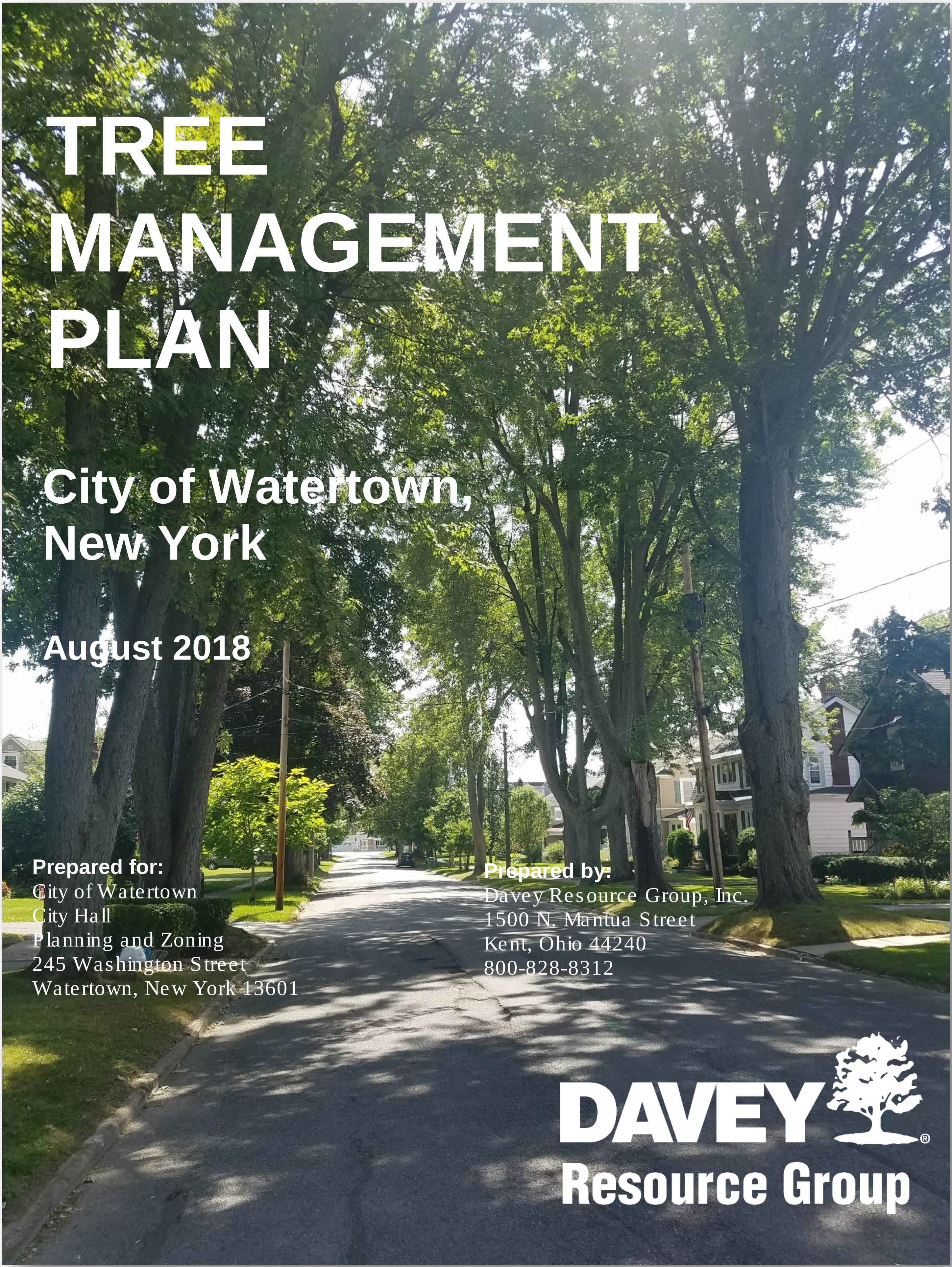

TREE MANAGEMENT PLAN

City of Watertown, New York

August 2018

Prepared for:
City of Watertown
City Hall
Planning and Zoning
245 Washington Street
Watertown, New York 13601

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MISSION STATEMENT

The City of Watertown, New York USA fosters an environment that ensures the health, safety, and general welfare of the community and its visitors by providing responsive services. Our city government provides leadership to enhance the quality of life while preserving our heritage.

VISION

The City of Watertown, New York USA aspires to be a vibrant, attractive community of rich recreational, cultural, and economic opportunity that maintains a small town appeal.

ACKNOWLEDGMENTS

Watertown's vision to promote and preserve the urban forest and improve the management of public trees was a fundamental inspiration for this project. This vision will ensure canopy continuity, which will reduce stormwater runoff and improve aesthetic value, air quality, and public health.

Watertown is thankful for the grant funding it received from the New York State Department of Environmental Conservation, Division of Lands and Forests, Urban Forestry Program. The Urban Forestry grants are part of New York's ongoing initiatives to address climate change and environmental justice, providing funding to expand the number of trees in areas that often have limited space. The grants are provided to communities through the State's Environmental Protection Fund (EDF). Projects target local environmental needs and will benefit the community and the environment.

The city also recognizes the support:

- Watertown City Council members, past and present
- City of Watertown Planning & Community Development Department
- City of Watertown Department of Public Works
- City of Watertown Parks and Recreation Department
- City of Watertown Engineering Department
- City of Watertown IT Department
- *Tree Watertown*, the City's street tree advisory board
- Watertown Noon Rotary Club
- The Northern New York Community Foundation, Inc.
- National Grid
- Watertown City School District
- Immaculate Heart Central Schools

Watertown would also like to acknowledge its community residents for their continued support of the city's urban forestry program.

EXECUTIVE SUMMARY

This plan was developed for the City of Watertown by DRG with a focus on addressing short-term and long-term maintenance needs for inventoried public trees. DRG completed a tree inventory to gain an understanding of the needs of the existing urban forest and to project a recommended maintenance schedule for tree care. Analysis of inventory data and information about the city's existing program and vision for the urban forest were utilized to develop this *Tree Management Plan*. Also included in this plan are economic, environmental, and social benefits provided by the trees in Watertown.

State of the Existing Urban Forest

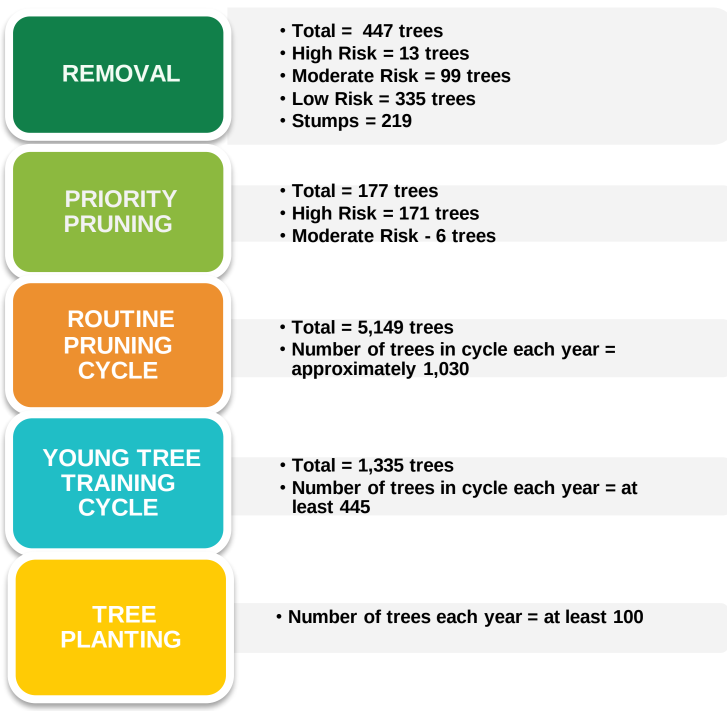
The August 2017 and June 2018 inventory included trees, stumps, and planting sites along public street rights-of-way (ROW), and in specified parks and public facilities. The parks selected for the inventory include: Academy Street Playground, Adams Park, Bicentennial Park, City Hall, Clinton Park, Cosgrove Park, Court Street Corner Lot, Emerson Place Playground, Factory Square Park, Fairgrounds, Gair Park, Hamilton Street Playground, Jefferson Street Playground, Kostyk Field, Lansingdorp Park, Marble Street Park, New York Ave Playground, Portage Street Playground, Public Square Park, Roswell P. Flower Memorial Library, Sewage Treatment Plant, Straus Memorial Walkway, Taylor Playground, Thompson Park, Thompson Park Zoo, Thompson Street Playground, Veterans Memorial Riverwalk, Waterworks Park, and Wight Drive & Temple Street Park.

A total of 9,239 sites were recorded during the inventory: 7,108 trees, 219 stumps, and 1,912 planting sites. Analysis of the tree inventory data found the following:

- *Acer saccharum* (sugar maple) comprises a large percentage of the population (9%) and threatens biodiversity.
- The diameter size class distribution of the inventoried tree population trends towards the ideal, with a greater number of young trees than established, maturing, or mature trees.
- The overall condition of the inventoried tree population is rated Fair.
- Approximately 11% of the inventoried trees had signs of stress.
- Approximately 9% of the inventoried trees had mechanical damage.
- Three Phase Powerlines are above 7% of the population.
- Hardscape lifting (0.75" or greater) from street trees occurs among 5% of the population.
- Granulate ambrosia beetle (*Xylosandrus crassiusculus*) and gypsy moth (*Lymantria dispar dispar*) pose the biggest threats to the health of the inventoried population.
- Watertown's trees have an estimated replacement value of $ 20,928,335.
- Trees provide approximately $715,343 in the following annual benefits:
    - *Aesthetic and other benefits*: valued at $286,346 per year.
    - *Air quality*: 10,041 pounds of pollutants removed valued at $52,469 per year.
    - *Net total carbon sequestered and avoided*: 1,010 tons valued at $6,669 per year.
    - *Energy*: 450 megawatt-hours (MWh) and 168,965 therms valued at $300,898 per year.
    - *Stormwater peak flow reductions*: 8,620,200 gallons valued at $68,961 per year.

Tree Maintenance and Planting Needs

Trees provide many environmental and economic benefits that justify the time and money invested in planting and maintenance. Recommended maintenance needs include: Tree Removal (5%); Stump Removal (2%); Tree Clean (58%); Young Tree Train (14%); and Plant Tree (21%). Maintenance should be prioritized by addressing trees with the highest risk first. The inventory noted 19 High Risk trees (0.3% of trees assessed); these trees should be removed or pruned immediately to promote public safety. Low and Moderate Risk trees should be addressed after all elevated risk tree maintenance has been completed. Trees should be planted to mitigate removals and create canopy.



Watertown's urban forest will benefit greatly from a three-year young tree training cycle and a five-year routine pruning cycle. Proactive pruning cycles improve the overall health of the tree population and may eventually reduce program costs. In most cases, pruning cycles will correct defects in trees before they worsen, which will avoid costly problems. Based on inventory data, at least 445 young trees should be structurally pruned each year during the young tree training cycle, and approximately 1,030 trees should be cleaned each year during the routine pruning cycle.

Planting trees is necessary to maintain and increase canopy cover, and to replace trees that have been removed or lost to natural mortality (expected to be 1–3% per year) or other threats (for example, construction, invasive pests, or impacts from weather events such as drought, flooding, ice, snow, storms, and wind). DRG recommends planting at least 100 trees of a variety of species each year to offset these losses, increase canopy, maximize benefits, and account for ash tree loss.

Photograph 1. The City of Watertown recognizes that its urban forest is critical to ecosystem health and economic growth. Planning and action are central to promoting and sustaining a healthy urban forest.

Citywide tree planting should focus on replacing tree canopy recommended for removal and establishing new canopy in areas that promote economic growth, such as business districts, recreational areas, trails, parking lots, areas near buildings with insufficient shade, and areas where there are gaps in the existing canopy. Various tree species should be planted; however, the planting of *Acer sacchuram* (sugar maple) should be limited until the species distribution normalizes. The city's existing planting list offers smart choices for species selection. Due to the species distribution and impending threats from emerald ash borer (EAB, *Agrilus planipennis*), all *Fraxinus* spp. (ash) trees should be temporarily removed from the planting list.

Urban Forest Program Needs

Adequate funding will be needed for the city to implement an effective management program that will provide short-term and long-term public benefits, ensure that priority maintenance is performed expediently, and establish proactive maintenance cycles. The estimated total cost for the first year of this five-year program is $260,784. This total will decrease to approximately $160,000 per year by Year 3 of the program. High-priority removal and pruning is costly; since most of this work is scheduled during the first year of the program, the budget is higher for that year. After high-priority work has been completed, the urban forestry program will mostly involve proactive maintenance, which is generally less costly. Budgets for later years are thus projected to be lower.

Over the long term, supporting proactive management of trees through funding will reduce municipal tree care management costs and potentially minimize the costs to build, manage, and support certain city infrastructure. Keeping the inventory up-to-date using TreeKeeper® 8.0 or similar software is crucial for making informed management decisions and projecting accurate maintenance budgets.

Watertown has many opportunities to improve its urban forest. Planned tree planting and a systematic approach to tree maintenance will help ensure a cost-effective, proactive program. Investing in this tree management program will promote public safety, improve tree care efficiency, and increase the economic and environmental benefits the community receives from its trees.

FY 2019 $260,784

- 13 High Risk Removals
- 6 High Risk Prunes
- 99 Moderate Removals
- 171 Moderate Prunes
- 49 Stump Removals
- RP Cycle: 1/5 of Public Trees Cleaned
- YTT Cycle: 445 Trees
- 100 Trees Recommended for Planting and Follow-Up Care
- Newly Found Priority Tree Work (Removal or Pruning): Costs TBD

FY 2020 $237,085

- 335 Low Risk Removals
- 46 Stump Removals
- RP Cycle: 1/5 of Public Trees Cleaned
- YTT Cycle: 445 Trees
- 100 Trees Recommended for Planting and Follow-Up Care
- Newly Found Priority Tree Work (Removal or Pruning): Costs TBD

FY 2021 $160,518

- 43 Stump Removals
- RP Cycle: 1/5 of Public Trees Cleaned
- YTT Cycle: 445 Trees
- 100 Trees Recommended for Planting and Follow-Up Care
- Newly Found Priority Tree Work (Removal or Pruning): Costs TBD

FY 2022 $159,953

- 41 Stump Removals
- RP Cycle: 1/5 of Public Trees Cleaned
- YTT Cycle: 445 Trees
- 100 Trees Recommended for Planting and Follow-Up Care
- Newly Found Priority Tree Work (Removal or Pruning): Costs TBD

FY2023 $159,851

- 40 Stump Removals
- RP Cycle: 1/5 of Public Trees Cleaned
- YTT Cycle: 000 Trees
- 100 Trees Recommended for Planting and Follow-Up Care
- Newly Found Priority Tree Work (Removal or Pruning): Costs TBD

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INTRODUCTION

The City of Watertown is home to more than 27,000 full-time residents who enjoy the beauty and benefits of their urban forest. The city's Planning and Community Development Department and the Department of Public Works: Building and Grounds staff manages and maintains trees on public property, including trees, stumps, and planting sites in specified parks, public facilities, and along the street rights-of-way (ROW).

In the wake of several severe storms in the 1990s, known as "the decade of disaster", the city began replanting trees along their streets and parks. Watertown has progressively increased their management of their street and park trees ever since. For example, in 2000, the city began a supplemental watering program for young trees, and in 2001, the city's young tree pruning program began.

Watertown continues to move ever forward with tree management, demonstrated by a recent inventory of public trees in 2017 and 2018. The city also has a tree ordinance, a street tree advisory board (Tree Watertown), maintains a budget of more than $2 per capita for tree-related expenses, celebrates Arbor Day (21st celebration as of 2018), and has been a Tree City USA community for 18 years.

Approach to Tree Management

The best approach to managing an urban forest is to develop an organized, proactive program using tools (such as a tree inventory and a tree management plan) to set goals and measure progress. These tools can be utilized to establish tree care priorities, build strategic planting plans, draft cost-effective budgets based on projected needs, and ultimately minimize the need for costly, reactive solutions to crises or urgent hazards.

In August 2017 and June 2018, Watertown worked with DRG to inventory trees and develop a management plan. This plan considers the diversity, distribution, and general condition of the inventoried trees, but also provides a prioritized system for managing public trees. The following tasks were completed:

- Inventory of trees, stumps, and planting sites along the street ROW and within public parks.
- Analysis of tree inventory data.
- Development of a plan that prioritizes the recommended tree maintenance.

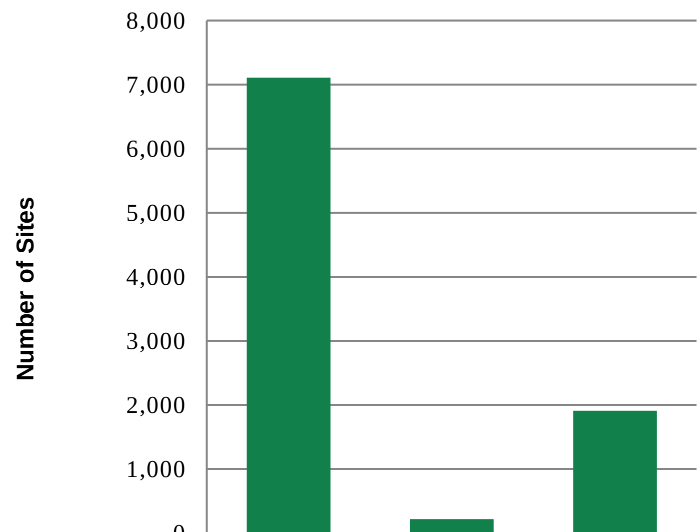
This plan is divided into five sections:

- *Section 1: Tree Inventory Analysis* summarizes the tree inventory data and presents trends, results, and observations.
- *Section 2: Benefits of the Urban Forest* summarizes the economic, environmental, and social benefits that trees provide to the community. This section presents statistics of an i-Tree Streets benefits analysis conducted for Watertown.
- *Section 3: Tree Management Program* utilizes the inventory data to develop a prioritized maintenance schedule and projected budget for the recommended tree maintenance over a five-year period.
- *Section 4: Storm Response and Recovery* introduces what a storm response and recovery plan is and the steps to take to begin to implement such a plan.
- *Section 5: Emerald Ash Borer Strategy* provides different management strategies for dealing with EAB.

SECTION 1: TREE INVENTORY ANALYSIS

In August 2017 and June 2018, DRG arborists certified by the International Society of Arboriculture, assessed and inventoried trees, stumps, and planting sites along the street ROW, specified parks, and public facilities. A total of 9,239 sites were collected during the inventory: 7,108 trees, 219 stumps, and 1,912 planting sites. Of the 9,239 sites collected, 60% were collected along the street ROW, and the remaining 40% were collected in parks and other public areas. Figure 1 provides a detailed breakdown of the number and type of sites inventoried.

The city's public street rights-of-way and parks were selected by Watertown for the inventory. The parks and public areas selected for the inventory include: Academy Street Playground, Adams Park, Bicentennial Park, City Hall, Clinton Park, Cosgrove Park, Court Street Corner Lot, Emerson Place Playground, Factory Square Park, Fairgrounds, Gair Park, Hamilton Street Playground, Jefferson Street Playground, Kostyk Field, Lansingdorp Park, Marble Street Park, New York Ave Playground, Portage Street Playground, Public Square Park, Roswell P. Flower Memorial Library, Sewage Treatment Plant, Straus Memorial Walkway, Taylor Playground, Thompson Park, Thompson Park Zoo, Thompson Street Playground, Veterans Memorial Riverwalk, Waterworks Park, and Wight Drive & Temple Street Park.



	Trees	Stumps	Vacant Sites
Number of Sites	7,108	219	1,912

Figure 1. Sites collected during the 2017–18 inventory.

Assessment of Tree Inventory Data

Photograph 2. *Davey's ISA* Certified Arborists inventoried trees along street ROW and in community parks to collect information about trees that could be used to assess the state of the urban forest.

Data analysis and professional judgment are used to make generalizations about the state of the inventoried tree population. Recognizing trends in the data can help guide short-term and long-term management planning. See Appendix A for more information on data collection and site location methods. In this plan, the following criteria and indicators of the inventoried tree population were assessed:

- *Species Diversity*, the variety of species in a specific population, affects the population's ability to withstand threats from invasive pests and diseases. Species diversity also impacts tree maintenance needs and costs, tree planting goals, and canopy continuity.
- *Diameter Size Class Distribution Data*, the statistical distribution of a given tree population's trunk-size class, is used to indicate the relative age of a tree population. The diameter size class distribution affects the valuation of tree-related benefits as well as the projection of maintenance needs and costs, planting goals, and canopy continuity.
- *Condition*, the general health of a tree population, indicates how well trees are performing given their site-specific conditions. General health affects both short-term and long-term maintenance needs and costs as well as canopy continuity.
- *Stocking Level* is the proportion of existing street trees compared to the total number of potential street trees (number of inventoried trees plus the number of potential planting spaces); stocking level can help determine tree planting needs and budgets.
- *Other Observations* include inventory data analysis that provides insight into past maintenance practices and growing conditions; such observations may affect future management decisions.
- *Further Inspection* indicates whether a particular tree requires additional inspection, such as a Level III risk inspection in accordance with ANSI A300, Part 9 (ANSI 2011), or periodic inspection due to particular conditions that may cause the tree to be a safety risk and, therefore, hazardous.

