TREE MANAGEMENT PLAN

City of Binghamton
New York

October 2018

Prepared for:

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ACKNOWLEDGMENTS

The City of Binghamton'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.

The City of Binghamton is thankful for the grant funding it received from the New York State Department of Environmental Conservation through its Urban and Community Forestry (U&CF) Grant Program. The U&CF Grant Program is designed to encourage communities to create and support long-term and sustained urban and community forestry programs throughout New York State.

The City of Binghamton also recognizes the support of New York State Department of Environmental Conservation; City of Binghamton Department of Planning, Housing, and Community Development; City of Binghamton Department of Parks and Recreation; and City of Binghamton Mayor's Office.

EXECUTIVE SUMMARY

This plan was developed for the City of Binghamton by Davey Resource Group, Inc. (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 Binghamton's existing program and vision for the urban forest were utilized to develop this *Tree Management Plan*.

State of the Existing Urban Forest

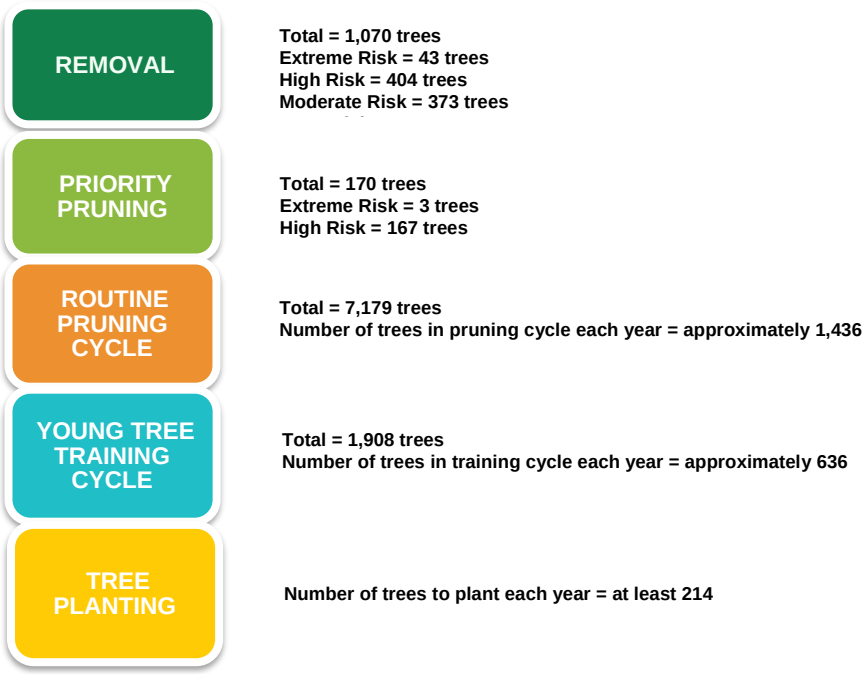
The 2016 and 2018 inventories included trees, stumps, and planting sites along public street rights-of-way (ROW), and in specified parks and public facilities. The parks selected for the inventory include: ACA Memorial Park, Alfred Street Park, Baseball Stadium, Boland Park, Booth Field, Brown Park, Cheri Lindsey Park, Columbus Park, Confluence Park, Ely Park Golf Course, Fairview Park, First Ward Park, Fritz Wallenburg Park, Kennedy Park, MacArthur Park, Martin Luther King, Jr. Park, Parlor City Commons, Sandy Beach Park, South Side Park, Southside Commons, State Street Park, Sunflower Park, Tyler Park, Valley Street Park, Walnut Street Park, Webster Street Park, and West End Park. A total of 16,700 sites were recorded during the inventories: 10,645 trees, 329 stumps, and 5,726 planting sites. Analysis of the tree inventory data found the following:

- Two species, *Acer platanoides* (Norway maple) and *Gleditsia triacanthos* (honeylocust), comprise a large percentage of existing street trees (22% and 11%, respectively) and threaten biodiversity.
- Two species, *Quercus rubra* (northern red oak) and *Acer rubrum* (red maple), comprise a large percentage of the existing park trees (12% and 9%, respectively) and threaten biodiversity.
- Regarding street trees, *Acer* (maple) was found to be overabundant (27%), which is a concern for Binghamton's biodiversity.
- Regarding park trees, both *Quercus* (oak) and *Acer* (maple) were found to be overabundant (23%), which is a concern for Binghamton's biodiversity.
- The diameter size class distribution of the inventoried tree population trends towards slightly ideal, with a greater number of established trees than young, maturing, or mature trees.
- The overall condition of the inventoried tree population is rated as fair.
- Approximately 8% of the inventoried trees had cavities or decay.
- Approximately 37% of the inventoried trees had a clearance issue.
- Granulate ambrosia beetle (*Xylosandrus crassiusculus*) and Asian longhorned beetle (*Anoplophora glabripennis*) pose the biggest threats to the health of the inventoried population.

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 (6%); Stump Removal (2%); Routine Pruning (43%); Young Tree Train (11%); and Plant Tree (34%). Maintenance should be prioritized by focusing on trees with the highest risk first.

The inventory noted some Extreme and many High-Risk trees (0.4% and 5%, respectively) and 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.



Binghamton'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 636 young trees should be structurally pruned each year during the young tree training cycle, and approximately 1,436 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). Davey Resource Group recommends planting at least 214 trees of a variety of species each year to offset these losses, increase canopy, maximize benefits, and account for ash tree loss.

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* (maple) along streets and in parks and *Quercus* (oak) in parks should be limited until the species distribution normalizes. The city's existing planting list offers astute 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 both short- 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 $499,000. This total will decrease to approximately $292,000 per year by Year 3 of the program. High-priority removal and pruning is costly and, 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* or similar software is crucial for making informed management decisions and projecting accurate maintenance budgets.

Binghamton 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.

2019 $499,000

Work	Concern	Trees	Cost
Removal	Extreme / High Risk	447	$179,719
Pruning	Extreme / High Risk	170	$25,595
Training	Young Tree	636	$13,010
5-yr Cycle	Routine Pruning	1441	$177,615
Planting	Replacement Trees	214	$59,920
Maintenance	New Tree Upkeep	214	$42,800
New	Discovery work	X	TBD

2020 $490,000

Work	Concern	Trees	Cost
Removal	Moderate / Low Risk	623	$175,325
Training	Young Tree	635	$12,980
5-yr Cycle	Routine Pruning	1437	$176,265
Planting	Replacement Plantings	214	$59,920
Maintenance	New Tree Upkeep	214	$42,800
New	Discovery work	X	TBD

2021 $292,000

Work	Concern	Trees	Cost
Training	Young Tree	634	$12,960
5-yr Cycle	Routine Pruning	1434	$176,095
New	Replacement Plantings	214	$59,920
Maintenance	New Tree Upkeep	214	$42,800
New	Discovery work	X	TBD

2022 $292,000

Work	Concern	Trees	Cost
Training	Young Tree	636	$13,010
5-yr Cycle	Routine Pruning	1434	$176,095
New	Replacement Plantings	214	$59,920
Maintenance	New Tree Upkeep	214	$42,800
New	Discovery work	X	TBD

2023 $292,000

Work	Concern	Trees	Cost
Training	Young Tree	636	$13,010
5-yr Cycle	Routine Pruning	1434	$176,095
New	Replacement Plantings	214	$59,920
Maintenance	New Tree Upkeep	214	$42,800
New	Discovery work	X	TBD

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INTRODUCTION

The City of Binghamton is home to more than 47,000 full-time residents who enjoy the beauty and benefits of their urban forest. The city's forestry program 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). For years, Binghamton's Parks Department has maintained staff committed to developing a strong urban forest.

Funding for the city's urban forestry program comes from the general fund. Binghamton conducted an inventory of public trees in two phases in the years 2016 and 2018. The city has a tree ordinance, maintains a budget of more than $2.62 per capita for tree-related expenses, celebrates Arbor Day, and has been a Tree City USA community for 16 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 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.

Starting in 2016, Binghamton worked closely 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 two sections:

- *Section 1: Tree Inventory Analysis* summarizes the tree inventory data and presents trends, results, and observations.
- *Section 2: 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 1: TREE INVENTORY ANALYSIS

In 2016 and 2018, DRG arborists assessed and inventoried trees, stumps, and planting sites in the street ROW, specified parks, and public facilities. A total of 16,700 sites were collected during the inventory: 10,645 trees, 329 stumps, and 5,726 planting sites. Of the 16,700 sites collected, 91% were collected in the street ROW, and the remaining 9% were collected in parks and public spaces. The city's public street rights-of-way were selected by Binghamton for the inventory. Table 1 provides a detailed breakdown of the number and type of sites inventoried.

Photograph 1. *Davey's ISA Certified Arborists inventoried trees along the street ROW and in community parks to collect information about trees that could be used to assess the state of the urban forest.*

Twenty-seven community parks and public spaces were selected by Binghamton for the tree inventory. Inventoried parks and public spaces include: ACA Memorial Park, Alfred Street Park, Baseball Stadium, Boland Park, Booth Field, Brown Park, Cheri Lindsey Park, Columbus Park, Confluence Park, Ely Park Golf Course, Fairview Park, First Ward Park, Fritz Wallenburg Park, Kennedy Park, MacArthur Park, Martin Luther King, Jr. Park, Parlor City Commons, Sandy Beach Park, South Side Park, Southside Commons, State Street Park, Sunflower Park, Tyler Park, Valley Street Park, Walnut Street Park, Webster Street Park, and West End Park.

Assessment of Tree Inventory Data

Data analysis and professional judgment are used to generalize the state of the inventoried tree population. Recognizing trends in the data can help guide short-and long-term management planning. See Appendix A for more information about 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.

