestry analysis and benefits assessment tools. The i-Tree Tools help communities of all sizes to strengthen their urban forest management and advocacy efforts by quantifying the structure of community trees and the environmental services that trees provide.

location (data field): A data field indicating the physical location of an inventoried tree: either street (ROW), borderline (on or near the ROW boundary), off ROW, or park/public.

Low Risk tree: The Low Risk category applies when consequences are "negligible" and likelihood is "unlikely"; or consequences are "minor" and likelihood is "somewhat likely." Some trees with this level of risk may benefit from mitigation or maintenance measures, but immediate action is not usually required.

mapping coordinates (data field): Helps to locate a tree; X and Y coordinates were generated for each tree using GPS.

Moderate Risk tree: The Moderate Risk category applies when consequences are "minor" and likelihood is "very likely" or "likely"; or likelihood is "somewhat likely" and consequences are "significant" or "severe." In populations of trees, Moderate Risk trees represent a lower priority than High or Extreme Risk trees.

monoculture: A population dominated by one single species or very few species.

multi-stem (data field): Indicates whether a tree has multiple trunks splitting less than 1.5 feet above ground level. If a tree had multiple stems, a comment was adding indicating the number of stems.

neighborhood (data field): The neighborhood within Hartford a site is located in.

Nitrogen Dioxide (NO_2): Nitrogen dioxide is a compound typically created during the combustion processes and is a major contributor to smog formation and acid deposition.

None (risk rating): Equal to zero. It is used only for planting sites and stumps.

on-street (data field): The street a site is physically located on.

ordinance: See **tree ordinance**.

overhead utilities (data field): The presence of overhead utility lines above a tree or planting site.

Ozone (O_3): A strong-smelling, pale blue, reactive toxic chemical gas with molecules of three oxygen atoms. It is a product of the photochemical process involving the Sun's energy. Ozone exists in the upper layer of the atmosphere as well as at the Earth's surface. Ozone at the Earth's surface can cause numerous adverse human health effects. It is a major component of smog.

park name (data field): The name of the park, cemetery, or other public property in which a site is located.

Particulate Matter ($PM_{2.5}$): A major class of air pollutants consisting of tiny solid or liquid particles of soot, dust, smoke, fumes, and mists.

pest detection (data field): If a pest species of concern in Hartford was detected, it was recorded in this data field.

plant (primary maintenance need): If collected during an inventory, this data field identifies planting sites as small, medium, or large (indicating the ultimate size that the tree will attain), depending on the growing space available and the presence of overhead wires.

primary maintenance need (data field): The type of tree work needed to reduce immediate risk.

pruning: The selective removal of plant parts to meet specific goals and objectives.

removal (Primary Maintenance Need): Data field collected during the inventory identifying the need to remove a tree. Trees designated for removal have defects that cannot be cost-effectively or practically treated. Most of the trees in this category have a large percentage of dead crown.

residual risk (data field): The risk rating of a tree after the recommended primary maintenance has been carried out. Residual risk may be equal to but never greater than the original risk rating.

right-of-way (ROW): See **street right-of-way**.

risk: Combination of the probability of an event occurring and its consequence.

risk assessment (data fields): see Appendix E.

risk assessment complete (data field): Indicates whether the arborist was able to complete a Level 2 qualitative risk assessment. Arborists may not be able to fully assess tree risk due to embankments, homeowner conflicts, fences, or other obstacles to getting a 360 degree view of the tree.

risk rating: Level 2 qualitative risk assessment will be performed on the ANSI A300 (Part 9) and the companion publication *Best Management Practices: Tree Risk Assessment*, published by International Society of Arboriculture (2011). Trees can have multiple failure modes with various risk ratings. One risk rating per tree will be assigned during the inventory. The failure mode having the greatest risk will serve as the overall tree risk rating. The specified time period for the risk assessment is one year.

secondary maintenance need (data field): The type of pruning required to improve tree structure, tree health, or public access around the tree.

side (data field): Each site is assigned a side value to aid in locating the site. Side values include *front, side, median* (includes islands), and *rear* based on the site's location in relation to the lot's street frontage. The *front* side is the side that faces the address street. *Side* is a side that is one corner away from the side that faces the address street. *Median* indicates a median or island. The *rear* is the side of the lot opposite the front.

site: Any point for which data was recorded during the inventory, including trees, vacant sites, and stumps.

species (data field): Fundamental category of taxonomic classification, ranking below a genus or subgenus, and consisting of related organisms capable of interbreeding.

stem: A woody structure bearing buds and foliage and giving rise to other stems.

street (data field): The name of a street right-of-way or road identified using posted signage or parcel information. The street to which the parcel a site is on is addressed.

street right-of-way (ROW): A strip of land generally owned by a public entity over which facilities, such as highways, railroads, or power lines, are built.

street tree: A street tree is defined as a tree within the right-of-way.

structural benefit: In i-Tree Eco, a benefit which is produced by the physical arrangement and composition of trees and tree parts and which is calculated as an aggregate over the lifetime of a tree.

structural defect: A feature, condition, or deformity of a tree or tree part that indicates weak structure and contributes to the likelihood of failure.

structural value: In i-Tree Eco, the compensatory value calculated based on the local cost of having to replace a tree with a similar tree.

stump removal (Primary Maintenance Need): Indicates a stump that should be removed.

suffix (data field): Data field indicating whether the address was assigned by the arborist.

Sulfur Dioxide (SO_2): A strong-smelling, colorless gas that is formed by the combustion of fossil fuels. Sulfur oxides contribute to the problem of acid rain.

topping: Characterized by reducing tree size using internodal cuts without regard to tree health or structural integrity; this is not an acceptable pruning practice.

tree: A tree is defined as a perennial woody plant that may grow more than 20 feet tall. Characteristically, it has one main stem, although many species may grow as multi-stemmed forms.

tree benefit: An economic, environmental, or social improvement that benefits the community and results mainly from the presence of a tree. The benefit received has real or intrinsic value associated with it.

tree inventory: Comprehensive database containing information or records about individual trees typically collected by an arborist.

tree ordinance: Tree ordinances are policy tools used by communities striving to attain a healthy, vigorous, and well-managed urban forest. Tree ordinances simply provide the authorization and standards for management activities.

tree size (data field): A tree's diameter measured to the nearest inch in 1-inch size classes at 4.5 feet above ground, also known as diameter at breast height (DBH) or diameter.

urban forest: All the trees within a municipality or a community. This can include the trees along streets or rights-of-way, in parks and greenspaces, in forests, and on private property.

Young Tree Train (Primary Maintenance Need): Data field based on *ANSI A300* standards, this maintenance activity is characterized by pruning of young trees to correct or eliminate weak, interfering, or objectionable branches to improve structure. These trees can be up to 20 feet tall and can be worked with a pole pruner by a person standing on the ground.

APPENDIX A: TREE PLANTING

Tree Planting

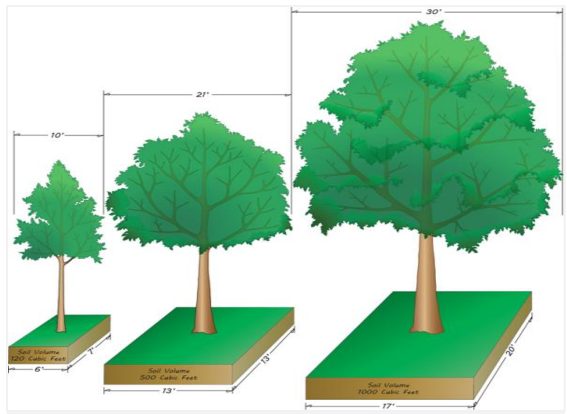
Planting trees is a valuable goal provided tree species are carefully selected and correctly planted. When trees are planted, they are planted selectively and with purpose. Without proactive planning and follow-up tree care, a newly planted tree may become a future problem instead of a benefit to the community.

When planting trees, it is important to be cognizant of the following:

- Consider the specific purpose of the tree planting.
- Assess the site and know its limitations (i.e., confined spaces, overhead wires, and/or soil type).
- Select the species or cultivar best suited for the site conditions.
- Examine trees before buying them and buy for quality.

Vacant Site Methodology

Not all potential sites are suitable to host a healthy and high-value tree. Vacant sites for planting were carefully selected following a set of standard protocols to ensure that new plantings do not interfere with existing trees or infrastructure and to provide the necessary space required for a new planting to grow and thrive. The vacant site standards used to select vacant sites for planting in Hartford are as follows:



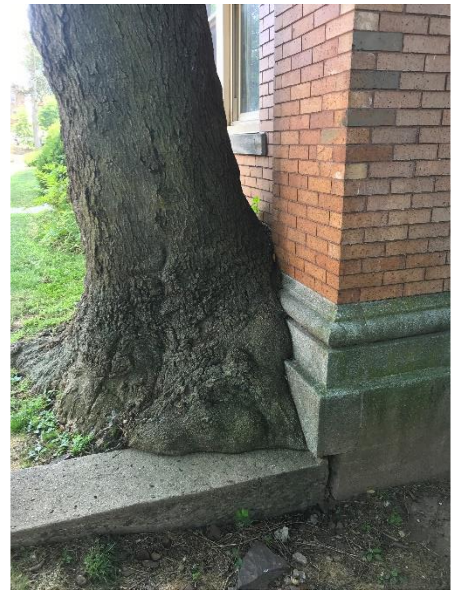
Minimum recommended requirements for tree sites is based on tree size/dimensions. This illustration is based on the work of Casey Trees (2008).

- All Vacant Sites must be: at least 15 feet from existing infrastructure, including utility poles and buildings; at least 20 feet from fire hydrants; at least 30 feet from intersections; at least 10 feet from driveways; 5–10 feet from underground utilities; and at least 10 feet from important traffic signs (not including parking signs which can be easily relocated).
- Small Vacant Sites must be: 4–5.9 feet wide in their smallest dimension; at least 20 feet from all other trees, stumps, or vacant sites; and may be placed underneath overhead utilities.
- Medium Vacant Sites must be: 6–7.9 feet wide in their smallest dimension; at least 30 feet from all other trees, stumps, or vacant sites; and must not be placed underneath overhead utilities.
- Large Vacant Sites must be: at least 8 feet wide in their smallest dimension; at least 40 feet from all other trees, stumps, or vacant sites; and must not be placed underneath overhead utilities.

The largest possible vacant site was always prioritized in order to maximize the benefits that will be provided by new plantings as they mature.

Tree Species Selection

Selecting a limited number of species could simplify decision-making processes; however, careful deliberation and selection of a wide variety of species is more beneficial and can save money. Planting a variety of species can decrease the impact of species-specific pests and diseases by limiting the number of susceptible trees in a population. This reduces time and money spent to mitigate pest- or disease-related problems. A wide variety of tree species can also help limit the impacts from physical events, as different tree species react differently to stress. Species diversity helps withstand drought, ice, flooding, strong storms, and wind.



Photograph 9. *Allowing sufficient space for new plantings is important to prevent future conflicts with hardscape, utilities, signage, and buildings.*

Hartford Connecticut is in USDA Hardiness Zone 6, which is identified as a climatic region with average annual minimum temperatures between 0°F and -10°F. Tree species selected for planting in Hartford should be appropriate for this zone.

Tree species should be selected for their durability and low-maintenance characteristics. These attributes are highly dependent on site characteristics below ground (soil texture, soil structure, drainage, soil pH, nutrients, road salt, and root spacing). Matching a species to its favored soil conditions is the most important task when planning for a low-maintenance landscape. Plants that are well matched to their environmental site conditions are much more likely to resist pathogens and insect pests and will, therefore, require less maintenance overall.

The Right Tree in the Right Place is a mantra for tree planting used by the Arbor Day Foundation and many utility companies nationwide. Trees come in many different shapes and sizes, and often change dramatically over their lifetimes. Some grow tall, some grow wide, and some have extensive root systems. Before selecting a tree for planting, make sure it is the right tree—know how tall, wide, and deep it will be at maturity. Equally important to selecting the right tree is choosing the right spot to plant it. Blocking an unsightly view or creating some shade may be a priority, but it is important to consider how a tree may impact existing utility lines as it grows taller, wider, and deeper. If the tree's canopy, at maturity, will reach overhead lines, it is best to choose another tree or a different location. Taking the time to consider location before planting can prevent power disturbances and improper utility pruning practices.

A major consideration for street trees is the amount of litter dropped by mature trees. Trees such as *Acer saccharinum* (silver maple) have weak wood and typically drop many small branches during a growing season. Others, such as *Liquidambar styraciflua* (American sweetgum), drop high volumes of fruit. In certain species, such as *Ginkgo biloba* (ginkgo), female trees produce large odorous fruit; male ginkgo trees, however, do not produce fruit. Furthermore, a few species of trees, including *Crataegus* spp. (hawthorn) and *Gleditsia triacanthos* (honeylocust), may have substantial thorns. These species should be avoided in high-traffic areas.

Seasonal color should also be considered when planning tree plantings. Flowering varieties are particularly welcome in the spring, and deciduous trees that display bright colors in autumn can add a great deal of appeal to surrounding landscapes.

DRG recommends limiting the planting of *Acer* (maple) species in the ROW and both *Acer* and *Quercus* (oak) species in parks and public properties until the species distribution normalizes. Of the inventoried population, *Acer* (maple) species already occupy 34% of the ROW and 20% of the inventoried public properties (oaks occupy 24% of the public properties), which exceeds the recommended 20% genus maximum. Excesses of trees in the same species or genus can make the urban forest more vulnerable to pest species and physical stressors and creates a situation where, should a pest species be introduced that attacks the over-abundant genus or species, the city stands to lose a massive portion of its urban canopy.

Planting native trees rather than exotic species can provide additional environmental benefits by providing food and shelter for a wide variety of native animal and insect species. While planting native species is not always possible in street ROW, parks and other public properties, as well as private lands, can be excellent places to encourage the planting of native trees.

Tips for Planting Trees

To ensure a successful tree planting effort, the following measures should be taken:

- Handle trees with care. Trees are living organisms and are perishable. Protect trees from damage during transport and when loading and unloading. Use care not to break branches, and do not lift trees by the trunk.
- If trees are stored prior to planting, keep the roots moist.
- Dig the planting hole according to the tree to be planted. Generally, the planting hole should be two to three times wider and not quite as deep as the root ball. The root flair should be at or just above ground level.
- Fill the hole with native soil unless it is undesirable, in which case soil amendments should be added as appropriate for local conditions. Gently tamp and add water during filling to reduce large air pockets and ensure a consistent medium of soil, oxygen, and water.
- Stake the tree as necessary to prevent it from shifting too much in the wind.
- Add a thin layer (1–2 inches) of mulch to help prevent weeds and keep the soil moist around the tree. Do not allow mulch to touch the trunk.

Newly Planted and Young Tree Maintenance

Caring for trees is just as important as planting them. Once a tree is planted, it must receive maintenance for several years.

Watering

Initially, watering is the key to survival; new trees typically require at least 60 days of watering to establish. Determine how often trees should be irrigated based on time of planting, drought status, species selection, and site condition.

Mulching

Photograph 10. *Mulch should not touch the trunk or be piled up around the tree. Improper "volcano" mulching can encourage the growth of harmful fungi and attract other pests that may damage young trees.*

Mulch can be applied to the growing space around a newly planted tree (or even a more mature tree) to ensure that no weeds grow, that the tree is protected from mechanical damage, and that the growing space is moist. Mulch should be applied in a thin layer, generally 1 to 2 inches, and the growing area should be covered. Mulch should not touch the tree trunk or be piled up around the tree.

Lifelong Tree Care

After the tree is established, it will require routine tree care, which includes inspections, routine pruning, watering, plant health care, and integrated pest management as needed.

Hartford should employ qualified arborists to provide most of the routine tree care. An arborist can determine the type of pruning necessary to maintain or improve the health, appearance, and safety of trees. These techniques may include: eliminating branches that rub against each other; removing limbs that interfere with wires and buildings or that obstruct streets, sidewalks, or signage; removing dead, damaged, or weak limbs that pose a hazard or may lead to decay; removing diseased or insect-infested limbs; creating better structure to reduce wind resistance and minimize the potential for storm damage; and removing branches—or thinning—to increase light penetration.

An arborist can help decide whether a tree should be removed and, if so, to what extent removal is needed. Additionally, an arborist can perform—and provide advice on—tree maintenance when disasters such as storms or droughts occur. Storm-damaged trees can often be dangerous to remove or trim. An arborist can assist in advising or performing the job in a safe manner while reducing further risk of damage to property.

Plant Health Care, a preventive maintenance process that keeps trees in good health, helps a tree better defend itself against insects, disease, and site problems. Arborists can help determine proper plant health so that Hartford's tree population will remain healthy and provide benefits to the community for as long as possible.

Integrated Pest Management is a process that involves common sense and sound solutions for treating and controlling pests. These solutions incorporate basic steps: identifying the problem, understanding pest biology, monitoring trees, and determining action thresholds. The practice of Integrated Pest Management can vary depending on the site and based on each individual tree. A qualified arborist will be able to make sure that Hartford's trees are properly diagnosed and that a beneficial and realistic action plan is developed.

The arborist can also help with cabling or bracing for added support to branches with weak attachment, aeration to improve root growth, and installation of lightning protection systems.

Educating the community on basic tree care is a good way to promote the urban forest and encourage tree planting on private property.

APPENDIX B: DATA COLLECTION AND SITE LOCATION METHODS

Data Collection Methods

DRG collected tree inventory data using a system that utilizes a customized ArcPad program loaded onto pen-based field computers equipped with geographic information system (GIS) and global positioning system (GPS) receivers. The knowledge and professional judgment of DRG's arborists ensure the high quality of inventory data.

At each site, the following data fields were collected:

- address
- assigned address (suffix)
- comments
- condition
- defects
- further inspection required
- grow space size
- grow space type
- infrastructure conflict
- mapping coordinates
- multi-stem
- neighborhood
- on street
- overhead utilities
- park name
- pest detection
- primary maintenance need
- risk rating
- secondary maintenance need
- side
- species
- street
- tree size*

* measured in inches in diameter at 4.5 feet above ground (or diameter at breast height [DBH])

Maintenance needs are based on *ANSI A300 (Part 1)* (ANSI 2008). Risk assessment and risk rating are based on *Best Management Practices: Tree Risk Assessment* (International Society of Arboriculture [ISA] 2011).

The data collected were provided in DRG's TreeKeeper© software, Microsoft Excel™ spreadsheet, KML data file, and an i-Tree Eco Data file.

All public ROW sites were inventoried during 2019 except for some public ROW within the South Meadows neighborhood. This neighborhood is primarily industrial and has very few ROW trees and thus was excluded from the inventory when budgetary constraints necessitated a rapid wrap-up of the inventory. Sites were also collected in selected parks, cemeteries, and other public properties, including: The Ancient Burying Ground, Barnard Park, Buckingham Square, Bushnell Park, Charter Oak Monument, Charter Oak Park (also called Charter Oak Landing), City Hall and Burr Mall, Colt Park, Columbus Green, Elizabeth Park, Forster Park (also called Forster Heights Playground), Franklin Avenue Recreation Center (also called Columbus Park), George Day Park, Goodwin Park, Hartford Police Affleck Street Substation, Hartford Public Safety Complex, Hartford Public Works Department, Hyland Park, Joseph V. Cronin Park, Keney Clock Tower, Keney Park, Keney Park Golf Course, Lozada Park, Marcus Garvey Park, Northwood Cemetery, Old North Cemetery, Old South Cemetery, Pope Park, Pope Park North, Pulaski Circle, Pulaski Mall, Riverfront Plaza (also called Riverfront Park), Riverside Park, Rocky Ridge Park, Sigourney

Square, Tower Square (also called Traveler's Tower), Wexford Park, and Zion Hill Cemetery. These public properties do not constitute all publicly owned lands within Hartford, nor was every site in these public properties collected during the 2019 inventory. In the public properties, inventory was focused on high-use areas, and forested or unmaintained sections of the public properties were not collected. When unmaintained areas were encountered along public ROW, only larger, more dominant trees were collected to prevent overcollection of small whips that are not likely to present major hazards or require extensive maintenance work. The scope of the 2019 inventory is important to keep in mind when reading and using the analyses provided in this report – the inventoried tree population may not be representative of the entire urban forest of Hartford, which includes trees on both public and private lands.

Site Location Methods

Equipment and Base Maps

Inventory arborists used FZ-G1 Panasonic Toughbook® unit(s) and the included internal GPS receiver(s).

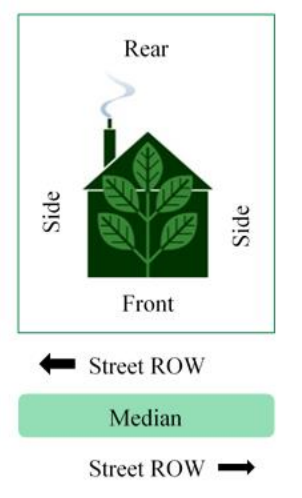
Base map layers were loaded onto these unit(s) to help locate sites during the inventory. The table below lists the base map layers along with source and format information for each layer.

Base Map Layers Utilized for Inventory

Imagery/Data Source	Date	Projection
1ft Aerial Imagery Nearmap Imagery	**2019**	**NAD 1983 StatePlane Connecticut, Feet**
Basemaps Hartford, CT GIS	**2018-2019**	**NAD 1983 StatePlane Connecticut, Feet**

Street ROW Site Location

Individual street ROW sites (trees, stumps, or planting sites) were located using a methodology that identifies sites by *address number*, *street name, on street name,* and *side*. This methodology was developed by DRG to help ensure consistent assignment of location.



Side values for street ROW sites.

Address Number

The *address number* was automatically filled based on GIS parcel addressing and was edited in the field as needed based on visual observation by the arborist at the time of the inventory (the address number was posted on a building at the inventoried site). Where there was no posted address number on a building, or where the site was located by a vacant lot with no GIS parcel addressing data available, the arborist used his/her best judgment to assign an address number based on opposite or adjacent addresses. If an address was assigned by the arborist, the Suffix (assigned address) field was changed from No to Yes.

Side

Each site was assigned a *side*. Side values include *front, side, median* (includes islands), or *rear* based on the site's location in relation to the lot's street frontage. The *front* is the side that faces the address street. Sites assigned the side value *front* will have the same street and on street value. *Side* indicates the side of a lot perpendicular to the address street. *Median* indicates a median or island. The *rear* is the side of the lot opposite the front. Sites assigned the side values *side* or *rear* will have different street and on street values.

Street and On Street

Block side information for a site includes the *street* and *on street*.

- The *street* is the street to which the lot is addressed. It is usually (although not always) the street which buildings on the lot face.
- The *on street* is the street on which the site is located. The *on street* may not match the address street. A site may be physically located on a street that is different from its street address (i.e., a site located on a side street). Sites with side value *front* will always have the same street and on street values. Sites with side value *side* or *rear* will never have the same street and on street values.

Site Location Examples

The tree trimming crew in the truck traveling westbound on E. Mac Arthur Street is trying to locate an inventoried tree with the following location information:

Address:	226
Street:	E. Mac Arthur Street
On Street:	Davis Street
Side:	Side

The tree site circled in red signifies the crew’s target site. Because the tree is located on the side of the lot, the *on street* is Davis Street, even though it is addressed as 226 East Mac Arthur Street.

Location information collected for inventoried trees at Corner Lots A and B.

Corner Lot A		Corner Lot B	
Address:	205	Address:	226
Street:	Hoover St.	Street:	E Mac Arthur St.
On Street:	Taft St.	On Street:	Davis St.
Side:	side	Side:	side
Address:	205	Address:	226
Street:	Hoover St.	Street:	E Mac Arthur St.
On Street:	Taft St.	On Street:	E Mac Arthur St.
Side:	side	Side:	front
Address:	205	Address:	226
Street:	Hoover St.	Street:	E Mac Arthur St.
On Street:	Taft St.	On Street:	E Mac Arthur St.
Side:	side	Side:	front
Address:	205		
Street:	Hoover St.		
On Street:	Hoover St.		
Side:	front		

APPENDIX C: INVASIVE PESTS AND DISEASES

In today's worldwide marketplace, the volume of international trade brings increased potential for pests and diseases to invade our country. Many of these pests and diseases have seriously harmed rural and urban landscapes and have caused billions of dollars in lost revenue and millions of dollars in cleanup costs. Keeping these pests and diseases out of the country is the number one priority of the USDA's Animal and Plant Inspection Service (APHIS).

Updated invasive pest distribution maps can be found at: https://www.nrs.fs.fed.us/tools/afpe/maps/ and updated invasive pest information can be found at: https://www.aphis.usda.gov/aphis/resources/pests-diseases/hungry-pests/Pest-Tracker.

Although some invasive species naturally enter the United States via wind, ocean currents, and other means, most invasive species enter the country with some help from human activities. Their introduction to the U.S. is a byproduct of cultivation, commerce, tourism, and travel. Many species enter the United States each year in baggage, cargo, contaminants of commodities, or mail.

Once they arrive, invasive pests grow and spread rapidly because controls, such as native predators, are lacking. Invasive pests disrupt the landscape by pushing out native species, reducing biological diversity, killing trees, altering wildfire intensity and frequency, and damaging crops. Some pests may even push species to extinction. The following sections include key pests and diseases that adversely affect trees in America at the time of this plan's development. This list is not comprehensive and may not include all threats.

It is critical to the management of community trees to routinely check APHIS, USDA Forest Service, and other websites for updates about invasive species and diseases in your area and in our country so that you can be prepared to combat their attack.

APHIS, Plant Health, Plant Pest Program Information
- www.aphis.usda.gov/plant_health/plant_pest_info

The University of Georgia, Center for Invasive Species and Ecosystem Health
- www.bugwood.org

USDA National Agricultural Library
- www.invasivespeciesinfo.gov/microbes

USDA Northeastern Areas Forest Service, Forest Health Protection
- www.na.fs.fed.us/fhp

Ash Yellows

Ash yellows is a tree disease caused by the phytoplasma *Candidatus Phytoplasma fraxini*. Phytoplasmas are obligate bacterial parasites of plant phloem tissue which are transmitted by insect pests. In the case of ash yellows, leaf hopping insects are the suspected vector for the phytoplasma.

Photograph 11. *Witches' broom with chlorotic foliage caused by ash yellows.*

Photograph courtesy of William Jacobi, Colorado State University, Bugwood.org

Candidatus Phytoplasma fraxini was first identified as the causal agent of ash yellow in 1971 and has only been identified in North America. Its origins are otherwise unknown. The phytoplasma invades the phloem sieve tubes, a component of the tree's vascular system, causing the gradual decline and death of the tree. Common signs and symptoms of ash yellows include gradual decline in growth rate, formation of witches' brooms, crown dieback, lack of leaf pigmentation (chlorosis), upturned leaf margins, vertical cracks and cankers near the base of the trunk, and reduced twig growth (short internodes) causing foliage to tuft at the tips. These signs and symptoms are not exclusive to ash yellows and can easily be confused with similar indicators of a variety of environmental stressors.

Ash yellows affect around 12 different species of ash in North America, although it appears to affect *Fraxinus americana* (white ash) most severely. Individual ash trees show different levels of resistance to the phytoplasma, with some trees dying within 5–10 years of infection and other surviving indefinitely with only minor symptoms.

Asian Longhorned Beetle

The Asian longhorned beetle (ALB, *Anoplophora glabripennis*) is an exotic pest that threatens a wide variety of hardwood trees in North America. The beetle was initially discovered in Chicago, New Jersey, and New York City, and is believed to have been introduced in the United States from wood pallets and other wood-packing material accompanying cargo shipments from Asia. ALB is a serious threat to America's hardwood tree species.

Photograph 12. *Adult Asian longhorned beetle.*

Photograph courtesy of New Bedford Guide 2011

Adults are large (3/4- to 1/2-inch long) with very long, black and white banded antennae. The body is glossy black with irregular white spots. Adults can be seen from late spring to fall depending on the climate. ALB has a long list of host species; however, the beetle prefers hardwoods, including several maple species. Examples include: *Acer negundo* (box elder); *A. platanoides* (Norway maple); *A. rubrum* (red maple); *A. saccharinum* (silver maple); *A. saccharum* (sugar maple); *Aesculus glabra* (buckeye); *A. hippocastanum* (horsechestnut); *Betula* spp. (birch); *Platanus* × *acerifolia* (London planetree); *Salix* spp. (willow); and *Ulmus* spp. (elm).

Bacterial Leaf Scorch

The bacterium for bacterial leaf scorch (BLS, *Xylella fastidiosa*) is spread primarily by xylem-feeding insects and grafting. Once present, the bacterium multiplies and colonizes the xylem, blocking transport of water to plant tissue. The tree's reaction to the bacterium causes further blocked transport ultimately leading to fatality.

Photograph 13. *Bacterial leaf scorch symptoms on elm leaves.*

Photograph courtesy of Jo-Ann Bentz, The United States National Arboretum

Presence of BLS has been found in states from New York to Texas, and in Washington, DC, California, Indiana, Kentucky, Nebraska, and Ohio. It causes a premature need for removal due to unsightly leaves or dead and dying parts of the infected tree. No cure or preventative is currently known for this disease.

Known hosts for BLS include *Catalpa* spp. (catalpa), *Ulmus americana* (America elm), *Ginkgo* spp. (ginkgo), *Celtis* spp. (hackberry), maple, *Morus* spp. (mulberry), *Quercus* spp.(oak), *Platanus* spp. (sycamore), and *Liquidambar* spp. (sweetgum).

Balsam Woolly Adelgid

Balsam woolly adelgid (*Adelges piceae*) was introduced to the northeastern United States sometime in the early 1900s and was discovered in the Pacific Northwest in 1929. The insects themselves and tiny and hard to see, but they cause certain characteristic symptoms and signs in trees they infest.

Photograph 14. *Gouting of a Frasier fir twig due to balsam woolly adelgid.*

Photograph courtesy of USDA Forest Service – Region 8 – Southern, Bugwood.org

The insect has a highly complex life cycle that includes two easily observable phases: the gout phase and the trunk phase. During the gout phase, swelling of twig nodes is the most obvious symptom of balsam woolly adelgid infestation, which is caused by the host tree reacting to chemicals injected by the insect when feeding. The swellings can impair the vascular system of the host tree and cause twig dieback or whole tree mortality if severe enough. During the trunk phase, white woolly spots or patches appear on the host tree trunk. These spots are protective coverings over various life stages of the adelgid feeding through the bark of the tree.

In its native range in Europe, the balsam woolly adelgid alternates between fir and spruce hosts, with male adelgids only produced on the alternate spruce host. Since an appropriate alternate host is not present in the United States, all balsam woolly adelgids in the US are female and reproduce parthenogenically, by laying eggs that exact replicas of the mother. This is fortunate, as it helps reduce the chances that the pest will become resistant to any given pesticide.

Balsam woolly adelgids can infest any true fir (*Abies*) species but have been particularly damaging to fir species that are typically grown in monocultures for Christmas trees and wreaths, such as *Abies fraseri* (Fraser fir) and *Abies balsamea* (balsam fir).

Beech Bark Disease

Beech bark disease is the result of an insect-fugus complex which begins when a non-native beech scale insect, *Cryptococcus fagisuga*, feeds on the bark of beech trees, creating lesions through which a native canker fungus, *Neonectria* spp., can enter the tree. The scale insect, which is native to Europe, was first introduced to Nova Scotia in the 1890s and has since spread west and south across Canada and the United States.

Photograph 15. *Perennial nectria cankers caused by beech bark disease on an American beech.*

Photograph courtesy of Linda Haugen, USDA Forest Service, Bugwood.org

Cryptococcus fagisuga is a soft-bodied scale insect which secretes a white wooly wax during the nymph stage which can make infested trees appear to be covered in wool. The insects feed on the bark, leaving punctures through which the nectria canker fungi can enter; 50–85% of infect beech trees will die within 10 years of infestation. Even trees that don't succumb to the disease may be significantly structurally weakened by the nectria cankers and are prone to "beech snap" or trunk failure. Such trees pose a safety hazard within the urban environment.

The beech scale and resulting beech bark disease is found on both *Fagus grandifolia* (American beech) and on *Fagus sylvatica* (European beech). There has been some success in breeding American beech trees that resistant to the disease.

Bruce spanworm

Bruce spanworm (*Operophtera buceata*) is a native species of moth found throughout the northern United States. Easily confused with the invasive winter moth (*O. brumata*), adult bruce spanworms are small, light brown moths that emerge in October and November. Female lay their eggs singly in the trunks and branches of host trees, and larvae emerge in late April or May, around budbreak. Early instar larvae feed by burrowing into emerging buds, causing the foliage to look ragged. As the larvae mature, they progress to consuming all but the midrib and veins of leaves. Mature bruce spanworm larvae are around 1 inch long and have three pale yellow stripes along each side.

Photograph 16. *Mature bruce spanworm larva.*

Photograph courtesy of E. Bradford Walker, Vermont Department of Forests, Parks, and Recreation; Bugwood.org

Outbreaks of bruce spanworm tend to be localized and may last three or four years. Since the species is native to the United States, natural control factors such as parasites, predators, and diseases prevent extensive or prolonged outbreaks. However, repeated defoliation during an outbreak can weaken host trees, leaving them susceptible to secondary infestations or infections. Common hosts of bruce spanworm include *Acer* (maple), *Populus* (poplar), *Salix* (willow), and *Fagus* (beech).

Butternut Canker

Butternut canker is a fungal disease of *Juglans cinerea* (butternut) caused by the fungus *Sirococcus clavigignenti-juglandacearum*. The first documented cases of the disease were found in Wisconsin in 1967 and it has since been found to be present throughout the native range of butternut. It is thought to have originated outside of the United States, but scientists are uncertain of the origin of the fugus. In some states and in Ontario, Canada, butternut canker has killed up to 80% of the butternut trees.

Butternut canker causes sunken, black cankers with white margins and folds of bark around the edges. The cankers disrupt the flow of water and nutrients through the tree, causing progressive dieback of the woody tissue above the canker. The canker-causing fungus spreads through spores which are dispersed from infected to non-infected tissue through rain splash, insects, and wind. Wounds are commonly the entry point for the fungus. Once infected, there is little that can be done to prevent tree death, although removing infected wood in the canopy may be successful, provided there are no cankers present on the stem of the tree.