Species Diversity

Species diversity affects maintenance costs, planting goals, canopy continuity, and the forestry program's ability to respond to threats from invasive pests or diseases. Low species diversity (large number of trees of the same species) can lead to severe losses in the event of species-specific epidemics such as the devastating results of Dutch elm disease (*Ophiostoma novo-ulmi*) throughout New England and the Midwest. Due to the spread of Dutch elm disease in the 1930s, combined with the disease's prevalence today, massive numbers of *Ulmus americana* (American elm), a popular street tree in Midwestern cities and towns, have perished (Karnosky 1979). Several Midwestern communities were stripped of most of their mature shade trees, creating a drastic void in canopy cover. Many of these communities have replanted to replace the lost elm trees. Ash and maple trees were popular replacements for American elm in the wake of Dutch elm disease. Unfortunately, some of the replacement species for American elm trees are now overabundant, which is a biodiversity concern. EAB and Asian longhorned beetle (ALB, *Anoplophora glabripennis*) are non-native insect pests that attack some of the most prevalent urban shade trees and certain agricultural trees throughout the country.

The composition of a tree population should follow the 10-20-30 Rule for species diversity: a single species should represent no more than 10% of the urban forest, a single genus no more than 20%, and a single family no more than 30%.

Findings

Analysis of Watertown's tree inventory data indicated that the urban tree population had relatively good diversity, with 58 genera and 134 species represented.

Figure 2 uses the 10% Rule to compare the percentages of the most common species identified during the inventory. *Acer saccharnum* (sugar maple) is approaching the 10% threshold.

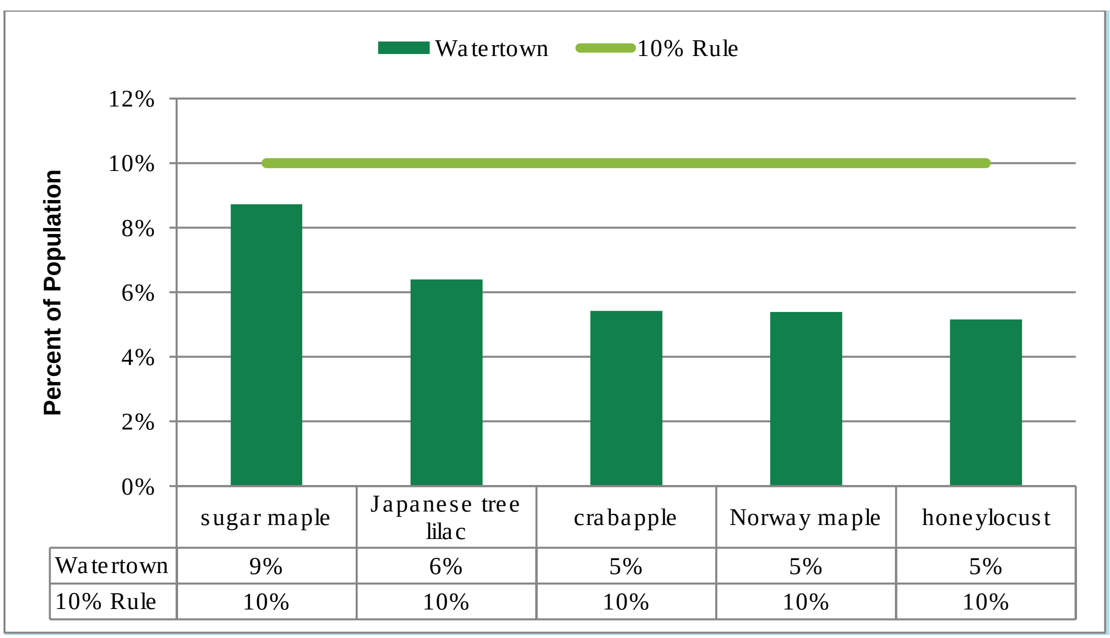
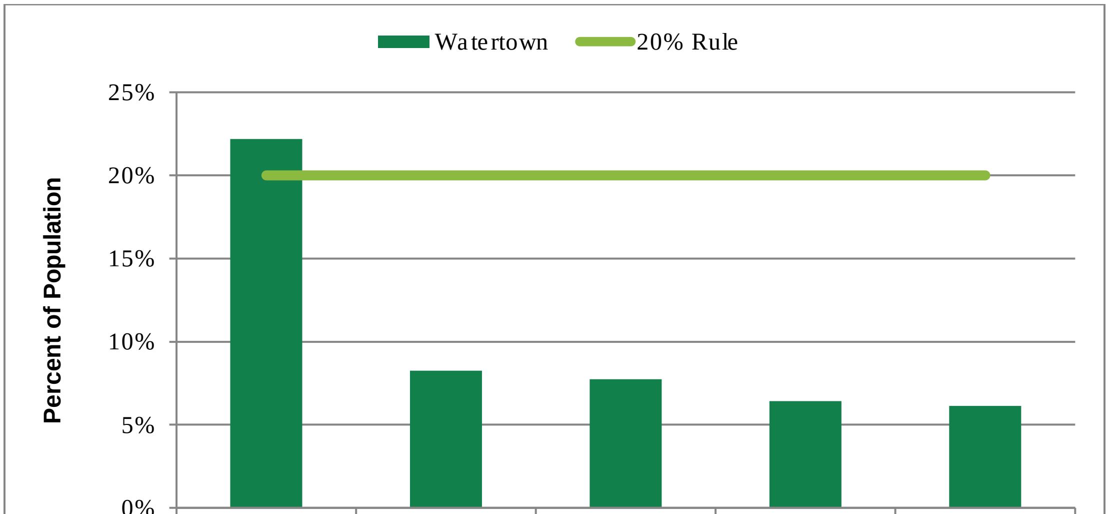


Figure 2. Five most abundant species of the inventoried population compared to the 10% Rule.

Figure 3 uses the 20% Rule to compare the percentages of the most common genera identified during the inventory. *Acer* (maple) exceeds the recommended 20% maximum for a single genus in a population, comprising 22% of the inventoried tree population.



	maple	pear	lilac	apple	ash
Watertown	22%	8%	8%	6%	6%
20% Rule	20%	20%	20%	20%	20%

Figure 3. Five most abundant genera of the inventoried population compared to the 20% Rule.

Discussion/Recommendations

Acer saccharnum (sugar maple) dominates the streets and parks. This is a biodiversity concern because its abundance in the landscape makes it a limiting species. Continued diversity of tree species is an important objective that will ensure Watertown's urban forest is sustainable and resilient to future invasive pest infestations.

Considering the large quantity of *Acer* (maple) in the city's population, along with its susceptibility to Asian longhorned beetle (ALB, *Anoplophora glabripennis*), the planting of *Acer* (maple) should be limited to minimize the potential for loss in the event that ALB threatens Watertown's urban tree population. See Appendix C for a recommended tree species list for planting.

Diameter Size Class Distribution

Analyzing the diameter size class distribution provides an estimate of the relative age of a tree population and offers insight into maintenance practices and needs.

The inventoried trees were categorized into the following diameter size classes: young trees (0–8 inches DBH), established (9–17 inches DBH), maturing (18–24 inches DBH), and mature trees (greater than 24 inches DBH). These categories were chosen so that the population could be analyzed according to Richards' ideal distribution (1983). Richards proposed an ideal diameter size class distribution for street trees based on observations of well-adapted trees in Syracuse, New York. Richards' ideal distribution suggests that the largest fraction of trees (approximately 40% of the population) should be young (less than 8 inches DBH), while a smaller fraction (approximately 10%) should be in the large-diameter size class (greater than 24 inches DBH). A tree population with an ideal distribution would have an abundance of newly planted and young trees, and lower numbers of established, maturing, and mature trees.

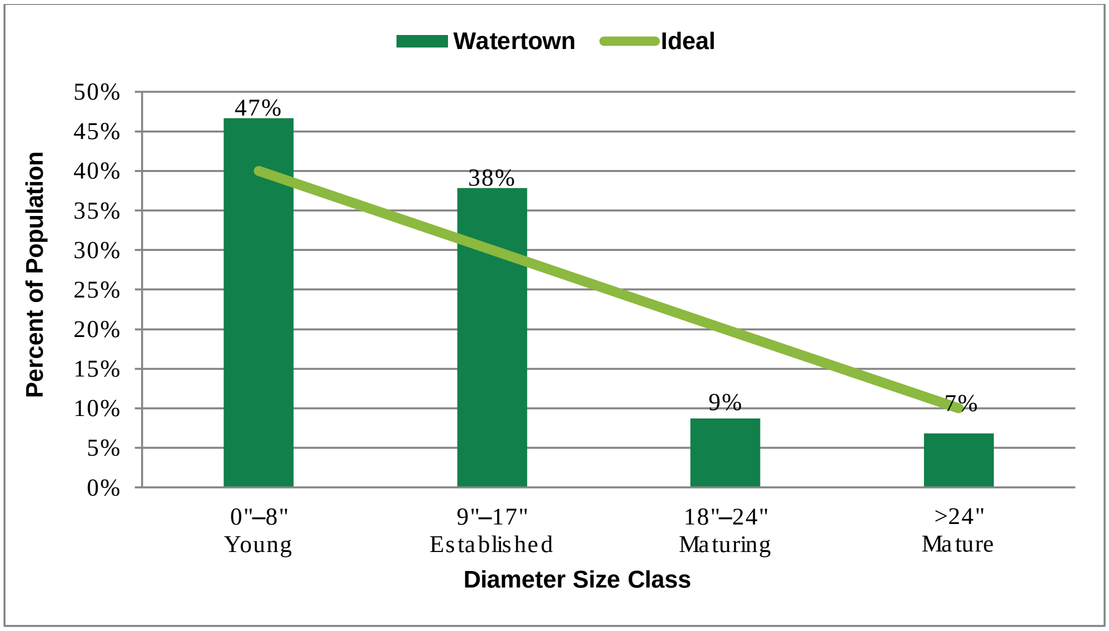


Figure 4. Comparison of diameter size class distribution for inventoried trees to the ideal distribution.

Findings

Figure 4 compares Watertown's diameter size class distribution of the inventoried tree population to the ideal proposed by Richards (1983). Watertown's distribution trends towards the ideal; young trees exceed the ideal by over 7%, while larger diameter size classes fall short of the ideal.

Discussion/Recommendations

Even though it may appear that Watertown may have too many young trees, this is not the case. Actually, Watertown has too few maturing, and mature trees, which indicates that the distribution is skewed. One of Watertown's objectives is to have an uneven-aged distribution of trees at the street, park, and citywide levels. DRG recommends that Watertown support a strong planting and maintenance program to ensure that young, healthy trees are in place to fill in gaps in tree canopy and replace older declining trees. The city must promote tree preservation and proactive tree care to ensure the long-term survival of older trees. See Appendix B for more information on risk assessment and priority maintenance. Additionally, tree planting and tree care will allow the distribution to normalize over time. See Appendix C for a recommended tree species list for planting. See Appendix D for planting suggestions and information on species selection.

Planting trees is necessary to increase canopy cover and replace trees lost to natural mortality (expected to be 1%–3% per year) and other threats (for example, invasive pests or impacts from weather events such as storms, wind, ice, snow, flooding, and drought). Planning for the replacement of existing trees and identifying the best places to create new canopy is critical.

Condition

DRG assessed the condition of individual trees based on methods defined by the International Society of Arboriculture (ISA). Several factors were considered for each tree, including: root characteristics, branch structure, trunk, canopy, foliage condition, and the presence of pests. The condition of each inventoried tree was rated Excellent, Very Good, Good, Fair, Poor, Critical, or Dead.

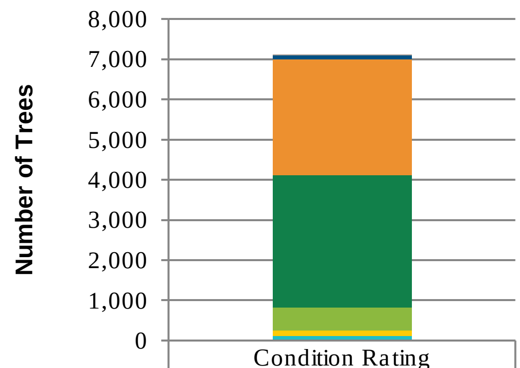
In this plan, the general health of the inventoried tree population was characterized by the most prevalent condition assigned during the inventory.

Comparing the condition of the inventoried tree population with relative tree age (or size class distribution) can provide insight into the stability of the population. Since tree species have different lifespans and mature at different diameters, heights, and crown spreads, actual tree age cannot be determined from diameter size class alone. However, general classifications of size can be extrapolated into relative age classes. The following categories are used to describe the relative age of a tree: young (0–8 inches DBH), established (9–17 inches DBH), maturing (18–24 inches DBH), and mature (greater than 24 inches DBH).

Figures 5 and 6 illustrate the general health and distribution of young, established, mature, and maturing trees relative to their condition.

Findings

Most of the inventoried trees were recorded to be in Good or Fair condition, 40% and 46%, respectively (Figure 5). Based on these data, the general health of the overall inventoried tree population is rated Fair. Figure 6 illustrates that most of the established, maturing, and mature trees were rated to be in Fair condition, and that most of the young trees were rated to be in Good condition.



	Condition Rating
Excellent	3
Very Good	113
Good	2,871
Fair	3,303
Poor	567
Critical	136
Dead	115

Figure 5. Conditions of inventoried trees.

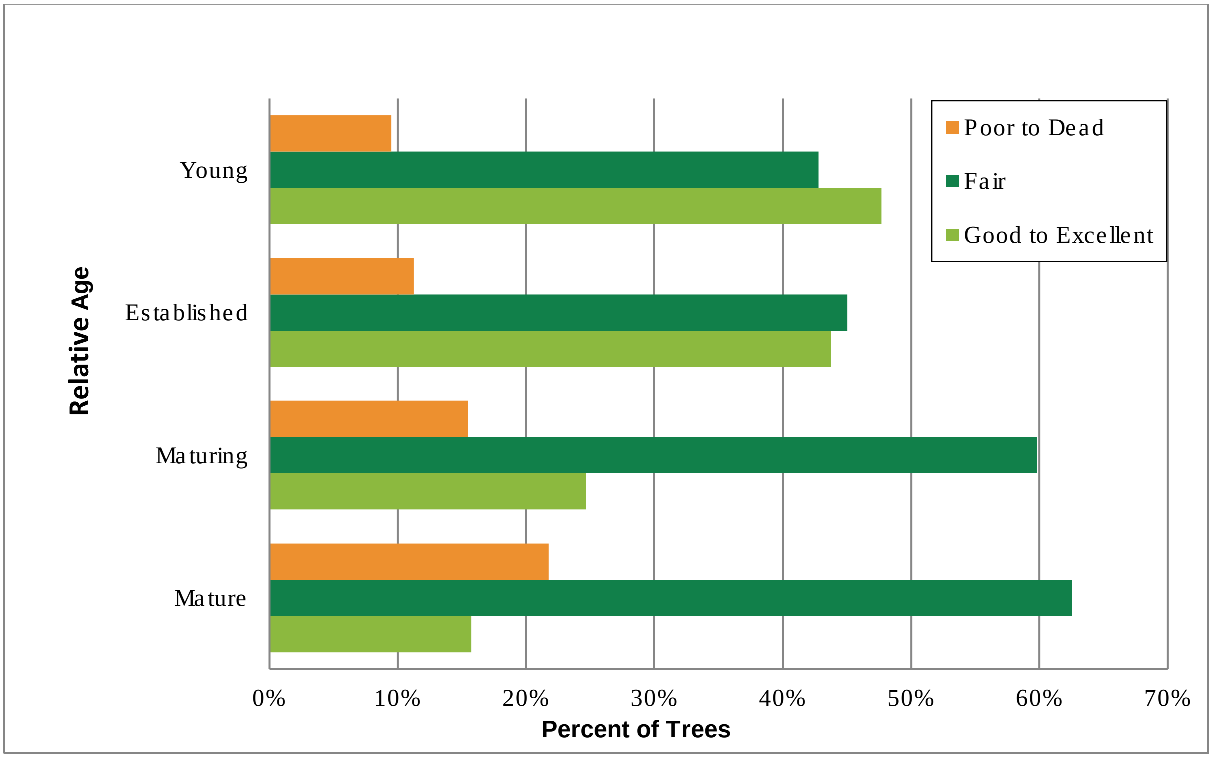


Figure 6. Tree condition by relative age during the 2017–18 inventory.

Discussion/Recommendations

Even though the condition of Watertown's inventoried tree population is typical, data analysis has provided the following insight into maintenance needs and historical maintenance practices:

- The similar trend in condition by relative age across urban tree population reveals that growing conditions and/or past management of trees were consistent.
- Dead trees and trees in Critical condition should be removed because of their failed health; these trees will likely not recover, even with increased care.
- Younger trees rated in Fair or Poor condition may benefit from improvements in structure that may improve their health over time. Pruning should follow *ANSI A300 (Part 1)* (ANSI 2008).
- 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. These trees will require corrective pruning, regular inspections, and possible intensive plant health care to improve their vigor.
- Proper tree care practices are needed for the long-term general health of the urban forest. Many of the newly planted trees were improperly mulched or had staking hardware attached to them long after they should have been removed. Following guidelines developed by ISA and those recommended by *ANSI A300 (Part 6)* (ANSI 2012) will ensure that tree maintenance practices ultimately improve the health of the urban forest.

Street ROW Stocking Level

Stocking is a traditional forestry term used to measure the density and distribution of trees. For an urban/community forest such as Watertown's, stocking level is used to estimate the total number of sites along the street ROW that could contain trees. Park trees and public property trees are excluded from this measurement.

Stocking level is the ratio of street ROW spaces occupied by trees to the total street ROW spaces suitable for trees. For example, a street ROW tree inventory of 1,000 total sites with 750 existing trees and 250 planting sites would have a stocking level of 75%.

For an urban area, DRG recommends that the street ROW stocking level be at least 90% so that no more than 10% of the potential planting sites along the street ROW are vacant.

Street ROW stocking levels may be estimated using information about the community, tree inventory data, and common street tree planting practices. Inventory data that contain the number of existing trees and planting sites along the street ROW will increase the accuracy of the projection. However, street ROW stocking levels can be estimated using only the number of trees present and the number of street miles in the community.

To estimate stocking level based on total street ROW miles and the number of existing trees, it is assumed that any given street ROW should have room for 1 tree for every 50 feet along each side of the street. For example, 10 linear miles of street ROW with spaces for trees to grow at 50-foot intervals along each side of the street account for a potential 2,110 trees. If the inventory found that 1,055 trees were present, the stocking level would be 50%.

The potential stocking level for a community with 10 street miles is as follows:

5,280 feet/mile ÷ 50 feet = 106 trees/mile

106 trees/mile × 2 sides of the street = 212 trees/mile

211 trees per street mile × 10 miles = 2,110 potential sites for trees

1,055 inventoried trees ÷ 2,110 potential sites for trees = 50% stocked

When the estimated stocking level is determined using theoretical assumptions, the actual number of planting sites may be significantly less than estimated due to unknown growing space constraints, including inadequate growing space size, proximity of private trees, and utility conflicts.

Watertown's inventory data set included planting sites. Since the data included vacant planting sites, the stocking level can be more accurately projected and compared to the theoretical stocking level.

Findings

The inventory found 1,893 planting sites. Of the inventoried sites, 530 were potential planting sites for large-size trees (8-foot-wide and greater growing space size); 1,314 were potential sites for medium-size trees (5- to 7-foot-wide growing space sizes); and 49 were potential sites for small-size trees (4- to 5 foot-wide growing space sizes, or under overhead utilities). Based on the data collected during this inventory, Watertown's current street ROW tree stocking level is 74 %.

Discussion/Recommendation

Fully stocking the street ROW with trees is an excellent goal. Inadequate tree planting and maintenance budgets, along with tree mortality, will result in lower stocking levels. Nevertheless, working to attain a fully stocked street ROW is important to promote canopy continuity and environmental sustainability. The city should consider improving its street ROW population's stocking level of 74% and work towards achieving the ideal of 90% or better. Generally, this entails a planned program of planting, care, and maintenance for the city's street trees.

The city of Watertown estimates that it plants up to 140 trees per year. At that rate, and with a current total of 1,893 planting sites along the street ROW, it would take approximately 12 years for the city to reach the recommended stocking level of 90%. If budgets allow, DRG recommends that Watertown increase the number of trees planted to 230 a year. If possible, exceed this recommendation to better prepare for impending threats and to increase the benefits provided by the urban forest.

Calculations of trees per capita are important in determining the density of a city's urban forest. The more residents and greater housing density a city possesses, the greater the need for trees to provide benefits.

Watertown's ratio of street trees per capita is 0.2, which falls slightly below the mean ratio of 0.37 reported for 22 U.S. cities (McPherson and Rowntree 1989). According to the citywide study, there is 1 tree for every 5 residents. Watertown's potential is 1 tree for every 4 residents.

Other Observations

Observations were recorded during the inventory to further describe a tree's health, structure, or location when more detail was needed.

Findings

Remove hardware, signs of stress, and mechanical damage were most frequently observations recorded (13%, 11% and 9% of inventoried trees, respectively). Of these 2,320 trees, 24 were recommended for removal (13 having mechanical damage), and 2 were rated to be Moderate Risk trees.

Nutrient deficiency was recorded for 29 trees. The primary species of concern is *Acer rubrum* (red maple); yellowing foliage was observed, indicating chlorosis.