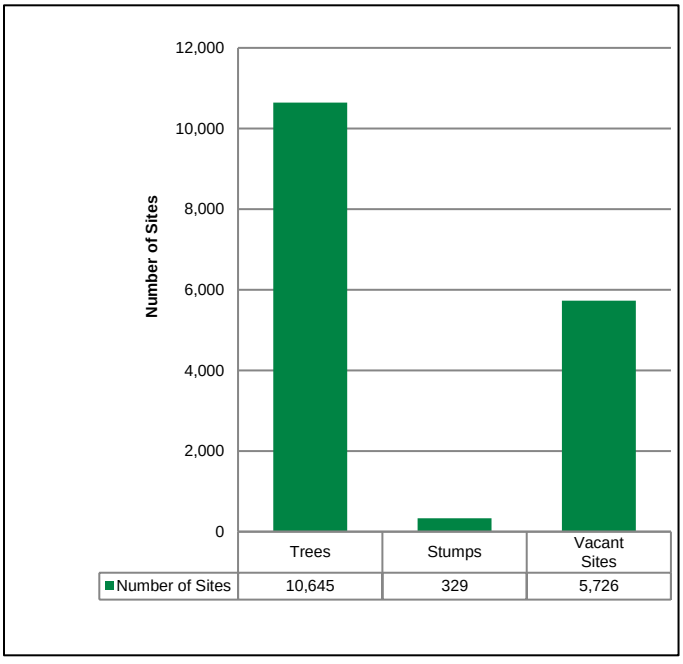


Figure 1. Sites collected during the 2016 and 2018 inventories.

- *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 tree requires additional inspection, such as a Level III risk inspection in accordance with ANSI A300, Part 9 (ANSI 2017), or periodic inspection due to certain conditions that may cause the tree to be a safety risk and, therefore, hazardous.

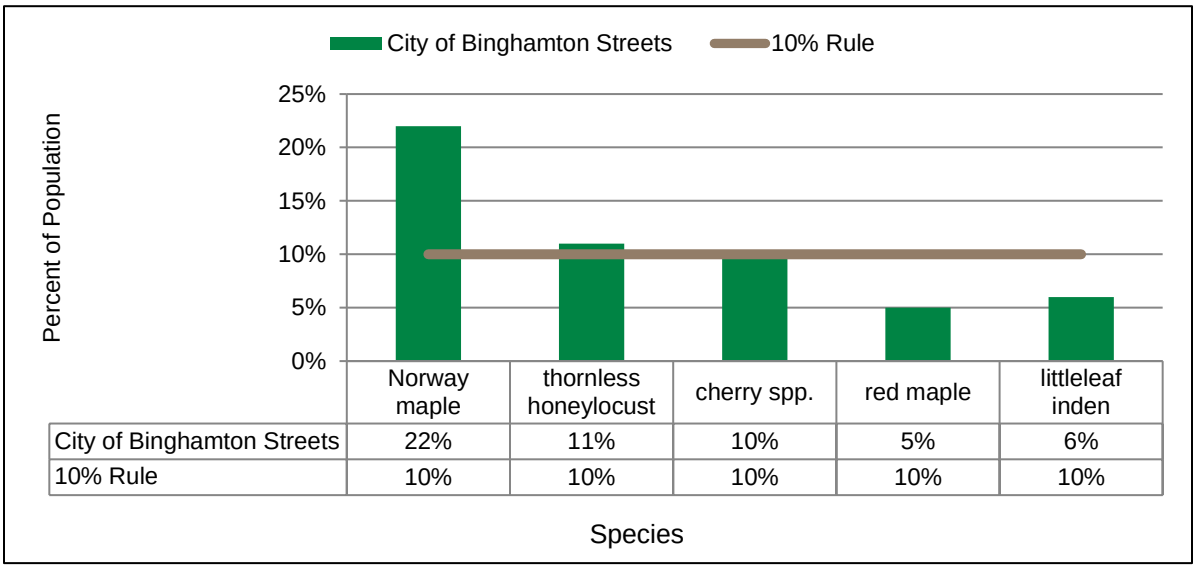
Species Diversity

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 (many 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 other 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

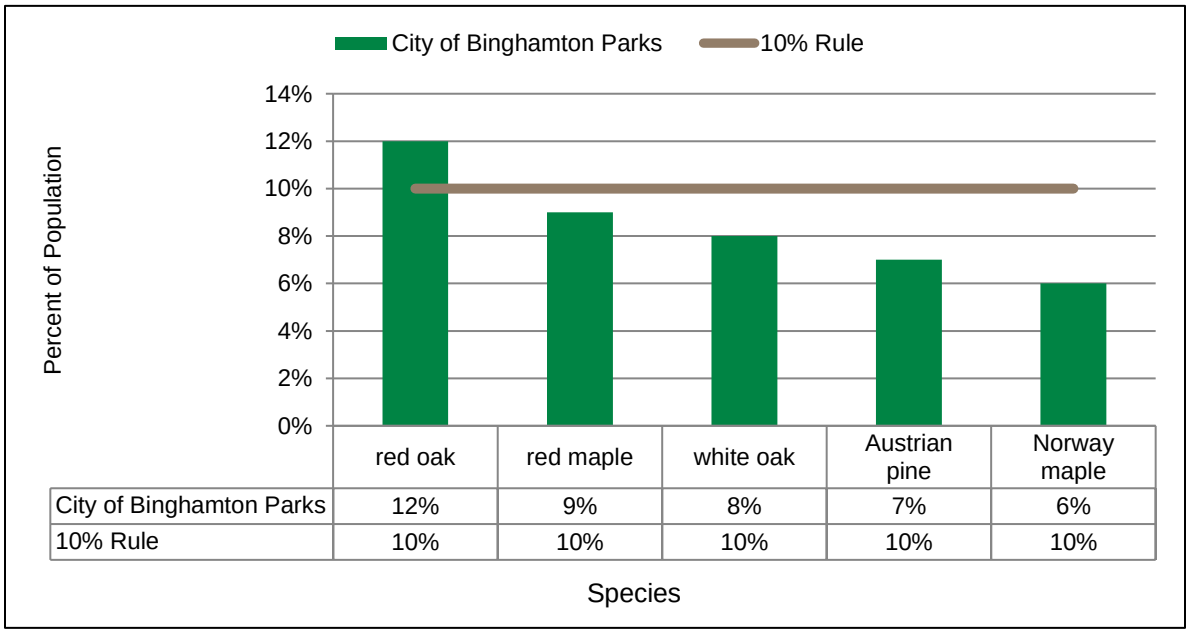
Analysis of Binghamton's tree inventory data indicated that the street ROW and park tree population had relatively good diversity, with 61 genera and 137 species represented.



	Norway maple	thornless honeylocust	cherry spp.	red maple	littleleaf linden
City of Binghamton Streets	22%	11%	10%	5%	6%
10% Rule	10%	10%	10%	10%	10%

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

Figure 2 uses the 10% Rule to compare the percentages of the most common species identified during the inventory to the street tree population. Norway maple (*Acer platanoides*) and thornless honeylocust (*Gleditsia triacanthos inermis*) exceed the recommended 10% maximum for a single species in a population, comprising 22% and 11% of the inventoried tree population, respectively. Cherry species (Prunus spp.) are at the 10% threshold.

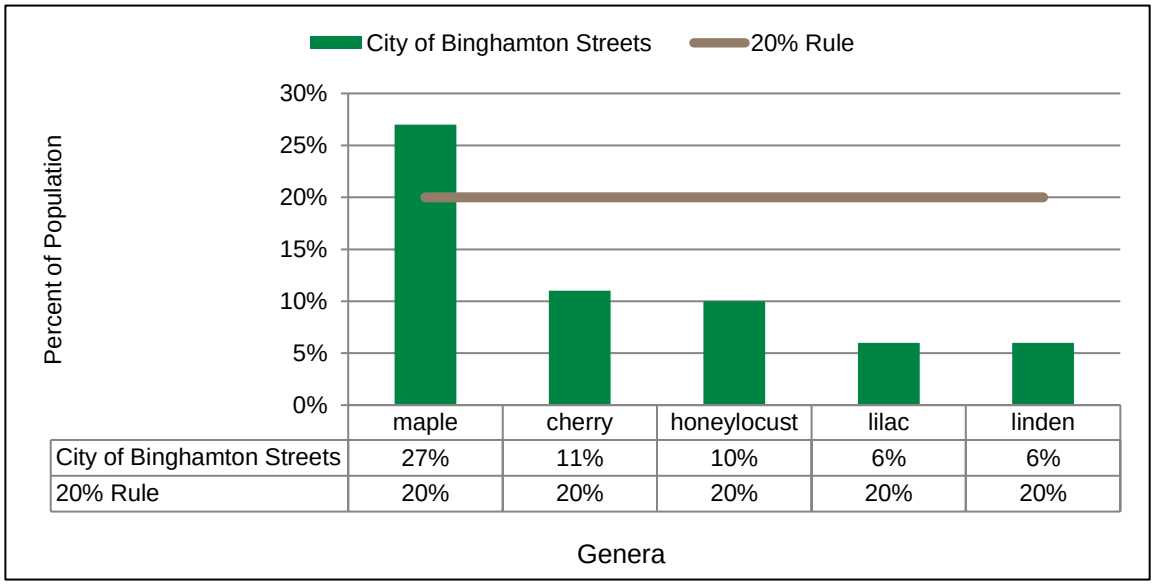


	red oak	red maple	white oak	Austrian pine	Norway maple
City of Binghamton Parks	12%	9%	8%	7%	6%
10% Rule	10%	10%	10%	10%	10%

Figure 3. Five most abundant Park species of the inventoried population compared to the 10% Rule.

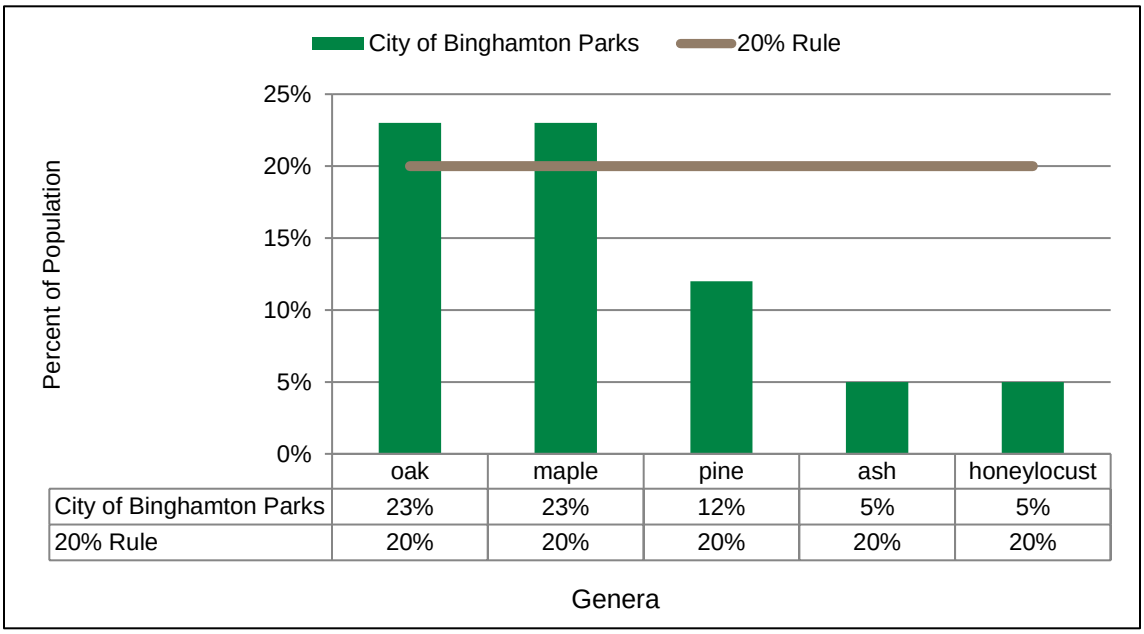
Figure 3 uses the 10% Rule to compare the percentages of the most common species identified during the inventory to the park tree population. Northern red oak (*Quercus rubra*) exceeds the recommended 10% maximum for a single species in a population, comprising 12% of the inventoried tree population. Red maple (acer rubrum) and white oak (*Quercus alba*) are at the 10% threshold.