Photograph 17. *Butternut canker symptoms on a butternut sapling.*

Photograph courtesy of Mike Ostry, USDA Forest Service, Bugwood.org

Dogwood Anthracnose

Dogwood anthracnose leaf blight and canker is caused by a fungal pathogen, *Discula destructiva*. The fungus in native to Asia and was introduced to eastern North American in the late 1970s, decimating natural populations of flowering dogwood (*Cornus florida*) in southern New England. Foliar symptoms of dogwood anthracnose include round or blotchy leaf spots with tan centers and reddish-purple margins, marginal leaf scorch, and complete blight of affected foliage. The fungus can also cause stem cankers with aggressive epicormic sprouting around the infected wood. Infected vascular cambium is a chocolate brown color rather than the pale tan of healthy sapwood. Much like the butternut canker fungus, dogwood anthracnose is spread during wet weather by rain splash and wind early in the growing season.

Photograph 18. *Leaf spots with tan centers and reddish-purple margins caused by dogwood anthracnose.*

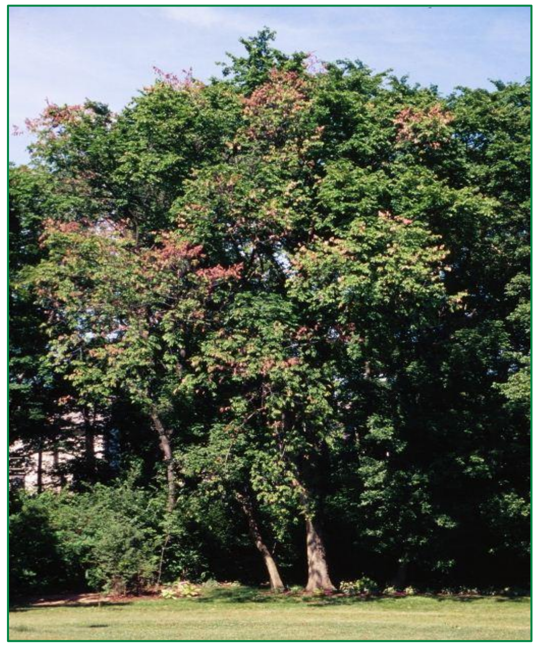
Photograph courtesy of Robert L. Anderson, USDA Forest Service, Bugwood.org

Flowering dogwood and *C. nuttallii* (Pacific dogwood) are both highly susceptible to this disease and tend to sustain serious damage from it. While *C. kousa* (Kousa dogwood) is also susceptible to infection, it is highly resistant to the disease, as are Kousa dogwood hybrids and many other common landscape dogwood, such as *C. alba* (Tatarian dogwood) and *C. sericea* (redosier dogwood). Management options for dogwood anthracnose include choosing open, sunny planting locations, since the fungus severity is inversely related to available sunlight and removing infected wood and leaves throughout the growing season. Fungicides may also be effective during wet spring weather.

Dutch Elm Disease

Considered by many to be one of the most destructive, invasive diseases of shade trees in the United States, Dutch elm disease (DED) was first found in Ohio in 1930; by 1933, the disease was present in several East Coast cities. By 1959, it had killed thousands of elms. Today, DED covers about two-thirds of the eastern United States and annually kills many of the remaining and newly planted elms. The disease is caused by a fungus that attacks the vascular system of elm trees, blocking the flow of water and nutrients, and resulting in rapid leaf yellowing, tree decline, and death. The species most affected by DED is the *Ulmus americana* (American elm).

There are two closely related fungi that are collectively referred to as DED. The most common is *Ophiostoma novo-ulmi*, which is thought to be responsible for most of the elm deaths since the 1970s. The fungus is transmitted to healthy elms by elm bark beetles. Two species carry the fungus: native elm bark beetle (*Hylurgopinus rufipes*) and European elm bark beetle (*Scolytus multistriatus)*.



Photograph 19. *Branch death, or flagging, at multiple locations in the crown of a diseased elm*

Photograph courtesy of Steven Katovich, USDA Forest Service, Bugwood.org (2011)

Elongate Hemlock Scale

The elongate hemlock scale (EHS, *Fiorina externa*) was introduced from Japan and was first observed in Queens, NY as early as 1908. It was not considered a major pest until the 2000s when its range and prevalence increased dramatically. This invasive scale insect has been found in 16 states to date, including Connecticut, Delaware, Maine, Maryland, Massachusetts, Michigan, New Hampshire, New Jersey, Nevada, New York, North Carolina, Ohio, Pennsylvania, Rhode Island, Tennessee, and Virginia as well as the District of Colombia. The insect is thought to have been spread widely on infested conifer products, including holiday wreaths and Christmas trees.

Photograph 20. *EHS covering the undersides of hemlock needles.*

Photograph courtesy of Eric R. Day, Virginia Polytechnic Institute and State University, bugwood.org (2011)

Adult female EHS are soft-bodied, amber, legless, and wingless. They are encased in an 2mm long, brown, waxy scale covered under which they feed and lay around 20 lemon-colored eggs. Males are enclosed in white, 1.5mm scales. While they have wings, they are weak fliers and travel only to mate. They do not feed. Young instars are called crawlers and are yellow and legged. They emerge from May–September and mature to later instars which feed under scales. The scales are a visible sign that a tree is infested with EHS, and needle yellowing, especially on lower branches, premature needle drop, and branch dieback are all common symptoms of EHS infestation. While these insects can kill trees outright by siphoning away nutrients and water from the tree, more commonly they weaken hosts, leaving them susceptible to other pests or environmental conditions.

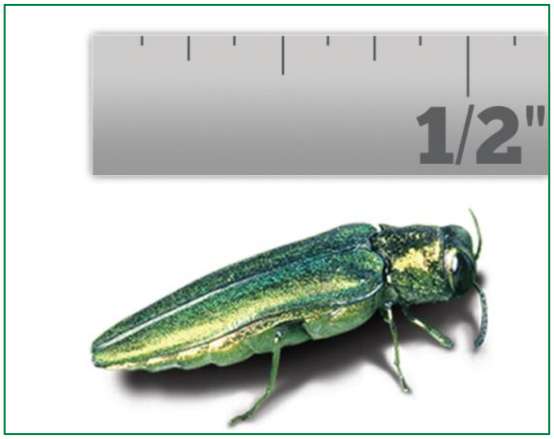
EHS's preferred host species include *Tsuga* (hemlock), *Abies* (fir), and *Picea* (spruce). Other, less preferred hosts include *Cedrus* (cedar), *Pseudotsuga menziesii* (Douglas-fir), *Pinus* (pine), and *Taxus* (yew). EHS is frequently found on the same trees as *Adelges tsugae* (hemlock woolly adelgid).

Emerald Ash Borer

Emerald ash borer (EAB, *Agrilus planipennis*) is responsible for the death or decline of tens of millions of ash trees in 14 states in the American Midwest and Northeast. Native to Asia, EAB has been found in China, Japan, Korea, Mongolia, eastern Russia, and Taiwan. It likely arrived in the United States hidden in wood-packing materials commonly used to ship consumer goods, auto parts, and other products. The first official United States identification of EAB was in southeastern Michigan in 2002.

Adult beetles are slender and 1/2-inch long. Males are smaller than females. Color varies but adults are usually bronze or golden green overall with metallic, emerald-green wing covers. The top of the abdomen under the wings is metallic, purplish-red and can be seen when the wings are spread.

The EAB-preferred host tree species are in the genus *Fraxinus* (ash).



Photograph 21. *Close-up of the emerald ash borer.*

Photograph courtesy of APHIS (2011)

Eastern Tent Caterpillar

Eastern tent caterpillar (*Malacosoma americanum*) was first observed in the United State in 1646. In spring, caterpillars make nests in the forks and crotches of tree branches. Caterpillars do not feed within the nest—they leave the nest to feed up to 3 feet from nest and return to rest and take shelter in wet weather. Large infestations may occur at 8- to 10-year intervals. Egg masses overwinter on twigs. Trees are rarely killed by eastern tent caterpillar, but health is compromised during outbreak years and aesthetic value is decreased.

Easter tent caterpillars have a wide range of hosts, including *Malus* (apple) and *Prunus* (cherry) species.

Photograph 22. *Eastern tent caterpillar nest.*

Photograph courtesy of Prairie Haven (2008)

Fall Webworm

Photograph 23. *Fall webworm infestation.*

Photograph courtesy of Eric Rebek, Oklahoma State University, Bugwood.org (2017)

The fall webworm *(Hyphantria cunea*) is native to the United States. Late summer and fall caterpillars make nests over the end of branches and skeletonize all leaves within the nests. During extreme infestations nests may envelope an entire tree. Trees are rarely killed by fall webworm, but health is compromised during outbreak years and aesthetic value is decreased.

Caterpillars are pale yellow and covered in whitish hairs that originate from black and orange warts. Pupa overwinters in cocoons within leaf litter, bark crevices, and soil.

Fall webworm feed on approximately 90 species of tree and shrubs but common hosts include: *Betula* (birch), *Carya* (hickory), *Malus* (apple), and *Prunus* (cherry) species.

Gypsy Moth

Photograph 24. *Close-up of male (darker brown) and female (whitish color) European gypsy moths.*

Photograph courtesy of APHIS (2011b)

The gypsy moth (GM, *Lymantria dispar dispar*) is native to Europe and first arrived in the United States in Massachusetts in 1869. This moth is a significant pest because its caterpillars have an appetite for more than 300 species of trees and shrubs. GM caterpillars defoliate trees, which makes the host trees vulnerable to diseases and other pests that can eventually kill the tree.

Male GMs are brown with a darker brown pattern on their wings and have a 1/2-inch wingspan. Females are slightly larger with a 2-inch wingspan and are nearly white with dark, saw-toothed patterns on their wings. Although they have wings, the female GM cannot fly.

The GMs prefer approximately 150 primary hosts but feed on more than 300 species of trees and shrubs. Many host species are found in these common genera: *Betula* (birch), *Juniperus* (cedar), *Larix* (larch), *Populus* (aspen, cottonwood, poplar), *Quercus* (oak), and *Salix* (willow).

Granulate Ambrosia Beetle

Photograph 25. *Adult granulate ambrosia beetle.*

Photograph courtesy of Paul M. Choate, University of Florida (Atkinson et al. 2011)

The granulate ambrosia beetle (*Xylosandrus crassiusculus*), formerly the Asian ambrosia beetle, was first found in the United States in 1974 on peach trees near Charleston, South Carolina. The native range of the granulate ambrosia beetle is probably tropical and subtropical Asia. In the United States, this species has spread along the lower Piedmont region and coastal plain to East Texas, Florida, Louisiana, and North Carolina. Populations were found in Oregon and Virginia in 1992, and in Indiana in 2002.

Adults are small and have a reddish-brown appearance with a downward facing head. Most individuals have a reddish head region and a dark-brown to black elytra (hard casings protecting the wings). Light-colored forms that appear almost yellow have also been trapped. A granulated (rough) region is located on the front portion of the head and long setae (hairs) can be observed on the back end of the wing covers. Females are 2–2.5mm and males are 1.5mm long. Larvae are C-shaped with a defined head capsule.

The granulate ambrosia beetle is considered an aggressive species and can attack trees that are not highly stressed. It is a potentially serious pest of ornamentals and fruit trees and is reported to be able to infest most trees and some shrubs (azalea, rhododendron) but not conifer. Known hosts in the United States include: *Acer* (maple); *Albizia* (albizia); *Carya* (hickory); *Cercis canadensis* (eastern redbud); *Cornus* (dogwood); *Diospyros* (persimmon); *Fagus* (beech); *Gleditsia* or *Robinia* (locust); *Juglans* (walnut); *Koelreuteria* (goldenrain tree); *Lagerstroemia* (crapemyrtle); *Liquidambar styraciflua* (sweetgum); *Liriodendron tulipifera* (tulip poplar); *Magnolia* (magnolia); *Populus* (aspen); *Prunus* (cherry); *Quercus* (oak); and *Ulmus parvifolia* (Chinese elm).

Hemlock Woolly Adelgid

The hemlock woolly adelgid (HWA, *Adelges tsugae*) was first reported in western North America in 1924 and first reported in the eastern United States in 1951 near Richmond, Virginia.

Photograph 26. *Hemlock woolly adelgids on a branch.*

Photograph courtesy of USDA Forest Service (2011a)

In their native range, populations of HWA cause little damage to the hemlock trees, as they feed on natural enemies and possible tree resistance has co-evolved with this insect. In eastern North America and in the absence of natural control elements, HWA attacks both *Tsuga canadensis* (eastern or Canadian hemlock) and *T. caroliniana* (Carolina hemlock), often damaging and killing them within a few years of becoming infested.

The HWA is now established from northeastern Georgia to southeastern Maine and as far west as eastern Kentucky and Tennessee.

Larch Sawfly

Considered the most damaging pest of larch (*Larix*) in North America, the larch sawfly (*Pristiphora erichsonii*) is present throughout Canada, Alaska, and most of the northern United States. There are several strains of the pest, many of which are non-native, but there is debate as to whether strains of the species found in North America prior to 1920 were native or simply introduced from Europe at an earlier date.

Photograph 27. *Mature larch sawfly larvae feeding on tamarack needles.*

Photograph courtesy of Steven Katovich, Bugwood.org

The pest can be detected by inspecting larch shoots for slits where female sawflies have deposited their eggs or by looking for groups of the greyish-green larvae feeding and crawling on the branches. Egg laying in the new shoots of the host trees causes them to dry and curl and eventually die back, and repeated years of infestation can therefore result in crown deformation. However, the primary damage caused by this pest is defoliation of larches due to larval feeding. As a deciduous tree, larches are more capable of withstanding defoliation than most conifers, but repeated years of defoliation can result in stunted growth, dieback, and even mortality, as well as weaken host trees, increasing their susceptibility to bark beetles and other pests.

Larch sawfly feeds on eastern larch (*Larix laricina*, also known as tamarack,), *Larix occidentalis* (western larch), and *Larix lyallii* (alpine larch).

Locust Leafminer

The locust leafminer (*Odontota dorsalis*) is a native insect pest of *Robinia pseudoacacia* (black locust), though it will also occasionally attack *Malus* (apple), *Betula* (birch), *Fagus* (beech), *Prunus* (cherry), *Ulmus* (elm), *Quercus* (oak), and *Cretaegus* (hawthorn). Originally problematic only in the native range of black locust, the pest has since spread northward along with plantings of black locust and can now be found throughout the eastern United States.

Photograph 28. *Locust leafminer larval "mines" in black locust leaves.*

Photograph courtesy of Chris Evans, University of Illinois; Bugwood.org

Adult leafminer beetles are small, about 6mm long, with a yellow head and black back. Fully grown beetles chew holds in leaves and skeletonize lower leaf surfaces. Larvae from a clutch of eggs will burrow into a leaf and form a communal mine within the leaf tissue before separating and forming individual mines that may meet and form irregular blotches. The mining of the leaves can cause the entire tree to appear scorched. Outbreaks of locust leafminer are common, but generally don't kill their host trees. However, if defoliation occurs concurrently with a drought or other stressor, host trees may die as a result. More commonly, the results of locust leafminer outbreaks and simply unsightly.

Needle Cast Diseases

Needle cast diseases are caused by a wide array of fungi which infect needles of *Pinus* (pine), *Picea* (spruce), *Pseudotsuga menziesii* (Douglas fir), and *Abies* (true fir). Symptoms of the fungal infection tend to show up in the winter or spring after infection occurs and include yellowing or browning of needles, growth of dark fungal fruiting structures on needles, and premature needle drop, or "cast". Premature needle cast typically starts with interior and low crown needles, giving the infected tree a sparse or thin appearance. Needle cast diseases are most commonly problematic in conifer plantations, such as Christmas tree plantations, where there is an abundance of susceptible host material in a restricted area.

Photograph 29. *A Pinus sylvestris (Scots pine) that succumbed to needle cast (left) compared to one treated with a fungicide (right).*

Photograph courtesy of USFS Northeastern Area, Bugwood.org

Like other fungal diseases, cultural controls such as planting conifers in full sun, pruning out diseased wood, and provided appropriate spacing between plantings can significantly decrease the damage done by needle cast diseases. Fungicides can also be used around bud break in the spring the curtail the disease. Before using fungicides, samples of the needle cast disease should be tested to determine the exact fungus so an appropriate fungicide can be selected.

Oak Leaf Roller

Oak leaf roller (*Archips semiferanus*) is one of several species of moth with the common name "oak leaf roller." This native species of moth is present throughout the eastern United States and southeastern Canada and is a major defoliator of Quercus (oak). Adult oak leaf roller moths are small, brown, and active in late spring to early summer. The larvae are small green caterpillars that use silk webbing to fold young leaves together, hence their common name. The young larvae feed within the protection of the folded and rolled leaves. Severe infestations can defoliate trees in a matter of weeks after caterpillar emergence. As with other defoliating insects, repeated defoliation by oak leaf rollers can kill trees outright and, at minimum, will stress hosts, making them susceptible to other insects and diseases.

Photograph 30. *An adult oak leaf roller moth on a Gambel oak leaf (Quercus gambelii).*

Photograph courtesy of William M. Ciesla, Forest Health Management International, Bugwood.org

In addition to defoliation, common signs and symptoms of oak leaf roller infestation include the presence of the moths or caterpillars, folded or rolled leaves held together with silk webbing, caterpillars dangling from webbing, and silk webbing strands building up on the ground and trunk of the infested tree. While oak leaf rollers prefer most species of oak, they will also feed on *Pyrus* (pear), apples, and *Malus* (crabapple).

Oak Wilt

Oak wilt was first identified in 1944 and is caused by the fungus *Ceratocystis fagacearum*. While considered an invasive and aggressive disease, its status as an exotic pest is debated since the fungus has not been reported in any other part of the world. This disease affects the oak genus and is most devastating to those in the red oak subgenus, such as *Quercus coccinea* (scarlet oak), *Q. imbricaria* (shingle oak), *Q. palustris* (pin oak), *Q. phellos* (willow oak), and *Q. rubra* (red oak). It also attacks trees in the white oak subgenus, although it is not as prevalent and spreads at a much slower pace in these trees.

Photograph 31. *Oak wilt symptoms on red oak leaves.*

Photograph courtesy of USDA Forest Service (2011a)

Just as with DED, oak wilt disease is caused by a fungus that clogs the vascular system of oaks and results in decline and death of the tree. The fungus is carried from tree to tree by several borers common to oaks, but the disease is more commonly spread through root grafts. Oak species within the same subgenus (red or white) will form root colonies with grafted roots that allow the disease to move readily from one tree to another.

Pine Shoot Beetle

The pine shoot beetle (*Tomicus piniperda L.*), a native of Europe, is an introduced pest of *Pinus* (pine) in the United States. It was first discovered in the United States at a Christmas tree farm near Cleveland, Ohio in 1992. Following the first detection in Ohio, the beetle has been detected in parts of 19 states (Connecticut, Illinois, Indiana, Iowa, Maine, Maryland, Massachusetts, Michigan, Minnesota, New Hampshire, New Jersey, New York, Ohio, Pennsylvania, Rhode Island, Vermont, Virginia, West Virginia, and Wisconsin).

Photograph 32. *Mined shoots on a Scotch pine.*

Photograph courtesy of USDA Forest Service (1993)

The beetle attacks new shoots of pine trees, stunting the growth of the trees. The pine shoot beetle may also attack stressed pine trees by breeding under the bark at the base of the trees. The beetles can cause severe decline in the health of the trees and, in some cases, kill the trees when high populations exist.

Adult pine shoot beetles range from 3 to 5 millimeters long, or about the size of a match head. They are brown or black and cylindrical. The legless larvae are about 5 millimeters long with a white body and brown head. Egg galleries are 10–25 centimeters long. From April to June, larvae feed and mature under the pine bark in separate feeding galleries that are 4–9 centimeters long. When mature, the larvae stop feeding, pupate, and then emerge as adults. From July through October, adults tunnel out through the bark and fly to new or 1-year-old pine shoots to begin maturation feeding. The beetles enter the shoot 15 centimeters or less from the shoot tip and move upwards by hollowing out the center of the shoot for a distance of 2.5–10 centimeters. Affected shoots droop, turn yellow, and eventually fall off during the summer and fall.

P. sylvestris (Scots pine) is preferred, but other pine species, including *P. banksiana* (jack pine), *P. nigra* (Austrian pine), *P. resinosa* (red pine), and *P. strobus* (eastern white pine), have been infested in the Great Lakes region.

Sirex Woodwasp

Sirex woodwasp (*Sirex noctillio*) has been the most common species of exotic woodwasp detected at United States ports-of-entry associated with solid wood-packing materials. Recent detections of Sirex woodwasp outside of port areas in the United States have raised concerns because this insect has the potential to cause significant mortality of pines. Awareness of the symptoms and signs of a Sirex woodwasp infestation increases the chance of early detection, thus increasing the rapid response needed to contain and manage this exotic forest pest.

Photograph 33. *Close-up of female Sirex Woodwasp.*

Photograph courtesy of USDA (2005)

Woodwasps (or horntails) are large robust insects, usually 1.0 to 1.5 inches long. Adults have a spear-shaped plate (cornus) at the tail end; in addition, females have a long ovipositor under this plate. Larvae are creamy white, legless, and have a distinctive dark spine at the rear of the abdomen. More than a dozen species of native horntails occur in North America.

Sirex woodwasps can attack living pine, while native woodwasps attack only dead and dying trees. At low populations, the Sirex woodwasp selects suppressed, stressed, and injured trees for egg laying. Foliage of infested trees initially wilts, and then changes color from dark green to light green, to yellow, and finally to red during the three to six months following attack. Infested trees may have resin beads or dribbles at the egg laying sites, but this is more common at the mid-bole level. Larval galleries are tightly packed with very fine sawdust. As adults emerge, they chew round exit holes that vary from 1/8 to 3/8 inch in diameter.

Southern Pine Beetle

The southern pine beetle (SPB, *Dendroctonus frontalis*) is the most destructive insect pest of pine in the southern United States. It attacks and kills all species of southern yellow pine including *P. strobus* (eastern white pine). Trees are killed when beetles construct winding, S-shaped egg galleries underneath the bark. These galleries effectively girdle the tree and destroy the conductive tissues that transport food throughout the tree. Furthermore, the beetles carry blue staining fungi on their bodies that clog the water conductive tissues (wood), which transport water within the tree. Signs of attack on the outside of the tree are pitch tubes and boring dust, known as frass, caused by beetles entering the tree.

Photograph 34. *Adult southern pine beetles.*

Photograph courtesy of Forest Encyclopedia Network (2012)

Adult SPBs reach an ultimate length of only 1/8 inch, similar in size to a grain of rice. They are short-legged, cylindrical, and brown to black in color. Eggs are small, oval-shaped, shiny, opaque, and pearly white.

Spotted Lanternfly

The spotted lanternfly (SLF, *Lycorma delicatula*) is native to China and was first detected in Pennsylvania in September 2014. Spotted lanternfly feed on a wide range of fruit, ornamental and woody trees, with the invasive *Ailanthus altissima* (tree-of-heaven) being one of the preferred hosts. Spotted lanternfly are invasive and can be spread long distances by people who move infested material or items containing egg masses. If allowed to spread in the United States, this pest could seriously impact the country's grape, orchard, and logging industries.

Photograph 35. *Profile of spotted lanternfly adult at rest.*

Photograph courtesy of Pennsylvania Department of Agriculture

Adult spotted lanternfly are approximately 1 inch long and 1/2 inch wide, and they have large and visually striking wings. Their forewings are light brown with black spots at the front and a speckled band at the rear. Their hind wings are scarlet with black spots at the front and white and black bars at the rear. Their abdomen is yellow with black bars. Nymphs in their early stages of development appear black with white spots and turn to a red phase before becoming adults. Egg masses are yellowish-brown in color, covered with a gray, waxy coating prior to hatching.

The spotted lanternfly lays its eggs on smooth host plant surfaces and on non-host material, such as bricks, stones, and dead plants. Eggs hatch in the spring and early summer, and nymphs begin feeding on a wide range of host plants by sucking sap from young stems and leaves. Adults appear in late July and tend to focus their feeding on tree-of-heaven and grapevine (*Vitis vinifera*). As the adults feed, they excrete sticky, sugar-rich fluid similar to honeydew. The fluid can build up on plants and on the ground underneath infested plants, causing sooty mold to form.

Sudden Oak Death

The causal agent of sudden oak death (SOD, also known as *Phytophthora* canker disease), *Phytophthora ramorum*, was first identified in 1993 in Germany and the Netherlands on ornamental rhododendrons. In 2000, the disease was found in California. Since its discovery in North America, SOD has been confirmed in forests in California and Oregon and in nurseries in British Columbia, California, Oregon, and Washington. SOD has been potentially introduced into other states through exposed nursery stock. Through ongoing surveys, APHIS continues to define the extent of the pathogen's distribution in the United States and limit its artificial spread beyond infected areas through quarantine and a public education program.

Photograph 36. *Drooping tanoak shoot.*

Photograph courtesy of Indiana Department of Natural Resources (2012)

Identification and symptoms of SOD may include large cankers on the trunk or main stem accompanied by browning of leaves. Tree death may occur within several months to several years after initial infection. Infected trees may also be infested with ambrosia beetles (*Monarthrum dentiger* and *M. scutellarer*), bark beetles (*Pseudopityophthorus pubipennis*), and sapwood rotting fungus (*Hypoxylon thouarsianum*). These organisms may contribute to the death of the tree. Infection on foliar hosts is indicated by dark grey to brown lesions with indistinct edges. These lesions can occur anywhere on the leaf blade, in vascular tissue, or on the petiole. Petiole lesions are often accompanied by stem lesions. Some hosts with leaf lesions defoliate and eventually show twig dieback.

This pathogen is devastating to *Quercus* (oak) but also affects several other plant species.

Thousand Cankers Disease

A complex disease referred to as thousand cankers disease (TCD) was first observed in Colorado in 2008 and is now thought to have existed in Colorado as early as 2003. TCD is considered to be native to the United States and is attributed to numerous cankers developing in association with insect galleries.

Photograph 37. Side view of a walnut twig beetle.

Photograph courtesy of USDA Forest Service (2011b)

TCD results from the combined activity of the *Geosmithia morbida* fungus and the walnut twig beetle (WTB, *Pityophthorus juglandis*). The WTB has expanded both its geographical and host range over the past two decades, and coupled with the *Geosmithia morbida* fungus, *Juglans* (walnut) mortality has manifested in Arizona, California, Colorado, Idaho, New Mexico, Oregon, Utah, and Washington. In July 2010, TCD was reported in Knoxville, Tennessee. The infestation is believed to be at least 10 years old and was previously attributed to drought stress. This is the first report east of the 100th meridian, raising concerns that large native populations of *J. nigra* (black walnut) in the eastern United States may suffer severe decline and mortality.

The tree species preferred as hosts for TCD are walnuts.

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APPENDIX D: SUGGESTED TREE SPECIES

Proper landscaping and tree planting are critical components of the atmosphere, livability, and ecological quality of a community's urban forest. The tree species listed below have been evaluated for factors such as size, disease and pest resistance, seed or fruit set, and availability. The following list is offered to assist all relevant community personnel in selecting appropriate tree species. These trees have been selected because of their aesthetic and functional characteristics and their ability to thrive in the soil and climate conditions throughout Zone 6 on the USDA Plant Hardiness Zone Map.

Deciduous Trees

Large Trees: Greater than 45 Feet in Height at Maturity

Scientific Name	Common Name	Cultivar
*Aesculus flava**	yellow buckeye	
*Betula alleghaniensis**	yellow birch	
*Betula lenta**	sweet birch	
Betula nigra	river birch	Heritage®
Carpinus betulus	European hornbeam	'Franz Fontaine'
Carya glabra	pignut hickory	
*Carya illinoensis**	pecan	
*Carya lacinata**	shellbark hickory	
*Carya ovata**	shagbark hickory	
Carya tomentosa	mockernut hickory	
*Castanea mollissima**	Chinese chestnut	
Celtis occidentalis	common hackberry	'Prairie Pride'
Cercidiphyllum japonicum	katsuratree	'Aureum'
*Diospyros virginiana**	common persimmon	
*Fagus grandifolia**	American beech	
*Fagus sylvatica**	European beech	(Numerous exist)
Ginkgo biloba	ginkgo	(Choose male trees only)
Gymnocladus dioicus	Kentucky coffeetree	Prairie Titan®
*Juglans nigra**	black walnut	
*Larix decidua**	European larch	
Liquidambar styraciflua	American sweetgum	'Rotundiloba'
*Liriodendron tulipifera**	tuliptree	'Fastigiatum'
*Magnolia acuminata**	cucumbertree magnolia	(Numerous exist)
Metasequoia glyptostroboides	dawn redwood	'Emerald Feathers'
*Platanus occidentalis**	American sycamore	
Platanus × acerifolia	London planetree	'Yarwood'
Quercus alba	white oak	
Quercus bicolor	swamp white oak	
Quercus coccinea	*scarlet oak*	
Quercus imbricaria	shingle oak	
Quercus lyrata	overcup oak	
Quercus macrocarpa	bur oak	

Scientific Name	Common Name	Cultivar
Quercus montana	chestnut oak	
Quercus muehlenbergii	chinkapin oak	
Quercus palustris	pin oak	
Quercus phellos	willow oak	
Quercus prinus	chestnut oak	
Quercus rubra	northern red oak	'Splendens'
Quercus shumardii	Shumard oak	
Taxodium distichum	common baldcypress	'Shawnee Brave'
Tilia americana	American linden	'Redmond'
Tilia cordata	littleleaf linden	'Greenspire'
Tilia × euchlora	Crimean linden	
Tilia tomentosa	silver linden	'Sterling'
Ulmus parvifolia	Chinese elm	Allée®
Zelkova serrata	Japanese zelkova	'Green Vase'

Medium Trees: 31 to 45 Feet in Height at Maturity

Scientific Name	Common Name	Cultivar
Aesculus × carnea	red horsechestnut	
Alnus cordata	Italian alder	
*Asimina triloba**	pawpaw	
Celtis laevigata	hackberry	
Cladrastis kentukea	American yellowwood	'Rosea'
Corylus colurna	Turkish filbert	
Eucommia ulmoides	hardy rubber tree	
Gleditsia triacanthos var. *inermis*	thornless honeylocust	'Shademaster'
Koelreuteria paniculata	goldenraintree	
Nyssa sylvatica	black gum, tupelo	
Ostrya virginiana	eastern hophornbeam	
Parrotia persica	Persian parrotia	'Vanessa'
Phellodendron amurense	amur corktree	'Macho'
Pistacia chinensis	Chinese pistache	
Prunus maackii	amur chokecherry	'Amber Beauty'
Prunus sargentii	Sargent cherry	
Prunus yedoensis	Yoshino cherry	
*Pterocarya fraxinifolia**	Caucasian wingnut	
Quercus acutissima	sawtooth oak	
Quercus cerris	European turkey oak	
Quercus robur f. *fastigiata*	fastigiate oak	
*Sassafras albidum**	sassafras	
Styphnolobium japonicum	pagoda tree	

Small Trees: 15 to 30 Feet in Height at Maturity

Scientific Name	Common Name	Cultivar
*Aesculus pavia**	red buckeye	
Amelanchier arborea	downy serviceberry	(Numerous exist)
Amelanchier canadensis	shadbush	
Amelanchier laevis	Allegheny serviceberry	
Amelanchier x grandiflora	hybrid serviceberry	'Autumn brilliance'
*Carpinus caroliniana**	American hornbeam	
Cercis canadensis	eastern redbud	'Forest Pansy'
Chionanthus virginicus	white fringetree	
Cornus alternifolia	pagoda dogwood	
Cornus amomum	silky dogwood	
Cornus kousa	Kousa dogwood	(Numerous exist)
Cornus mas	corneliancherry dogwood	'Spring Sun'
Corylus avellana	European filbert	'Contorta'
*Cotinus coggygria**	common smoketree	'Flame'
*Cotinus obovata**	American smoketree	
*Crataegus phaenopyrum**	Washington hawthorn	Princeton Sentry™
Crataegus viridis	green hawthorn	'Winter King'
*Franklinia alatamaha**	Franklinia	
*Halesia tetraptera**	Carolina silverbell	'Arnold Pink'
Laburnum × watereri	goldenchain tree	
Maackia amurensis	amur maackia	
*Magnolia macrophylla**	bigleaf magnolia	
*Magnolia × soulangiana**	saucer magnolia	'Alexandrina'
*Magnolia stellata**	star magnolia	'Centennial'
*Magnolia tripetala**	umbrella magnolia	
*Magnolia virginiana**	sweetbay magnolia	Moonglow®
Malus spp.	flowering crabapple	(Disease resistant only)
Oxydendrum arboreum	sourwood	'Mt. Charm'
Prunus cerasifera	cherry plum	'Thunderleaf'
Prunus serrulata	Kwanzan cherry	
Prunus subhirtella	Higan cherry	'Pendula'
Prunus virginiana	common chokecherry	'Schubert'
*Staphylea trifolia**	American bladdernut	
Stewartia ovata	mountain stewartia	
Stewartia pseudocamellia	Japanese stewartia	
*Styrax japonicus**	Japanese snowbell	'Emerald Pagoda'
Syringa reticulata	Japanese tree lilac	'Ivory Silk'

Note: * denotes species that are not recommended for use as street trees.