Table 1. Observations Recorded During the Tree Inventory

Observation	Number of Trees	Percent
Cavity or Decay	575	8.09%
Poor Structure	504	7.09%
Poor Location	39	0.55%
Serious Decline	169	2.38%
Improperly Pruned	530	7.46%
Pest Problem	117	1.65%
Mechanical Damage	610	8.58%
Grate or Guard	4	0.06%
Poor Root System	255	3.59%
Remove Hardware	950	13.37%
Memorial Tree	5	0.07%
Improperly Installed	9	0.13%
Nutrient Deficiency	29	0.41%
Signs of Stress	760	10.69%
Improperly Mulched	52	0.73%
None	2,500	35.17%
Total	**7,108**	**100%**

Photographs 3 and 4. These trees located in Thompson Park have recent mechanical damage from mowers.

Discussion/Recommendations

Unless slated for removal, trees noted as having poor structure (504 trees) or cavity or decay (575 trees) should be regularly inspected. Corrective actions should be taken when warranted. If their condition worsens, removal may be required. Of the 575 trees noted for cavity or decay, 139 were recommended for removal. Of the 504 trees noted for poor structure, only 8 were recommended for removal.

Staking should only be installed when necessary to keep trees from leaning (windy sites) or to prevent damage from pedestrians and/or vandals. Stakes should only be attached to trees with a loose, flexible material. Installed hardware that has been attached to any tree for more than one year, and hardware that may no longer be needed for its intended purposes, should be inspected and removed as appropriate.

The costs for treating deficient trees must be considered to determine whether removing and replacing the tree is the more viable option.

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, and utility wires and pipes, which may pose risks to public health and safety. Existing or possible conflicts between trees and infrastructure recorded during the inventory include:

- *Clearance Requirements*—The inventory recorded secondary maintenance needs. Two of the options noted if tree need to be raised or reduced. This could be due to the tree blocking the visibility of traffic signs or signals, streetlights, or other safety devices. This information should be used to schedule pruning activities.
- *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.
- *Hardscape Damage*—Trees can adversely impact hardscape, which affects tree root and trunk systems. The inventory recorded damage related to trees, causing curbs, sidewalks, and other hardscape features to lift. These data should be used to schedule pruning and plan repairs to damaged infrastructure. To limit hardscape damage caused by trees, trees should only be planted in growing spaces where adequate above ground and below ground space is provided.

Findings

There were 817 trees recorded with some type of clearance issue. Most of those (78%) were related to conflicts with vehicles or pedestrians. When the bottom of a tree's canopy over the road was less than 14 feet or rubbing from vehicles was noted, this clearance (raise) was recorded.

There were 2011 trees with utilities directly above, or passing through, the tree canopy. Of those trees, 28% were large- or medium-size trees.

Hardscape damage was minimal: only 5% of the tree population raised sidewalk slabs or curbs.

Table 2. Trees Noted to be Conflicting with or nearby Infrastructure

Conflict	Presence/Need	Number of Trees	Percent
Clearance Prune	Reduce	178	2.50%
	Raise	639	8.99%
	Thin, restoration, or none	6291	88.51%
Overhead Utilities	Phone/cable service drop	174	2.45%
	Electric service drop	280	3.94%
	Single phase powerlines	691	9.72%
	Secondary distribution line	367	5.16%
	Three phase powerlines	499	7.02%
	None	5,097	71.71%
Hardscape Damage	Yes (0.75" or greater)	368	5.18%
	None (less than 0.75")	6,740	94.82%
Total		**7,108**	**100%**

Discussion/Recommendations

Tree canopy should not interfere with vehicular or pedestrian traffic, nor should it rest on buildings or block signs, signals, or lights. Pruning to avoid clearance issues and raise tree crowns should be completed in accordance with *ANSI A300 (Part 9)* (2011). DRG's clearance distance guidelines are as follows: 14 feet over streets; 8 feet over sidewalks; and 5 feet from buildings, signs, signals, or lights.

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.

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.

Secondary maintenance needs were identified during the inventory and relate to managing trees for infrastructure compatibility. Of the 7,108 trees recorded during the inventory, 639 (9%) should be raised and 178 (2.5%) should be reduced. Completing these secondary maintenance recommendations will reduce conflicts with Watertown's infrastructure and citizens.

Growing Space

Information about the type and size of the growing space was recorded. Growing space size was recorded as the minimum width of the growing space needed for root development. Growing space types are categorized as follows:

- Island—surrounded by pavement or hardscape (for example, parking lot divider)
- Median—located between opposing lanes of traffic
- Open/Restricted—open sites with restricted growing space on two or three sides
- Open/Unrestricted—open sites with unrestricted growing space on at least three sides
- Tree Lawn/Parkway—located between the street curb and the public sidewalk
- Natural Area—located in areas that do not appear to be regularly maintained
- Well/Pit—at grade level and completely surrounded by sidewalk

Findings

Forty percent of the tree population is located in tree lawns, with the greatest percentage (62%) being in 6+ foot tree lawns. Most of planting sites are between tree lawns (74%) or in open/unrestricted areas (20%).

Discussion/Recommendations

To prolong the useful life of street trees, small-growing tree species should be planted in tree lawns 4–5 feet wide, medium-size tree species in tree lawns 5–7 feet wide, and large-growing tree species in tree lawns at least 8 feet wide. 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.

Further Inspection

This data field indicates whether a particular tree requires further inspection, such as a Level III risk inspection in accordance with ANSI A300, Part 9 (ANSI, 2011), or periodic inspection due to particular conditions that may cause it to be a safety risk and, therefore, hazardous. If a tree was noted for further inspection, city staff should investigate as soon as possible to determine corrective actions.

Photograph 5 and 6. These Fraxinus americanas (white ash) in Thompson park and zoo have been marked for removal due to their condition. Other ashes in the area have been marked for further inspection due to dieback and possible emerald ash borer (EAB). Observations from the ground for the larger ash trees were inconclusive, and an aerial lift may be required.

Findings

DRG recommended 138 trees for further inspection.

Discussion/Recommendations

An ISA Certified Arborist should perform additional inspections of the trees. If it is determined that these trees exceed the threshold for acceptable risk, the defective part(s) of the trees should be corrected or removed, or the entire tree may need to be removed.

The 17 inventoried ash trees that showed possible symptoms of EAB should be monitored. If signs of EAB manifest, the tree should be removed and the site should be inspected for potential replacement.

Potential Threats from Pests

Insects and diseases pose serious threats to tree health. Awareness and early diagnosis are essential to ensuring the health and continuity of street and park trees. Appendix E provides information about some of the current potential threats to Watertown's trees and includes websites where more detailed information can be found.

Many pests target a single species or an entire genus. The inventory data were analyzed to provide a general estimate of the percentage of trees susceptible to some of the known pests in New York. (see Figure 7). It is important to note that the figure only presents data collected from the inventory. Many more trees throughout Watertown, including those on public and private property, may be susceptible to these invasive pests.

Findings

Granulate ambrosia beetle (*Xylosandrus crassiusculus*) and gypsy moth (*Lymantria dispar dispar*) are known threats to a large percentage of the inventoried street trees (39% and 24%, respectively). Granulate ambrosia beetle was not detected in Watertown, but if was detected the city could see severe losses in its tree population. Gypsy moth was detected and should be monitored.

There were 435 ash trees inventoried along Watertown's street ROW, but only 17 showed potential symptoms of emerald ash borer. Private trees that were not part of the inventory may be a future concern as well.

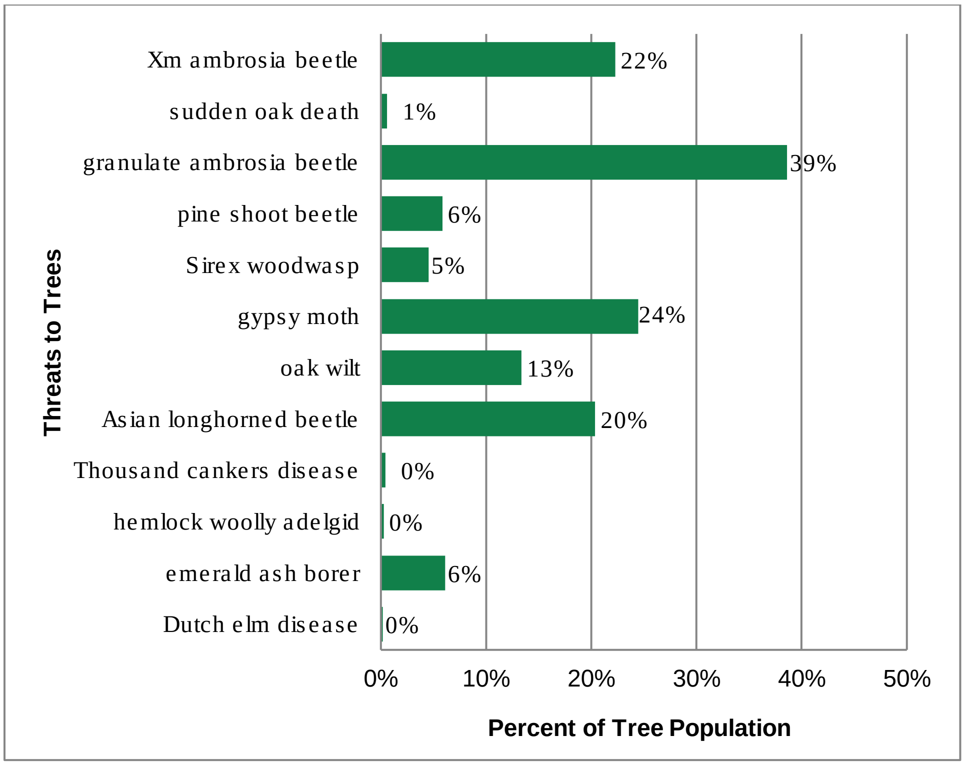


Figure 7. Potential impact of insect and disease threats noted during the 2017–18 inventory.

Discussion/Recommendations

Watertown should be aware of the signs and symptoms of potential infestations and should be prepared to act if a significant threat is observed in its tree population or a nearby community. An integrated pest management plan should be established. The plan should focus on identifying and monitoring threats, understanding the economic threshold, selecting the correct treatment, properly timing management strategies, recordkeeping, and evaluating results. DRG's recommendations for managing the ash tree population and mitigating EAB will be discussed in detail in Section 4.

SECTION 2: BENEFITS OF THE URBAN FOREST

The urban forest plays an important role in supporting and improving the quality of life in urban areas. A tree's shade and beauty contribute to a community's quality of life and soften the often hard appearance of urban landscapes and streetscapes. When properly maintained, trees provide communities abundant environmental, economic, and social benefits that far exceed the time and money invested in planting, pruning, protection, and removal.

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).
- When surrounded by trees, physical signs of personal stress, such as muscle tension and pulse rate, were measurably reduced within three to four minutes (Ulrich 1991).

The trees growing along the public streets constitute a valuable community resource. They provide numerous tangible and intangible benefits such as pollution control, energy reduction, stormwater management, property value increases, wildlife habitat, education, and aesthetics.

The services and benefits of trees in the urban and suburban setting were once considered to be unquantifiable. However, by using extensive scientific studies and practical research, these benefits can now be confidently calculated using tree inventory information. The results of applying a proven, defensible model and method that determines tree benefit values for the City of Watertowns's tree inventory data are summarized in this report using the i-Tree's Streets application. The results of Watertown's tree inventory provide insight into the overall health of the city's public trees and the management activities needed to maintain and increase the benefits of trees into the future.

Photograph 7. Trees provide significant aesthetic value to the community. Additionally, the tangible services of trees provide quantifiable benefits that justify the time and money invested in planting and maintenance.

Tree Benefit Analysis

i-Tree Streets

In order to identify the dollar value provided and returned to the community, the city's street tree inventory data were formatted for use in the i-Tree Streets benefit-cost assessment tool.

i-Tree Streets, a component of i-Tree Tools, analyzes an inventoried tree population's structure to estimate the costs and benefits of that tree population. The assessment tool creates an annual benefit report that demonstrates the value street trees provide to a community:

These quantified benefits and the reports generated are described below.

- **Aesthetic/Other Benefits:** Shows the tangible and intangible benefits of trees reflected by increases in property values (in dollars).
- **Stormwater:** Presents reductions in annual stormwater runoff due to rainfall interception by trees measured in gallons.
- **Carbon Stored:** Tallies all of the carbon dioxide (CO_2) stored in the urban forest over the life of its trees as a result of sequestration. Carbon stored is measured in pounds and has been translated to tons for this report.
- **Energy:** Presents the contribution of the urban forest towards conserving energy in terms of reduced natural gas use in the winter (measured in therms [thm]) and reduced electricity use for air conditioning in the summer (measured in Megawatt-hours ([MWh]).

- **Carbon Sequestered:** Presents annual reductions in atmospheric CO_2 due to sequestration by trees and reduced emissions from power plants due to reductions in energy use. This is measured pounds and has been translated to tons for this report. The model accounts for CO_2 released as trees die and decompose and CO_2 released during the care and maintenance of trees.
- **Air Quality:** Quantifies the air pollutants (ozone [O_3], nitrogen dioxide [NO_2], sulfur dioxide [SO_2], particulate matter less than 10 micrometers in diameter [PM_{10}]) deposited on tree surfaces, and reduced emissions from power plants (NO_2, PM_{10}, volatile organic compounds [VOCs], SO_2) due to reduced electricity use in pounds. The potential negative effects of trees on air quality due to biogenic volatile organic compounds (BVOC) emissions is also reported.
- **Importance Value (IV):** IVs are calculated for species that comprise more than 1% of the population. The Streets IV is the mean of three relative values (percentage of total trees, percentage of total leaf area, and percentage of canopy cover) and can range from 0 to 100, with an IV of 100 suggesting total reliance on one species. IVs offer valuable information about a community's reliance on certain species to provide functional benefits. For example, a species might represent 10% of a population but have an IV of 25% due to its substantial benefits, indicating that the loss of those trees would be more significant than just their population percentage would suggest.

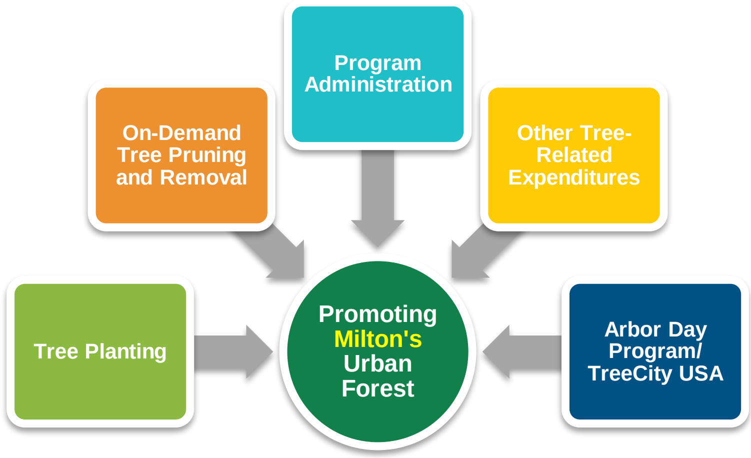
i-Tree Tools

i-Tree

i-Tree Tools software was developed by the U.S. Department of Agriculture, Forest Service (USDA FS) with the help of several industry partners, including The Davey Tree Expert Company. Learn more at www.itreetools.org.

THE BENEFITS OF WATERTOWN'S URBAN FOREST

i-Tree Streets Inputs



In addition to tree inventory data, i-Tree Streets requires cost-specific information to manage a community's tree management program—including administrative costs and costs for tree pruning, removal, and planting. Regional data, including energy prices, property values, and stormwater costs, are required inputs to generate the environmental and economic benefits trees provide. If community program costs or local economic data are not available, i-Tree Streets uses default economic inputs from a reference city selected by USDA FS for the climate zone in which your community is located. Any default value can be adjusted for local conditions.

Watertown's Inputs

Local data were available at the time of this plan and were used to the greatest extent possible with i-Tree Streets to calculate the benefits Watertown's trees provide its citizens.

Annual Benefits

i-Tree Tools

A common example of a natural BVOC is the gas emitted from pine trees, which creates the distinct smell of a pine forest.

The i-Tree Streets model estimated that the inventoried street trees provide a total annual benefit of $715,342. Essentially, $715,342 was saved to cool buildings, manage stormwater, and clean the air. In addition, community aesthetics were improved and property values increased because of the presence of trees. On average, one of Watertown's trees provides an annual benefit of $100.64.

The assessment found that energy conservation benefits trees provide were the greatest value to the community. Approximately 42% of the total annual benefits were due to energy conservation. Aesthetics and other tangible and intangible benefits also provide a great value to the community, at 40% of the total annual benefits. In addition to increasing property values, trees also play a major role in stormwater management. The city's street trees alone intercepted over 8.6 million gallons of rainfall, which equates to a savings of $68,961 in stormwater management costs. Stormwater management comprises 10% of the annual benefits street trees provide. Air quality benefits and reductions in CO_2 are important but account for lesser amounts of work performed by community trees. Air quality benefits accounted for 7% of the annual benefits, while CO_2 reductions accounted for 1% of the annual benefits.

Figure 8 summarizes the annual benefits and results for the street tree population. Table 3 presents results for individual tree species from the i-Tree Streets analysis.

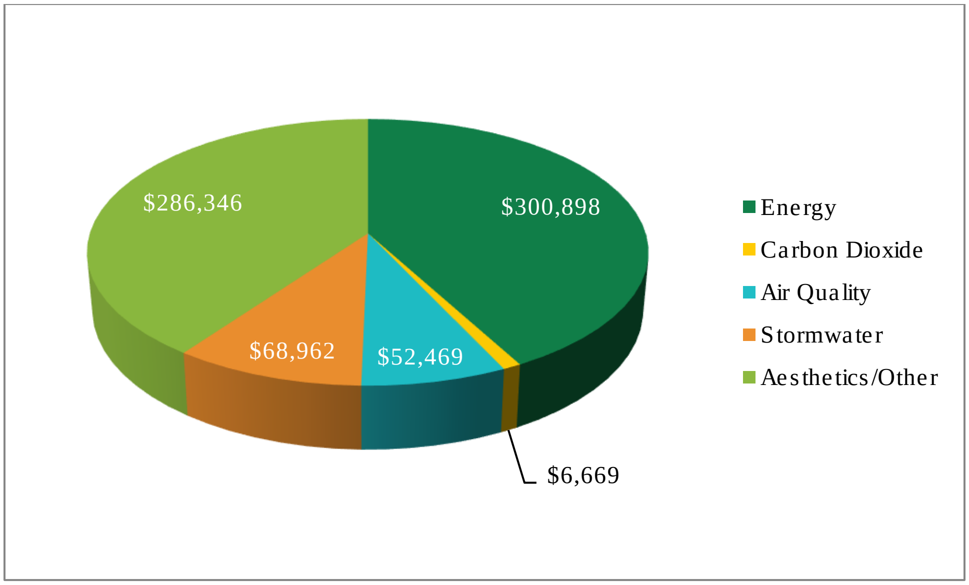


Figure 8. Breakdown of total annual benefits provided to Watertown.

Table 3. Benefit Data for Common Street Trees by Species

Most Common Trees Collected During Inventory		Number Trees on the ROW	Percent of Total Trees	Benefit Provide By Street Trees						Importance Value (IV)
				Aesthetic/ Other	Stormwater	Carbon Dioxide Stored	Energy	Carbon Sequestered	Air Quality	
Common Name	Botanical Name		(%)	Average/$/Tree						0–100 (higher IV = more important species)
sugar maple	Acer saccharum	620	8.7	60.40	19.07	27.15	69.63	1.68	11.94	14.7
Japanese tree lilac	Syringa reticulata	455	6.4	10.75	2.24	1.94	17.38	0.36	2.65	3.2
flowering crabapple	Malus spp.	386	5.4	11.49	2.74	3.13	20.61	0.45	3.18	2.9
Norway maple	Acer platanoides	383	5.4	51.68	10.97	16.01	53.45	1.62	9.63	6.0
thornless honeylocust	Gleditsia triacanthos inermis	367	5.2	59.27	8.55	4.55	46.88	0.92	7.78	5.3
northern red oak	Quercus rubra	359	5.1	45.64	14.82	17.38	63.34	1.50	10.84	7.0
Norway spruce	Picea abies	327	4.6	22.04	13.45	5.65	46.88	0.88	9.07	4.8
littleleaf linden	Tilia cordata	262	3.7	37.05	5.83	4.08	31.18	0.71	4.94	2.8
white ash	Fraxinus americana	217	3.1	44.51	9.63	3.77	49.58	0.91	8.43	3.2
green ash	Fraxinus pennsylvanica	215	3.0	46.05	10.81	4.07	56.05	1.04	9.60	3.4
callery pear	Pyrus calleryana	198	2.8	74.41	6.18	3.18	27.06	0.88	5.26	2.1
eastern white pine	Pinus strobus	196	2.8	22.78	11.16	4.11	39.44	0.75	7.55	2.5
Colorado spruce	Picea pungens	186	2.6	23.01	9.93	3.61	34.63	0.66	6.58	2.2
northern hackberry	Celtis occidentalis	173	2.4	71.31	8.26	3.90	49.47	0.93	7.67	2.3
silver maple	Acer saccharinum	166	2.3	44.51	38.24	82.67	111.06	2.49	22.56	7.0
Kentucky coffeetree	Gymnocladus dioicus	152	2.1	69.31	6.35	1.99	46.02	0.85	6.67	1.7
freeman maple	Acer x freemanii	135	1.9	42.67	12.69	12.12	54.60	1.14	9.48	2.3
other street trees	~43 other genera and ~117 other species	2,311	32.50	35.73	6.45	4.27	29.40	0.64	5.16	26.6
ROW Total	~55 genera and ~134 species on the ROW	7108	100	40.28	9.70	9.49	42.33	0.94	7.38	100

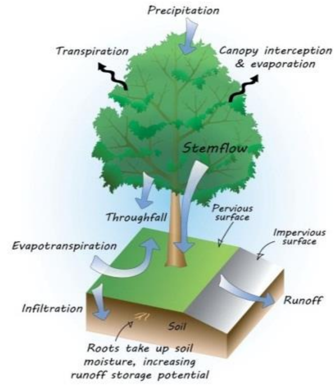
Aesthetic/Other Benefits

The total annual benefit associated with property value increases and other tangible and intangible benefits of street trees was $286,345. The average benefit per tree equaled $40.28 per year.