Figure 4 uses the 20% Rule to compare the percentages of the most common genera identified during the inventory to the street tree population. Maple (*Acer*) far exceed the recommended 20% maximum for a single genus in a population, comprising 27% of the inventoried tree population.



	maple	cherry	honeylocust	lilac	linden
City of Binghamton Streets	27%	11%	10%	6%	6%
20% Rule	20%	20%	20%	20%	20%

Figure 4. Five most abundant Street genera of the inventoried population compared to the 20% Rule.



	oak	maple	pine	ash	honeylocust
City of Binghamton Parks	23%	23%	12%	5%	5%
20% Rule	20%	20%	20%	20%	20%

Figure 5. Five most abundant Park genera of the inventoried population compared to the 20% Rule.

Figure 5 uses the 20% Rule to compare the percentages of the most common genera identified during the inventory to the park tree population. Oak (*Quercus*) and maple (*Acer*) exceed the recommended 20% maximum for a single genus in a population, comprising 23% of the inventoried tree population.

Discussion/Recommendations

Acer (maple) and *Quercus* (oak) dominate the streets and parks. This is a biodiversity concern because their abundance in the landscape makes them a limiting species. Continued diversity of tree species is an important objective that will ensure Binghamton's urban forest is sustainable and resilient to future invasive pest infestations.

Considering the large quantity of Norway maple (*Acer platanoides*) in the city's population, especially along city streets, and given its susceptibility to Asian longhorned beetle (ALB, *Anoplophora glabripennis*), the planting of Norway maple should be limited to minimize the potential for loss in the event that ALB threatens Binghamton'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.

Findings

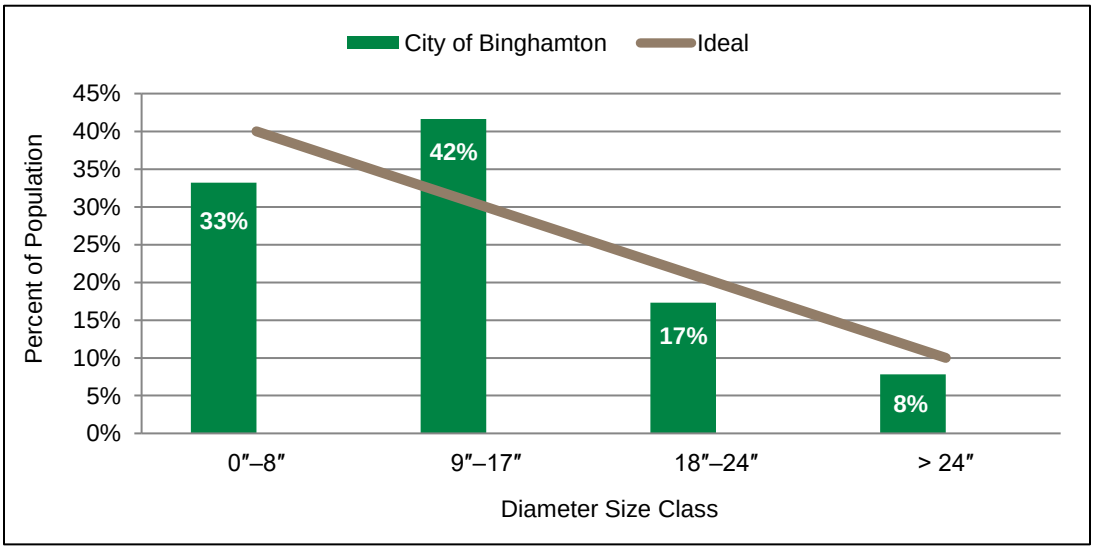


Figure 6. Comparison of diameter size class distribution for inventoried trees to the ideal distribution.

Figure 6 compares Binghamton's diameter size class distribution of the inventoried tree population to the ideal proposed by Richards (1983). Binghamton's distribution trends towards the ideal; established trees exceed the ideal by over 12%, while larger diameter size classes fall short of the ideal. The diameter size class distribution of the park and street tree populations trends to the ideal as well; however, young trees fall short of the ideal by nearly 7%, while mature trees exceed the ideal.

Discussion/Recommendations

Even though it may appear that Binghamton may have too many established trees, this is not the case. Binghamton has too few maturing, and mature trees, which indicates that the distribution is skewed. One of Binghamton's objectives is to have an uneven-aged distribution of trees at the city-wide level. DRG recommends that Binghamton 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 its older trees. See Appendix B for more information about 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 about species selection.

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, and 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.

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.

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

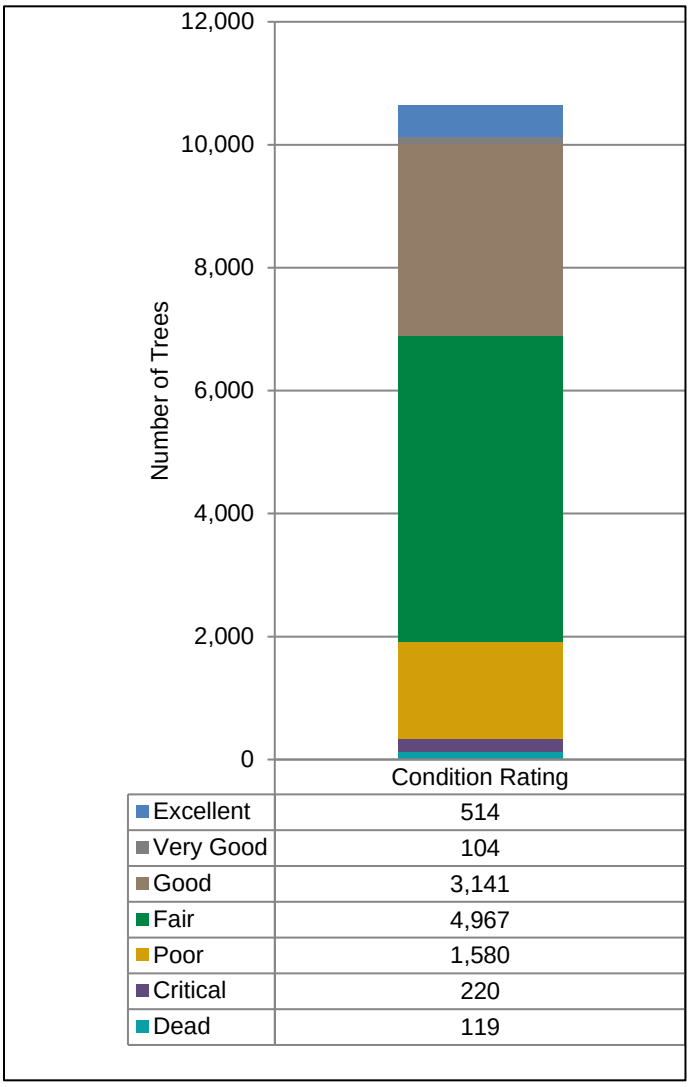


Figure 7. Conditions of inventoried trees.

Findings

Most of the inventoried trees were recorded to be in Fair and Good condition, 47% and 30%, respectively (Figure 7). Based on these data, the general health of the overall inventoried tree population is rated Fair. Figure 8 illustrates that most of the young, established, and maturing trees were rated to be in Good condition, and that most of the mature trees were rated to be in Fair condition.

Discussion/Recommendations

Even though the condition of Binghamton'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 across street and park trees reveals that growing conditions and/or past management of trees were consistent.

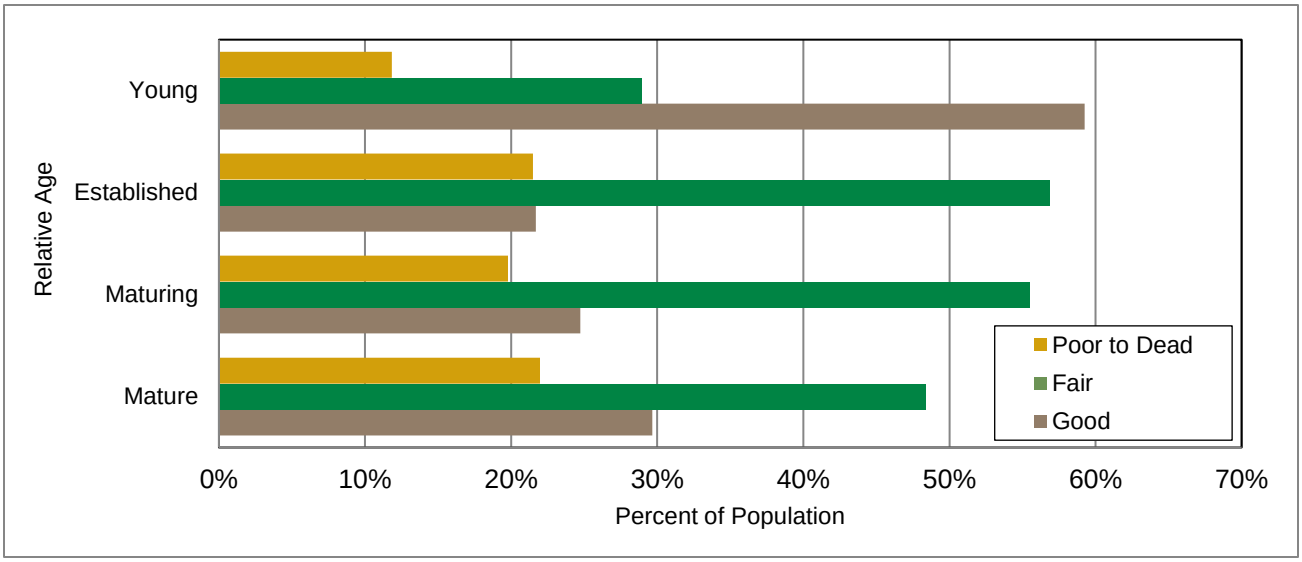


Figure 8. Tree condition by relative age during the 2016-2018 inventory.