Coniferous and Evergreen Trees

Large Trees: Greater than 45 Feet in Height at Maturity

Scientific Name	Common Name	Cultivar
Abies balsamea	*balsam fir*	
Abies concolor	white fir	'Violacea'
Cedrus libani	cedar-of-Lebanon	
Chamaecyparis nootkatensis	Nootka falsecypress	'Pendula'
Cryptomeria japonica	Japanese cryptomeria	'Sekkan-sugi'
× *Cupressocyparis leylandii*	Leyland cypress	
Ilex opaca	American holly	
Larix laricina	larch, tamarack	
*Metasequoia glyptostroboides**	dawn redwood	
Picea omorika	Serbian spruce	
Picea orientalis	Oriental spruce	
Pinus densiflora	Japanese red pine	
Pinus strobus	eastern white pine	
Pinus sylvestris	Scotch pine	
Pinus taeda	loblolly pine	
Pinus virginiana	Virginia pine	
Psedotsuga menziesii	Douglas-fir	
Taxodium distichum	bald cypress	
Thuja plicata	western arborvitae	(Numerous exist)
Tsuga canadensis	eastern hemlock	

Medium Trees: 31 to 45 Feet in Height at Maturity

Scientific Name	Common Name	Cultivar
Chamaecyparis thyoides	atlantic whitecedar	(Numerous exist)
Juniperus virginiana	eastern redcedar	
Pinus bungeana	lacebark pine	
Pinus flexilis	limber pine	
Pinus parviflora	Japanese white pine	
Thuja occidentalis	eastern arborvitae	(Numerous exist)

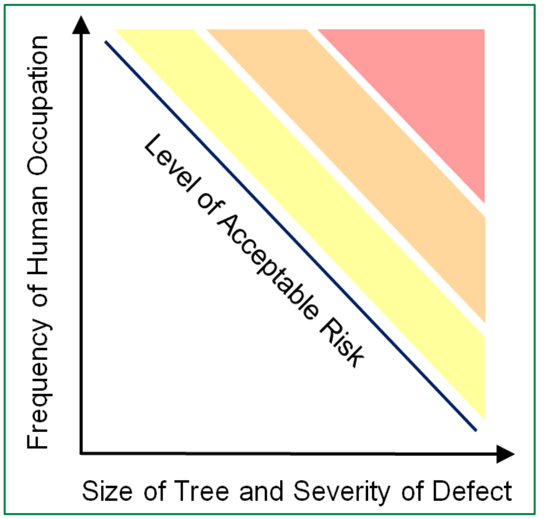
Small Trees: 15 to 30 Feet in Height at Maturity

Scientific Name	Common Name	Cultivar
Ilex × attenuata	Foster's holly	
Pinus aristata	bristlecone pine	
Pinus mugo mugo	mugo pine	

Dirr's Hardy Trees and Shrubs (Dirr 2013) and *Manual of Woody Landscape Plants (5th Edition)* (Dirr 1988) were consulted to compile this suggested species list. Cultivar selections are recommendations only and are based on DRG's experience. Tree availability will vary based on availability in the nursery trade.

APPENDIX E: RISK ASSESSMENT / PRIORITY AND PROACTIVE MAINTENANCE

Risk Assessment



Every tree has an inherent risk of tree failure or defective tree part failure. During the inventory, DRG performed a Level 2 qualitative risk assessment for each tree and assigned a risk rating based on the *ANSI A300 (Part 9)*, and the companion publication *Best Management Practices: Tree Risk Assessment* (ISA 2011). Trees can have multiple failure modes with various risk ratings. One risk rating per tree was assigned during the inventory. The failure mode having the greatest risk served as the overall tree risk rating. The specified time period for the risk assessment was one year.

- **Likelihood of Failure**—Identifies the most likely failure and rates the likelihood that the structural defect(s) will result in failure based on observed, current conditions.
    - Improbable—The tree or branch is not likely to fail during normal weather conditions and may not fail in many severe weather conditions within the specified time period.
    - Possible—Failure could occur but is unlikely during normal weather conditions within the specified time period.
    - Probable—Failure may be expected under normal weather conditions within the specified time period.
    - Imminent—Failure has started or is most likely to occur in the near future even if there is no significant wind or increased load. The imminent category overrides the stated time frame.
- **Likelihood of Impacting a Target**—The rate of occupancy of targets within the target zone and any factors that could affect the failed tree as it falls towards the target.
    - Very low—The chance of the failed tree or branch impacting the target is remote.
        - Rarely used sites
        - Examples include rarely used trails or trailheads
        - Instances where target areas provide protection
    - Low—It is not likely that the failed tree or branch will impact the target.
        - Occasionally used area fully exposed to tree
        - Frequently used area partially exposed to tree
        - Constant use area that is well protected

- Medium—The failed tree or branch may or may not impact the target.
  - Frequently used areas that are partially exposed to the tree on one side
  - Constantly occupied area partially protected from the tree
- High—The failed tree or branch will most likely impact the target.
  - Fixed target is fully exposed to the tree or tree part

- **Categorizing Likelihood of Tree Failure Impacting a Target**—The likelihood for failure and the likelihood of impacting a target are combined in the matrix below to determine the likelihood of tree failure impacting a target.

Likelihood of Failure	Likelihood of Impacting Target			
	Very Low	Low	Medium	High
Imminent	Unlikely	Somewhat likely	Likely	Very Likely
Probable	Unlikely	Unlikely	Somewhat likely	Likely
Possible	Unlikely	Unlikely	Unlikely	Somewhat likely
Improbable	Unlikely	Unlikely	Unlikely	Unlikely

- **Consequence of Failure**—The consequences of tree failure are based on the categorization of target and potential harm that may occur. Consequences can vary depending upon size of defect, distance of fall for tree or limb, and any other factors that may protect a target from harm. Target values are subjective and should be assessed from the client's perspective.
  - Negligible—Consequences involve low value damage and do not involve personal injury.
    - Small branch striking a fence
    - Medium-sized branch striking a shrub bed
    - Large tree part striking structure and causing very low monetary damage
    - Disruption of power to landscape lights
  - Minor—Consequences involve low to moderate property damage, small disruptions to traffic or communication utility, or very minor injury.
    - Small branch striking a house roof from a high height
    - Medium-sized branch striking a deck from a moderate height
    - Large tree part striking a structure, causing moderate monetary damage
    - Short-term disruption of power at service drop to house
    - Temporary disruption of traffic on neighborhood street
  - Significant—Consequences involve property damage of moderate to high value, considerable disruption, or personal injury.
    - Medium-sized part striking a vehicle from a moderate or high height
    - Large tree part striking a structure resulting in high monetary damage
    - Disruption of distribution of primary or secondary voltage power lines, including individual services and street-lighting circuits
    - Disruption of traffic on a secondary street

- Severe—Consequences involve serious potential injury or death, damage to high-value property, or disruption of important activities.
  - Injury to a person that may result in hospitalization
  - Medium-sized part striking an occupied vehicle
  - Large tree part striking an occupied house
  - Serious disruption of high-voltage distribution and transmission power line
  - Disruption of arterial traffic or motorways

- **Risk Rating**—The overall risk rating of the tree will be determined based on combining the likelihood of tree failure impacting a target and the consequence of failure in the matrix below.

Likelihood of Failure	Consequences			
	Negligible	Minor	Significant	Severe
Very likely	Low	Moderate	High	Extreme
Likely	Low	Moderate	High	High
Somewhat likely	Low	Low	Moderate	Moderate
Unlikely	Low	Low	Low	Low

Trees have the potential to fail in more than one way and can affect multiple targets.

Tree risk assessors will identify the tree failure mode having the greatest risk, and report that as the tree risk rating. Generally, trees with the highest qualitative risk ratings should receive corrective treatment first. The following risk ratings will be assigned:

- None—Used for planting and stump sites only.
- Low—The Low Risk category applies when consequences are "negligible" and likelihood is "unlikely"; or consequences are "minor" and likelihood is "somewhat likely." Some trees with this level of risk may benefit from mitigation or maintenance measures, but immediate action is not usually required.
- Moderate—The Moderate Risk category applies when consequences are "minor" and likelihood is "very likely" or "likely"; or likelihood is "somewhat likely" and consequences are "significant" or "severe." In populations of trees, Moderate Risk trees represent a lower priority than High or Extreme Risk trees.
- High—The High Risk category applies when consequences are "significant" and likelihood is "very likely" or "likely," or consequences are "severe" and likelihood is "likely." In a population of trees, the priority of High Risk trees is second only to Extreme Risk trees.
- Extreme—The Extreme Risk category applies in situations where tree failure is imminent and there is a high likelihood of impacting the target, and the consequences of the failure are "severe." In some cases, this may mean immediate restriction of access to the target zone area to avoid injury to people.

Trees with elevated (Extreme or High) risk levels are usually recommended for removal or pruning to eliminate the defects that warranted their risk rating. However, in some situations, risk may be reduced by adding support (cabling or bracing) or by moving the target away from the tree. DRG recommends only removal or pruning to alleviate risk. But in special situations, such as a memorial tree or a tree in a historic area, Hartford may decide that cabling, bracing, or moving the target may be the best option for reducing risk.

Determination of acceptable risk ultimately lies with town managers. Since there are inherent risks associated with trees, the location of a tree is an important factor in the determination and acceptability of risk for any given tree. The level of risk associated with a tree increases as the frequency of human occupation increases in the vicinity of the tree. For example, a tree located next to a heavily traveled street will have a higher level of risk than a similar tree in an open field.

Priority Maintenance

Identifying and ranking the maintenance needs of a tree population enables tree work to be assigned priority based on observed risk. Once prioritized, tree work can be systematically addressed to eliminate the greatest risk and liability first (Stamen 2011).

Risk is a graduated scale that measures potential tree-related hazardous conditions. A tree is considered hazardous when its potential risks exceed an acceptable level. Managing trees for risk reduction provides many benefits, including:

- Lower frequency and severity of accidents, damage, and injury
- Less expenditure for claims and legal expenses
- Healthier, long-lived trees
- Fewer tree removals over time
- Lower tree maintenance costs over time

Regularly inspecting trees and establishing tree maintenance cycles generally reduce the risk of failure, as problems can be found and addressed before they escalate.

Proactive Maintenance

Proactive tree maintenance requires that trees are managed and maintained under the responsibility of an individual, department, or agency. Tree work is typically performed during a cycle. Individual tree health and form are routinely addressed during the cycle. When trees are planted, they are planted selectively and with purpose. Ultimately, proactive tree maintenance should reduce crisis situations in the urban forest, as every tree in the inventoried population is regularly visited, assessed, and maintained. DRG recommends proactive tree maintenance that includes pruning cycles, inspections, and planned tree planting.

APPENDIX F: STORM RESPONSE CATEGORIES FOR THE URBAN FOREST

Storm Emergency Categories in the Urban Forest

Storm severity and resulting damage in the urban forest will vary; the degrees of response and resources need to respond will vary as well. For planning purposes, severe weather can generally be classified into three classes: Class I, II, and III. The following descriptions of these classes and the responses are offered for City consideration and adoption as part of an official emergency response plan.

Class I – Minor Storm Event

Class I storms are those that are moderate in severity municipality-wide and/or those which are more severe, but damage is restricted to very few locations or a small geographic area.

Damage reports and service requests are made to the government department directly by citizens and from staff inspections. Damage is corrected, and debris is disposed of by municipal staff and contractors on site or following customary procedures.

Generally, Class I storms require no outside assistance for parks or streets personnel, and only limited (if any) assistance from contractors or others. Storm damage remediation and cleanup are achieved by municipal staff and/or contractors, requires no additional funding or special equipment, and is completed quickly.

Class I – Storm Mitigation Procedures

- Municipal urban forestry staff receive calls/reports from citizens and partnering agencies.
- Municipal urban forestry staff inspect and determine appropriate mitigation; utility company is called as required.
- Municipal urban forestry staff and/or contractors immediately resolve damage and dispose of debris.
- Municipal urban forestry staff perform a final inspection, complete a work order, and/or otherwise note the occurrence in the tree inventory database.

Class II – Large Storm Event

Class II storms are those that are long in duration or are severe enough to cause widespread damage. Damage mitigation may also include trees on private property that fall into or threaten the public right-of-way or other property. Mitigation priority areas will be major roads, public health and services facilities, and areas or sites where public safety is at risk.

Class II storms exceed the normal staff and resources of the municipality and/or contractors alone. Damage mitigation for these storms will usually require the assistance of outside contractors and from other government departments. The assistance will come in the forms of additional staff and equipment, communication assistance, public safety measures, electrical hazard reduction, and customer service.

Class II Storm Mitigation Procedures

- Municipal urban forestry staff assess damage and immediately communicate with police and fire to determine the extent of the damage.
- The informal Emergency Operations Center should be convened to receive calls/reports and to coordinate mitigation response.
- Municipal urban forestry staff inspect damage, determine mitigation levels and needs, and set work priorities.
- Municipal urban forestry staff designate personnel and equipment resources under the guidance of the EOC leader.
- Municipal urban forestry staff and contractual staff resolve damage, process debris on site where appropriate, or transport debris to storage site.
- Municipal urban forestry staff make final inspection and update the tree inventory database.
- Debris is processed appropriately.
- Municipal urban forestry staff should communicate with the citizens about its response activities and status using the city's website and social media platforms.

Class III – Catastrophic Storm Event

Class III storms will be rare but can occur. Generally, these will result from hurricanes or snowstorms and widespread ice storms. Damage will be severe and widespread on both public and private property.

A "State of Emergency" will likely be called during and after a Class III storm event. A full EOC should be convened by municipality officials. Other local, state, and federal emergency management agencies will become involved, as well as department of transportation and natural gas and electric utility providers. It will become necessary to identify municipal funding that can be used to finance additional contractual services, equipment, and staff overtime for the mitigation efforts.

Mitigation priorities will be first determined by public safety, health, and welfare needs. Primary streets and highways that provide for evacuation and/or access to hospitals, shelters, police, fire and rescue stations, and other facilities providing vital public services should be the first priorities when clearing roads.

The second priority of streets and highways to be cleared of debris are those that provide access to components of the public and private utility systems that are vital to the restoration of essential utility services, such as electrical power stations and substations, municipal water and sanitary sewer pumping stations, and communication stations and towers. The last priority of roadways to be cleared are residential streets and alleys/access ways.

<u>No debris is intended to be removed during the initial emergency road-clearing operations.</u> Rather, debris is to be moved to the side of the roadway that will allow for a minimum of one lane of traffic in each direction and not create conflict with future utility restoration efforts by others.

Class III - Storm Mitigation Procedures

- Municipal urban forestry staff assesses damage and immediately communicates with the EOC and the designated municipal staff leader to determine the extent of the damage. County and State Emergency Management agencies may also be in the communication channels.
- Municipal urban forestry staff secures additional regional tree debris disposal site(s) as needed.
- Municipal urban forestry staff inspects tree related damage, determines mitigation levels and needs, and sets work priorities.
- Municipal, county, DOT and other agencies combine sufficient and appropriate personnel and equipment resources under the guidance of the municipality to mitigate tree related situations.
- Municipality, allied agencies, and contractual staff resolve damage, process debris on site where appropriate, or transport debris to storage site.
- Municipal urban forestry staff make final inspection and update the tree inventory database.
- Debris is processed appropriately.
- Municipal urban forestry staff assist EOC team members and municipal leaders with completion of required state and Federal Emergency Management Agency (FEMA) forms.
- Municipal urban forestry staff should communicate with the citizens about its response activities and status and provide advice for the treatment of private trees that have been damaged using the municipal website and social media platforms.

APPENDIX B

Davey Resource Group Tree Condition Criteria

Davey Resource Group Tree Condition Criteria

From: Rodbell, Sophia
To: Emily Weckman
Subject: Re: Conditions Criteria
Date: Monday, February 24, 2020 7:17:40 AM
Attachments: image001.png

Hi Emily, below is an excerpt from our work spec with Hartford:

1. **Condition**—Signs of stress, poor structure, mechanical damage, soil and root problems, disease, and pests are all considerations in the assessment of tree condition.

    a. *Good.* A good tree shows no major problems.

    b. *Fair.* A fair tree has minor problems that may be corrected with time or corrective action.

    c. *Poor.* A poor tree has major problems that are irrecoverable.

    d. *Dead.* A dead tree shows no sign of life.

APPENDIX C

Davey Resource Group Vacant Lot Criteria

Vacant Site Protocol

- Vacant Site Small
  - 4-5.9’ grow space minimum dimension
  - 20’+ from all other trees/stumps/vacant sites
  - 15’+ from infrastructure (including utility poles and buildings)
  - 20’+ from hydrants
  - 30’+ from intersections
  - 10’+ from driveways
  - 5’-10’ from underground utilities
  - **CAN** be located under overhead utilities including drop lines (OH utilities = P&NC)
  - 10’+ from important traffic signs (stop signs, pedestrian crossing, etc…)(does not include parking signs, which can be moved if needed)
- Vacant Site Medium
  - 6-7.9’ grow space
  - 30’+ from all other trees/stumps/vacant sites
  - 15’+ from infrastructure (including utility poles and buildings)
  - 20’+ from hydrants
  - 30’+ from intersections
  - 10’+ from driveways
  - 5-10’ from underground utilities
  - Can **NOT** be located underneath utility lines, including drop lines (OH utilities = NP)
  - 10’ from important traffic signs (stop signs, pedestrian crossing, etc…)(does not include parking signs, which can be moved if needed)
- Vacant Site Large
  - 8’+ grow space
  - 40’+ from all other trees/stumps/vacant sites
  - 15’+ from infrastructure (including utility poles and buildings)
  - 20’+ from hydrants
  - 30’+ from intersections
  - 10’+ from driveways

    - 5-10’ from underground utilities
    - Can **NOT** be located underneath utility lines, including drop lines (OH utilities = NP)(does not include parking signs, which can be moved if needed)
    - 10’+ from important traffic signs (stop signs, pedestrian crossing, etc…)

General rules:

- You must always prioritize the largest possible vacant site. For example, if you have a planting strip that is 6 feet wide and 120 feet long with no overhead utilities, you **must** put 5 vacant sites mediums, not 7 vacant site smalls.
- Try not to place vacant sites in front of walkways or in places that would interfere with pedestrians

APPENDIX D

To Design Case Study, January 2020

HARTFORD'S URBAN TREE CANOPY

- Case Study Review and Hartford Research -

January 10, 2020

A Case Study Review focusing on:

- Inventory
    - Technology
    - Communicating
    - Prioritized Planting Areas

- Funding

- Action Plan
    - Planting
    - Maintenance

- Hartford
    - Inventory
    - Funding
    - Action Plan

	Million TreesNYC	TreeBaltimore	TreePhilly	Durham, NC	New Haven , CT TreeHaven 10K	Hartford
Population	8.5 million people	2,325,000 people	5,717,000 people	274,291 people	857,794 people	122,587 people
Technology/ Inventory	Volunteers/ USDA Forest Service; Tree-Maps to show progress and maintenance records	Davey Resource Group; Priority Planting Mapping	Lidar mapping; does not provide detailed information on each tree	Data Collection	Street Tree Inventory Map updated by URI	GIS, iTree, Davey
Funding	Public and Private $400 million (NYC), Sponsors, Private Donations	Public (Local, State, Federal) and non-profit	2019-2021 $7 million from City, State, and Fairmount Park Conservancy, $1.13 million TD Bank	Public and Private	Partnership between Urban Resource Initiative and the City of New Haven; 75% City, 25% URI through fundraising	
Marketing	Aggressive Marketing/ Outreach to communities	Aggressive Marketing/ Outreach	Moderately Aggressive Marketing	Minimal	Moderate	
Budget	No set budget or cost per tree	No budget provided	No budget provided	No Budget provided Bareroot $50 +/- Container $200 +/- B&B $650 +/-		
Planting Goals	1 million trees by 2017; planned in 2007 10 years	Expand UTC from 27.4% to 40% by 2037 20 years	Grow UTC from 20% to 30%	1500 new trees annually, increase canopy from 52% to 55% by 2040	Goal: 10,000 in 5-years 2009-2014, 5,000 on public and 5,000 on private (homeowners and institutions) Have planted 6,000 trees since 2010	3000/ year for 50 years 150,000 trees
Non-profits	NYRP Additional on stewardship end; Brooklyn Botanical Gardens, Tree New York, Greenbelt Conservancy	Baltimore Tree Trust, Parks and People Foundation, Blue Water Baltimore and more	Fairmount Park Conservancy	Keep Durham Beautiful, Duke Park Neighborhood Association	Urban Resource Initiative – does all City of New Haven public tree planting	KNOX, Hartford Climate Stewardship Initiative

Million TreesNYC

- Benchmark Plantings @ 70% public and 30% private
- Maps that communicate goals and data
- Interactive Maps for stewardship
- Aggressive Marketing/ Community Outreach
- Planting Guidelines
- Successful Partnership with City and Non-profit
    - Non-profit is liaison with Residential/ private properties

Million TreesNYC

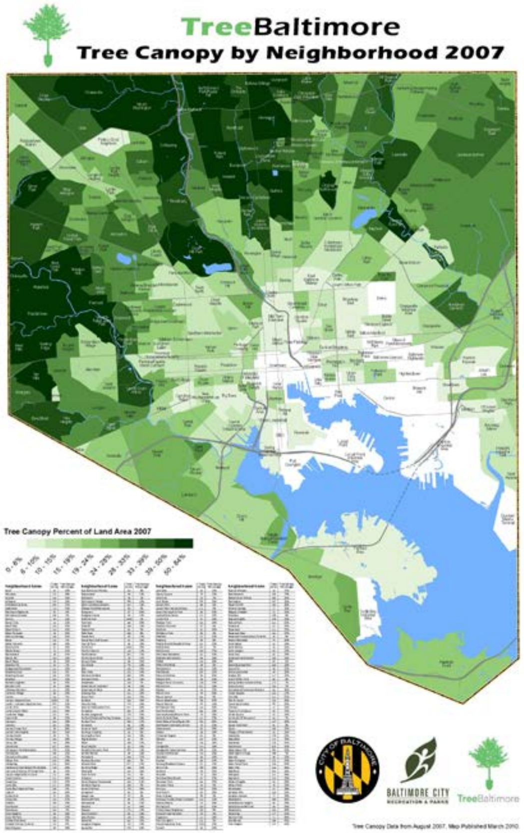
- Goal: 1 million trees to expand urban forest by 20% by 2017
- Who: NYC Parks and NYRP (New York Restoration Project)
- Where:
    - 70% street trees and parks
    - 30% homeowners, businesses
    - Set up neighborhoods of priority plantings based on Urban Tree Canopy Study
- How:
    - Technology
        - Documented Existing Street Trees in Tree Census 2005 and Urban Canopy
            - Volunteers and UTC Analysis by USDA Forest Service
        - Tree Canopy Map Study and Healthy Survey Maps to create "Trees for Public Health" planting areas
        - **Track planting, maintenance and stewards**
            - https://tree-map.nycgovparks.org/
    - Funding – Public and Private
        - NYC allocated $400 million at original allocation to cover cost of 750,000 tree planting, NYC Parks, NYRP, Sponsors (Home Depot, TD Bank, Toyota; $1 million each), Private Donations (Bloomberg and Rockefeller $10 million each)
    - **Aggressive Marketing**
        - Community Outreach (NYRP)
            - Giveaways, block plantings, education
        - Communication – Flagging locations, Tree Tags, TreeLC Website
    - Plant Guidelines
        - Contracted with 3 local nurseries to grown plants per their strict standards
        - 5'x10' tree pit, 2 year maintenance contract; plant in fall; 2.5-3" branched at 5' H branching height
        - Avoided planting in high mortality areas like medians
        - Plant List
    - Advisory Board
    - Stewardship – Super Stewards, NYRP, NYC Parks, Brooklyn Botanical Gardens, Tree New York, Greenbelt Conservancy
        - TreeLC Map

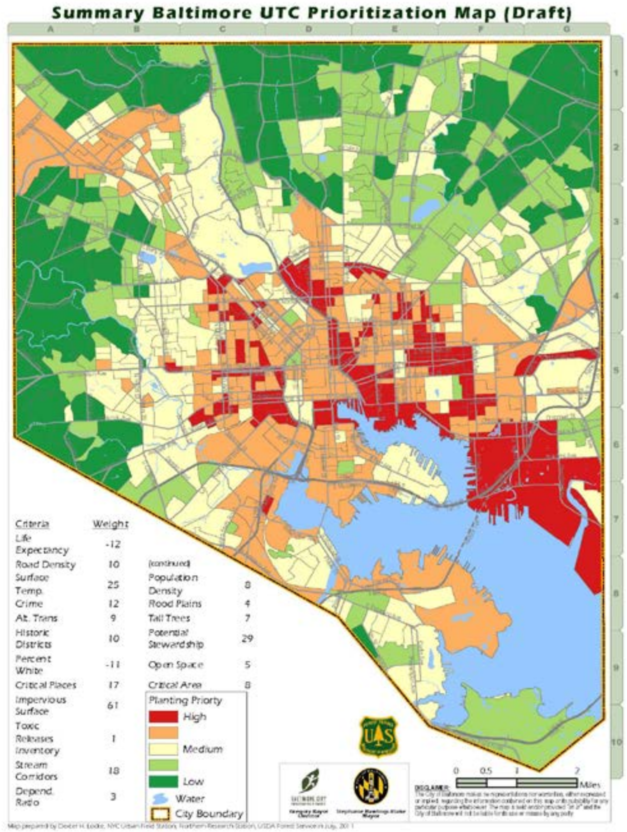
TreeBaltimore

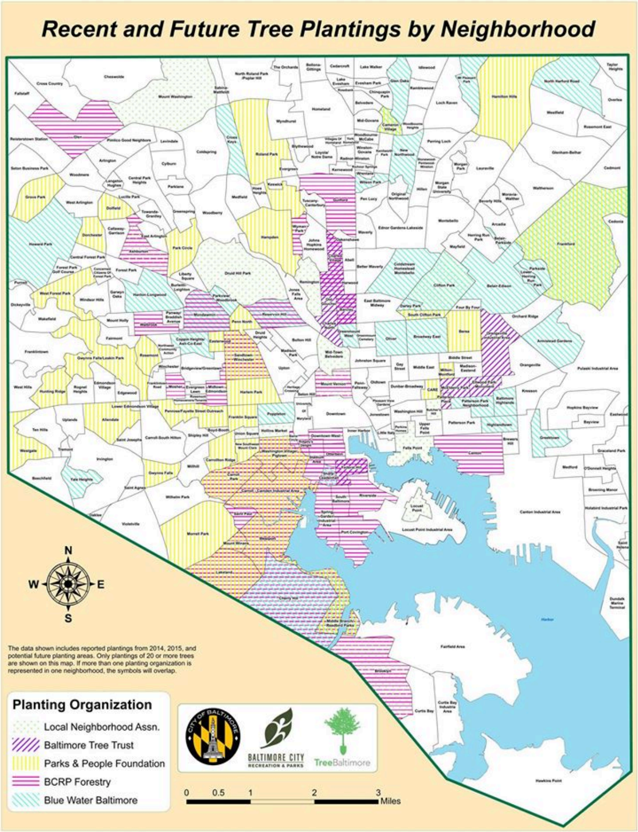
- Inventory maps that delineates planting opportunities in ROW
- Maps that communicate goals, responsible parties and planting priorities
- Marketing
- Successful Partnership with City and Non-profit

TreeBaltimore

- Goal: Expand urban forest from 27.4% to 40% by 2037
- Who: Baltimore City of Recreation and Parks along with Blue Water Baltimore, Parks and People Foundation, Baltimore Tree Trust, and the Alliance for the Chesapeake Bay
- Where:
  - Trees in ROW and Private
  - No real #'s or % goals given
- How:
  - Technology
    - Davey Resource Group inventoried Existing Street Trees within public ROW
      - Located trees, stumps, vacant sites, vacant sites not suitable
      - http://baltimore.maps.arcgis.com/apps/webappviewer/index.html?id=d2cfbbe9a24b4d988de127852e6c26c8
    - **Maps to direct planting**
      - http://www.treebaltimore.org/maps/#.XfpIRWRKi70
  - Funding – Public and Private
    - Local, State, Federal and Non-Profit
  - Aggressive Marketing
    - Community Outreach
      - Giveaways, block plantings, education
  - Plant Guidelines
    - Maintenance is on home owner
    - Plant List
    - Communication Plant Guidelines
    - Quick How to Plant online
  - Stewardship – TreeKeeper, WeedWarriors


TreeBaltimore
Tree Canopy by Neighborhood 2007
Tree Canopy Percent of Land Area 2007
TreeBaltimore


Summary Baltimore UTC Prioritization Map (Draft)
Criteria Weight
Life Expectancy -12
Road Density 10
Surface Temp. 25
Crime 12
Alt. Trans 9
Historic Districts 10
Percent White -11
Critical Places 17
Impervious Surface 61
Toxic Releases Inventory 1
Stream Corridors 18
Depend. Ratio 3
(continued)
Population Density 8
Flood Plains 4
Tall Trees 7
Potential Stewardship 29
Open Space 5
Critical Area 8
Planting Priority
High
Medium
Low
Water
City Boundary
Miles

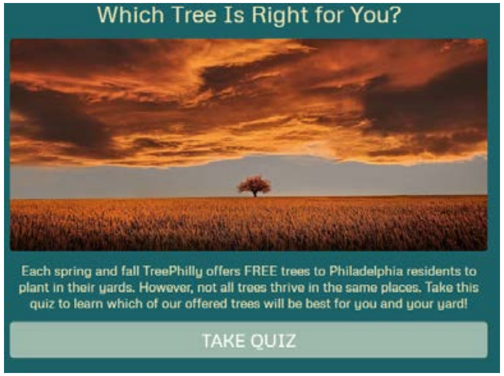

Recent and Future Tree Plantings by Neighborhood
N
W
E
S
The data shown includes reported plantings from 2014, 2015, and potential future planting areas. Only plantings of 20 or more trees are shown on this map. If more than one planting organization is represented in one neighborhood, the symbols will overlap.
Planting Organization
Local Neighborhood Assn.
Baltimore Tree Trust
Parks & People Foundation
BCRP Forestry
Blue Water Baltimore
0 0.5 1 2 3
Miles

TreePhilly

- **Tree Inventory**
- **Tree Quiz**
- **Marketing**
- **Successful Partnership with City and Non-profit**
- **On-going sponsors**

TreePhilly

- Goal: Maintain existing 20% Tree Canopy with 30% Tree Canopy Cover Goal
- Who: Philadelphia Parks and Recreation and Fairmount Park Conservancy
- Where: Undefined
- How:
    - Technology
        - UTC Report 2010 to understand existing UTC
        - TreePhilly Map https://www.opentreemap.org/phillytreemap/map/?z=16/40.0132/-75.2367
        - Existing trees were not fully inventoried, all vacant spots, used LIDAR mapping doesnt tell species and give tree detail
    - Funding – Public and Private
        - TD Bank 1.125$ over next 3 years
    - Aggressive Marketing
        - Community Outreach
            - Giveaways, block plantings, education
        - Communication
    - Plant Guidelines
        - **Tree Quiz http://treephilly.org/tree_quiz/**
        - Planting Guides online
    - Stewardship – TreeKeepers



Keep Durham Beautiful

- **Planting Priority Neighborhoods**
- **Existing Tree Management Plan**
- **Costs per tree**
- **Successful Partnership with City and Non-profit**

Durham, NC Keep Durham Beautiful

- Goal 1: Preserve, Manage, and Expand
  - Preserve
    - Maintain 52% UTC
    - **increase annual plantings to 1500 trees**
    - increase canopy to 55% by 2040
  - Manage
    - Inventory all new trees
    - Program all tree evaluation and maintenance
    - Keep tree assessment updated
  - Expand
    - Suggest land development and redevelopment to emphasize preserving and enhancing tree canopy on private property.
- Goal 2: Maximize benefits for all residents
  - A Priority Planting
    - High priority planting areas – inventory 100% available street tree planting sites in these area during first year
    - 85% of 1500 new trees to be planted in these areas
    - Remaining 15% will be prioritized
  - B Livability
    - Plant where greatest impact
    - Maintenance without resident initiated – block management
  - C Environmental Benefits
    - High priority areas to improve air, water and heat
    - Tree selection based on diversity and tolerance to urban environments

- Who: City of Durham General Services Department/ Forestry

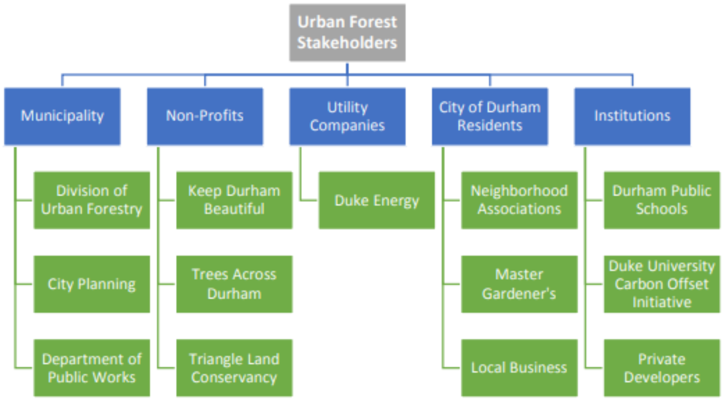


Figure 1. Stakeholders in the Urban Forest in the City of Durham

Durham, NC Keep Durham Beautiful

- How:
  - Technology
    - Tracking newly planted trees
    - Tracking maintenance
  - Funding – Public and Private
  - **Planting Costs –**
    - Bareroot (4.5-6'H) $15-25 per tree and labor .2-.4 staff hours, no heavy equipment
    - Container Trees (#3-#30 cont), $25-150$ per tree and labor.3-1.0 staff hours, no heavy equipment
    - Ball and Burlap, 1.5-3" cal, $200-400 per tree and labor 5 staff hours including machinery(50$/hr = +/-$650/tree nic maint)
  - Staff Costs
    - Short term: Part-time intern to identify and inventory planting sites in high priority districts
    - Long Term: one full time Tree Planting Coordinator to manage community outreach and logistics for planting new trees
    - City's Urban Forestry/ General Services Department and Landscape Services budget will be applied to planting and maintenance by shifting funds and acquiring additional
  - Marketing?
  - Plant Guidelines
    - Use City staff to plant 1,200 of 1,500 tree goal annually
    - Contract growing with nursery
    - Bio-diversity goals; 10% of same species, 20% same genus, 30% of same family
  - **Stewardship** –
    - City staff to provide maintenance on all trees on public land
      - Newly planted tree maintenance – City to provide staff and tools to water, mulch and prune
      - Trees 10 years and younger- inspected/ pruned every 1-2 year
      - Established Trees –pruned every 3-5 years
      - Mature Trees – inspect/ prune every 1-2 years
  - Policies
    - No net tree loss; even with utility companies
  - Partnership
    - Trees in ROW or public space – City Staff
    - Private Trees – City to support Keep Durham Beautiful, Duke Park Neighborhood Association with technical support, purchase, storage and transport of trees. Non-profits to decide locations. Non-profits must have commitment from owner to maintain new tree. Groups are encourage to provide education and tools.
    - Volunteers – City to train

Others

- New Haven CT
    - Tree Haven 10k
    - Goal: Plant 10,000 trees from 2009-2014
        - Planted 6,000 since 2010
        - Plants in ROW, BROW (up to 10' beyond ROW) and other City owned land
    - Method:
        - Partnership between City and Non-profit
        - Selects target neighborhood then goes door to door.
        - Resident must accept watering responsibilities
        - Focuses on Fall Planting
        - Block give-aways not cost effective

- New Britain 2013 report
    - 32% UTC; CT average urban UTC is 49.3%

- Norwalk, CT 2018
    - Plant 250 trees per year; to reach 61.5 UTC
    - $770.42 spent to plant a tree and maintain for 2 years
        - Maintenance cost per year needed; small tree $20, $27 med, $34 large
        - For every $1 spent, receives $3.50 in benefits

Hartford Urban Tree Canopy

• Goal: Set clear goals

- 25% existing UTC
- 1500 annual tree planting, would struggle to preserve UTC at 25% (City of Hartford Tree Plan 2018-2019 by Tree Advisory Committee)
- 2,500 trees annually: Hartford Climate Action Plan recommends
- 3,000 trees annually: Increase UTC to 35% by 2035 (City of Hartford Tree Plan 2018-2019 by Tree Advisory Committee)

- 2013: 20,000 trees in 20 years under Mayor Segarra
  - 1000 trees a year since 2012-2014; 2014-2019 dropped to under 300/yr
- Release goals to public or keep private?