Stormwater Benefits

Trees intercept rainfall, which helps lower costs to manage stormwater runoff. The inventoried trees in Watertown intercept 8,620,200 gallons of rainfall annually (Table 5). On average, the estimated annual savings for the city in stormwater runoff management is $68,961.

Of all species inventoried, sugar maple contributed most of the annual stormwater benefits. The population of sugar maple (9% of ROW) intercepted approximately 1.5 million gallons (17%) of annual rainfall. On a per-tree basis, large trees with leafy canopies provided the most value. Silver maple comprised 2% of the ROW population but absorbed 793,500 gallons (9%) of annual rainfall. These large-statured trees with big canopies offered the greatest benefits.



- *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 and reduce pollutants by absorbing nutrients and other pollutants from soils and water through their roots.*
- *Trees transform pollutants into less harmful substances.*

Air Quality Improvements

The inventoried tree population annually removes 28,978 pounds of air pollutants (including ozone, nitrogen dioxide, sulfur dioxide, and particulate matter) through deposition. The population also avoids 27,181 pounds annually.

The i-Tree Streets calculation takes into account the biogenic volatile organic compounds (BVOC's) that are released from trees. The net total value of these benefits is estimated to be $52,468. The inventoried trees removed or avoided more pollutants than they emitted, resulting in a positive economic value. The trees that provided the most benefits based on an annual per-tree average value were American beech and Siberian elm ($28.61 and $25.35), respectively.

Using the annual per-tree values in Table 4, the trees that provided the most benefits based on the annual per-tree average value were *Acer saccharinum* (silver maple) and *A. saccharum* (silver maple), providing $22.56 and $11.94, respectively.

Table 4. Stormwater Benefits Provided by ROW Trees

Most Common Trees Collected During Inventory		Number of Trees on the ROW	Percent of Total Trees	Total Rainfall Interception
Common Name	Botanical Name		(%)	(gal.)
sugar maple	Acer saccharum	620	8.7	1,477,705
Japanese tree lilac	Syringa reticulata	455	6.4	127,478
flowering crabapple	Malus spp.	386	5.4	132,289
Norway maple	Acer platanoides	383	5.4	525,040
thornless honeylocust	Gleditsia triacanthos inermis	367	5.2	392,300
northern red oak	Quercus rubra	359	5.1	665,083
Norway spruce	Picea abies	327	4.6	549,758
littleleaf linden	Tilia cordata	262	3.7	190,918
white ash	Fraxinus americana	217	3.1	261,196
green ash	Fraxinus pennsylvanica	215	3	290,584
callery pear	Pyrus calleryana	198	2.8	152,939
eastern white pine	Pinus strobus	196	2.8	273,361
Colorado spruce	Picea pungens	186	2.6	230,827
northern hackberry	Celtis occidentalis	173	2.4	178,575
silver maple	Acer saccharinum	166	2.3	793,517
Kentucky coffeetree	Gymnocladus dioicus	152	2.1	120,613
freeman maple	Acer x freemanii	135	1.9	214,113
other street trees	~43 other genera and ~117 other species	2,311	32.5	2,043,904
ROW Total	~55 genera and ~134 species on the ROW	7,108	100	8,620,200

Carbon Storage and Carbon Sequestration

Trees store some of the carbon dioxide (CO_2) they absorb. This prevents CO_2 from reaching the upper atmosphere, where it can react with other compounds and form harmful gases like ozone, which adversely affects air quality. These trees also sequester some of the CO_2 during growth (Nowak et al. 2013).

Photograph 8. Trees improve quality of life and help enhance the character of a community. Trees filter air, water, and sunlight, moderate local climate, slow wind and stormwater, shade homes, and provide shelter to animals and recreational areas for people.

The i-Tree Streets calculation takes into account the carbon emissions that are *not* released from power stations due to the heating and cooling effect of trees (i.e., conserved energy in buildings and homes). It also calculates emissions released during tree care and maintenance, such as driving to the site and operating equipment. The net carbon benefit is approximately $6,669 per year.

The city's street trees store 10,218 tons of carbon (measured in CO_2 equivalents). This amount reflects the amount of carbon they have amassed during their lifetimes. Through sequestration and avoidance, 1,010 tons of CO_2 are removed each year. Silver maple provided the most carbon benefits, with each tree storing an annual average of $82.67 and sequestering $2.96 worth of carbon.

Energy Benefits

Acer saccharum **(sugar maple)**	Syringa reticulata **(Japanese tree lilac)**	Malus spp. **(flowering crabapple)**	Acer platanoides **(Norway maple)**
8.7% of ROW	**6.4% of ROW**	**5.4% of ROW**	**5.4% of ROW**
64MWh Electricity	**9MWh Electricity**	**10MWh Electricity**	**30MWh Electricity**
24,310thm Natural Gas	**4,682thm Natural Gas**	**4,688thm Natural Gas**	**11,516thm Natural Gas**
$69.63 Average $/tree	**$17.38 Average $/tree**	**$20.61 Average $/tree**	**$53.45 Average $/tree**

Public trees conserve energy by shading structures and surfaces, which reduces electricity use for air conditioning in the summer. Trees divert wind in the winter to reduce natural gas use. Based on the inventoried trees, the annual electric and natural gas savings are equivalent to 449.65 MWh of electricity and 168,965 therms of natural gas, which accounts for an annual savings of $300,898 in energy consumption.

Sugar maple contributed $69.63 per tree to the annual energy benefits of the urban forest, but its contribution was mostly due to its dominance on the streets. Other tree species, specifically silver maple, contributed more to reduce energy usage on a per-tree basis. The annual value this tree provides exceeds $111 per tree, although they comprise only 2% of the population. These large leafy canopies are valuable because they provide shade, which reduces energy usage. Smaller trees inventoried such as Japanese tree lilac and flowering crabapple were found to have smaller reductions in energy usage on a per-tree basis. Japanese tree lilac, the second most planted tree on the ROW, is valued at only $17.38 per tree.

Importance Value (IV)

Understanding the importance of a tree species to the community is based on its presence on the ROW, but also its ability to provide environmental and economic benefits to the community. The IV calculated by the street computer model takes into account the total number of trees of a species, its percentage in the population, and its total leaf area and canopy cover. The IV can range from 0 to 100, with an IV of 100 suggesting total reliance on one species. If IV values are greater or less than the percentage of a species on the ROW, it indicates that the loss of that species may be more important or less important than its population percentage implies.

The i-Tree Streets assessment found that sugar maple has the greatest IV in the ROW population at 14.7, even though it comprises only 8.7% of the ROW. This indicates that the loss of the sugar maple population would be even more economically detrimental than its percentage of the population leads us to believe. The second highest IVs were for northern red oak and silver maple (7.0) followed by Norway maple (6.0). The abundances of northern red oak (5.1%) and silver maple (2.3%) on the ROW are not as great as Japanese tree lilac (6.4%), but their IVs are greater, with Japanese tree lilac sitting at an IV of 3.21. Because they are large growing, the size and canopy of broadleaf species by nature provide more environmental benefits to the community, which all factor into assigning IV. The IV for Japanese tree lilac is much less than its percentage of the population, indicating that if Japanese tree lilac was lost, its economic impact would not be as significant.

Discussion/Recommendations

The i-Tree Streets analysis found that ROW trees provide environmental and economic benefits to the community by virtue of their mere presence on the streets. Currently, the energy benefits provided by ROW trees were rated as having the greatest value to the community. The value of trees as shade and windbreaks helps to reduce the overall energy usage by the town’s residents. The aesthetic benefit of the town’s trees was also found to make up a large amount of the tree’s value. The property value increase provided by trees is important to stimulate economic growth. In addition to decreasing energy use and increasing aesthetics and property values, trees manage stormwater through rainfall interception and store and sequester CO_2. Trees work to intercept rainfall and reduce runoff—in Watertown, as little as 7,108 ROW trees absorb over 8.6 million gallons of rainfall.

i-Tree Streets analysis found that the sugar maple is the most influential tree along Watertown's ROWs. If this species was lost to an invasive insect such as the Asian longhorned beetle or other threats, its loss would be felt more than the community may realize.

To increase the benefits the urban forest provides, the city should plant young, large-statured tree species. Leafy, large-stature trees consistently created the most environmental and economic benefits. The following list of tree species is used for improving air quality (ICLEI 2006):

- *Betula nigra* (river birch)
- *Celtis laevigata* (sugar hackberry)
- *Fagus grandifolia* (American beech)
- *Metasequoia glyptostroboides* (dawn redwood)
- *Tilia cordata* (littleleaf linden)
- *Tilia europea* (European linden)
- *Tilia tomentosa* (silver linden)
- *Ulmus americana* (American elm)
- *Ulmus procera* (English elm)

SECTION 3: TREE MANAGEMENT PROGRAM

This tree management program was developed to uphold Watertown's comprehensive vision for preserving its urban forest. This five-year program is based on the tree inventory data; the program was designed to reduce risk through prioritized tree removal and pruning, and to improve tree health and structure through proactive pruning cycles. Tree planting to mitigate removals and increase canopy cover and public outreach are important parts of the program as well.

While implementing a tree care program is an ongoing process, tree work must always be prioritized to reduce public safety risks. DRG recommends completing the work identified during the inventory based on the assigned risk rating; however, routinely monitoring the tree population is essential so that other Extreme or High Risk trees can be identified and systematically addressed. While regular pruning cycles and tree planting are important, priority work (especially for Extreme or High Risk trees) must sometimes take precedence to ensure that risk is expediently managed.

Priority and Proactive Maintenance

In this plan, the recommended tree maintenance work was divided into either priority or proactive maintenance. Priority maintenance includes tree removals and pruning of trees with an assessed risk rating of High and Extreme Risk. Proactive tree maintenance includes pruning of trees with an assessed risk of Moderate or Low Risk and trees that are young. Tree planting, inspections, and community outreach are also considered proactive maintenance.

Tree and Stump Removal

Extreme Risk
- Perform tree maintenance immediately to reduce hazards
- Includes tree removal and pruning
- Mostly high-use areas

High Risk
- Perform tree maintenance immediately to reduce hazards and improve tree health
- Includes tree removal and pruning
- Generally high-use areas

Moderate Risk
- Perform tree maintenance as soon as possible to improve tree health
- Includes tree removal and pruning
- May be high- or low-use areas

Low Risk
- Perform tree maintenance when convenient to improve aesthetics and eliminate nuisance trees and stumps
- Includes tree removals and pruning
- Mostly low-use areas but may be high-use areas as well

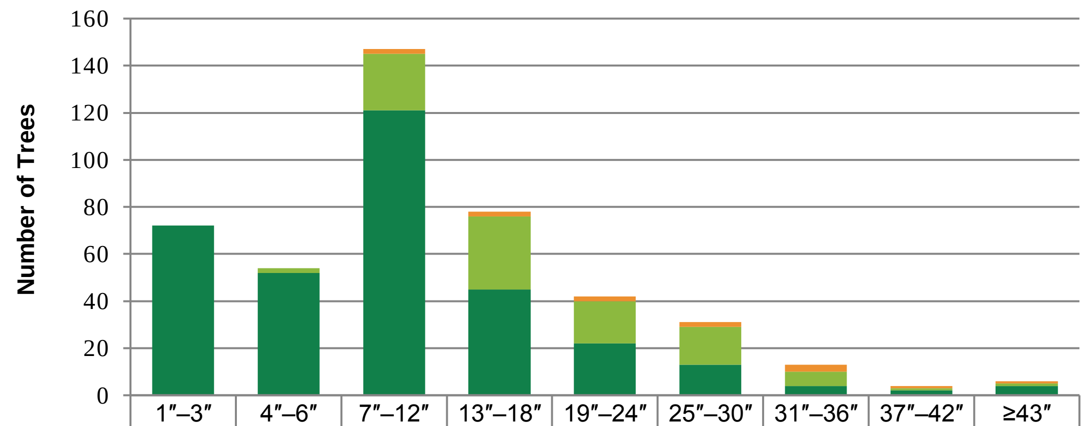
Routine Pruning
- Perform tree maintenance when convenient to improve aesthetics and eliminate nuisance trees

Training Prune
- Perform corrective pruning to young trees to increase structural integrity and develop a strong architecture of branches before serious problems develop

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. DRG recommends that trees 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. Expedient removal reduces risk and promotes public safety.

Figure 9 presents tree removals by risk rating and diameter size class. The following sections briefly summarize the recommended removals identified during the inventory.



	1″–3″	4″–6″	7″–12″	13″–18″	19″–24″	25″–30″	31″–36″	37″–42″	≥43″
Extreme	0	0	0	0	0	0	0	0	0
High	0	0	2	2	2	2	3	1	1
Moderate	0	2	24	31	18	16	6	1	1
Low	72	52	121	45	22	13	4	2	4

Diameter Size Class

Figure 9. Tree removals by risk rating and diameter size class.

Findings

The inventory identified 13 High Risk trees, 99 Moderate Risk trees, and 335 Low Risk trees that are recommended for removal.

The diameter size classes for High Risk trees ranged between 7–12 inches diameter at breast height (DBH) and ≥ 43inches DBH. These trees should be removed immediately based on their assigned risk. Extreme and High Risk removals and pruning can be performed concurrently.

Most Moderate Risk trees were smaller than 36 inches DBH. These trees should be removed as soon as possible after all High Risk removals and pruning have been completed.

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. All Low Risk trees should be removed when convenient and after all High and Moderate Risk removals and pruning have been completed.

The inventory identified 18 ash trees recommended for removal.

The inventory identified 219 stumps recommended for removal. Almost all of these stumps were larger than 4 inches in diameter. Stump removals should occur when convenient.

Discussion/Recommendations

Unless already slated for removal, trees noted as having poor structure (504 trees) or cavity or decay (575 trees) should be inspected on a regular basis. Corrective action should be taken when warranted. If their condition worsens, tree removal may be required. Proactive tree maintenance that actively mitigates elevated-risk situations will promote public safety.

Updating the tree inventory data can streamline work load management and lend insight into setting accurate budgets and staffing levels. Inventory updates should be made electronically and can be implemented using TreeKeeper 8.0 or similar computer software.

Tree Pruning

High and Moderate Risk pruning generally require cleaning the canopy of both small and large trees to remove defects such as dead and/or broken branches that may be present even when the rest of the tree is sound. In these cases, pruning the branch or branches can correct the problem and reduce risk associated with the tree.

Figure 10 presents the number of High and Moderate Risk trees recommended for pruning by size class. The following sections briefly summarize the recommended pruning maintenance identified during the inventory.

	1″–3″	4″–6"	7″– 12″	13″–18″	19″– 24″	25″–30″	31″– 36″	37″– 42″	≥43″
High	0	0	0	0	0	4	2	0	0
Moderate	0	0	15	28	39	48	16	11	14

Figure 10. Extreme and High Risk pruning by diameter size class.

Findings

The inventory identified, 6 High Risk trees, and 171 Moderate Risk trees recommended for pruning.

High Risk trees ranged in diameter size classes from 25–30 inches DBH to 31–36 inches DBH. This pruning should be performed immediately based on assigned risk and may be performed concurrently with other High Risk removals and pruning. Low Risk trees recommended for pruning should be included in a proactive, routine pruning cycle after all the higher and moderate risk trees are addressed.

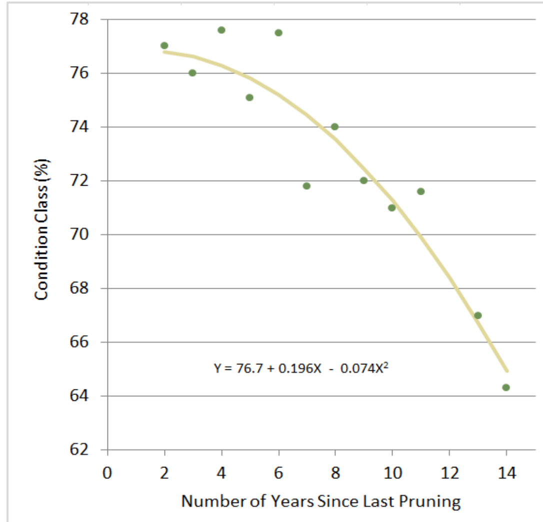


Figure 11. Relationship between average tree condition class and the number of years since the most recent pruning (adapted from Miller and Sylvester 1981).

Pruning Cycles

The goals of pruning cycles are to visit, assess, and prune trees on a regular schedule to improve health and reduce risk. DRG recommends that pruning cycles begin after all Extreme and High Risk trees are corrected through removal or pruning. However, due to the long-term benefits of pruning cycles, DRG recommends that the cycles be implemented as soon as possible. To ensure that all trees receive the type of pruning they need to mature with better structure and lower associated risk, two pruning cycles are recommended: the young tree training cycle (YTT Cycle) and the routine pruning cycle (RP Cycle). The cycles differ in the type of pruning, the general age of the target tree, and length.

The recommended number of trees in the pruning cycles will need to be modified to reflect changes in the tree population as trees are planted, age, and die. Newly planted trees will enter the YTT Cycle once they become established. As young trees reach maturity, they will be shifted from the YTT Cycle into the RP Cycle. When a tree reaches the end of its useful life, it should be removed and eliminated from the RP Cycle.

Why Prune Trees on a Cycle?

Miller and Sylvester (1981) examined the frequency of pruning for 40,000 street and boulevard trees in Milwaukee, Wisconsin. They documented a decline in tree health as the length of the pruning cycle increased. When pruning was not completed for more than 10 years, the average tree condition was rated 10% lower than when trees had been pruned within the last several years. Miller and Sylvester suggested that a pruning cycle of five years is optimal for urban trees.

For many communities, a proactive tree management program is considered unfeasible. An on-demand response to urgent situations is the norm. Research has shown that a proactive program that includes a routine pruning cycle will improve the overall health of a tree population (Miller and Sylvester 1981). Proactive tree maintenance has many advantages over on-demand maintenance, the most significant of which is reduced risk. In a proactive program, trees are regularly assessed and pruned, which helps detect and eliminate most defects before they escalate to a hazardous situation with an unacceptable level of risk. Other advantages of a proactive program include: increased environmental and economic benefits from trees, more predictable budgets and projectable workloads, and reduced long-term tree maintenance costs.

Young Tree Training Cycle

Trees included in the YTT Cycle are generally less than 8 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 risk and creating potential liability.

YTT pruning is performed to improve tree form or structure; the recommended length of a YTT Cycle is three years because young trees tend to grow at faster rates (on average) than more mature trees.

The YTT Cycle differs from the RP Cycle in that these trees generally can be pruned from the ground with a pole pruner or pruning shear. The objective is to increase structural integrity by pruning for one dominant leader. YTT Pruning is species-specific, since many trees such as *Betula nigra* (river birch) may naturally have more than one leader. For such trees, YTT pruning is performed to develop a strong structural architecture of branches so that future growth will lead to a healthy, structurally sound tree.

Recommendations

DRG recommends that Watertown implement a three-year YTT Cycle to begin after all High Risk trees are removed or pruned. The YTT Cycle will include existing young trees. During the inventory, 1,335 trees smaller than 9 inches DBH were inventoried and recommended for young tree training. Since the number of existing young trees is relatively small, and the benefit of beginning the YTT Cycle is substantial, DRG recommends that an average of 445 trees be structurally pruned each year over 3 years, beginning in Year One of the management program.

If trees are planted, they will need to enter the YTT Cycle after establishment, typically a few years after planting.

In future years, the number of trees in the YTT Cycle will be based on tree planting efforts and growth rates of young trees. The city should strive to prune approximately one-third of its young trees each year.

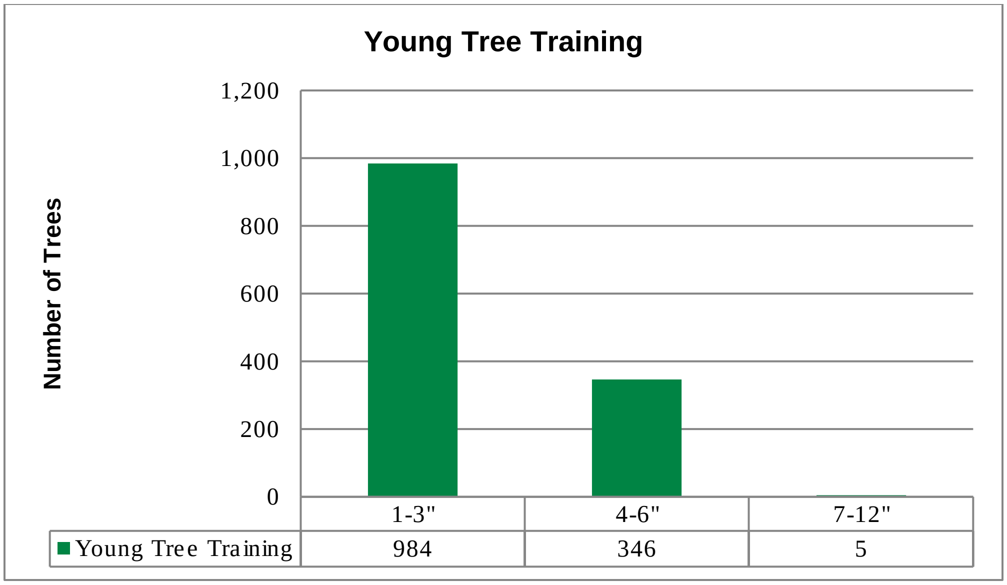


Figure 12. Trees recommended for the YTT Cycle by diameter size class.