- Dead trees and trees in Critical condition should be removed because of their failed health; Critical condition 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 the number of 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, but may not always be successful
- 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 Binghamton'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%.

Findings

The inventory found 5,726 planting sites. Of the inventoried sites, 217 were potential planting sites for large-size trees (8-foot-wide and greater growing space sizes); 544 were potential sites for medium-size trees (6- to 7-foot-wide growing space sizes); and 4,965 were potential sites for small-size trees (4- to 5-foot-wide growing space sizes). Based on the data collected during this inventory, Binghamton's current street ROW tree stocking level is 66%.

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 stocking level of 66% 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 Binghamton estimates that they currently plant between 150 to 300 trees per year. With a current total of 5,726 planting sites along the street ROW, it would take approximately 23 years for the city to reach the recommended stocking level of 90%. This does not take into consideration a natural morality rate of trees in the urban environment.

If budgets allow, DRG recommends that Binghamton plant no less than 214 to account for an annual mortality rate of 2%. 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 possess, the greater the need for trees to provide benefits.

Binghamton's ratio of street trees per capita is 0.23, which is 38% below the mean ratio of 0.37 reported for 22 U.S. cities (McPherson and Rowntree 1989). According to the city-wide study, there is 1 tree for every 4.4 residents. Binghamton's potential is 1 tree for every 2.8 residents.

Table 1. Observations recorded during the street/park tree inventory

Observation	Number of Trees	Percent
Cavity or Decay	1,409	8.44%
Poor Root System	825	4.94%
Mechanical Damage	461	2.76%
Improperly Pruned	274	1.64%
Poor Structure	129	0.77%
Remove Hardware	126	0.75%
Poor Location	99	0.59%
Pest Problem	95	0.57%
Grate or Guard	86	0.51%
Serious Decline	83	0.50%
Improperly Installed	64	0.38%
Improperly Mulched	19	0.11%
Memorial Tree	1	0.01%
None	13,029	78%
Total	**16,700**	**100.00%**

Other Observations

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

Findings

Cavity or decay and Poor Root System were most frequently observed and recorded (8% and 5% of inventoried trees, respectively). Of these 2,234 trees, 391 were recommended for removal, and 6 were rated as High-Risk trees.

Discussion/Recommendations

Unless slated for removal, trees noted as having poor structure (129 trees) or cavity or decay (1,409 trees) should be regularly inspected. Corrective actions should be taken when warranted. If the condition worsens, removal may be required. Of the 1,409 trees noted for cavity or decay, 212 were recommended for removal. Of the 129 trees noted for poor structure, only 15 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.

Photograph 2. *The green ash (Fraxinus pennsylvanica) located at 6 Lawton Avenue has poor structure. With the location of the tree, size of defect, and potential for failure, this tree was assigned a High-Risk rating. Given the severity of the split crotch, as well as the species consideration, Removal is recommended.*

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 noted trees blocking the visibility of traffic signs or signals, streetlights, or other safety devices. This information should be used to schedule pruning activities.

Table 2. Trees noted to be conflicting with infrastructure

Conflict	Type	Number of Trees	Percent
Clearance Requirements	Vehicle	3,908	23.40%
	Pedestrian	1,766	10.57%
	Building	305	1.83%
	Light/sign/signal	132	0.79%
	None	10,589	63.41%
Total		**16,700**	**100%**

Findings

There were 6,111 trees recorded with some type of clearance issue. Most of these (23%) were related to conflicts with vehicles. When the bottom of a tree's canopy over roads was less than 14 feet or contact with vehicles was noticed, this clearance type was recorded in the inventory data.

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)* (2017). DRG's clearance distance guidelines are as follows: 14 feet over streets, 8 feet over sidewalks, and at least 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 near 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 10,645 trees recorded during the inventory, 5,259 (49%) should be raised and 155 (1%) should be reduced. Completing these secondary maintenance recommendations will reduce conflicts with Binghamton'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
- Raised Planter—in an above-grade or elevated planter
- Tree Lawn/Parkway—located between the street curb and the public sidewalk
- Unmaintained/Natural Area—located in areas that do not appear to be regularly maintained
- Well/Pit—at grade level and completely surrounded by sidewalk

Findings

Most (67%) of the tree population is located in tree lawns that range between 4 feet and 22 feet wide, with the greatest percentage (49%) being in 4-foot tree lawns. Suggested planting sites are split between tree lawns (72%) and open/unrestricted areas (25%).

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 6–7 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 tree requires further inspection, such as a Level III risk inspection in accordance with ANSI A300, Part 9 (ANSI, 2017), or periodic inspection due to 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.

Findings

Davey Resource Group recommended 535 trees for further inspection.

Discussion/Recommendations

An ISA Certified Arborist should perform additional inspections of the 535 trees with this designation. If it is determined that these trees exceed the threshold of acceptable risk, the defective part(s) of the trees should be corrected or removed, or the entire tree may need to be removed.

The 434 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 Binghamton'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 9 below). It is important to note that the figure only presents data collected from the inventory. Many more trees throughout Binghamton, including those on public and private property, may be susceptible to these invasive pests.

Findings

Granulate ambrosia beetle (*Xylosandrus crassiusculus)* and Asian longhorned beetle (ALB or *Anoplophora glabripennis*) are known threats to a large percentage of the inventoried street and park trees (53% and 32%, respectively). These pests were not detected in Binghamton, but if they were detected, the city could see severe losses in its tree population.

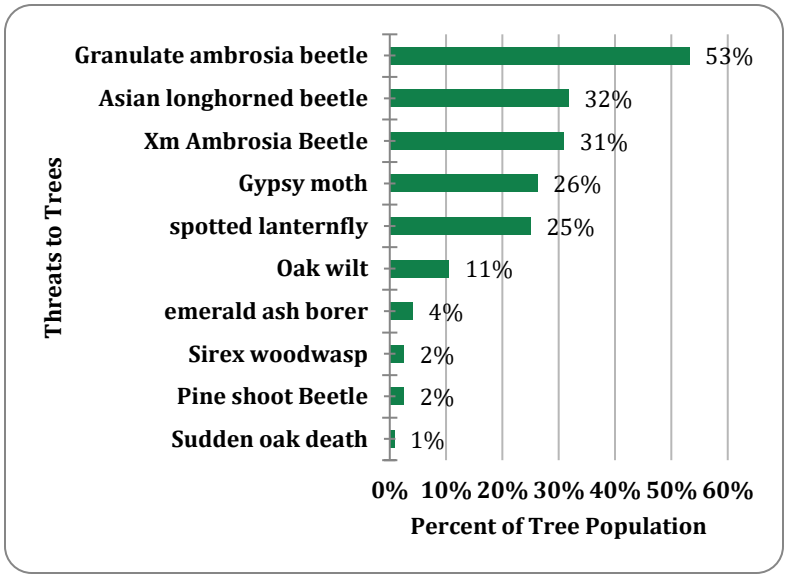


Figure 9. Potential impact of insect and disease threats noted during the 2016-2018 inventory.

There were 434 ash trees inventoried along Binghamton's street ROW and parks, but only a limited number showed potential symptoms. Private trees that were not part of this inventory also showed symptoms of infestation. Additionally, the spread of spotted lanternfly (*Lycorma delicatula*) into Pennsylvania and New Jersey along with the recent detection in New York threatens the grape, orchard and managed trees of the area. The spread/detection of the insect should be monitored to determine if it is a threat to Binghamton's tree population in the future.

Discussion/Recommendations

Binghamton 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. If not begun already, the city should prepare and implement an EAB Management Plan as soon as possible.

SECTION 2: TREE MANAGEMENT PROGRAM

This tree management program was developed to uphold Binghamton'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 managed expediently.

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

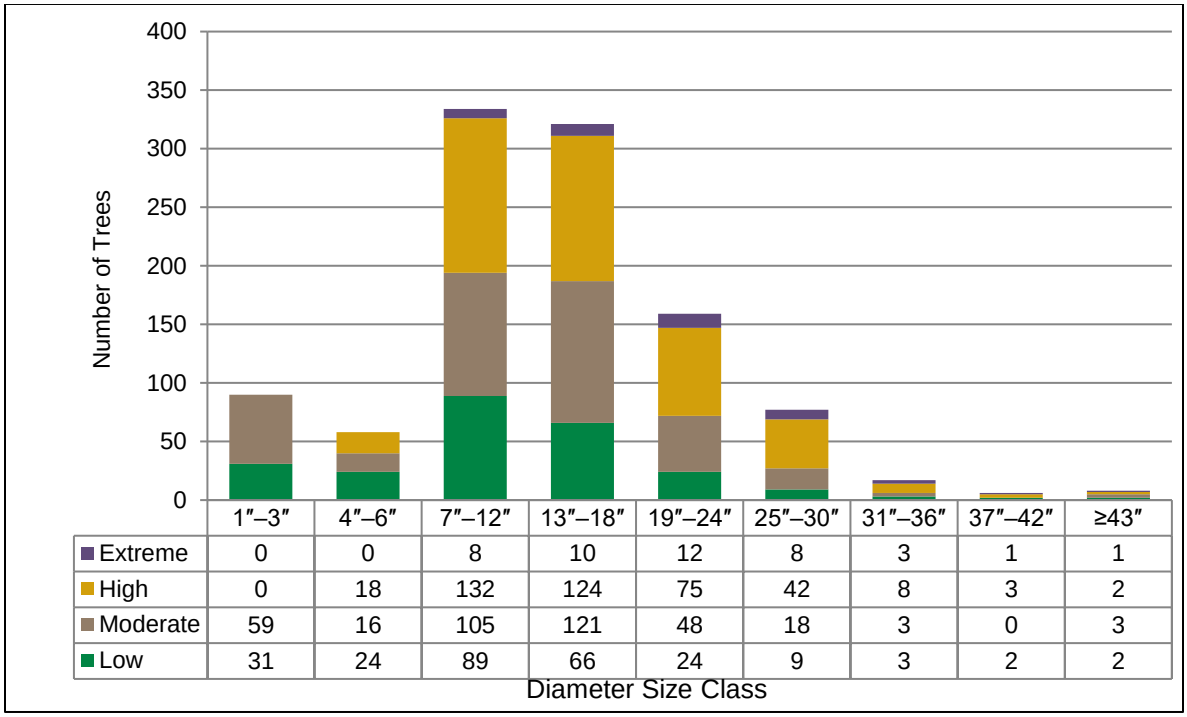
Extreme Risk	Perform tree maintenance immediately to reduce hazards Includes tree removal and pruning Mostly high-use areas
High Risk	Perform tree maintenance immediately to reduce hazards and improve tree health Includes tree removal and pruning Generally high-use areas
Moderate Risk	Perform tree maintenance 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 10 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	8	10	12	8	3	1	1
High	0	18	132	124	75	42	8	3	2
Moderate	59	16	105	121	48	18	3	0	3
Low	31	24	89	66	24	9	3	2	2

Figure 10. Tree removals by risk rating and diameter size class.