- Who:
  - **Establish an umbrella campaign/ BRAND**
  - Department of Public Works/ City Forester
    - Divide UTC responsibility between City Forester, DPW, Sustainability Manager so each can focus on specific tasks
  - Office of Sustainability
    - Hartford Climate Stewardship Initiative
  - Tree Advisory Commission
  - **NON-PROFIT GROUP!** KNOX, iQuilt, Riverfront Recapture, Hartford Foundation for Public Giving

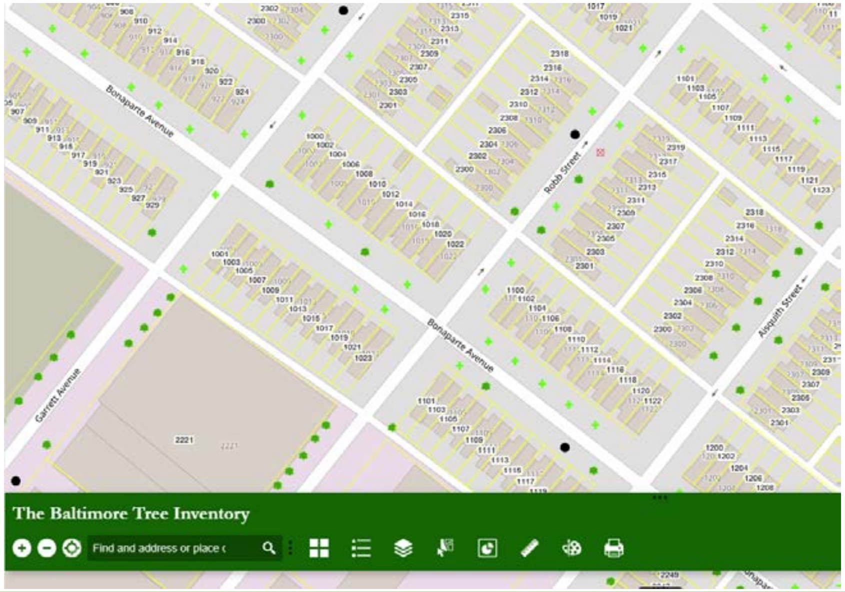
- Where: If following suit of NYC
  - Set up neighborhoods of priority plantings based on completed Urban Tree Canopy Study (TreeBaltimore and NYC MillionTrees)
  - 70% street trees and parks : Public Works?
  - 30% homeowners/ businesses/ commercial/ institutional/ religious: KNOX/non-profit?
  - Delineate/Map who is responsible for what areas of planting (TreeBaltimore)
  - City to plant on Private Property?

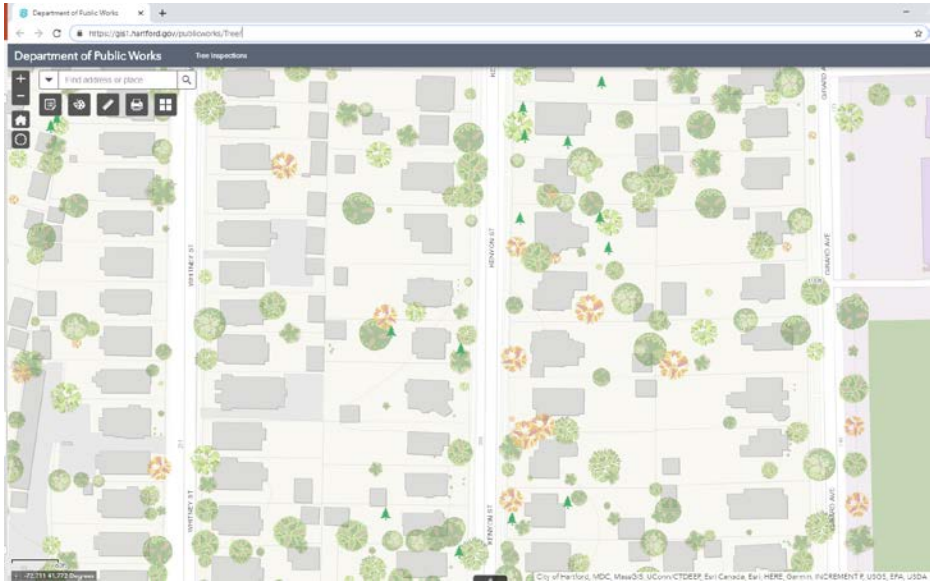
Hartford's ROW contain 16% existing TC and 32% Possible TC!

City, State/Province	Initial Canopy Cover Level		Canopy Cover Goal	
	UTC Cover	Year Assessed	UTC Cover	Target Date
Annapolis, MD	42.0%	2006	50%	30-year plan (2036)
Atlanta, GA	47.9%	2008	Increase	Ongoing
Austin, TX	32.0%	2006	40%	Ongoing
Baltimore, MD	20.0%	2007	40%	2036
Boston, MA	29.0%	2006	49%	10-year plan (2016)
Chicago, IL	17.2%	2007	25%	Ongoing
Denver, CO	16.4%	2010	31%	20-year plan (2025)
Detroit, MI	22.5%	2008	40%	Ongoing
Indianapolis, IN	13.8%	2008	19%	10-year plan (2018)
Las Vegas, NV	8.6%	2012	20%	2035
Leesburg, VA	27.0%	2006	40%	25-year plan (2031)
Los Angeles, CA	21.0%	2006	28%	2040
Milwaukee, WI	21.6%	2008	40%	Ongoing
New Haven, CT	38.0%	2009	Add 10K trees	5-year plan (2014)
New Orleans, LA	23.3%	2009	Increase	Ongoing
New York, NY	24.0%	2006	30%	2036
Philadelphia, PA	20.0%	2011	30%	15-year plan (2025)
Phoenix, AZ	10.0%	2007	25%	2030
Pittsburgh, PA	40.0%	2011	60%	20-year plan (2031)
Port Angeles, WA	27.3%	2011	40%	Ongoing
Portland, OR	29.9%	2014	33%	Ongoing
Providence, RI	23.0%	2007	30%	10-year plan (2020)
Sacramento, CA	5.2-15.4%	1998	35%	Ongoing
Seattle, WA	23.0%	2007	30%	30-year plan (2037)
Tacoma, WA	19.0%	2010	30%	20-year plan (2030)
Washington, DC	35.0%	2009	40%	20-year plan (2029)

Hartford Urban Tree Canopy

- How:
  - **Website and Marketing of campaign**
  - Technology – **COMBINE DATA! Focus on Davey**
    - Hartford Public Works GIS
      - https://gis1.hartford.gov/publicworks/Tree/
      - Tree Report link not working
    - Davey Tree Inventory
      - https://hartfordct.treekeepersoftware.com/
      - Complete Inventory: 20,000 of 30,000 and 13,000 priority areas
        - **Graphically – where are 13,000 priority? Blue Triangle?**
        - Street tree every 50'?
      - Mobilize volunteers
        - Helps facilitate future Tree Census crew/ possible stewards etc. to input tree data
      - **Improve graphics to clearly define existing tree, stump, vacant/ possible location, vacant but not suitable.**





Hartford GIS tree mapping

City of Hartford new tree inventory platform; TreeKeeper.
Indicates locations of existing trees, vacant/ suitable for tree planting locations, location of stump, vacant- not suitable for tree planting

Hartford Urban Tree Canopy

- How:
  - Technology – continued
    - Establish/ map of priority neighborhoods for planting
    - **IS THIS DONE? Elaborate, establish focus areas, determine who will be in charge of what areas**

Table 6. Zoning District Tree Canopy Results and Changes from 2008 to 2014

Zoning District Tree Canopy	Urban Tree Canopy Assessment (%)		
	2008	2014	Gain / Loss
Downtown Development (B-1)	6.1%	5.4%	−0.7%
Downtown Perimeter (B-2)	9.6%	9.9%	+0.3%
General Business (B-3)	10.7%	9.0%	−1.6%*
Neighborhood Business (B-4)	13.3%	13.5%	+0.2%
Commercial (C-1)	13.0%	13.2%	+0.2%
Industrial (I-1)	8.2%	8.0%	−0.1%*
Industrial (I-2)	11.1%	11.3%	+0.2%
Public Property and Cemeteries (P)	46.1%	46.1%	+0.0%
High Density Residential (R-1)	16.0%	15.6%	−0.3%*
High Density Residential (R-2)	24.7%	24.5%	−0.2%
Medium Density Residential (R-3)	23.2%	23.4%	+0.3%*
Three-Family Residential (R-4)	27.6%	25.9%	−1.7%
One and Two Family Residential (R-5)	32.4%	32.7%	+0.2%*
One Family Residential (R-6)	27.0%	27.0%	+0.0%
One Family Residential (R-7)	37.4%	37.3%	−0.1%
One Family Residential (R-8)	57.4%	57.4%	+0.1%*
Residence-Office (RO-1)	17.5%	17.0%	−0.4%*
Residence-Office (RO-2)	26.6%	26.5%	−0.1%
Residence-Office (RO-3)	19.7%	18.6%	−1.2%*

**** Canopy gain and loss values appear slightly different than expected due to rounding.***

Neighborhood Analysis

The Downtown neighborhood has the lowest Existing TC (Figures 10, 11), but this densely-developed area also has relatively low Possible TC (just two other neighborhoods have lower Possible TC and both have higher Existing TC). In contrast, the North Meadows, South Meadows, and Sheldon-Charter Oak neighborhoods have slightly higher Existing TC than the Downtown neighborhood, but all have greater than 52% Possible TC.

Existing TC | Possible TC

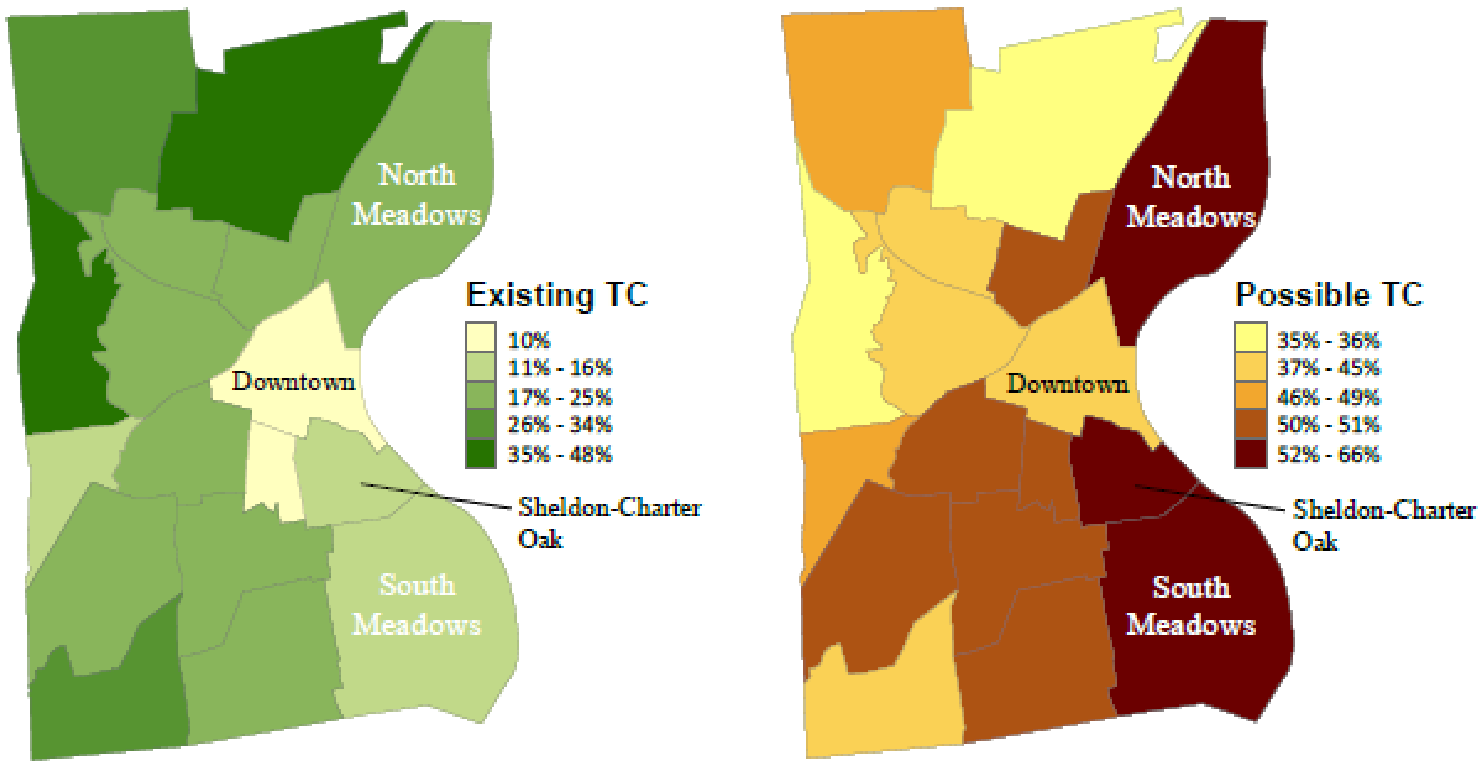


Figure 10. Possible TC (left) and Existing TC (right) as a percentage by neighborhood.

Hartford Urban Tree Canopy

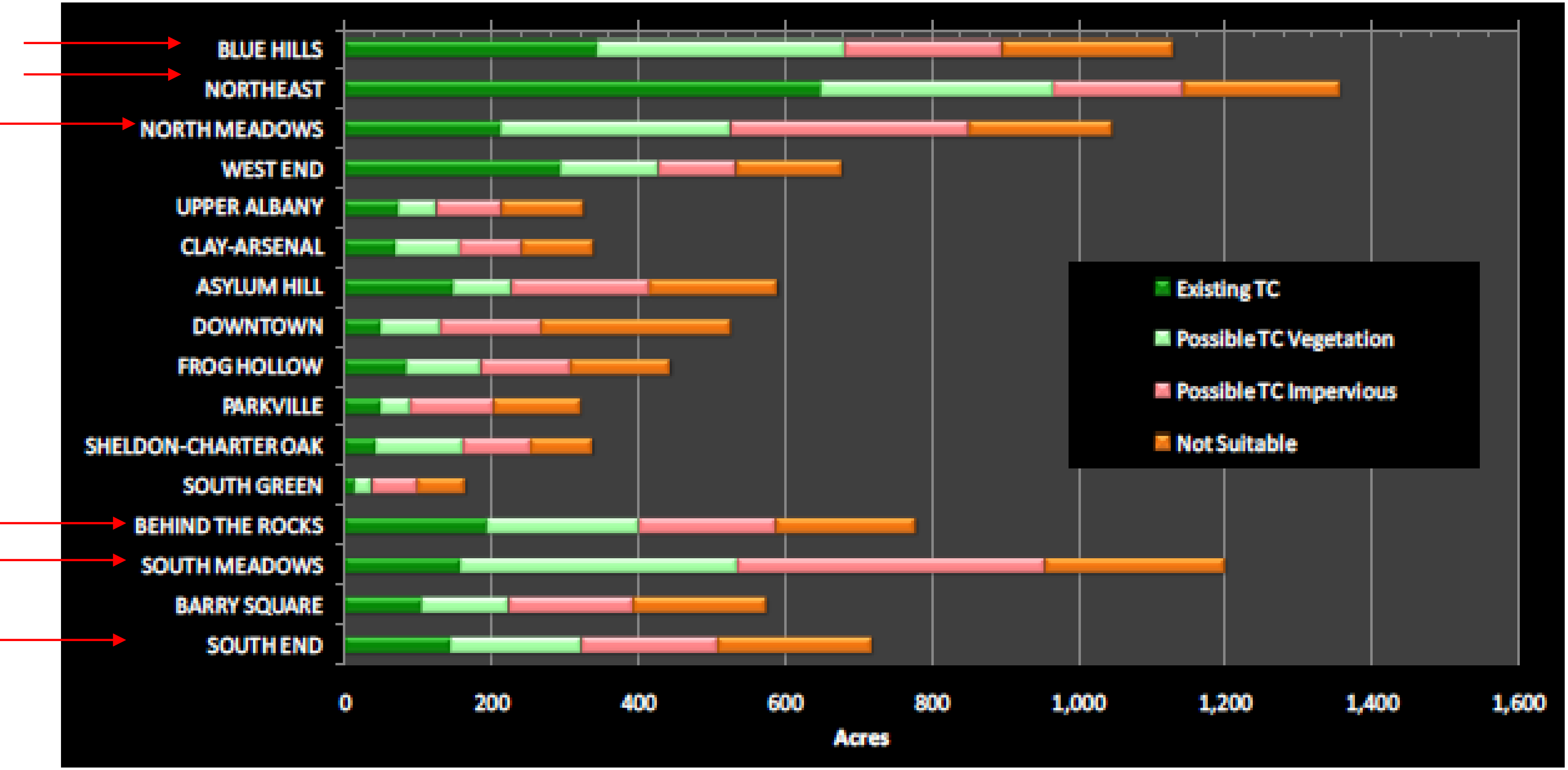
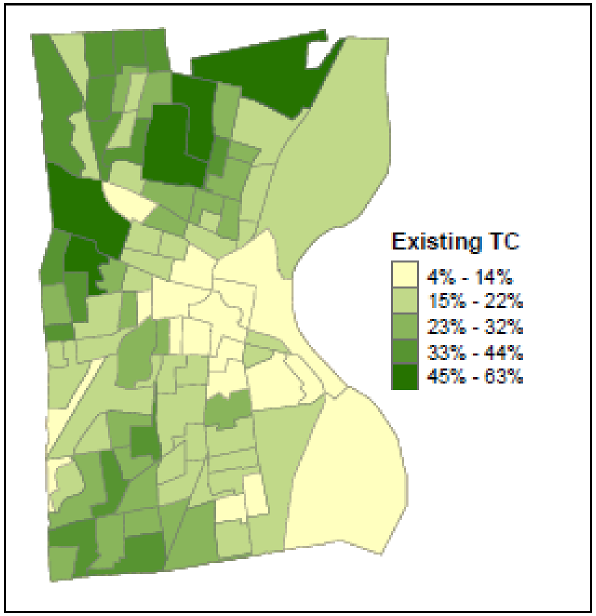


Figure 11: TC metrics summarized by neighborhood.

Hartford Urban Tree Canopy

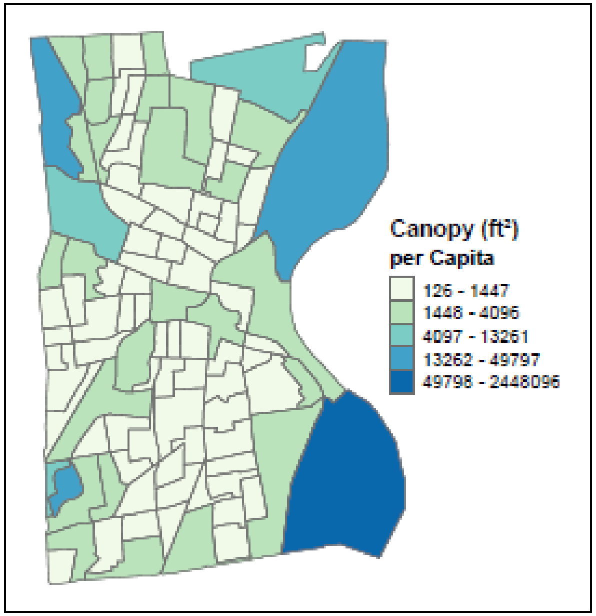
- How:
  - Technology – continued



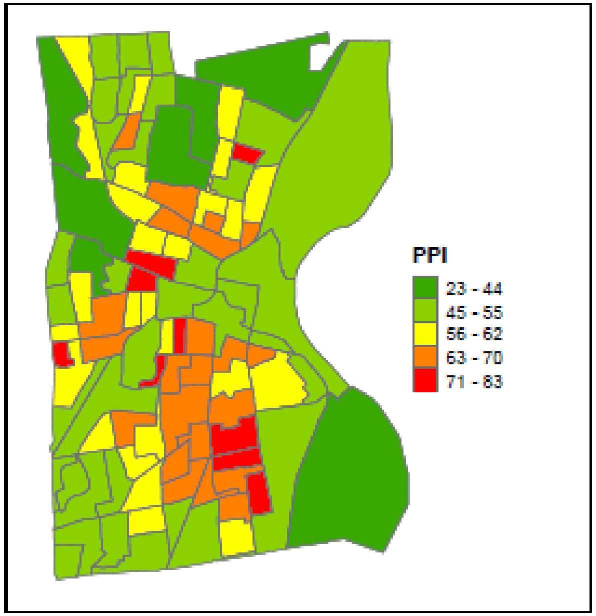
(a)

Workable scale for maps

Starting Point for ROW block street tree planting, community outreach and tree give-aways



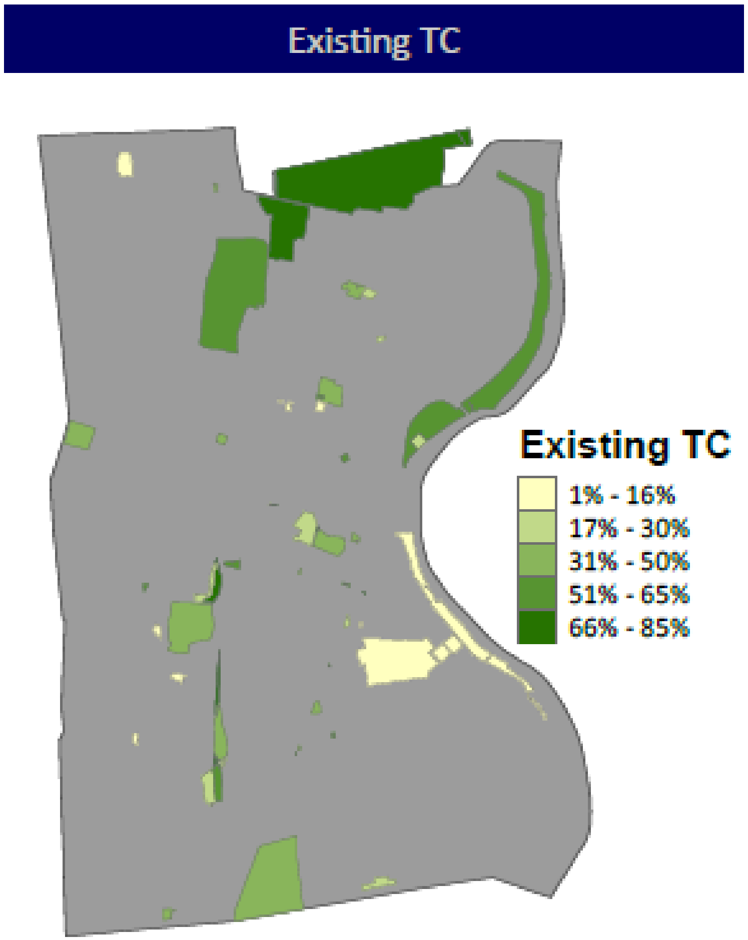
(c)

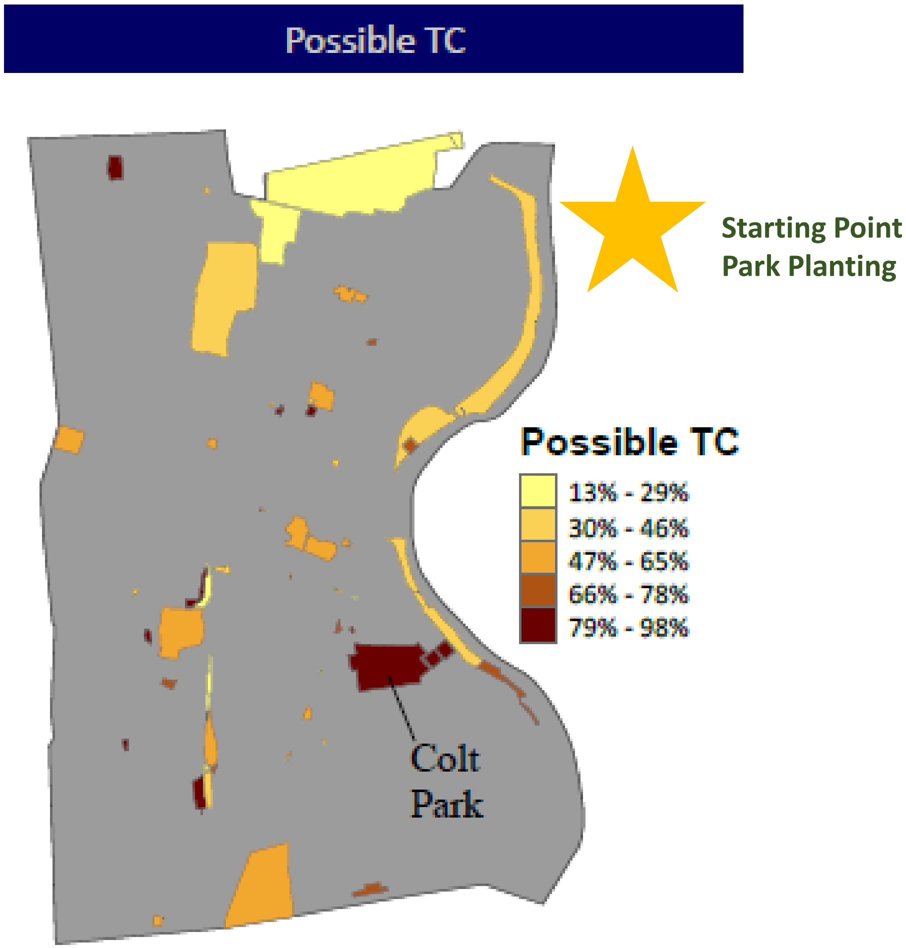


(d)

Hartford Urban Tree Canopy

- How:
  - Technology – continued





Expanding Tree Cover in Parks!

Hartford Urban Tree Canopy

- How:
  - Technology – continued

Energy Savings

The cooling benefit provided by trees is easily recognized; simply stand in the shade in a hot day. But this cooling effect also means less energy is needed to keep buildings cool during the hot summer months. Each year, Hartford's trees save 3,843,654 kWhs in energy use. This savings translates to $277,665 in value each year.

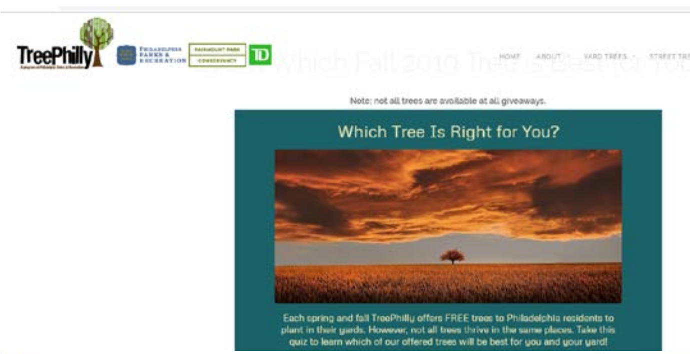
Table 7. Estimated Ecosystem Benefits Provided by Harford's Tree Canopy in 2014

Hartford Tree Canopy Ecosystem Benefits	Annual Ecosystem Benefits	
	Quantity	Value
Air: CO removed	5,400 lbs.	$3,600
Air: NO_2 removed	15,260 lbs.	$6,466
Air: O_3 removed	109,020 lbs.	$198,218
Air: SO_2 removed	2,920 lbs.	$369
Air: particulate matter removed	15,190 lbs	$47,437
Carbon sequestered	11,264 tons	$225,280
Stormwater: reduction in runoff	591,022,346 gallons	$4,728,178
Energy: savings from cooling	3,843,654 kWhs	$277,665
Total Annual Benefits		**$5,487,213**
Current stored carbon*	362, 445 tons	$7,248,900
Property: increase in property values*	-	$11,416,730
Total		**$18,665,630**

**Current stored carbon and contribution to property value are measures of total contribution, not an annual value.*

Hartford Urban Tree Canopy

- How:
  - Technology – continued
    - Establish a website to Track planting, maintenance and stewards; extension of Davey (NYC)
    - Plant Guides
      - Tree Selector Quiz (TreePhilly) to help residents select tree
      - Overall Tree List….narrow it down?, Knox List, City of Hartford, Urban Tree Canopy Assesment
      - Planting Manual – DEEP guide is done and good enough
        - Could improve and make more user friendly/ consolidated
        - Include guide online to download and provide easy how-to-steps on website.
        - Forestry Website is being Updated to include these
        - http://www.hartford.gov/dpw/forestry-division



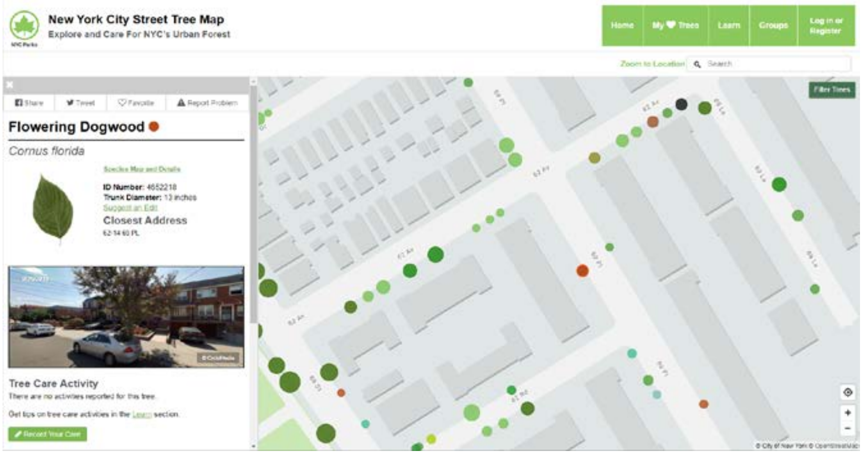


Table 11. A Selection of Tree Species Suitable for Hartford that Contribute to Intercepting Stormwater, Mitigating Heat Island Effects, and Improving Air Quality

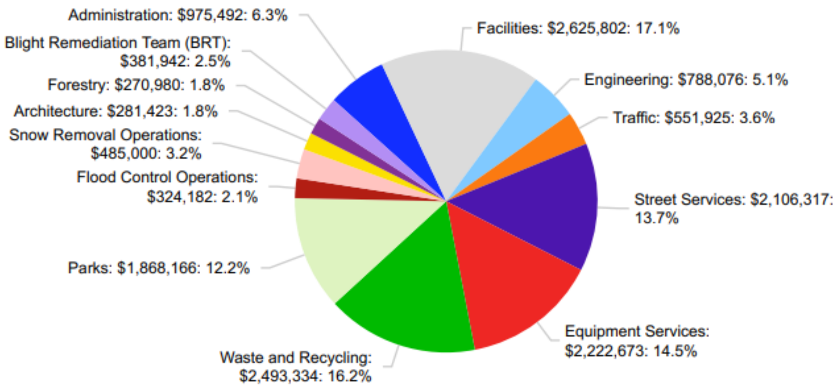
Tree Species* and Mature Size			Ecosystem Benefit Contribution		
Scientific Name	Common Name	Size	Stormwater	Heat Island	Air Quality
Acer rubrum	red maple	large	yes		
Acer × freemanii	Freeman maple	large	yes		
Aesculus × carnea	red horsechestnut	medium			yes
Aesculus flava	yellow buckeye	large	yes		yes
Betula nigra	river birch	medium	yes		yes
Carpinus betulus	European hornbeam	large	yes		yes
Celtis occidentalis	common hackberry	large	yes		yes
Cercidiphyllum japonicum	Katsuratree	large	yes		
Corylus colurna	Turkish hazelnut	large	yes		
Liriodendron tulipifera	tuliptree	large	yes		yes
Magnolia acuminata	cucumber tree magnolia	large	yes		yes
Magnolia macrophylla	bigleaf magnolia	large	yes		
Magnolia tripetala	umbrella magnolia	small	yes		
Ostrya virginiana	eastern hophornbeam	medium	yes		yes
Phellodendron amurense	Amur corktree	medium	yes		
Platanus × acerifolia	London planetree	large	yes		
Platanus occidentalis	American sycamore	large	yes	yes	
Quercus alba	white oak	large		yes	
Quercus macrocarpa	bur oak	large		yes	
Quercus shumardii	Shumard oak	large	yes		
Tilia americana	American linden	large	yes		yes
Tilia cordata	littleleaf linden	large	yes		
Tilia tomentosa	silver linden	large	yes		yes
Zelkova serrata	Japanese zelkova	large	yes		yes

**This species list is not inclusive of all trees recommended and/or suitable for Hartford's climate. While all trees will contribute ecosystem benefits to some degree, these species were simply identified by i-Tree researchers as being in the top 10% of species for each ecosystem benefit identified.*

Hartford Urban Tree Canopy

- How continued:
  - Funding – **Public and Private**
    - Funding for 20,000 trees under Segarra?
  - **WHAT CAN WE AFFORD?**
    - **How many trees?**
    - **Start annual maintenance/ pruning program?**
    - **Complete inventory?**
    - **Mayor Budget**
      - **Forestry $270,980 from General Fund**
      - **Neighborhood Environmental Improvements $713,838?**
  - Establish annual funds available
    - Grants
    - Capital Improvements – provides most reliable long term funding
    - Where did funds come from for 1000 tree plantings in 2012-2014
    - Mayor Budget $271,000 to forestry budget for staffing
    - Secure funds from other departments/ non-profit
    - MDC Clean Water Project?
    - Keep Kids Cool?
    - Riverfront Recapture?
    - **Big Sponsors**
      - Hartford Courant, Bank of America, American Forests, The Hartford, Eversource, Hartford Hospital, Hartford HealthCare, St Francis, CCMC, Pratt & Whitney, Subway, United Technology, Stanley Black and Decker, Aetna, Cigna, Otis, Carrier, Yard Goats,…….