Routine Pruning Cycle

The RP Cycle includes established, maturing, and mature trees (mostly greater than 8 inches DBH) that need cleaning, crown raising, and reducing to remove deadwood and improve structure. Over time, routine pruning can reduce reactive maintenance, minimize instances of elevated risk, and provide the basis for a more defensible risk management program. Included in this cycle are Low Risk trees that require pruning and pose some risk but have a smaller size of defect and/or less potential for target impact. The defects found within these trees can usually be remediated during the RP Cycle.

The length of the RP Cycle is based on the size of the tree population and what was assumed to be a reasonable number of trees for a program to prune per year. Generally, the RP Cycle recommended for a tree population is five years, but may extend to seven years if the population is large.

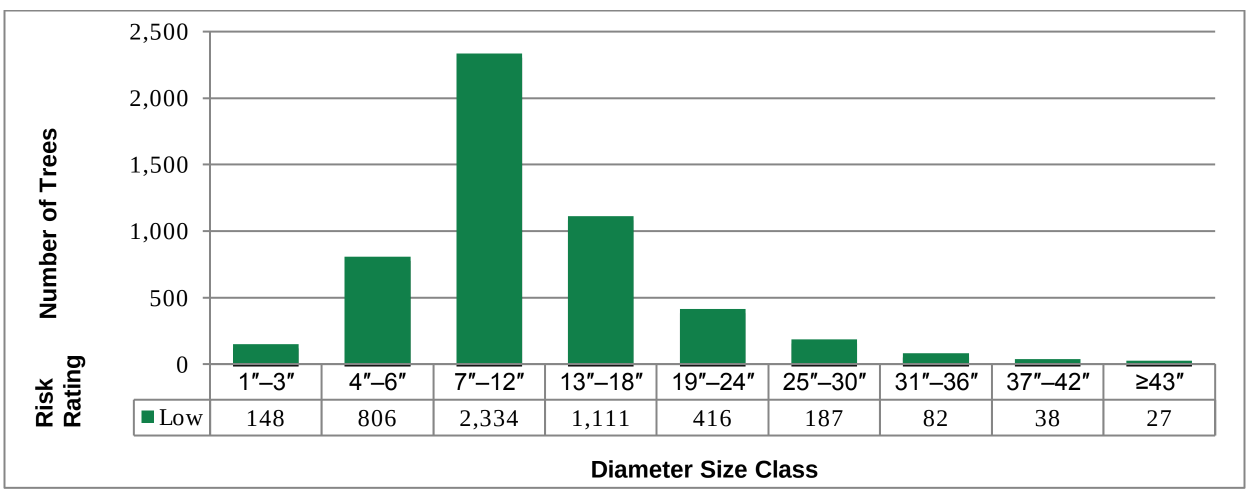


Figure 13. Trees recommended for the RP Cycle by diameter size class.

Recommendations

DRG recommends that the city establish a five-year RP Cycle in which approximately one-fifth of the tree population is to be pruned each year. The 2016 tree inventory identified approximately 5,149 trees that should be pruned over a five-year RP Cycle. An average of 1,030 trees should be pruned each year over the course of the cycle. DRG recommends that the RP Cycle begin in Year One of this five-year plan, after High Risk trees are pruned.

The inventory found that most trees (72%) on the street ROW needed routine pruning. Figure 13 shows that a variety of tree sizes will require pruning; however, most of the trees that require routine pruning were smaller than 24 inches DBH.

Maintenance Schedule

Utilizing data from the 2017–2018 City of Watertown tree inventory, an annual maintenance schedule was developed that details the number and type of tasks recommended for completion each year. DRG made budget projections using industry knowledge and public bid tabulations. Actual costs were not specified by Watertown. A complete table of estimated costs for Watertown's five-year tree management program follows.

The schedule provides a framework for completing the inventory maintenance recommendations over the next five years. Following this schedule can shift tree care activities from an on-demand system to a more proactive tree care program.

To implement the maintenance schedule, the city's tree maintenance budget should be no less than $260,000 for the first year of implementation, no less than $237,000 for the second year, and no less than $160,000 for the final three years of the maintenance schedule. Annual budget funds are needed to ensure that extreme and High Risk trees are remediated and that crucial YTT and RP Cycles can begin. With proper professional tree care, the safety, health, and beauty of the urban forest will improve.

If routing efficiencies and/or contract specifications allow for the completion of more tree work, or if the schedule requires modification to meet budgetary or other needs, then the schedule should be modified accordingly. Unforeseen situations such as severe weather events may arise and change the maintenance needs of trees. Should conditions or maintenance needs change, budgets and equipment will need to be adjusted to meet the new demands.

Table 5. Estimated Costs for Five-Year Urban Forestry 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	
High Risk Removals	1-3"	$28	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	4-6"	$58	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	7-12"	$138	2	$275	0	$0	0	$0	0	$0	0	$0	$275
	13-18"	$314	2	$627	0	$0	0	$0	0	$0	0	$0	$627
	19-24"	$605	2	$1,210	0	$0	0	$0	0	$0	0	$0	$1,210
	25-30"	$825	2	$1,650	0	$0	0	$0	0	$0	0	$0	$1,650
	31-36"	$1,045	3	$3,135	0	$0	0	$0	0	$0	0	$0	$3,135
	37-42"	$1,485	1	$1,485	0	$0	0	$0	0	$0	0	$0	$1,485
	43"+	$2,035	1	$2,035	0	$0	0	$0	0	$0	0	$0	$2,035
Activity Total(s)			**13**	**$10,417**	0	$0	0	$0	0	$0	0	$0	**$10,417**
Moderate and Low Risk Removals	1-3"	$28	0	$0	72	$1,980	0	$0	0	$0	0	$0	$1,980
	4-6"	$58	2	$115	52	$2,990	0	$0	0	$0	0	$0	$3,105
	7-12"	$138	24	$3,300	121	$16,638	0	$0	0	$0	0	$0	$19,938
	13-18"	$314	31	$9,719	45	$14,108	0	$0	0	$0	0	$0	$23,826
	19-24"	$605	18	$10,890	22	$13,310	0	$0	0	$0	0	$0	$24,200
	25-30"	$825	16	$13,200	13	$10,725	0	$0	0	$0	0	$0	$23,925
	31-36"	$1,045	6	$6,270	4	$4,180	0	$0	0	$0	0	$0	$10,450
	37-42"	$1,485	1	$1,485	2	$2,970	0	$0	0	$0	0	$0	$4,455
	43"+	$2,035	1	$2,035	4	$8,140	0	$0	0	$0	0	$0	$10,175
Activity Total(s)			**99**	**$47,014**	**335**	**$75,040**	0	$0	0	$0	0	$0	**$122,054**
Stump Removals	1-3"	$18	3	$53	2	$35	2	$35	2	$35	2	$35	$193
	4-6"	$28	16	$440	16	$440	16	$440	16	$440	15	$413	$2,173
	7-12"	$44	14	$616	13	$572	13	$572	13	$572	13	$572	$2,904
	13-18"	$72	7	$501	7	$501	7	$501	6	$429	6	$429	$2,360
	19-24"	$94	3	$281	3	$281	3	$281	2	$187	2	$187	$1,216
	25-30"	$110	3	$330	3	$330	2	$220	2	$220	2	$220	$1,320
	31-36"	$138	1	$138	1	$138	0	$0	0	$0	0	$0	$275
	37-42"	$160	1	$160	1	$160	0	$0	0	$0	0	$0	$319
	43"+	$182	1	$182	0	$0	0	$0	0	$0	0	$0	$182
Activity Total(s)			**49**	**$2,698**	**46**	**$2,455**	**43**	**$2,048**	**41**	**$1,883**	**40**	**$1,856**	**$10,940**
High and Moderate Risk Pruning	1-3"	$20	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	4-6"	$30	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	7-12"	$75	15	$1,125	0	$0	0	$0	0	$0	0	$0	$1,125
	13-18"	$120	28	$3,360	0	$0	0	$0	0	$0	0	$0	$3,360
	19-24"	$170	39	$6,630	0	$0	0	$0	0	$0	0	$0	$6,630
	25-30"	$225	52	$11,700	0	$0	0	$0	0	$0	0	$0	$11,700
	31-36"	$305	18	$5,490	0	$0	0	$0	0	$0	0	$0	$5,490
	37-42"	$380	11	$4,180	0	$0	0	$0	0	$0	0	$0	$4,180
	43"+	$590	14	$8,260	0	$0	0	$0	0	$0	0	$0	$8,260
Activity Total(s)			**177**	**$40,745**	0	$0	0	$0	0	$0	0	$0	**$40,745**
Routine Pruning (5-year cycle)	1-3"	$20	30	$600	30	$600	30	$600	29	$580	29	$580	$2,960
	4-6"	$30	162	$4,860	161	$4,830	161	$4,830	161	$4,830	161	$4,830	$24,180
	7-12"	$75	467	$35,025	467	$35,025	467	$35,025	467	$35,025	466	$34,950	$175,050
	13-18"	$120	223	$26,760	222	$26,640	222	$26,640	222	$26,640	222	$26,640	$133,320
	19-24"	$170	84	$14,280	83	$14,110	83	$14,110	83	$14,110	83	$14,110	$70,720
	25-30"	$225	38	$8,550	38	$8,550	37	$8,325	37	$8,325	37	$8,325	$42,075
	31-36"	$305	17	$5,185	17	$5,185	16	$4,880	16	$4,880	16	$4,880	$25,010
	37-42"	$380	8	$3,040	8	$3,040	8	$3,040	7	$2,660	7	$2,660	$14,440
	43"+	$590	6	$3,540	6	$3,540	5	$2,950	5	$2,950	5	$2,950	$15,930
Activity Total(s)			**1,035**	**$101,840**	**1,032**	**$101,520**	**1,029**	**$100,400**	**1,027**	**$100,000**	**1,026**	**$99,925**	**$503,685**
Young Tree Training Pruning (3-year cycle)	1-3"	$20	328	$6,560	328	$6,560	328	$6,560	328	$6,560	328	$6,560	$32,800
	4-8"	$30	117	$3,510	117	$3,510	117	$3,510	117	$3,510	117	$3,510	$17,550
Activity Total(s)			**445**	**$10,070**	**445**	**$10,070**	**445**	**$10,070**	**445**	**$10,070**	**445**	**$10,070**	**$50,350**
Replacement Tree Planting	Purchasing	$170	100	$17,000	100	$17,000	100	$17,000	100	$17,000	100	$17,000	$85,000
	Planting	$110	100	$11,000	100	$11,000	100	$11,000	100	$11,000	100	$11,000	$55,000
Activity Total(s)			**200**	**$28,000**	**200**	**$28,000**	**200**	**$28,000**	**200**	**$28,000**	**200**	**$28,000**	**$140,000**
Replacement Young Tree Maintenance	Mulching	$100	100	$10,000	100	$10,000	100	$10,000	100	$10,000	100	$10,000	$50,000
	Watering	$100	100	$10,000	100	$10,000	100	$10,000	100	$10,000	100	$10,000	$50,000
Activity Total(s)			**200**	**$20,000**	**200**	**$20,000**	**200**	**$20,000**	**200**	**$20,000**	**200**	$20,000	**$100,000**
Activity Grand Total			**2,018**		**2,058**		**1,717**		**1,713**		**1,711**		
Cost Grand Total				**$260,784**		**$237,085**		**$160,518**		**$159,953**		**$159,851**	**$978,190**

Community Outreach

The data collected and analyzed to develop this plan contribute significant information about the tree population and can be utilized to guide the proactive management of that resource. These data can also be utilized to promote the value of the urban forest and the tree management program in the following ways:

- Tree inventory data can be used to justify necessary priority and proactive tree maintenance activities as well as tree planting and preservation initiatives.
- Species data can be used to guide tree species selection for planting projects with the goals of improving species diversity and limiting the introduction of invasive pests and diseases.
- Information in this plan can be used to advise citizens about threats to urban trees (such as granulate ambrosia beetle, emerald ash borer, and gypsy moth).

There are various avenues for outreach. Maps can be created and posted on websites, in parks, or in business areas. Public service announcements can be developed. Articles can be written and programs about trees and the benefits they provide can be developed. Arbor Day and Earth Day celebrations can become community traditions. Signs can be hung from trees to highlight the contributions trees make to the community. Contests can even be created to increase awareness of the importance of trees. Trees provide oxygen we need to breathe, shade to cool our neighborhoods, and canopies to stand under when it rains.

Watertown's data are instrumental in helping to provide tangible and meaningful outreach about the urban forest.

Tree Watertown is a wonderful program that advises and guides tree related issues in the city of Watertown. Tree Watertown sponsors a fall city planting every year, which helps educate community members on the benefits of trees. Data from this inventory can be shared to the public through Tree Watertown programs.

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.

Trees along the street ROW should be regularly inspected and attended to as needed based on the inspection findings. When trees need additional or new work, they should be added to the maintenance schedule and budgeted as appropriate. Use appropriate computer management software such as TreeKeeper 8.0 to update inventory data and work records. In addition to locating potential new hazards, inspections are an opportunity to look for signs and symptoms of pests and diseases. Watertown has a large population of trees that are susceptible to pests and diseases, such as ash, oak, and maple.

Inventory and Plan Updates

DRG recommends that the inventory and management plan be updated using an appropriate computer software program so that the city can sustain its program and accurately project future program and budget needs:

- Conduct inspections of trees after all severe weather events. Record changes in tree condition, maintenance needs, and risk rating in the inventory database. Update the tree maintenance schedule and acquire the funds needed to promote public safety. Schedule and prioritize work based on risk.
- Perform routine inspections of public trees as needed. Windshield surveys (inspections performed from a vehicle) in line with *ANSI A300 (Part 9)* (ANSI 2011) will help city staff stay apprised of changing conditions. Update the tree maintenance schedule and the budget as needed so that identified tree work may be efficiently performed. Schedule and prioritize work based on risk.
- If the recommended work cannot be completed as suggested in this plan, modify maintenance schedules and budgets accordingly.
- Update the inventory database using TreeKeeper 8.0 as work is performed. Add new tree work to the schedule when work is identified through inspections or a citizen call process.
- Re-inventory the street ROW, and update all data fields in five years, or a portion of the population (1/5) every year over the course of five years.
- Revise the *Tree Management Plan* after five years when the re-inventory has been completed.

SECTION 4: STORM RESPONSE AND RECOVERY PLAN

An urban forestry-focused disaster management plan is critical in tree canopy preservation—both pre- and post-storm—and can take many forms.

Pre-Storm. Most of the work in pre-storm disaster management is proactive maintenance of trees described in Section 3. This will greatly reduce the number of hazards present and ultimately make the urban forest more storm-ready and less susceptible to damage. However, work systems can be planned in advance that serve as an addendum to a city-wide management plan, or simply as a summary of the urban forestry division's expected role in a disaster for staff education and preparedness purposes.

Plans can include:

- Chain-of-command description and clarification
- Method of communication to be used in emergencies
- A triage process for tree debris removal (often clearing critical lanes and access to hospitals and other key sites first)
- Designated pre-set sites for debris to facilitate quick and safe removals
- Prearranged tree pruning and removal contract agreements after disasters to avoid high-rate fees in last-minute situations

Post-Storm. The first steps post storm are to implement the triage process and clear major thoroughfares and dangerous situations in a methodical and prioritized order as described above. However, disaster management related to urban trees needs to look further than immediate response. A predefined communications plan will make major strides in tree preservation in the weeks after a storm (mentioned in Section 3). Many trees can withstand high winds and storm damage and rebound after severe storm events. However, after a storm, trees with no leaves may appear dead or dangerous to the untrained eye, and unwarranted removals may occur. Forward-thinking disaster plans can include a communication plan to explain this to the public, along with a system or access to expertise to help property owners safely determine which trees can be saved. Without a proactive preservation plan, many trees fall prey to uneducated contractors offering to remove every tree that experiences any damage.

After a storm event, the plan should be updated and modified to increase efficiency and reflect any organizational changes.

Tool to Estimate Management of Storm Damage

i-Tree Storm is a free tool available to municipalities that standardize a method to assess widespread damage immediately after a severe storm in a simple, credible, and efficient manner. This assessment method provides information on the time and funds needed to mitigate storm damage.

Pre-Storm. Using the pre-storm protocol, randomized street tree assessments are performed to obtain the potential time and cost estimates for debris cleanup by calculating the amount of tree debris in cubic yards, hazard tree pruning, and tree removals. The reason for completing this pre-storm random sample assessment is twofold:

- Helping community officials understand the implications of storm related tree damage in terms of costs and resources needed for the cleanup; and
- Obtaining more accurate calculations from an i-Tree Storm actual post-storm assessment, which eases the reporting required by FEMA.

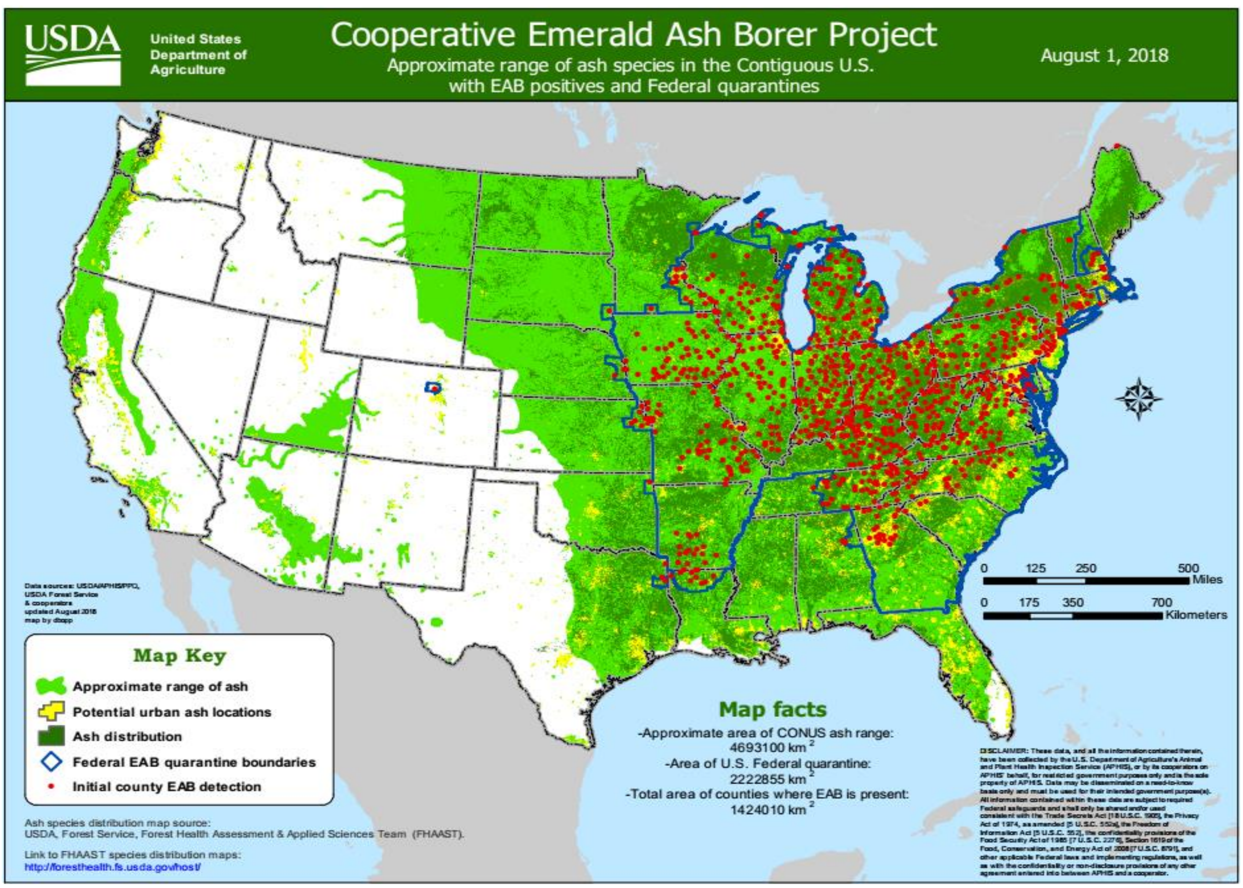
Post Storm: After a storm hits, the same sample plots are resurveyed, and time and cost estimates are produced community-wide for use in reporting. The sample post-storm damage assessment should be followed by an extensive survey of tree damage to obtain a complete and accurate account of the necessary cleanup work and direct the prioritization of cleanup.

SECTION 5: EMERALD ASH BORER STRATEGY

Throughout the United States, urban and community forests are under increased pressure from exotic and invasive insects and diseases. Exotic pests that arrive from overseas typically have no natural predators and become invasive when our native trees and shrubs do not have appropriate defense mechanisms to fight them off. Mortality from these pests can range from two weeks with oak wilt (*Ceratocystis fagacearum*) to at least seven years with emerald ash borer (EAB) (*Agrilus planipennis*).