Findings

The inventory identified 43 Extreme Risk trees, 404 High Risk trees, 373 Moderate Risk trees, and 250 Low Risk trees that are recommended for removal.

The diameter size classes for High Risk trees ranged between 1–3 inches diameter at breast height (DBH) and ≥43 inches 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 31 inches DBH. These trees should be removed as soon as possible after all Extreme and 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 116 ash trees recommended for removal.

The inventory identified 339 stumps recommended for removal. Most of the stumps ranged in DBH from 6-23 inches in diameter. Stump removals should occur when convenient.

Discussion/Recommendations

Unless already slated for removal, trees noted as having poor structure (114 trees) or cavity or decay (1,188 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* or similar computer software.

Tree Pruning

Extreme and High 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 11 presents the number of High-Risk trees recommended for pruning by size class. The following sections briefly summarize the recommended pruning maintenance identified during the inventory.

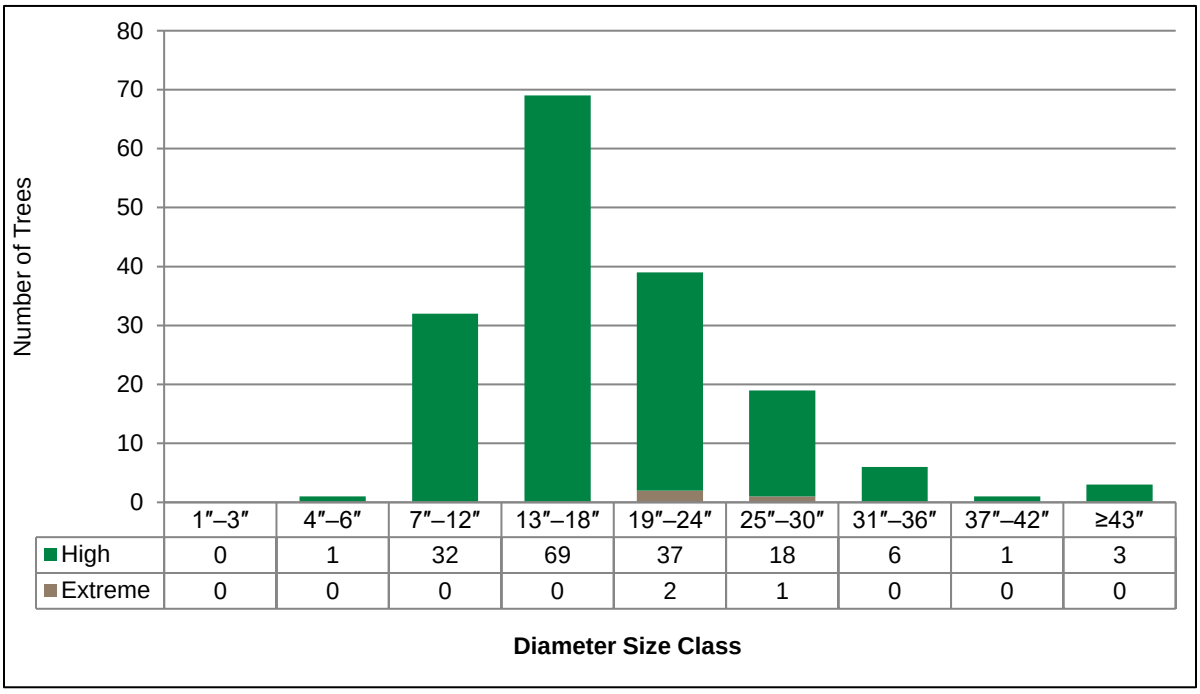


Figure 11. Extreme and High-Risk pruning by diameter size class.

Findings

The inventory identified 3 Extreme Risk trees, 167 High Risk trees, and 2,383 Moderate Risk trees recommended for pruning.

Most of the High-Risk trees ranged in diameter size classes from 7-12 inches DBH to ≥43 inches DBH. This pruning should be performed immediately based on assigned risk and may be performed concurrently with other Extreme and High-Risk removals and pruning. Moderate and Low Risk trees recommended for pruning should be included in a proactive, routine pruning cycle after all the higher risk trees are addressed.

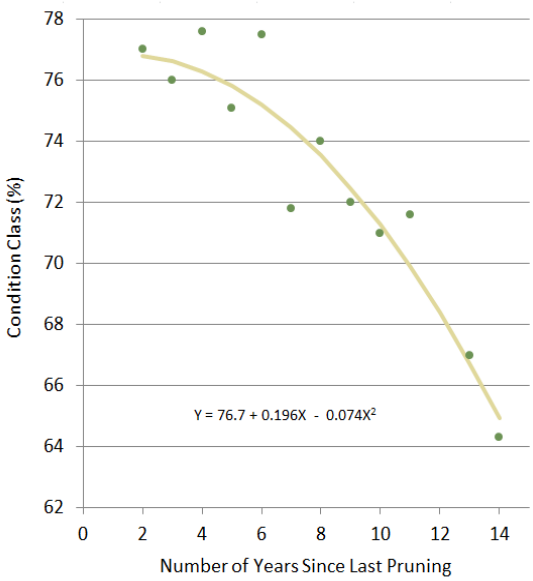


Figure 12. Relationship between average tree condition class and the number of years since the most recent pruning (adapted from Miller and Sylvester 1981).

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, Figure 12). 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 shears. The objective is to increase structural integrity by pruning for one dominant leader. YTT Pruning is species-specific, since many trees, such as river birch (*Betula nigra*) may naturally have more than one leader or main trunk. 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 Binghamton implement a three-year YTT Cycle begins after all Extreme and High-Risk trees are removed or pruned. The YTT Cycle will include existing young trees.

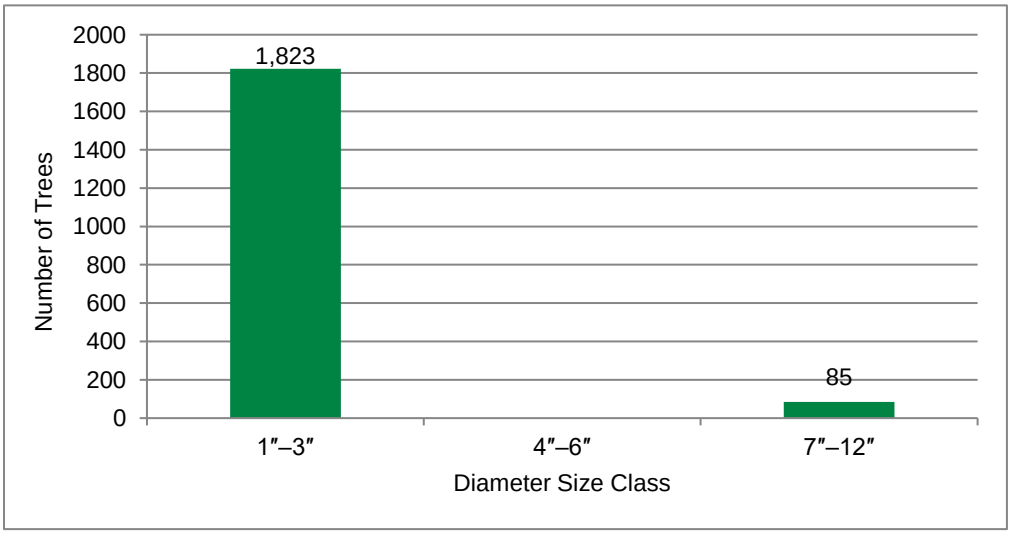


Figure 13. Trees recommended for the YTT Cycle by diameter size class.

During the inventory, 1,908 trees smaller than 12 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 636 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.

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 Moderate and 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.

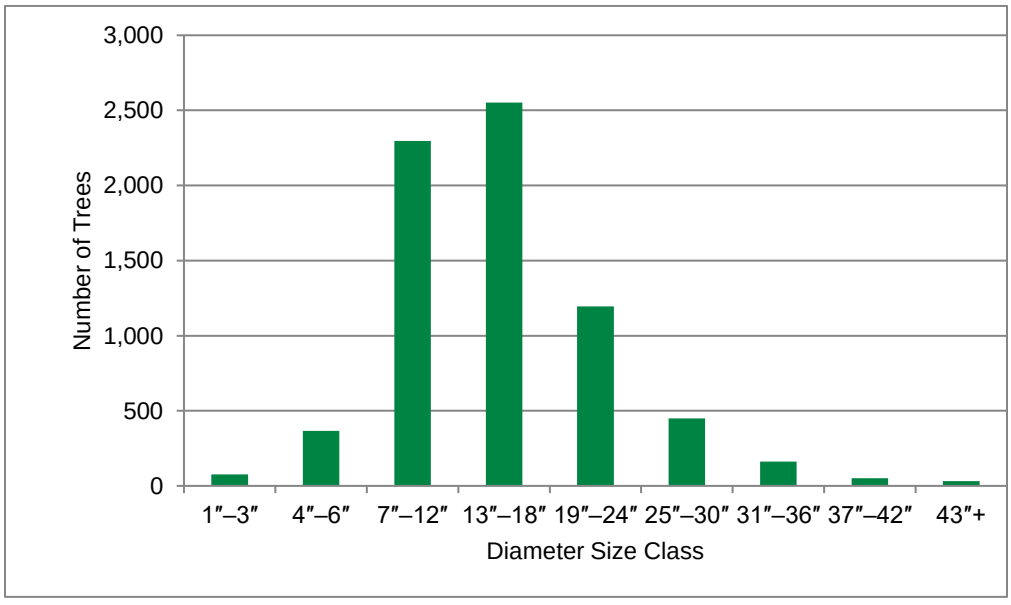


Figure 14. Trees recommended for the RP Cycle by diameter size class.