Department General Fund Budget by Program
General Fund Total: $15,375,312



NEIGHBORHOOD ENVIRONMENTAL IMPROVEMENTS

Department: Public Works
Location: Citywide

Operating Impact: Minimal
Type of Impact: M

Project Description: Continuing Citywide maintenance and improvements that may include tree pruning, fertilization and removal, and the planting of new trees in accordance with the City's forestry master plan.

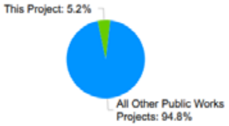
FINANCIAL SUMMARY

FY2020 Recomm	FY2021 Projected	FY2022 Projected	FY2023 Projected	FY2024 Projected	Total Five Year
$713,838	$500,000	$500,000	$500,000	$500,000	$2,713,838

Financial Activity	As of 03/31/2019
Total Authorizations	$1,699,404
Total Expenditures	$1,381,515
Remaining Authorizations	$295,537

MUNIS Project Numbers:	
	W1706
	W1808

FY2020 Anticipated Cash Flow



Forestry

The goal of the Forestry Program is to provide the residents of Hartford, and the region, with a healthy and safe urban forest, vibrant streetscapes, and parks to enjoy. As well as to rapidly respond to tree-related issues in the City and improve customer service for our residents, while also significantly reducing the costs needed to fund the work of private tree contractors. The forestry program substantially increases the number of tree removal and tree maintenance work orders that can be addressed by the City and to performs critical routine maintenance to the urban forest which will extend the life span of the City's trees and thereby reducing cost associated with tree removal and replanting.

General Fund Expenditures:	$270,980
General Fund Revenue:	$0
General Fund Positions:	4
General Fund FTEs:	4.00

Program Services:

Service	Goal	Legal Mandate
Tree Inspection	Provide comprehensive tree inspection services to identify sick, damaged, dead, or otherwise hazardous trees for either treatment or removal.	
Tree Pruning	Provide selective removal of branches, buds, and roots to improve the health and extend the life of the City's trees.	
Tree Removal	Provide removal and disposal services for dead or sick trees, and other trees that are deemed to pose a specific hazard to the public.	✓
Downed Tree and Branch Cleanup	Provide removal and disposal services of downed trees and limbs in public areas such as parks, City facilities, and the public right-of-way, including storm response activities.	✓
Other Tree Maintenance	Provide additional general maintenance services and specific tree care practices for the City's trees including: treatment for diseases or pest infestations; mulching; soil management; installation of tree protection measures; and managing tree and turf grass conflicts.	
Tree Planting	As available grant and capital funds permit, coordinate internally and with outside organizations for the planting of new trees to replace those lost to age, disease and environmental factors.	
Coordination and Planning for Urban Forest Activities	Provide staffing and coordination with other City departments, boards, and commissions on multiple stakeholder activities that support health, maintenance, and safety of the City's urban forest, and provide medium- and long-range planning guidance in support of the City's environmental goals as they relate to trees.	

Hartford Urban Tree Canopy

- How continued:
  - **Funding $713,838 (2020)?**
    - Assume 75% to maintenance =$535,378
    - =remaining $178,459
    - $650 (Durham, NC medium b&b tree) = 279 trees (NIC 2 year maint)

    - HARTFORD
    - 2017-2018 budget $75,000 +$75,000 (Hartford Decides – Keep Kids Cool to fund 250 trees= $600/tree)
    - 2018-2019 125 trees with Kids Keep Cool cost $75,000 = $600/ tree
      - Knox tree planting qty?

Goal 1500 trees @ 600$ = $900,000 +/- (nic maint.)

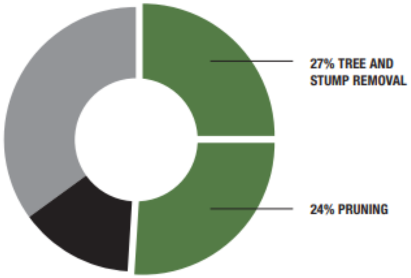
1500 trees @800$=$1,200,000 (includes 2year maint)

SEVEN SOURCES

Across the nation, the largest source of funding for public trees is, by far, the general fund.

GENERAL FUND	71.2%
ASSESSMENT DISTRICT	5.3%
GAS TAX	3.1%
STATE/FEDERAL GRANTS	2.6%
STORMWATER/UTILITY FEES	1.4%
OTHER	15.0%
PERMIT FEES	1.4%

Source: 2014 Municipal Tree Care and Management in the U.S.



WHERE THE MONEY GOES

Nationally, urban forestry budgets are generally allocated primarily for maintenance, administration and other expenditures, and planting.

MAINTENANCE	51%
PLANTING	14%
ADMINISTRATION/OTHER	35%

Source: 2014 Municipal Tree Care and Management in the U.S.

NEIGHBORHOOD ENVIRONMENTAL IMPROVEMENTS

Department: Public Works
Location: Citywide

Operating Impact: Minimal
Type of Impact: M

Project Description: Continuing Citywide maintenance and improvements that may include tree pruning, fertilization and removal, and the planting of new trees in accordance with the City's forestry master plan.

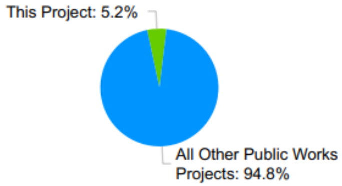
FINANCIAL SUMMARY

FY2020 Recomm	FY2021 Projected	FY2022 Projected	FY2023 Projected	FY2024 Projected	Total Five Year
$713,838	$500,000	$500,000	$500,000	$500,000	$2,713,838

Financial Activity	As of 03/31/2019
Total Authorizations	$1,699,404
Total Expenditures	$1,381,515
Remaining Authorizations	$295,537

MUNIS Project Numbers:	W1706
	W1808

FY2020 Anticipated Cash Flow



Resource List

Hartford

Technology
- Hartford GIS Hazardous Tree and Tree Removal
    - http://gis1.hartford.gov/publicworks/Tree/
- GIS Tree Report – *Link not working*
    - http://gis1.hartford.gov/publicworks/Treereport/
- Davey Tree Inventory
    - https://hartfordct.treekeepersoftware.com/

Reports
- Hartford State of the Forest Report 2019
    - 2019
    - Provides quick statistics on tree planting, removals and maintenance, accomplishments and goals for Tree Advisory Committee and City Forester.
- Park Planting Plan Matrix
    - 2019
    - Lists each Hartford Park and if it has been inventoried and if there are plans
- City of Hartford Tree Plan – 2018-2019
    - August 2018; City of Hartford Tree Advisory Committee
    - Summary of Hartford's State of the Forest, goals/ accomplishments for the Tree Advisory Commission and City Forester. Provides tree planting quantities to maintain current UTC and to expand UTC
- Hartford Tree Recommendations
    - 2018
    - Spreadsheet for Hartford's Recommended Trees
- New Maintenance Log_Forestry_2017-2018
    - 2017-2018
- Hartford Climate Action Plan
    - 2017
    - A 6 part City action plan that focuses Energy, Food, Landscape, Transportation, Waste and Water. Regarding Landscape, it acknowledges the importance of UTC and sets future planting and maintenance goals.
- Urban Tree Canopy Assessment & Planting Plan
    - 2014 (i-Tree); Bank of America, USDA, American Forests (RELEAF)
    - Provides benefits and costs analysis for the existing and expansion of the UTC. iTree mapping provides graphics for existing tree canopy and priority planting areas
- A Report on the City of Hartford, Connecticut's Existing and Possible Tree Canopy
    - 2010 (Spatial Analysis Laboratory (SAL))
    - An initial UTC and water shed study that starts to outline existing canopy and areas to expand UTC. Provided by University Vermont, USDA Forest Service
- Hartford's Urban Forest – The Challenge
    - 2007 GIS to conduct sample areas for (Urban Forest Effects (UFORE))
    - City of Hartford, Knox Park Foundation, US Forest Service
    - Statistics of the Hartford Forest , the trees that make it up, cost benefits and analysis of the trees and their impacts of air quality.
- Connecticut Tree Owner's Manual
    - CT DEEP, USDA
    - A guide for selecting, planting and caring for trees.

Resource List

Case Studies

Million TreesNYC

- plaNYC 2007
- plaNYC 2014
- MillionTreesNYC Strategic Plan: Tree Planting
- NYC Global Partners: Best Practice: Planting One Million Trees to Develop the Urban Forest
- MillionTreesNYC – The Integration of Research and Practice-
- NYC Parks Approved Tree Lists
- TreeLC Handbook
- New York Restoration Project (NYRP) www.nyrp.org
- Million TreesNYC www.milliontreesnyc.org
- MillionTreesNYC – TreeLC Program Final Report
- NYC Parks
  - TreesCount Program https://www.nycgovparks.org/trees/treescount
  - New York City Street Tree Map https://tree-map.nycgovparks.org/
- Street Tree Planting Standards for New York City 2016
- Tree Procurement Contracts

TreeBaltimore

- http://treebaltimore.org/

TreePhilly

- A Report on the City of Philadelphia's Existing and Possible Tree Canopy
- http://treephilly.org/

Durham

- Urban Forest Management Plan, 2018
- Replanting Durham's Urban Forest, 2016
- Recommendations for Sustaining a Healthy Urban Forest in Durham, NC, 2015

Funding

- Financing Urban Tree Canopy Programs: Guidebook for Local Governments in the Chesapeake Bay Watershed, March 2019
- Public Tree Programs, March 2016 www.pwmag.com
- Funding Your Urban forest Program: A Guide for New and Seasoned City Foresters

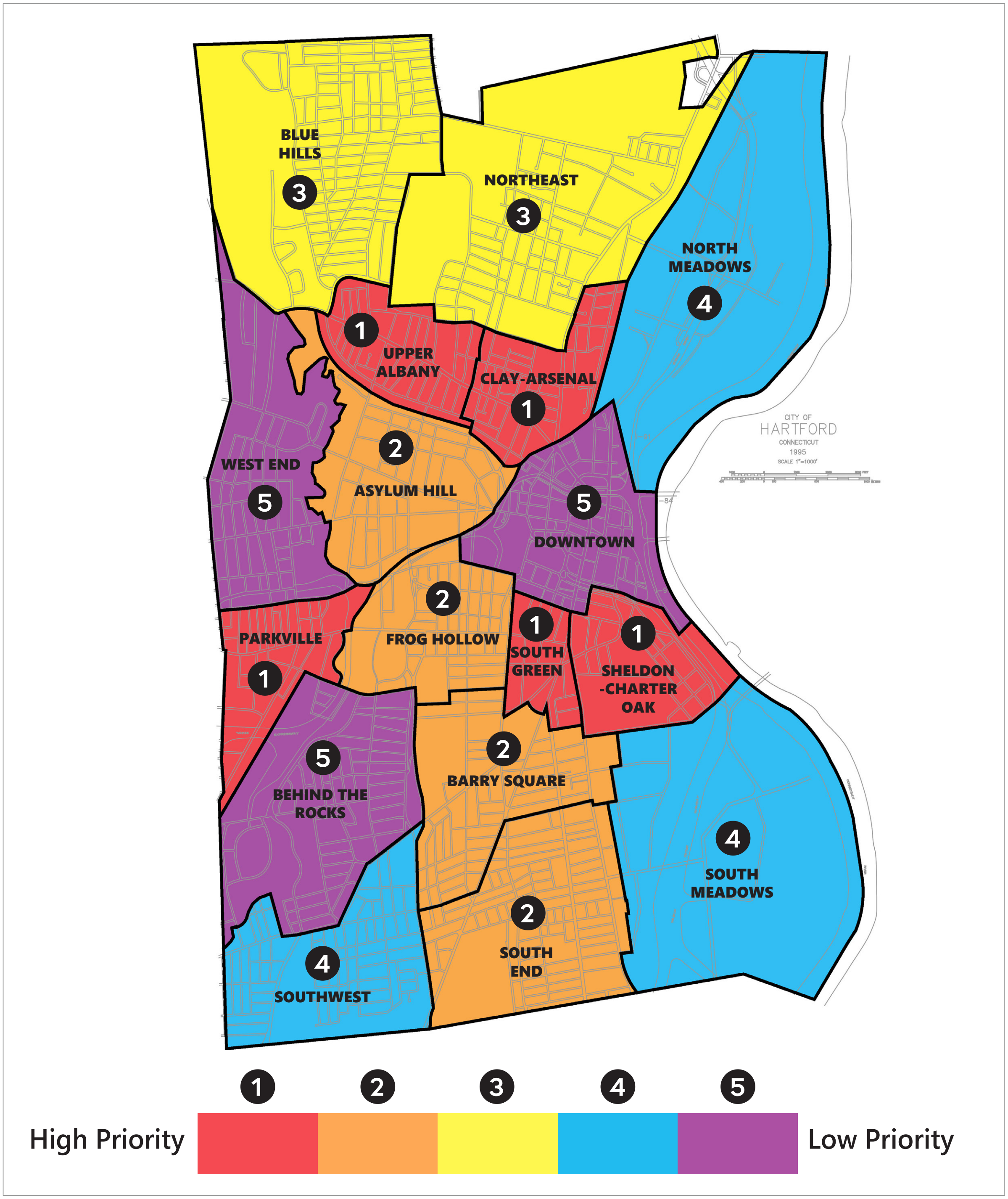
Other

- The Sustainable Urban Forest: A Step by Step Approach, September 2016

APPENDIX E

Priority Planting Neighborhood Maps

Priority Planting Neighborhood Maps



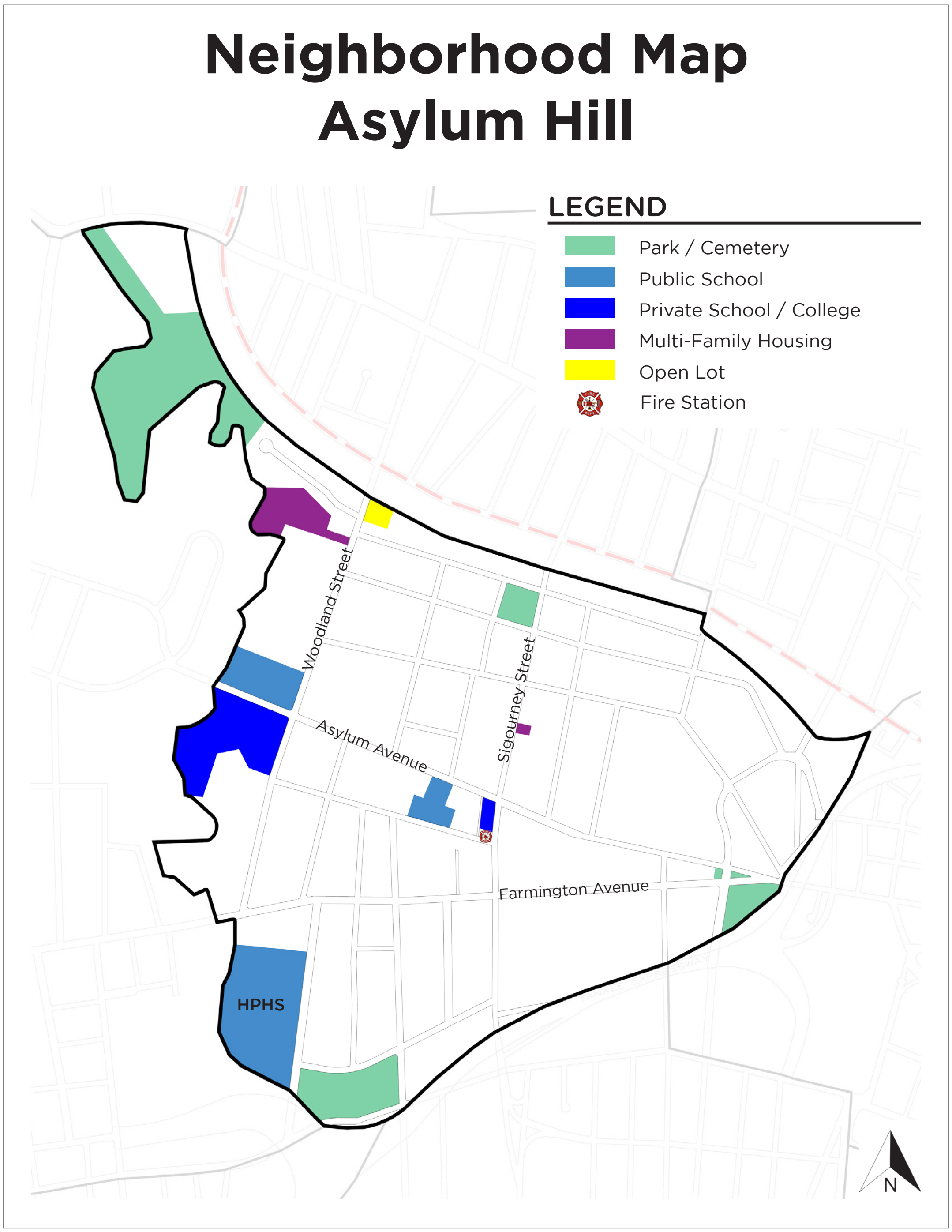
APPENDIX F

Neighborhood Maps

Neighborhood Maps

Asylum Hill Neighborhood: Public Tree Planting Opportunities

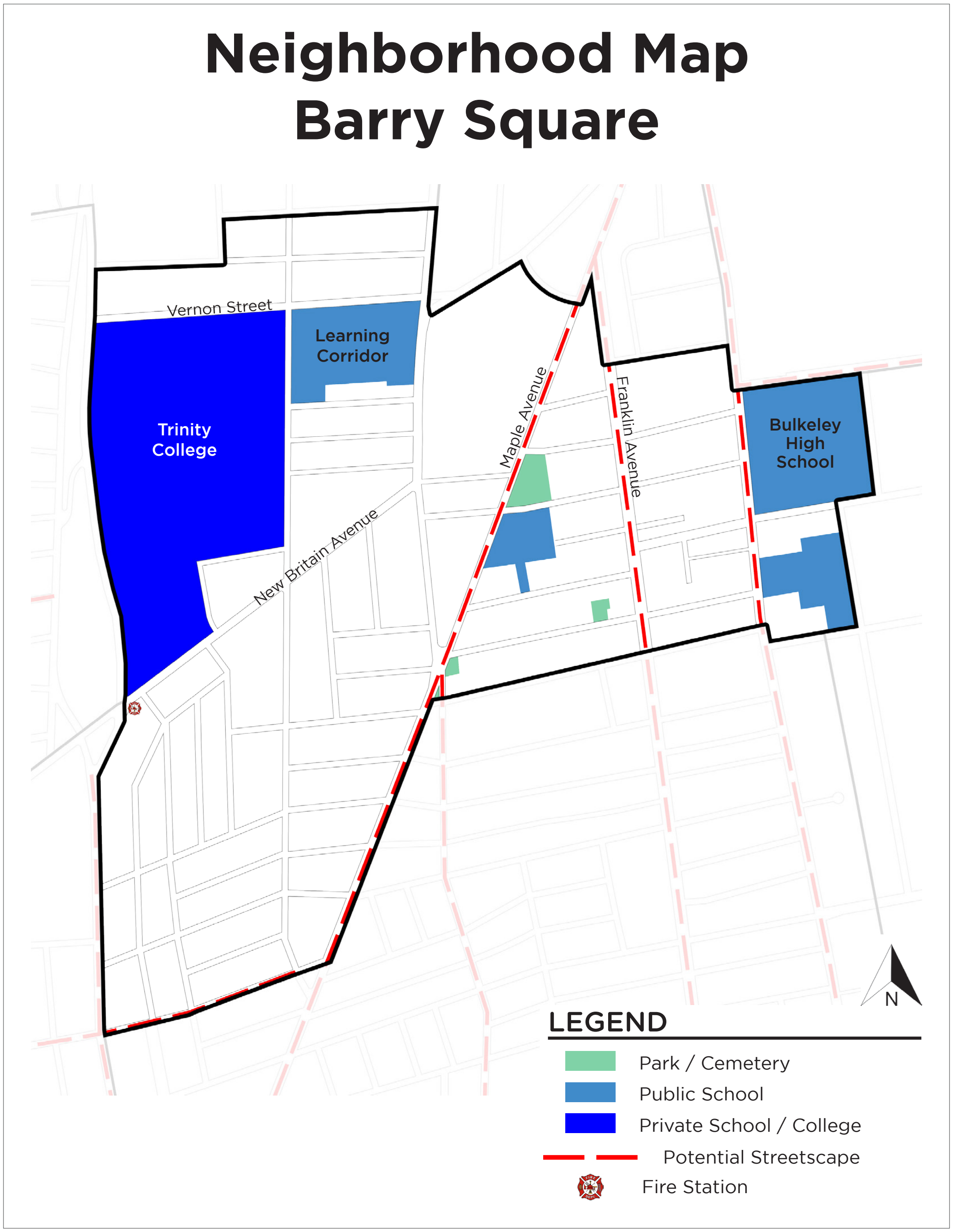
Tree Opportunities Located by TreeKeeper	350
Parks	165-185
Schools	60-80
Fire Stations	2-7
Total Public Tree Planting Opportunities	**577-622**



Neighborhood Maps

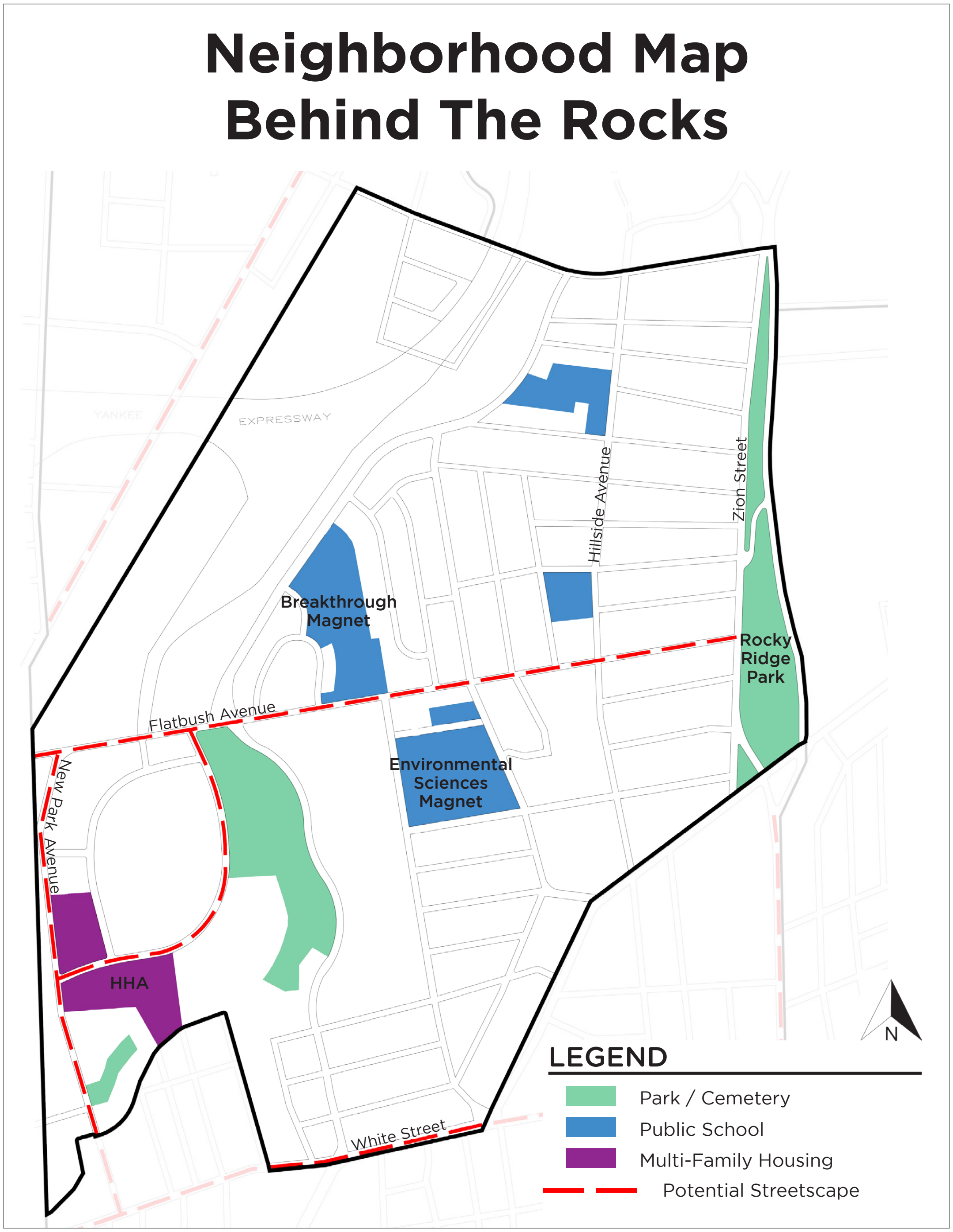
Barry Square Neighborhood: Public Tree Planting Opportunities

Tree Opportunities Located by TreeKeeper	593
Parks	19-28
Schools	100-130
Fire Stations	1-3
Total Public Tree Planting Opportunities	**713-754**



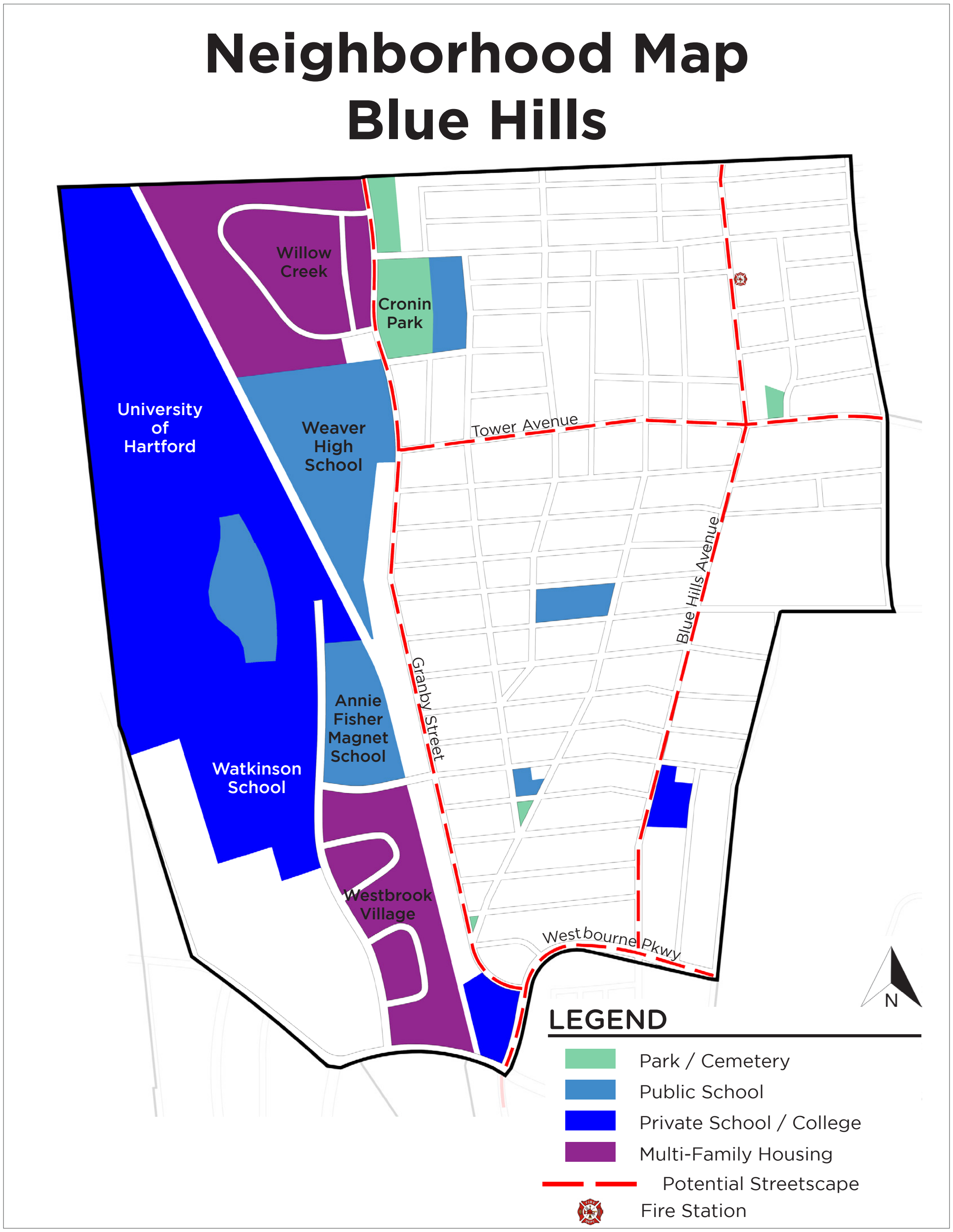
Behind the Rocks Neighborhood: Public Tree Planting Opportunities

Tree Opportunities Located by TreeKeeper	1,653
Parks	75-100
Schools	100-125
Fire Stations	0
Total Public Tree Planting Opportunities	**1,828-1,878**

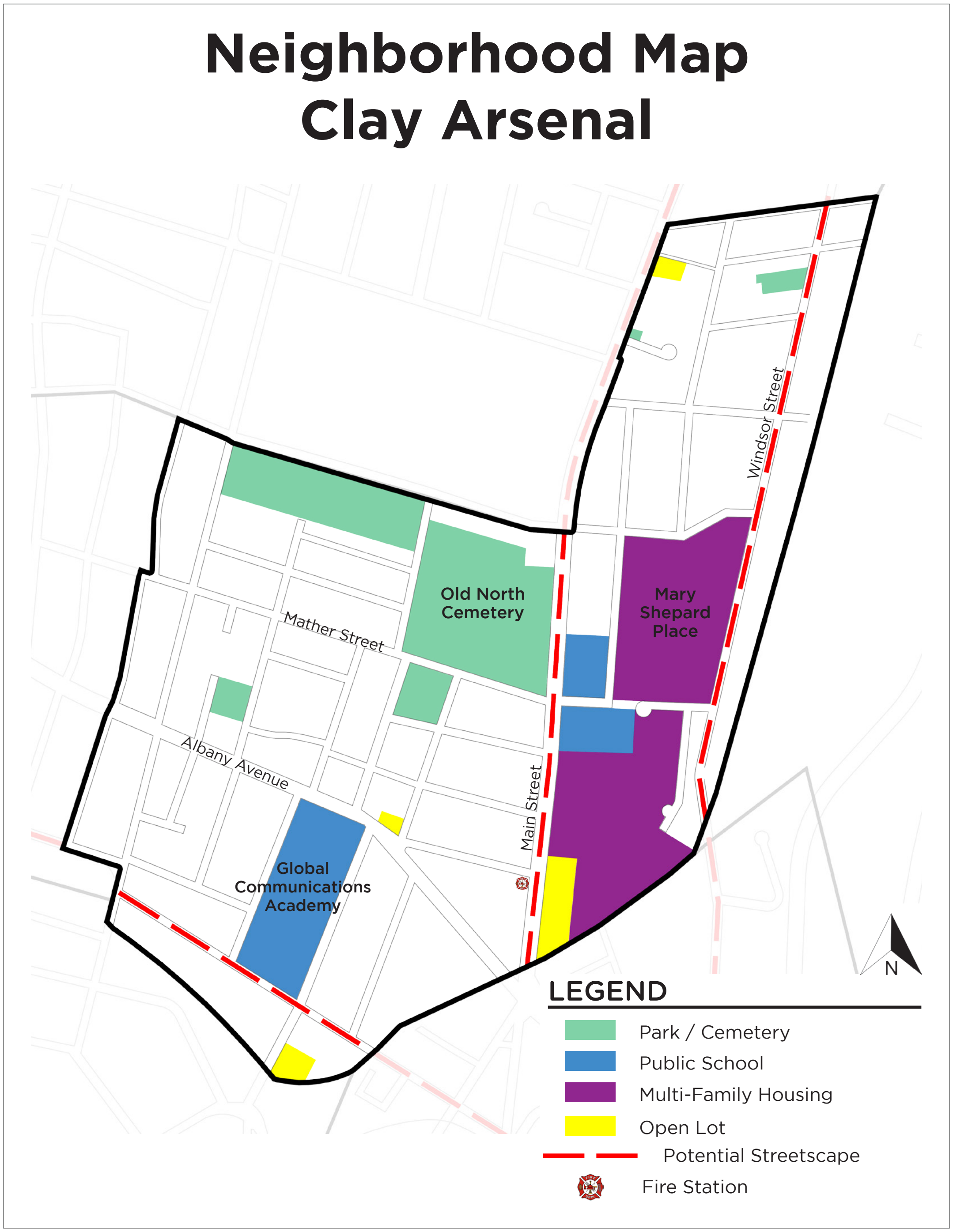


Blue Hills Neighborhood: Public Tree Planting Opportunities

Tree Opportunities Located by TreeKeeper	1,803
Parks	30-40
Schools	160-200
Fire Stations	5-7
Total Public Tree Planting Opportunities	**1,998-2,050**