An integral part of tree management is maintaining awareness of invasive insects and diseases in the area and knowing how to best manage them. Depending on the tree diversity within Watertown's urban forest, an invasive insect or disease has the potential to negatively impact the tree population.

This chapter provides different management strategies for dealing with EAB. Included are sections on how to effectively monitor EAB, increase public education, handle ash debris, approach reforestation, work with stakeholders, and utilize ash wood. Appendix F contains additional EAB reference materials.



Map 1. EAB detections throughout North America as of August 1st, 2018. Map by United States Department of Agriculture, Animal and Plant Health Inspection Service.

Emerald Ash Borer

Emerald ash borer is a small insect native to Asia. In North America, the borer is an invasive species that is highly destructive to ash trees in its introduced range. The potential damage of EAB rivals that of chestnut blight and Dutch elm disease.

Chestnut blight is a fungus that was introduced in North America around 1900. By 1940, chestnut blight virtually wiped out most of the mature American chestnut population. Chestnut blight is believed to have been imported by chestnut lumber or through imported chestnut trees. Dutch elm disease (DED) is a fungus spread sexually by the elm bark beetle. DED was first reported in the United States in 1928 and was believed to have been introduced by imported timber. Since its discovery in the United States, it has killed millions of elm trees.

EAB is thought to have been introduced into the United States and Canada in the 1990s; however, it was not positively identified in North America until 2002 in Canton, Michigan. The presence of EAB has been confirmed in 35 states. EAB has killed at least 50–100 million ash trees and threatens another 7.5 billion ash trees throughout North America. Currently, no EAB has been discovered in Watertown. See Map 2 for areas in New York state with known EAB infestations. EAB is a serious pest that threatens the health of all ash tree species in the state. With an estimated 6% ash trees at risk in Watertown's woods (based on NY DEC ash distribution per total basal area) — the state is committed to early detection and thoughtful management of this pest. In the United States, EAB has been known to attack all native ash trees.

Photograph 9. EAB adults grow to 5/8 inch in length (photograph credit www.wisconsin.gov).

Photograph 10. EAB larvae (photograph credit

Identification

The adult beetle is elongate, metallic green and 3⁄8–5⁄8 inch long. The adult beetle emerges from late May until early August, feeding on a small amount of foliage. The adult females then lay eggs on the trunk and branches of ash trees and, in roughly a week, the eggs hatch into larvae, which then bore into the tree. Larvae are creamy white in color and can grow up to an inch long and are found underneath the bark of the trees. The larvae tunnel and feed on the inner bark and phloem, creating winding galleries as they feed. This cuts off the flow of the water and nutrients to the tree, causing dieback and death.

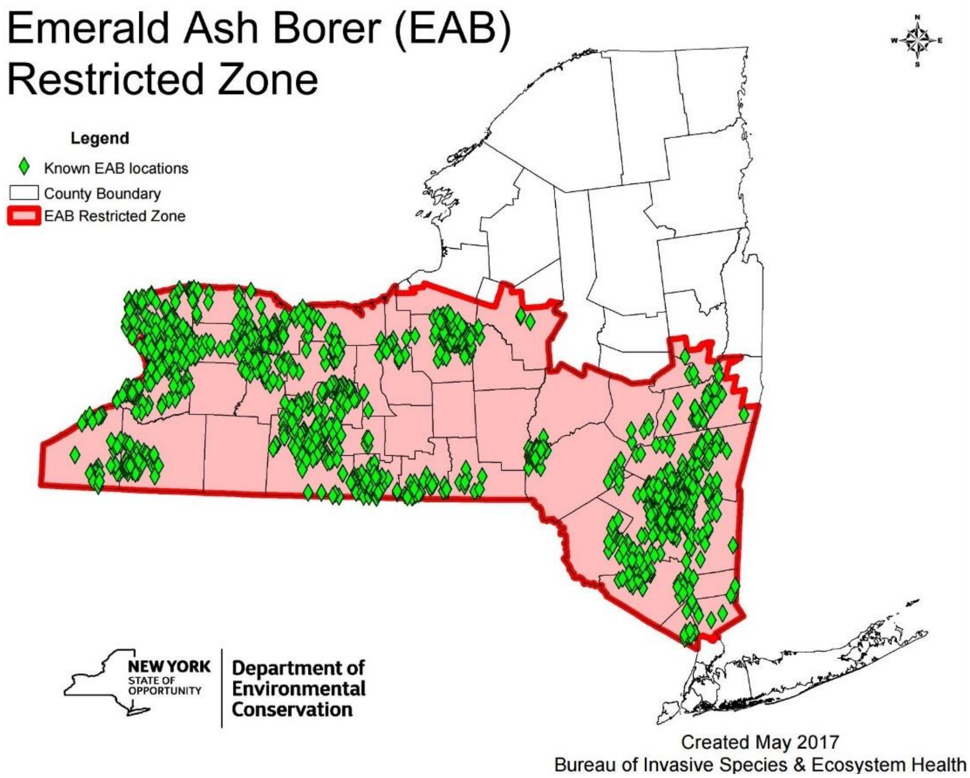
Photograph 11. Larvae consume the cambium and phloem, effectively girdling the tree and eventually causing death within a few years.

EAB can be very difficult to detect. Initial symptoms include yellowing and/or thinning of the foliage and longitudinal bark splitting. The entire canopy may die back, or symptoms may be restricted to certain branches. Declining trees may sprout epicormic shoots at the tree base or on branches. Woodpecker injury is often apparent on branches of infested trees, especially in late winter. Removal of bark reveals tissue callusing and frass-filled serpentine tunneling. The S-shaped larval feeding tunnels are about 1⁄4 inch in diameter. Tunneling may occur from upper branches to the trunk and root flare. Adults exit from the trunk and branches in a characteristic D-shaped exit hole that is about 1/8 inch in diameter. The loss of water and nutrients from the intense larvae tunneling can cause trees to lose between 30% and 50% of their canopies during the first year of infestation. Trees often die within two years following infestation.

Photograph 12. This ash tree is declining from EAB infestation. The loss of water and nutrients from intense larvae tunneling can cause the trees to lose between 30% and 50% of their canopies during the first year of infestation (Photograph courtesy http://labs.russell.wisc.edu/ eab/signs-and-symptoms/)

State and Federal Response

The New York Department of Environmental Conservation is the leading agency responsible for control of invasive pests in New York. The federal agency USDA-APHIS assists with regulatory and control action of invasive pests. The DEC has declared EAB a public nuisance in New York and has enacted a state-wide quarantine restricting the movement of ash trees and non-coniferous firewood.



Map 2. Watertown is susceptible to the spread of EAB.

Federal agencies have been actively researching control measures, including biological controls, developing resistant species, and testing various insecticides. Since 2003, American scientists, in conjunction with the Chinese Academy of Forestry, have searched for natural enemies of EAB in the wild. This has led to the discovery of several parasitoid wasps, namely *Tetrastichus planipennisi*, a gregarious larval endoparasitoid; *Oobius agrili*, a solitary, parthenogenic egg parasitoid; and *Spathius agrili*, a gregarious larval ectoparasitoid. These parasitoid wasps have been released into the Midwestern United States as a possible biological control of EAB. States that have released parasitoid wasps include Indiana, Michigan, and Minnesota.

Ash Population

With the threat of EAB nearing Watertown, it is crucial that the city has an action plan. Some of the most important questions to answer will include:

- How many ash trees do we have?
- Where are they located?
- What actions should we take?

In order to answer these questions, Watertown needs to maintain an up-to-date inventory, know what resources are available, and understand the city's priorities.

Based on the current public tree inventory, there are 435 ash trees distributed throughout the city's urban forest. Of these trees, 18 were recommended for removal based on health or safety concerns identified during the 2018 inventory. The majority of the ash population was in Good condition (56%), with 37% in Fair condition and a significantly smaller percentage in Poor or Critical (6%) condition. Table 6 reflects the diameter class of each ash tree by condition class. Of the 435 ash trees inventoried, 14 were identified as having shown potential signs and symptoms of EAB.

Table 6. Tree Condition Versus Diameter Class Matrix

	1–3	4–6	7–12	13–18	19–24	25–30	31–36	37–42	43+	Total
Excellent	0	0	0	0	0	0	0	0	0	0
Very Good	0	0	4	1	0	0	0	0	0	5
Good	0	19	161	64	0	0	0	0	1	245
Fair	4	19	98	38	2	0	0	0	0	161
Poor	1	6	4	3	0	1	0	0	0	15
Critical	0	1	4	2	0	1	0	0	0	8
Dead	0	0	1	0	0	0	0	0	0	1
Total	**5**	**45**	**272**	**108**	**2**	**2**	**0**	**0**	**1**	**435**

Ash Tree Risk Reduction Pruning and Removals

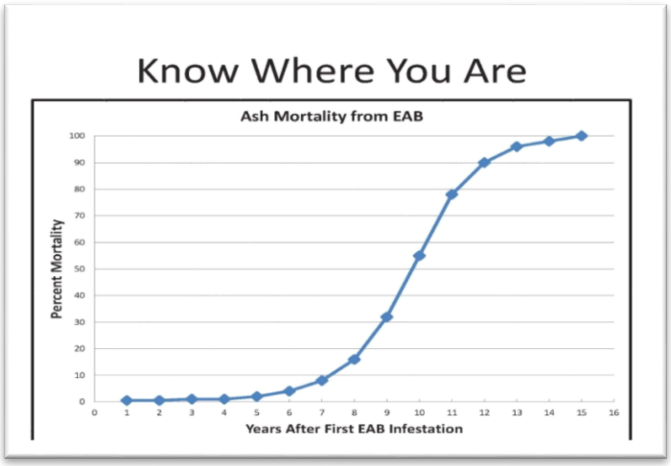
As infestation of EAB becomes prevalent in Watertown, the city's highest priority is to focus budgeted funds and personnel to concentrate more closely on the ash tree population. DRG recommends that Watertown perform both treatment and safety-related activities on ash trees. This activity will end up saving money and increasing productivity in Watertown.

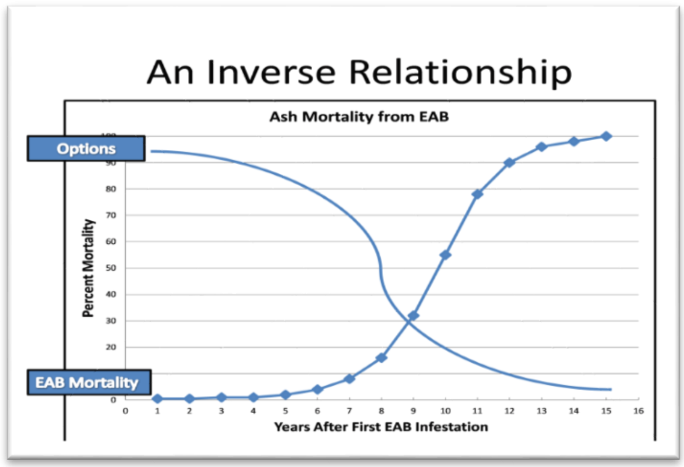
DRG also recommends that Watertown proactively remove ash trees during road reconstruction projects and other public works associated activities. By proactively removing ash trees during construction, the cost and impacts should be lower.

DRG recommends that Watertown first remove all ash trees less than 7 inches DBH, along with trees in Poor, Critical, or Dead condition. Fair trees between 7 and 12 inches should also be removed. These trees provide little benefit and have current health problems.

EAB Management Options

Watertown should explore different options for managing EAB. The graphs below present a unique tool for a city when deciding on viable management options for varying levels of EAB infestations. Considering its proximity to confirmed infestations, Watertown's tree population can be approximated at Year One on both graphs, since there has been no confirmed EAB infestation within 20 miles. At this position, the city has time to prepare as well as select a management option. When infestation occurs, as depicted in the graph, the city's options for management decrease.





Source: Emerald Ash University (www.emeraldashborer.info)

EAB Management Options

With no specific strategy or budget in place for the impending infestation of EAB, Watertown should explore strategies for managing EAB that provide the most economic benefit and increase public safety. These EAB management strategies include doing nothing, removing and replacing all ash, treating all ash, or a combination of the strategies. The following are current strategies for managing EAB and costs associated with these strategies.

Photograph 13. This is an example of a Do Nothing strategy. These ash trees became infested with EAB and eventually died. They have now become a public safety issue.

EAB Strategy 1: Do Nothing

This means letting EAB run its course and having no strategy for dealing with EAB. This strategy includes not removing and not treating any ash trees. This strategy is economical in the beginning of an infestation because it doesn't cost the city any money, but it would become an extreme public safety issue within a few years. DRG does not recommend this management strategy.

EAB Strategy 2: Remove and Replace All Ash

By the end of 2018, remove and replace all 435 ash trees. This strategy would benefit public safety from the EAB infestation but would have an impact on the city's budget. In order to achieve this strategy and remove all of the ash trees by 2018, the city would most likely have to contract out work. Removing mature ash trees in Good and Fair condition would take away all of the valuable benefits that these trees provide to the city and would leave some areas with a full canopy of ash with no moderate- or large-sized trees at all. By increasing public safety, this strategy ultimately benefits the city but requires high upfront cost. Replacing all of these ash trees once they have been removed will be very important.

The total approximate cost for this strategy would be $222,577: $79,093 to remove all ash trees; $21,684 to remove all stumps; and $121,800 to replace all ash trees. Refer to Table 7.

Table 7. Cost to Remove and Replace All Ash

Management Strategy	Management Action	# of Trees	Cost
Remove and Replace All Ash Trees	Remove All	435	$79,093
	Replace All	435	$121,800
	Stump Removal	435	$21,684
	Total		**$222,577**

EAB Strategy 3: Treat all Ash

Treating all of Watertown's ash trees could reduce the annual mortality rate, stabilize removals, and would be less expensive than removing and replacing all ash trees. Treating all ash would enable these trees to continue providing the city with the monetary benefits that they provide. On the other hand, treating all ash trees is not an ideal practice because some of these ash trees eventually become infested with EAB and some are less desirable to retain.

If Watertown wanted to treat all of its 435 ash trees every two years, it would cost approximately $144,765 over a six-year period. This means that it would cost the city approximately $48,255 every two years to treat the 435 ash trees.

Table 8. Cost to Treat All Ash

Management Strategy	Management Action	# of Trees	Cost
Treat All Ash Trees	Treat all Ash Trees for Six Years	435	$144,765

EAB Strategy 4: Combination of Removals and Treatment

This strategy is intended to give the city options for a combination of removing and treating ash trees to stabilize annual removals, annual budgets, and prolong the life of ash trees in Good and Fair condition. Table 9 is an EAB matrix table intended to organize trees that should be considered for removal and trees that should be considered for treatment. The following sections explain why certain ash trees should be considered for removal and treatment.

Table 9. EAB Matrix Table

		1–3	4–6	7–12	13–18	19–24	25–30	31–36	37–42	43+	Total
Condition Class	Excellent	0	0	0	0	0	0	0	0	0	0
	Very Good	0	0	4	1	0	0	0	0	0	5
	Good	0	19	161	64	0	0	0	0	1	245
	Fair	4	19	98	38	2	0	0	0	0	161
	Poor	1	6	4	3	0	1	0	0	0	15
	Critical	0	1	4	2	0	1	0	0	0	8
	Dead	0	0	1	0	0	0	0	0	0	1
	Total	**5**	**45**	**272**	**108**	**2**	**2**	**0**	**0**	**1**	**435**

Based on these numbers, DRG makes the following recommendations:

164 Trees for Removal

- Trees in the Poor, Critical, and Dead condition class are recommended for removal because they are more susceptible to EAB infestation. If these trees are not removed, they could pose a public safety issue in the future. A total of 24 of these trees are recommended for removal and replacement.
- The remaining 140 trees that are less than 7 inches DBH, and trees in Fair condition and between 7 inches and 12 inches DBH, are recommended for removal and replacement. These trees do not provide as many benefits to the community compared to mature ash trees. It would be in the best interest of the city to remove these trees and replace them with a more diversified mix of trees.

40 Candidate Trees for Chemical Treatment (Low–Moderate Priority of Treatment)

- The intent here is to defer removal of a large block of Fair conditioned trees between 13 inches and 43+ inches DBH. These 40 trees are considered to be low–moderate priority for chemical treatment. Eventually, many of these trees may become infested with EAB if treatments stop, meaning these trees would have to be removed. Treating these trees could help minimize short-term budgets due to removals. Treatment can be economically beneficial and reduce the chance for a public safety issue in the near future.

231 Candidate Trees for Chemical Treatment (High Priority of Treatment)

- Candidates for chemical treatment should be in Good condition or better with no more than 30% dieback. Such trees should be located in an appropriate site (i.e., not under overhead utilities). Continually treating these 231 ash trees will help keep these trees around for a long time; the city will profit from the monetary benefits these ash trees provide.

Table 10. Costs Associated with Combination Treatment and Removal EAB Strategy

Activity	Diameter	Cost/Tree	# of Trees	Total Cost
Removal	1-3"	$28	5	$140
	4-6"	$58	45	$2,610
	7-12"	$138	107	$14,766
	13-18"	$314	5	$1,570
	19-24"	$605	0	$0
	25-30"	$825	2	$1,650
	31-36"	$1,045	0	$0
	37-42"	$1,485	0	$0
	43"+	$2,035	0	$0
Activity Total(s)			164	$20,736
Treatment (over six years)	1-3"	$45	0	$0
	4-6"	$150	0	$0
	7-12"	$300	161	$48,300
	13-18"	$480	103	$49,440
	19-24"	$660	2	$1,320
	25-30"	$840	0	$0
	31-36"	$1,020	0	$0
	37-42"	$1,200	0	$0
	43"+	$1,350	1	$1,350
Activity Total(s)			271	$100,410
Stump Removal	1-3"	$18	5	$90
	4-6"	$28	45	$1,260
	7-12"	$44	107	$4,708
	13-18"	$72	5	$360
	19-24"	$94	0	$0
	25-30"	$110	2	$220
	31-36"	$138	0	$0
	37-42"	$160	0	$0
	43"+	$182	0	$0
Activity Total(s)			164	$6,638
Replanting		$280	164	$45,920
Activity Total(s)			164	$45,920
Option Totals			435	$173,704

For maximum retention of urban tree canopy, DRG recommends that the city of Watertown treat all 271 ash trees that are low-moderate and high candidates for treatment, and that the rest of the ash trees be removed. DRG also recommends that all stumps be removed and that replacement trees be planted immediately. Table 10 shows that the cost will be approximately $173,704 during the first six years of the strategy. This option is $48,873 lower (not including continued treatments after 6 years) than the cost to remove and replace all ash trees, and it means that many beautiful, shady trees will be saved. After six years, treatment costs will be less than $57,901 every two years, depending on ash tree mortality.

Private Trees

In addition to ash trees located on public property, EAB will impact trees located on private property. The number of private ash trees is unknown but could be equal to or greater than the ash trees located on public property. During the inventory, the arborists observed an abundance of ash trees located on private properties. The cost to remove ash trees will be higher on private property due to greater inaccessibility to these areas. It is crucial that the city promotes public education about EAB so that it can reduce the potential of city involvement with regulating tree removals on private properties. The public education section explains more on how to minimize anxiety from private homeowners. The section also provides examples on how to best inform the public about managing their ash trees.

Photograph 14. Hangers will help make private homeowners aware of the management options available for EAB.

Dying and infested ash trees on private property will pose a threat to human and public safety. In the event that city officials have to get involved with private property owners about a potential infested ash tree, Watertown should consider utilizing the current city tree and landscape ordinance. Watertown should consider amending the ordinance so that EAB is specifically acknowledged as a public nuisance and treated in similar fashion as Dutch elm disease and other insect pests or plant diseases.

Public Education

It is crucial for Watertown property owners to be well informed about EAB. Their assistance and cooperation will be vital in helping detect EAB, managing ash trees on private property, and expediting reforestation that will occur after removals of infected ash trees are complete. Watertown should inform the public that EAB has been discovered in Orange County. If EAB should be identified in Watertown, the public must be immediately informed. A well-informed community is more likely to cooperate with the city's requests. The city should inform the public in the following ways:

- News release
- City newsletter articles
- Radio programs
- Post information about EAB on the city's website

Photograph 15. Posting information about EAB on ash trees around the city could encourage private homeowners to become more proactive in managing their

It is vital for Watertown to educate the public on how to detect EAB, provide information about treatment options, and relay the importance of reforestation. If the public is advised on how to detect EAB, it can make proactive choices about managing infested ash trees. This could help put city officials at ease by not having as many private trees become a public safety issue. Property owners may want to keep their ash trees because of the benefits they receive from them.

The city should provide information about treatment options so that their trees can last for years to come. It will be important for the city to inform the public about reforestation, the important benefits trees provide to neighborhoods, and how trees increase real estate value. This can help fund and promote neighborhood tree plantings. The following are examples of ways the city can inform the public about these issues:

- Display information packets at public buildings
- Postcard mailings to ash tree owners
- Door hangers explaining maintenance options
- Presentations to community groups
- Post information about EAB on the city's website
- Tie ribbons around ash trees and place tags on the trees with information about EAB

Reforestation

As the ash tree population is being reduced in Watertown, the city will need to come up with a plan to replant where ash trees have been removed. The city could potentially lose 6% of its tree population due to EAB. A prompt reforestation in Watertown is essential due to the numerous benefits ash trees provide to the community. Benefits include removing pollutants from the air, helping moderate temperatures, reducing stormwater runoff, and providing social and psychological benefits.