Recommendations

DRG recommends that the city establishes a five-year RP Cycle in which approximately one-fifth of the tree population is pruned each year. The 2016 and 2018 tree inventories identified approximately 7,179 trees that should be pruned over a five-year RP Cycle, meaning an average of 1,436 trees should be pruned each year over the course of the cycle. DRG recommends that the RP Cycle begins in Year One of this five-year plan, after all Extreme and High-Risk trees are pruned.

The inventory found that most trees (67%) in the street ROW and parks needed routine pruning. Figure 14 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 2016and 2018 City of Binghamton 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 Binghamton. A complete table of estimated costs for Binghamton's five-year tree management program is presented in Table 3.

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 $499,000 for the first year of implementation, no less than $490,000 for the second year, and no less than $292,000 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 3. 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	
Extreme and High-Risk Removals	1-3"	$28	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	4-6"	$58	18	$1,035	0	$0	0	$0	0	$0	0	$0	$1,035
	7-12"	$138	140	$19,250	0	$0	0	$0	0	$0	0	$0	$19,250
	13-18"	$314	134	$42,009	0	$0	0	$0	0	$0	0	$0	$42,009
	19-24"	$605	87	$52,635	0	$0	0	$0	0	$0	0	$0	$52,635
	25-30"	$825	50	$41,250	0	$0	0	$0	0	$0	0	$0	$41,250
	31-36"	$1,045	11	$11,495	0	$0	0	$0	0	$0	0	$0	$11,495
	37-42"	$1,485	4	$5,940	0	$0	0	$0	0	$0	0	$0	$5,940
	43"+	$2,035	3	$6,105	0	$0	0	$0	0	$0	0	$0	$6,105
Activity Total(s)			**447**	**$179,719**	**0**	**$0**	**0**	**$0**	**0**	**$0**	**0**	**$0**	**$179,719**
Moderate and Low-Risk Removals	1-3"	$28	0	$0	90	$2,475	0	$0	0	$0	0	$0	$2,475
	4-6"	$58	0	$0	40	$2,300	0	$0	0	$0	0	$0	$2,300
	7-12"	$138	0	$0	194	$26,675	0	$0	0	$0	0	$0	$26,675
	13-18"	$314	0	$0	187	$58,625	0	$0	0	$0	0	$0	$58,625
	19-24"	$605	0	$0	72	$43,560	0	$0	0	$0	0	$0	$43,560
	25-30"	$825	0	$0	27	$22,275	0	$0	0	$0	0	$0	$22,275
	31-36"	$1,045	0	$0	6	$6,270	0	$0	0	$0	0	$0	$6,270
	37-42"	$1,485	0	$0	2	$2,970	0	$0	0	$0	0	$0	$2,970
	43"+	$2,035	0	$0	5	$10,175	0	$0	0	$0	0	$0	$10,175
Activity Total(s)			**0**	**$0**	**623**	**$175,325**	**0**	**$0**	**0**	**$0**	**0**	**$0**	**$175,325**
Stump Removals	1-3"	$18	0	$0	18	$315	0	$0	0	$0	0	$0	$315
	4-6"	$28	0	$0	27	$743	0	$0	0	$0	0	$0	$743
	7-12"	$44	0	$0	105	$4,620	0	$0	0	$0	0	$0	$4,620
	13-18"	$72	0	$0	85	$6,078	0	$0	0	$0	0	$0	$6,078
	19-24"	$94	0	$0	50	$4,675	0	$0	0	$0	0	$0	$4,675
	25-30"	$110	0	$0	27	$2,970	0	$0	0	$0	0	$0	$2,970
	31-36"	$138	0	$0	14	$1,925	0	$0	0	$0	0	$0	$1,925
	37-42"	$160	0	$0	2	$319	0	$0	0	$0	0	$0	$319
	43"+	$182	0	$0	1	$182	0	$0	0	$0	0	$0	$182
Activity Total(s)			**0**	**$0**	**329**	**$21,826**	**0**	**$0**	**0**	**$0**	**0**	**$0**	**$21,826**
Extreme and High-Risk Pruning	1-3"	$20	0	$0	0	$0	0	$0	0	$0	0	$0	$0
	4-6"	$30	1	$30	0	$0	0	$0	0	$0	0	$0	$30
	7-12"	$75	32	$2,400	0	$0	0	$0	0	$0	0	$0	$2,400
	13-18"	$120	69	$8,280	0	$0	0	$0	0	$0	0	$0	$8,280
	19-24"	$170	39	$6,630	0	$0	0	$0	0	$0	0	$0	$6,630
	25-30"	$225	19	$4,275	0	$0	0	$0	0	$0	0	$0	$4,275
	31-36"	$305	6	$1,830	0	$0	0	$0	0	$0	0	$0	$1,830
	37-42"	$380	1	$380	0	$0	0	$0	0	$0	0	$0	$380
	43"+	$590	3	$1,770	0	$0	0	$0	0	$0	0	$0	$1,770
Activity Total(s)			**170**	**$25,595**	**0**	**$0**	**0**	**$0**	**0**	**$0**	**0**	**$0**	**$25,595**
Tree Cleaning (5-year cycle)	1-3"	$20	16	$320	16	$320	15	$300	15	$300	15	$300	$1,540
	4-6"	$30	74	$2,220	74	$2,220	73	$2,190	73	$2,190	73	$2,190	$11,010
	7-12"	$75	460	$34,500	459	$34,425	459	$34,425	459	$34,425	459	$34,425	$172,200
	13-18"	$120	511	$61,320	511	$61,320	510	$61,200	510	$61,200	510	$61,200	$306,240
	19-24"	$170	239	$40,630	239	$40,630	239	$40,630	239	$40,630	239	$40,630	$203,150
	25-30"	$225	90	$20,250	90	$20,250	90	$20,250	90	$20,250	89	$20,025	$101,025
	31-36"	$305	33	$10,065	32	$9,760	32	$9,760	32	$9,760	32	$9,760	$49,105
	37-42"	$380	11	$4,180	10	$3,800	10	$3,800	10	$3,800	10	$3,800	$19,380
	43"+	$590	7	$4,130	6	$3,540	6	$3,540	6	$3,540	6	$3,540	$18,290
Activity Total(s)			**1,441**	**$177,615**	**1,437**	**$176,265**	**1,434**	**$176,095**	**1,434**	**$176,095**	**1,433**	**$175,870**	**$881,940**
Young Tree Training Pruning (3-year cycle)	1-6"	$20	607	$12,140	607	$12,140	606	$12,120	607	$12,140	607	$12,140	$60,680
	7-12"	$30	29	$870	28	$840	28	$840	29	$870	28	$840	$4,260
Activity Total(s)			**636**	**$13,010**	**635**	**$12,980**	**634**	**$12,960**	**636**	**$13,010**	**635**	**$12,980**	**$64,940**
Replacement Tree Planting	Purchasing	$170	214	$36,380	214	$36,380	214	$36,380	214	$36,380	214	$36,380	$181,900
	Planting	$110	214	$23,540	214	$23,540	214	$23,540	214	$23,540	214	$23,540	$117,700
Activity Total(s)			**428**	**$59,920**	**428**	**$59,920**	**428**	**$59,920**	**428**	**$59,920**	**428**	**$59,920**	**$299,600**
Replacement Young Tree Maintenance	Mulching	$100	214	$21,400	214	$21,400	214	$21,400	214	$21,400	214	$21,400	$107,000
	Watering	$100	214	$21,400	214	$21,400	214	$21,400	214	$21,400	214	$21,400	$107,000
Activity Total(s)			**428**	**$42,800**	**428**	**$42,800**	**428**	**$42,800**	**428**	**$42,800**	**428**	$42,800	**$214,000**
Activity Grand Total			**3,122**		**3,452**		**2,496**		**2,498**		**2,496**		
Cost Grand Total				**$498,659**		**$489,115**		**$291,775**		**$291,825**		**$291,570**	**$1,862,944**

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 be created to increase awareness of the importance of trees.

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

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. Qualified arborists are knowledgeable about the needs of trees and are trained and equipped to provide proper care.

Trees in 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* 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. Binghamton has a large population of trees that are susceptible to pests and diseases, such as ash, oak, and maple.

Inventory and Plan Updates

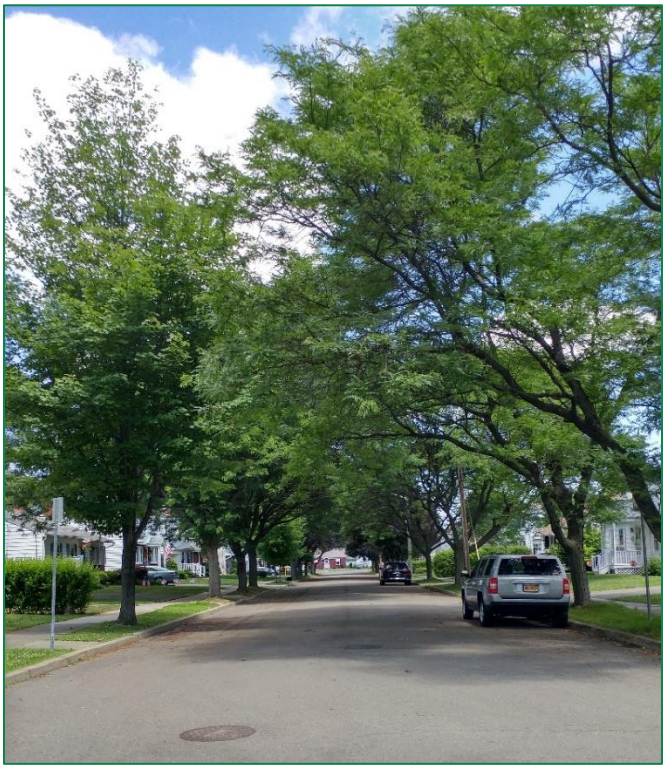
DRG recommends that the inventory and management plan be updated using an appropriate computer software program so that the city can sustain its program and accurately project future program and budget needs:

- 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 2017) 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* 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 Parks, and update all data fields in five years, or a portion of the population (1/5 or 20%) every year over the course of five years.
- Revise the *Tree Management Plan* after five years when the re-inventory has been completed.