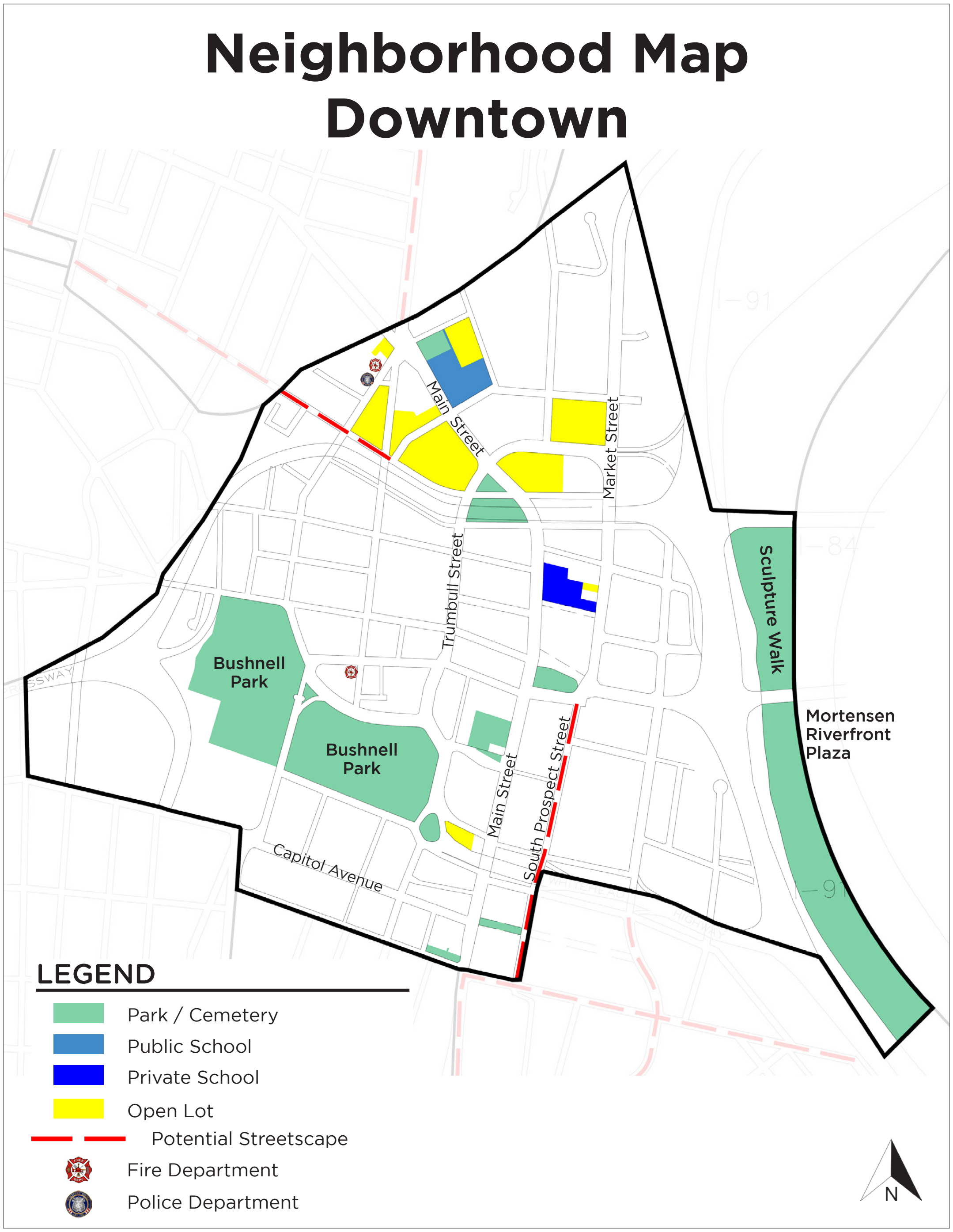


Clay Arsenal Neighborhood: Public Tree Planting Opportunities	
Tree Opportunities Located by TreeKeeper	146
Parks	41-70
Schools	45-55
Fire Stations	3
Total Public Tree Planting Opportunities	**235-274**



Downtown Neighborhood: Public Tree Planting Opportunities

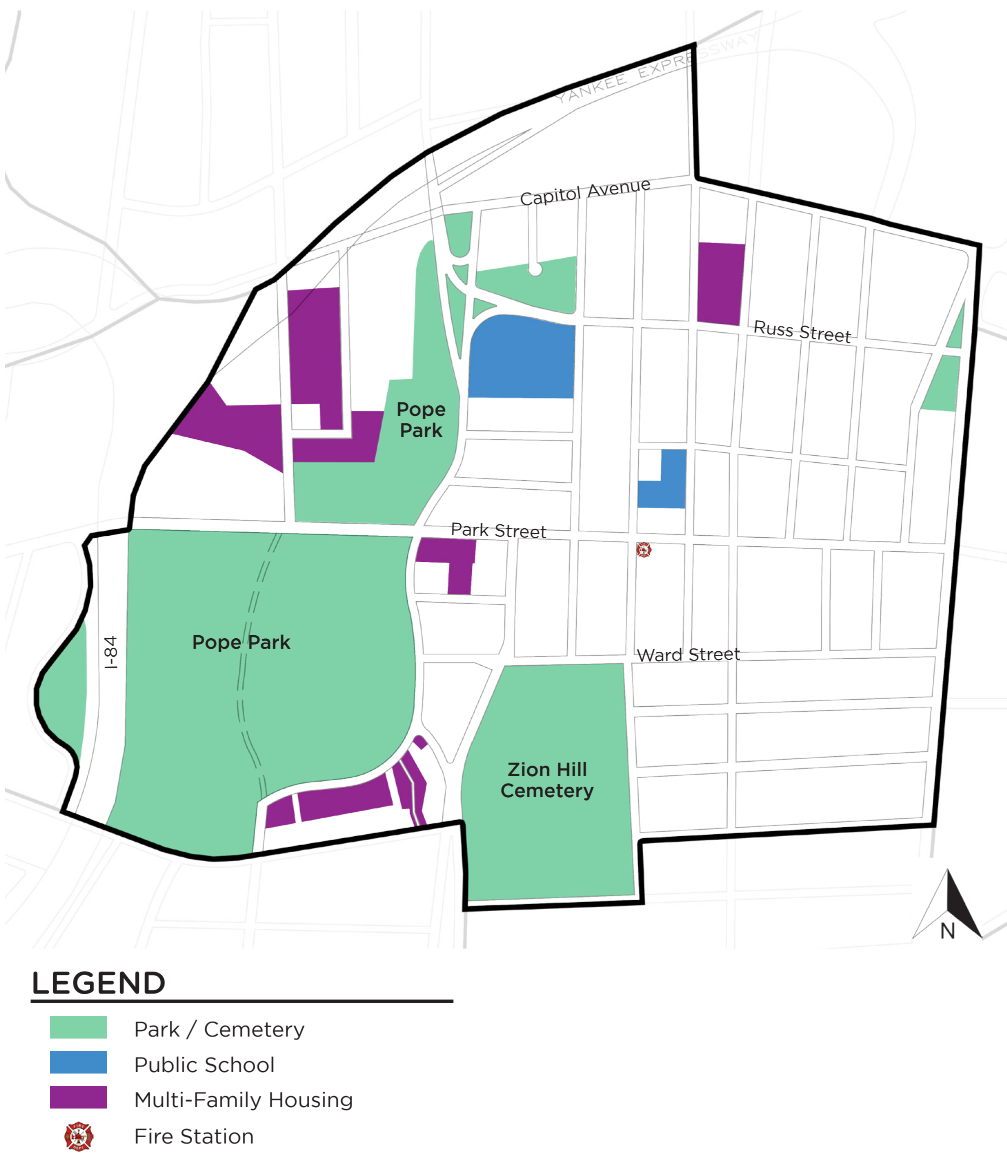
Tree Opportunities Located by TreeKeeper	294
Parks	176-225
Schools	30-35
Fire Stations	0
Total Public Tree Planting Opportunities	**500-554**



Frog Hollow Neighborhood: Public Tree Planting Opportunities

Tree Opportunities Located by TreeKeeper	357
Parks	180-260
Schools	55-65
Fire Stations	2-5
Total Public Tree Planting Opportunities	**594-687**

Neighborhood Map
Frog Hollow

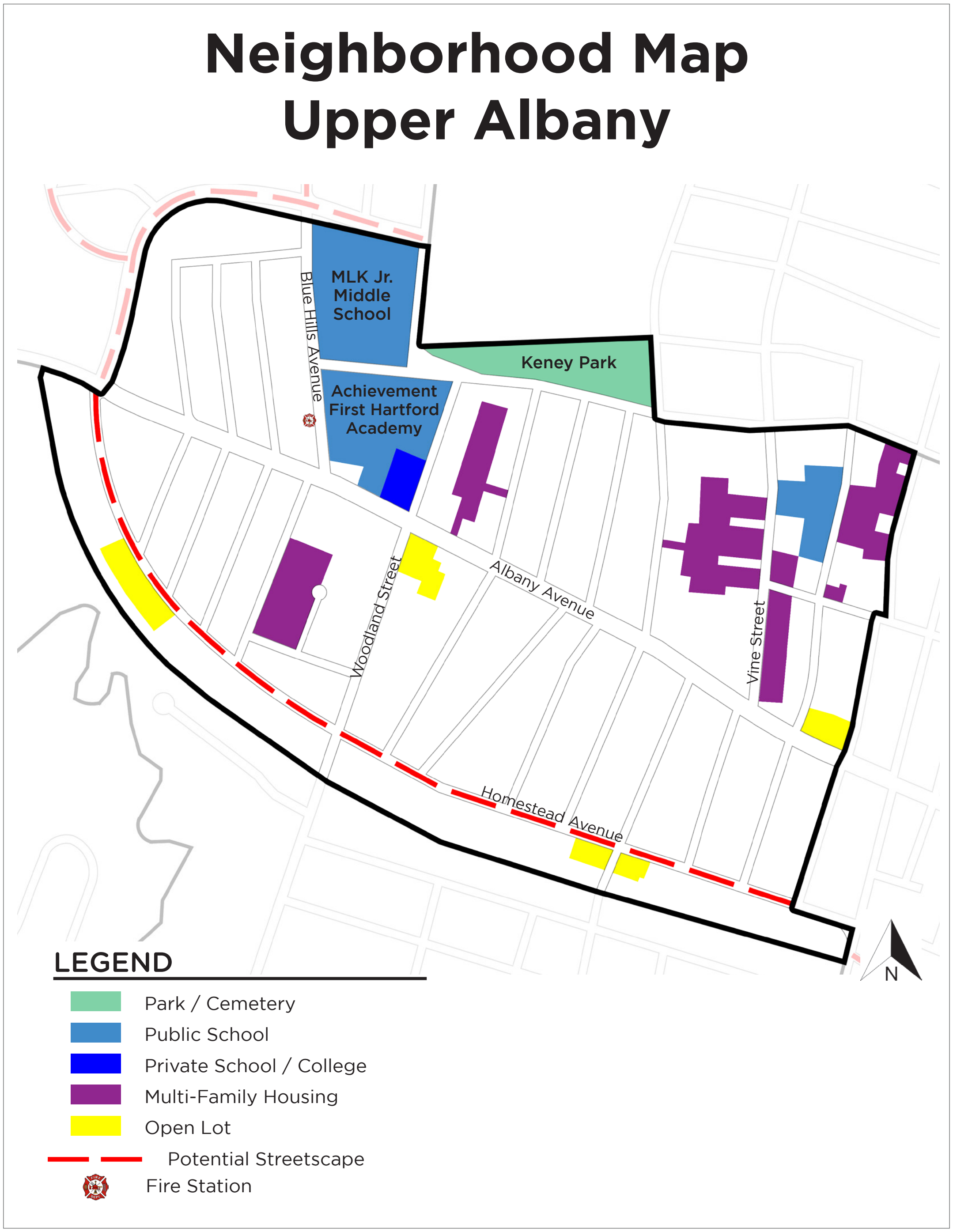


North Meadows Neighborhood: Public Tree Planting Opportunities

Tree Opportunities Located by TreeKeeper	441
Parks	300-400
Schools	0
Fire Stations	0
Total Public Tree Planting Opportunities	**741-841**

Parkville Neighborhood: Public Tree Planting Opportunities

Tree Opportunities Located by TreeKeeper	127
Parks	51-105
Schools	10-15
Fire Stations	0
Total Public Tree Planting Opportunities	**188-247**



Parkville Neighborhood: Public Tree Planting Opportunities

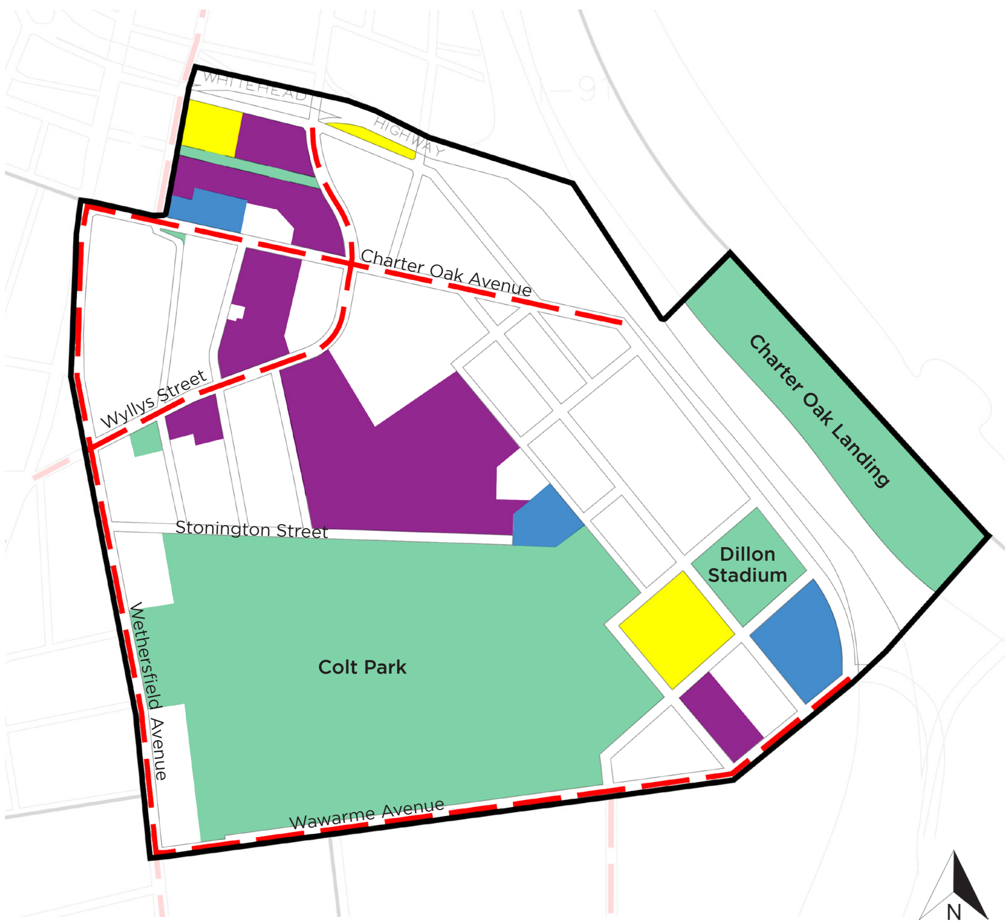
Tree Opportunities Located by TreeKeeper	127
Parks	51-105
Schools	10-15
Fire Stations	0
Total Public Tree Planting Opportunities	**188-247**

Neighborhood Maps

Sheldon-Charter Oak Neighborhood: Public Tree Planting Opportunities

Tree Opportunities Located by TreeKeeper	537
Parks	166-230
Schools	25-40
Fire Stations	0
Total Public Tree Planting Opportunities	**728-807**

Neighborhood Map
Sheldon-Charter Oak

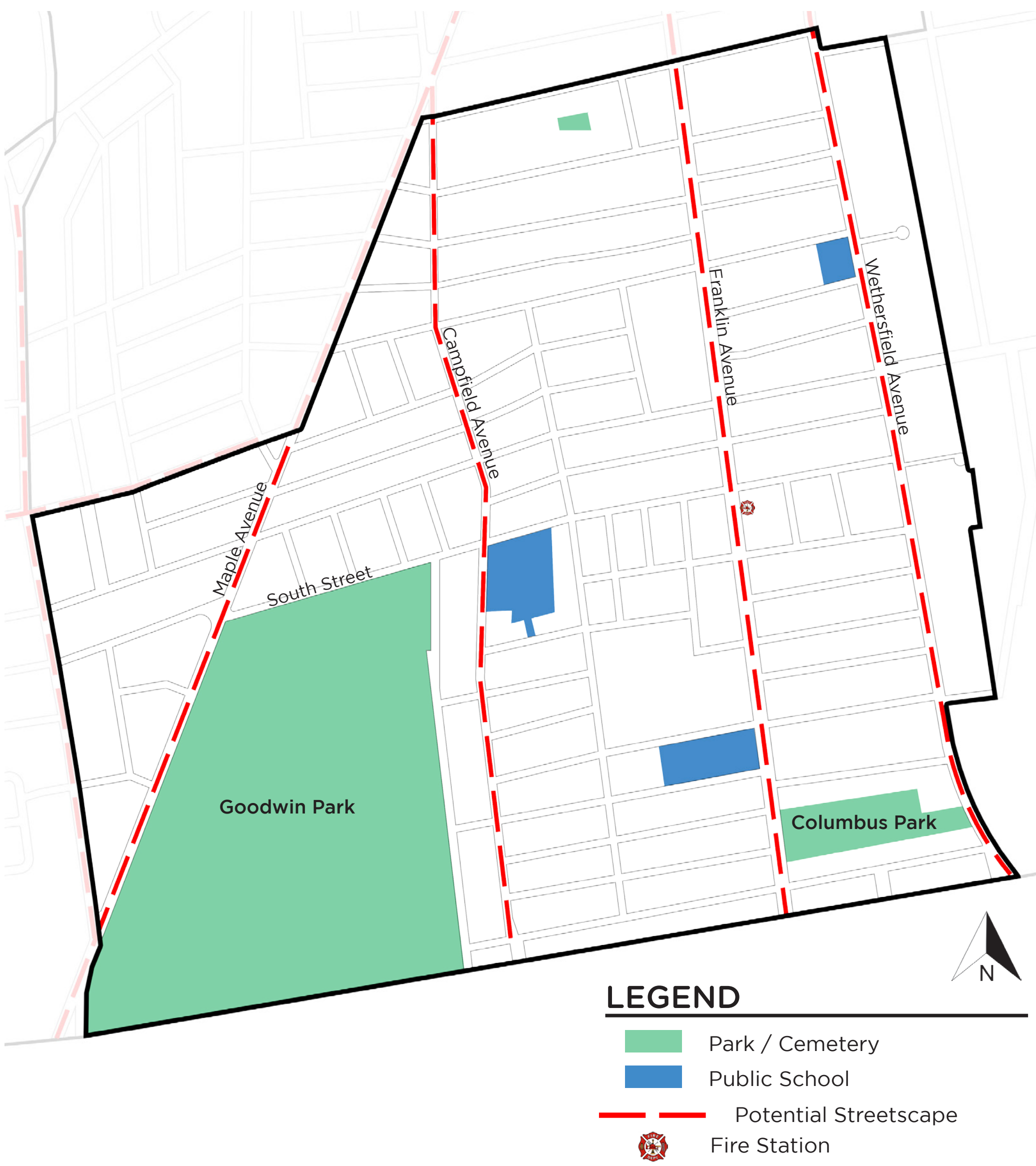


LEGEND
- Park / Cemetery
- Public School
- Multi-Family Housing
- Open Lot
- Potential Streetscape

South End Neighborhood: Public Tree Planting Opportunities

Tree Opportunities Located by TreeKeeper	396
Parks	150-200
Schools	40-55
Fire Stations	3-6
Total Public Tree Planting Opportunities	**589-657**

Neighborhood Map South End

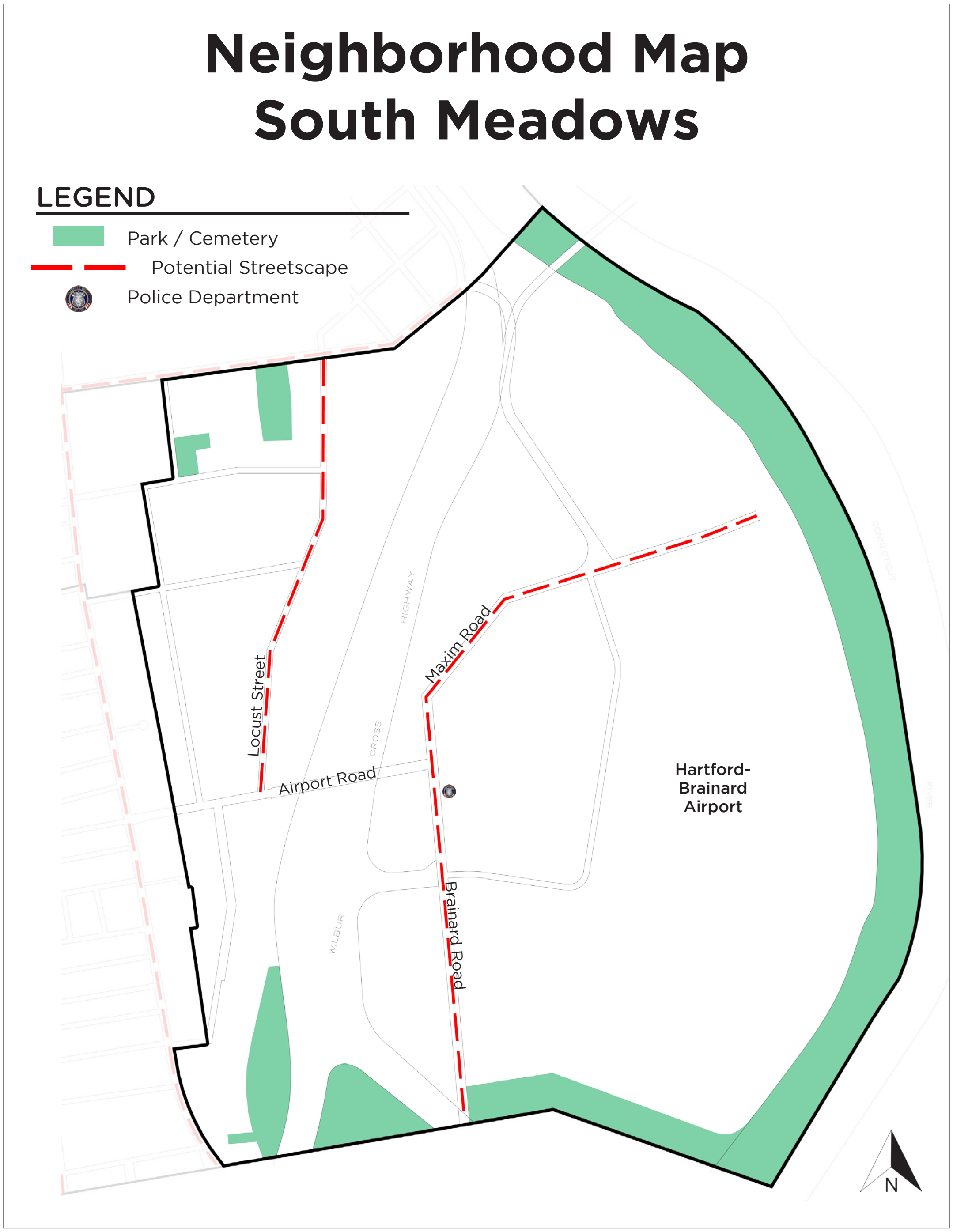


South Green Neighborhood: Public Tree Planting Opportunities

Tree Opportunities Located by TreeKeeper	85
Parks	10-15
Schools	5-7
Fire Stations	1
Total Public Tree Planting Opportunities	**101-108**

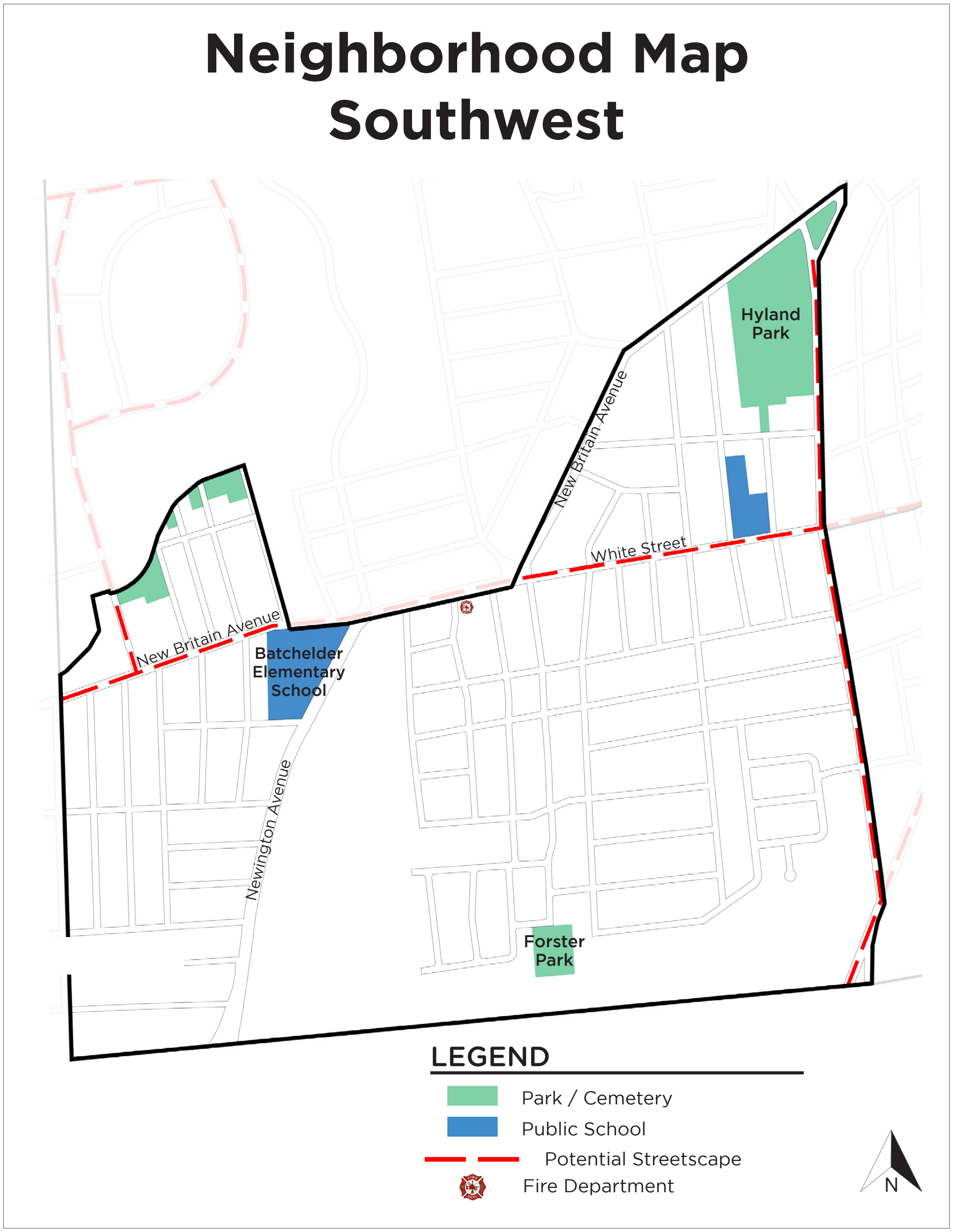
South Meadows Neighborhood: Public Tree Planting Opportunities

Tree Opportunities Located by TreeKeeper	8
Parks	200-300
Schools	0
Fire Stations	0
Total Public Tree Planting Opportunities	**208-308**



Southwest Neighborhood: Public Tree Planting Opportunities

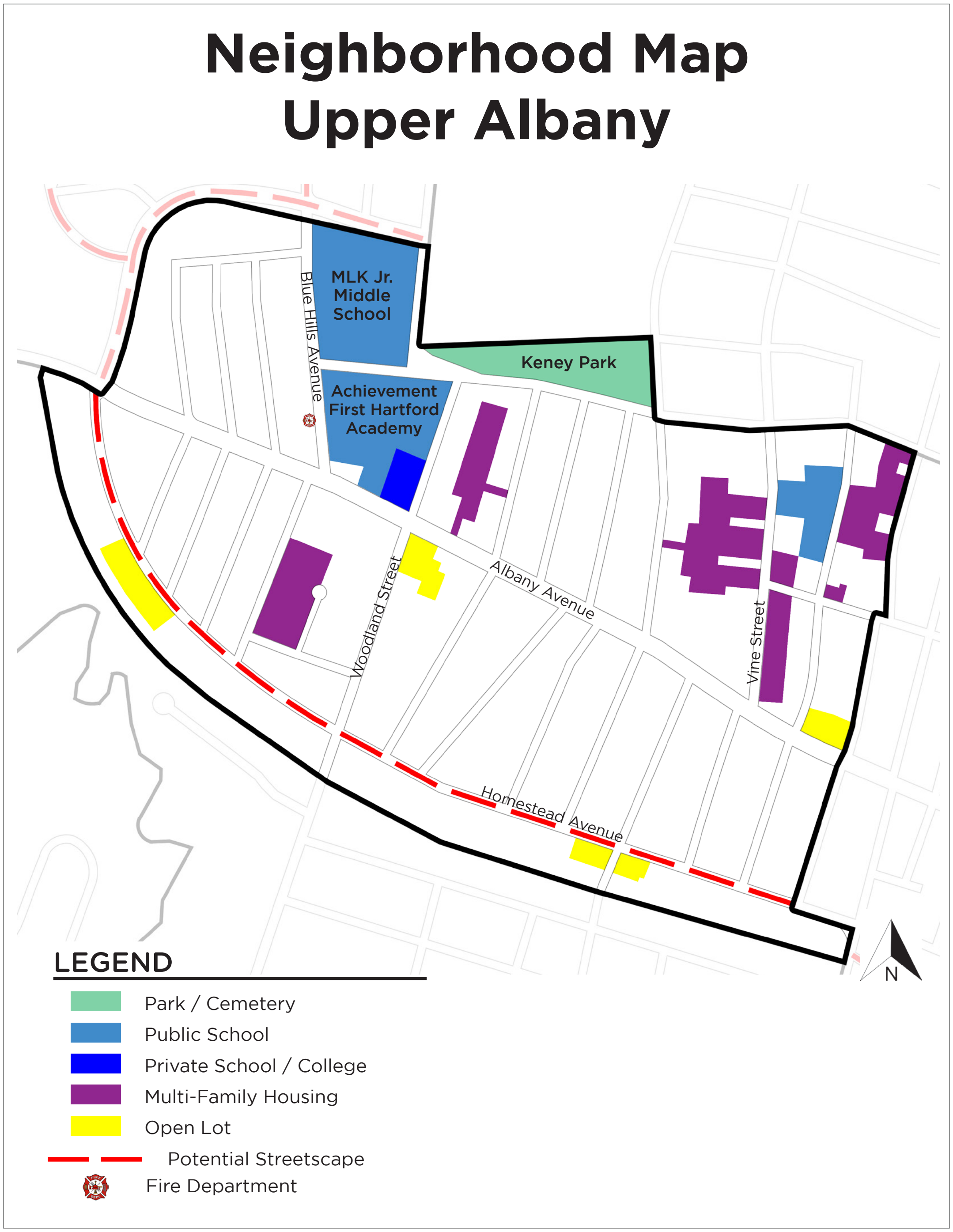
Tree Opportunities Located by TreeKeeper	1,632
Parks	50-65
Schools	5-10
Fire Stations	3-5
Total Public Tree Planting Opportunities	**1,690-1,712**



Neighborhood Maps

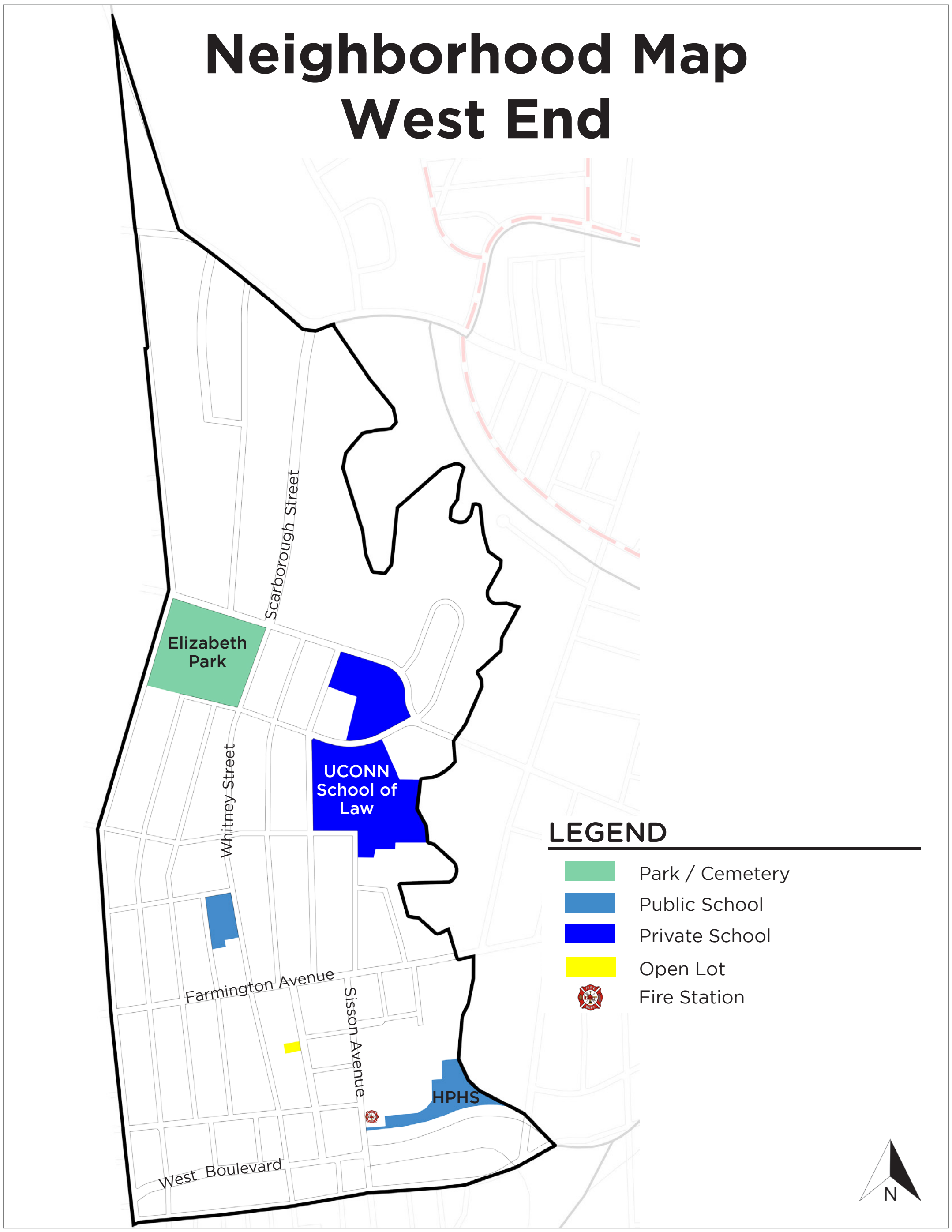
Upper Albany Neighborhood: Public Tree Planting Opportunities