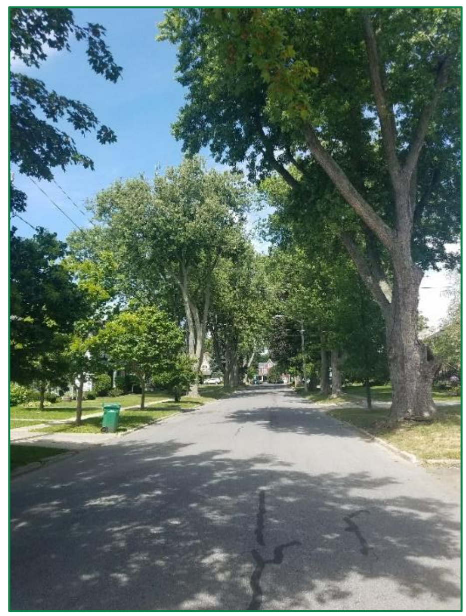
If the city is able to replace all of the ash trees, it will cost approximately $121,800. This would be a financial burden on the city, but it will be important that these trees be replaced. The cost of replanting ash trees could be spread out over multiple years by establishing a goal that a certain amount of trees need to be planted each year. If the city was to plant 72 replacement trees a year, Watertown could replace all of the ash trees within 6 years. This cost could be reduced if the city comes up with a plan to work with volunteers and private property owners. This could include giving private property owners the option of paying for the tree and getting to pick the tree they want from a list of recommended species. Watertown should also explore grants for reforestation. Organizing volunteer groups to participate in planting trees could help decrease the cost for planting trees. It is important to consider diversification when replacing ash trees. Without diversification, a community is much more vulnerable to catastrophic losses that impact budgets and community appearance. DRG recommends that at most, no one species represents more than 10% and that no one genus comprises more than 20% of the total public tree population.

Even smaller percentages would reduce the likelihood of major loss due to future infestation from another pest or disease. Since EAB has hit local communities, there might be a possibility that local nurseries have a shortage of trees. Chelsea might want to consider nurseries in other regions for trees.

CONCLUSIONS

Every hour of every day, public trees in Watertown are su pporting and improving the quality of life. The city's trees provide an annual benefit of $715,343. When properly maintained, trees provide numerous environmental, economic, and social benefits that far exceed the time and money invested in planting, pruning, protection, and removal.

Managing trees in urban areas is often complicated. Navigating the recommendations of experts, the needs of residents, the pressures of local economics and politics, concerns for public safety and liability, physical components of trees, forces of nature and severe weather events, and the expectation that these issues are resolved all at once is a considerable challenge. The city should prepare and implement an EAB Management Plan as soon as possible.



Photograph 16. A street well stocked with trees provides economic, environmental, and social benefits, including temperature moderation, reduction of air pollutants, energy conservation, and increased property values.

The city must carefully consider these challenges to fully understand the needs of maintaining an urban forest. With the knowledge and wherewithal to address the needs of the city's trees, Watertown is well positioned to thrive. If the management program is successfully implemented, the health and safety of Watertown's trees and citizens will be maintained for years to come.

GLOSSARY

aboveground utilities (data field): Shows the presence or absence of overhead utilities at the tree site.

address number (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 an "X" was added to the number in the database to indicate that the address number was assigned.

Aesthetic/Other Report: The i-Tree Streets Aesthetic/Other Report presents the tangible and intangible benefits of trees reflected by increases in property values in dollars ($).

Air Quality Report: The i-Tree Streets Air Quality Report quantifies the air pollutants (ozone [O_3], nitrogen dioxide [NO_2], sulfur dioxide [SO_2], coarse particulate matter less than 10 micrometers in diameter [PM_{10}]) deposited on tree surfaces and reduced emissions from power plants (NO_2, PM_{10}, Volatile Oxygen Compounds [VOCs], SO_2) due to reduced electricity use measured in pounds (lbs.). Also reported are the potential negative effects of trees on air quality due to Biogenic Volatile Organic Compounds (BVOC) emissions.

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.

area (data fields): A collection of data fields collected during the inventory to aid in finding trees, including park section number.

Benefit-Cost Ratio (BCR): The i-Tree Streets (BCR) is the ratio of the cumulative benefits provided by the landscape trees, expressed in monetary terms, compared to the costs associated with their management, also expressed in monetary terms.

biogenic volatile organic compounds (BVOC): Gases emitted from trees, like pine trees, which create the distinct smell of a pine forest. When exposed to sunlight in the air, BVOCs react to form tropospheric ozone, a harmful gas that pollutes the air and damages vegetation.

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.

canopy spread (data field): Estimates the width of a tree's canopy in 5-foot increments.

Carbon Dioxide Report: The i-Tree Streets Carbon Dioxide Report presents annual reductions in atmospheric CO_2 due to sequestration by trees and reduced emissions from power plants due to reduced energy use in pounds. The model accounts for CO_2 released as trees die and decompose and CO_2 released during the care and maintenance of trees.

clearance requirements (data field): Illustrates the need for pruning to meet clearance standards over streets and sidewalks, or where branches are considered to be interfering with the movement of vehicles or pedestrians or where they are obstructing signs and street or traffic lights.

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: Excellent (100%), Very Good (90%), Good (80%), Fair (60%), Poor, (40%), Critical (20%), Dead (0%).

cycle: Planned length of time between vegetation maintenance activities.

defect: See **structural defect**.

diameter: See **tree size**.

diameter at breast height (DBH): See **tree size**.

Energy Report: The i-Tree Streets Energy Report presents the contribution of the urban forest toward conserving energy in terms of reduced natural gas use in winter measured in therms (th) and reduced electricity use for air conditioning in summer measured in megawatt-hours (MWh).

Espalier (Secondary Maintenance Need): Type of pruning that combines supporting and training branches to orient a plant in one plane.

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.

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): Identifies the minimum width of the tree grow space for root development.

grow space type (data field): Best identifies the type of location where a tree is growing. During the inventory, grow space types were categorized as island, median, open/restricted, open/unrestricted, raised planter, tree lawn/parkway, unmaintained/natural area, or well/pit.

hardscape damage (data field): Indicates trees damaged by hardscape or hardscape damaged by trees (for example, damage to curbs, cracking, lifting of sidewalk pavement 1 inch or more).

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 Streets displayed in table form for all species that make up more than 1% of the population. The i-Tree Streets IV is the mean of three relative values (percentage of total trees, percentage of total leaf area, and percentage of canopy cover) and can range from 0 to 100, with an IV of 100 suggesting total reliance on one species. IVs offer valuable information about a community's reliance on certain species to provide functional benefits. For example, a species might represent 10% of a population, but have an IV of 25% because of its great size, indicating that the loss of those trees due to pests or disease would be more significant than their numbers suggest.

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 has the ability to 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**.

IPED (data field): Invasive pest detection protocol; a standardized method for evaluating a tree for possible insect or disease.

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.

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 fields): A collection of data fields collected during the inventory to aid in finding trees, including address number, street name, site number, side, and block side.

location rating (data field): Describes/rates the position of a tree based on existing land use of the site, the functional and aesthetic contributions of the tree to the site, and surrounding structures or landscapes. Categories for location value include: Excellent, Good, Fair, and Poor. The location rating, along with species, size, and condition ratings, is used in determining a tree's value.

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.

Management Costs: Used in i-Tree Streets, they are the expenditures associated with street tree management presented in total dollars, dollars per tree, and dollars per capita.

mapping coordinate (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.

Net Annual Benefits: Specific data field for i-Tree Streets. Citywide benefits and costs are calculated according to category and summed. Net benefits are calculated as benefits minus costs.

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.

None (Secondary Maintenance Need): Used to show that no secondary maintenance is recommended for the tree. Usually a vacant planting site or stump will have a secondary maintenance need of *none*.

notes (data field): Describes additional pertinent information.

observations (data field): When conditions with a specific tree warrant recognition, it was described in this data field. Observations include cavity decay, grate guard, improperly installed, improperly mulched, improperly pruned, mechanical damage, memorial tree, nutrient deficiency, pest problem, poor location, poor root system, poor structure, remove hardware, serious decline, and signs of stress.

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.

Palm Prune (Primary Maintenance Need): Routine horticultural pruning to remove any dead, dying, or broken fronds.

Particulate Matter (PM_{10}): A major class of air pollutants consisting of tiny solid or liquid particles of soot, dust, smoke, fumes, and mists.

Plant Tree (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 growspace available and the presence of overhead wires.

Pollard (Secondary Maintenance Need): Pruning method in which tree branches are initially headed and then reduced on a regular basis without disturbing the callus knob.

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.

Raise (Secondary Maintenance Need): Signifies a maintenance need for a tree. Raising the crown is characterized by pruning to remove low branches that interfere with sight and/or traffic. It is based on *ANSI A300 (Part 1)*.

Reduce (Secondary Maintenance Need): Signifies a maintenance need for a tree. Reducing the crown is characterized by selective pruning to decrease height and/or spread of the crown in order to provide clearance for electric utilities and lighting.

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.

Restoration (Secondary Maintenance Need): Signifies a maintenance need for a tree. Restoration is selective pruning to improve the structure, form, and appearance of trees that have been severely headed, vandalized, or damaged.

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 B

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): Recommended maintenance for a tree, which may be risk oriented, such as raising the crown for clearance, but generally was geared toward improving the structure of the tree and enhancing aesthetics.

side value (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 the name of the street the arborist is walking towards or away as data are being collected. *Median* indicates a median or island. The *rear* is the side of the lot opposite the front.

site number (data field): All sites at an address are assigned a *site number*. Sites numbers are not unique; they are sequential to the side of the address only (the only unique number is the tree identification number assigned to each site). Site numbers are collected in the direction of vehicular traffic flow. The only exception is a one-way street. Site numbers along a one-way street are collected as if the street were actually a two-way street, so some site numbers will oppose traffic.

species: 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.

stems (data field): Identifies the number of stems or trunks splitting less than 1 foot above ground level.

Stored Carbon Report: While the i-Tree Streets Carbon Dioxide Report quantifies annual CO_2 reductions, the i-Tree Streets Stored Carbon Report tallies all of the Carbon (C) stored in the urban forest over the life of the trees as a result of sequestration measured in pounds as the CO_2 equivalent.

Stormwater Report: A report generated by i-Tree Streets that presents the reductions in annual stormwater runoff due to rainfall interception by trees measured in gallons (gals.).

street name (data field): The name of a street right-of-way or road identified using posted signage or parcel information.

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 defect: A feature, condition, or deformity of a tree or tree part that indicates weak structure and contributes to the likelihood of failure.

Stump Removal (Primary Maintenance Need): Indicates a stump that should be removed.

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.

Summary Report: A report generated by i-Tree Streets that presents the annual total of energy, stormwater, air quality, carbon dioxide, and aesthetic/other benefits. Values are reflected in dollars per tree or total dollars.

Thin (Secondary Maintenance Need): Signifies a maintenance need for a tree. Thinning the crown is the selective removal of water sprouts, epicormic branches, and live branches to reduce density.

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 Clean (Primary Maintenance Need): Based on *ANSI A300 Standards*, these trees require selective removal of dead, dying, broken, and/or diseased wood to minimize potential risk.

tree height (data field): If collected during the inventory, the height of the tree is estimated by the arborist and recorded in 10-foot increments.

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 of 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.

urban tree canopy (UTC) assessment: A study performed of land cover classes to gain an understanding of the tree canopy coverage, particularly as it relates to the amount of tree canopy that currently exists and the amount of tree canopy that could exist. Typically performed using aerial photographs, GIS data, or Lidar.

Utility (Secondary Maintenance Need): Selective pruning to prevent the loss of service, comply with mandated clearance laws, prevent damage to equipment, avoid access impairment, and uphold the intended usage of the facility/utility space.

Volatile Organic Compounds (VOCs): Hydrocarbon compounds that exist in the ambient air and are by-products of energy used to heat and cool buildings. Volatile organic compounds contribute to the formation of smog and/or are toxic. Examples of VOCs are gasoline, alcohol, and solvents used in paints.

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.

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APPENDIX A
DATA COLLECTION AND SITE LOCATION METHODS

Data Collection Methods

DRG collected tree inventory data using Rover mobile mapping software. Rover is a GIS field data collection system built by DRG.

The software both collects data and processes data validations. Rover spatially joins features such as points, lines or polygons with GIS layers in order to derive data. The tool's GPS capabilities allow it to merge nearby camera hardware with the tablet computer to attach photos to features and render data on top of Google Terrain Maps, Google Hybrid Maps and Open Street Maps (when Internet connection is available.)

Rover's on and offline functionality gives field technicians the ability to directly distribute information to clients. Data uploads or electronic forms are transmitted to clients in real-time. The knowledge and professional judgment of DRG's arborists ensure the high quality of inventory data.

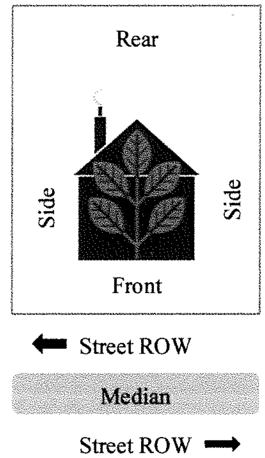
Data fields are defined in the glossary of the management plan. At each site, the following data fields were collected:

- condition
- grow space size
- grow space type
- further inspection
- hardscape damage
- location
- primary maintenance needs
- mapping coordinates
- observations
- overhead utilities
- notes
- risk assessment
- risk rating
- secondary maintenance needs
- species
- stems
- tree height
- tree size*

* measured in inches in diameter at 4.5 feet above ground (or diameter at breast height [DBH])

Maintenance needs are based on *Best Management Practices: Tree Risk Assessment* (International Society of Arboriculture [ISA] 2011).

The data collected were provided in an ESRI® shapefile, Access™ database, and Microsoft Excel™ spreadsheet on a CD-ROM that accompanies this plan.



Side values for street ROW sites.

Site Location Methods

Equipment and Base Maps

Inventory arborists use FZ-G1 Panasonic Toughpad® unit(s) and internal GPS receiver(s).

Base map layers were loaded onto these unit(s) to help locate sites during the inventory. Table 1 lists the base map layers, utilized along with source and format information for each layer.

Base Map Layers Utilized for Inventory

Imagery/Data Source	Date	Projection
Basemap Data Watertown, NY GIS Dept GIS ESRI Server https://watertown-ny.maps.arcgis.com/apps/webappviewer/index.html?id=8ae9de7760a9464b931f2b475d1e0970	2016-2018	NAD 1983 2011 StatePlane New York Central, FT
Aerial Imagery NY GIS Clearinghouse https://gis.ny.gov/	2015	NAD 1983 2011 StatePlane New York Central, FT

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, or side*. This methodology was developed by DRG to help ensure consistent assignment of location.

Address Number and Street Name

The *address number* was recorded 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. An "X" was then added to the number in the database to indicate that it was assigned (for example, "37X Choice Avenue").

Sites in medians or islands were assigned an address number using the address on the right side of the street in the direction of collection closest to the site. Each segment was numbered with an assigned address that was interpolated from addresses facing that median/island. If there were multiple median/islands between cross streets, each segment was assigned its own address.

The *street name* assigned to a site was determined by street ROW parcel information and posted street name signage.

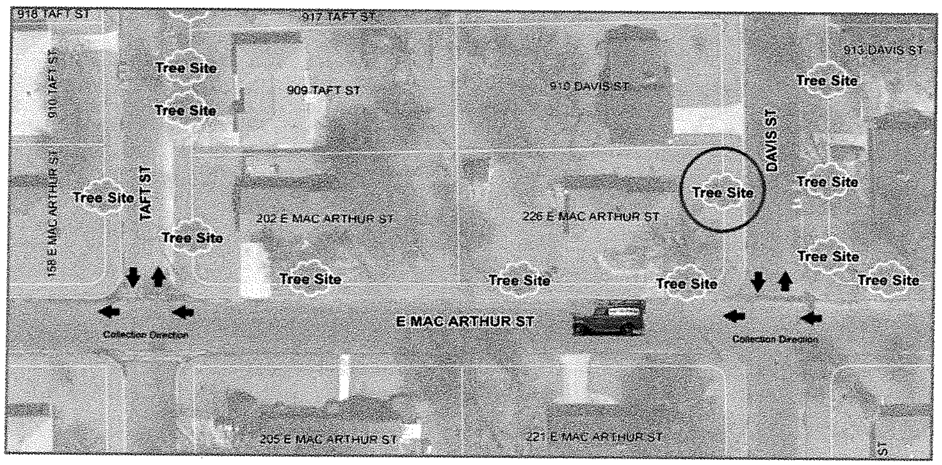
Side Value

Each site was assigned a *side value*. Side values include: *front, side, median* (includes islands), or *rear* based on the site's location in relation to the lot's street frontage (Figure 1). The *front side* is the side that faces the address street. *Side* is the name of the street the arborist walks towards or away from while collecting data. *Median* indicates a median or island. The *rear* is the side of the lot opposite the front.

Park and/or Public Space Site Location

Park and/or public space site locations were collected using the same methodology as street ROW site.

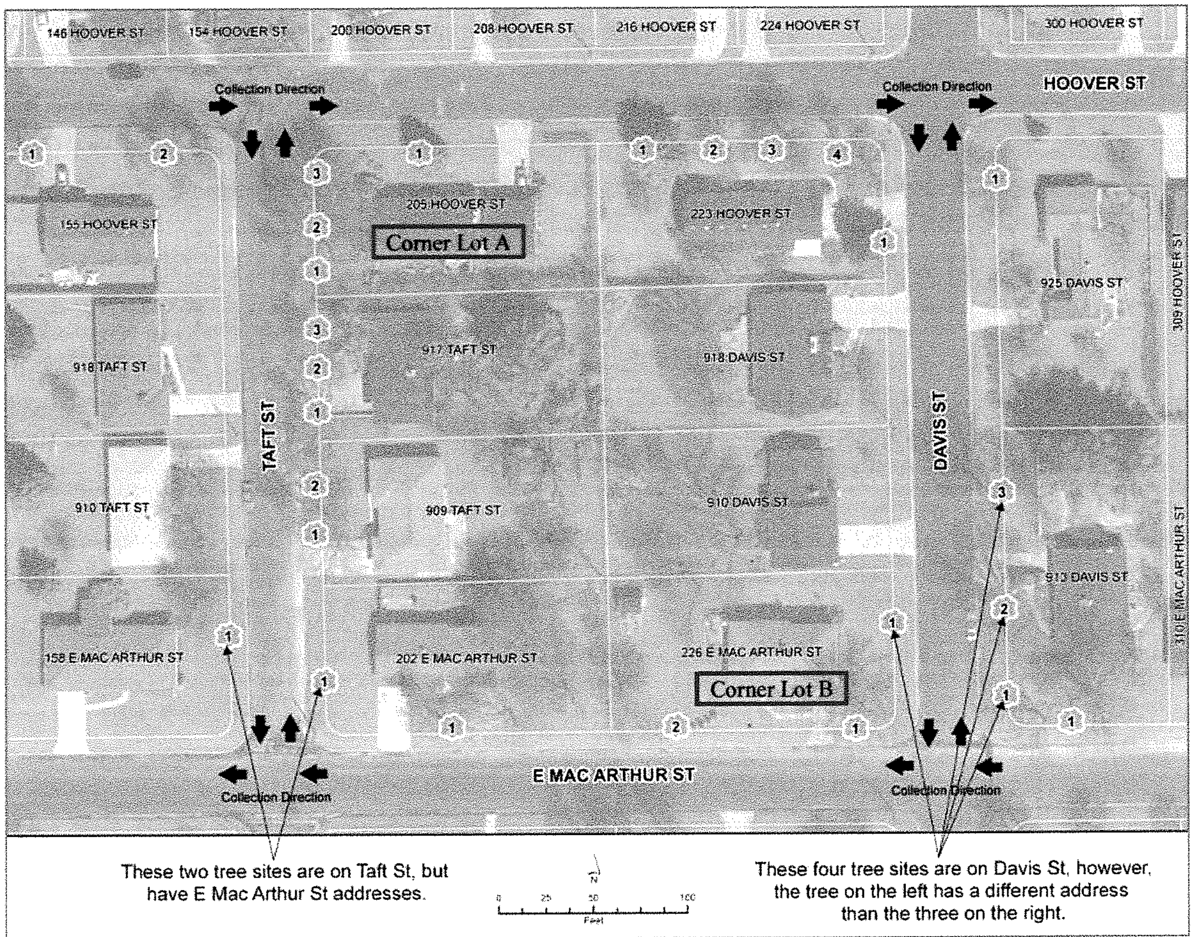
Site Location Examples



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/Street Name:	226 E. Mac Arthur Street
Side:	Side
On Street:	Davis Street

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.

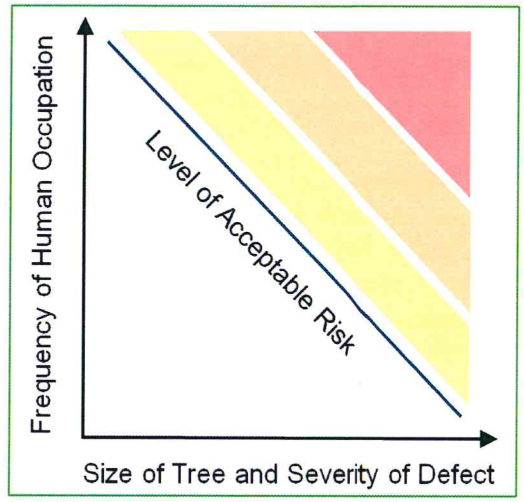


Location information collected for
inventoried trees at Corner Lots A and B.