CONCLUSIONS

Every hour of every day, public trees in Binghamton are supporting and improving the quality of life. The city's trees provide an annual benefit of $1,208,078 based on our i-Tree (TreeKeeper® 8) national tree benefits calculator analysis. 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.



Photograph 3. *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.*

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 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, Binghamton is well positioned to thrive. If the management program is successfully implemented, the health and safety of Binghamton'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.

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.

block side (data field): Address information for a site that includes the *on street*, *from street*, and *to street*. The *on street* is the street on which the site is actually located. The *from street* is the cross street from which one moves away when heading in the direction of traffic flow. The *to street* is the cross street from which one moves towards when heading in the direction of traffic flow.

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.

clearance requirements (data field): Illustrates the need for pruning to meet clearance standards over streets and sidewalks, or where branches are 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**.

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 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.

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 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.

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 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.

Restore (Secondary Maintenance Need): Signifies a maintenance need for a tree. Restoring 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): The risk assessment is a point-based assessment of each tree by an arborist using a protocol based on the U.S. Forest Service Community Tree Risk Rating System. In the field, the probability of tree or tree part failure is assigned 1–4 points (identifies the most likely failure and rates the likelihood that the structural defect(s) will result in failure based on observed, current conditions), the size of the defective tree part is assigned 1–3 points (rates the size of the part most likely to fail), the probability of target impact by the tree or tree part is assigned 1–3 points (rates the use and occupancy of the area that would be struck by the defective part), and other risk factors are assigned 0–2 points (used if professional judgment suggests the need to increase the risk rating). The data from the risk assessment is used to calculate the risk rating that is ultimately assigned to the tree.

risk rating: Level 2 qualitative risk assessment will be performed on the ANSI A300 (Part 9) and the companion publication *Best Management Practices: Tree Risk Assessment*, published by International Society of Arboriculture (2011). Trees can have multiple failure modes with various risk ratings. One risk rating per tree will be assigned during the inventory.

The failure mode having the greatest risk will serve as the overall tree risk rating. The specified time period for the risk assessment is one year.

Secondary Maintenance Need (data field): 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 to*, *side away*, *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 to* is the name of the street the arborist is walking towards as data are being collected. The *side from* is the name of the street the arborist is walking away from while collecting data. *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.

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 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.

Vista Prune (Secondary Maintenance Need): Pruning to enhance a specific view without jeopardizing the health of the tree.

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

Davey Resource Group, Inc. "DRG" collected tree inventory data using a system that utilizes a customized GIS data collection program loaded onto pen-based field computers equipped with geographic information system (GIS) and global positioning system (GPS) receivers. The knowledge and professional judgment of DRG's arborists ensure the high quality of inventory data.

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

- aboveground utilities
- block side
- clearance requirements
- condition
- grow space size
- grow space type
- further inspection
- hardscape damage
- location
- primary maintenance needs
- mapping coordinates
- observations
- notes
- risk assessment
- risk rating
- secondary maintenance needs
- species
- stems
- tree size*

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

Maintenance needs are based on the *ANSI A300 (Part 1)* (ANSI 2008). Risk assessment and risk rating are based on *Urban Tree Risk Management* (Pokorny et al. 1992) for information collected in 2016, and *Best Management Practices: Tree Risk Assessment* (International Society of Arboriculture [ISA] 2011) for information collected in 2018.

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

Site Location Methods

Equipment and Base Maps

Inventory arborists use FZ-G1 Panasonic ToughPad® unit(s).

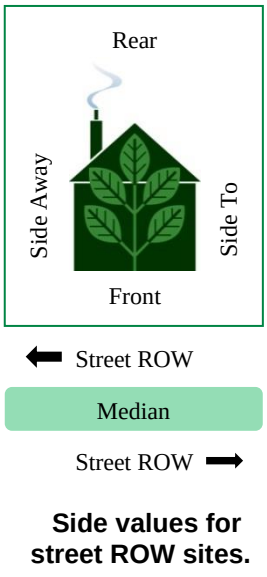
Base map layers were loaded onto these unit(s) to help locate sites during the inventory. Table 1 lists the base map layers, utilized along with source and format information for each layer.

Table 1. Base Map Layers Utilized for Inventory

Imagery/Data Source	Date	Projection
Basemap Data NY GIS Clearinghouse https://gis.ny.gov/	2016-2018	NAD 1983 2011 StatePlane New York Central, FT
Aerial Imagery, 1ft 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*, *side*, *site number*, or *block side*. This methodology was developed by Davey Resource Group to help ensure consistent assignment of location.



Side values for street ROW sites.

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* and *site number*. Side values include: *front*, *side to*, *side away*, *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 to* is the name of the street the arborist walks towards as data are being collected. *Side from* is the name of the street the arborist walks away from while collecting data. *Median* indicates a median or island. The *rear* is the side of the lot opposite the front.

Block Side

Block side information for a site includes the *on street*.

- The *on street* is the street on which the site is located. The *on street* may not match the address street. A site may be physically located on a street that is different from its street address (i.e., a site located on a side street).

Park and/or Public Space Site Location

Park and/or public space site locations were collected using the same methodology as street ROW sites; however, the *on street* would be the park and/or public space's name (not street names).

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:

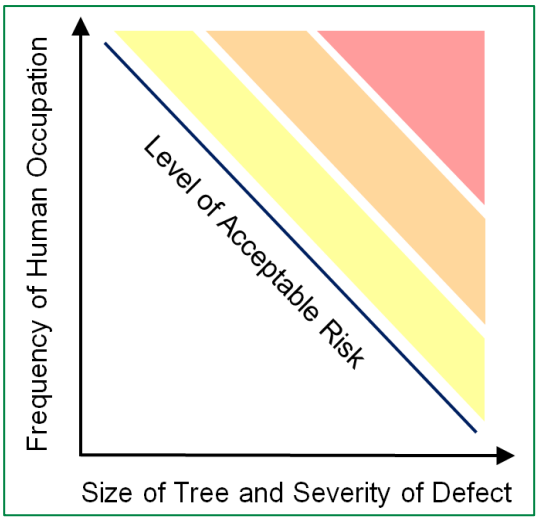
Address/Street Name:	226 E. Mac Arthur Street
Side:	Side To
On Street:	Davis Street

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.

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 2016 inventory, DRG performed a risk assessment for each tree and assigned a risk rating following protocol based on *Urban Tree Risk Management* (Pokorny et al. 1992). The probability of failure, size of defective part, probability of target impact, and other risk factors were evaluated for each tree inventoried tree. Independent point values were assigned and summed to generate the risk rating.



- *Probability of Failure* (1–4 points)—Identifies the most likely failure and rates the likelihood that the structural defect(s) will result in failure based on observed, current conditions.
- *Size of Defective Part* (1–3 points)—Rates the size of the part most likely to fail.
- *Probability of Target Impact* (1–3 points)—Rates the use and occupancy of the area that would be struck by the defective part.
- *Other Risk Factors* (0–2 points)—This category is used if professional judgment suggests the need to increase the risk rating. It is especially helpful when growth characteristics become a factor in risk rating. For example, some tree species have growth patterns that make them more vulnerable to certain defects such as weak branch unions and branching shedding.

Once risk rating is calculated, a level of risk is assigned to each tree. The assigned risk rating allows for effective prioritization of tree maintenance work.

- *Severe Risk* (rating of 9 or 10)—Trees described as Severe Risk have defects that cannot be cost-effectively or practically treated. Most of the trees in this category have multiple or significant defects in the trunk, crown, or critical root zone. Defective trees and/or tree parts are generally larger than 20 inches in diameter and are found in areas of frequent occupation, such as a congested street, a main thoroughfare, and/or near a school.
- *High Risk* (rating of 7 or 8)—Trees designated as High Risk have defects that may or may not be cost-effectively or practically treated. Most of the trees in this category have multiple or significant defects that affect more than 40% of the trunk, crown, or critical root zone. Defective trees and/or tree parts are generally 4–20 inches in diameter and are found in areas of frequent occupation, such as a congested street, main thoroughfare, and/or near a school.
- *Moderate Risk* (rating of 5 or 6)—Trees described as Moderate Risk have defects that may be cost-effectively or practically treated. Most of the trees in this category exhibit several

moderate defects that affect less than 40% of a tree's trunk, crown, or critical root zone. These trees may be in high-, moderate-, or low-use areas.

- *Low Risk* (rating of 3 or 4)—Trees designated as Low Risk have minor visible structural defects or wounds and are typically found in areas with moderate- to low-use areas.
- *None* (rating of 0)—Used for planting sites and stumps.