Tree Opportunities Located by TreeKeeper	89
Parks	0
Schools	45-55
Fire Stations	0
Total Public Tree Planting Opportunities	**134-144**



West End Neighborhood: Public Tree Planting Opportunities

Tree Opportunities Located by TreeKeeper	806
Parks	100-150
Schools	5-10
Fire Stations	1
Total Public Tree Planting Opportunities	**912-967**



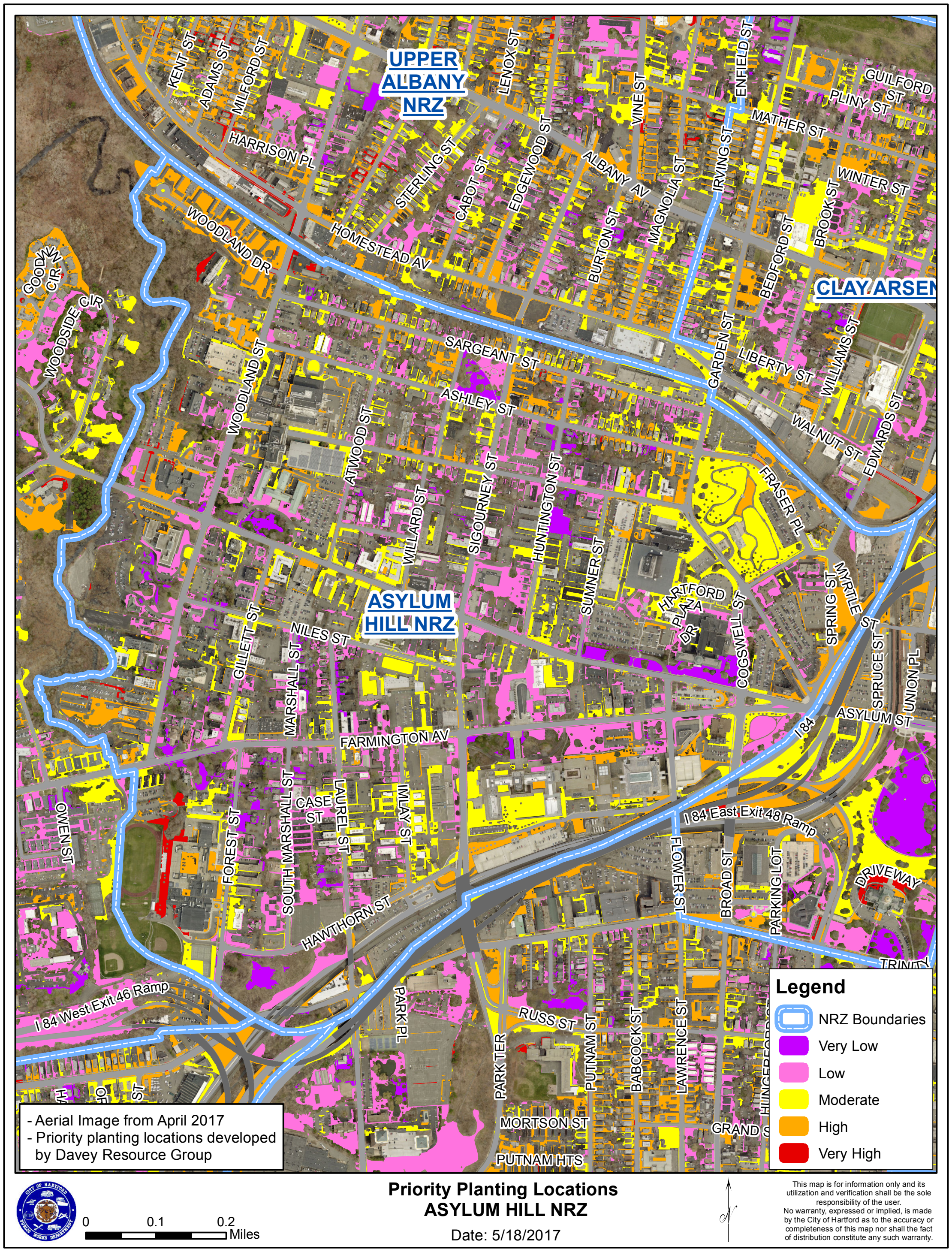
APPENDIX G

Priority Planting Locations (2017), by Davey Resource Group

Priority Planting Locations (2017)

By Davey Resource Group

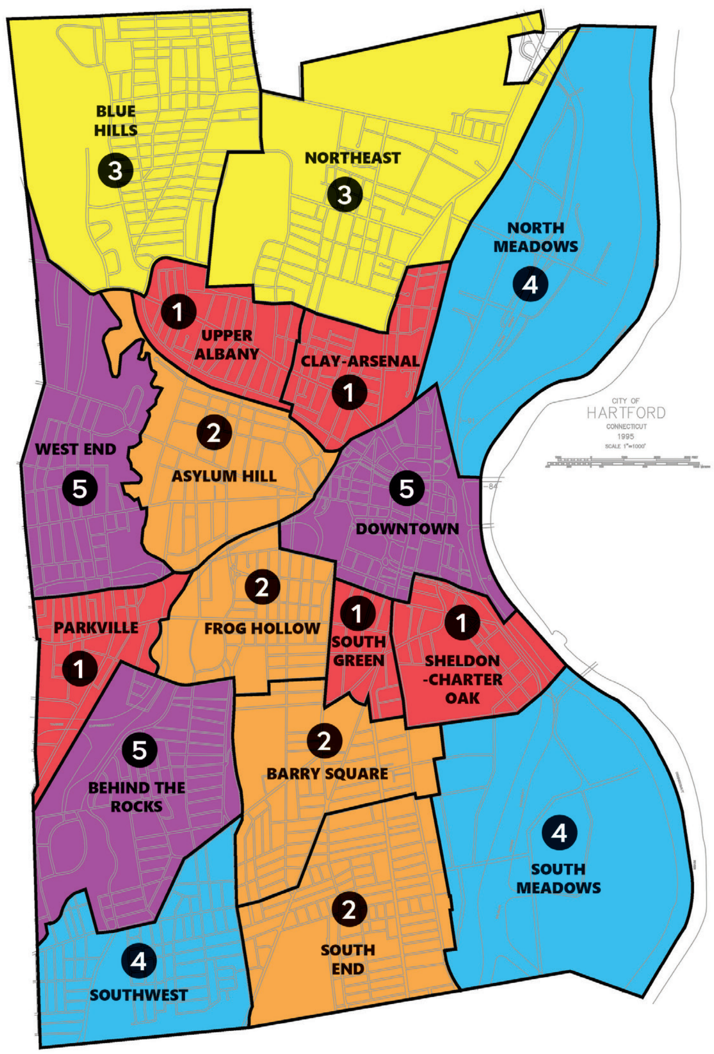
Example plan. Click on the link to access the plans:
https://hartfordclimate.files.wordpress.com/2016/12/map-gis-nrz_priorityplanting.pdf



APPENDIX H

Priority Planting Park Map

Priority Planting Park Map



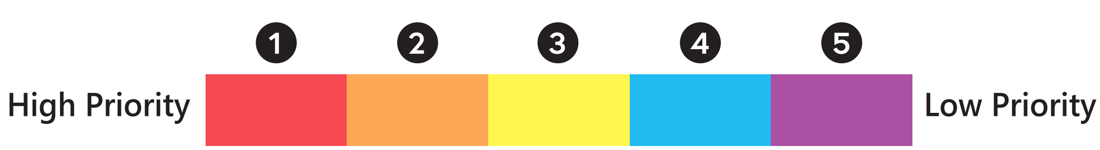
1. CLAY ARSENAL/ PARKVILLE/ SHELDON-CHARTER OAK/ SOUTH GREEN/ UPPER ALBANY
- COLT PARK
- PORTER MEMORIAL
- PULASKI MALL
- OLD NORTH CEMETERY
- WILLIE WARE PARK
- SOUTH GREEN/ BARNARD PARK
- HARRIET TUBMAN PARK
- JULIO LOZADA PARK
- WEST QUIRK TURF
- POPE PARK WEST
- GEORGE DAY PARK

2. ASYLUM HILL/ BARRY SQUARE/ FROG HOLLOW/ SOUTH END
- ZION HILL CEMETERY
- POPE PARK
- BABY POPE PARK
- COLUMBUS GREEN
- OLD SOUTH CEMETERY
- TURNING POINT PARK
- BOND STREET PARKETT
- CAMPFIELD MEMORIAL GROUNDS
- CAMPFIELD GREEN
- GALLAUDET SQUARE
- GOODWIN PARK
- COLUMBUS PARK
- SIGOURNEY SQUARE PARK

3. BLUE HILLS/ NORTHEAST
- JOSEPH V. CRONIN PARK
- ROBERTA JONES PLAYGROUND
- NORTHWOOD CEMETERY/ SOLDIERS FIELD
- KENEY WAVERLY PARK
- BRACKETT PARK
- KENEY WOODLAND PARK
- KENEY BARBOUR PARK

4. NORTH MEADOWS/ SOUTHWEST/ SOUTH MEADOWS
- THOMAS J. HYLAND MEMORIAL
- FORSTER PARK
- NEW BRITAIN AVE TRIANGLE
- RIVERSIDE PARK
- CHARTER OAK LANDING

5. BEHIND THE ROCKS/ DOWNTOWN/ WEST END
- ROCKY RIDGE PARK
- BUCKINGHAM SQUARE
- KENEY MEMORIAL CLOCK TOWER
- BUSHNELL PARK
- NEW ROSS COUNTY WEXFORD PARK
- ELIZABETH PARK
- ANCIENT BURYING GROUNDS
- PULASKI CIRCLE



APPENDIX I

Capital City Parks Guide (Sasaki Master Plans 2014)

(Sasaki Master Plans 2014)

Click on the link to access the plans: http://www.hartford.gov/dds-docs. Refer to the Parks, Recreation and Natural Resources section. Concept plans begin in Part 3.

Turning Point

- new design element
- low-mow area
- existing tree
- new tree
- bicycle lane
- sharrow (shared lane)

152

APPENDIX J

Colt Park Master Plan

COLT PARK MASTER PLAN

LEGEND

- EXISTING TREE
- PROPOSED TREE
- NO MOW LAWN
- EXISTING SERVICE PATH
- NEW SERVICE PATH
- NEW WALKWAY

100 0 100 200
1" = 100'

todesign

114 WEST MAIN STREET
SUITE 202
NEW BRITAIN, CT 06051
860-612-1700

todesignllc.com

SITE DESIGN
LANDSCAPE ARCHITECTURE
URBAN PLANNING

PROJECT #6197 August 27, 2019; Updated April 17, 2020

APPENDIX K

Hartford Parks Master Plan

Hartford Parks Master Plan

Click on the link to below to access the report:
http://www.hartford.gov/images/Planning/DocumentLibrary/NeighborhoodPlans/Parks_Master_Plan.pdf

CITY OF HARTFORD
Contract #1156
HARTFORD PARKS MASTER PLAN
FINAL REPORT

prepared by
LANDSCAPES
Landscape Architecture, Planning, Historic Preservation
Patricia M. O'Donnell, ASLA, APA
Charles A. Birnbaum, ASLA
PRE/view
Landscape Architecture, Visual Simulation
Stuart H. Sachs, ASLA
assisted by
David Schuyler, Historian
Noyes Vogt Architects, Architecture
Theodore Haskell, Maintenance
Christopher Greene, ASLA, Programs/Finance
George Wheeler, PhD, Monuments Conservation

APPENDIX L

Silverton Tree Giveaway Program Guidelines

SILVERTON TREE GIVEAWAY PROGRAM GUIDELINES

The Village of Silverton Parks, Arts, Trees and Culture Committee (PACT Com) is pleased to offer Silverton property owners trees at no cost to ensure the health and vitality of our community's tree canopy. Silverton is proud of its Tree City USA designation, the environmental benefits stemming from our urban forest, and the quality of life residents derive from our public and private trees.

Our goal is to ensure that future generations of Silverton residents can enjoy the same urban forestry that we enjoy in Silverton today. This program helps our community accomplish this goal.

In 2015, the Urban Forestry Board launched a Silverton Tree Planting program to give all Silverton property owners free and high-quality trees to plant in accordance with the terms, conditions, and requirements for this program. Below are the terms and conditions for the program which now falls under the Pact Com.

1. Trees shall be provided to Silverton property owners only. Residents of Silverton who rent residential property may receive a tree with the property owner's written permission, and provided the renter and property owner both agree to abide by the terms and conditions of this program.

2. A property owner who does not reside inside the Village of Silverton may receive a tree to be planted on their Silverton property, provided the property owner agrees to abide by the terms and conditions of this program.

3. Trees from this program shall be planted on property inside the Village corporate limits only, and only one tree shall be permitted for a property address per year. Trees shall not be planted or moved to a different property outside the Village of Silverton corporate limits.

4. Trees shall be given away on a first come, first serve basis. The PACT Com shall determine the deadlines and protocol each year to ensure a fair chance for all property owners to obtain a tree through this program. Residents who received a tree through this program in the year immediately prior are eligible to apply again, though priority will be given to residents who did not receive a tree through this program in the year immediately prior.

5. Silverton's Village Council shall determine the level of funding for the program annually through its budget process.

6. The PACT Com shall annually recommend several tree species to be ordered for the tree giveaway program. The PACT Com shall recommend trees to ensure that the urban tree canopy is diverse and provides for a healthy and sustainable urban forest inside Silverton.

7. All trees provided under this program shall be ordered by the Service Director or the Service Director's designate, and all ordering and receiving shall follow Silverton purchasing policies and procedures.

8. By accepting a tree, a property owner shall commit to the following:

    a. The tree shall be planted on the property designated on the application form.

    b. The tree shall be planted in a timely manner and using best planting practices to provide the best odds for its survival. The Village will provide written planting instructions with each tree given to a property owner.

    c. The property owner agrees to make reasonable effort to encourage the survival and thriving of the tree, including but not limited to watering and pruning it.

    d. The Village of Silverton and the PACT Com do not guarantee the tree and are not responsible for its care, removal, or replacement. The property owner assumes all risk for the tree, its planting, and its long-term care.

    e. Trees may be planted on any suitable location on private property. Property owners should take note of the location of overhead power lines to avoid eventual conflicts between service lines and a growing tree. Property owners should be considerate of adjacent property owners. Planting the tree in a location visible from the public right of way is encouraged.

    f. Property owners shall be responsible to call a utility locate service at least 2 to 10 days before digging the receiving tree hole. Property owners shall dig their own receiving holes prior to the moving of a tree to the end location. The telephone number for the local locating service is either: 8-1-1 or 1-800-362-2764.

    g. Should a property owner fail to comply with these guidelines in previous years, the Village reserves the absolute right to discontinue offering said property owner a tree in subsequent tree giveaways.

9. An applicant must read and sign this policy for it to be considered.

10. All forms shall be sent to the following:

Silverton Tree Giveaway Program
PACT Committee
6943 Montgomery Road
Silverton, OH 45236

Or scanned and emailed to: R.Lehmkuhl@Silvertonohio.us

APPENDIX M

Yearly Tree Planting Location Guide

Yearly Tree Planting Location Guide

Year 1 Tree Plantings
2,134 City-wide trees (Public, private and replacement trees)

Replacement Tree Planting: 634 (*Tree Resource Management Plan* High and Low Risk Removals)
City-wide Tree Planting Goal: 1,500 trees **(**Public Trees: 1,050**/** Private Tree: 450)

#1 Priority Neighborhoods: Clay Arsenal, Parkville, Sheldon-Charter Oak, South Green & Upper Albany
Private Trees: 450 locations to be determined within Priority Neighborhood #1
Public Trees
TreeKeeper Inventoried Possible Tree Planting Locations: 984

• Clay Arsenal	146 located:	plant	146
• Parkville	127 located:	plant	127
• Sheldon-Charter Oak	537 located:	plant	537
• South Green	85 located:	plant	85
• Upper Albany	89 located:	plant	89
			984

Neighborhood Locations: Locate 66 Trees in Colt Park

Year 2 Tree Plantings
2,131 City-wide trees (Public, private and replacement trees)

Replacement Tree Planting: 631 (*Tree Resource Management Plan* High and Low Risk Removals)
City-wide Tree Planting Goal: 1,500 trees (Public Trees: 1,050**/** Private Tree: 450)

#2 Priority Neighborhoods: Asylum Hill, Barry Square, Frog Hollow, South End
Private Trees: 450 locations to be determined within Priority Neighborhood #2
Public Trees
TreeKeeper Inventoried Possible Tree Planting Locations: 1,696

• Asylum Hill	350 located:	plant	149
• Barry Square	593 located:	plant	412
• Frog Hollow	357 located:	plant	232
• South End	396 located:	plant	257
			1,050

Year 3 Tree Plantings

1,951 City-wide trees (Public, private and replacement trees)

Replacement Tree Planting: 451 (*Tree Resource Management Plan* High and Low Risk Removals)
City-wide Tree Planting Goal: 1,500 trees (Public Trees: 1,050**/** Private Tree: 450)

#3 Priority Neighborhoods: Blue Hills, Northeast, Southwest, South End
Private Trees: 450 locations to be determined within Priority Neighborhood #3
Public Trees

TreeKeeper Inventoried Possible Tree Planting Locations: 2,548

• Blue Hills	1803 located:	plant	540
• Northeast	745 located:	plant	510
			1,050

Year 4 Tree Plantings

1,590 City-wide trees (Public, private and replacement trees)

Replacement Tree Planting: 90 (*Tree Resource Management Plan* Projected Annual Replacements)
City-wide Tree Planting Goal: 1,500 trees (Public Trees: 1,050**/** Private Tree: 450)

#4 Priority Neighborhoods: North Meadows, Southwest, South Meadows
Private Trees: 450 locations to be determined within Priority Neighborhood #4
Public Trees

TreeKeeper Inventoried Possible Tree Planting Locations: 2,081

• North Meadows	441 located:	plant	286
• Southwest	1632 located:	plant	756
• South Meadows	8 located:	plant	8
			1,050

Year 5 Tree Plantings

3,090 City-wide trees (Public, private and replacement trees)

Replacement Tree Planting: 90 (*Tree Resource Management Plan* Projected Annual Replacements)
City-wide Tree Planting Goal: *3,000 trees* (Public Trees: 2,100**/** Private Tree: 900)

#5 Priority Neighborhoods: Behind the Rocks, Downtown, West End
Private Trees: 900 locations to be determined within Priority Neighborhood #5
Public Trees

TreeKeeper Inventoried Possible Tree Planting Locations: 2,753

• Behind the Rocks	1653 located:	plant	1,331
• Downtown	294 located:	plant	205
• West End	806 located:	plant	564
			2,100

Year 6 Tree Plantings

3,090 City-wide trees (Public, private and replacement trees)

Replacement Tree Planting: 90 (*Tree Resource Management Plan* Projected Annual Replacements)
City-wide Tree Planting Goal: 3,000 trees (Public Trees: 2,100**/** Private Tree: 900)

#1 Priority Neighborhoods: Clay Arsenal, Parkville, Sheldon-Charter Oak, South Green & Upper Albany
Private Trees: 900 locations to be determined within Priority Neighborhood #1
Public Trees: 2,100 ROW and Neighborhood Locations
TreeKeeper Inventoried Possible Tree Planting Locations: 100% previously planted

Neighborhood Locations: Locate trees in opportunity areas identified on Neighborhood Maps

2,100 Trees located at: Parks, Schools, Vacant Lots, Fire Stations, other City owned land and BROW at Multi-Family Housing

Parks: 269-420 Potential Tree Locations
(refer to the Priority Tree Planting Park Map for Park Priorities)

- Clay Arsenal: 41-70
  - 10-20 Trees: Old North Cemetery
  - 20-25 Trees: Willie Ware Park (City Parks Guide Concept Plan)
  - 1-5 Trees: Harriet Tubman Park (City Parks Guide Concept Plan)
  - 5-10 Trees: Lozada Park
  - 5-10 Trees: West Quirk Turf
- Parkville: 51-105
  - 50-100 Trees: Pope Park West
  - 2-5 Trees: George Day Park
- Sheldon-Charter Oak: 166-230
  - 150-200 Trees: Colt Park
  - 15-20 Trees: Porter Memorial (City Parks Guide Concept Plan)
  - 1-10 Trees: Pulaski Mall (City Parks Guide Concept Plan)
- South Green
  - 10-15 Trees: South Green Barnard (City Parks Guide Concept Plan)
- Upper Albany

Schools: 130-172 Potential Tree Locations

- Clay Arsenal
  - 25-30 Trees: Global Communications Academy
  - 20-25 Trees: S.A.N.D. School
- Parkville
  - 10-15 Trees: Parkville Community School
- Sheldon-Charter Oak
  - 5-10 Trees: R.J. Kinsella Magnet School of Performing Arts
  - 10-15 Trees: Sport and Medical Sciences Academy
  - 10-15 Trees: Ramon E. Betances Early Reading Lab
- South Green
  - 5-7 Trees: Dr. Joseph S. Renzulli Gifted and Talented Academy
- Upper Albany
  - 15-20 Trees: Achievement First Hartford Academy
  - 30-35 Trees: Martin Luther King Junior School

- 10-15 Trees: Ramon E. Betances Early Reading Lab
- South Green
  - 5-7 Trees: Dr. Joseph S. Renzulli Gifted and Talented Academy
- Upper Albany
  - 15-20 Trees: Achievement First Hartford Academy
  - 30-35 Trees: Martin Luther King Junior School

Fire Station: 4 Potential Tree Locations

- Clay Arsenal
  - 3 Trees: Fire Department Engine Co.2/ District 2
- Parkville (0)
- Sheldon-Charter Oak (0)
- South Green
  - 1 Tree: Hartford Fire Department Engine Co.1/ Ladder Co. 6
- Upper Albany:
  - 0 Trees: Fire Department Engine Co. 14 / Ladder Co. 4

LOVE HARTFORD GREEN HARTFORD

Year 7 Tree Plantings
3,090 City-wide trees (Public, private and replacement trees)

Replacement Tree Planting: 90 (Tree Resource Management Plan projected removals)
City-wide Tree Planting Goal: 3,000 trees (Public Trees: 2,100**/** Private Tree: 900)

#2 Priority Neighborhoods: Asylum Hill, Barry Square, Frog Hollow, South End
Private Trees: 900 locations to be determined within Priority Neighborhood #2
Public Trees: 2,100 ROW and Neighborhood Locations

TreeKeeper Inventoried Possible Tree Planting Locations: 646 located

• Asylum Hill	350 located: previously planted 149;	remainder to plant 201
• Barry Square	593 located: previously planted 412;	remainder to plant 181
• Frog Hollow	357 located: previously planted 232;	remainder to plant 125
• South End	396 located: previously planted 257;	remainder to plant 139
		646

Neighborhood Locations: locate 1,454 trees

Parks: 594-758 Potential Tree Locations
(refer to the Priority Tree Planting Park Map for Park Priorities)

- Asylum Hill: 165-185
  - 140-150 Trees: Turning Point Park (City Parks Guide Concept Plan)
  - 10-15 Trees: Gallaudet Square (City Parks Guide Concept Plan)
  - 15-20 Trees: Sigourney Square Park
- Barry Square: 19-28
  - 15-20 Trees: Old South Cemetery
  - 1-5 Trees: Bond Street Parkett (City Parks Guide Concept Plan)
  - 2 Trees: Campfield Memorial Grounds
  - 1 Trees: Campfield Green
- Frog Hollow: 180-260
  - 75-100 Trees: Zion Cemetery
  - 75-100 Trees: Pope Park
  - 25-50 Trees: Baby Pope Park
  - 5-10 Trees: Columbus Green
- South End: 230-285
  - 150-200 Trees: Goodwin Park
  - 80-85 Trees: Columbus Park (City Parks Guide Concept Plan)

Schools: 260-330 Potential Tree Locations

- Asylum Hill
  - 15-20 Trees: Classical Magnet
  - 30-35 Trees: HPHS Academy of Engineering and Green Technology
  - 10-15 Trees: Opportunity High School
  - 5-10 Trees: West Middle School
- Barry Square
  - 40-50 Trees: Alfred E. Burr Elementary
  - 30-40 Trees: Bulkeley High School
  - 20-25 Trees: Dr. Michael D. Fox School
  - 10-15 Trees: Hartford Magnet Trinity College Academy
- Frog Hollow
  - 25-30 Trees: Burns Latino Studies Academy

- 30-35 Trees: Maria C. Colon Sanchez Elementary
- South End
  - 15-20 Trees: Asian Studies Academy at Bellizzi
  - 5-10 Trees: Betances STEM Magnet
  - 20-25 Trees: Dr. James H Naylor/CCSU Leadership Academy

Fire/ Police Station: 8-22 Potential Tree Locations

- Asylum Hill
  - 1-2 Trees: Fire Department Engine No. 5
  - 1-5 Trees: Northwest Police Substation
- Barry Square
  - 1-3 Trees: Fire Depart Engine Co. 15/ Ladder Co. 2
- Frog Hollow
  - 1 Tree: Fire Department Engine No. 8
  - 1-5 Trees: Southwest Police Substation
- South End
  - 3-6 Trees: Fire Depart Engine Co. 10

LOVE HARTFORD
GREEN HARTFORD

Year 8 Tree Plantings
3,090 City-wide trees (Public, private and replacement trees)

Replacement Tree Planting: 90 (Tree Resource Management Plan projected removals)
City-wide Tree Planting Goal: 3,000 trees (Public Trees: 2,100**/** Private Tree: 900)

#3 Priority Neighborhoods: Blue Hills, Northeast, Southwest, South End
Private Trees: 900 locations to be determined within Priority Neighborhood #3
Public Trees: 2,100 ROW and Neighborhood Locations
TreeKeeper Inventoried Possible Tree Planting Locations: 1,498

• Blue Hills	1803 located: previously planted 540;	remainder to plant 1,263
• Northeast	745 located: previously planted 510;	remainder to plant 235
		1,498

Neighborhood Maps: Locate 602 trees

Parks: 995-1,360 Potential Tree Locations
(refer to the Priority Tree Planting Park Map for Park Priorities)

- Blue Hills: 30-40
  - 25-30 Trees: Joseph V. Cronin Park (City Parks Guide Concept Plan)
  - 5-10 Trees: Roberta jones Playground (City Parks Guide Concept Plan)
- Northeast: 965-1,320
  - 50-100 Trees: Northwood Cemetery/ Soldiers Field
  - 300-400 Trees: Keney Waverly Park
  - 15-20 Trees: Brackett Park
  - 300-400 Trees: Keney Woodland Park
  - 300-400 Trees: Keney Barbour Park

Schools: 255-320 Potential Tree Locations

- Blue Hills
  - 20-25 Trees: Breakthrough Magnet School, North
  - 40-45 Trees: Montessori Magnet School at Annie Fisher
  - 5-10 Trees: Hartford Pre-K Magnet School
  - 15-20 Trees: Sarah J. Rawson Elementary
  - 40-50 Trees: University High School or Science and Engineering
  - 40-50 Trees: Weaver High School
- Northeast
  - 5-10 Trees: Clark School
  - 30-35 Trees: Journalism and Media Academy Magnet School
  - 30-40 Trees: Simpson Waverly School
  - 30-35 Trees: Museum Academy at Wish

Fire Station: 7-13 Potential Tree Locations

- Blue Hills (2)
  - 3-5 Trees: Blue Hills Fire Department
  - 2-5 Trees: Fire Department Engine Co. 16
- Northeast (1)
  - 2-3 Trees: Fire Department Engine Co. 7

Year 9 Tree Plantings
3,090 City-wide trees (Public, private and replacement trees)

Replacement Tree Planting: 90 (Tree Resource Management Plan projected removals)
City-wide Tree Planting Goal: 3,000 trees (Public Trees: 2,100**/** Private Tree: 900)

#4 Priority Neighborhoods: North Meadows, Southwest, South Meadows
Private Trees: 900 locations to be determined within Priority Neighborhood #4
Public Trees: 2,100 ROW and Neighborhood Locations
TreeKeeper Inventoried Possible Tree Planting Locations: 1,031

North Meadows	441 located: previously planted 286;	remainder to plant 155
Southwest	1,632 located: previously planted 756;	remainder to plant 876
South Meadows	8 located: previously planted 8;	remainder to plant 0
		1,031

Neighborhood Locations: Locate 1,069 trees

Parks: 550-765 Potential Tree Locations
(refer to the Priority Tree Planting Park Map for Park Priorities)

- North Meadows
  - 300-400 Trees: Riverside Park
- Southwest: 50-65
  - 20-25 Trees: Thomas J. Hyland Memorial (City Parks Guide Concept Plan)
  - 25-30 Trees: Forster Heights (City Parks Guide Concept Plan)
  - 5-10 Trees: New Britain Ave Triangle
- South Meadows
  - 200-300 Trees: Charter Oak Landing

Schools: 5-10 Potential Tree Locations

- North Meadows (0)
- Southwest
  - 5-10 Trees: E. B. Kennelly School
- South Meadows (0)

Fire Station: 3-5 Potential Tree Locations

- North Meadows (0)
- Southwest
  - 3-5 Trees: Fire Department Engine Co. 9
- South Meadows (0)

Year 10 Tree Plantings
3,090 City-wide trees (Public, private and replacement trees)

Replacement Tree Planting: 90 (Tree Resource Management Plan projected removals)
City-wide Tree Planting Goal: 3,000 trees (Public Trees: 2,100**/** Private Tree: 900)

#5 Priority Neighborhoods: Behind the Rocks, Downtown, West End
Private Trees: 900 locations to be determined within Priority Neighborhood #5
Public Trees: 2,100 ROW and Neighborhood Locations

TreeKeeper Inventoried Possible Tree Planting Locations: 653

• Behind the Rocks	1653 located: previously planted 1,331;	remainder to plant	322
• Downtown	294 located: previously planted 205;	remainder to plant	89
• West End	806 located: previously planted 564;	remainder to plant	242
			653

Neighborhood Maps: Locate 1,447 trees

Parks: 350-505 Potential Tree Locations
(refer to the Priority Tree Planting Park Map for Park Priorities)

- Behind the Rocks
  - 75-100 Trees: Rocky Ridge Park
- Downtown: 176-255
  - 10-20 Trees: Buckingham Square
  - 1-5 Trees: Keney Memorial Clock Tower (City Parks Guide Concept Plan)
  - 150-200 Trees: Bushnell Park
  - 5-10 Trees: Wexford Park
  - 5-10 Trees: Ancient Burying Grounds
  - 5-10 Trees: Pulaski Circle
- West End
  - 100-150 Trees: Elizabeth park

Schools: 135-170 Potential Tree Locations

- Behind the Rocks
  - 40-50 Trees: Breakthrough Magnet School, South
  - 25-30 Trees: Environmental Sciences Magnet School at Mary Hooker
  - 10-15 Trees: Expeditionary Learning Academy at Moylan School
  - 25-30 Trees: McDonough Middle School
- Downtown
  - 30-35 Trees: Capital Preparatory Magnet
- West End
  - 5-10 Trees: Noah Webster MicroSociety Magnet

Fire Station: 1 Potential Tree Locations

- Behind the Rocks (0)
- Downtown (2)
  - 0 Trees: Fire Department TAC 1/ District 1
  - 0 Trees: Fire Department Headquarters
- West End
  - 1 Tree: Fire Department Engine Co. 11/ Ladder Co.5

APPENDIX N

Hartford Tree Recommendations (August 2018)