Corner Lot A		Corner Lot B	
Address/Street Name:	205 Hoover St.	Address/Street Name:	226 E Mac Arthur St.
Side:	Side	Side:	Side
On Street:	Taft St.	On Street:	Davis St.
Address/Street Name:	205 Hoover St.	Address/Street Name:	226 E Mac Arthur St.
Side:	Side	Side:	Front
On Street:	Taft St.	On Street:	E Mac Arthur St.
Address/Street Name:	205 Hoover St.	Address/Street Name:	226 E Mac Arthur St.
Side:	Side	Side:	Front
On Street:	Taft St.	On Street:	E Mac Arthur St.
Address/Street Name:	205 Hoover St.		
Side:	Front		
On Street:	Hoover St.		

APPENDIX B
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 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.

- **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.
- **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.
    - Occasional use 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 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, Watertown may decide that cabling, bracing, or moving the target may be the best option for reducing risk.

Determination of acceptable risk ultimately lies with city 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.

In this plan, all tree removals and Extreme and High Risk prunes are included in the priority maintenance program.

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 C
RECOMMENDED SPECIES FOR FUTURE PLANTING

Proper landscaping and tree planting are critical components of the atmosphere, livability, and ecological quality of Watertown'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, among others. The following list is offered to assist all relevant Watertown 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 Zones 4b and 5a on the USDA Plant Hardiness Zone Map.

Deciduous Trees

Large Trees: Greater than 45 Feet in Height at Maturity

Scientific Name	Common Name	Cultivar
Acer nigrum	black maple	
Acer platanoides	Norway maple	'Cleveland', 'Deborah', 'Pond', 'Summershade'
Acer rubrum	red maple	'Brandywine', October Glory®, Red Sunset®
Acer saccharum	sugar maple	'Green Mountain', 'Legacy'
Acer × freemanii	Freeman maple	Numerous exist
Aesculus flava*	yellow buckeye	
Aesculus glabra*	Ohio buckeye	
Betula alleghaniensis*	yellow birch	
Betula lenta*	sweet birch	
Betula nigra	river birch	Heritage®
Betula papyrifera*	paper birch	
Carpinus betulus	European hornbeam	Numerous exist
Carya cordiformis*	bitternut hickory	
Carya illinoinensis × ovata*	hican	
Carya illinoinensis*	pecan	
Carya laciniosa*	shellbark hickory	
Carya ovata*	shagbark hickory	
Castanea mollissima*	Chinese chestnut	
Catalpa speciosa*	northern catalpa	
Celtis occidentalis	common hackberry	'Prairie Pride'
Cercidiphyllum japonicum	katsuratree	'Aureum'
Corylus colurna	Turkish filbert	
Diospyros virginiana*	common persimmon	
Fagus grandifolia*	American beech	
Fagus sylvatica*	European beech	Numerous exist
Ginkgo biloba	ginkgo	Male trees only
Gleditsia triacanthos inermis	thornless honeylocust	Numerous exist
Gymnocladus dioica	Kentucky coffeetree	Prairie Titan®
Juglans cinerea*	butternut	'Chamberlin'
Juglans nigra*	black walnut	'Buckley', 'Emma Kay', 'Morehead', 'Rowher'

Large Trees: Greater than 45 Feet in Height at Maturity (Cont'd.)

Scientific Name	Common Name	Cultivar
Juglans regia*	English walnut	
Liquidambar styraciflua	American sweetgum	'Rotundiloba'
Liriodendron tulipifera*	tuliptree	'Fastigiatum'
Magnolia acuminata*	cucumbertree magnolia	Numerous exist
Magnolia macrophylla*	bigleaf magnolia	
Nyssa sylvatica	blackgum	
Platanus occidentalis*	American sycamore	
Platanus × acerifolia	London planetree	Numerous exist
Quercus alba	white oak	
Quercus bicolor	swamp white oak	
Quercus coccinea	scarlet oak	
Quercus imbricaria	shingle oak	
Quercus macrocarpa	bur oak	
Quercus muehlenbergii	chinkapin oak	
Quercus palustris	pin oak	
Quercus prinus	chestnut oak	
Quercus robur	English oak	
Quercus robur fastigiata × bicolor	Regal Prince® oak	
Quercus rubra	northern red oak	'Splendens'
Quercus stellata*	post oak	
Quercus velutina*	black oak	
Quercus × macdanielli	Heritage® oak	
Styphnolobium japonicum	Japanese pagodatree	'Regent'
Tilia americana*	American linden	'Redmond'
Tilia cordata	littleleaf linden	'Greenspire'
Tilia tomentosa	silver linden	'Sterling'
Ulmus americana	American elm	'Delaware #2', 'Princeton', 'Valley Forge', 'Washington'
Ulmus japonica	Japanese elm	Numerous exist
Ulmus parvifolia	Chinese elm	Numerous exist
Ulmus ×	hybrid elm	Numerous exist
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	'Briotii'
Alnus cordata	Italian alder	
Asimina triloba*	common pawpaw	
Cladrastis kentukea	American yellowwood	'Rosea'
Corylus colurna	Turkish filbert	
Eucommia ulmoides	hardy rubber tree	
Koelreuteria paniculata*	goldenraintree	
Ostrya virginiana	American hophornbeam	
Parrotia persica	Persian parrotia	'Vanessa'
Phellodendron amurense*	Amur corktree	'Macho'
Populus tremuloides*	quaking aspen	
Prunus maackii	Amur chokecherry	'Amber Beauty'
Prunus sargentii	Sargent cherry	
Pterocarya fraxinifolia*	Caucasian wingnut	
Quercus acutissima*	sawtooth oak	
Quercus cerris	European turkey oak	
Sassafras albidum*	sassafras	
Tilia × euchlora	Crimean linden	

Small Trees: 15 to 30 Feet in Height at Maturity

Scientific Name	Common Name	Cultivar
Acer buergerianum	trident maple	Streetwise®
Acer campestre	hedge maple	Queen Elizabeth™
Acer cappadocicum	coliseum maple	'Aureum'
Acer griseum	paperbark maple	
Acer miyabei	Miyabe maple	'Morton'
Acer oliverianum	Chinese maple	
Acer palmatum	Japanese maple	
Acer pensylvanicum*	striped maple	
Acer tataricum ginnala*	Amur maple	Red Rhapsody™
Acer triflorum	three-flower maple	
Aesculus pavia*	red buckeye	
Amelanchier arborea	downy serviceberry	Numerous exist
Amelanchier laevis	Allegheny serviceberry	
Amelanchier × grandiflora	apple serviceberry	'Autumn Brilliance'
Betula populifolia	gray birch	
Betula ×	hybrid birch	Numerous exist
Carpinus caroliniana*	American hornbeam	
Cercis canadensis	eastern redbud	'Forest Pansy'
Chionanthus virginicus	white fringetree	
Cornus alternifolia	pagoda dogwood	
Cornus kousa	kousa dogwood	Numerous exist
Cornus mas	corneliancherry dogwood	'Spring Sun'

Small Trees: 15 to 30 Feet in Height at Maturity (Cont'd.)

Scientific Name	Common Name	Cultivar
Corylus avellana*	European filbert	'Contorta'
Cotinus coggygria*	common smoketree	'Flame'
Cotinus obovatus*	American smoketree	
Crataegus crusgalli*	cockspur hawthorn	
Crataegus phaenopyrum*	Washington hawthorn	Princeton Sentry™
Crataegus spp.	hawthorns	Numerous exist
Crataegus viridis	green hawthorn	'Winter King'
Halesia tetraptera*	Carolina silverbell	'Arnold Pink'
Heptacodium miconioides	seven-son flower	
Laburnum × watereri	goldenchain tree	
Maackia amurensis	Amur maackia	
Magnolia stellata*	star magnolia	'Centennial'
Magnolia tripetala*	umbrella magnolia	
Magnolia virginiana*	sweetbay magnolia	Moonglow®
Magnolia × soulangiana*	saucer magnolia	'Alexandrina'
Malus spp.	flowering crabapple	Disease resistant only
Prunus subhirtella	Higan cherry	'Pendula'
Prunus virginiana	common chokecherry	'Canada Red'
Sorbus alnifolia	Korean mountainash	
Staphylea trifolia*	American bladdernut	
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	'Candicans', 'Violacea'
Larix decidua	European larch	Deciduous conifer
Larix laricina	tamarack	Deciduous conifer
Metasequoia glyptostroboides	dawn redwood	Deciduous conifer
Picea abies	Norway spruce	
Picea glauca	white spruce	
Picea glauca densata	Black Hills spruce	
Picea mariana	black spruce	Numerous exist
Picea omorika	Serbian spruce	
Picea orientalis	Oriental spruce	
Picea pungens	Colorado spruce	'Foxtail', 'Hoopsii'
Pinus densiflora	Japanese red pine	
Pinus heldreichii leucodermis	Bosnian pine	
Pinus koraiensis	Korean white pine	
Pinus ponderosa	ponderosa pine	

Large Trees: Greater than 45 Feet in Height at Maturity (Cont'd.)

Scientific Name	Common Name	Cultivar
Pinus strobus	eastern white pine	
Pinus sylvestris	Scotch pine	
Psedotsuga menziesii	Douglas-fir	
Pseudolarix amabilis	golden larch	Deciduous conifer
Taxodium distichum	common baldcypress	'Shawnee Brave' Deciduous conifer
Taxodium distichum nutans	pondcypress	Deciduous conifer
Tsuga canadensis	eastern hemlock	
Xanthocyparis nootkatensis	Nootka falsecypress	'Pendula'

Medium Trees: 31 to 45 Feet in Height at Maturity

Scientific Name	Common Name	Cultivar
Chamaecyparis thyoides	Atlantic whitecedar	Numerous exist
Ilex opaca	American holly	Numerous exist
Juniperus virginiana	eastern redcedar	
Pinus bungeana	lacebark pine	
Pinus cembra	Swiss stone 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
Juniper spp.	junipers	Numerous exist
Pinus aristata	bristlecone pine	
Pinus mariana	black spruce	Numerous exist
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 D
TREE PLANTING

Tree Planting

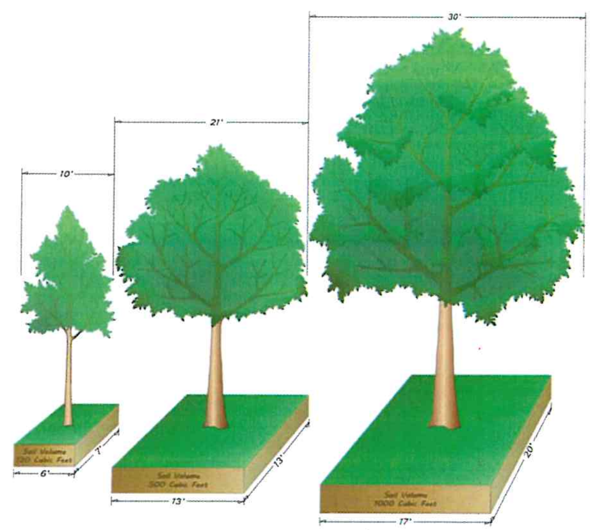
Planting trees is a valuable goal as long as tree species are carefully selected and correctly planted. When trees are planted, they are planted selectively and with purpose. Without proactive planning and follow-up tree care, a newly planted tree may become a future problem instead of a benefit to the 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.

Inventoried Street ROW Planting Space

The goal of tree planting is to have a vigorous, healthy tree that lives to the limits of its natural longevity. That can be difficult to achieve in an urban growing environment because irrigation is limited and the soils are typically poor quality. However, proper planning, species selection, tree planting techniques, and follow-up tree maintenance will improve the chance of tree planting success.



Minimum recommended requirements for tree sites is based on tree size/dimensions. This illustration is based on the work of Casey Trees (2008).

Findings

The inventory found 1,912 planting sites, of which 3% are designated for small-sized mature trees, 69% for medium-sized trees, and 28% for large-sized trees. Plant small-sized trees where the growing space is either too small for a medium- or large-sized species or where overhead utilities are present.

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 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.

Watertown is located in USDA Hardiness Zone 4b, which is identified as a climatic region with average annual minimum temperatures between −25°F and −20°F. Tree species selected for planting in Watertown 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 saccharum* (sugar maple) until the species distribution normalizes.

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 climate. Generally, the planting hole is two to three times wider and not quite as deep as the root ball. The root flair is 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

Mulch can be applied to the growspace 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 growspace 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.

Watertown 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 Watertown'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 the city'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 city's urban forestry program and encourage tree planting on private property. Watertown should encourage citizens to water trees on the ROW adjacent to their homes and to reach out to the city if they notice any changes in the trees, such as signs or symptoms of pests, early fall foliage, or new mechanical or vehicle damage.

APPENDIX E
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 clean-up costs. Keeping these pests and diseases out of the country is the number one priority of the United States Department of Agriculture's (USDA) Animal and Plant Inspection Service (APHIS).

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, hungry 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.

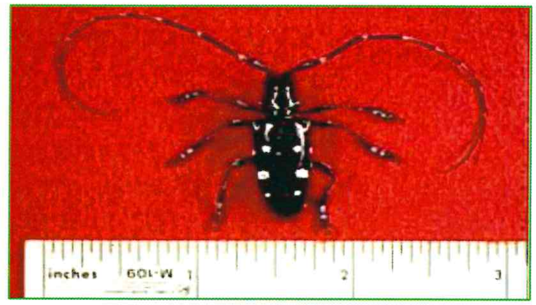
USDA APHIS, Plant Health, Plant Pest Program Information
- www.aphis.usda.gov/plant_health/plant_pest_info

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

Asian Longhorned Beetle



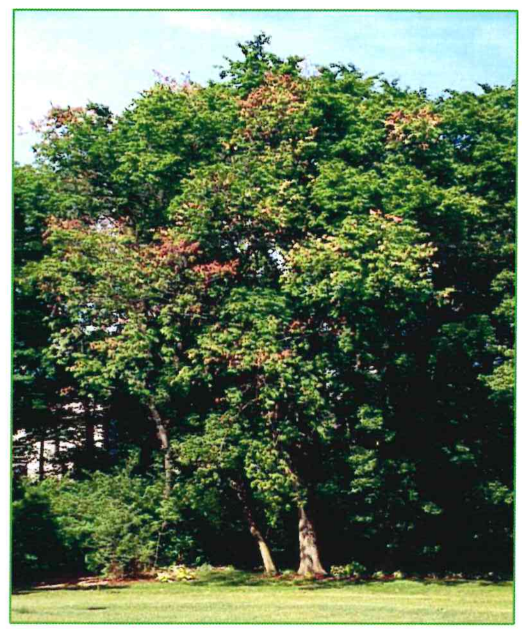
Adult Asian longhorned beetle

Photograph courtesy of New Bedford Guide 2011

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 introduced 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.

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* (birch), *Platanus* × *acerifolia* (London planetree), *Salix* (willow), and *Ulmus* (elm).

Dutch Elm Disease



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)

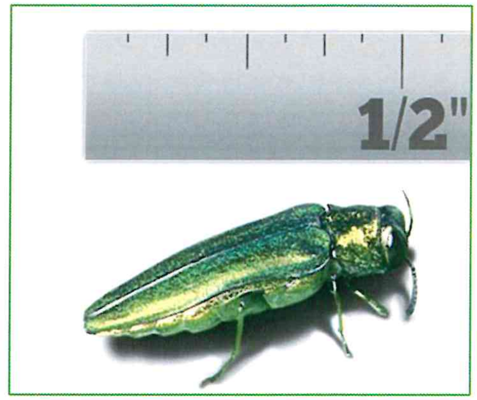
Considered by many to be one of the most destructive, invasive diseases of shade trees in the United States, Dutch elm disease (DED) was first found in Ohio in 1930; by 1933, the disease was present in several East Coast cities. By 1959, it had killed thousands of elms. Today, DED covers about two-thirds of the eastern United States, including Illinois, 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, resulting in rapid leaf yellowing, tree decline, and death.

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).*

The species most affected by DED is the *Ulmus americana* (American elm).

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.



Close-up of the emerald ash borer

Photograph courtesy of APHIS (2011)

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).

Gypsy Moth

The gypsy moth (GM) *(Lymantria 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 species vulnerable to diseases and other pests that can eventually kill the tree.

Close-up of male (darker brown) and female (whitish color) European gypsy moths

Photograph courtesy of APHIS (2011b)

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. Some trees are found in these common genera: *Betula* (birch), *Juniperus* (cedar), *Larix* (larch), *Populus* (aspen, cottonwood, poplar), *Quercus* (oak), and *Salix* (willow).

Granulate Ambrosia Beetle

Adult granulate ambrosia beetle

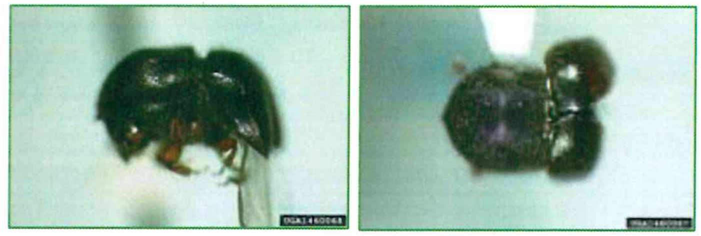
Photograph courtesy of Paul M. Choate, University of Florida (Atkinson et al. 2011)

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. The beetle is globally present in countries such as equatorial Africa, Asia, China, Guinea, Hawaii, India, Japan, New South Pacific, Southeast Indonesia, Sri Lanka, and the United States. 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 conifers. 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). *Carya illinoinensis* (pecan) and *Pyrus calleryana* (Bradford pear) are commonly attacked in Florida and in the southeastern United States.

Xm Ambrosia Beetle



Xm ambrosia beetle

Photograph courtesy of Michael C. Thomas, Florida Department of Agriculture and Consumer Services (Rabaglia et al 2003)

The Xm ambrosia beetle (*Xylosandrus mutilatus*), is native to Asia and was first detected in the United States in 1999 in traps near Starkville, Mississippi. By 2002, the beetle spread throughout Missouri and quickly became well-established in Florida. The species also has been found in Alabama, northern Georgia, and Texas. In addition to its prevalence in the southeastern United States, the Xm ambrosia beetle is currently found in China, India, Indonesia, Japan, Korea, Malaya, Myanmar, Papua New Guinea, Sri Lanka, Taiwan, and Thailand.

This species generally targets weakened and dead trees. Since the beetle attacks small diameter material, it may be commonly transported in nursery stock. Female adults are prone to dispersal by air currents and can travel 1–3 miles in pursuit of potential hosts. This active capability results in a broad host range and high probability of reproduction. The species is larger than any other species of *Xylosandrus* (greater than 3 millimeters) in the U.S. and is easily recognized by its steep declivity and dark brown to black elytra (hard casings protecting the wings). Larvae are white and c-shaped with an amber colored head capsule.

Known hosts in the U.S. include: *Acer* (maple); *Albizia* (silktree); *Benzoin* (northern spicebush); *Camellia* (camellia); *Carpinus laxiflora* (looseflower hornbeam); *Castanae* (sweet chestnut); *Cinnamomum camphora* (camphor tree); *Cornus* (dogwood); *Cryptomeria japonica* (Japanese cedar); *Fagus crenata* (Japanese beech); *Lindera erythrocarpa* (spicebush); *Machilus thurnbergii* (Japanese persea); *Ormosia hosiei* (ormosia); *Osmanthus fragrans* (sweet osmanthus); *Parabezion praecox*; *Platycarpa*; and *Sweitenia macrophylla* (mahogany).

Hemlock Woolly Adelgid

The hemlock woolly adelgid (HWA, *Adelges tsugae*) was first described in western North America in 1924 and first reported in the eastern United States in 1951 near Richmond, Virginia.

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 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.

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.

Oak wilt symptoms on red and white 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

Mined shoots on a Scotch pine

Photograph courtesy of USDA Forest Service (1993)

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).

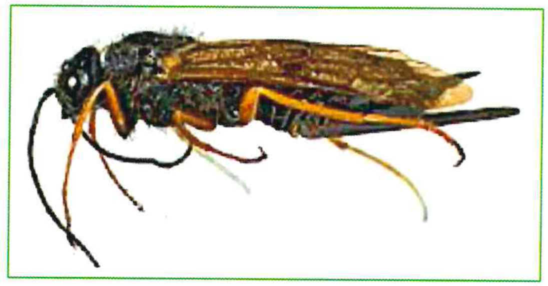
The beetle attacks new shoots of pine trees, stunting the growth of the trees. The pine shoot beetle may also attack stressed pine trees by breeding under the bark at the base of the trees. The beetles can cause severe decline in the health of the trees and, in some cases, kill the trees when high populations 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.



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 pines, while native woodwasps attack only dead and dying trees. At low populations, 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 pines 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.

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.

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.

Drooping tanoak shoot

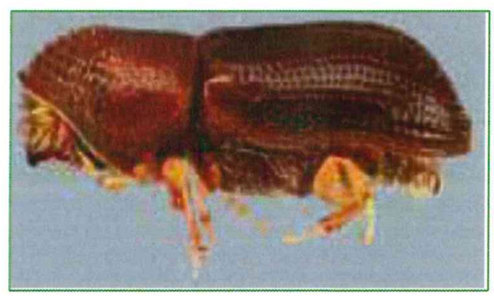
Photograph courtesy of Indiana Department of Natural Resources (2012)

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* (oaks) 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.



Walnut twig beetle, side view

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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