During the 2018 inventory, Davey Resource Group, Inc. "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, Manchester 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 a community's urban forest. The tree species listed below have been evaluated for factors such as size, disease and pest resistance, seed or fruit set, and availability. The following list is offered to assist all relevant community personnel in selecting appropriate tree species. These trees have been selected because of their aesthetic and functional characteristics and their ability to thrive in the soil and climate conditions throughout Zones 6b 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 rubrum	red maple	Red Sunset®
Acer saccharum	sugar maple	'Legacy'
Acer nigrum	black maple	
*Betula alleghaniensis**	yellow birch	
*Betula lenta**	sweet birch	
Betula nigra	river birch	Heritage®
Carpinus betulus	European hornbeam	'Franz Fontaine'
*Carya illinoensis**	pecan	
*Carya lacinata**	shellbark hickory	
*Carya ovata**	shagbark hickory	
*Castanea mollissima**	Chinese chestnut	
Celtis laevigata	sugarberry	
Celtis occidentalis	common hackberry	'Prairie Pride'
Cercidiphyllum japonicum	katsuratree	'Aureum'
*Diospyros virginiana**	common persimmon	
*Fagus grandifolia**	American beech	
*Fagus sylvatica**	European beech	(Numerous exist)
Ginkgo biloba	ginkgo	(Choose male trees only)
Gymnocladus dioica	Kentucky coffeetree	Prairie Titan®
*Juglans nigra**	black walnut	
*Larix decidua**	European larch	
Liquidambar styraciflua	American sweetgum	'Rotundiloba'
*Liriodendron tulipifera**	tuliptree	'Fastigiatum'
*Magnolia acuminata**	cucumbertree magnolia	(Numerous exist)
*Magnolia macrophylla**	bigleaf magnolia	
Metasequoia glyptostroboides	dawn redwood	'Emerald Feathers'
Nyssa sylvatica	blackgum	
*Platanus occidentalis**	American sycamore	
Platanus × acerifolia	London planetree	'Yarwood'
Quercus alba	white oak	

Large Trees: Greater than 45 Feet in Height at Maturity (Continued)

Scientific Name	Common Name	Cultivar
Quercus bicolor	swamp white oak	
Quercus coccinea	scarlet oak	
Quercus lyrata	overcup oak	
Quercus macrocarpa	bur oak	
Quercus montana	chestnut oak	
Quercus muehlenbergii	chinkapin oak	
Quercus palustris	pin oak	
Quercus imbricaria	shingle oak	
Quercus phellos	willow oak	
Quercus robur	English oak	Heritage®
Quercus shumardii	Shumard oak	
Styphnolobium japonicum	Japanese pagodatree	'Regent'
Taxodium distichum	common baldcypress	'Shawnee Brave'
Tilia americana	American linden	'Redmond'
Tilia cordata	littleleaf linden	'Greenspire'
Tilia × euchlora	Crimean linden	
Tilia tomentosa	silver linden	'Sterling'
Ulmus parvifolia	Chinese elm	Allée®
Zelkova serrata	Japanese zelkova	'Green Vase'

Medium Trees: 31 to 45 Feet in Height at Maturity

Scientific Name	Common Name	Cultivar
Aesculus × carnea	red horsechestnut	
Alnus cordata	Italian alder	
*Asimina triloba**	pawpaw	
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'
Pistacia chinensis	Chinese pistache	
*Pterocarya fraxinifolia**	Caucasian wingnut	
Quercus acutissima	sawtooth oak	
Quercus cerris	European turkey oak	
*Sassafras albidum**	sassafras	

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 ginnala	Amur maple	Red Rhapsody™
Acer griseum	paperbark maple	
Acer oliverianum	Chinese maple	
*Acer pensylvanicum**	striped maple	
Acer triflorum	three-flower maple	
*Aesculus pavia**	red buckeye	
Amelanchier arborea	downy serviceberry	(Numerous exist)
Amelanchier laevis	Allegheny serviceberry	
*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'
Corylus avellana	European filbert	'Contorta'
*Cotinus coggygria**	common smoketree	'Flame'
*Cotinus obovata**	American smoketree	
*Crataegus phaenopyrum**	Washington hawthorn	Princeton Sentry™
Crataegus viridis	green hawthorn	'Winter King'
*Franklinia alatamaha**	Franklinia	
*Halesia tetraptera**	Carolina silverbell	'Arnold Pink'
Laburnum × watereri	goldenchain tree	
Maackia amurensis	Amur maackia	
*Magnolia × soulangiana**	saucer magnolia	'Alexandrina'
*Magnolia stellata**	star magnolia	'Centennial'
*Magnolia tripetala**	umbrella magnolia	
*Magnolia virginiana**	sweetbay magnolia	Moonglow®
Malus spp.	flowering crabapple	(Disease resistant only)
Oxydendrum arboreum	sourwood	'Mt. Charm'
*Staphylea trifolia**	American bladdernut	
Stewartia ovata	mountain stewartia	
*Styrax japonicus**	Japanese snowbell	'Emerald Pagoda'
Syringa reticulata	Japanese tree lilac	'Ivory Silk'

Note: * denotes species that are **not** recommended for use as street trees.

Coniferous and Evergreen Trees

Large Trees: Greater than 45 Feet in Height at Maturity

Scientific Name	Common Name	Cultivar
Abies balsamea	balsam fir	
Abies concolor	white fir	'Violacea'
Cedrus libani	cedar-of-Lebanon	
Chamaecyparis nootkatensis	Nootka falsecypress	'Pendula'
Cryptomeria japonica	Japanese cryptomeria	'Sekkan-sugi'
× *Cupressocyparis leylandii*	Leyland cypress	
Ilex opaca	American holly	
Picea omorika	Serbian spruce	
Picea orientalis	Oriental spruce	
Pinus densiflora	Japanese red pine	
Pinus strobus	eastern white pine	
Pinus sylvestris	Scotch pine	
Pinus taeda	loblolly pine	
Pinus virginiana	Virginia pine	
Psedotsuga menziesii	Douglas-fir	
Thuja plicata	western arborvitae	(Numerous exist)
Tsuga canadensis	eastern hemlock	

Medium Trees: 31 to 45 Feet in Height at Maturity

Scientific Name	Common Name	Cultivar
Chamaecyparis thyoides	Atlantic whitecedar	(Numerous exist)
Juniperus virginiana	eastern redcedar	
Pinus bungeana	lacebark pine	
Pinus flexilis	limber pine	
Pinus parviflora	Japanese white pine	
Thuja occidentalis	eastern arborvitae	(Numerous exist)

Small Trees: 15 to 30 Feet in Height at Maturity

Scientific Name	Common Name	Cultivar
Ilex × *attenuata*	Foster's holly	
Pinus aristata	bristlecone pine	
Pinus mugo mugo	mugo pine	

Dirr's Hardy Trees and Shrubs (Dirr 2013) and *Manual of Woody Landscape Plants (5th Edition)* (Dirr 1988) were consulted to compile this suggested species list. Cultivar selections are recommendations only and are based on Davey Resource Group, Inc.'s experience. Tree availability will vary based on availability in the nursery trade.

APPENDIX D
TREE PLANTING

Tree Planting

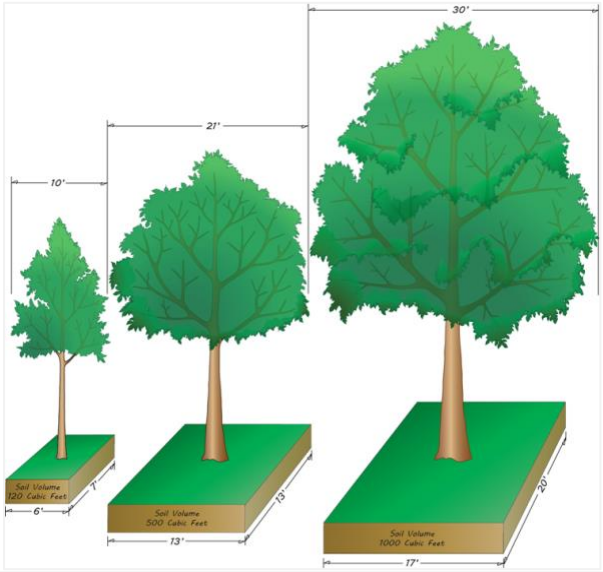
Planting trees is a valuable goal as long as tree species are carefully selected and correctly planted. When trees are planted, they are planted selectively and with purpose. Without proactive planning and follow-up tree care, a newly planted tree may become a future problem instead of a benefit to the 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 5,726 planting sites, of which 86% are designated for small-sized mature trees, 10% for medium-sized trees, and 4% 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.

Binghamton is located in USDA Hardiness Zone 6b, which is identified as a climatic region with average annual minimum temperatures between -5°F and 0°F. Tree species selected for planting in Binghamton 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.

Davey Resource Group, Inc. "DRG" recommends limiting the planting of Norway maples in the street ROW and northern red oak in the parks until the species distribution normalizes. Of the inventoried population, Norway maples and northern red oak already occupy 22% and 12%, both of which exceed the recommended 10% species maximum.

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.

The city 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 the city'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. The city 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.

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

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.

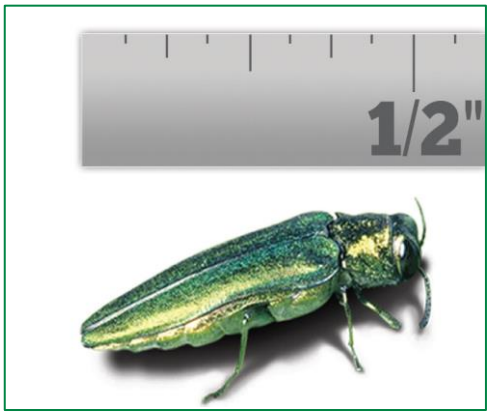
Adult Asian longhorned beetle

Photograph courtesy of New Bedford Guide 2011

Adults are large (3/4- to 1/2-inch long) with very long, black and white banded antennae. The body is glossy black with irregular white spots. Adults can be seen from late spring to fall depending on the climate. ALB has a long list of host species; however, the beetle prefers hardwoods, including several maple species. Examples include: *Acer negundo* (box elder); *A. platanoides* (Norway maple); *A. rubrum* (red maple); *A. saccharinum* (silver maple); *A. saccharum* (sugar maple); *Aesculus glabra* (buckeye); *A. hippocastanum* (horsechestnut), *Betula* (birch), *Platanus* × *acerifolia* (London planetree), *Salix* (willow), and *Ulmus* (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

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.

Adult granulate ambrosia beetle

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

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

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.

Xm ambrosia beetle

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

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).

Oak Wilt

Oak wilt symptoms on red and white oak leaves

Photograph courtesy of USDA Forest Service (2011a)

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.

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.

Spotted lanternfly

The spotted lanternfly (*Lycorma delicatula*) is native to China, Bangladesh, Vietnam, and introduced to Japan and Korea where it has become a major pest of grapes. Following first detection in Pennsylvania, it has been discovered in New Jersey, Delaware and Virginia. This insect has the potential to greatly impact to the grape, orchard and logging industries.

Close-up of spotted lanternfly, Photograph courtesy of, Pennsylvania Department of Agriculture, bugwood.org

The Spotted Lanternfly adult is approximately 1" long and 1/2" wide, and their forewing is tan with speckled black spots at the wings tips. The hind wings have contrasting patches of red and black with a white band. The legs and head are black; the abdomen is yellow with broad black bands. Immature stages are black with white spots and develop red patches as they grow.

The spotted lanternfly has a wide array of hosts but strongly prefers Tree of Heaven. Infested trees will develop weeping wounds and will develop a fermented odor. The adults will lay egg masses on host trees and nearby smooth surfaces in late fall. Nymphs will have white spots with a black background and turn red just before reaching adulthood. Egg masses are mustard in color with a grayish waxy coating.

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