Hartford Tree Recommendations - August 2018 DRAFT

Note: Other evergreen trees may be accepted upon approval from the City Forester

Green = Yes/Applicable
Yellow = US Native
Orange = Pest Risk Concern

* See Notes

Size	Common Name	Scientific Name	Mature Size		Species Characteristics						Eco Benefits			Site Selection Characteristics							
			Height	Spread	CT Native (US native in yellow)	Salt Tolerant	Urban Tolerant	Potential Pest Risk	Positive Past Performance	Not Readily Available in the Trade	Stormwater	Heat Island	Air Quality	Residential	Commercial	Full Sun	Part Shade	Can Be Under Wires	Needs Offset	Street Tree	Small pit okay
SMALL	speckled alder	Alnus incana subsp. rugosa	20	var.																	
	Shadbush,serviceberry	Amelanchier canadensis	15	var.																	
	Apple Serviceberry, Hybrid Serviceberry	Amelanchier x grandiflora 'Autumn brilliance'	23	23																	
	American Hornbeam	Carpinus caroliniana	25	25																	
	Eastern Redbud	Cercis canadensis	25	30					*												
	silky dogwood	Cornus amomum	8	8																	
	Flowering Dogwood	Cornus florida	20	20					*												
	Kousa Dogwood	Cornus kousa	25	25					*												
	eastern red cedar	Juniperus virginiana	45	15						*											
	Amur maackia	Maackia amurensis	25	25						*											
	Prarie Crabapple	Malus ioensis	25	25																	
	Sourwood	Oxydendrum arboreum	28	20						*											
	Cherry Plum	Prunus cerasifera	23	20																	
	Purple Leaf Plum	Prunus cerasifera Thunderleaf	20	20																	
	Kwanzan Cherry	Prunus serrulata	63	var.																	
	Japanese/Deciduous Stewartia	Stewartia pseudocamellia	30	30						*											
	Japanese Tree Lilac	Syringa reticulata	25	20																	
	Bald Cypress	Taxodium distichum	60	25																	
	Northern White Cedar	Thuja occidentalis	50	13																	
MEDIUM	Hackberry	Celtis laevigata	45	45																	
	yellowwood	Cladrastis kentukea	40	50																	
	Hardy rubber tree	Eucommia ulmoides	50	50																	
	honey locust	Gleditsia triacanthos	50	50																	
	Black gum, tupelo	Nyssa sylvatica	40	25																	
	eastern hophornbeam	Ostrya virginiana	35	30																	
	Amur corktree	Phellodendron amurense	40	40																	
	Eastern White Pine	Pinus strobus	65	30																	
	fastigiate oak	Quercus robur f. fastigiata	55	15												*					
	pagoda tree	Styphnolobium japonicum	60	60																	
LARGE	European hornbeam	Carpinus betulus	50	40																	
	Pignut hickory	Carya glabra	55	30																	
	Shagbark Hickory	Carya ovata	70	35																	
	Mockernut hickory	Carya tomentosa	55	25																	
	Turkish hazelnut (filbert)	Corylus colurna	45	25																	
	ginkgo	Ginkgo biloba	65	var.																	
	coffee tree	Gymnocladus dioicus	70	45						*											
	Larch, Tamarack	Larix laricina	60	25																	
	sweet gum	Liquidambar styraciflua	70	45																	
	tuliptree	Liriodendron tulipifera	80	45																	
	cucumber tree magnolia	Magnolia acuminata	65	65						*											
	bigleaf magnolia	Magnolia macrophylla	15	15																	
	umbrella magnolia	Magnolia tripetala	25	25																	
	Dawn Redwood	Metasequoia glyptostroboides	85	25																	
	Yoshino Cherry	Prunus yedoensis	45	45																	
	white oak	Quercus alba	70	70					*							*					
	swamp white oak	Quercus bicolor	55	55					*							*					
	scarlet oak	Quercus coccinea	70	45					*							*					
	shingle oak	Quercus imbricaria	55	55						*											
	Overcup Oak	Quercus lyrata	50	50						*											
	bur oak	Quercus macrocarpa	75	75																	
	pin oak	Quercus palustris	65	35																	
	willow oak	Quercus phellos	50	35						*											
	chestnut oak	Quercus prinus	65	65					*	*						*					
	English Oak	Quercus robur	50	50						*											
	red oak	Quercus rubra	70	70					*	*						*					
	Shumard oak	Quercus shumardii	50	50						*											
	American linden	Tilia americana	70	30																	
	littleleaf linden	Tilia cordata	65	40																	
	silver linden	Tilia tomentosa	60	35																	
	Japanese zelkova	Zelkova serrata	70	70																	

Species Susceptible to Asian Longhorn Beetle- Plant with caution

Green = Yes/Applicable
Yellow = US Native
Orange = Pest Risk Concern

* See Notes

Size	Common Name	Scientific Name	Mature Size		Species Characteristics						Eco Benefits			Site Selection Characteristics							
			Height	Spread	CT Native (US native in yellow)	Salt Tolerant	Urban Tolerant	Potential Pest Risk	Positive Past Performance	Not Readily Available in the Trade	Stormwater	Heat Island	Air Quality	Residential	Commercial	Full Sun	Part Shade	Can Be Under Wires	Needs Offset	Street Tree	Small pit okay
SMALL	Paperbark Maple	Acer griseum	25	25				ALB													
MEDIUM	trident maple	Acer buergerianum	30	20				ALB		*											
	hedge maple	Acer campestre	30	30				ALB		*											
	red horsechestnut	Aesculus x carnea	35	35				ALB		*											
	river birch	Betula nigra	55	50				ALB	*	*											
	black willow	Salix nigra	45	45				ALB													
	lacebark elm	Ulmus parvifolia	45	45				ALB		*											
	Goldenrain tree	Koelreuteria paniculata	35	35				ALB													
LARGE	yellow buckeye	Aesculus flava	70	40				ALB													
	horse chestnut	Aesculus hippocastanum	65	var.				ALB	*	*											
	Katsuratree	Cercidiphyllum japonicum	50	50				ALB													
	London planetree	Platanus hybrida	85	75				ALB													
	eastern cottonwood	Populus deltoides	90	65				ALB		*											
	American elm	Ulmus americana	70	40				ALB	*												
	slippery elm	Ulmus rubra	50	40				ALB													
	common hackberry	Celtis occidentalis	50	50				ALB		*											
	American sycamore	Platanus occidentalis	85	85				ALB													

Size	Tree Species			Other Characteristics	Source									Notes
Size	Scientific Name	Common Name	Hardiness Zone	Possible Pest Risks	Davey	Zoning code	CTSW	iTree	UConn	Dirr's	Morton	URI	USFS	
SMALL	Alnus incana subsp. rugosa	speckled alder	3 ~ 6	Alder aphids, Japanese beetles, and leaf miners			X			X	X			
	Amelanchier canadensis	Shadbush,serviceberry	3 ~7(8)*				X		X	X	X			Hardiness zone information from Dirr's Encyclopedia, not iTree
	Amelanchier spp.	Shadbush, serviceberry	5 ~ 8*			X		X	X	X		X		Amelanchier laevis (Allegheny Serviceberry) is a specific US native species. Shadblow Serviceberry/Thicket Serviceberry (Amelanchier canadensis) is a specific salt tolerant species. iTree notes that there is moderate uncertainty concerning the hardiness zone.
	Amelanchier x grandiflora 'Autumn brilliance'	Apple or Hybrid Serviceberry	4(5) ~ 8(9)*							X	X			Hardiness zone information from Dirr's Encyclopedia, not iTree.
	Carpinus caroliniana	American Hornbeam	3 ~ 9*			X			X	X	X	X		Hardiness zone information from Dirr's Encyclopedia, not iTree.
	Cercis canadensis	Eastern Redbud	4 ~ 9*	Borers		X			X	X	X	X		This species must be planted at a wet site. Hardiness zone information from Dirr's Encyclopedia, not iTree. Good for residential planting, not for tree lawns
	Cornus amomum	silky dogwood	4 ~ 8*				X		X	X	X			Hardiness zone information from Dirr's Encyclopedia, not iTree. Grows more like a shrub.
	Cornus florida	Flowering Dogwood	5 ~ 9			X	X	X	X	X	X	X		Previously planted varieties include 'cher. brave.' This species must be planted ata wet site. Good for residential planting not for tree lawns
	Cornus kousa	Kousa Dogwood	(4)5 ~ 8*	Borers		X			X	X	X			Previously planted varieties include 'Milky Way.' Hardiness zone information from Dirr's Encyclopedia, not iTree. Good for residential planting not for tree lawns
	Cornus spp.	Dogwood	5 ~ 8*			X*		X	X	X		X		These species must be planted at a wet site. Tatarian Dogwood (Cornus alba), Kousa Dogwood (Cornus kousa), Cornelian Cherry Dogwood (Cornus mas), Gray Dogwood (Cornus racemose), Stellar Series Dogwood (Cornus Rutgers Hybrids), and Redosier Dogwood (Cornus sericea) are urban tolerant. Only Flowering dogwood and Kousa dogwood are in the zoning code. Cornus florida, Cornus kousa, Cornus florida cher. Brave, Cornus kousa 'Milky way' are common previously planted species. Moderate uncertainty to hardiness zone. Some species can be planted as street trees, but not Cornus florida. Good for residential planting not for tree lawns.
	Juniperus virginiana	eastern red cedar	4 ~ 9	Cedar rusts (cedar-apple, cedar-hawthorn and cedar-quince) and bagworm are common.			X	X	X	X	X			Purchase Availability: Order before March
	Maackia amurensis	Amur maackia	4 ~ 7*			X			X	X	X	X		Hardiness zone information from Dirr's Encyclopedia, not iTree. Rare
	Malus ioensis	Prairie Crabapple	4 ~ 8	Gypsy Moth, Winter Month				X			X			Height and spread from Morton Arboretum, not Dirr's Encyclopedia.
	Malus spp.	Crabapple	6*	Many species are vulnerable to Gypsy moth and/or Winter moth		X		X	X	X	X	X	.	Japanese Flowering Crabapple (Malus floribunda), Tea Crabapple (Malus hupehensis), Hybrid Crabapple (Malus hybrids), Sargent Crabapple (Malus sargentii), and Flowering Crabapple (Malus x zumi) are urban tolerant. Prairie crabapple (Malus ioensis) is a common previously planted species. While hardiness zone ranges vary by species, a number of species are tolerant of zone 6. Height from Morton Arboretum, not Dirr's Encyclopedia.
	Oxydendrum arboreum	Sourwood	5 ~ 8			X		X	X	X	X			Slow growing, expensive, and not readily available
	Prunus cerasifera	Cherry Plum	6 ~ 8			X		X	X	X		X		***
	Prunus cerasifera Thunderleaf	Purple Leaf Plum				X			X	X		X		
	Prunus serrulata	Kwanzan Cherry	6 ~ 8					X	X	X	X			Previously planted varieties include 'Kwanzan' and 'Snowgoose.'
	Prunus spp.	Stone Fruit Trees	6*	A number of species (but not all) are vulnerable to Gypsy moth or Winter moth		X		X	X	X				American Plum (Prunus americana), Schip Laurel/Cherry laurel (Prunus laurocerasus 'Schipkaensis'), Beach Plum (Prunus maritima), Purpleleaf Sand Cherry (Prunus x cistena) are the salt tolerant species. Kwanzan Flowering Cherry (Prunus serrulata), Higan Cherry (Prunus subhirtella 'Pendula'), Purpleleaf Sand Cherry (Prunus x cistena) are urban tolerant species. Black Cherry (Prunus Serotina) has air pollutant removal benefits. While hardiness zone ranges vary by species, a number of species are tolerant of zone 6.
	Prunus spp. -Cherry Species-	Cherry	6*	Some species are vulnerable to Winter moth				X	X	X		X		Black Cherry (Prunus serotina) has UV radiation Reduction/UHI and air quality benefits. Kwanzan Flowering Cherry (Prunus serrulata), Higan Cherry (Prunus subhirtella 'Pendula'), and Purpleleaf Sand Cherry (Prunus x cistena) are urban tolerant. Schip Laurel/Cherry laurel (Prunus laurocerasus 'Schipkaensis') and Purpleleaf Sand Cherry (Prunus x cisterna) are salt tolerant. Prunus yedoensis, Prunus serrulata, Prunus serrulata 'snowgoose,'and Prunus 'kwanzan' are common previously planted species. While hardiness zone ranges vary by species, a number of species are tolerant of zone 6.
	Stewartia pseudocamellia	Japanese/Deciduous Stewartia	4(5) ~ 7*			X			X	X		X		This species needs to be planted at a wet site. It is slow growing, very expensive, and not readily available
	Syringa reticulata	Japanese Tree Lilac	3 ~ 7*			X			X	X	X	X		Hardiness zone information from Dirr's Encyclopedia, not iTree.
	Taxodium distichum	Bald Cypress	4 ~ 10					X	X	X	X			
	Thuja occidentalis	Northern White Cedar	3 ~ 7					X	X	X	X			Previously planted varieties include 'Emerald.'
MEDIUM	Celtis laevigata	Hackberry	5 ~ 10			X		X	X	X		X		
	Cladrastis kentukea	yellowwood	5 ~ 8*			X		X	X	X	X			
	Crataegus spp.	Hawthorne	6*	Gypsy Moth, Winter Moth		X	X	X	X	X		X		Previously planted species include Green Hawthorn (Crataegus viridis). Washington Hawthorn (Crataegus phaenopyrum) and Green Hawthorn (Crataegus viridis) are the two species that are urban tolerant. Cockspur Hawthorn (Crataegus crusgalli) and Singleseed Hawthorn (Crataegus monogyna) are two salt tolerant species. Many crataegus species are susceptible to the pest 'Gypsy Moth,' and a handful are vulnerable to 'Winter Moth.' While hardiness zone ranges vary by species, a number of species are tolerant of zone 6.
	Eucommia ulmoides	Hardy rubber tree	5 ~ 7			X		X	X	X		X		
	Gleditsia triacanthos	honey locust	4 ~ 8			X	X	X	X	X		X		Previously planted varieties include 'Shademaster' and 'Skyline.' This species tolerates wet site conditions and some salting.
	Nyssa sylvatica	Black gum, tupelo	5 ~ 9			X	X	X	X	X		X		This species must be planted at a wet site.
	Ostrya virginiana	eastern hophornbeam	4 ~ 9	Gypsy Moth	X	X		X	X	X		X		
	Phellodendron amurense	Amur corktree	4 ~ 8		X			X	X	X	X			
	Pinus strobus	Eastern White Pine	4 ~ 7	Pine Shoot Beetle, Sirex Wood Wasp, Southern Pine Beetle, White Pine Blister Rust			X	X	X	X	X			
	Quercus robur f. fastigiata	fastigiate oak				X			X	X				Susceptible to mildew
	Styphnolobium japonicum	pagoda tree	4 ~ 7			X		X	X	X		X		AKA Sophora japonica. This species tolerates some salting.
LARGE	Carpinus betulus	European hornbeam	5 ~ 7		X	X		X	X	X		X		ZC lists as medium; Previously planted varieties include 'Fastigiata.' This species has a narrow canopy.
	Carya glabra	Pignut hickory	5 ~ 9					X	X	X	X		.	Do not plant near driveways or roads.
	Carya ovata	Shagbark Hickory	4 ~ 9					X	X	X	X			
	Carya spp.	Hickory	5 ~ 9*				X	X	X	X			.	Moderate uncertainty to hardiness zone. Carya ovata is a common previously planted species. Do not plant near driveways or roads.
	Carya tomentosa	Mockernut hickory	5 ~ 9*					X	X		X			Moderate uncertainty to hardiness zone. Height and spread from Morton Arboretum, not Dirr's Encyclopedia. Do not plant near driveways or roads.
	Corylus colurna	Turkish hazelnut (filbert)	5 ~ 7		X			X	X	X		X		ZC lists as a medium-sized species. This species has a narrow canopy.
	Ginkgo biloba	ginkgo	4 ~ 8			X		X	X	X		X		This species tolerates some salting and has a narrow canopy.
	Gymnocladus dioicus	coffee tree	4 ~ 8*			X		X	X	X		X		Purchase Availability: Not rare, but also not common
	Larix laricina	Larch, Tamarack	1 ~ 4(5)*	Larch case-bearer, larch sawfly			X		X	X				Hardiness zone information from Dirr's Encyclopedia, not iTree
	Liquidambar styraciflua	sweet gum	6 ~ 9	Gypsy Moth		X		X	X	X	X			
	Liriodendron spp.	Tuliptree	5 ~ 9*					X	X	X		X		There are two species in this genus: tulipifera and chinense. Both have stormwater and air quality benefits. The hardiness zone for both species is the same, but there is moderate uncertainty concerning the chinense. The Chinense is not on UConn Horticulture's database, so there is no salt or urban tolerance information for that species.
	Liriodendron tulipifera	tuliptree	5 ~ 9		X	X		X	X	X	X			
	Magnolia acuminata	cucumber tree magnolia	4 ~ 8		X	X		X	X	X	X			Previously planted varieties include 'Magnolia Butterflies,' a hybrid between M. acuminata x M. denudata. The hybrid is commonly available for purchase in the trade.
	Magnolia macrophylla	bigleaf magnolia	5 ~ 8		X	X		X		X				
	Magnolia spp.	Magnolia	6*		X	X		X	X	X	X			Southern Magnolia/Bull Bay (Magnolia grandiflora) is the specific species that is salt-tolerant. The Cucumber tree magnolia (Magnolia acuminata) provides stormwater and air quality benefits. Bigleaf magnolia (Magnolia macrophylla) and umbrella magnolia (Magnolia tripetala) both provide stormwater benefits. While hardiness zone ranges vary by species, a number of species are tolerant of zone 6.
	Magnolia tripetala	umbrella magnolia	5 ~ 8		X	X		X	X	X	X			
	Metasequoia glyptostroboides	Dawn Redwood	5 ~ 8					X	X	X	X			
	Prunus yedoensis	Yoshino Cherry	6 ~ 8					X	X	X				
	Quercus alba	white oak	4 ~ 9	Gypsy Moth, Oak Wilt, Winter Moth	X	X	X	X	X	X		X		
	Quercus bicolor	swamp white oak	4 ~ 8	Gypsy Moth, Oak Wilt, Winter Moth		X	X	X	X	X		X		
	Quercus coccinea	scarlet oak	4 ~ 8	Gypsy Moth, Oak Wilt, Winter Moth		X		X	X	X		X		
	Quercus imbricaria	shingle oak	4 ~ 8	Gypsy Moth, Oak Wilt, Winter Moth		X		X	X	X		X		Purchase Availability: Common, but only sold in small quantities
	Quercus lyrata	Overcup Oak	6 ~ 9	Gypsy Moth, Oak Wilt, Winter Moth				X		X				Purchase Availability: Common, but only sold in small quantities
	Quercus macrocarpa	bur oak	3 ~ 8	Gypsy Moth, Oak Wilt, Winter Moth	X	X		X	X	X		X		
	Quercus palustris	pin oak	4 ~ 8	Gypsy Moth, Oak Wilt, Sudden Oak Death, Winter Moth		X	X	X	X	X		X		This species tolerates wet site conditions.
	Quercus phellos	willow oak	5 ~ 9	Gypsy Moth, Oak Wilt, Winter Moth		X		X	X	X		X		Purchase Availability: Order early on in the year
	Quercus prinus	chestnut oak	4 ~ 8	Gypsy Moth, Oak Wilt, Winter Moth		X		X	X	X		X		Purchase Availability: Common, but only sold in small quantities
	Quercus robur	English Oak	5 ~ 8	Gypsy Moth, Oak Wilt, Polyphagous Shot Hole Borer		X		X	X	X		X		Purchase Availability: Common, but only sold in small quantities
	Quercus rubra	red oak	4 ~ 8	Gypsy Moth, Oak Wilt, Sudden Oak Death, Winter Moth		X	X	X	X	X		X		This species tolerates some salting. Purchase Availability: Common, but only sold in small quantities
	Quercus shumardii	Shumard oak	6 ~ 9	Gypsy Moth, Oak Wilt, Winter Moth	X			X	X	X		X		This species tolerates some salting. Purchase Availability: Common, but only sold in small quantities
	Tilia americana	American linden	4 ~ 9	Gypsy Moth, Winter Moth	X	X		X	X	X		X		
	Tilia cordata	littleleaf linden	4 ~ 7	Gypsy Moth	X	X		X	X	X		X		
	Tilia spp.	Linden	6*	Many species are vulnerable to Gypsy moth; Tilia Americana is also at risk from Winter moth	X	X		X	X	X				The little leaf linden (Tilia Cordata), Silver linden (tilia tomentosa), and American Linden (Tilia Americana) provide both stormwater and air quality benefits. Bigleaf Linden (Tilia platyphyllos) provides stormwater and UHI benefits. Littleleaf Linden (Tilia cordata), Silver Linden (Tilia tomentosa), and Crimean Linden (Tilia x euchlora) are urban tolerant. While hardiness zone ranges vary by species, a number of species are tolerant of zone 6.
	Tilia tomentosa	silver linden	5 ~ 7	Gypsy Moth	X	X		X	X	X		X		
	Zelkova serrata	Japanese zelkova	5 ~ 8		X	X		X	X	X	X			

Species Susceptible to Asian Longhorn Beetle- Plant with caution

					Source									
Size	Scientific Name	Common Name	Hardiness Zone	Possible Pest Risks	Davey	Zoning code	CTSW	iTree	UConn	Dirr's	Morton	URI	USFS	Notes
Small	Acer griseum	Paperbark Maple	4 ~ 7	Asian Longhorned Beetle		X		X	X	X	X		X	Expensive
mediu	Acer buergerianum	trident maple	5 ~ 9	Asian Longhorned Beetle		X		X	X	X		X	X	This species has a narrow canopy. Purchase Availability: Order early on in the year
mediu	Acer campestre	hedge maple	5 ~ 8	Asian Longhorned Beetle		X		X	X	X		X	X	Purchase Availability: Order early on in the year
mediu	Aesculus x carnea	red horsechestnut	5 ~ 7	Asian Longhorned Beetle	X			X	X	X	X		X	Purchase Availability: Order early on in the year
mediu	Betula nigra	river birch	4 ~ 9	Asian Longhorned Beetle, Gypsy Moth, Large Aspen Tortrix, Winter Moth	X		X	X	X	X			X	The multistem variety is readily available and has performed well in Hartford. The single stem version is less common.
mediu	Koelreuteria paniculata	Goldenrain tree	6 ~ 8	Potential Host of Asian Longhorned Beetle		X		X	X	X		X	X	
mediu	Salix nigra	black willow	4 ~ 8	Asian Longhorned Beetle, Aspen Leafminer, Gypsy Moth, Large Aspen Tortrix, Winter Moth			X	X		X	X		X	Purchase Availability: Order early on in the year
mediu	Ulmus parvifolia	lacebark elm	6 ~ 10	Asian Longhorned Beetle, Gypsy Moth		X		X	X	X		X	X	This species has a narrow canopy and tolerates wet site conditions.
large	Aesculus flava	yellow buckeye	4 ~ 8	Asian Longhorned Beetle	X			X	X	X	X		X	
large	Aesculus hippocastanum	horse chestnut	4 ~ 7	Asian Longhorned Beetle		X		X	X	X		X	X	Purchase Availability: Common, but only sold in small quantities. Vulnerable to vandalism in Hartford.
large	Celtis occidentalis	common hackberry	3 ~ 9	Potential Host of Asian Longhorned Beetle	X		X	X	X	X	X		X	Purchase Availability: Order early on in the year
large	Cercidiphyllum japonicum	Katsuratree	5 ~ 8	Asian Longhorned Beetle	X	X		X	X	X	X		X	
large	Platanus hybrida	London planetree	5 ~ 8*	Asian Longhorned Beetle	X	X		X	X	X			X	AKA Platanus x acerifolia
large	Platanus occidentalis	American sycamore	5 ~ 9	Potential Host of Asian Longhorned Beetle	X		X	X	X	X	X		X	
large	Populus deltoides	eastern cottonwood	3 ~ 9	Asian Longhorned Beetle, Winter Moth			X	X	X	X	X		X	Rare
large	Ulmus americana	American elm	3 ~ 9	Asian Longhorned Beetle, Dutch Elm Disease, Winter Moth		X		X	X	X		X	X	Previously planted varieties include 'Valley Forge' and 'Princeton,' which have done well in Hartford in the past. This species tolerates wet site conditions.
large	Ulmus rubra	slippery elm	4 ~ 9*	Asian Longhorned Beetle, Dutch Elm Disease, Winter Moth			X	X		X	X		X	

Section	Label	Description (Largely taken from Source definitions)	Source(s)
Species Characteristics	CT Native (US native in yellow)	CT native trees are indigenous to the state. Native species are often great planting choices as they have already adapted to the local area. While foreign species can also be planted, they typically do not support the wildlife as well as native plants. Moreover, certain foreign species can be invasive and can wreak havoc on the area. However, it should be noted the CT native trees are gradually moving north. To plant with future tree migration in mind, choose species with hardiness ranges that include zone 7 or perhaps even zone 8.	UConn CT DEEP
	Salt Tolerant	Species that can handle some level of road salt (during the winter) or salt spray have been listed as Salt Tolerant.	UConn CT DEEP Morton Arboretum
	Urban Tolerant	Species that can handle poor conditions associated with urban areas have been listed as Urban Tolerant. There are no specific definition provided in the UConn database.	UConn
	Positive Past Performance	"Positive Past Performance" references the performance of these trees based on the extensive experience of the City's planting partner KNOX, who has planted over 5,000 trees in Hartford in the past seven years.	KNOX Inc.
	Not Readily Available in the Trade	"Not Readily Available in the Trade" refers to tree species that are not commonly available at nurseries.	KNOX Inc.
	Potential Pest Risk	Pest risk is based on pest host lists and ranges. The insects and diseases reported indicate that the tree species is a host to that pest and the pest's range covers Hartford.	iTree Species Morton Arboretum
	Susceptibility to Asian Longhorn Beetle	Asian Longhorn Beetle (ALB) is an invasive species that has the potential to decimate over half of Hartford's canopy. As such, ALB susceptible species have been placed in a separate section. Plant with caution, and watch for symptoms of infestation.	iTree Species NYIS UVM
	Hardiness Zone	Hardiness zones are based on USDA Hardiness zones. Certain species have uncertainty in their hardiness zone. These species have been marked with an asterisk in their column.	iTree Species Dirr's Encyclopedia of Trees & Shrubs
Environmental Benefits	Stormwater	Trees can help slow stormwater runoff by intercepting rainfall and through evapotranspiration. Using the iTree Species tool, the top 10% of tree species with the highest potential to reduce runoff and stream flow were chosen for this section.	iTree Species Davey Resource Group
	Heat Island	Plant leaves absorb 90–95% of UV radiation that passes through them. Trees lower air and pavement temperatures with shade and also reduce risk of sunburn or other related skin conditions. Using the iTree Species tool, the top 10% of tree species with the highest potential to reduce ultraviolet radiation were chosen.	iTree Species Davey Resource Group
	Air Quality	The urban forest can help improve air quality by reducing air temperature, directly removing pollutants from the air, and reducing energy consumption in buildings, which consequently reduces air pollutant emissions from the power sources. Using the iTree Species tool, the top 10% of tree species with the highest potential to reduce a range of air pollutants were chosen for this section.	iTree Species Davey Resource Group
Site Selection	Residential	No specific definition provided by URI	Yale Urban Resources Initiative (URI) Morton Arboretum
	Commercial	No specific definition provided by URI. When selecting trees for commercial sites, avoid "messy" trees that drop large seeds and fruits (e.g. oak, sweetgum).	Yale Urban Resources Initiative
	Full Sun	The planting location receives 6 hours of direct light daily	Yale Urban Resources Initiative
	Part Shade	The planting location receives 4-6 hours of light daily	Yale Urban Resources Initiative
	Can Be Under Wires	In order to protect the tree against bad pruning in the future, smaller trees must be planted under power lines.	Yale Urban Resources Initiative Morton Arboretum
	Needs Offset	If there is not adequate space for a tree in the curb strip, the tree can be offset from the ROW into the front yard. Offset trees are recommended to be no more than 10 feet from the sidewalk, so that the tree still provides public benefits. Even if there are wires along the street, trees offset in yards should be larger shade trees due to the available overhead space. Exception: If the yard is less than 10 feet deep, a small tree should be chosen to avoid conflicts with existing structures.	Yale Urban Resources Initiative
	Street Tree	Species that can handle various challenging factors associated with street plantings receive this designation. Issues can include a combination of salting, small pits, and damage from pedestrians/bikes/vehicles.	Hartford Department of Public Works
	Small pit okay	For public trees, the tree needs adequate space to grow within the pit. If there is not enough space to expand the tree pit, and the curb strip is less than 4 feet wide, consider planting a medium sized tree (e.g. Turkish filbert, zelkova, goldenrain tree) that will not conflict with the sidewalk in the future. For pits less than 3 feet wide, consider a small tree with a less extensive root system (e.g. hedge maple, serviceberry, crabapple).	Yale Urban Resources Initiative
Size based on canopy	Small	If a tree canopy (look straight up at the leaves above) is 300 square feet, it is a small tree. No ranges were provided in the City's zoning code.	COH DDS Dirr's Encyclopedia of Trees & Shrubs
	Medium	If a tree canopy (look straight up at the leaves above) is 700 square feet, it is a medium tree. No ranges were provided in the City's zoning code.	COH DDS Dirr's Encyclopedia of Trees & Shrubs
	Large	If a tree canopy (look straight up at the leaves above) is 1,000 square feet, it is a Large tree. No ranges were provided in the City's zoning code.	COH DDS Dirr's Encyclopedia of Trees & Shrubs
Mature Size (ft)	Height	This is the height of the tree from the base of the trunk upwards to the top.	Dirr's Encyclopedia of Trees & Shrubs Morton Arboretum
	Spread	This is the diameter of the canopy. Measure from one edge of the tree's leaf cover to the exact opposite edge (think of a line cutting a circle in half)	Dirr's Encyclopedia of Trees & Shrubs

APPENDIX O

2018-2019 Hartford Tree Planting Plan

Hartford Tree Planting Plan

This is a conceptual plan to provide guidance for any tree plantings in the city in the near future. Recommended species may change based on experience and changes in the environment.

Tree Sizes

In our recommended tree list, trees are classified as small, medium, and large. In general, small trees are suitable for planting under utility lines or as ornamental accents to home grounds. Typically, small trees grow no higher than 25 feet. Medium trees are typically in the 40 to 50 foot range. They are suitable for various locations that are somewhat constrained. Large trees can reach 70 to 80 feet or higher. Because of the volume of their mature crowns, they provide the greatest environmental and health benefits per tree.

During FY 2016-17, 31% of trees planted were small size, 3% were medium, and 70% were large. We recommend that in the coming year, to get the most value for dollars spent, 75% of trees planted should be large, 5% should be medium, and 20% should be small.

Tree Species

Within each size range, there should be a range of options to fit specific circumstances, availability, and preferences of neighbors. We are recommending about ten species for each size range, though our recommended tree list is more expansive. Trees are listed alphabetically by botanical name. Fastigiate trees should be used only where circumstances prevent the use of trees with more spreading habit.

Small

Amelanchier canadensis	Shadbush, serviceberry, x grandiflora ‘Autumn Brilliance’
Carpinus caroliniana	American Hornbeam (this one needs a lot of shade to grow)
Cercis canadensis	Eastern Redbud
Cornus kousa	Kousa Dogwood
Malus ioensis	Prairie Crabapple
Oxydendrum arboreum	Sourwood
Prunus cerasifera	Cherry plum
Prunus cerasifera Thunderleaf	Purple Leaf Plum
Prunus serrulata	Kwanzan Cherry
Syringa reticulata	Japanese Tree Lilac
Crataegus phaenopyrum	Washington Hawthorn

Medium

Celtis laevigata	Hackberry
Cladrastis kentukea	Yellowwood
Eucommia ulmoides	Hardy Rubber Tree
Gleditsia triacanthos	Honey Locust
Nyssa sylvatica	Black Gum, Tupelo
Ostrya virginiana	Eastern hophornbeam
Phellodendron amurense	Amur Corktree
Quercus robur f. fastigiata	Fastigiate Oak
Styphnolobium japonicum	Pagoda Tree
Magnolia acuminate	Cucumber tree magnolia
Magnolia macrophylla	Big leaf Magnolia

Large

Carya glabra & tomentosa	Pignut Hickory, Mockernut Hickory
Ginkgo biloba	Ginkgo
Gymnocladus dioicus	Coffee Tree
Liquidambar styraciflua	Sweet Gum
Liriodendron tulipifera	Tuliptree
Quercus lyrata	Overcup Oak
Quercus palustris	Pin Oak
Quercus rubra	Red Oak, also: Q. coccinea (scarlet oak)
Tilia americana	American Linden
Pinus strobus	Eastern White Pine

Planting location

In general, the vast majority of planting should be done in areas that have demonstrated significant heat island effect in our satellite imagery analysis. Specific planting locations should be based on the desirability of the location for the health of the trees and the wishes of adjacent property owners. Most trees should be planted in or adjacent to public rights of way or on public lands where paved areas or locations where people gather would benefit from additional shade. Other considerations such as screening, noise reduction, aesthetics, or maintenance of tree lines may be taken into account.

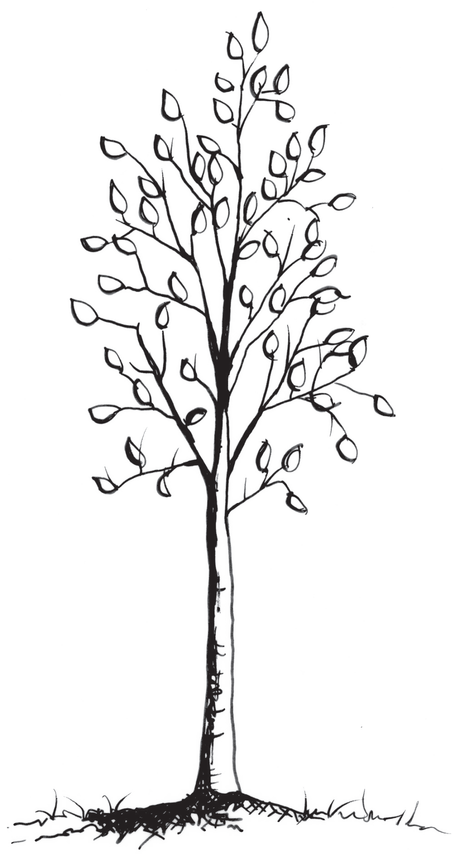
APPENDIX P

Connecticut Tree Owner's Manual

Connecticut Tree Owner’s Manual

Click on the link to access the manual:
https://portal.ct.gov/-/media/DEEP/forestry/CTTreeOwnersManualpdf.pdf

Connecticut Tree Owner's Manual



A Guide for Selecting, Planting and Caring for Young Trees

www.ct.gov/deep/lib/deep/forestry/cttreeownersmanual.pdf

Adapted, with permission, from the

Tree Owner's Manual,
published by the

United States
Department of Agriculture

Forest Service

Northeastern Area
State and Private Forestry

NA-FR-01-10

APPENDIX Q

Tree Maintenance Map

Tree Maintenance Map

3 Year Cycle

- Year 1: Red Area (Planting Priority Areas 1-2)
- Year 2: Orange Area (Planting Priority Area 3)
- Year 3: Yellow Area (Planting Priority Areas 4-5)